INCT for Climate Change Phase 2
(INCT MC2)

Porto Alegre inundada depois de cheia histórica do rio Guaíba — Foto: Renan Mattos/Reuters

Ref: FAPESP 2014/50848-9
CNPq 465501/2014-1
CAPES 88887.136402/2017-00
INCT-MCTI/CNPq/CAPES/FAPs 16/204

Year 7

September 2024

Principal Researcher and Coordinator:
Jose Antônio Marengo Orsini

CEMADEN/MCTI

SUMMARY

1. Overview

The INCT for Climate Change Phase 2 (INCT MC2) aims to implement and develop a comprehensive network of interdisciplinary research on global change and sustainability, and is based on the cooperation between about 30 research groups from all regions of Brazil from various national international research groups, involving in its entirety over approximately 350 researchers, students and collaborators and establishing itself as one of the largest networks of environmental research developed in Brazil (Figure 1.1)

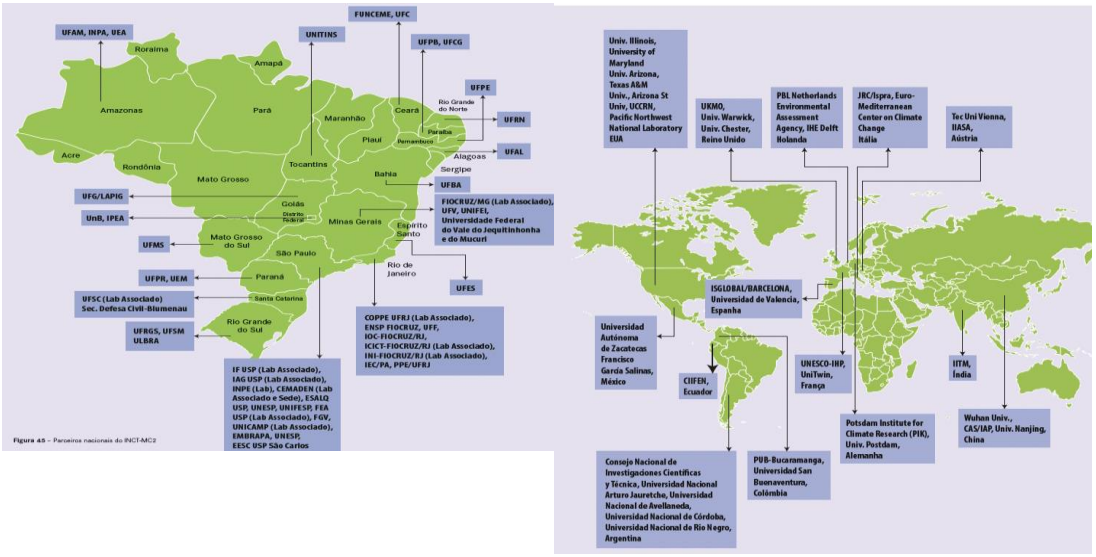


Figure 1.1. National and international partners of the INCT MC2

The program consists of six thematic lines (or subcomponents):

1. Food security;
2. Water security;
3. Energy security;
4. Health and climate change;
5. Natural disasters, impacts on physical infrastructure in urban areas and urban development;
6. Impacts on Brazilian ecosystems in view of changes in land use and biodiversity.

All these components are connected via 3 integrative themes or cross cutting themes:

7. Economy and impacts in key sectors;
8. Modelling the earth system and production of future climate scenarios to study vulnerability, impacts, adaptation and resilience;
9. Communication, dissemination of knowledge and education for sustainability.

Starting in Year 6, we have created a new phase of Integration and synthesis of the results of the 9 components, and the structure of the projects until the end of the project in 2025 is shown in Figure 1.2.

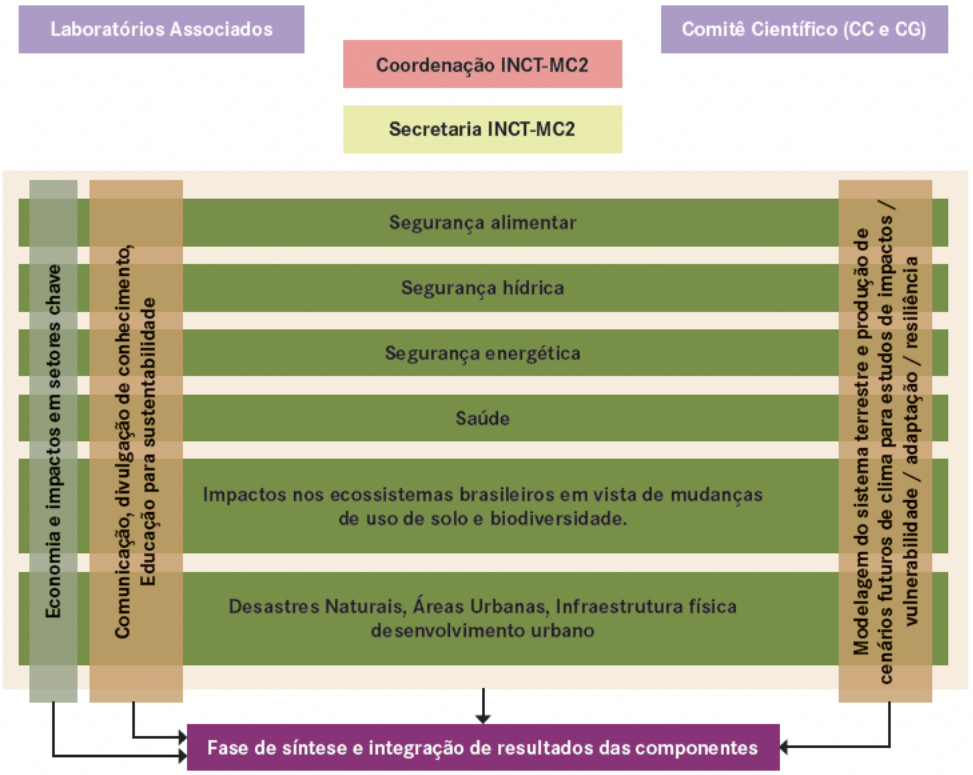


Figure 1.2. New structure of the INC MC2 since 2022.

So far, the scientific agenda of the INCT-MC2 was developed as planned, starting in 2017 and ending in 2025. This agenda provides scientific excellence in various areas of global environmental change and their implications for sustainable development. Emphasis on the impacts of climate change in agriculture, health, renewable energy, urban development and natural disasters such as central themes integrated into environmental modeling, the economics and communication of these impacts to the public, the scientific community and the academia, industry, business and government can contribute to maintaining excellence in activities in Science & Technology and Innovation as the axis of the sustainable environmental development, with character integrative and innovative.

Different from the Report of Year 1, where only FAPESP funded components were explained, in Years 2, 3, 4, 5, 6 and now in year 7 we decided to include all components of the project, that include contributions of the UFMG and FIOCRUZ in MG, and partnerships with UFSC, UFRJ, IPEA, and other institutions outside of the State of Sao Paulo. This provides a holistic view of the project and its components.

Perhaps one of the most important contributions of the INCT MC2 was the participation of several of the researchers of this project in the elaboration of the Scientific Report of Science Panel for the Amazon (SPA) and related activities in 2023 and 2024. In response to these challenges and inspired by the Leticia Pact for the Amazon, a group of over 200 preeminent scientists from the region have untied to form the unprecedented. The Panel was convened by the United Nations Sustainable Development Solutions Network (SDSN), and provided a comprehensive, first-of-its-kind scientific assessment of the state of the Amazon, current trends, and recommendations for the long-term well-being of the ecosystem and its people. Its recommendations promote conservation as well as sustainable development of the region, with a vision of a standing forest, flowing rivers bioeconomy based on local and Indigenous knowledge, technology, and innovation. On March 2023 the SPA released their initial findings as well as a draft version of their full report for public consultation. The SDSN and the World Bank co-hosted a high-level dialogue in Belem, Pará to present these initial findings and foster conversations between scientists and policymakers to advance sustainable development pathways in the Amazon. We also plan to provide scientific information for the COP 29 in Baku in November 2024, and the COP-30 that will be held in Belem in 2025 and have participated and sponsored the International Conference of the Rede Clima in Brasilia. From 18-20 June 2024 I participated at the launching of the Policy Brief on drought organized by the SPA in New York on July 8th 2024.

2. Objectives and goals

The objectives of the INCT MC2 have not changed:

- To implement and develop a comprehensive network of interdisciplinary research on global environmental change and sustainability
- To develop actions aimed at assessing adaptation to environmental changes and the transformation to sustainability, to reflect the vulnerabilities and resilience trajectories and propose ways in adapting to these changes, especially in relation to decision in the political sphere.
- To merge science with education from primary to the post-graduate levels.
- To provide an overview of issues related to sustainability and environmental-social-corporate responsibility, to facilitate the participation or even the implementation of activities in different areas of management of public and private institutions and their relationships with stakeholders.
- To maintain excellence in activities in Science & Technology & Innovation as the structural axis of sustainable environmental development, with an integrator and innovative character.
- To transfer knowledge using instruments that go beyond only scientific articles, but producing audio-visual material, web tools, and other outlets that allow the development of a scientific culture in society, improving the impact of Brazilian science and enabling increased international insertion of Brazil in environmental negotiations.
- To develop a research agenda in global change to identify and understand the current impacts of climate variability on natural and human systems in Brazil;
- To enhance and expand the scope of studies on global changes and their impacts on important sectors to the economy of Brazil.
- To engage and educate society, aiming to increase the resilience of these sectors.
- To sensitize the public perception of science and technology in relation to global change and impacts on society.
- To contribute prominently in the research and development of the National Plan on Climate Change and the National Adaptation Plan to Combat Drought and

Desertification, in partnership with federal, state and international research programs on global change

- To produce publications and model data that can be used to provide scientific contributions to scientific panels, The Rede Clima, special reports of the Brazilian Panel of Climate Change and the Fifth National communication of Brazil to UNFCCC.

3. Coordination

Coordinator: Jose A. Marengo, Researcher, Level 1 B-CNPq classification, CEMADEN, Sao Paulo
Vice-Coordinator: Tercio Ambrizzi, Researcher, Level 1 A-CNPq classification, IAG USP, Sao Paulo

-**Steering Committee**

Name	**Field of work**	**Institution**	**e-mail**
Jose Antonio Marengo Orsini	Project's coordinator. Climate modelling, impacts and vulnerability assessments	CEMADEN	jose.marengo@cemaden.gov.br
Tercio Ambrizzi	Vice-coordinator, Climatology, climate studies, water security	IAG USP	ambrizzi@model.iag.usp.br
Paulo Nobre	Oceanic and coupled atmosphere-ocean modelling	CPTEC INPE	pnobre@cptec.inpe.br
Roberto Schaeffer	Energy and climate change	COPPE UFRJ	roberto@ppe.ufrj.br
Paulo Eduardo Artaxo Neto	Environmental physics, Amazonia, and climate change	IF USP	artaxo@if.usp.br
Eduardo Mario Mendiondo	Hydrology and water security	USP EESC	emm@sc.usp.br
Ulisses E C Confalonieri	Health and climate change	UFMG e FIOCRUZ	uconfalonieri@gmail.com efrangel@ioc.fiocruz.br
Eduardo Haddad	Economy of climate change	FEA USP	ehaddad@usp.br

All members of the Steering Committee (CG) are also coordinators of the Associated Laboratories. The Federal University of the Sate of Santa Catarina (UFSC) and the State University of Campinas (UNICAMP) are also Associated Laboratories. Associated Laboratories are those centers whose members are part of the CG but are not part of the group that is submitting the proposal. The progress of the Project is monitored by a Scientific Committee (CC), that is constituted by the coordinators of the subcomponents (themes) and from the cross-cutting activities. We have meet virtually in March 2023 and June 2024 to see the progress of the project.

The transfer of knowledge to society must be developed from a system of investigation, management and experimentation information in climate change, by means of:

• Theoretical strengthening of studies that support actions that invest in scientific communication and dissemination.
• The generation of analyzes of the relationships between sciences, technologies and society.
• The creation of new approaches methodologies that allow experimenting with social media and languages.
• The investigation of potentialities cultural artefacts (newspapers, magazines, movies, TV shows, works
art, blogs, videos, radio shows, podcasts, etc).
• The production and dissemination of information and quality materials that can serve as tools for public managers and civil society organizations in the evaluation, policy formulation and implementation public.

In this project, we want the community to science in global environmental change is heard, not only to legitimize what has already been decided by governments, but to influence the processes that are ongoing in public administration regarding environmental policies and major undertakings that may affect the environment.

The experience gained at the INCT-MC2 in the period 2017-2024 can be evaluated from the degree of interdisciplinary synergy in S&T and its continuity social impacts. Internally, the INCT-MC2 values this synergy in the integration between Subcomponents and Cross Axes. On the one hand, this synergy is accelerated in the Security Subcomponents Food, Water Security, Security Energy, Health, Impacts on Ecosystems Brazilians in view of changes in land use and Biodiversity, Natural Disasters, Analysis Integrated for Policy and Decision-Making Public. Also, the synergy is strengthened in the Transversal Axes of Economy and impacts on highlighted sectors, Communication, Disclosure, Education and Modeling of the Earth System and Production of Future Scenarios. On the other hand, in the period 2020-2024, the INCT MC2 Subcomponents and Transversal Axes brought global recommendations for the federal, state and municipal levels in Brazil.

The coordination of the components of the project have been updated:

CARGOS	COORDENADORES (INSTITUIÇÃO, ESTADO)	ATIVIDADES DESENVOLVIDA
Coordenador	J. Marengo (CEMADEN, SP)	Coordenação do projeto, modelag avaliações de impactos e vulnerab adaptação, líder do CG e CC. Sinte restados do projeto.
Vice-coordenador	T.Ambrizzi (IAG-USP, SP)	Vice-coordenador do projeto, clim climáticos, segurança hídrica, mer Sintese e Integração dos restados

SUBCOMPONENTES OU TEMAS INTEGRATIVOS/ TRANSVERSAIS	COORDENADORES (INSTITUIÇÃO, ESTADO)	ATIVIDADES DESENVOLVIDA
Segurança hídrica	E. Mendiondo (EESC-USP, SP)	Hidrologia, segurança hídrica, ava coordenador de subcomponente,
	S. Montenegro (UFPE, PE)	Modelagem hidrológica em áreas semiárido brasileiro, coordenador
Segurança alimentar	E. D. Assad (EMBRAPA, SP)	Segurança alimentar, modelagem coordenador de subcomponente.
Segurança energética	R. Schaeffer (COPPE UFRJ, RJ)	Energia e mudanças climáticas, c subcomponente e membro do CG
	E. B. Pereira (CCST-INPE, SP)	Energias renováveis, energia e mu Cenários de energia eólica e pote coordenador de subcomponente.
	A. Szklo (COPPE-UFRJ, RJ)	Energia e mudanças climáticas, c subcomponente.
Saúde	U. Confalonieri (UFMG-FIOCRUZ, MG)	Saúde e mudanças climáticas, vul climática, coordenador de subcon do CG.
	E. Rangel (FIOCRUZ, RJ)	Saúde e comunicação social, educ de subcomponente.
Economia e impactos em setores-chave	E. Haddad (FEA-USP, SP),	Economia das mudanças climática tema integrativo, membro do CG.
	S. Margulis (IPEA, DF; Way Carbon, MG)	Economia das mudanças climática tema integrativo.
	J. Feres (IPEA, DF),	Economia das mudanças climática tema integrativo.

SUBCOMPONENTES OU TEMAS INTEGRATIVOS/ TRANSVERSAIS	COORDENADORES (INSTITUIÇÃO, ESTADO)	ATIVIDADES DESENVOLVID
Comunicação, difusão de conhecimento e educação para sustentabilidade	A. Amorim (UNICAMP, SP)	Linguagens, comunicação científi tema integrativo.
	S. Dias (UNICAMP, SP)	Educação – conhecimento e arte, tema integrativo.
Modelagem do sistema terrestre e produção de cenários futuros de clima para estudos de vulnerabilidade, impactos, adaptação e resiliência	P. Nobre (CPTEC-INPE, SP)	Desenvolvimento de modelo oceâ oceano-atmosfera, BESM – Brazili Model, coordenador de tema inte CG.
	S. Chou (CPTEC-INPE, SP),	Modelagem climática regional, ce mudanças climáticas de alta reso de tema integrativo.
Desastres naturais, áreas urbanas, infraestrutura física e desenvolvimento urbano	R. Alvalá (CEMADEN, SP)	Desastres naturais, avaliações de coordenador de tema integrativo.
	R. Rodrigues (UFSC, SC)	Desastres naturais, zonas costeir tema integrativo.
	M. Barata (FIOCRUZ, RJ)	Mudanças climáticas e desenvolv cidades resilientes, coordenador
Impactos nos ecossistemas brasileiros frente às mudanças do uso da terra e à biodiversidade	P. Artaxo (IF-USP, SP)	Física ambiental, Amazônia, coor integrativo, membro do CG.
	M. Bustamante (UNB, DF)	Inventários de emissões de gases estudos na região do Cerrado, co subcomponente.

*Dr Amorim from UNICAMP has left the Project since Year 6 and has been substituted by Dr. Renzo Taddei also from UNICAMP

4. New Developments on the future of the INCT MC2

The new component was created to support the integration of results from all the components of both the main themes as cross-cutting themes. this integration is being done using the NEXUS+ methodology used in the Fourth Communication of Brazil with the UNFCCC(4CN), always considering the relevance to the Sustainable Development Goals SDG-12 (sustainable agriculture), SDG-3 (ensure healthy living), SDG-7 (Clean energy and affordable: ensure access to cheap energy), SDG-11 (Sustainable Cities and Communities), SDG-13 (Action against global climate change), SDG-15 (Terrestrial Life: Protect, Restore, and Promote the sustainable use of terrestrial ecosystems), between others. By early 2024, hundreds of publications were generated by the collaboration between the various components of the INCT MC2, as well as such as numerous lectures, seminars, podcasts, interviews on social networks, in magazines and newspapers from Brazil and abroad, highlighting the theme of climate change and its characteristic transversal and integrative. So far 6 yearly reports have already been generated and approved by the FAPESP and CNPq.

An extension of the project until 2025 will help to include topics that were not contemplated when the proposal was drafted in 2015, and which were gradually included in the current search schedule. For example, the theme of climatic extremes observed in Brazil and the another containing some reflections on the relationship between COVID-19 and climate change, were included, although it is still a controversial topic and still without a consensus in the community scientific about their associations.

Few online meetings too place among INCTs between 2020 and 2024. Recently, CNPq and some FAPs approved 60 new INCTs in 2023, and there are conversations with MCTIs to make the INCTs a regular programme from CNPq. This was discussed in the 75th annual meeting of the Brazilian Society of Science Progress (SBPC) that occurred in Curitiba, Parana, during 23-29 July 2023. The main topic of the agenda was the current and future situation of INCTˆs One in person meeting of coordinators of INCTs took place in January 2024 in the Brazilian Academy of Sciences, Rio de Janeiro.

5. Reports by component

In the following we focus on the reports from each subcomponent and crosscutting component, showing main results and activities developed in Year 4 of the project. We also include information on new team members coming into the project, explain some changes in the coordination of the components if that is the case and plans for Year 6. All information on scientific production and activities from each of the components (workshops, publications, participation in events, use of the BC and RT, fellowships [bolsas] are listed in upcoming sections. The report is from activities developed by all components of the project.

5.1 Coordination

The two coordinators Jose Marengo and Tercio Ambrizzi have meet during year 7 in several occasions, some of these meetings took place USP, and other during other meetings and conferences where we both were there. We have changed the way the coordination works. For the administrative issues, CEMADEN hired Ms. Josiane Rosa, who is working part time to provide administrative support to this project. Ms Rosa helps the coordination with the procedures to indicate *bolsas* to CNPq, CAPES and FAPESP, with payments, meetings organization and air travel arrangements for participant scientists to meetings among INCT MC2 participants.

In addition to administrative activities, the coordinators together with their students, bolsistas and collaborators have developed a scientific agenda on investigation of observed climate variability and change, with focus on extremes in regions such Amazonia, Northeast Brazil, Pantanal and major cities, such as Sao Paulo. Some papers have been produced as well as reports in various journals and newspapers, magazines and the Revista Pesquisa FAPESP and Agencia FAPESP. This is being done since the beginning of the project and constitutes a background fall all components. All these results are detailed in the reports by component.

In the following we report some of the major studies developed by the coordination. As mentioned in Year 6, the coordination works on some comprehensive e studies dealing with observed weather and climate extremes, providing some ground basis for the work of the components. From year 1-4 we have relayed on graduate students and bolsistas from INPE, USP and UNESP and from years 5 to 7 we will work with a bolsista that will work on the integration of results from all components. This shows that years 5-7 will be mainly integration of research results from years 1-4. The bolsistas will come from the extension approved by the CNPq and FAPESP for 2 more years of the project.

5**.1.1** Critical transitions in the Amazon forest system (Flores et al 2024)

The possibility that the Amazon forest system could soon reach a tipping point, inducing large-scale collapse, has raised global concern1–3. For 65 million years, Amazonian forests remained relatively resilient to climatic variability. Now, the region is increasingly exposed to

unprecedented stress from warming temperatures, extreme droughts, deforestation and fires, even in central and remote parts of the system1. Long existing feedback between the forest and environmental conditions are being replaced by novel feedback that modify ecosystem resilience, increasing the risk of critical transition. Here we analyse existing evidence for five major drivers of water stress on Amazonian forests, as well as potential critical thresholds of those
drivers that, if crossed, could trigger local, regional or even biome-wide forest collapse. By combining spatial information on various disturbances, we estimate that by 2050, 10% to 47% of Amazonian forests will be exposed to compounding disturbances that may trigger unexpected ecosystem transitions and potentially exacerbate regional climate change. Using examples of disturbed forests across the Amazon, we identify the three most plausible ecosystem trajectories, involving different feedback and environmental conditions. We discuss how the inherent complexity of the Amazon adds uncertainty about future dynamics, but also reveals opportunities for action. Keeping the Amazon forest resilient in the Anthropocene will depend on a combination of local efforts to end deforestation and degradation and to expand restoration, with global efforts to stop greenhouse gas emissions (Figure 5.1.1)_

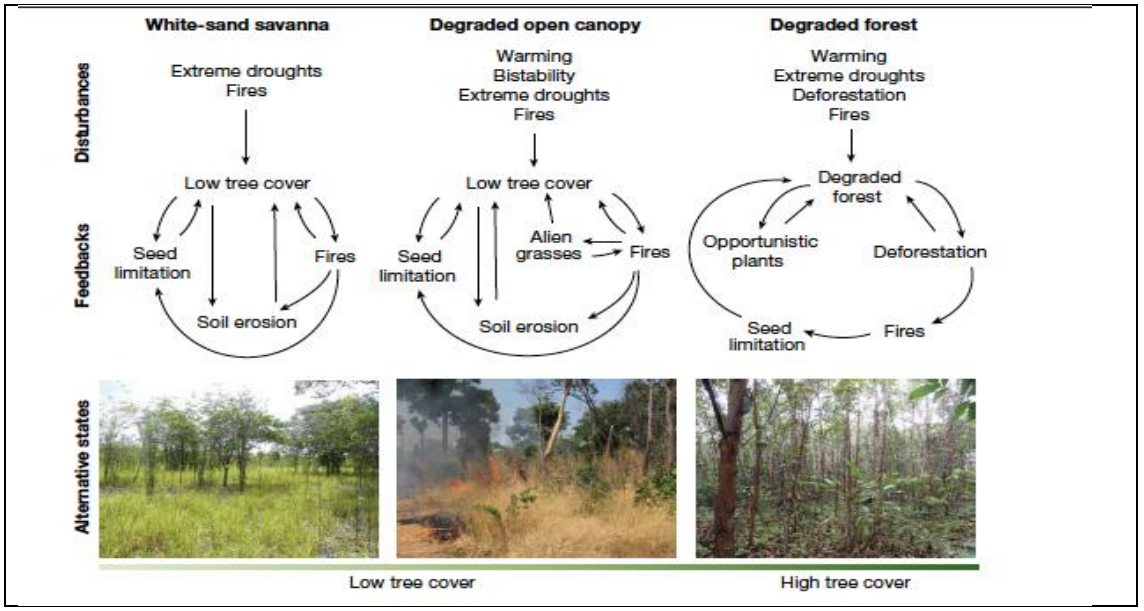


Figure 5.1.1. Alternative ecosystem trajectories for Amazonian forests that transition due to compounding disturbances

5.1.2 Analysis of extreme rainfall and landslides in the metropolitan region of the Paraiba do Sul River Valley and North Coast of Sao Paulo, Brazil

The impact of hydrological and geological disasters has resulted in significant social, economic, and human losses, which added climate change impacts, and such events have become more frequent and intense. Therefore, our objective is to analyze the extreme rainfall (trends) in the Metropolitan Region of the Paraiba do Sul Valley and North Coast of Sao Paulo (RMVPLN). This analysis will support the most affected areas by landslides identification, which mainly impact roads and their population. In addition, evaluate the atmosphere conditions that supported these extreme rainfall events. To achieve our objectives, we have surveyed historical landslide data reported by the Brazilian government and information related by press and media. The precipitation evaluation used CHIRPS v.2 data and ETCCDI indices and the vertically integrated moisture flow and wind speed were calculated by ERA5 reanalysis. Our results show that the frequency and intensity of rainfall indicators such as seasonal PRCPTOT, R20mm, R30mm, and SDII have increased, particularly in the coastal and mountainous regions of Sao

Paulo. This is due to positive anomalies of moisture transport and an increase of ocean winds influenced by the intense South Atlantic Subtropical Anticyclone (SASA). The region with the highest susceptibility to landslides triggered by extreme rainfall is the one that combines deforested areas, high slope topography, and excessive anthropic intervention. The presence of mountainous regions increases the risk of landslides, which can damage local infrastructure and expose the vulnerability of populations in these risk areas (Figure 5.1.2).

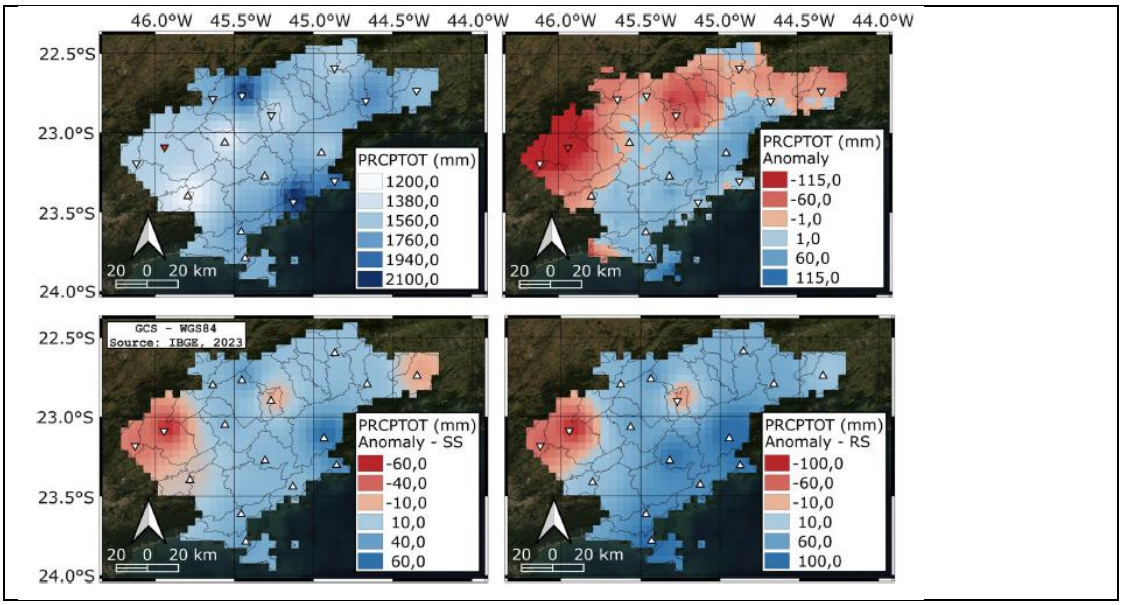


Figure 5.1.2. Annual and seasonal distribution of rainfall in the RMVPLN. SS represents the summer season and RS the rainy season. The upward triangles represent positive rainfall trends and when blue with statistical significance. Downward triangles represent negative trends and when red with statistical significance.

5.1.3 Deadly disasters in southeastern South America: flash floods and landslides of February 2022 in Petrópolis, Rio de Janeiro (Alcantara et al 2023)

On 15 February 2022, the city of Petrópolis in the highlands of the state of Rio de Janeiro, Brazil, received an unusually high volume of rain within 3 h (258 mm), generated by a strongly invigorated mesoscale convective system. It resulted in flash floods and subsequent landslides that caused the deadliest landslide disaster recorded in Petrópolis, with 231 fatalities. In this paper, we analyzed the root causes and the key triggering factors of this landslide disaster by assessing the spatial relationship of landslide occurrence with various environmental factors. Rainfall data
were retrieved from 1977 to 2022 (a combination of ground weather stations and the Climate Hazards Group InfraRed Precipitation – CHIRPS). Remotely sensed data were used to map the landslide scars, soil moisture, terrain attributes, line of-sight displacement (land surface deformation), and urban sprawling (1985–2020). The results showed that the average monthly rainfall for February 2022 was 200 mm, the heaviest recorded in Petrópolis since 1932. Heavy rainfall was also recorded mostly in regions where the landslide occurred, according to analyses of the rainfall spatial distribution. As for terrain, 23% of slopes between 45–60 had landslide occurrences and east-facing slopes appeared to be the most conducive for landslides as they recorded landslide occurrences of about 9% to 11 %. Regarding the soil moisture, higher variability was found in the lower altitude (842 m) where the residential area is concentrated. Based on our land deformation assessment, the area is geologically stable, and the landslide occurred only in the thin layer at the surface. Out of the 1700 buildings found in the region of interest, 1021 are on the slope between 20 to 45 and about 60 houses were directly affected by

the landslides. As such, we conclude that the heavy rainfall was not the only cause responsible for the catastrophic event of 15 February 2022; a combination of unplanned urban growth on slopes between 45–60 , removal of vegetation, and the absence of inspection were also expressive driving forces of this disaster. (Figure 5.1.3)

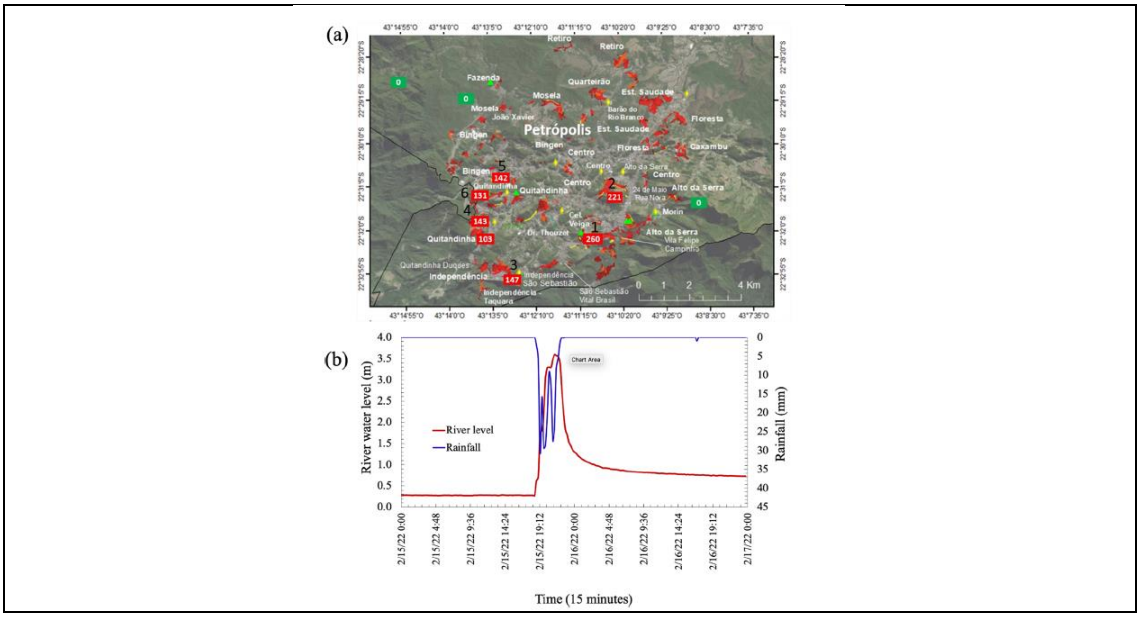


Figure 5.1.3. (a) Accumulated precipitation in 24 h on 15 February 2022 at CEMADEN rain gauges. Red contours correspond to areas of risk for landslides at Petrópolis. The black line indicates the municipality limit. The cartographic base was obtained from © OpenStreetMap contributors 2022. Distributed under the Open Data Commons Open Database License (ODbL) v1.0. (b) Rainfall (blue) and river level (red) time series for 15 February 2022 time event, at Alto da Serra hydrological station (INEA).

5.1.4 State of Climate for Latin America and Caribbean 2023 (WMO 2024)

The present WMO report is the fourth in an annual series starting with the year 2020. It summarizes the observed climate trends and high-impact events, as well as associated socioeconomic impacts, in Latin America and the Caribbean (LAC). Tropical cyclones, heavy precipitation and flooding events, extreme heat and severe droughts led to significant human and economic losses in the region throughout 2023. The second half of 2023 was particularly influenced globally by El Niño conditions, which contributed to a record warm year and exacerbated extreme events in the region. This happened on top of well-established long-term climate change and the associated rising frequency and intensity of extreme weather and climate events.

Among many climatic hazards recorded in LAC, Hurricane *Otis* hit Acapulco, in Mexico, as a Category 5 hurricane, devastating the area and leading to dozens of fatalities and billions of dollars in damage. The drought in the Amazon was another noteworthy high-impact event of the year. It was so intense that the Negro River, at Manaus, recorded its lowest level in more than 120 years of observations. The report highlights the advances made in integrating meteorological data into health surveillance (focusing on disease), reflecting a move towards stronger public health strategies. Despite this improvement, there is still a need for substantial developments and investments in weather services infrastructure and tailored climate services.

There are major gaps in the weather and climate observing networks, especially in the least developed countries and small island developing States; these gaps represent an obstacle to the

provision of early warnings, adequate climate services and effective climate monitoring, especially at the regional and national scales. WMO works with its Members and partners to improve climate observations through the Global Climate Observing System (GCOS) and by ensuring adequate financial mechanisms for weather and climate observations through the Systematic Observations Financing Facility (SOFF). Early warnings are fundamental for anticipating and reducing the impacts of extreme events. WMO is leading the United Nations Early Warnings for All initiative and its Executive Action Plan. The Action Plan, launched by United Nations Secretary-General António Guterres during the World Leaders Summit at the United Nations 2022 Climate Change Conference (COP27), provides a new horizon for strengthening Earth system observations, monitoring and warning capabilities.

Among the key messages we can mention :

-In Latin America and the Caribbean, 2023 was the warmest year on record.
-Sea level continued to rise at a higher rate than the global mean around much of the Atlantic part of the region, threatening the coastal areas of several countries and small island developing States.
-Hurricane *Otis* made landfall as a Category 5 strength hurricane near Acapulco, Mexico, leading to major losses in life and infrastructure. *Otis* was the strongest landfalling hurricane on record in the eastern Pacific Basin, with one of the most rapid rates of intensification.
-Floods and landslides triggered by heavy rainfall led to significant fatalities and economic losses across the region. In São Sebastião, Brazil, 683 mm of rainfall accumulated in 15 hours, triggering a landslide that led to at least 65 deaths.
-Climate services are pivotal in enhancing decision-making and action in various sectors. Despite recent developments and successful initiatives, only 38% of WMO Members in the region indicated providing tailored climate products for the health sector.
-Extreme heat and heatwaves led to health impacts throughout the year, including excess mortality. Between 2000 and 2019, there was an average of 36 695 heat-related excess deaths in the region per year.
-Intense and severe drought, exacerbated by heatwaves, affected large areas of Latin America during 2023. By the end of the year, 76% of Mexico was experiencing some degree of drought.
-The Negro River in the Amazon hit a record low level since observations began in 1902. In the Panama Canal, low water levels restricted ship traffic from August onward.
-Exceptionally high temperatures and dry conditions also impacted wildlife. In Tefé Lake, in the Brazilian Amazon, water temperature reached a record high and over 150 river dolphins (*Boto-cor-de-rosa*) were reported dead.
-Agricultural losses were reported in many countries in the region due to extreme weather and climate events. Such impacts exacerbated food insecurity, especially in communities reliant on agriculture for their livelihoods.

Based on information from the Centre for Research on the Epidemiology of Disasters (CRED) Emergency Events Database (EM-DAT),54 in 2023, 67 meteorological, hydrological and climate-related hazards were reported in the Latin America and the Caribbean region. Of these 67 hazards, 77% were storm- and flood-related events and accounted for 69% of the 909 fatalities documented in this database (Figure 5.1.4). The estimated USD 21 billions of economic damage reported to EMDAT was mainly due to storms (66%) (including the USD 12 billions of damages associated with Hurricane *Otis*), floods (16%) and droughts (14%). The actual amount of damage related to the impacts of extreme events is likely to be worse because of under-reporting and because data on impacts are not available for some countries.

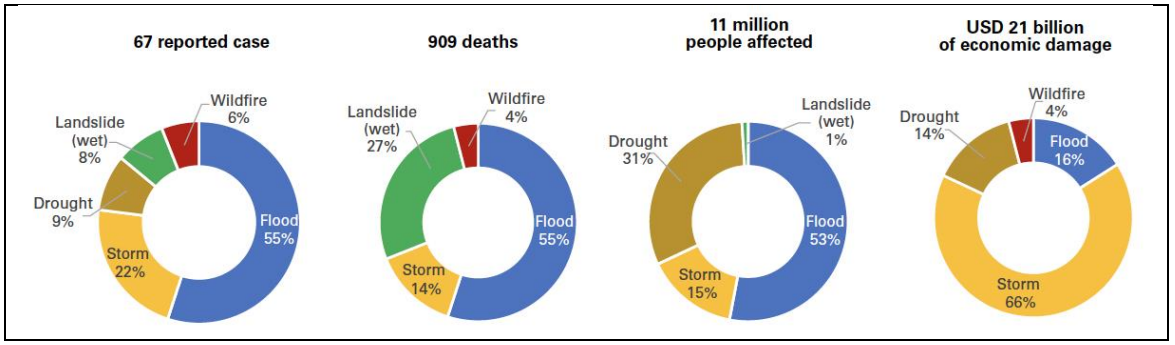


Figure 5.1.4. Weather-, climate- and water-related disasters in Latin America and the Caribbean in 2023. Note: Impact numbers for some disaster occurrences may be lacking due to data unavailability. *Source:* CRED EM-DAT, accessed 21 February 2024

5.1.4 The new record of drought and warmth in the Amazon in 2023 related to regional and global climatic features (Espinoza et al 2024)

In 2023 Amazonia experienced both historical drought and warm conditions. On October 26th 2023 the water levels at the port of Manaus reached its lowest record since 1902 (12.70 m). In this region, October monthly maximum and minimum temperature anomalies also surpassed previous record values registered in 2015 (+ 3 °C above the normal considering the 1981–2020 average). This historical dry and warm situation in Amazonia is associated with two main atmospheric mechanisms: (i) the November 2022–February 2023 southern anomaly of vertical integrated moisture flux (VIMF), related to VIMF divergence and extreme rainfall deficit over southwestern Amazonia, and (ii) the June–August 2023 downward motion over northern Amazonia related to extreme rainfall deficit and warm conditions over this region. Anomalies of both atmospheric mechanisms reached record values during this event. The first mechanism is significantly correlated to negative sea surface temperature (SST) anomalies in the equatorial Pacific (November–February La Niña events). The second mechanism is significantly correlated to positive SST anomalies in the equatorial Pacific, related to the impacts of June–September El Niño on the Walker Circulation. While previous extreme droughts were linked to El Niño (warmer North Tropical Atlantic SST) during the austral summer (winter and spring), the transition from La Niña 2022–23 to El Niño 2023 appears to be a key climatic driver in this record-breaking dry and warm situation, combined to a widespread anomalous warming over the worldwide ocean.

Amazonia hosts the Earth's largest tropical forests characterized by a unique biodiversity. The Amazon basin represents the largest hydrological basin on Earth (about 6.87 million km2) with 16–18% of the global freshwater discharge to the oceans. It is the largest and most intense terrestrial convective center in the Earth system, coupled to global atmospheric circulations. Approximately 13% of global precipitation over the continental areas is concentrated in the Amazon basin, which just accounts for 4.6% of the world's land area. Due to climate change and deforestation this biome is moving towards a "tipping point", especially in those regions affected by largescale deforestation, forest fragmentation and degradation over the last decades. Particularly in those regions a warming trend, the lengthening of the dry season length, and a decline of carbon sink are observed. At the Port of Manaus (Central Amazonia; Fig. 5.1.5), where daily water level measurements of the Rio Negro exist since September 1902, a state of emergency is declared when the water level is below 15.8 m (a threshold value determined by the Brazilian Geological Survey—CPRM to decree drought). This is due to low water levels that affect navigation and, as a result, the transport of goods and of people living along the riverbanks.

On the other hand, extreme floods (when the critical level surpass 29.0 m) were reported with a major frequency and intensity, particularly since 2009 (Fig. 5.1.5). However, extreme droughts in Amazonia were also observed in 1997–98, 2005, 2010 and 2015–169. These historical droughts were associated with El Niño events during the austral summer (December–February) and/or warm conditions in the North Tropical Atlantic during austral winter and spring (June–September). These events are related to an increased atmospheric subsidence over Amazonia, associated with anomalies of the Hadley and Walker cells during El Niño. In addition, a deficit of moisture transport from the Atlantic Ocean toward central and southern Amazonia, and atmospheric subsidence over tropical South America is detected during warm events in the tropical North Atlantic. On the other hand, during the Austral Spring and summer, anomalous dry conditions in subtropical South America are related to the weakening of the South American low-level jet east of the Andes modulated by La Nina-related teleconnections. Moreover, during multi-years La Nina events (such as the period 2020–22) dry conditions are observed over southwestern Amazonia. A lower frequency of low-level winds is noticed over southwestern Amazonia during La Nina years. Since December 2022, dry situation over the Amazon region coincides with a record-breaking warming, particularly intense since June 2023. The warm and dry conditions in 2023 are causing severe impacts on Amazonian populations and ecosystems. Unlike previous extreme droughts, this historical event began during the 2022–23 La Nina event, followed by El Ni.o during the austral winter and spring of 2023.

Below normal water levels of the Rio Negro at the Port of Manaus were observed in December 2022 and January 2023 (19.10 m; Fig. 1a). During this period southwestern tributaries of the Amazon, such as the Peruvian Ucayali and Amazonas rivers also reported below normal water levels (Fig. S1a,b), reaching the historical December low values in Requena Station in the Ucayali River. In contrast, no anomalies were reported in the northwestern tributaries during the 2022–23 austral summer (e.g., on Marañon River; Fig. S1c). Water levels at the Port of Manaus approach normal values from May to August 2023, during the seasonal flooding period (maximum water level 28.3 mm). However, according to the Brazilian Geological Survey (www. sgb. gov. br) since the end August a rapid decrease was observed, reaching values below the emergency threshold of 15.8 m on September 30th (15.66 m; Fig. 1a). On October 26th the water levels at the port of Manaus reach 12.70 m which is the lowest record since 1902 (Fig. 1b), exceeding the levels recorded during previous historical droughts, such as 13.63 m in 2010, 13.64 m in 1963, 14.37 m in 1997 and 14.75 m in 2005. This historical drought comes 13 and 18 years after the extreme 2010 and 2005 droughts, respectively. During the last 15 years, the Amazon River has been mainly characterized by extreme floods, such as in 2009, 2012–2015, 2017, 2019 and 2021–202211 (Fig. 1b). The descending water level in 2023 has an amplitude of 15.6 m, the highest on record, which exceeds the long-term average (10.4 m) by 50%. During the last 15 years the fourth highest maximum (2021, 2012, 2009, 2022) and the two lowest minimum (2023, 2010) annual water level have been recorded, concentrated on the last 12.3% of the 122-yr-long long-term instrumental record.

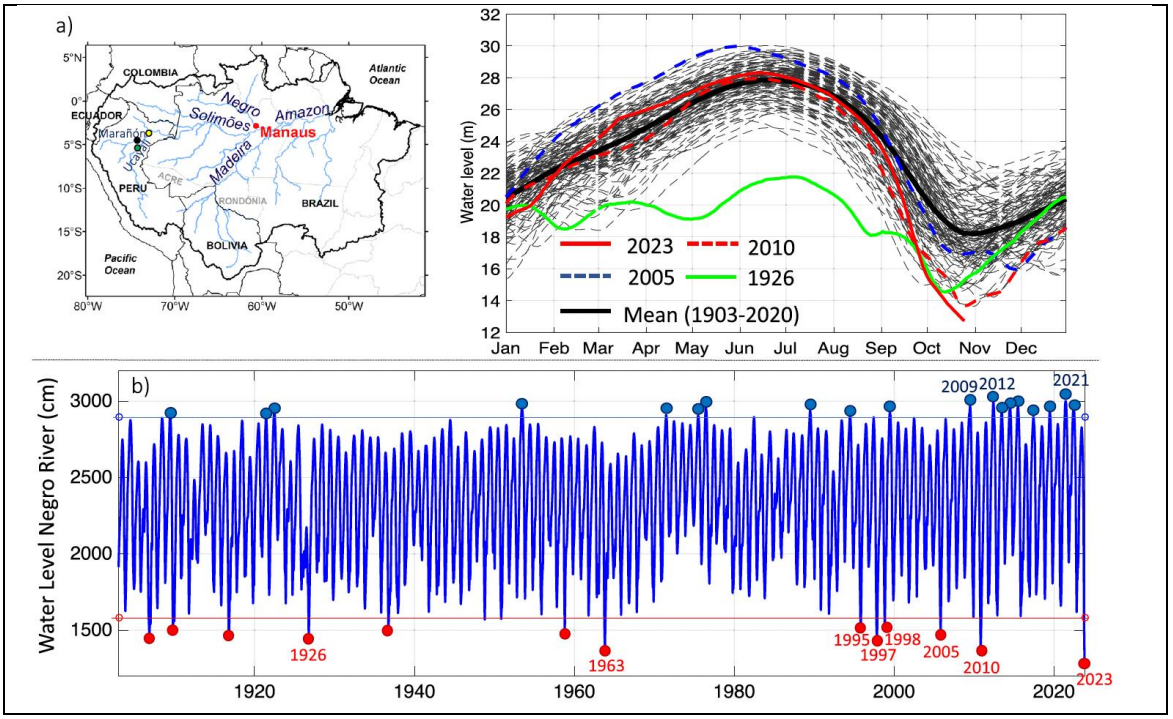


Figure 5.1.5. (a) Daily water level at the Port of Manaus (Brazil) during the 1903–2023 period (grey dotted lines), mean annual cycle (solid black line) and water level during extreme drought years in 1926 (solid green line), 2005 (dotted blue line), 2010 (dotted red line) and 2023 (solid red line). The black outline on the map indicates the boundary of the Amazonian region. The location of Manaus (red dot), Tamshiyacu (yellow dot), Requena (green dot), San Regis (black dot) and the name of the main rivers, states and countries are indicated in the subpanel. (b) Time evolution of the water level of the Rio Negro at Manaus (1903–2023). Years corresponding to extreme drought (flood) with water level below (surpassing) 1580 cm (2900 cm) are indicated with red (blued) dots. All the data come from the platform Hidroweb, available on the National Water Resources Information System (SNIRH) operated by the Brazilian National Water and Sanitation Agency (ANA) and the Geological Survey of Brazil (CPRM). Data visualisations produced using Matlab 2023b (https:// matlab.mathworks.com).

5.2 Food security

- Activity 1 - Climate, agriculture and implications for food security
- Activity 2 - Economy, Climate and implications for food security
- Activity 3 - Climate, livestock and implications for food security

Summary of the activities carried out in the last year and the results obtained so far, including discoveries.

5.2.1 Scientific Activities developed in year 6 (June 2023 to June 2024),

Activity 1 - Climate, agriculture and implications for food security

In this stage, studies were carried out to identify potential areas for converting degraded pastures into integrated systems, which will favor the intensification of agricultural and livestock production in Brazil. The potential for converting degraded pastures was analyzed at municipality, state and biome level. The study focused on two areas of action: converting degraded pastures into permanent grain crops and restoring the productive capacity of degraded pastures. The two axes interact strongly due to the process of displacement of livestock farming, especially the cattle breeding phase, because of the change in land use (pasture/grain), imposing

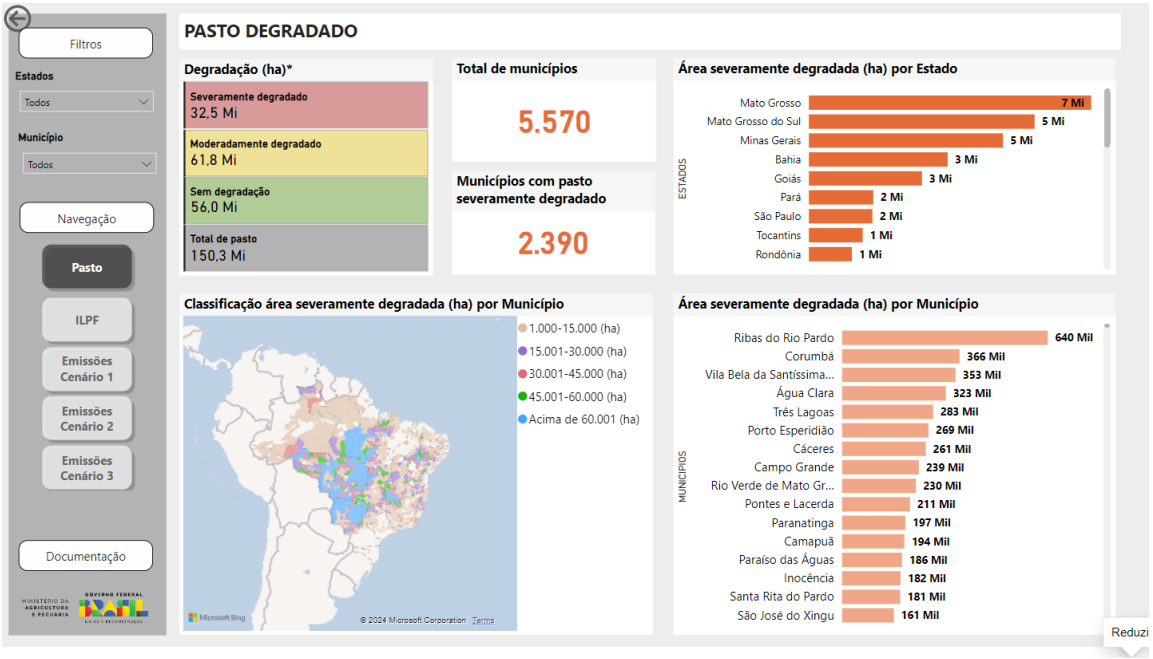
the need to recover the support capacity and productivity of areas consolidated with livestock farming (pasture/grazing), to accommodate this contingent of breeding stock. This systemic form of action by the Program considers two very important economic activities and, at the same time, makes it possible to reduce the pressure of expansion of agricultural activities into natural forest environments> It also contributes to the decarbonization of the activity and makes it possible to reduce enteric methane emissions. Both axes will be supported by the technologies established in the ABC+ Program and could be covered by the credit lines already in operation. Complementary studies could spatially define the preferred regions for establishing conversion priorities, based on soil and climatic conditions, infrastructure and logistics, making it possible to more accurately define the scope and financial resources required. Taking these premises into account, the next stage of the project was to quantify, with the help of information from MAPBIOMAS and LAPIG, the spatial identification of areas with severely degraded pasture, degraded pasture and other types of categories. The PowerBI system was used to quickly identify where these areas are and quantify them by state and municipality. At the same time, it checks the suitability of these areas for implementing integrated crop-livestock-forest systems.
The stages of the study were:

Determine and map the areas of degraded pasture that have been updated
Adjust the areas of degraded pastures for each Brazilian state
Determine the areas suitable for ILPF in each Brazilian state
Establish the cross-referencing of preferred ILPF areas with degraded pastures for each Brazilian state
Determine GHG emissions for each defined territory
Determine the costs of restoring pastures and adopting ILPF in the defined territories
Determine the herd increase for each defined territory
Determine the gain in grain production for the defined territory

The emission factors taken into account are those indicated in the latest report on GHG emissions metrics and methodologies, namely https://agro.fgv.br/publicacao/ocbio-quantificacao-das-emissoes-de-gee-no-setor-agropecuario-fatores-de-emissao.
In order to achieve all the steps described above, a query system based on PowerBI was developed;
https://app.powerbi.com/view?r=eyJrIjoiYzk0ZjY0ZTYtYmRiOC00MjhlLWExZTItYjgzMGU5ZmU2ODYwIiwidCI6ImY0MDU4ODExLWY1YmQtNGYzMi05ZjkxLTQ3YmM4ZWRiNjEwYyJ9

The main results are:

Identification of degraded pastures in Brazil, by state and municipality

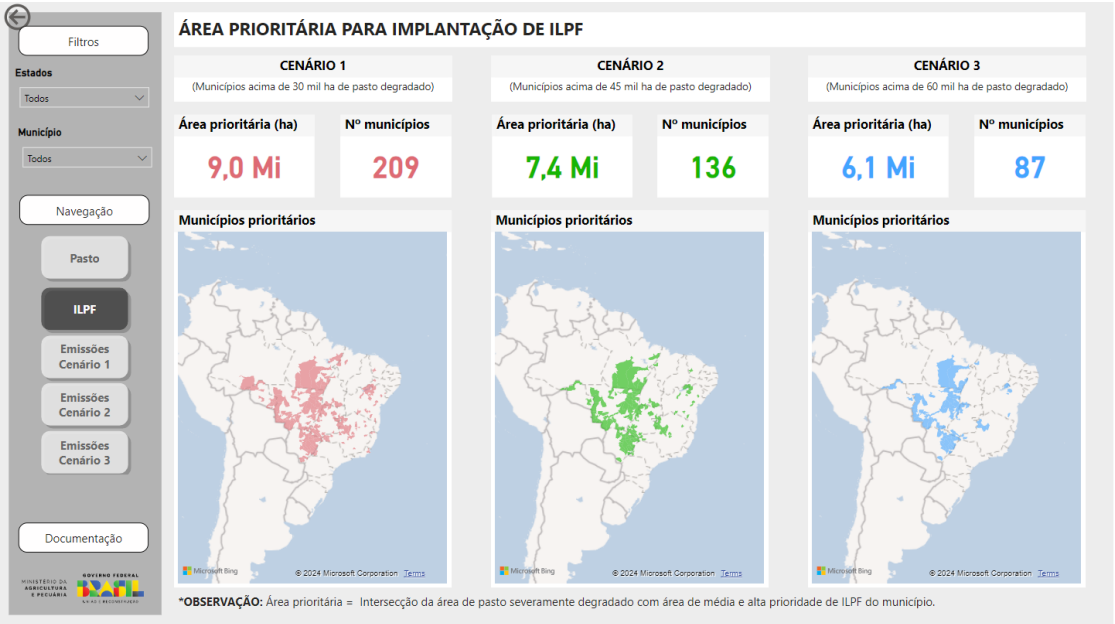


We then identified 32.5 million hectares with severely degraded pastures, 61.8 million moderately degraded pastures and 56 million hectares without degraded pastures, giving a total area with pastures in Brazil in all categories of 150.3 million hectares. Of the 5,570 municipalities, at least 2,390 have severely degraded pastures, and these would be the ones that should be prioritized for converting severely degraded pastures into recovered pastures, or into integrated production systems. The state of Mato Grosso has identified the largest number of degraded pastures, totaling 7 million hectares.

Identification, quantification and location of priority areas for implementing ILP, by state and municipality.

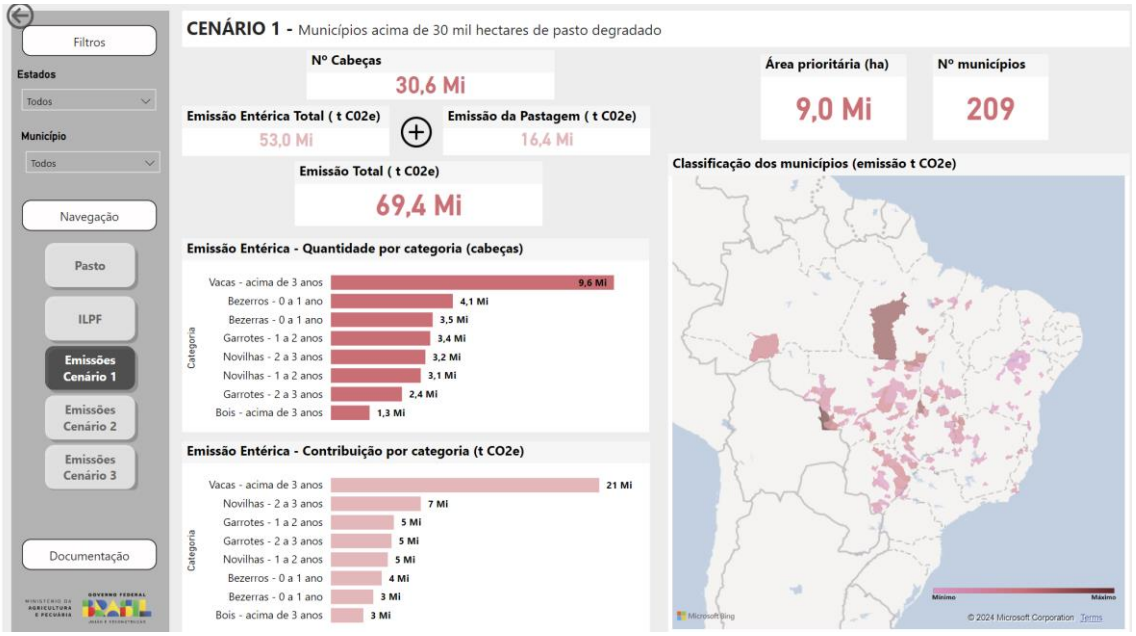
Based on the identification of severely degraded pastures and using information generated by Embrapa on the agricultural suitability of regions for the implementation of integrated systems such as ILP and ILPF (Crop-Livestock Integration and Crop-Livestock-Forest Integration), municipalities with between 30,000 and 45,000 hectares, between 45,000 and 60,000 hectares and over 60,000 hectares per municipality were mapped. The results indicate that in scenario 1, with up to 30,000 hectares of degraded pastures, 209 municipalities fall into this category, totaling 9.0 million hectares. From a public policy point of view, these are the municipalities that should receive priority for using incentives to recover pastures. Next, in scenario 2, with municipalities

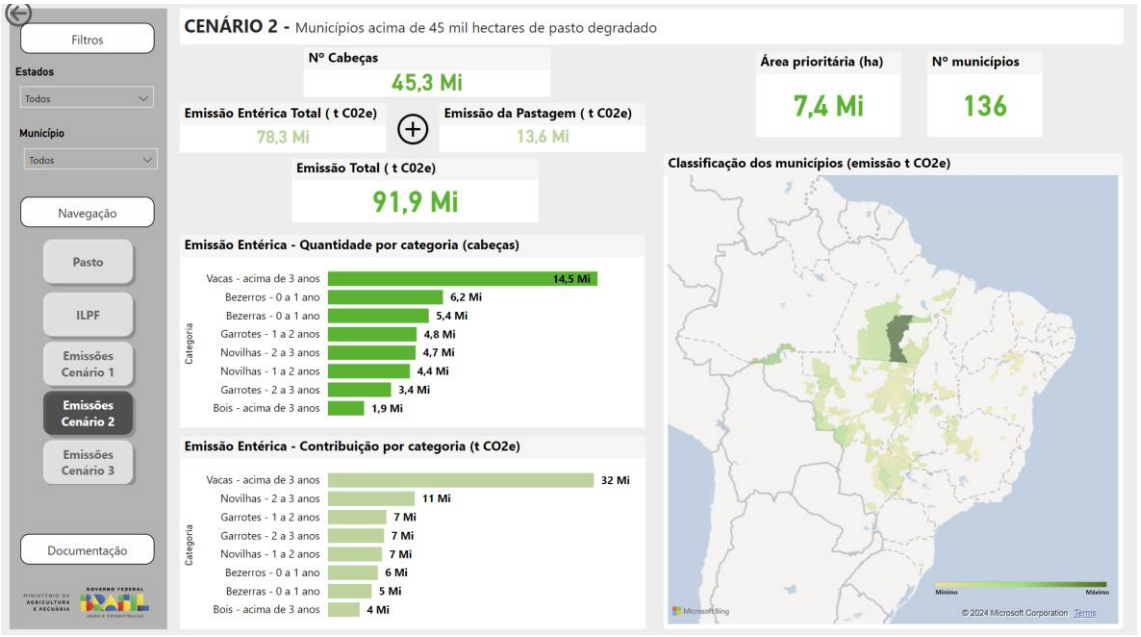
with more than 45,000 hectares of degraded pastures, 136 municipalities were identified, totaling 7.4 million hectares. Finally, in scenario 3, with municipalities with more than 60,000 hectares of degraded pastures, 87 municipalities were identified, totaling 6.1 million hectares. The level of degradation considered was "severely degraded pastures".

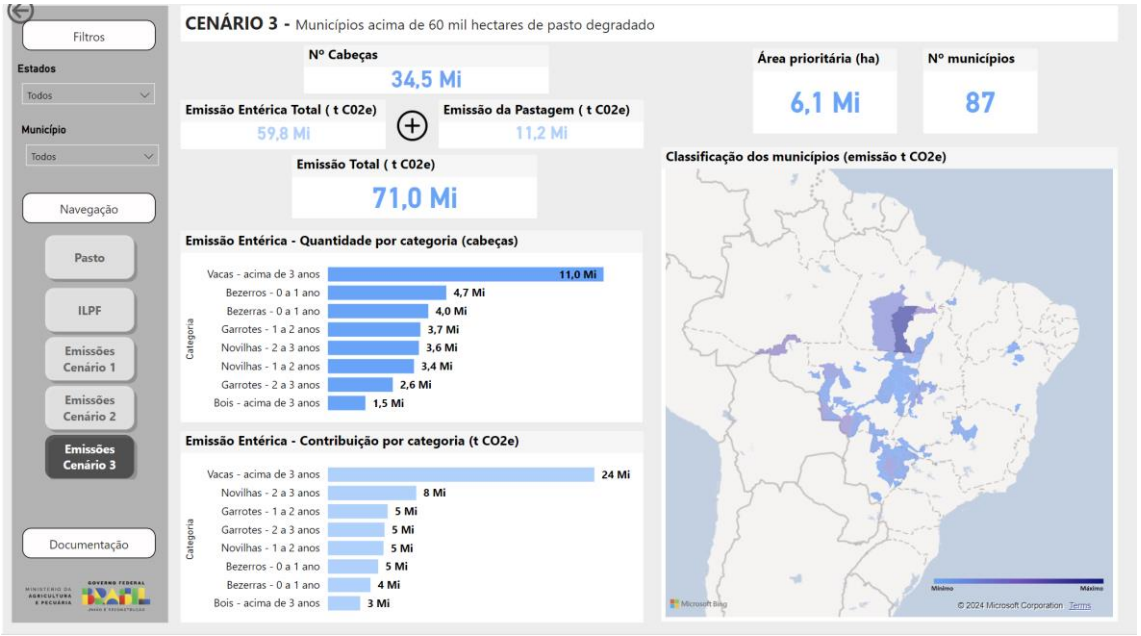


Mapping and quantifying emissions in tCO2 eq. in the municipalities.

For each scenario, the emissions that can be avoided by recovering degraded pastures or implementing integrated agricultural production systems were determined.







5.2.2 Activity 2 - Economy, Climate and implications for food security

Once the areas with degraded pastures had been identified, cost estimates were made for recovering degraded and/or severely degraded pastures.

Specifically, about meat production, Brazil is the largest exporter and the second largest producer, with an important characteristic being the predominance of herds raised on pasture, i.e. extensively (RODRIGUES; MARTA-COSTA, 2021). Pastures are a major differentiator in Brazil's competitiveness, and, in this context, there is growing interest in technological alternatives to maintain the productive capacity of pastures sustainably and ensure animal welfare.

One of the alternatives available is the recovery of degraded pastures. In a **degraded pasture** there is a significant reduction in the ideal support capacity, and the ability to maintain

biological productivity may or may not have been compromised (DIAS-FILHO, 2015). This concept can be better understood by analyzing 1.

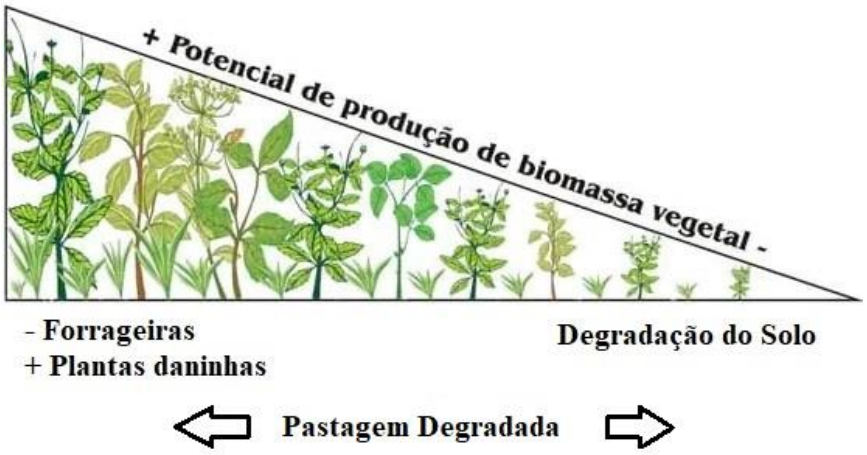


Figure 5.2.1. Representation of the concept of degraded pasture. mSource: Adapted from Dias-Filho (2008).

Pasture degradation can be the result of one or more factors such as: inadequate grazing and/or pasture management practices, lack of soil preparation, inadequate choice of forage, poor seed quality, pasture pests, physiological problems, *etc*. In addition, pastures can show different levels of degradation. The **levels of degradation**, according to limiting parameters and indicators of a drop in carrying capacity (SC), are shown in figure 2.

Figure 5.2.2. Levels of pasture degradation. Source: Adapted from Dias-Filho (2017).

Therefore, the long-term extensive use of pastures can result in compromised productive, economic and environmental efficiency. As a result, there is a reduction in productivity and profitability and an increase in greenhouse gas (GHG) emissions, since the degradation of these areas creates incentives for new areas of natural vegetation to be converted into pastures (BATISTA et al., 2020; ASSAD et al., 2021).

Recovering degraded pastures is one of the strategies set out in Brazil's Nationally Determined Contribution (NDC) to reduce greenhouse gas emissions by 48% by 2025 and 53% by 2030, compared to 2005 emissions (BRASIL, 2024). In addition, in 2023 the federal government instituted the *National Program for the Conversion of Degraded Pastures into Sustainable Agricultural and Forestry Production Systems*, a policy that aims to double the current level of productivity by incorporating 40 million degraded hectares into the production system. Therefore, the increase in productivity would occur without advancing into forest areas, contributing to reducing the pressure on native vegetation, as well as favoring adaptation and mitigation of the adverse effects of climate change.

Figure 3 shows the spatial distribution of pasture areas in Brazil[1] . Pasture areas are found in all of the country's regions and biomes, concentrated mainly in the Cerrado (56.6 Mha) and Amazon (around 50 Mha) biomes, followed by the Atlantic Forest (32.4 Mha), Caatinga (28.8 Mha), Pampa (5.5 Mha) and Pantanal (3.9 Mha). Considering the quality of pastures, in 2022, at least 53% of the areas destined for pasture in the Cerrado and Amazon biomes were degraded or under degradation.

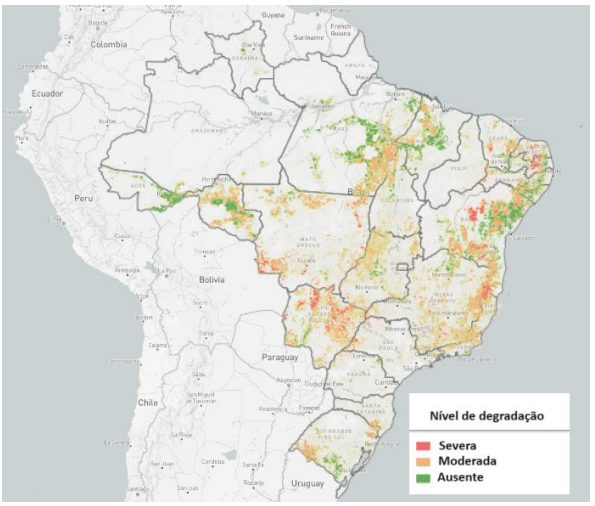


Figure 5.2.3. Spatial distribution of pasture areas in Brazil in 2022, considering different levels of degradation. Source: Image Processing and Geoprocessing Laboratory - LAPIG (2024b).

About the federal units, Minas Gerais, Mato Grosso and Pará are the ones that concentrate the largest areas of pasture with, respectively, around 22 Mha, 21 Mha and 19 Mha. Figure 4 shows the proportion of pasture areas in the states, by level of degradation, in 2022.

[1] The pasture quality information generated by Lapig (2024) is based on the degradation classifications initially proposed by Dias-Filho (2015). Based on EVI (Enhanced Vegetation Index) values, provided by the MODIS MOD 13Q1 product (Huete et al., 2002), it is possible to assess the state of degradation and obtain estimates of biomass in pastures, since vegetation indices have a positive correlation with vegetation vigor. After normalizing the annual average EVI images by biome (EVI.d_norm), the annual images are stratified into pasture degradation classes. As the method is not effective in distinguishing the Light and Moderate classes from each other, these classes are grouped together and, for this reason, only three levels of degradation are considered: Absent (not degraded), Moderate and Severely Degraded.

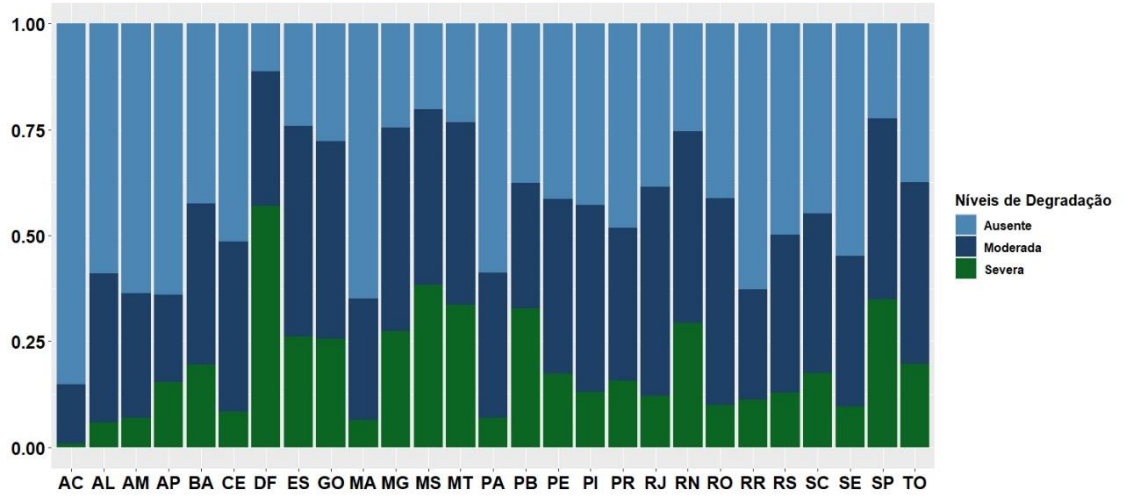


Figure 5.2.4. Pasture areas in the Brazilian states (including the Federal District), by level of degradation, in 2022. Source: Own elaboration based on data from Lapig (2024a).

Although the significant extent of degraded pasture areas is alarming and represents a significant challenge for livestock farming in the country, the existence of these areas and the possibility of recovering them, presents as a positive point a great potential for increasing livestock productivity and mitigating the balance of greenhouse gas emissions (DIAS-FILHO, 2015; ASSAD et al., 2021).

Pasture recovery costs

To measure and evaluate the economic costs of recovering degraded pastures in Brazil, all the Brazilian states and the Federal District were considered as the unit of analysis, as well as the six major Brazilian continental biomes, as described by the Brazilian Institute of Geography and Statistics (IBGE): Amazonia, Caatinga, Cerrado, Atlantic Forest, Pampa and Pantanal. The costs, per hectare, were calculated in such a way as to consider the impact of the characteristics of the soils and biomes on the expenditure.

More specifically, existing information in the specialized literature on the following aspects is considered: the most adapted forage plants, soil correction and fertilization specific to each location, since these are important factors in determining the success of the recovery process, as well as the level of investment required.

The choice of recovery strategy to be adopted depends on the level of degradation of the pasture. In this study, the strategy considered to promote the reversal of the degradation process is the direct recovery of pastures at a moderate stage of degradation and the reform of pastures at a severe stage of degradation. The specialized literature describes various ways of carrying out recovery/retirement. Although these strategies consider different combinations and use of inputs, there is consensus that the rehabilitation of degraded pastures involves minimum conditions common to the various strategies (TOWNSEND et al., 2010).

In the case of pastures in a moderate stage of degradation, the less advanced stage of degradation makes it possible, through appropriate agronomic practices and management, to correct soil fertility and recover the level of productivity and vigor of the forage plants. This strategy is economically more attractive when compared to the costs of a pasture renovation strategy (DIAS-FILHO, 2017).

However, when the pasture is at a severe level of degradation, it is not possible to use a recovery strategy, since it is necessary to prepare the soil and replant the forage in the entire area.

The description of the variables and the data sources consulted to measure the costs associated with operations and inputs are shown in Table. The costs for all the inputs used in the recovery/refurbishment are based on the price level for the year 2024 .[2]

Table 5.2.1. Description of the operations and inputs used in the recovery and renovation of degraded pastures and the data sources consulted.

Operation/inputs	**Unit**	**Data Source**
Soil preparation/correction		
Plow harrowing	h/ha	ABC Foundation
Intermediate harrowing	h/ha	ANNUALPEC
Grading	h/ha	ABC Foundation
Dolomitic limestone	t	CONAB
Liming loading (mechanized)	h/m	ANNUALPEC
Liming training (mechanized)	h/m	IFAG
Liming training (manual)	h/h	ANNUALPEC
Planting		
Seed	kg/ha	UNIPASTO
Sowing by hand (mechanized)	h/m	ABC Foundation
Sowing by hand	h/h	ANNUALPEC
Seed compaction	h/m	ANNUALPEC
Fertilization (mechanized)	h/m	ANNUALPEC
Fertilizing (manual)	h/h	
Simple superphosphate	t	CONAB
Phosphating loading (mechanized)	h/m	ANNUALPEC
Formation phosphating (mechanized)	h/m	
Phosphating training (manual)	h/h	

[2]Due to the unavailability of updated data, the price levels of some of the inputs used in the recovery/refurbishment have been adjusted by the Broad National Consumer Price Index (IPCA).

Potassium Chloride (KCL)	t	CONAB
Urea	t	

Source: Own elaboration.
Note:[1] h/ha = hours/hectare; t = tons; h/m = hour/machine; h/h = man/hours.

In addition to the costs of recovering pastures in moderate and severe stages of degradation, maintenance costs were also considered. Pasture maintenance is essential to maintain long-term productivity and prevent the soil from being degraded again.

The inputs considered, as well as the application/operation intervals and data sources, are shown in Table. It is important to note that although Table describes all the inputs considered in pasture maintenance, the use of each input was conditioned to the characteristics of the soil for each of the biomes analyzed. Therefore Table presents the inputs and operations used in general, but not necessarily all of them are included in a single maintenance approach.

Table 5.2.2. Description of the operations and inputs used to measure maintenance costs and the data sources consulted.

Operation/inputs	**Unit**	**Interval (years)**	**Data source**
Soil correction			
Dolomitic limestone	t	5	CONAB
Liming loading (mechanized)	h/m	5	ANNUALPEC
Liming training (mechanized)	h/m		IFAG
Liming training (manual)	h/h		ANNUALPEC
Fertilization			
Fertilizing (mechanized)	h/m	1	ANNUALPEC
Fertilizing (manual)	h/h		
Fertilizer 00-20-20	t	2	CONAB
Fertilizer 05-20-20	t	2	
Simple superphosphate	t	2	
Potassium chloride	t	2	
Urea	t	1	

Source: Own elaboration.
Note:[1] t = tons; h/m = hour/machine; h/h = man/hours; ha = hectare.

In addition to the inputs and operations used in the process of recovering pastures at different levels of degradation, the costs associated with the logistics of acquiring fertilizers are

also considered. Brazil is one of the largest consumers of fertilizers in the world but has a production deficit in relation to the volume demanded, which means that the country is dependent on the foreign market and subject to international prices. Due to the high costs of these inputs, it is also important to consider the costs involved in distribution logistics. For this reason, freight costs are also included[3] .

It should be emphasized that the economic costs measured do not consider the temporal dynamics of pasture areas and the values associated with recovery, renovation and maintenance costs, or even the opportunity costs related to livestock farming in the areas analyzed. Taxes, depreciation and improvements are also not included.

Pasture recovery costs in Brazilian biomes and states

Table 5.2.3 shows the average costs of recovering pastures in a moderate and severe state of degradation, as well as the average maintenance costs, in the Amazon, Caatinga, Cerrado, Atlantic Forest, Pampa and Pantanal biomes.

Considering biomes as the unit of analysis, the average cost to restore one hectare of moderately degraded pasture ranged from R$1,009.39 to R$1,831.69[4] . In turn, the average cost to renovate one hectare of severely degraded pasture ranged from R$1,806.02 to R$2,605.59[5] .

Table 5.2.3. Average costs (R$/ha) of pasture recovery/refurbishment and maintenance technologies in Brazilian biomes.

Biomes	**Moderate (R$/ha)**	**Severo (R$/ha)**	**Maintenance (R$/ha)**
Amazon	1.745,21	2.551,52	491,52
Caatinga	1.585,80	2.381,31	575,14
Cerrado	1.336,84	2.115,76	383,55
Atlantic Forest	1.009,39	1.806,02	380,87
Pampa	1.831,69	2.605,59	1.011,58
Pantanal	1.072,50	1.900,86	281,79

Source: Own elaboration.
Note: Real values as of 03/2024.

[3]The freight calculation was based on spatial statistics. Municipal data made available by the Ministry of Agriculture, Supply and Livestock (MAPA) through the Integrated System of Agricultural Products and Establishments (SIPEAGRO) was used. The data available refers to traders, producers and importers of fertilizers. With this data, the *Nearest Neighbors Search* (*knn*) algorithm was implemented to obtain the reference points for calculating the centroids (points with longitude/latitude that represent the center of each state). Based on the centroids, the average distances to the possible markets for obtaining fertilizers are calculated. Freight costs follow the minimum price table of the National Land Transport Agency (ANTT - resolution No. 6.034).

[4] Note: Real values as of 03/2024.

[5] Note: Real values as of 03/2024.

The initial investments required to recover pastures in moderate and severe stages of degradation are lower in the Atlantic Forest and Pantanal biomes. This result is mainly explained by the lower average costs associated with the use of fertilizers and correctives and those linked to the logistics of these products. The highest levels of investment required are observed in the Pampa and Amazon biomes, where the costs related to the consumption of these inputs are higher.

Some conditions explain this finding. Specifically in the case of the Atlantic Forest biome, the recommendations in the literature regarding the application of correctives and fertilizers highlight the greater need for correctives and phosphate fertilization, compared to other nutrients (LIMA et al., 2014; OLIVEIRA et al., 2014). In the Atlantic Forest region, the prices of these inputs and transportation costs are significantly lower, given the proximity to producers, traders or importers of these products.

About the Pantanal biome, the lower expenditure on correctives and fertilizers is due to the region's low responsiveness to nutrients, especially in areas free from flooding and sandy soils with low natural fertility (SANTOS et al., 2018; SANTOS et al., 2019). This lower response means that correction and fertilization recommendations are lower than those indicated for other biomes, resulting in lower costs for the recovery and maintenance of pastures with some level of degradation.

In the Amazon region, most of the inputs used to fertilize and correct the soil arrive at uncompetitive prices, mainly due to freight and transport costs, especially the high costs of Potassium Chloride and Urea fertilizers (TOWNSEND et al. 2010; DIAS-FILHO, 2015).

In the Caatinga and Pampa biomes, the highest fertilizer recommendations stand out, including those for pasture maintenance. In the Pampa, in particular, the costs of these inputs are relatively lower than those observed in the Caatinga biome, but the quantities required are substantially higher, increasing the necessary investments.

Main results

- At least 47% of the operating costs incurred in the recovery process are due to the planting stage, mainly due to the use of fertilizers, seed costs and mechanized operations. As the direct recovery strategy for moderately degraded pastures does not involve more intensive soil preparation techniques, the costs of machinery, although significant, are lower.

-Labor costs represent the smallest share of investments for the recovery of pastures with moderate signs of degradation in all biomes. Freight costs are more significant in the Amazon region. Regarding maintenance costs, the most significant costs are found in the Pampa, Caatinga and Amazon biomes, representing 36.94%, 26.62% and 21.97% of the average costs per hectare, respectively.

-The actual operating costs associated with the process of recovering severely degraded pastures are higher and can be explained mainly by the fact that the strategy requires the adoption of more intensive techniques. In this sense, these costs include soil preparation practices (plowing, intermediate and leveling harrowing) and the additional use of Potassium Chloride (KCl).

-Due to the greater intervention in soil preparation, the actual operating costs for this stage are higher and represent at least 30% of the average costs per hectare, especially the use of machinery and liming costs (especially dolomitic limestone). However, although these costs are higher than those observed in the recovery of moderately degraded pastures, the planting stage

is still the costliest for the producer, mainly due to the use of NPK fertilizers[6] , which represent around 51%, 44% and 37% of the average operating costs in the Pampa, Caatinga and Amazon biomes, respectively.

-Using the Brazilian states as a unit (including the Federal District), the costs of recovering pastures in moderate and severe stages of degradation also vary significantly. In the case of recovering moderately degraded pastures, the costs per hectare vary between R$914.26 and R$2,267.80[7] (figure 6). In turn, the cost of renovating one hectare of pasture in a severe stage of degradation varies between R$1,710.22 and R$3,112.04[8] (Figure).

-The highest costs are seen in the states of Acre, Amazonas and Roraima and can be explained by the costs involved in the planting stage, the most expensive in the recovery process. At least 55% of the investments required to recover moderately degraded areas in these states are attributed to this stage.

-The states with the lowest costs were Rio Grande do Norte, Paraná and Santa Catarina. This result is mainly due to lower costs related to the use of fertilizers and correctives, seeds and lower transport costs.

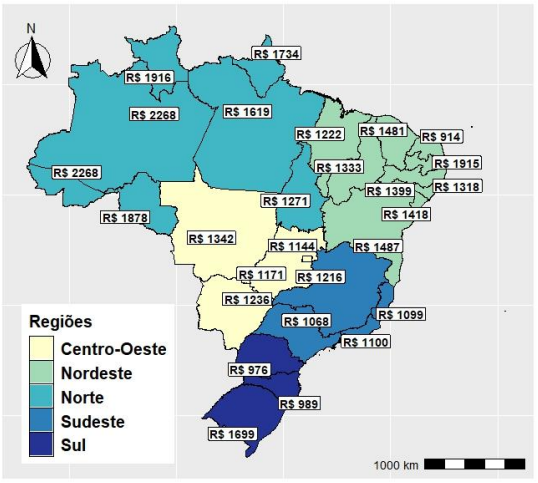


Figure 5.2.5. Average costs of recovering pasture areas at a moderate stage of degradation in Brazilian states.

[6] NPK fertilizers **are made** up of three of the main elements needed for the proper growth and development of forage plants: nitrogen (N), phosphorus (P) and potassium (K).
[7] Note: Real values as of 03/202 4.
[8] Note: Real values as of 03/2024.

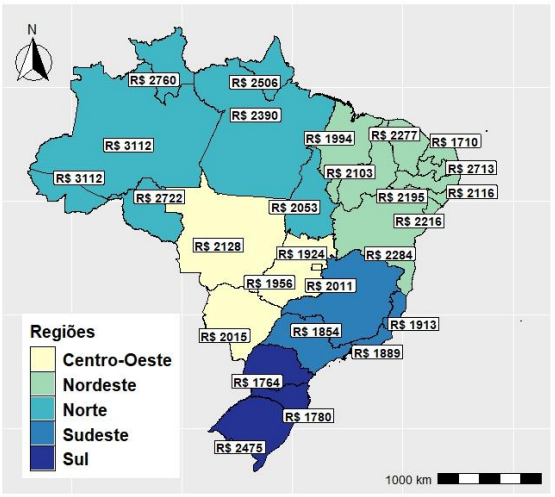


Figure 5.2.6. Average costs of recovering pasture areas in a severe stage of degradation in Brazilian states.

5.2.3 Activity 3 - Climate, livestock and implications for food security

In the next report, we will present the surveys of small animal emissions linked to family farming.

5.3 Water security

5.3.1 General aspects

1- Synergistic and Interdisciplinary Dialogues: in the Nat. Conf. Of Climate Change - Water Resources Session organized by RedeClima, the 5th Nat.Conf. of Sci. & Tech. “Water Security & Society” co-organized by the ABRHidro, the Scientific colloquium, 50 years of Evolution of Science of Hydrology, organized by UNESCO-IHP and the UNESCO *Towards a Pact for the Future* providing transdisciplinary areas addressed by the Pact for the Future, one of the proposed documents of the 2024 Summit of the Future;

2- EDI-driven (*Equity, Diversity & Inclusion*) research groups linked to the SDGs: namely, the Nat. Observatory of Water Security & Adaptive Mgmt ("ONSEAdapta", SDG6) , “Fighting Hunger” (SDG 2), and the CEPID-Center for Biodiversity Dynamics and Climate Change (SDG 15), “IEA/USP Planetary Health” (SDG 3), FAPESP “CEPIDs” (CeMEAI-“Applied Maths for Industry", SDG 9), the UNESCO Chair on Urban Water (SDG 4), the Center for Research on Biodiversity Dynamics and Climate Change (SDG 15), FAPESP Eng. Res. Center (C4AI-“Artificial Intelligence”), and FAPESP (MADIS-“Mgmt Disaster Risk and Societal Resilience”;

3- New Educative Game-Changing Accelerators and Serious Games: throught the INterdisciplinary CLimate INvestigation cEnter (INCLINE), the Center for Education and Research on Disasters (CEPED/USP), with new open tools, i.e. community water models for Latin America; the SuPEr/APAC in Pernambuco; “Flood awareness through dam-break serious games“ using reservoirs’ dataset of ANA/SNISB; the "Drought in play: A socio-hydrological tool to increase social participation”; and the Digital Water Globe at the IAHS;

4- New Demonstrative Pilot Projects (without Complementary Benefits): the FAPESP-From risk to adaptation and resilience, and the FAPESP “Perceiving-Making Forest”;

5- FAIR & CARE datasets: PNSH/ANA, CAMELS’BR, CABra and Digital Water Globe;

6- New Centers of Global Change Climate Action e-Courses: through ABRHidro-Education Technical Comission, IAHS International Commission on Human-Water Feedbacks; the IAHS WG History of Hydrology, and the IWA Digital Water Programme/Earth Observation of Water

Management Community of Practice;

7- Social action of Unprecedented Floods in Rio Grande do Sul: #OneDropOfScience #OneDoseOfResilience #BeFAIRwithCARE #GenerationRestoration. ABRHidro Interdisciplinary Professional Dataset Volunteering for Relief of the 2024 Rio Grande do Sul Flood Tragedy.

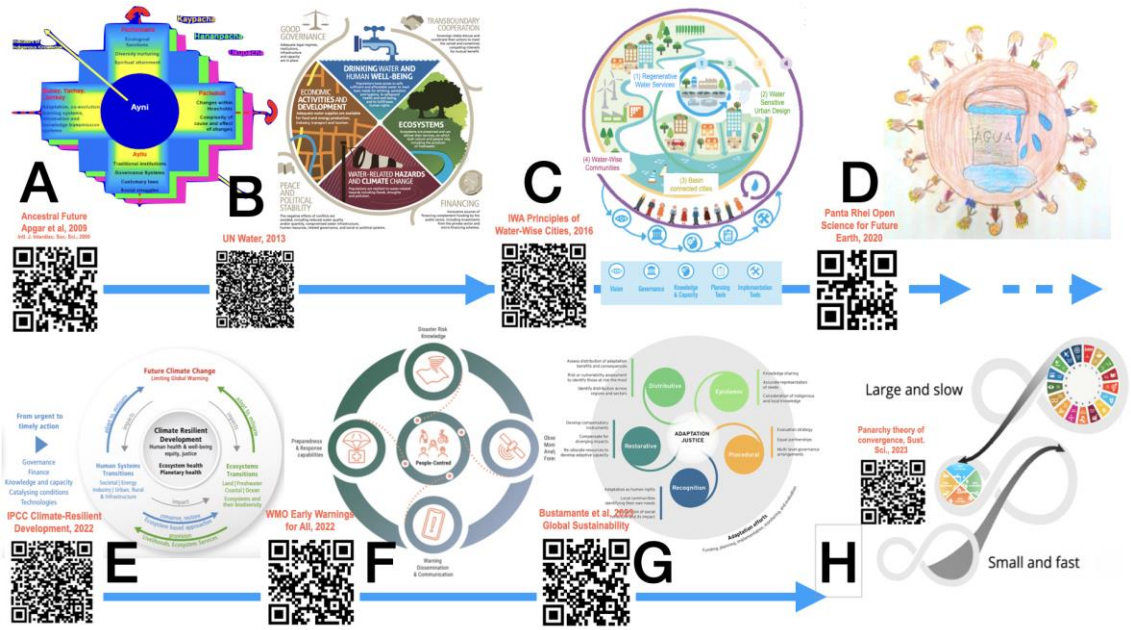


Figure 5.3.1. A combined chart of potential archetypes for the evolution of polycentric governance of the INCTMC-2 water security subcomponent. Legends: A: Ancestral transdisciplinarity for complex lessons from indigenous practice (Apgar et al, 2009); B: Water Security approach without adaptive management (UN Water (2013); C: Principles for Water-Wise Cities (IWA, 2016); D: 9-year child for climate justice (Panta Rhei Open Science for Future Earth illustration, 2020); E: Planetary-centred for climate resilient development (IPCC/AR6, 2022); F: UN Early Warnings for All with people-centred value diagram (UN & WMO, 2022); G: Adaptation justice and adaptation planning (Bustamante et al, 2023); H: UN SDGs in a panarchy theory for convergence and adaptative systems (Sundstrom et al., 2023). A combination of these archetypes are revisited with synergies at: i) the I Braz. Conf. Climate Change, 2024; ii) the INCT Observatory of water security and adaptive management, iii) the UNESCO hydro resilience, citizen and open science for climate adaptation (UNESCO, 2024), linked to the UN Sustainable Development Goals Framework integrated with the UN DRR Sendai Framework, to be discussed in the 2024 International Symposium on Integrated Water Resources Management (IWRM).

5.3.1 Scientific and Management Actors (Science-For-Policy)

This part outlines a summary of activities developed by INCTMC2's water security (WS) affiliated institutions, i.e. UFPE, UFCG, USP, UFCG, UFRGS, CEMADEN, INPE, FUNCEME and EMBRAPA, with new affiliated institutions: UFMS, UFSC, UnB and ABRHidro, boosted through community presence with both the Digital Water Globe, relaunched at the European Geophysical Union 2024 (Vienna, 2024; Figure 2), and the UNESCO IHP 50th Anniversary (Paris, 2024; Figure 3). Detailed information can be consulted in respective publications (see Section B). Highlights of the INCTMC's 7th year (2023/2024) were addressed in how Brazilian INCTMC2-WS' actions met global programs of UNDRR, UNFCCC, UN-Habitat, UNESCO-

IHP-IX (2022-2029) and socio-hydrology initiatives of IAHS/Panta Rhei and IAHS/Unsolved

Problems in Hydrology (UPH).

Figure 5.3.2. Digital Water Globe Community at the EGU 2024 https://www.egu24.eu/. Picture: EMM.
Figure 5.2.3. UNESCO-IHP 50th Scientific Conference (2024). Source: https://unesdoc.unesco.org/ark:/48223/pf0000389979

The polycentric governance statement of the INCTMC2-WS subcomponent is: *"how new sustainable, resilient private-public partnerships promote targeted investment in climate services to strengthen community-based, hybrid early warning systems and decision support for water resources adaptation in climate-sensitive sectors and for most vulnerable people in the Tropics, through metrics and levels of indices*[9]*, with flexible, adaptable and participatory mechanisms*[10]*,* and *using resilience-driven (absorptive, adaptive, transformative) methods*[11]*"*.

[9] Indices: *Nationally Determined Contributions of Parties (NDC) for UNFCCC, Nature's Contribution to People (NCP) for CDB & IPBES, and Digital Sequence Information" (DSI) for Natural Capital from CBD.*

[10] Mechanisms: - *Enhanced Transparency Framework (ETF), post-Paris 2015/UNFCCC, Monitoring, Report & Verification (MRV) on GHG from UNFCCC, Global Stocktake (GST) from UNFCCC, Sustainable Development Mechanism (SDM) of zero-net targets, Principles*

A.1. Advances in Polycentric Water Governance

In this 2023/2024 period, research groups of INCTMC2-Water Security have gained advances in polycentric water governance (Figure 5)

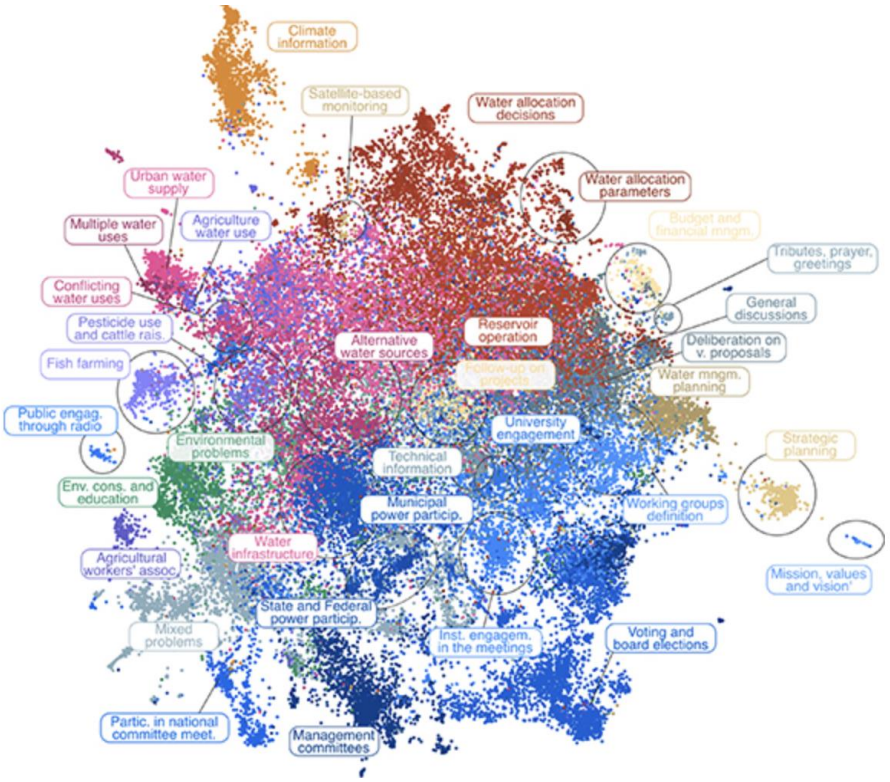


Figure 5.2.4.Unveiling Water Allocation Dynamics from Stakeholder Meetings (Nunes et al, 2024) https://doi.org/10.1088/1748-9326/ad37cd

5.3.2 **Advances in prediction-driven patterns for water scarcity**

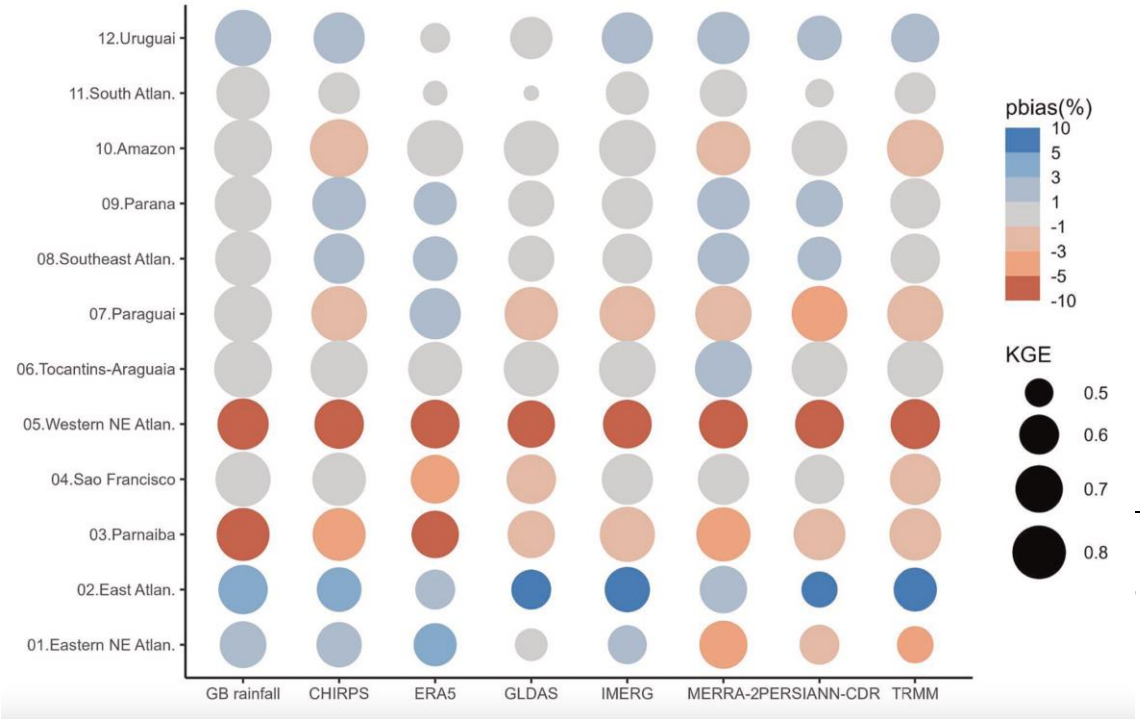


Figure 5.2.5. Diagram of the twelve hydrographic regions in descending order by aridity index of Brazil for the ground-based (GB) rainfall and the seven products to calibration phase. The size of each circle indicates the median KGE value of the catchments located in a given hydrographic region and a given precipitation product. The colour of each circle indicates the median pbias value. Source: Moura Neto et al (2024)

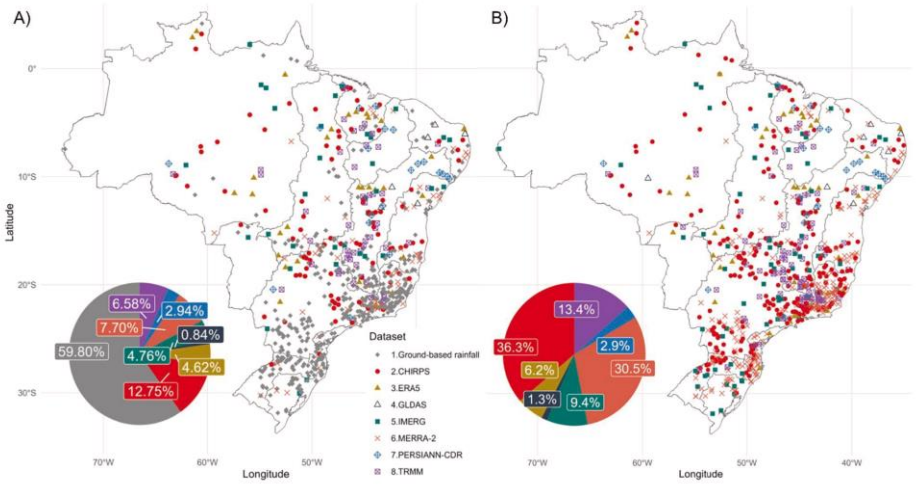
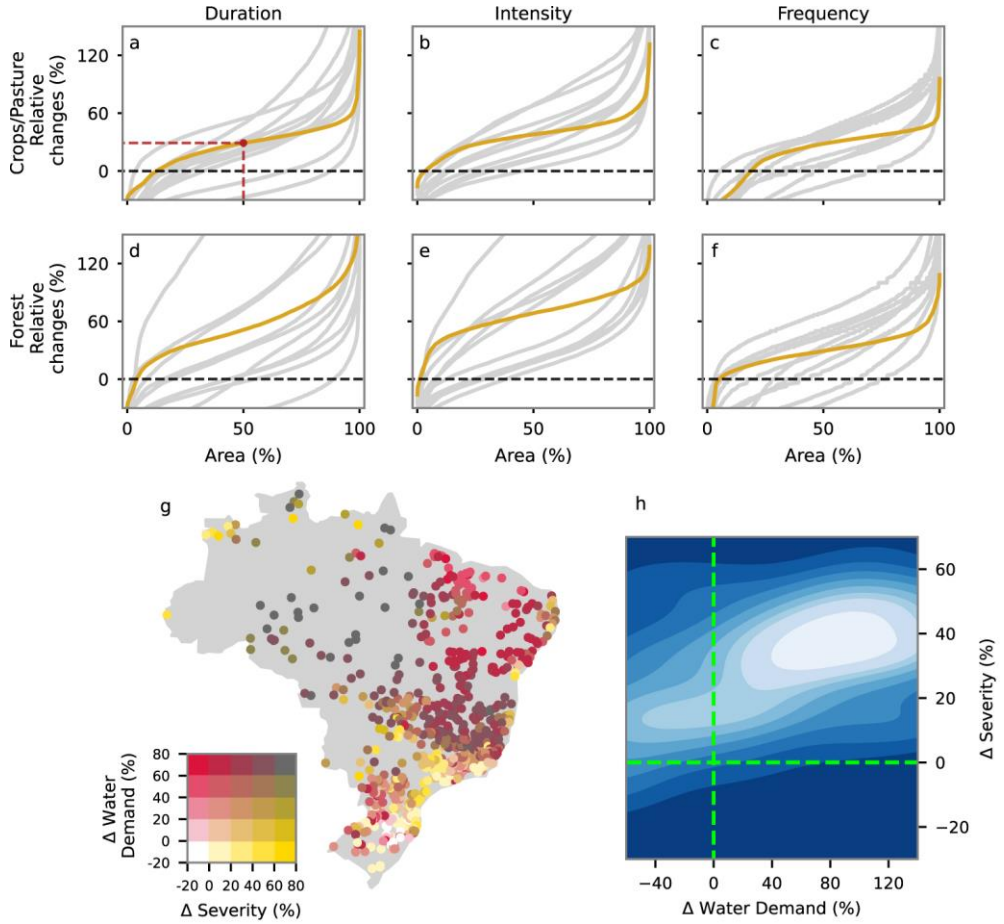


Figure 5.2.6. Best values of KGE for the calibration period. A) All precipitation products



including ground-based rainfall. B) All precipitation products excluding ground- based rainfall. Source: Moura Neto et al (2024)

5.3.4 Advances in water security at local scales

The studies developed by the research groups working at INCT - Climate Change in the axis of water security for local scale provide important advances in the theme of climate change and water resources. The component is strongly based on the use of geotechnologies and hydrological models to represent the hydrological cycle and to estimate the flow in hydrographic basins, as well as on the identification and projection of anomalies in the hydrological variables under different climatic and land use scenarios, to subsidize actions in water management that provide better quality of life for the local and regional population. These surveys associated with the analysis of extreme drought and flood events in local watersheds, specifically in the State of Pernambuco, as well as the occurrence of flooding in urbanized areas, represent an important tool for understanding the climatic factors acting on local and regional hydrology.

A. Hydrological modeling and climate change at different space scales.

In the soil moisture simulation, from 2016 to 2017, FEST-EWB presented good results from the two different climate regions of the basin (Caatinga and Atlantic Forest) (Figure 7). Importantly, for this study, FEST-EWB was defined with a spatial resolution of 250 m and a temporal resolution of 1 hour, providing 24 images per day, with low errors, according to the adopted statistical metrics (Table 1).

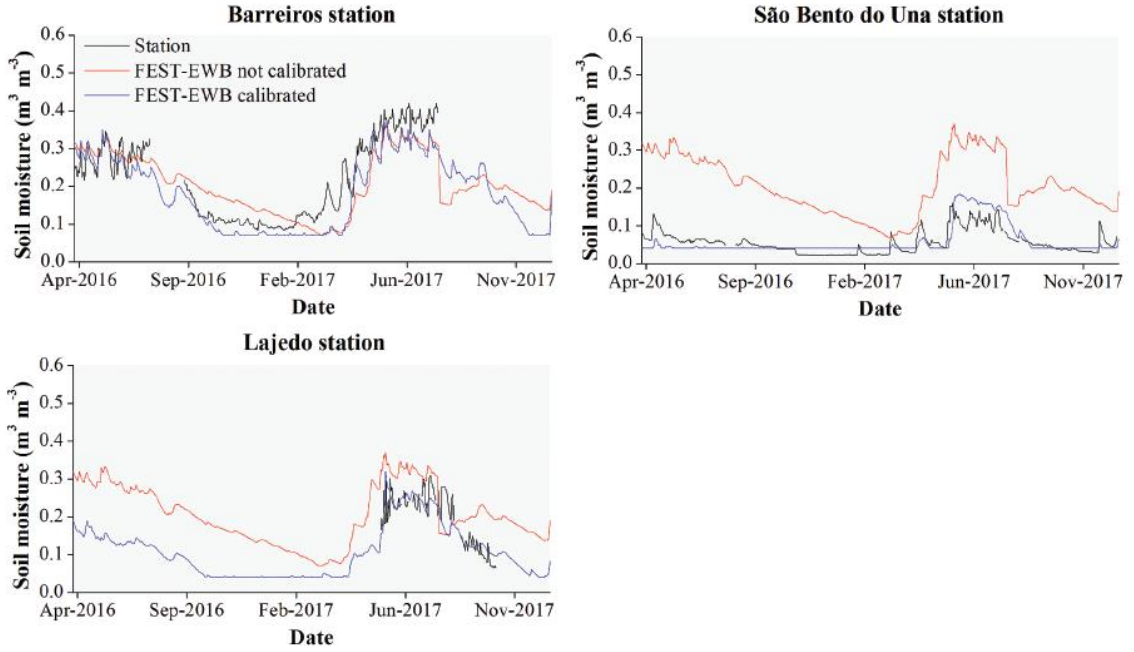


Figure 5.3.7. Comparison between observed and simulated soil moisture in the Una River basin during 2016–2017.

Table 1. Indices for evaluation of soil moisture before and after calibration of the FEST-EWB model over the Una River basin. MBE and AMBE are expressed in $m^3\ m^{-3}$.

Station	Climate type	Before calibration			After calibration		
		MBE	AMBE	R^2	MBE	AMBE	R^2
Barreiros	Atlantic Forest	−0.01	0.08	0.63	−0.03	0.05	0.80
São Bento do Una	Semi-arid	0.16	0.16	0.52	0.00	0.03	0.51
Lajedo	Semi-arid	0.06	0.09	0.23	−0.01	0.03	0.67

FEST-EWB: Flash–flood Event–based Spatially distributed rainfall–runoff Transformation–Energy Water Balance; MBE: mean bias error; AMBE: absolute mean beas error; R^2: determination coefficient.

In the case of the analysis of the nine CMIP6 models for projection of possible climate change in Pernambuco, there is a noticeable trend of increasing temperature over the course of the decade, both in the moderate greenhouse gas emissions scenario (SSP245) and in the more pessimistic one (SSP585). As expected, the impact will be greater in the more drastic scenario, with the most significant intensity at the end of the century (2081-2100), where a temperature increase of up to 5 °C is projected throughout the state, especially in the semiarid region (Figure 8).

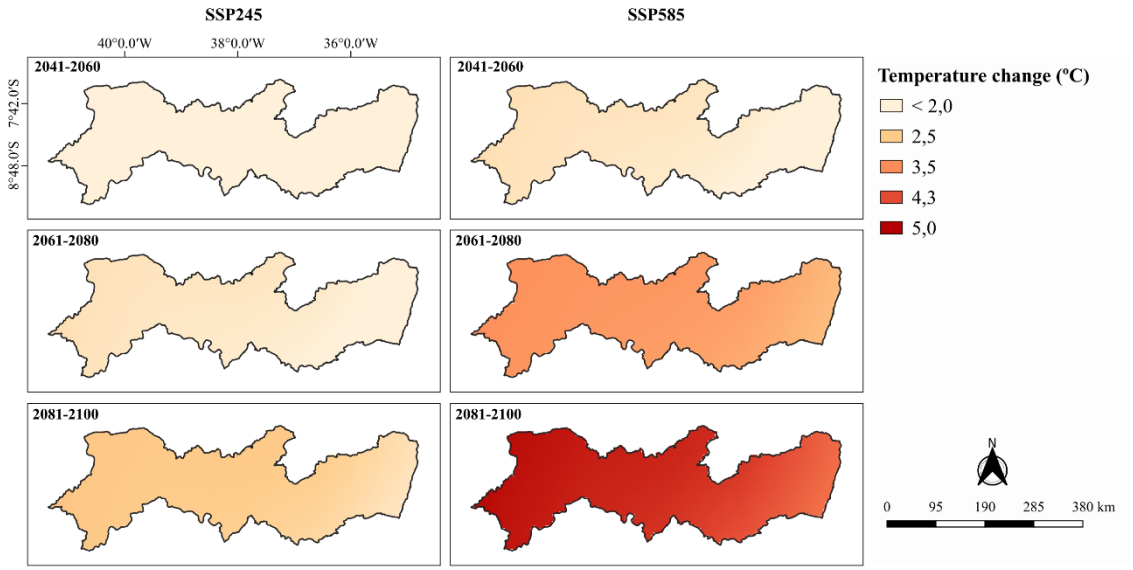


Figure 5.3.8. Temperature increases in the State of Pernambuco for the period from 2041 to 2100, based on CMIP6 models for the SSP245 and SSP585 scenarios.

Just as with air temperature, precipitation is expected to undergo significant changes over the years, especially in the Zona da Mata Pernambucana, where a more pronounced reduction in rainfall regimes is anticipated, with reductions of up to 300 mm year-1 in SSP585, during the period from 2081-2100 (Figure 3). The more pronounced reduction in this region may be related to the annual precipitation volume itself. Given that it is an area with high accumulations, exceeding 2200 mm, it is expected that models predict a greater reduction in precipitation. In the Sertão and Agreste regions, reductions will occur with less intensity and will be more homogeneous. It is important to note that the anomaly map follows a similar pattern to historical average precipitation (Silva et al., 2022), with a greater reduction in precipitation recorded in areas with higher rainfall indices. Nevertheless, even in the intermediate scenario (SSP245) and for the upcoming years (2041-2060), a reduction in precipitation is already noticeable.

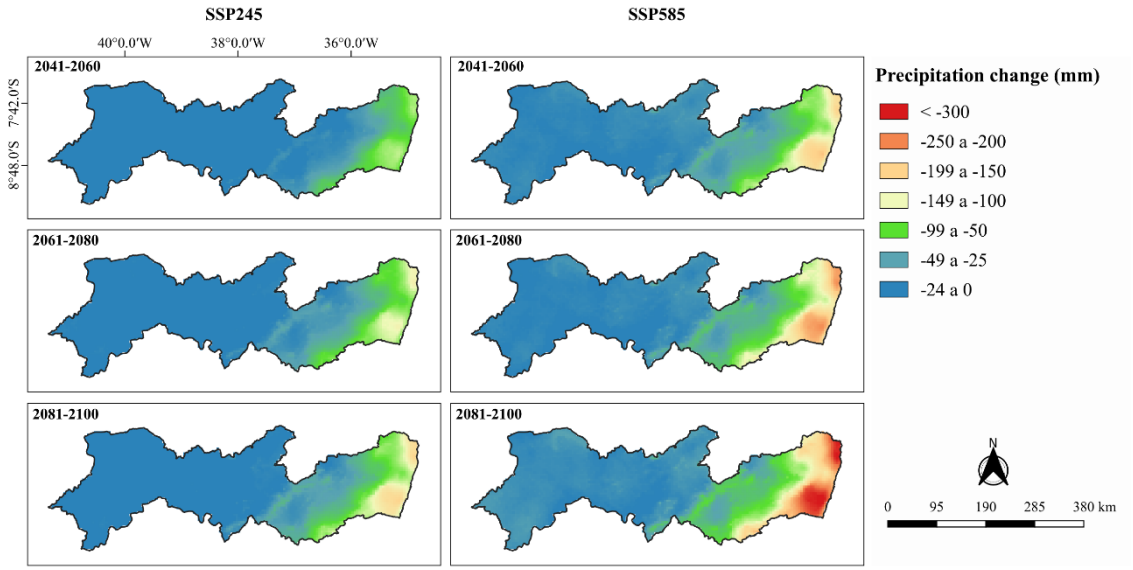


Figure 5.3.9. Precipitation anomalies for the State of Pernambuco until the end of the century, based on CMIP6 models for the SSP245 and SSP585 scenarios.

The results, in both studies, indicate the need for investment in constant monitoring, using a combination of different sources of data, to ensure resilience and adaptation to extreme events, in accordance with the dimensions of the National Water Security Plan (PNSH), which already foresees the northeast region of Brazil as the one that has the lowest degree of water security, a situation that tends to intensify even more in the coming years.

5.3.5 Impacts of meteorological, agricultural and hydrological drought in a basin in the Caatinga/Atlantic Forest ecotone, through future scenarios of climate change and land use and Cover.

According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change – IPCC (IPCC, 2022), the occurrence and intensity of extreme climate events will increase, and severe climate change is expected to have a greater impact on cities with weak adaptation capacity. Studies in northeastern Brazil show that future climate change scenarios suggest a reduction of up to approximately 22% in precipitation (IPCC, 2014). The frequency, severity, and duration of extreme hydrological events such as droughts, floods and landslides are expected to intensify in the coming decades (Almagro et al., 2020; IPCC, 2014).

The Capibaribe river basin (Figure 4) is an important region of the state of Pernambuco, which begins in the semiarid region and extends to the coast. It is responsible for 36% of the water supply in the metropolitan region of Recife and is home to an important textile hub in the state. Furthermore, it exhibits variability in its characteristics along its length. The Government policies of the Capibaribe River Basin, which was elaborated in 2002, established the subdivision of the basin into four analysis units (AU) and metropolitan region of Recife (RMR). These divisions were initially adopted in the Hydroenvironmental Plan of the Capibaribe River Basin (Pernambuco, 2010), and this same approach is being adopted for the present study.

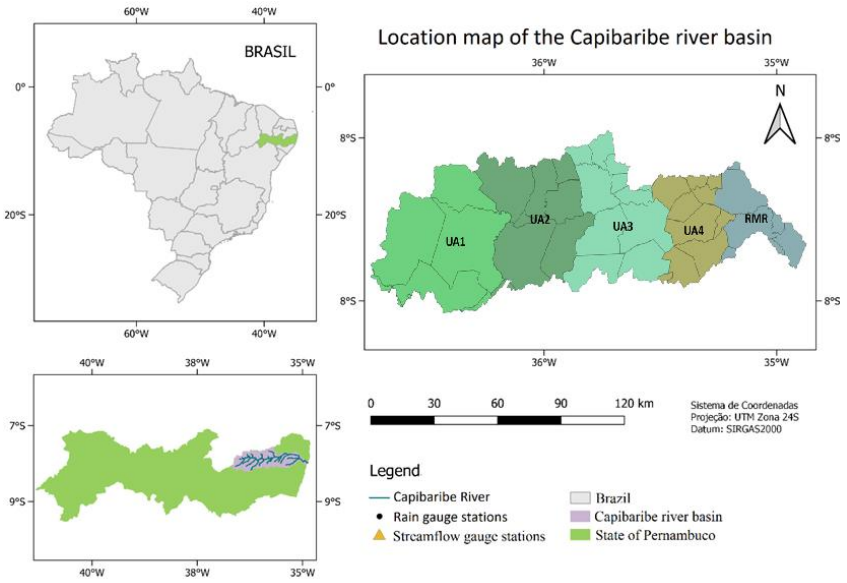


Figure 5.3.10. Location of Capibaribe watershed and Division of the Analysis

Climate change has a profound impact on the hydrology of the basin, affecting the quantity and availability of water (Bhatta et al., 2014), and consequently, damage to agricultural lands, properties, and human lives may increase (Tenagashaw et al., 2022).

To ensure adequate planning for climate change and mitigation policies, projections are essential, albeit posing a significant challenge for the scientific community due to the diversity of climate-sensitive factors that require consideration (Almagro et al., 2020). The predominant tools for these climate predictions are Global Climate Models (GCMs) (Teutschbein and Seibert, 2010; Marengo, 2007). The GCM, with some degree of uncertainty, possible changes in future climate extremes, such as heatwaves, cold spells, heavy rainfall, floods, droughts, and more (Marengo, 2007). These models use scenarios that describe possible future developments of anthropogenic factors of climate change, such as greenhouse gases, chemically reactive gases, aerosols, and land use, in line with socioeconomic evolution and play a crucial role in climate research (O'Neil et al., 2016; Marengo, 2007).

This study used a dataset from 10 Global Climate Models made available by CLIMBra - Climate Change Dataset for Brazil (Ballarin et al., 2023). To compare the observed historical data with that of the models, observed data from Xavier et al. (2016) covering the historical period from 1980 to 2010 were used. Both datasets contain gridded daily series with a spatial resolution of 0.25° × 0.25°. The Quantile Mapping (QM) method was used for bias correction, known for its effectiveness in correcting climate model data (Abbas et al., 2022; Anil and Raj, 2022; Shrestha et al., 2017; Heo et al., 2019).

To use of future climate change scenarios projected by global circulation models, it is important that the historical period of these data adequately matches the observed historical behavior in the watershed. This assessment seeks to verify if the model can accurately represent past conditions, thus ensuring the integrity of its future projections. Figure 5 presents the correlation of the historical period for the observed database compared to the raw data of the climate models, before and after bias correction.

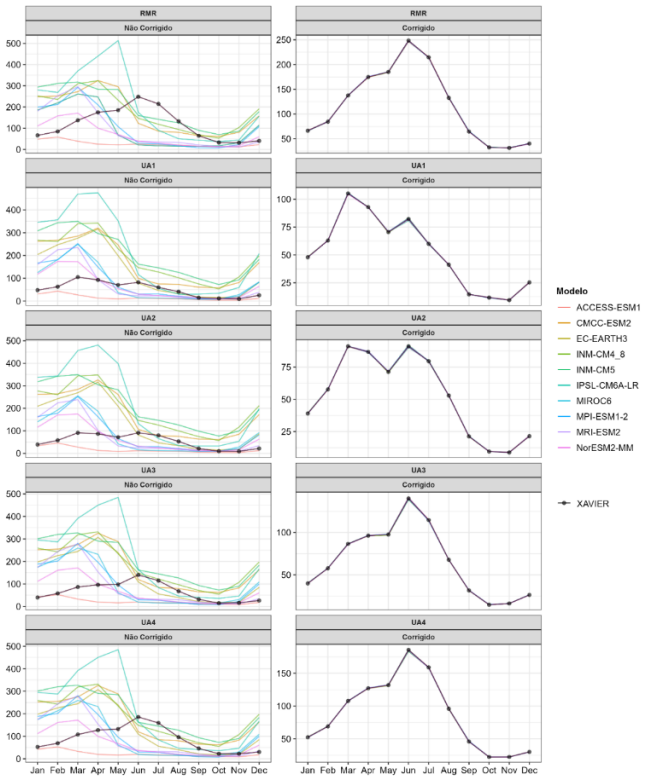


Figure 5.3.11. Climatological normals from CMIP6 models, compared to data observed during the period 1980 to 2010, before and after bias correction.

It can be observed that the raw data from the models exhibit systematic errors, manifested by differences in seasonality and total precipitation, mainly highlighting the shift in the rainfall concentration period. Correction was carried out using the QM method and the method proved to be effective and corrected satisfactorily, especially regarding rainfall seasonality, resulting in a significant reduction in biases in all global circulation models after correction.

Changes in the frequency and intensity of extreme weather events have the potential to cause immediate and significant impacts on society and the environment, exacerbating any existing challenges in a hydrographic basin. Using daily precipitation data, the study seeks to enhance understanding of changes and trends in climate extremes indices. Among these indices, 10 are relevant to the region and were selected for this study: Annual total precipitation in wet days (PRCPTOT); Monthly maximum 1-day precipitation (Rx1day); Monthly maximum consecutive 5-day precipitation (Rx5day); Simple pricipitation intensity index (SDII); Annual count of days when PRCP≥ 20mm (R20mm); Maximum number of consecutive days with RR < 1mm (CDD); Maximum number of consecutive days with RR ≥ 1mm (CWD);

To assess the changes between future and historical periods, the relative change in each Climate Extremes Index (CEI) was calculated using Equation 1 presented by Bador et al. (2018) and adapted by Medeiros et al. (2022).

$$ICE = \frac{\bar{ICE}_{future} - \bar{ICE}_{historical}}{\bar{ICE}_{histórical}} * 100 \qquad \text{Eq. 1}$$

Where $\bar{ICE}_{future}$ represents the average index for the short-term (2015-2044), medium-term (2045-2074), and long-term (2075-2100) future periods, and $\bar{ICE}_{historical}$ represents the historical averages (1980–2010) for each region.

Table 5.3.2 presents the result that the average of the ten models shows for each precipitation climatic index in the intermediate emission scenario SSP2-4.5, while Table 3 presents the indices of the average of the 10 models for the scenario SSP5-8.5.

Table 5.3.2. Relative changes in the mean of the ten models for each climate index of extreme precipitation in the five regions of Capibaribe in the short, medium, and long term in its intermediate emissions scenario SSP2-4.5.

		Climate extreme indices (%)						
	Regions	PRCPTOT	RX1day	RX5day	R20mm	SDII	CDD	CWD
Short	UA1	-0.74	11.99	11.50	7.23	-0.66	5.15	-1.35
	UA2	-1.50	7.15	20.55	12.07	3.11	14.23	-6.08
	UA3	-3.73	-0.74	18.23	1.59	-0.02	6.28	4.23
	UA4	-4.51	1.10	13.02	-2.41	-0.23	28.78	8.15
	RMR	-5.55	1.32	13.92	-7.10	-1.60	38.72	0.64
Medium	UA1	-0.19	13.58	12.40	10.55	9.37	14.15	-0.74
	UA2	-1.82	9.06	19.81	17.24	6.14	22.85	-8.13
	UA3	-5.46	-3.12	14.38	0.30	1.09	15.96	1.22
	UA4	-7.03	-0.90	8.43	-3.67	-0.45	42.09	4.68
	RMR	-8.55	0.51	10.56	-11.55	-2.78	48.60	-1.08
Long	UA1	-2.11	20.61	17.47	19.92	14.81	25.30	-8.36
	UA2	-4.29	15.44	25.01	22.92	9.72	36.55	-14.20
	UA3	-8.68	2.26	16.88	2.74	3.17	30.63	-5.90
	UA4	-10.30	2.25	9.59	-6.04	0.86	57.15	0.82
	RMR	-12.13	0.13	9.14	-14.00	-2.34	71.63	-6.28

Table 5.3.3. Relative changes in the mean of the ten models for each climate index of extreme precipitation in the five regions of Capibaribe in the short, medium, and long term in its intermediate emissions scenario SSP5-8.5.

		Climate extreme indices (%)						
	Regions	PRCPTOT	RX1day	RX5day	R20mm	SDII	CDD	CWD
Short	UA1	-5.61	9.46	7.93	1.91	6.08	16.74	-1.66
	UA2	-7.01	1.53	13.92	9.82	2.33	23.89	-11.20
	UA3	-10.06	-10.92	7.59	-5.87	-1.64	20.56	-3.63
	UA4	-10.89	-7.63	3.27	-8.70	-2.08	42.88	-1.66
	RMR	-11.43	-5.32	7.04	-11.84	-4.31	50.92	-7.92
Medium	UA1	-0.84	21.63	22.91	20.56	15.40	31.47	-2.75
	UA2	-3.88	12.21	26.57	26.25	9.74	39.85	-12.21
	UA3	-9.11	-0.23	17.27	0.25	3.15	34.19	-6.18
	UA4	-11.25	0.01	9.49	-7.32	0.78	62.97	-3.27
	RMR	-15.58	0.11	7.63	-16.64	-2.82	91.97	-14.56
Long	UA1	2.51	28.15	29.68	43.16	28.32	45.00	-2.53
	UA2	-2.53	20.46	37.63	47.74	19.89	57.54	-14.92
	UA3	-10.69	6.56	26.56	2.26	9.27	51.58	-7.49
	UA4	-13.69	6.11	16.41	-4.71	5.29	88.91	-9.00
	RMR	-17.06	3.57	14.17	-18.11	-0.53	110.9	-15.41

The results of the models point to a more pronounced reduction in PRCPTOT in the Metropolitan Region of Recife and the coast, with the percentage of this reduction gradually decreasing in the inner regions of the state, such as UA1 and UA2. Considering the average of the 10 models, a decreasing trend in total precipitation is observed in the RMR and UA4 ranging from 11% in the SSP2-4.5 scenario to 12% in the SSP5-8.5 scenario. For the UA1 and UA2 regions, in the hinterland, the reduction ranged from 1% to 4.5%. The reduction in precipitation totals can impact socioeconomic sectors such as agriculture, irrigation, and water availability.

For RX1day and RX1day, projections for the medium and long-term future indicate an increase in these extreme events across all five regions, with particular emphasis on the “agreste” region, comprising regions UA1 and UA2. In contrast to PRCPTOT, both RX1day and RX5day show

notable increases in the medium and long term for UA1 and UA2, while RMR exhibits smaller percentage increases. The UA1 varies from 12% to 21% for both indices, and RMR shows an increase ranging from 0.1% to 1% for RX1day and from 9% to 14% for RX5day.

The R20mm and SDII indexes exhibited similar behavior, showing an increase in analysis units 1 and 2, where precipitation exceeding 20mm daily and average daily intensity increased by 1% to 23% in the medium and long term. UA3 showed a slight increase, ranging from 0.3% to 4%. UA4 and RMR, on the other hand, experienced a reduction of approximately 0.2% to 14%. This indicates that projections point to an increase in daily precipitation and rainfall intensity in the more inland regions of the state compared to the metropolitan region of Recife.

The CWD showed an opposite pattern to that of CDD, as it exhibited a reduction in wet days across all regions. On the other hand, the maximum number of consecutive dry days increased, with a maximum increase of 25% in UA1, 36% in UA2, 30% in UA3, 57% in UA4, and 71% in the RMR for the SSP2-4.5 scenario, with even higher values for the SSP5-8.5 scenario of up to 45% in UA1, 57% in UA2, 51% in UA3, 89% in UA4, and 110% in the RMR. This result indicates more favorable conditions for water deficit in the future. Overall, future projections show a reduction in PRCPTOT and CWD and increases in CDD, which is a trend towards a drier future climate, but with more intense rainfall as compared to the results obtained from RX1day and RX5day.

5.3.5 Land use and land cover trends and their impact on streamflow and sediment yield in a humid basin of Brazil's Atlantic Forest Biome.

Land use and land cover (LULC) are fundamental factors shaping terrestrial environments. The expansion of urban, agricultural, and pasture lands has resulted in significant alterations to natural landscapes. These transformations exert a direct impact on water resources, influencing both streamflow and sediment transport (Loiselle et al., 2022). Streamflow and sediment yield serve as pivotal components of the hydrological cycle, and changes in LULC can modify river flow regimes (Yin et al., 2023). The conversion of natural areas to agricultural uses can influence water availability; intensive irrigation practices, coupled with the removal of native vegetation, may diminish the recharge of subterranean aquifers and reduce baseflows in rivers (Juma et al., 2022). Accordingly, this study investigates the effects of LULC changes on the dynamics of streamflow and sediment yield within a humid tropical basin of the Atlantic Forest biome in Brazil, the Pirapama River basin (Pernambuco), with a focus on the period from 2000 to 2016.
The methodology focuses on analyzing Land Use and Land Cover (LULC) trends and their impact on surface runoff and sediment yield, using annual data from MapBiomas and the SWAT (Soil and Water Assessment Tool) model. The research employs non-parametric statistical tests: Mann–Kendall, Pettitt, and Sen's Slope to investigate temporal trends in LULC. Additionally, ecological indices like Shannon–Weaver, Simpson, and Pielou are applied to assess forest fragmentation, along with the Forest Fragmentation Index.

Figure 6c discloses that a substantial portion of the basin underwent changes in LULC over the analyzed period. Intriguingly, the eastern part of the basin has largely retained its original configuration, while the remaining areas have experienced transformations. These findings are consistent with Figure 6d, which displays the calculated Forest Fragmentation Index for the study area, with values ranging from 1 to 8. It is important to emphasize that categories 6 and 8 registered the largest extent of fragmentation.

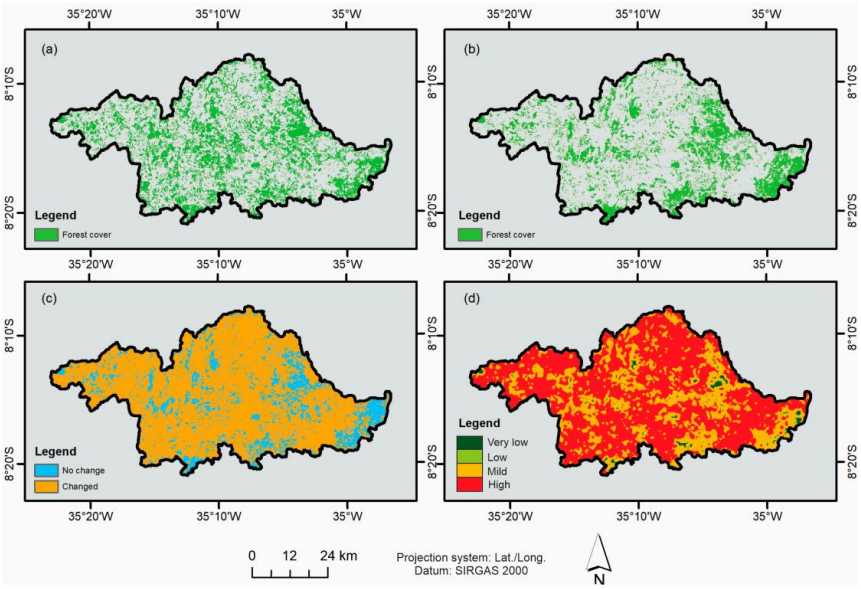


Figure 5.3.12. (a) Forest cover in 2000, (b) forest cover in 2016, (c) areas with and without LULC changes, and (d) spatial distribution of the Forest Fragmentation Index for the Pirapama River basin.

Regarding sediment yield, the simulations indicated greater variations, resulting in higher percentage differences, especially for CR2013 (215.61%), which had the largest diffeence compared to the baseline among the scenarios (Figure 7). When compared with the variability of land uses, a behavior more aligned with low-lying vegetation was observed, indicating that as this class varies across the scenarios, so does sediment yield (Figure 7). This may be attributed to the influence that the class labeled "pasture" (PAST) in the SWAT model, designated as low-lying vegetation in this research, has on sediment yield behavior and how alterations to this use over the years affect the dynamics of this estimate. According to Castello et al. (2013) in the Cobres River basin, located in the semi-arid region of Portugal, the authors found that Scenario 2 (pasture) produced the highest sedimentation rate among the scenarios, whereas Scenario 3 (forest) presented the lowest average value. The authors concluded that land-use types interfere with hydro-sedimentological processes and, consequently, with flow regimes and sediment yield in watersheds, particularly those where flow is ephemeral.

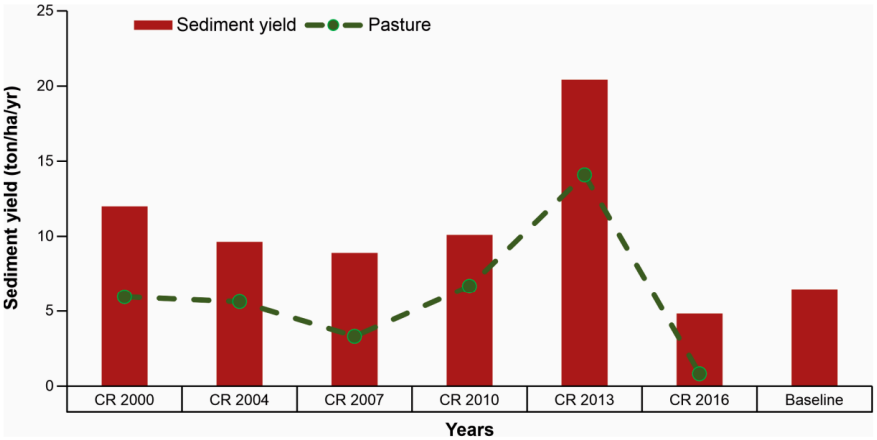


Figure 5.3.13. Annual average sediment yield in the Pirapama River basin and the percentage difference compared to the baseline scenario.

Trends in land use and occupancy showed that classes such as urban areas, pasture, water, and sugarcane have increased, whereas mangrove and rainforest areas have experienced a decline.

These land use alterations have substantially impacted the hydrological balance in a wetland basin of the Atlantic Forest biome in Brazil. With respect to the flow analysis for various scenarios, the results displayed minimal variation across simulations. This suggests that the examined land-use changes were insufficient to represent a discernable trend in either increased or decreased flow rates. Similarly, minimal variation was observed in the hydrological balance variables from one scenario to another, particularly for estimated values of surface runoff, percolation, and, most notably, evapotranspiration.

5.3.5 Land use and land cover and precipitation effects in the flow regime of the Rio Grande Basin, Bahia.

The Rio Grande basin (BHRG) is an important tributary of the São Francisco river, it is part of one of the most active agricultural frontiers in the world and has been undergoing changes in land use and land cover (LUCC). Additionally, the decade from 2010 to 2020 was marked by a reduction in rainfall, which contributed to an almost exponential increase in irrigated agriculture. Such factors culminated in the increase of land and water tenure conflicts. Thus, understanding the hydrological processes becomes crucial for the management of the basin's waters.
The research aimed to evaluate the effects/impacts of changes in land cover use and precipitation on the components of the water balance of the Rio Grande basin, in particular on the flow regime. The two variables – precipitation and the LUCC – were then initially studied separately and, subsequently, hydrological modeling was carried out and, finally, simulations were carried out to evaluate separately and separately the effects of the two variables on surface runoff. Due to the low density of the rainfall network, it chose to use the rainfall estimated by the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) product, which required validation using the “point-to-pixel” technique. Eleven rainfall stations were used and then compared with those estimated by CHIRPS, monthly using the period 1981 to 2020. CHIPRS was accurate in detecting rainfall, satisfactory in the probability of detecting these events and exhibited good ability to represent spatial variation. precipitation time.

The LUCC analysis was carried out using landscape ecology metrics (from 1990 to 2020) and correlations of areas of use classes with flows near the basin outlet. Significant reductions in the areas of the classes were observed, especially of native vegetation (reductions) and anthropized areas (increase). There was a trend of reductions in average, minimum and maximum flows and strong significant correlations between average and minimum flows with the increase in areas of rainfed agriculture, irrigated agriculture, pasture and urban infrastructure.

In the hydrological modeling, the Soil and Water Assessment Tool (SWAT) model was used, which was fed with CHIRPS estimates, calibrated and validated for three different periods (LUCC 1990 and climatological data from 1981 to 1995; LUCC 2010 and climatological data from 1996 to 2010; LUCC 2015 and climatological data from 2011 to 2020) using the multi-sitesequential calibration technique. After this stage, using the 'one factor at a time' technique, experiments were simulated – LUCC combination arrangement and precipitation series estimated by CHIRPS. The results show that the SWAT performed satisfactorily in its analysis in the three periods studied on a monthly scale, especially in the headwaters sub-basins. The model well represented the progressive decline of flows in all fluviometric stations. Precipitation was the most sensitive variable in the generation of runoff, however as precipitation is reduced, the sensitivity of runoff from BHGR to LUCC increases.

5.3.6. Central pivot irrigation in the sedimentary basins of the Brazilian Semi-arid Region and the export of virtual waters.

Socioeconomic development and population growth face challenges due to the unequal distribution and variability of global water resources. The importance of virtual water, which

affects income, population, cultivated area, and the water availability of a country, although it does not always benefit water-scarce regions.

The water footprint (WF) measures the use of freshwater in production and consumption, comprising three components: blue (surface and groundwater), green (rainwater in the soil), and gray (water to dilute pollutants). For primary crops, the green and blue footprints are calculated by the total volume of water used divided by the total produced, and the gray footprint calculates the volume of clean water needed to dilute the polluted water from agricultural processes.

With the growing interest in increasing agricultural production in Brazil's Semi-arid region, the number of areas irrigated by central pivots has significantly increased in recent years. In this context, it becomes essential to conduct a detailed survey to identify the geographic location and the irrigated area of these pivots. This mapping will allow for a more precise understanding of the irrigated agriculture situation in the region, as well as enable the estimation of areas with increased water use pressure for agricultural irrigation and the calculation of the WF.

This study aims to map and quantify the variation of the irrigated area by central pivots in the Brazilian Semi-arid region between 1985 and 2022, analyzing data at the municipality, micro-region, state, and hydrographic basin levels. The obtained information will serve as a basis for formulating strategies for the use of irrigated agriculture and implementing water resource management and environmental conservation policies in the region's hydrographic basins, as well as estimating the amount of water per type of irrigated crop.

To investigate the expansion of the irrigated area between 1985 and 2022 in the Semi-arid, data from central pivot irrigation systems available through the Google Earth Engine platform via MapBiomas Brazil, specifically from collection 6, were used. The mapping of central pivot irrigation systems was performed using annual mosaics of Landsat series images obtained by the Google Earth Engine platform (Collection 1 Tier 1 TOA) covering the period from 1985 to 2022. Only images with less than 80% cloud and shadow coverage were considered. To map central pivot irrigation systems in Brazil, the territory was divided into grids of 05' x 05' degrees (approximately 300 thousand hectares each). Only the grids that showed occurrences of central pivot irrigation systems in any year from 1985 to 2022 were selected. A total of 723 grids were chosen, distributed over an approximate area of 212 million hectares.

The areas irrigated with central pivots in the Brazilian Semi-arid are predominantly located in regions of sedimentary basins due to the abundant availability of groundwater in these areas, facilitating irrigation. Between 1985 and 2022, a significant expansion of these irrigated areas with central pivots was observed, with notable increases in the years 1985, 1990, 2000, 2005, 2010, 2014, and 2022 (Figure 8).

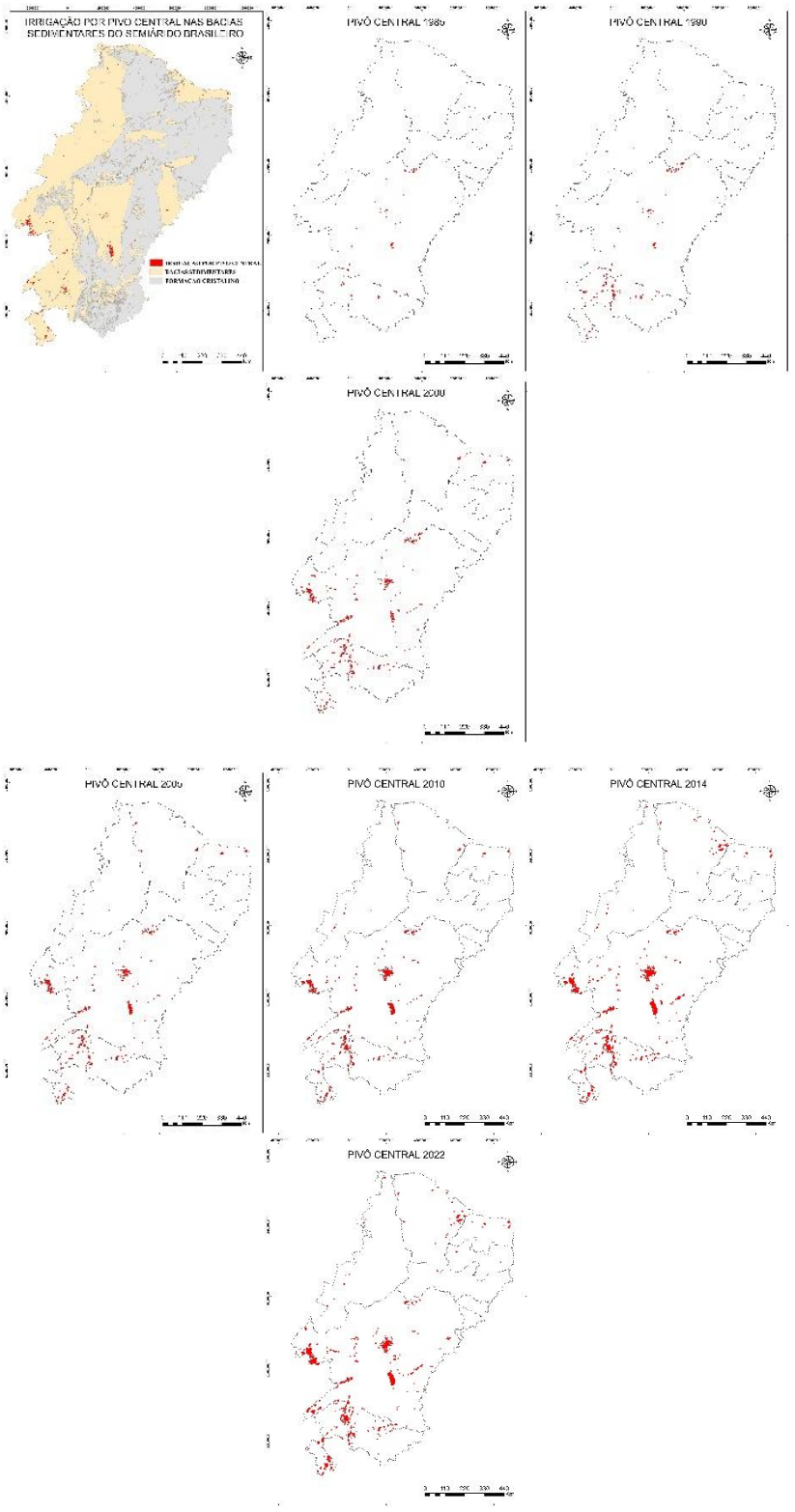


Figure 5.3.14. Location of central pivots in Sedimentary Basins and their temporal variation from 1985 to 2022.

The states that showed the greatest growth in areas irrigated with central pivots were Bahia and Minas Gerais. In Bahia, the irrigated area increased from 7,406 hectares in 1985 to 158,752 hectares in 2022. In Minas Gerais, which has part of its territory within the semi-arid limits, the irrigated area grew from 2,042 hectares in 1985 to 52,563 hectares in 2022. Data regarding the

growth of irrigated areas in other states are detailed in Table 4. All states experienced an increase in their irrigated areas except Pernambuco, which showed a reduction in 2022.

Table 5.3.4. Evolution of irrigated areas in the Semi-arid by States.

Ano	AL		BA		CE		MA		MG		PB		PE		PI		RN	
	Área (ha)	%	Área (ha)	%	Área (ha)	%	Área (ha)	%	Área (ha)	%	Área (ha)	%	Área (ha)	%	Área (ha)	%	Área (ha)	%
1985	0	0.0%	7406	2.4%	0	0.0%	0	0.0%	2042	1.7%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
1990	0	0.0%	8671	2.9%	175	1.2%	0	0.0%	12207	10.4%	0	0.0%	2227	32.4%	123	5.1%	72	1.3%
2000	0	0.0%	45757	15.1%	2449	17.5%	0	0.0%	18437	15.7%	0	0.0%	2772	40.3%	231	9.5%	1165	21.7%
2010	24	33.8%	82444	27.2%	3169	22.6%	0	0.0%	32462	27.6%	20	3.7%	1071	15.6%	449	18.5%	1497	27.8%
2022	47	66.2%	158752	52.4%	8213	58.6%	176	100.0%	52563	44.7%	527	96.3%	810	11.8%	1623	66.9%	2642	49.1%

This significant growth in Bahia and Minas Gerais reflects the strategic importance of these regions for the expansion of the country's agricultural frontier. The growing demand for food and the high values of commodities in the international market are factors driving this expansion. However, it is crucial that this expansion occurs sustainably, considering the availability and quality of water, as well as potential conflicts of use in hydrographic basins.

To ensure the sustainability of irrigation, it is necessary to implement strategies that include improving water quality through effluent treatment and pollution reduction; conserving springs and permanent preservation areas (PPAs) to maintain water flow and preserve biodiversity; using water efficiently with the adoption of precision irrigation technologies; and managing conflicts over water use through public policies that reconcile diverse interests.

Sustainable planning of agricultural expansion is essential to preserve water resources and ensure the continuity of agricultural production, meeting current demands without compromising the needs of future generations.

5.3.6. Retrospective analysis of meteorological and agricultural droughts using remote sensing in the Capibaribe catchment, Pernambuco, Brazil.

The research proposal aims to analyze the retrospective severity of drought (both spatially and temporally) in a basin located at the ecotone of Caatinga and Atlantic Forest and investigate the relationship between hydroclimatology and the predictability of meteorological, agricultural, and hydrological droughts using different components of the water balance. For this purpose, data from the Climate Hazard Group InfraRed Precipitation Satellite (CHIRPS) were used to obtain a historical precipitation series, and thus, to calculate the Standardized Precipitation Index (SPI) for the entire region. The Normalized Difference Vegetation Index (NDVI) from the MOD13Q1 product with a spatial resolution of 250 m was also employed to characterize the vegetation response to drought events. Annual trends in precipitation and NDVI across the basin were evaluated. All variables were compared at the sub-basin level, totaling 53 delineated in the SWAT model.

To identify regions potentially more vulnerable to drought events across various time scales (3, 6, and 12 months), a spatial distribution of the percentage of months experiencing droughts in different categories was constructed (Figure 9). This distribution was calculated based on the total number of months with a Standardized Precipitation Index (SPI) $\leq$ -1 (Figure 9a), considering results for moderate (-1.49 < SPI < -1), severe (-1.99 < SPI < -1.5), and extreme droughts (< -2). It should be noted that the durations of the events were not considered in this analysis. For instance, taking the SPI-3 and sub-basin 42, located at the basin's outlet, 79 months were identified with SPI equal to or less than -1, and 46, 25, and 8 months in the moderate, severe, and extreme categories, respectively. Consequently, in this case, the frequencies of months with moderate, severe, and extreme droughts were approximately 58%, 32%, and 10%, respectively.

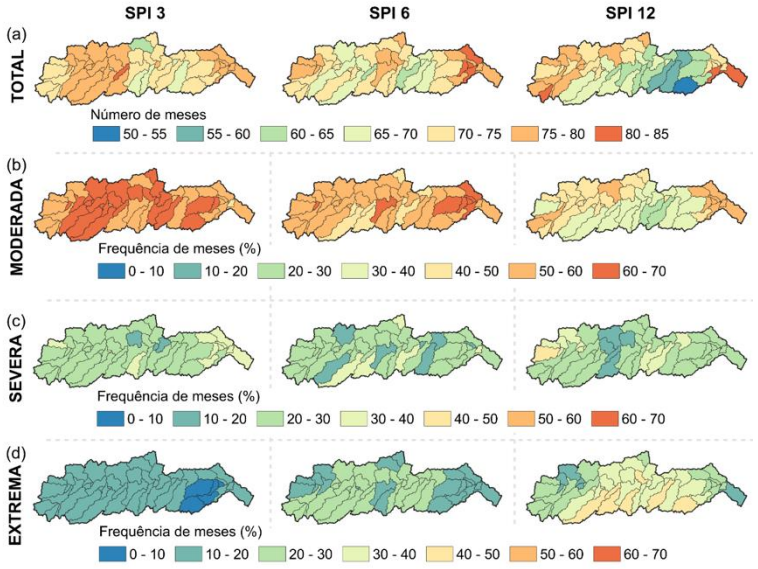


Figure 5.3.15. Spatial distribution of (a) the total number of months with SPI ≤ -1, and the frequency of months with drought in the categories (b) moderate (-1.49 < SPI < -1), (c) severe (-1.99 < SPI < -1.5), and (d) extreme (< -2) for the SPI 3, 6, and 12.

The results of precipitation and NDVI trends are displayed in Figure 10. Upon examining all data from the 53 sub-basins, a significant trend of precipitation reduction (-2.472 mm/year) is observed, indicating a general decrease in annual totals across the entire basin area over the two decades analyzed. This strong trend is associated with the prolonged recent drought period in the Northeast from 2012 to 2018 (Marengo et al., 2020). The dispersion of annual average NDVI values demonstrated heterogeneity in the distribution of the index throughout the basin during the assessed period. The entire basin exhibited an extremely significant negative trend in NDVI with a p-value of 0.000 and a slope of -0.002/year, indicating a general reduction in vegetation over the series.

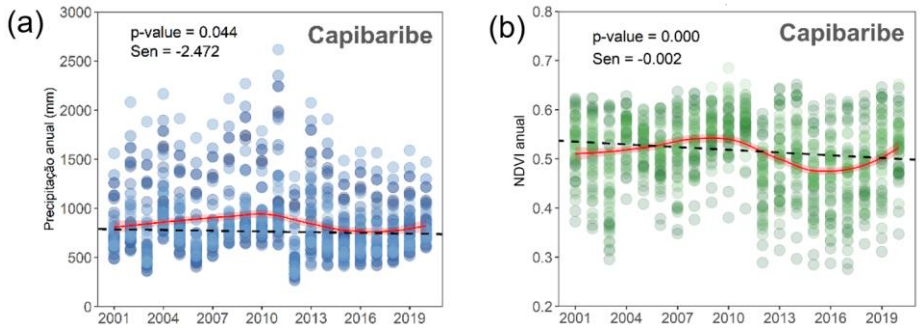


Figure 5.3.16. Trend analysis of precipitation (a) and NDVI (b) in the Capibaribe catchment for the period from 2001 to 2020.

5.3.6. Analysis of the performance of a Hydrological Model with land use input data obtained through vegetation index for the Pajeú river basin.

This study aimed to analyze land use products in the performance of surface flow simulations in the Pajeú River basin area, in the state of Pernambuco. To obtain the land use maps for the years 2002 and 2015, a remote sensing technique, the Normalized Difference Vegetation Index (NDVI), was used. For the watershed's hydrological modeling, the Soil and Water Assessment Tool (SWAT) model was used for two stages: (i) simulation without parameter adjustment and (ii) simulation with adjusted parameters. For the first stage, two simulations were carried out,

one for each land use map, and then it was analyzed which map performed better in simulating flow when compared to the observed (in situ) data set. In the second stage, the parameter adjustment procedure was performed in SWAT-CUP, using the land use map that previously performed better, and finally, the flow values were compared to the observed data set and the flow values obtained by the SUPer simulation.

The results indicated that regarding land use changes, there was an increase in the area of bare soil classes (2.83%) and herbaceous vegetation (12.96%) and a decrease in the areas of shrub vegetation (12.43%) and tree vegetation (3.12%) when comparing the maps of 2002 and 2015. The performance analysis of the model without parameter adjustment showed that the simulation with the 2002 land use input provided positive results for the five gauging stations (NS, PBIAS, and R^2). However, for the 2015 land use map, the performance was unsatisfactory, obtaining negative values for the gauging stations. The comparison between the SUPer simulation, the simulation for the 2002 land use map, and the observed (in situ) data showed that for the five gauging stations, the obtained values followed the same graphical behavior, but with varying lower statistical parameters.

The simulated sub-basin, the sub-basin 36, when analyzing the minimum flow, it is observed that both the observed flow and the adjusted flow obtained a value of 0 m^3/s, whereas for the SUPer it was 0.01 m^3/s and for the adjusted NDVI 2002 it was 0.17 m^3/s. As for the maximum flows, there is a tendency towards underestimation. For the observed series (130.13 m^3/s), both the SUPer results (98.17 m^3/s) and the adjusted results (88.23 m^3/s) show underestimation, with the adjusted value varying by 32% of the observed value and the SUPer value by 24%. Following similar results, sub-basin 41 (Figure 2), shows statistics obtained after adjusting the flow data, indicating a minimum flow of 0 m^3/s for all groups. The maximum flows were underestimated compared to the observed series (210.70 m^3/s), with values of 99.79 m^3/s for SUPer and 93.73 m^3/s for the adjusted data, representing 52% and 55% of the observed value, respectively. The observed average was 8.70 m^3/s, while the SUPer and adjusted NDVI 2002 simulations were overestimated at 9.97 m^3/s and 11.43 m^3/s, respectively.

H. Efficiency of global precipitation datasets in tropical and subtropical catchments revealed by large sampling hydrological modelling.

Satellite-based and reanalysis precipitation products are widely adopted as complementary information to in situ measurements for estimating river discharge using hydrological modelling. However, there is still a notable research gap in the literature associated with assessing the accuracy of satellite-based or reanalysis products in different tropical and sub-tropical catchments at large-sampling hydrological modelling with sensitivity analysis. This research investigated the accuracy of precipitation, hydrological model performance and parameter sensitivity related to seven precipitation data sets based on satellite and reanalysis products, i.e., CHIRPS, TRMM, GLDAS, IMERG, MERRA-2, PERSIANN-CDR, and ERA5 over 714 contrasting tropical and subtropical catchments located in Brazil (Figure 11). We used the Génie Rural Journalier 4 (GR4J) hydrological model to simulate the hydrological processes of the different catchments with two approaches for the calibration: using measured ground-based precipitation data (approach I) or using each individual satellite/reanalysis precipitation products (approach II) to calibrate the models.

The results showed that the precipitation products tend to overestimate precipitation, except for ERA5 and MERRA-2. CHIRPS is the only product that produces unbiased precipitation estimates for most catchments. The model calibration using each precipitation product individually improved the hydrological model performance. CHIRPS, IMERG, and MERRA-2 showed good accuracy in terms of both, precipitation estimation and hydrological simulation performance in the calibration period. In the validation period, the best products in terms of

KGE were CHIRPS, IMERG and TRMM (KGE > 0.64). The errors in precipitation products are better compensated via hydrological modelling in wet regions. The model parameter sensitivity varies according to precipitation input, climate, and catchment aridity. Overall, all seven products exhibited their worst hydrological performance in arid regions.

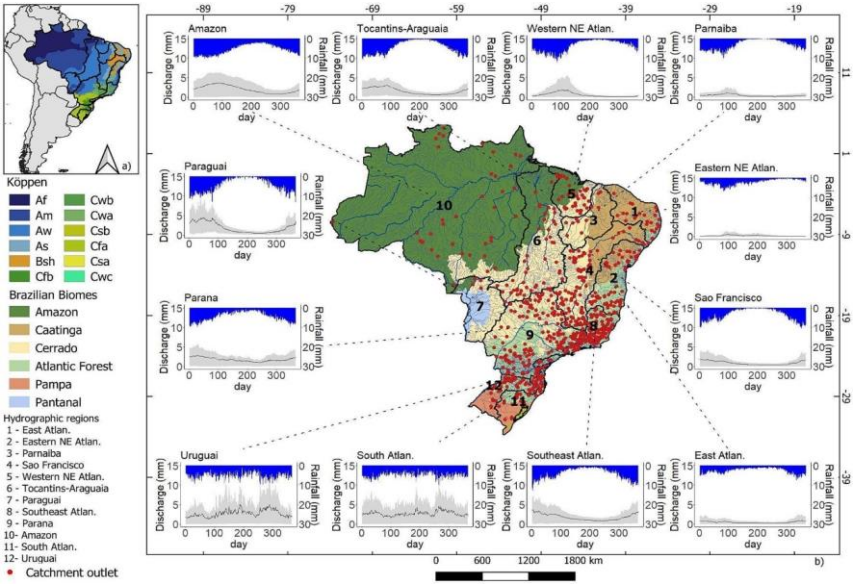


Figure 5.3.17. (a) Location and characteristics of the study region and (b) Location map containing the 714 catchments (outlets shown by red dots) in which the precipitation products were assessed. Note that the boundaries of each catchment are not shown (only the catchment outlet) due to the large number of catchments. For each hydrographic region, the long-term average precipitation of the area and the average flow of all catchments within it are represented in the sub-frames. The shaded (grey) areas represent the daily flow range for the hydrographic regions.

This study helps to improve our understanding of the catchment response in tropical and subtropical regions while also providing key insights into the reliability of satellite/reanalysis rainfall products for streamflow simulation. This study is valuable in hydrometeorological applications, climate change assessment, water resources and disaster management, especially in regions with a relatively sparse density of precipitation stations.

5.4 Human health and climate change

5.4.1 Introduction

Human health is deeply affected by the physical and social environment, and atmospheric processes play a crucial role in this context. Biometeorology, along with disciplines such as physics, biology, and medicine, has been investigating the effects of the atmosphere on health for decades (Fdez-Arroyabe, 2015). Although solar geomagnetic activity may initially seem less relevant, it shows significant correlations between human health and the environment (Palmer et al., 2006). To support scientific models, robust observational data, such as those provided by DATASUS, are essential.

This project aims to investigate mortality rates from specific diseases in the Northeast and South regions of Brazil, selected due to the different intensities of geomagnetic effects in these areas (Palmer et al., 2006). The study covers mortality from cardiovascular, neurodegenerative,

infectious, and autoimmune diseases, using data from 1996 to 2022 to identify long-term patterns and trends, providing insights for public health actions (Bigazzi et al., 2020).

The Schumann Resonance, which oscillates at extremely low frequencies, around 7.83 Hz (INTERMAGNET1, 2023; SuperMAG, 2023; Embrace MagNet, 2023), will be considered to analyze its impact on health. The methodology included the analysis of mortality data and Schumann Resonance measurements, applying bivariate statistics to identify correlations. Upon identifying significant correlations, the study will seek to understand the effects of geomagnetic activity on health, aligning with the research of the National Institute of Science and Technology for Climate Change (INCT-MC) and integrating interdisciplinary knowledge in epidemiology, geophysics, and statistics.

Methodology

Study Area

The analysis covers two distinct regions of Brazil: the Northeast and the South. The Northeast, composed of the states of Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, and Bahia, features a varied climate that ranges from humid tropical in the coastal areas to semi-arid in the Sertão. This climatic diversity contributes to epidemiological challenges related to chronic and acute diseases, which are exacerbated by socioeconomic disparities, healthcare infrastructure, and the influence of the physical environment.

On the other hand, the Southern region, including Paraná, Santa Catarina, and Rio Grande do Sul, is characterized by a climate that ranges from subtropical to temperate, with four well-defined seasons and climatic variations influenced by latitude and regional mountain ranges. These characteristics impact rainfall distribution and temperature, which are reflected in the public health and epidemiological patterns of each region.

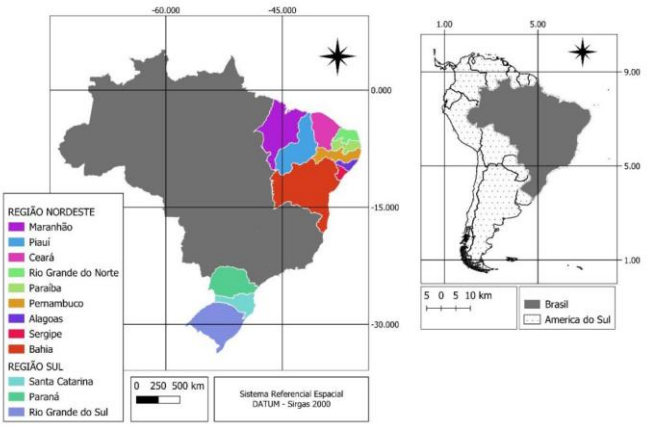


Figure 5.4.1: Data collection sites for mortality rates in the Northeast and South regions of Brazil. Source: Author

The methodology for this project involved analyzing the interaction between the Schumann Resonance and mortality rates from specific diseases in the Northeast and South regions of Brazil, using data from 1996 to 2022. The study was conducted in three main stages: data collection and preparation, statistical analysis, and interpretation of the results.

Data Collection and Preparation:

Mortality Data: These were obtained from the Department of Information of the Unified Health System (DATASUS), covering categories of cardiovascular, neurodegenerative, infectious, and autoimmune diseases. The data were grouped by year and region for analysis.

Schumann Resonance Data: These included historical measurements of the Earth's electromagnetic field, focusing on extremely low frequencies (ELF) around 7.83 Hz. This data was extracted from geophysical databases such as INTERMAGNET, SuperMAG, and Embrace MagNet.

Figure 5.4.1 shows the locations of the magnetic stations selected for the research, where data from 1996 to 2022 can be found on the website: https://intermagnet.org/. It is an international platform that promotes collaboration among institutions operating geomagnetic observatories and stations. They provide data and information about the Earth's magnetic field, serving as an important tool for our study of extremely low frequency (ELF) and its effects on the terrestrial environment, including its influence on atmospheric and climatic phenomena..

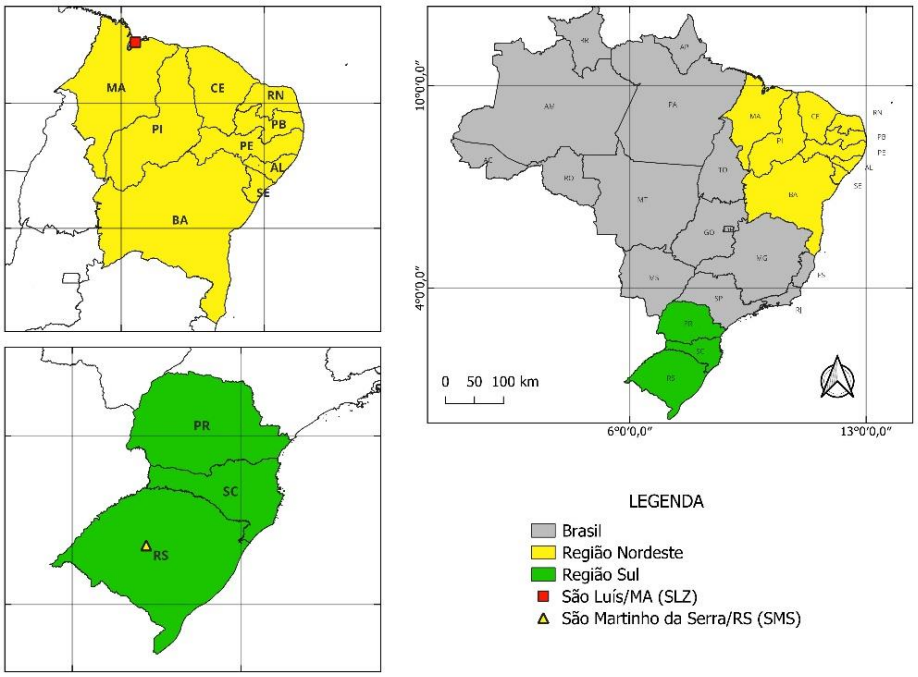


Figure 5.4.2: Shows the locations of the stations: São Luiz/MA - SLZ (red square); São Martinho da Serra/RS - SMS (yellow triangle). Source: Author

Statistical Analysis:

Statistical Methods: Bivariate statistics were used to analyze the relationship between Schumann Resonance and mortality rates. Correlation coefficients, least squares adjustments, and autocorrelation functions were applied to identify significant correlations

Data Modeling: The Schumann Resonance model was applied to assess the influence of variations in the electromagnetic field on mortality. The analysis included Fourier filters to decompose complex signals and calculate the dip latitude $\left(\theta_{dip} = arctan\left(\frac{1}{2}\, tan\, I\right)\right)$.

Interpretation of Results:

Correlation and Causality: We identified whether there was a significant correlation between variations in Schumann Resonance and mortality rates for certain diseases. We assessed whether these correlations could suggest cause-and-effect relationships.

Impact and Applications: Based on the correlations found, we assessed the need for further investigations into the effects of geomagnetic activity on health.

The approach is interdisciplinary, involving epidemiology, geophysics, and statistics, and aligns with the research of the National Institute of Science and Technology for Climate Change (INCT-MC-Phase 3). The methodology aims to provide a comprehensive understanding of the potential impacts of Schumann Resonance and other geomagnetic parameters on public health.

Development of the Script for Magnetic Field Analysis

A script was developed to access and process data from the Intermagnet website with the aim of analyzing the Earth's magnetic field behavior and identifying Schumann Resonance frequencies. The **script** uses data from magnetometer networks to examine fluctuations in the magnetic field, influenced by atmospheric and electrical phenomena, and to calculate the characteristic frequencies of Schumann Resonance, which are relevant for studies on atmospheric electricity and climatic phenomena.

The development of this **script** required a significant amount of time, involving the design, coding, and testing of functions to ensure accuracy and efficiency. The creation of the code, from defining functions to debugging and error correction, involved a detailed process that took several weeks to complete. This time is essential to ensure that the **script** can handle the complexity of the data and provide reliable results for the analysis of Schumann Resonance frequencies.

The presented code is of utmost importance for transforming and analyzing temporal data of the magnetic field, providing a foundation for identifying and understanding Schumann Resonance frequencies.

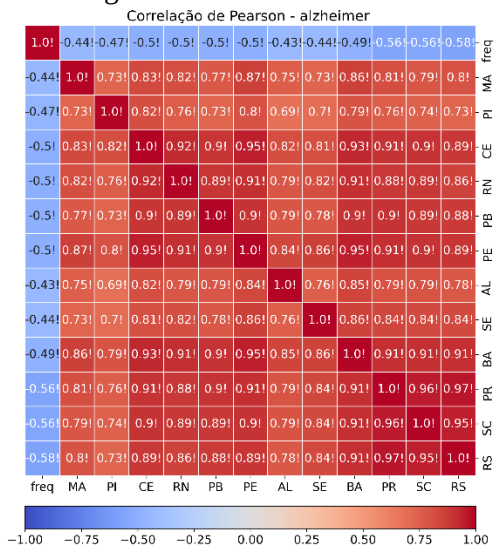
```python
def load_qd_data(station, path):
    #
    L_27 = ['CZT','DRV','PAF']
    L_26 = ['NGK','DRV','MAW','CNB','HAD','TSU','HON','KAK','BOU','KOU','HBK','BMT','TDC']
    L_24 = ['HUA']
    #
    skiprows = 17
    if station.upper() in L_27:
        skiprows = 27
    if station.upper() in L_26:
        skiprows = 26
    if station.upper() in L_24:
        skiprows = 24

    files_station = glob(path + '/*')
    files_station.sort()

    df_station = pd.concat( (pd.read_csv(file, sep='\s+',usecols = [0,1,3,4,5,6],
                    header = None,skiprows = skiprows,
                    parse_dates = {'Date': ['date', 'Time']},
                    names = ['date','Time','X','Y','Z','F']) for file in files_station),
                    ignore_index = True)
    df_station['Date'] = pd.to_datetime(df_station['Date'], format = '%Y-%m-%dd %H:%M:%S.%f')
    #df_station['Hour'] = pd.to_datetime(df_station['Hour'], format = '%H:%M:%S.%f').dt.time
    df_station.set_index('Date', inplace = True)


    df_station.loc[df_station['X'] == 99999.0, 'X'] = np.nan
    df_station.loc[df_station['Y'] == 99999.0, 'Y'] = np.nan
    df_station.loc[df_station['Z'] == 99999.0, 'Z'] = np.nan
    df_station.loc[df_station['F'] >= 88888.0, 'F'] = np.nan

    return df_station
```

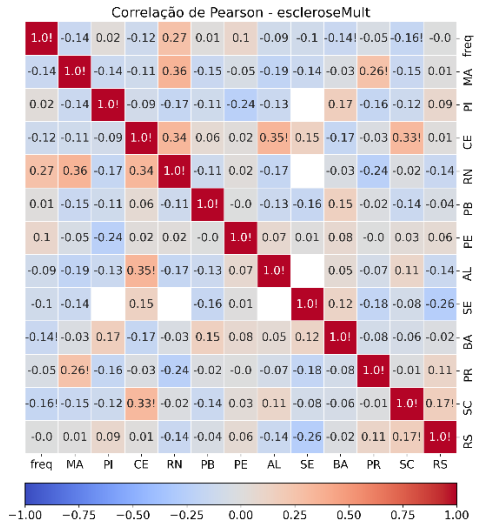
Figure 5.4.3: A snippet of the script developed for magnetic field analysis. Source: Author

Partial Results:

Pearson correlation coefficients were calculated to evaluate the relationship between the monthly averages from 1996 to 2022 of Schumann Resonance frequency and the rates obtained for each disease (Figures 4 and 5) in each state of the Northeast and South regions, showing the significance indices, with (!!) p-value < 0.01 and (!) p-value < 0.05.

The results suggest that there are statistically significant associations between variations in Schumann Resonance frequency and the incidence of certain diseases, indicating a possible influence of geomagnetic factors on human health. These correlations may not only contribute to a better understanding of the underlying mechanisms involved in disease occurrence but also open possibilities for future research, considering the importance of environmental factors in the epidemiological context.





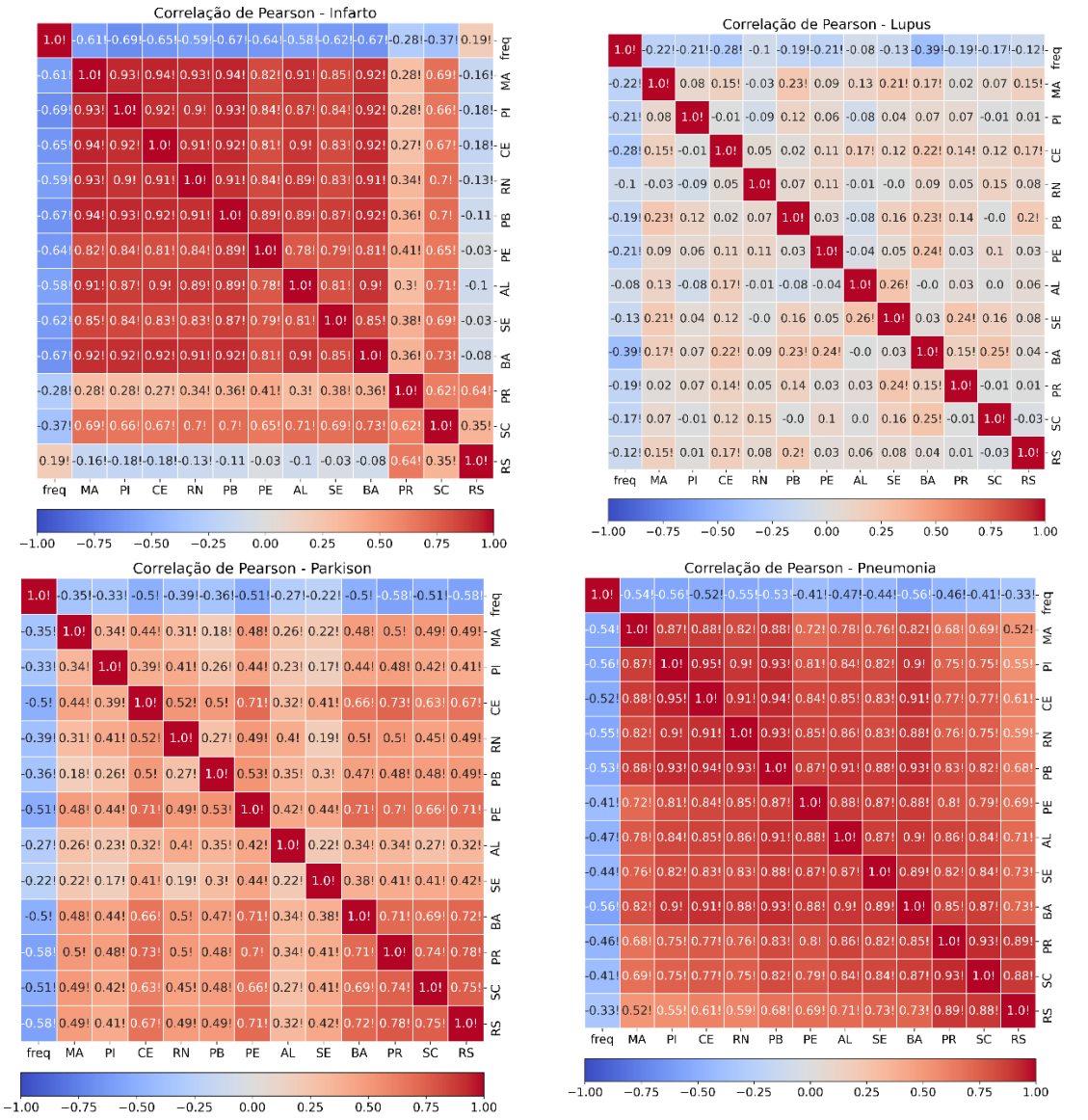


Figure 5.4.4: Pearson correlation coefficients were calculated to assess the relationship between the monthly averages from 1996 to 2022 of Schumann Resonance frequency and mortality rates for each disease and state in the Northeast and South regions, with significance indices using (!!) p-value < 0.01 and (!) p-value < 0.05. Source: Author.

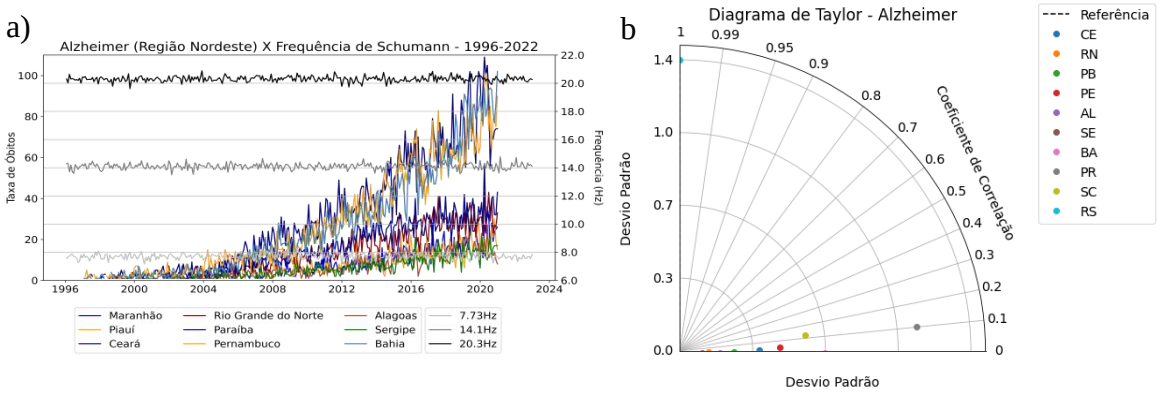


Figure 5.4.5: a) Shows the peak frequencies of 7.73, 14.1, and 20.3 Hz identified from the data we collected on the Earth's magnetic field; b) Shows an analysis performed using the Taylor

Diagram for the rate obtained for Alzheimer's (this is still a preliminary result). Source: Author

Preliminary Conclusions:

This study, covering data from 1996 to 2020 and corresponding to Solar Cycles 23 and 24, reveals important results about the relationship between geomagnetic activity and mortality rates in different regions of Brazil.

The analysis of geomagnetic activity data and mortality rates associated with specific diseases, using monthly, annual, and seasonal averages, showed that regional variation in geomagnetic activity plays a crucial role. The choice of the South and Northeast regions of Brazil was based on the significant variation observed between these areas. The South region, with its distinct climatic and geographical characteristics, demonstrated a more pronounced influence compared to the Northeast.

The results indicate that extreme values of geomagnetic activity, both high and low, have more pronounced adverse effects on health, especially among more vulnerable population subgroups. The correlation observed between Schumann frequencies and mortality rates for Acute Myocardial Infarction and Pneumonia was particularly significant in the South region. These findings suggest that geomagnetic activity may have a relevant impact on public health, influencing mortality rates related to these conditions.

Additionally, fluctuations in geomagnetic activity appear to be associated with variations in environmental conditions that affect health, such as environmental stress and changes in atmospheric pressure.

These results reinforce the importance of considering geomagnetic activity as a relevant factor in the analysis of epidemiological patterns and public health. The study provides a solid foundation for future investigations into the impacts of geomagnetic activity and its interactions with environmental and health conditions.

5.4.2 Projections of diseases- FIOCRUZ-RJ

This work is being carried out with the aim of making projection models related to the distribution of the vectors of the etiological agents that transmit leishmaniasis, as well as predicting future scenarios of the disease in the face of climate change. It is important to note that leishmaniasis is one of the most important diseases in public health, especially in the eco-epidemiological regions of the world, in the Americas, North and East Africa and West and Southeast Asia, with four main forms: visceral leishmaniasis, the most serious and almost always fatal if left untreated; post-kalazar dermal leishmaniasis; mucocutaneous leishmaniasis; and cutaneous leishmaniasis, the most common form. In 2020, Brazil was among seven countries responsible for reporting more than 80% of new cases of cutaneous leishmaniasis in the world to the World Health Organization (WHO) and with regard to visceral leishmaniasis, among the six countries, Brazil accounted for 79% of all new cases for this severe form of the disease.

a. Activities developed

Factors such as environmental changes caused by climate or deforestation can contribute to the spread of leishmaniasis, as they influence different epidemiological scenarios due to the close relationship between vectors, etiological agents and reservoir animals involved in the disease transmission cycle. In this way, the generation of knowledge through mathematical modeling and geoprocessing can contribute, as a tool, to understanding the spatialization of the disease and improving public surveillance and control policies. Climate change has also contributed to an increase in the number of people in situations of vulnerability and social inequality, factors

which can contribute to the incidence of the disease. Thus, in the first year of this study, projections were made for climate change scenarios in Brazil in relation to the distribution of important vectors of American Tegumentary Leishmaniasis (ATL), in its cutaneous and mucocutaneous forms, namely *Bichromomyia flaviscutellata*, *Nyssomyia whitmani*, *Nyssomyia intermedia* and *Nyssomyia neivai*. In the second year, the study was expanded to include other vectors of the disease, *Psychodopygus wellcomei*, *Psychodopygus complex*, *Nyssomyia umbratilis* and *Migonemyia migonei*, as well as the vectors of American Visceral Leishmaniasis (AVL), *Lutzomyia longipalpis* and *Lutzomyia cruzi*. The following year, scenario analyses for climate adaptation were carried out, studying these vectors individually, also associating them with cases of ATL and AVL. In the fourth year, there was an update from the Intergovernmental Panel on Climate Change (IPCC), bringing new scenarios, where the database for modeling the vectors was updated, making it possible to project the vector distribution in association with variables of socioeconomic conditions and the incidence of leishmaniasis, to calculate vulnerability indices for Brazilian municipalities, which are extremely important results for the National Leishmaniasis Control Program and the country's State and Municipal Health Departments, helping to plan surveillance and control actions. In the fifth year, the analysis of the municipal vulnerability of the state of Rio de Janeiro to transmission of AVL, both human and canine, was carried out, as well as the analysis of the spatial distribution of *Ny. whitmani* in the country, associated with land cover and use, observing the density of the vector in Dense Ombrophilous Forests, Seasonal Deciduous Forests, Seasonal Semideciduous Forests, Cerrado and Steppe, as well as carrying out a review and a forecast model showing how the distribution of Covid-19, a disease that caused a pandemic from March 2020 to May 2023, may be affected by climatic conditions in the country.

In year 6, the geographical distribution of the *Ny. whitmani* species, the most important vector in Brazil for ATL, was correlated with the populations vulnerable to the disease in projection to the scenarios of environmental changes caused by land use, finally, the municipal vulnerability for the state of Rio de Janeiro, previously carried out only for *Lu. longipalpis* was extended to *Mg. migonei*, since the species was also included as a vector of AVL, the vector distribution database of these two species in the Southeast Region of the country was updated, in addition to the creation of thematic maps of the spatial distribution of the species for the state of Minas Gerais, risk stratification, municipal vulnerability and land use and cover in relation to these vectors. This past year, the study was expanded to the other Southeastern states of São Paulo, Espírito Santo and Rio de Janeiro, with the production of maps related to land use and land cover; the distribution of the vectors, the disease and municipal vulnerability in the states of São Paulo and Espírito Santo, with emphasis on the state of Minas Gerais, which is responsible for around 70% of the cases of the disease notified in the Southeastern Region of Brazil. It is believed that the incorporation of these new results can collaborate with public authorities, providing relevant information that can be used to make decisions related to leishmaniasis surveillance, prevention and control measures.

a.1. Spatial Distribution of Vectors of AVL and their Environmental Suitability in the State of Minas Gerais, Brazil

In Brazil, of the states that make up the Southeast Region, Minas Gerais has the highest number of notifications of American Visceral Leishmaniasis (AVL), with more than 60% of cases in the last 20 years, and the highest incidence rates, as well as a number of deaths that exceeds that of the state of Maranhão, in the Northeast, the state with the highest record of cases in the country.

According to the Köppen-Geiger classification, the state of Minas Gerais has a Tropical Monsoon (Am), Tropical Savannah (Aw/As), Humid Subtropical (Cfa), Oceanic Subtropical (Cfb), Dry Winter Subtropical (Cwa) and Altitude Subtropical (Cwb) climate. Average temperatures vary between 22°C and 24°C in the areas close to Espírito Santo, in the central areas of the state the temperature varies between 19°C and 21°C and in the mountainous areas it varies between 14°C and 18°C, influenced by latitude, often with negative temperatures during the coldest mornings. The state is made up of three biomes: the Cerrado, occupying 57% of the

total area; the Atlantic Forest, with around 41% and the Caatinga, with 2%. Average rainfall varies between 650 and 2,100 mm, with peak rainfall in January and the end of the rainy season between March and May.

The state is made up of 853 municipalities and the spatial distribution of AVL vectors was recorded in only 96 municipalities, where in 32 only *Lu. longipalpis* was found, in 35 *Mg. migonei* and in 29 both species, in the mesoregion of Vale do Mucuri (Figure 1) the presence of both vectors was not recorded (Figure 2). However, with regard to AML, more than twice as many municipalities reported autochthonous cases between 2018 and 2022, with 193 municipalities reporting cases, occurring in all mesoregions. Of these, 142 municipalities had cases but no record of the vectors (or no entomological survey). Significant cases were recorded in all years in the municipalities of Belo Horizonte and Monte Claros, and in the municipality of Sete Lagoas in the last four years (Figure 3).

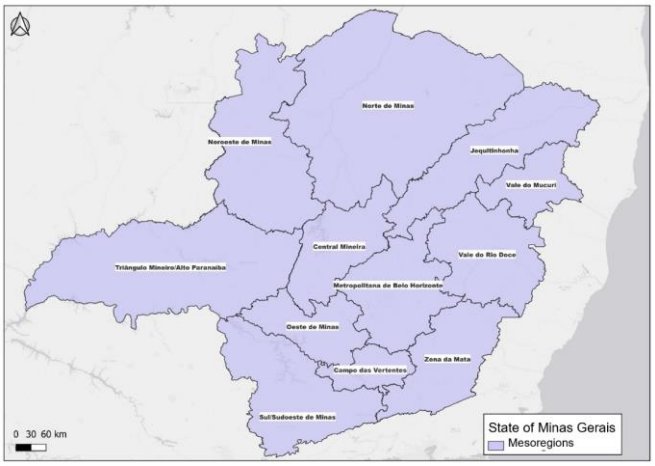


Figure 5.4.5 - Map of the mesoregions of the state of Minas Gerais, Brazil.

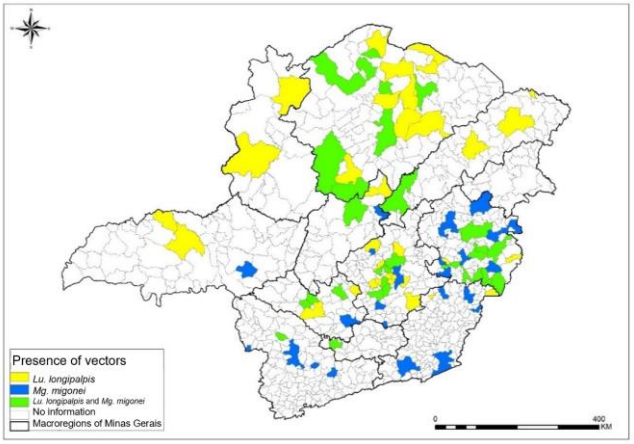


Figure 5.4.6. Spatial distribution of the vectors *Lutzomyia longipalpis* and *Migonemyia migonei* in the state of Minas Gerais, Brazil.

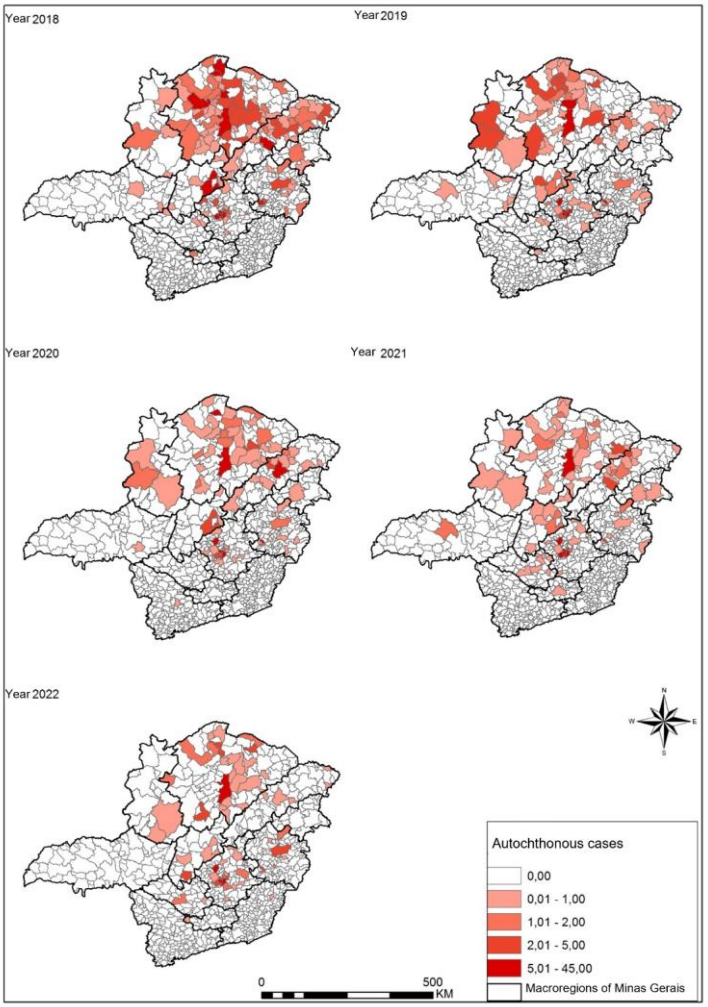


Figure 5.4.7 Spatial distribution of American Visceral Leishmaniasis cases in the state of Minas Gerais, Brazil, from 2018 to 2022.

Predictive modeling of the *Lu. longipalpis* and *Mg. migonei* species was carried out using climatic and environmental variables: mean annual temperature, mean diurnal interval (monthly mean (maximum temperature - minimum temperature)), isotherm, temperature seasonality, precipitation of the driest month, precipitation seasonality, precipitation of the warmest quarter and precipitation of Coldest Quarter, at different resolutions, where two models were made, one using this set of eight bioclimatic variables with low multicollinearity and the other using four environmental variables, altitude, percentage of tree cover, land use and cover and vegetation, in addition to the result of the first model.

The first model, carried out for the extension of South America, showed an AUC-ROC metric for *Lu. longipalpis* of 0.85 and *Mg. migonei* of 0.88, which is equivalent to a high degree of adequacy and therefore both showed good predictive power (Figure 4).

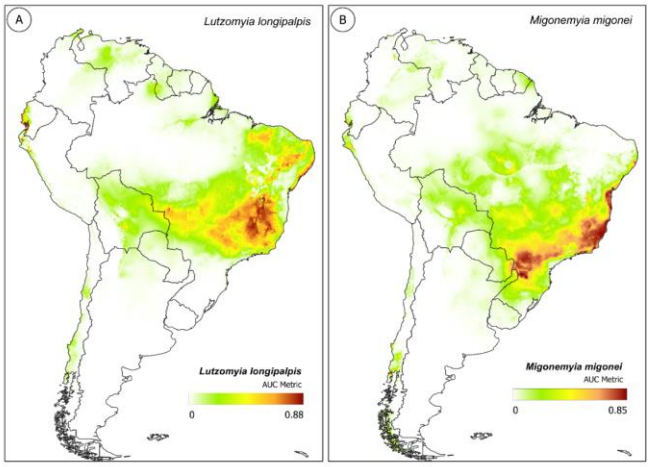


Figure 5.4.8 - Model 1 - Map of South America for the AUC-ROC metric for the *Lutzomyia longipalpis* and *Migonemyia migonei* species.

This result was used as a variable for the second model and the AUC-ROC value for the species *Lu. longipalpis* and *Mg. migonei* was 0.94, demonstrating reliable predictive power for both. The areas with the greatest environmental suitability for *Lu. Longipalpis* are concentrated in the north-central region of Minas Gerais, while the most suitable areas for *Mg. migonei* are concentrated in the southeast of the state (Figure 5.4.8).

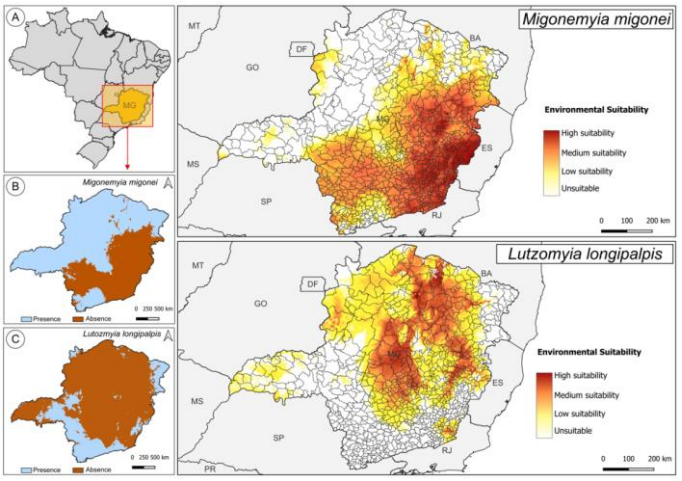


Figure 5.4.9 - Map of Brazil, highlighting the state of Minas Gerais (A); maps of the state with the presence and absence of *Migonemyia migonei* (B) and *Lutzomyia longipalpis* (C) and the environmental suitability of both species.

Still in Figure 5.4.8, of the municipalities that make up the state, 574 (67.29%) showed high and medium suitability for the occurrence of *Lu. longipalpis*, while 468 municipalities (54.87%) showed high and medium suitability for the presence of *Mg. migonei*. In 383 (44.90%) municipalities there was high or medium suitability for both species. Considering only the municipalities in Minas Gerais with high environmental suitability for both species, it was possible to observe 120 (14.07%) municipalities with high suitability for *Lu. longipalpis* and 71 (0.82%) for *Mg. migonei*, observing a high susceptibility for the southeast region of the Rio Doce Valley and northeast of the Zona da Mata for *Mg. migonei* and northeast of Norte de Minas, east of Central Mineira and central-north of Metropolitana de Belo Horizonte for *Lu. longipalpis*. The municipalities of Belo Horizonte and Monte Claros showed low suitability for *Mg. migonei* and medium suitability for *Lu. longipalpis*, while Sete Lagoas also showed low suitability for *Mg. migonei*, but the opposite was true, with *Lu. longipalpis* showing high environmental suitability.

Land use and land cover, together with climate suitability, contributed the highest percentage to the environmental suitability of both species, *Mg. migonei* (80.4% and 15.3%, respectively) and *Lu. longipalpis* with 77.1% and 17.4% (Table 1).

Table 5.4.1. Influence of the five environmental variables on the final model of *Migonemyia migonei* and *Lutzomyia longipalpis*, in the state of Minas Gerais, Brazil.

Variable	Percentage of contribution *Migonemyia migonei*	Percentage of contribution *Lutzomyia longipalpis*
Land use and cover	80.4	77.1
Climate suitability (model 1)	15.3	17.4
Vegetation	1.9	2.8
Altitude	1.8	2.0
Percentage of tree cover	0.6	0.7

When analyzed individually using the Jackknife test, which evaluates the conditions of the variables individually, excluding one variable at a time and keeping the others during the prediction analysis, land use and cover and climate suitability were the variables that contributed most to the AUC-ROC values of *Mg. migonei* and *Lu. longipalpis* (AUC-ROC > 0.8). On the other hand, the vegetation variables, altitude and percentage of tree cover had little influence on the models for both species (Figure 6).

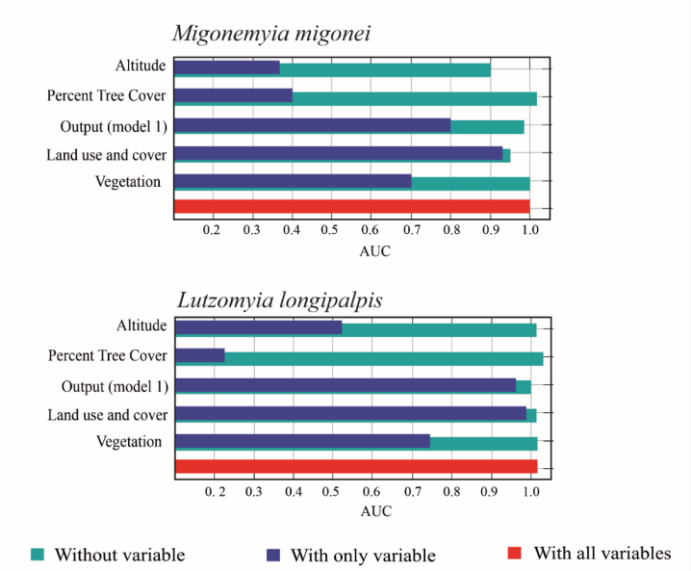


Figure 5.4.10 - Jackknife test for the predicted environmental suitability of *Migonemyia migonei* and *Lutzomyia longipalpis* in the state of Minas Gerais. Without variable, model performance without the variable analyzed; with variable only, performance when the variable is analyzed in isolation; with all variables, performance when all variables are analyzed simultaneously.

These results indicate a heterogeneous distribution of *Lu. longipalpis* and *Mg. migonei* vectors in the state of Minas Gerais, with predominance in different regions. Although there is high and medium suitability for the occurrence of these vectors in a significant number of municipalities, many have only one or none of the species recorded. At the same time, the incidence of AVL is more widespread, with a substantially higher number of municipalities reporting autochthonous cases in the years of this study, covering all mesoregions of the state. And the prediction models showed good discriminatory power, indicating a reliable ability to predict environmental suitability for *Lu. longipalpis* and *Mg. migonei*, with the first species showing greater environmental suitability in the north-central region of Minas Gerais and the second species in the southeastern region of the state. It is important to note that land use and land cover, together with climate suitability, emerged as the main factors influencing the distribution of these

vectors, standing out for their significant contribution to the prediction models. Thus, the analysis reveals a complex interaction between environmental and epidemiological factors in the distribution of vectors and the incidence of AVL in Minas Gerais, reinforcing the need for integrated surveillance, prevention and control strategies to tackle this important public health issue in the state.

a.2. Spatial Distribution of AVL, its Vectors, Land Use and Cover and Vulnerability of Municipalities in the States of São Paulo, Espírito Santo and Rio de Janeiro, Brazil

In the last fifty years, South America has experienced rapid warming and this trend is expected to continue and increase until the end of the 21st century, where studies have observed a reduction in the number of rainfall events in the states of Rio de Janeiro and Espírito Santo, which may be related to warming and consequent changes in water vapor saturation along the northern margin of the South Atlantic Convergence Zone. However, other factors that cause environmental changes, such as the effect of rapid urbanization and land use and change, can play a significant role in the trends observed in precipitation. On the other hand, there has also been an increase in dry seasons and increasingly high temperatures, which can have the effect of increasing rainfall over shorter periods of time, which can lead to an increase in emerging diseases. According to the Ministry of the Environment, the Atlantic Forest biome, a tropical forest that covers the southeast of Brazil, is the Brazilian ecosystem that has suffered the most from anthropogenic alterations and currently has less than 15% of its original coverage.

The Southeast Region of Brazil is made up of the states of Minas Gerais, Espírito Santo, Rio de Janeiro and São Paulo, and is the most populous region in the country, as well as the largest generator of wealth, having been the main center of economic activity since the 18th century. It concentrates around 44% of Brazil's population and 49.5% of the country's Gross Domestic Product (GDP), but this population and economic growth has been accompanied by serious environmental problems which can be seen in the poor quality and scarcity of water, the population's health problems and the recurring natural disasters in the region. One of the health-related problems is the increase in the number of cases of AVL, where a trend line with a slight increase has been observed since 2000 and despite the decrease in recent years, there has been an increase in new areas. According to data from the Notifiable Diseases Information System (SINAN), between 2000 and 2022, 72,292 cases were reported in Brazil, with the Southeast accounting for around 16% of cases, the state with the highest number being Minas Gerais with 70.8%, followed by São Paulo with 27.6% and Rio de Janeiro and Espírito Santo with just 0.8% each. However, it is worth noting an increase in cases in the states of São Paulo, Espírito Santo and Rio de Janeiro, where the latter was quite significant.

We therefore need to think about alternative proposals for short- and medium-term planning, looking at future scenarios, identifying areas vulnerable to the occurrence of these diseases, working with surveillance as a health-promoting tool. In view of this, this study analyzed the spatial distribution of AVL vectors, *Lu. longipalpis* and *Mg. migonei*, in the states of São Paulo, Espírito Santo and Rio de Janeiro, as well as the distribution of the disease, land use and land cover and the municipal vulnerability of the states.

The state of São Paulo has 645 municipalities. The vectors of visceral leishmaniasis were found in only 172 municipalities, where in 24 only the presence of *Lu. longipalpis* was recorded and in 125 *Mg. migonei*, the meeting of the two was recorded in 23 municipalities (Figure 1). Between 2018 and 2022, there were 412 cases of the disease in 93 municipalities, more than 50% of which were reported in municipalities in the northeast of São Paulo, such as Bauru, Araçatuba, Presidente Epitácio, Tupã, Marília, Pereira Barreto, Fernandópolis, Penápolis, Presidente Prudente and Andradina (Figure 2). In relation to land use and cover (Figure 3), Mg. migonei is present in the largest artificial area in the São Paulo Metropolitan region, and Lu. longipalpis in the most peripheral part of the region. In the analysis of municipal vulnerability, it stands out that the silent and non-receptive municipalities (with no record of vectors) were vulnerable, with no non-vulnerable municipality recorded in the state (Figure 4).

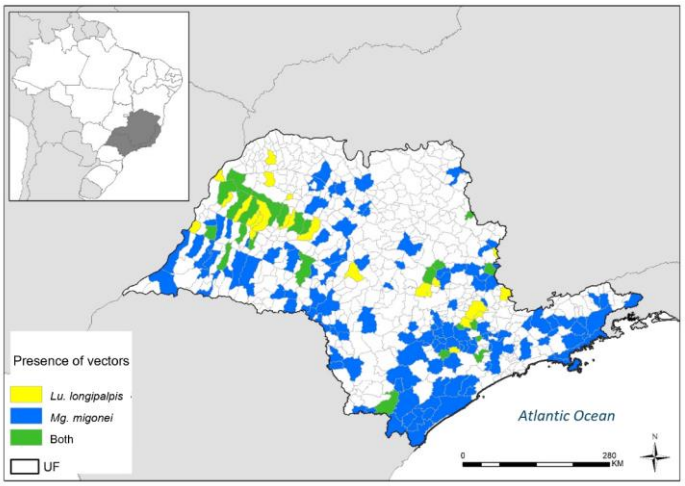


Figure 5.4.11. Spatial distribution of the vectors *Lutzomyia longipalpis* and *Migonemyia migonei* in the state of São Paulo, Brazil.

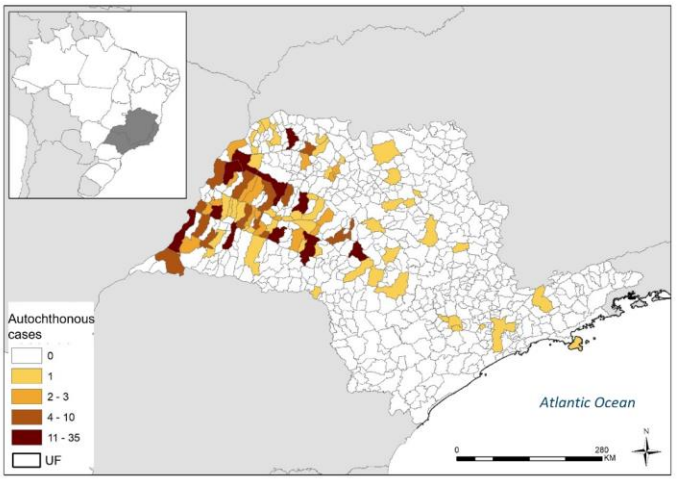


Figure 5.4.12. Spatial distribution of American Visceral Leishmaniasis cases in the state of São Paulo, Brazil, from 2018 to 2022.

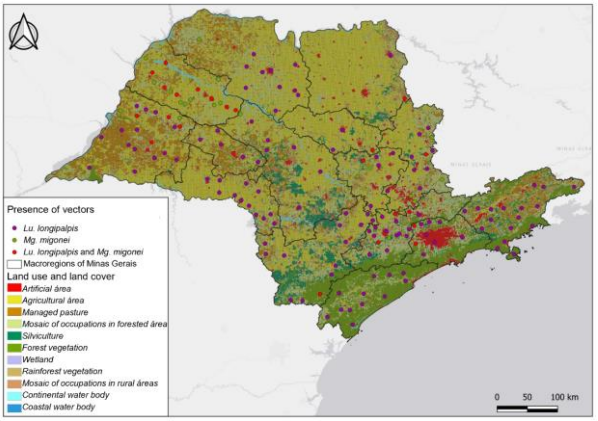


Figure 5.4.13 - Map of the distribution of the vectors *Lutzomyia longipalpis* and *Migonemyia migonei* associated with land use and land cover in the state of São Paulo, Brazil.

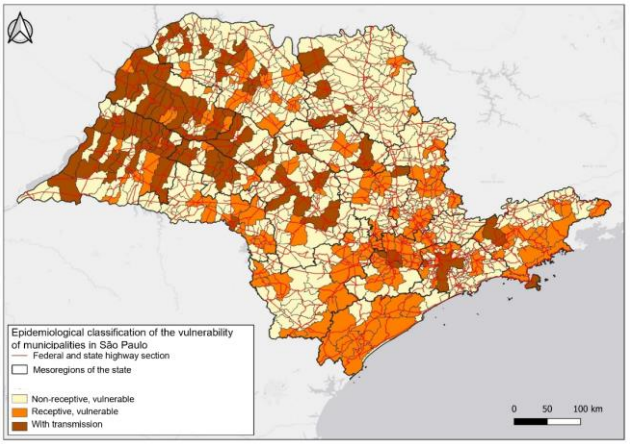


Figure 5.4.14- Map of municipal vulnerability to visceral leishmaniasis in the state of São Paulo, Brazil.

In Espírito Santo, only two of the 78 municipalities recorded the presence of *Lu. longipalpis* and 18 of *Mg. migonei*, while both species were recorded in 11 municipalities (Figure 5). The state had only 12 reported cases between 2018 and 2022, 10 in the municipality of Baixo Guandu and two in Colatina (Figure 6). Regarding land use and cover, there was no association between the species and urban agglomerations, located on the Espírito Santo North Coast (Figure 7). In the analysis of municipal vulnerability, 58% of the municipalities were classified as non-receptive, vulnerable (Figure 8).

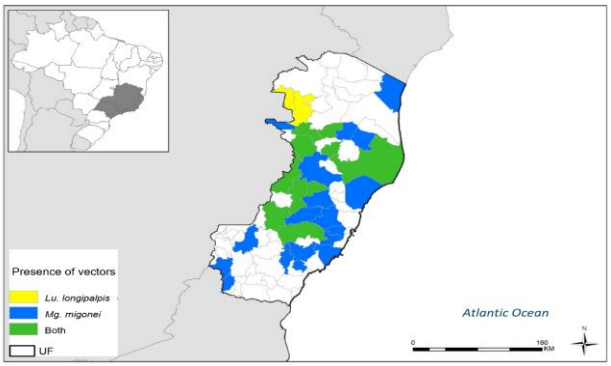


Figure 5.4.15 - Spatial distribution of the vectors *Lutzomyia longipalpis* and *Migonemyia migonei* in the state of Espírito Santo, Brazil.

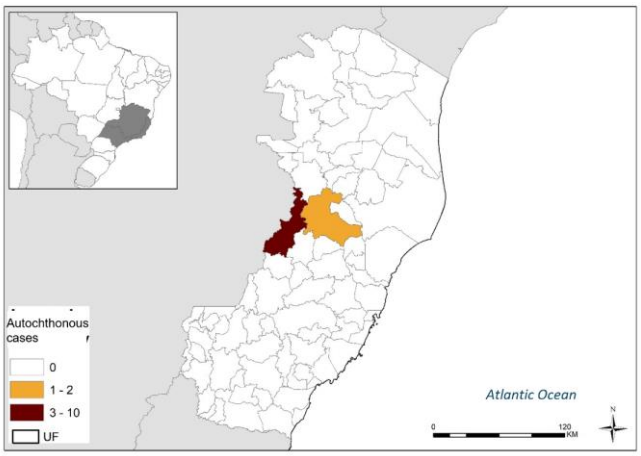


Figure 5.4.16. Spatial distribution of American Visceral Leishmaniasis cases in the state of Espírito Santo, Brazil, from 2018 to 2022.

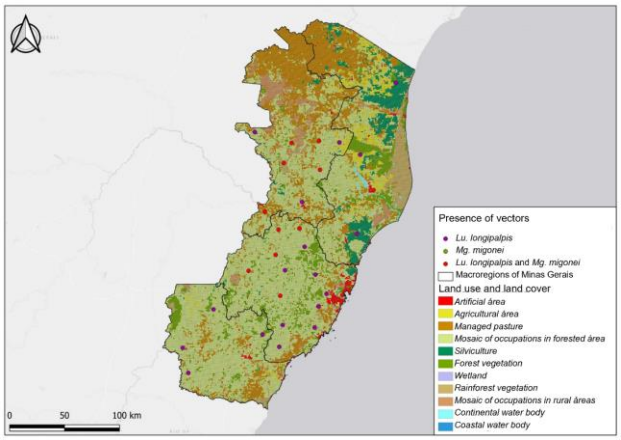


Figure 5.4.17 - Map of the distribution of *Lutzomyia longipalpis* and *Migonemyia migonei* vectors associated with land use and land cover in the state of Espírito Santo, Brazil.

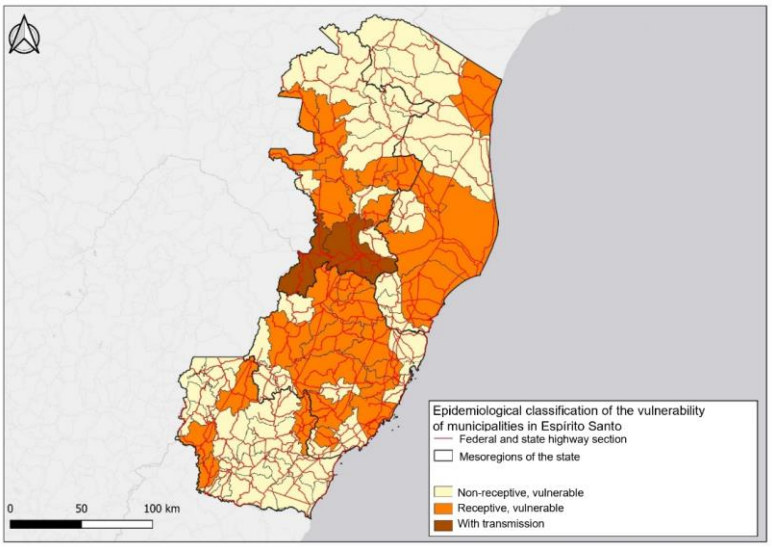


Figure 5.4.18. Map of municipal vulnerability to visceral leishmaniasis in the state of Espírito Santo, Brazil.

The state of Rio de Janeiro, with its 92 municipalities, had the presence of both vectors recorded in 15 municipalities, and in 16 with the presence of only *Mg. migonei* and in 3 municipalities only *Lu. longipalpis* (Figure 9). Only 8 municipalities recorded 26 cases of visceral leishmaniasis between 2018 and 2022, Rio de Janeiro with the highest number (12), followed by Volta Redonda (5), Nova Iguaçu (3), Barra do Piraí (2), Rio Bonito, Saquarema, Barra Mansa and Natividade with one case each (Figure 10). In the analysis of land use and cover, the association of the two species can be seen in areas of anthropogenic modification, in the Metropolitan region of the state (Figure 11). As with the other two states in relation to municipal vulnerability to AVL, it was observed that the silent states are vulnerable to the disease, although not receptive (Figure 12).

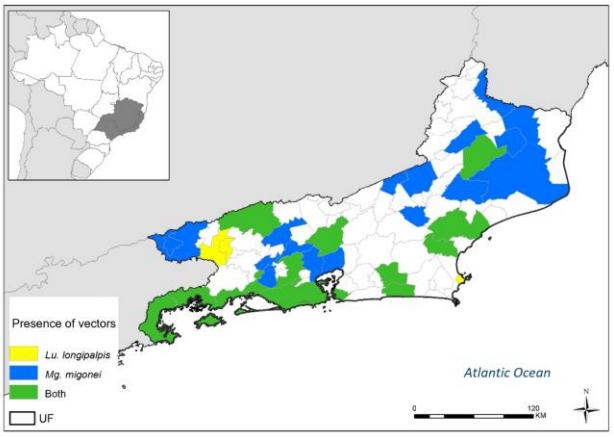


Figure 5.4.19. Spatial distribution of the vectors *Lutzomyia longipalpis* and *Migonemyia migonei* in the state of Rio de Janeiro, Brazil.

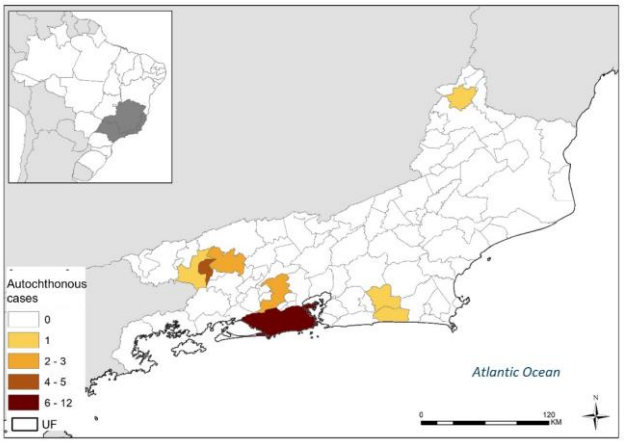


Figure 5.4.20. Spatial distribution of American Visceral Leishmaniasis cases in the state of Rio de Janeiro, Brazil, from 2018 to 2022.

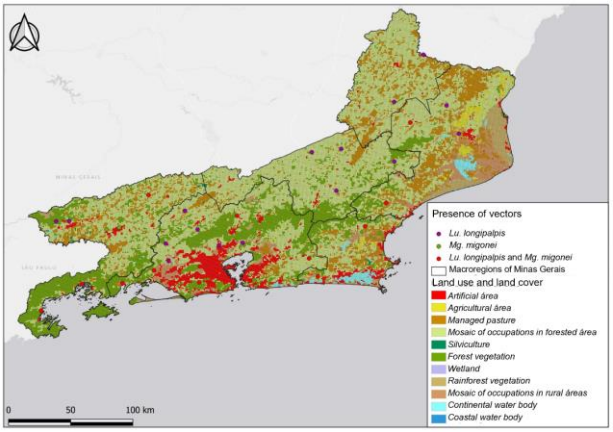


Figure 5.4.21. Map of the distribution of *Lutzomyia longipalpis* and *Migonemyia migonei* vectors associated with land use and land cover in the state of Rio de Janeiro, Brazil.

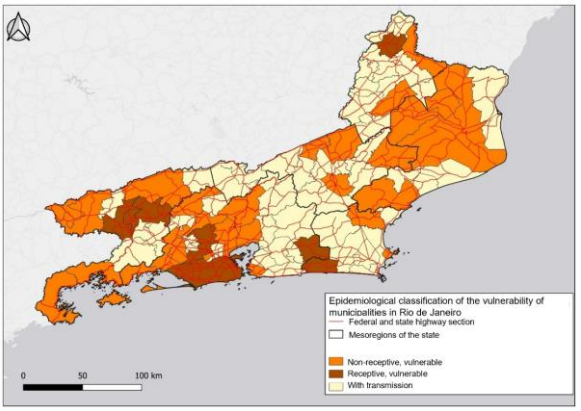


Figure 5.4.22. Map of municipal vulnerability to visceral leishmaniasis in the state of Rio de Janeiro, Brazil.

The analysis of this data contributes to the evaluation of the impacts of climate change, as well as poorly planned land use policies, which are challenges that society will have to face, both from a health and economic-social point of view, since this process increases the degree of vulnerability of populations living in areas at risk of vector-borne diseases, such as AVL. New transmission profiles are observed in these vector-borne diseases, and the Ministry of Health's spending on combating vectors and domestic reservoirs is not being able to contain the spread of the disease to new areas. Thus, this work could contribute to knowledge regarding the spatialization of vectors and the occurrence of the disease and its association with land use, optimizing planning through vector surveillance as a way of containing the spread of AVL.

5.5 Energy security

5.5.1. Objective

This report aims to investigate how renewable energy resources respond to future climate scenarios, taking into consideration the growing energy demand to achieve sustainable socioeconomic development in a low-carbon economy and Brazil's commitments made during climate conferences.

5.5.2. Activities carried out during the seventh year

a.1) CLOUD FORECASTING WITH A SKY CAMERA AND MACHINE LEARNING

Clouds, as key players in the hydrological cycle and atmospheric radiative balance, hold immense significance in various human activities, from solar energy generation to aviation. The increasing exploration of data-driven modeling tools in the study of short-term cloud forecasting underscores its crucial role. This research, therefore, is a significant step in creating a forecasting system for the variables involved in cloudiness (cloud cover fraction, cloud type, horizontal and vertical visibility, irradiance) for a very short time scale (next 10-30 minutes). The data obtained during the GoAmazon experimental campaign (2014-15) for these variables, particularly the all-sky images (ASI) obtained using the TSI camera and cloud cover fraction (CF) values estimated using the camera manufacturer’s algorithm, is being utilized.

An algorithm was created to estimate CF in ASI’s. In the first version, minimum cross entropy (MCE) segmentation was used to identify the pixels corresponding to interferences other than sky and clouds, and another MCE segmentation with adaptive thresholding was used to identify the regions of the image with clouds and clear skies. A conversion of the color model to LAB (luminosity and the red-green and yellow-blue color components) is applied to correct images detected as yellowish at times when the sun is close to the horizon. A second version of the CF estimation algorithm was developed to avoid manual and subjective choices of constants linked to previous methods. In it, a more efficient version of the convex closure mechanism was used

for data selection (features obtained from the ASIs and CF estimated by the TSI algorithm as a label) to create valid training, test and validation sets; feature selection, with the aim of defining the best inputs and determining the network topology; and estimation of the best network parameters. A type of Multi-Objective Genetic Algorithm (MOGA) was then applied to generate the best model with the data provided to estimate the FC values. This technique also makes it possible to identify images that show misalignment of the camera's shadow band and other interferences, which is explained in an article to be submitted in June/2024.

In addition to shallow learning techniques (MOGA), deep learning techniques (CNN and LSTM) will be used to forecast cloud variables and compare the results with each other and with the literature.

a.2) STATISTICAL REFINEMENT METHODS OF CLIMATE PROJECTIONS FOR QUANTIFYING SOLAR AND WIND POTENTIAL IN BRAZIL

Energy security is becoming increasingly climate dependent as the penetration of renewable sources in the global energy matrix grows, making this topic recurrent on the international scientific agenda. In Brazil, due to the diversity of high-potential energy sources and its vast territorial extension, this trend has been confirmed, especially with the expansion of the wind and solar power sectors. Quantifying the future risk to the energy sector involves better understanding the relationships between climate projections and the availability of renewable energy resources in our territory, as discussed in several studies. Thus, the Energy Security team aims to develop computational tools that assess the future risk to Brazil's solar and wind power generation sector based on climate projections. Within the scope of activities carried out in this project over the past 24 months, the statistical corrections made to atmospheric reanalysis data that showed the best performance compared to other data used as a reference are presented here. Over 40 CMIP6 models were selected, corrected for historical periods, and evaluated to define the best for future impact analyses. These activities are planned in the submitted work plan schedule, with the results presented here as part of the goals set within the scope of the Energy Security component of the INCT-Climate Change Project.

Objectives:

- Generation of a reference climatological database for the historical period (baseline) through the calibration of solar irradiance and wind estimates generated by a set of reanalyses (ERA5, MERRA-2, and CFSR) at hourly resolution for the Brazilian territory. These models will be adjusted based on historical surface observational data (INMET, INPE, METAR);
- Development and validation of computational methodologies for statistical downscaling of wind and solar radiation from global and regionalized climate projections (i.e., modeling deviations between climate models and observational database);
- Development of computational algorithms to investigate spatial correlations that indicate regions of hydro-solar-wind complementarity;
- Survey and qualification of observational data on wind and solar radiation incident on the surface for trend analysis of average or extreme climatological values.

Methodology:

The investigation utilized surface solar radiation (GHI) and wind speed (WS10) data available from three data repositories: the Coupled Model Intercomparison Project Phase 6 (CMIP6), ERA5 reanalysis provided by the ECMWF (European Centre for Medium-Range Weather Forecasts), and the Brazilian Solar Energy Atlas (BSR) data. CMIP6 provides SSR and WS10 data from global climate models used by the Intergovernmental Panel on Climate Change (IPCC) for a historical period (1980-2014) and for the future in three time intervals: 2015-2040, 2041-2070 and 2071-2100. Before using CMIP6 data to investigate the impact of future climate

scenarios, it is crucial to evaluate how representative their SSR and WS10 results are of observational patterns by comparing them with a reference database for the historical period. Several studies have shown that ERA5 data meet the necessary characteristics (long and continuous temporal coverage, hourly temporal resolution, and reliable land data assimilation) to be reference data (Avila-Diaz et al., 2020; Firpo et al., 2022). Satellite-based products have the disadvantage of not having long series, like reanalysis sets, but they have better accuracy (URRACA et al., 2018). Previous studies show that the Brazilian Solar Energy Atlas (BSR) time series has a low bias throughout the Brazilian territory (Pereira et al., 2017). However, its temporal coverage is shorter than necessary to serve as reference data in evaluating CMIP6 models. To meet the temporal coverage and reliability required for reference data in evaluating CMIP6 model performance, we applied a bias correction method to the ERA5 database, assuming BSR as a reference.

Results:

Figure 1 displays seasonal maps of the average CCF for the Brazilian territory in the near future (2015-2040) and at the end of the century (2070-2100). In the summer of the near future, an increase of up to 3% in SSR is expected in areas of Amazon and Central Brazil, including the Southeast of Brazil, which are closer to most electricity consumers. At the end of the century, the summer season shows an apparent decrease of up to -2% (-4%) in SSR in the northern part of the Northeast region under SSP2-4.5 (SSP5-8.5). On the other hand, an increase of up to 4% (6%) is expected in Brazil's Amazon, Central, and Southeast regions under SSP2-4.5 (SSP5-8.5).

For the autumn soon, positive CCF (about 2%) is concentrated in the Amazon and Northeast regions of Brazil under SSP2-4.5 conditions. The same pattern may extend to the Southeast region under the SSP5-8.5 pathway, offering hope for increased solar resources in this region. Looking further ahead to the end-of-century period, a similar geographic pattern occurs, with a maximum CCF of about 6% in a central area of the Amazon. However, a decrease in SSR is projected for the Southern region, with CCF reaching -2% (-4%) under SSP2-4.5 (SSP5-8.5) pathways.

For the winter of the 2015-2040 period, the CCF maps show a positive CCF (up to 3%) over the semi-arid area of the Northeast and part of the Southeast regions of Brazil under SSP2-4.5. The pattern extends over the Central region of Brazil under SSP5-8.5. The geographic pattern also occurs in the 2071-2100 period but with higher CCF values, reaching around 5% in parts of the Southeast and Amazon regions. As in autumn, SSR decreases in Southern Brazil in the end-of-century period in both climate scenarios, reaching CCF values around -3% (-5%) under SSP2-4.5 (SSP5-8.5).

During the spring, positive CCF covers a vast part of Brazil, extending from the Western Amazon to the Atlantic coastal areas of the Northeast and Southeast regions. The semi-arid region and the northern part of the Southeast region show the highest CCF values, around 4% (5%) in the 2015-2040 period and 6% (10%) in the end-of-century period based on the SSP2-4.5 (SSP5-8.5) scenarios. The Southeast region hosts the largest Brazilian cities and the most distributed solar energy systems, which is coincidentally where the most significant increase in SSR is forecasted.

These amplified positive signals in SSR during the spring in the semi-arid and Central Brazil regions (where most large-scale solar power plants are located) play an important role in the vulnerability of the Brazilian electric system to climate change. Brazil's National Interconnected System (SIN) still primarily relies on hydroelectric power and faces more stringent operations at the end of the rainy season (September to November), when reservoirs are usually depleted and exposed to climate variability, implying high risks. Severe electricity supply crises in the past are unequivocal evidence of this (Hunt et al., 2018). In this context, higher solar resources

during the spring add resilience to the future operation of the national electric system in both scenarios. However, an impact on other renewable energy resources (wind, hydroelectric) is expected, and they must be evaluated together.

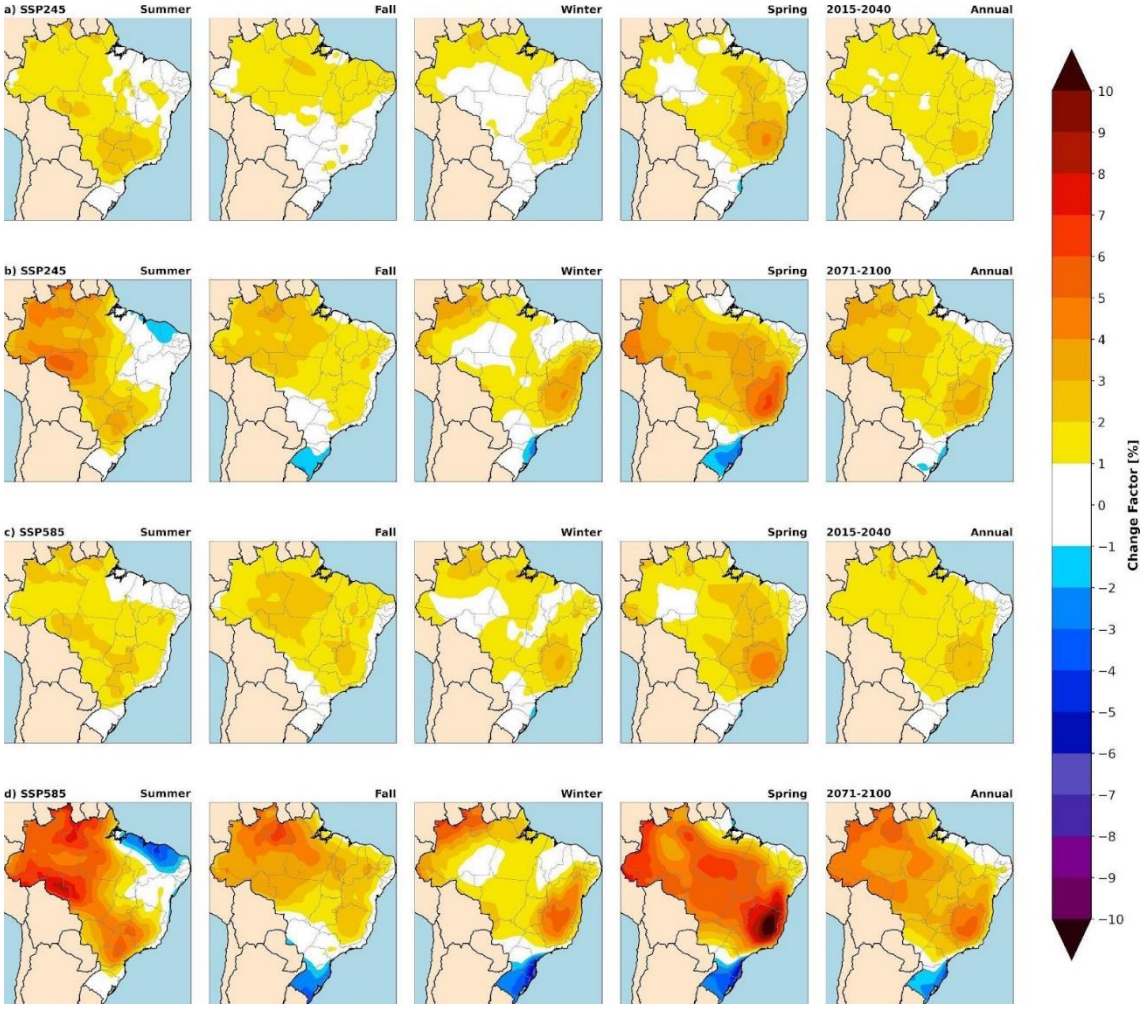


Figure 5.5.1. The seasonal SSR change factor predicted by the SME under SSP2-4.5 (first two rows) and SSP5-8.5 (last two rows) for the periods of 2015-2040 (odd rows) and 2071-2100 (even rows). The seasons are from left to right: summer, autumn, winter, spring, and annual average.

Figure 5.5.2 showcases the seasonal maps of the average CCF for the Brazilian territory, highlighting significant regional disparities soon (2015-2040) and at the end of the century (2070-2100). Soon, the summer is expected to see an increase of up to 15% in WPD100 in the Northeast and South of Brazil. However, by the end of the century, this increase is projected to be more pronounced, reaching up to 30% (or even more) in the Northeast region under SSP2-4.5 (SSP5-8.5). Conversely, a decrease of up to -4% is anticipated in parts of the Ceará region (SSP2-4.5), a trend not observed under the SSP5-8.5 scenario.

For the autumn soon, the CCF is positive (ranging from 15% to 30%) in almost all regions of Brazil, except in parts of the Amazon and Central West regions under SSP2-4.5 conditions, which show a decrease that can reach about -10%. The same pattern can extend under the SSP5-8.5 pathway but with positive values around 30% and negative values in parts of the Central West and South of Brazil (about -5%).

For the winter of 2015-2040, the CCF maps show a positive CCF (up to 20%) over Brazil's South and Southeast regions under SSP2-4.5 for the beginning of the century. At the end of the century, an increase of about 15% is observed across Brazil, except in areas of Northern Brazil, with a decrease of around 10%.

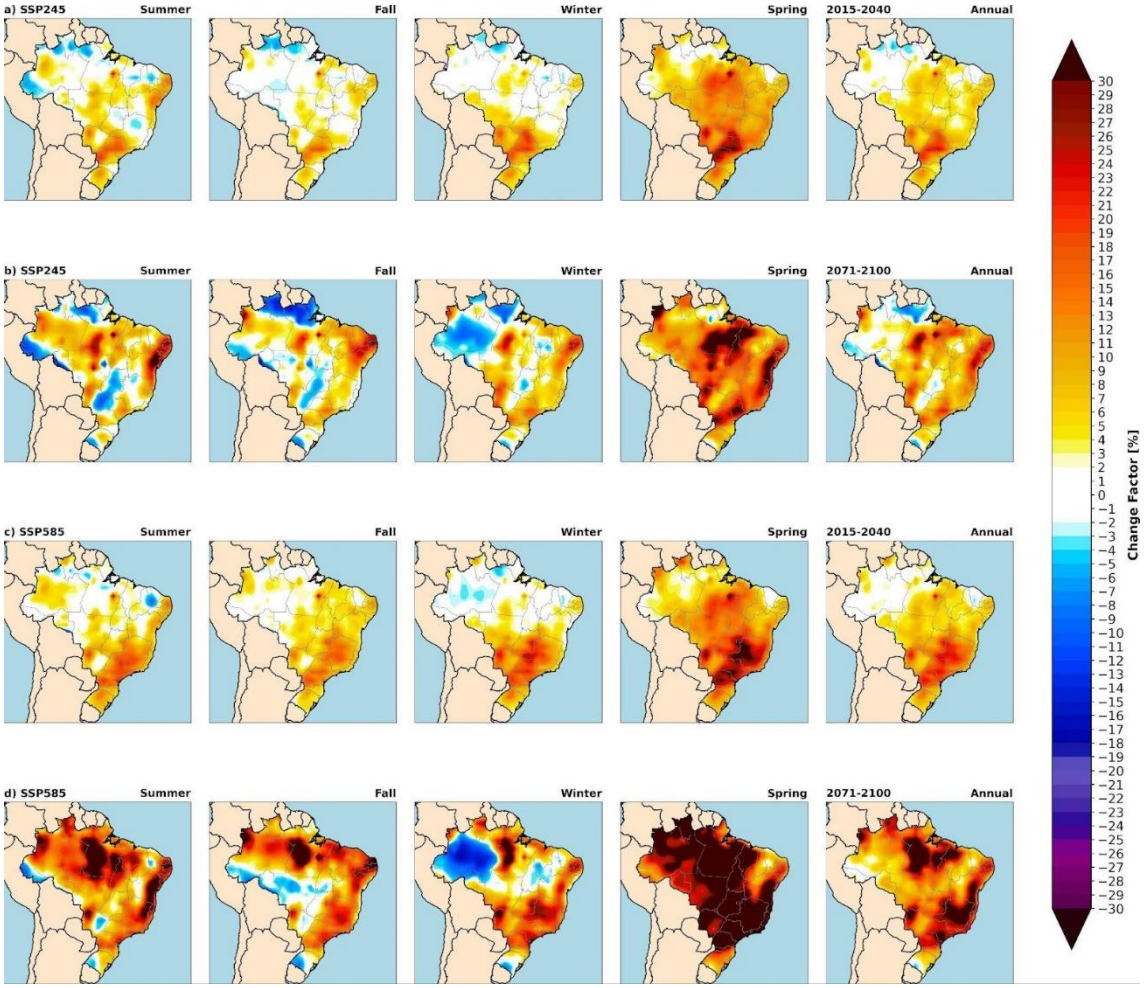


Figure 5.5.2. The seasonal WPD100 change factor predicted by the SME under SSP2-4.5 (first two rows) and SSP5-8.5 (last two rows) for the periods of 2015-2040 (odd rows) and 2071-2100 (even rows). The seasons are from left to right: summer, autumn, winter, spring, and annual average.

In the spring of both scenarios and periods, there is an increase in CCF in all regions of Brazil, with values around 30% under SSP2-4.5. The geographic pattern also occurs in the 2071-2100 period but with higher CCF values, reaching greater than 30% in all regions of Brazil. On an annual average, the spring geographic pattern repeats, except for negative values in small areas of the Amazon and Southern Brazil, around -4% in the SSP2-4.5 scenarios in both periods.

a.3) GREEN HYDROGEN: A MULTICRITERIA ANALYSIS APPLIED TO JUST ENERGY TRANSITION IN ISOLATED SYSTEMS IN THE AMAZON

Isolated Power Systems (SISOL) are concentrated in the Northern Region of Brazil and present in several states encompassing the Legal Amazon. Those systems predominantly utilize diesel oil as the primary electricity generation source, followed by natural gas. Due to the prevalence of fossil fuels, such systems constitute an electrical matrix characterized by a high emission factor. Furthermore, they incur substantial costs, amalgamating expenses associated with fuel

procurement, logistical operations, and subsidies disbursed through the Fuel Consumption Account (CCC) to align electricity pricing with other regions within the country. Nevertheless, the reliance on intricate fuel supply logistics imposes heightened susceptibility to interruptions on isolated systems, particularly exacerbated during periods of precipitation (for areas accessible via highways) and aridity (for regions accessible via river transportation). Consequently, the populace served by SISOL becomes increasingly vulnerable to energy deficits. Against this backdrop, it is discerned that the current prevailing model of electrical energy generation within SISOL exposes the served population and the Amazon region to adverse repercussions across economic, environmental, and social dimensions.

This study endeavors to assess whether the substitution of fossil sources with green hydrogen complemented by photovoltaic solar energy for electricity supply in isolated systems within the Amazon region represents a viable option tailored to the area's characteristics and possesses the potential to facilitate a just energy transition for the local inhabitants. The hypothesis underpinning this investigation posits that transitioning from fossil fuels to locally sourced renewable energy reservoirs holds promise in curtailing the risk of power generation interruptions while concurrently fostering sustainable development in the region. The evaluation study focuses on the feasibility of green hydrogen (H2V) and solar photovoltaic (PV) amalgamation, configured as a hybrid PV-H2V plant, across social, environmental, and policy dimensions (the latter stipulating alignment with national statutes and global accords), transcending the confines of technical and economic viability evaluations. In the envisaged hybrid plant, photovoltaic solar energy serves as a direct electricity source for SISOL-served locations and functions as an energy input in the electrolysis procedure for hydrogen production. The hydrogen produced can be stored for continuous renewable power generation, supplementing the solar source. In tandem with the PV-H2V plant, consideration is given to integrating lithium-ion batteries for short-term energy storage.

To ensure the applicability of the proposed energy generation model for isolated systems within the Amazon region, a comprehensive evaluation and comparison with existing generation configurations will be conducted. This evaluation will consider multiple criteria, including technological efficacy, risk of shortfall, service life, capital outlays, greenhouse gas (GHG) emissions, emissions averted, and potential social advantages. Preliminary estimations suggest a significant reduction in emissions with the proposed PV-H2V plant. The energy optimization software Calliope will be used to examine the technical, economic, and environmental performance of diverse alternatives. The forthcoming Multicriteria Analysis utilizing the AHP method (Analytic Hierarchy Process) will further support decision-making processes. The objective is to compile a hierarchy of alternatives that will facilitate a just energy transition within the Amazon region.

The symbiotic utilization of solar resources and hydrogen storage not only emerges as a mitigation measure but also as an adaptive mechanism fortifying natural and human systems against the climatic vagaries impacting natural and energy reserves. By attenuating reliance on fossil fuel consumption and supply logistics, the PV-H2V hybrid plant can bolster the resilience of the Amazon region in electricity production.

A.4) STRATEGIES TO STRENGTHEN ENERGY SECURITY IN HIGHLY RENEWABLE ENERGY SYSTEMS CONSIDERING WATER STRESS SCENARIOS.

The hydrological stress due to climate change associated with long-term increased electricity demand may affect the country's energy security. The electrical system must be expanded to ensure supply for the projected demand by 2050, t. This project aims to explore long-term solutions for the electricity sector through a spatially explicit optimization model. The model uses Calliope, an energy modeling software for system analysis that considers high temporal and spatial resolution. Additionally, the model can optimize capacity and dispatch simultaneously, minimizing costs. In the first stage, the electrical system was modeled for 2050 without

considering climate alterations. In the second stage, strategies were explored to increase system reliability and opportunities amidst long-term hydrological stress scenarios using the same model with disturbances in hydrological time series. Input data for both models include a temporal series of energy resources. Twenty years of hourly wind and solar energy were simulated using MERRA-2 reanalysis data and validated against available data such as wind and solar atlases. Twenty years of Natural Inflow Energy (ENA) data provided by ONS were used for hydrological resources. Demand for 2050 was adjusted to the load curve also provided by ONS. The model was run at a temporal resolution of 3 hours for the reference year 2017. Sensitivity analysis was also performed for 20 years, highlighting the effect of interannual variability of hydrological, wind, and solar resources. Results from the first phase indicate that installed capacity in Brazil by 2050 should range from 353 to 428 GW depending on the climatic year considered, with a predominance of wind and solar parks. In the second phase, where hydrological stress is considered, wind energy remains predominant, and natural gas declines. However, extensive penetration of wind complexes is only possible when combined with storage systems, which remain primarily reservoir based. Severe cases of hydrological stress can increase energy system costs by up to 14.9% when combined with 100% renewable systems. Moderate cost scenarios show optimal results like advanced (optimistic) costs, indicating high competitiveness between wind and solar alternatives. Furthermore, expanding wind parks can lead to surpluses of wind energy, especially during the dry season when energy demand is lower. This excess energy could produce 0.46 Mt of green hydrogen annually, exceeding the current industry demand of 0.33 Mt. Effective spatial planning is crucial, especially considering that green hydrogen production requires water, and the surplus energy comes predominantly from the Northeast, where intense drought events are frequent.

5.6 Natural disasters, impacts on physical infrastructure in urban areas and urban development

5.6.1 Introduction

In the seventh year of the project, the efforts were to prioritize studies in order to contribute to improving scientific knowledge on extreme events, management of disaster risks occurred in 2023 and 2024; and vulnerability of cities as strategies for mitigation and adaptation to climate change. Thus, the following proposed studies were conducted in order to improve knowledge about **(i)** Attribution studies of the most severe extreme events in Brazil during 2023/2024; **(ii)** Inundation mapping using hydraulic modeling with high-resolution remote sensed data: a case study in the Acre River Basin, Brazil; **(iii)** Hydrometeorological drought analysis through Two-variate Standardized Index for the Paraná River Basin, Brazil; **(iv)** Analysis of indicators for drought impacts in urban areas; **(v)** Heavy rains and hydrogeological disasters in the city of São Sebastião on the Northern coast of the State of São Paulo, Brazil; **(vi)** Analysis of the hydrological disaster occurred in the state of Rio Grande do Sul, Brazil in September 2023: Vulnerabilities and risk management capabilities; **(vii)** Community disaster resilience in Brazilian small urban centers; **(viii)** Spatial and temporal evaluation of social vulnerability in Rio Grande do Sul, Brazil; **(ix)** Identification of the vulnerable population to disasters in Brazilian capitals in the context of the early warning system; **(x)** The exposure of schools and the education sector to flooding in the public calamity scenario of May 2024 in municipalities of Rio Grande do Sul, Brazil; **(xi)** Additional contribution to the INCT-MC-II.

The present report integrates and summarizes the research/contributions conducted during year 7 by the groups from (i) National Center for Monitoring and Early Warning of Natural Disasters (CEMADEN), coordinated by Dr. Regina Célia dos Santos Alvalá; (ii) Federal University of Santa Catarina, coordinated by Dr. Regina Rodrigues Rodrigues and (iii) Oswaldo Cruz Foundation (FIOCRUZ), coordinated by Dr. Martha Barata. Additionally, the schedule for the year 7 is presented, in order to achieve the general objective of the sub-component.

This section presents the main advances developed during the seventh year of activities, including an elaboration of a project submitted and approved by CNPq, which is coordinated by a research of the INCT-MC-II team. This project was proposed in order to develop an early warning system for landslides, which includes analyses on regional, municipal and local scales, integrating high-resolution meteorological products, considering geotechnical characteristics and including vulnerable resident populations leaving at risk areas.

5.6.1 Attribution studies of the most severe extreme events in Brazil during 2023/2024

Understanding and quantifying the influence of human-induced climate change on extreme events has been an important goal of the climate science community. Extreme weather events, such as heatwaves, heavy rainfall, storms and droughts, are becoming more frequent and stronger in many parts of the world because of human-caused climate change. However, not all events are becoming more likely, and changes are uneven across the world. These events often have widespread impacts on society, including the loss of crops and farmland, destruction of property, severe economic disruption and loss of life. Following an extreme event with severe impacts, a great deal of public interest is generated in its causes. Increasingly, the dominant question is: "Was this event caused by climate change?"

Until recently, scientists largely avoided connecting any individual event with climate change, instead pointing towards the trend and saying that an event might reflect the sort of thing we can expect to see more of in the future. However, climate change is already having a profound influence on the weather we are experiencing and has done so for decades. The science is finally becoming commensurate with this fact. In recent years, methods have been developed that enable scientists to work out the link between global climate change and an individual extreme weather event, calculating how much more or less likely and how much more or less intense an event has become because of global warming.

Event attribution studies calculate whether and to what degree climate change made a specific extreme event more (or less) likely and/or intense. The current attribution methodology consists of three separate but related methods. The steps listed above describe one part of the modern methodology: simulating and comparing the modern and pre-industrial climates with climate models. Several different climate models are used to ensure that. The second part uses a method that incorporates observations of weather data from the present and the past to see how the probability of similar events has changed. The final part uses climate models in the same way as observations. Rather than simulating the world with and without human influence, it simulates the climate from a historical date (1900) to the modern day, with slowly rising human emissions. This enables the detection of trends in the extreme as well as the calculation of an overall probability change. Using several attribution methods, as well as different climate models, to assess the influence of climate change increases the reliability of the results. Vulnerability and exposure in communities and countries are also considered to understand what actions may increase resilience to future extreme weather events. This methodology was applied to the 2023 severe drought in the Amazon, the 2024 floods in RS and the recent fires in Pantanal.

2023 Amazon Drought

In order to assess whether and to what extent human-induced climate change was a driver of 2023 Amazon drought we combine observations-based data products and climate models and look at the 6-month meteorological drought as well as agricultural drought (Clarke et al., 2024a). We find that the likelihood of the meteorological drought occurring has increased by a factor of 10, while the agricultural drought has become about 30 times more likely (Figure 1). Using the US drought monitoring classification system, based on agricultural drought, this

means that what is now classified as an exceptional drought (D4) would have only been a 'severe drought' (D2) without the effects of climate change caused by burning fossil fuels and deforestation. In datasets based on weather records, the drought is exceptional, even in today's climate, characterised as a 1 in 100 year event for the meteorological drought (SPI) and approx. a 1 in 50 year event in SPEI. While there is a strong drying trend in the meteorological drought, the trend in agricultural drought is even stronger, meaning this agricultural drought would have been extremely rare in a cooler climate.

El Niño reduced the amount of precipitation in the region by about the same amount as climate change; however, the strong drying trend was almost entirely due to increased global temperatures, so the severity of the drought currently being experienced is largely driven by climate change. Unless the world rapidly stops burning fossil fuels and deforestation, these events will become even more common in the future. In a world of 2°C warmer than preindustrial, an event like this would become even more likely by a further factor of 4 for the agricultural drought (every 10-15 years) and a further factor of 3 for the meteorological drought (every ~30 years).

Exposure to drought impacts was compounded by historical land, water, and energy management practices, including deforestation, destruction of vegetation, fires, biomass burning, corporate farming, cattle ranching and other socio-climate problems which have decreased the water and moisture retention capacity of the land and thus worsened drought conditions. Highly vulnerable populations were disproportionately affected by the drought. Small-holder farmers and indigenous, rural and river communities across the region were among the most vulnerable due to high poverty rates and their high dependency on agricultural food production, availability of freshwater, and import of goods via rivers.

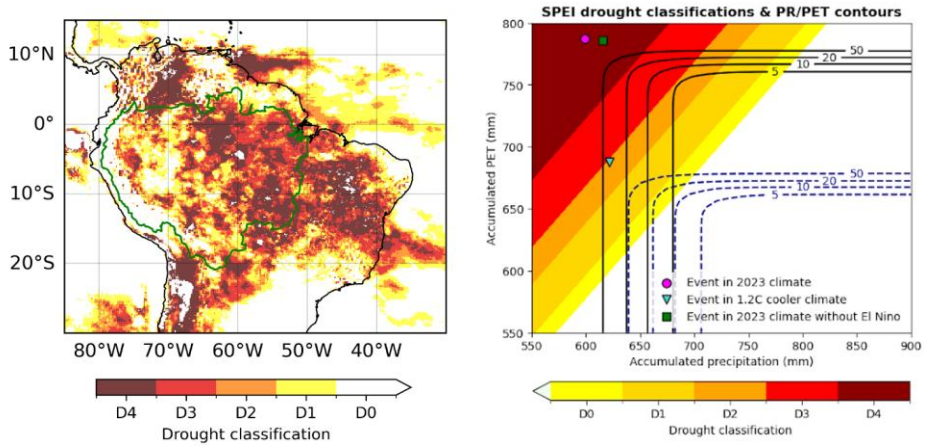


Fig. 5.6.1 – Amazon drought: 6-month SPEI (SPEI-6) over the Amazon River Basin (highlighted in blue), from June-November 2023, categorised according to the US Drought Monitor system (left); Joint distribution of 6-month accumulated precipitation and PET with corresponding SPEI drought classification (right). The solid contours indicate return periods under the joint distribution in the current climate, while the dashed contours indicate the same return periods in a 1.2°C cooler climate. The shaded contours represent different levels of drought severity. The magenta circle indicates the 2023 drought in the current climate; the turquoise triangle shows an event of equivalent severity in a 1.2°C cooler climate; and the green square shows an event of equivalent severity in the 2023 climate, but with a neutral ENSO phase.

2024 Rio Grande do Sul Floods

To capture the nature of the extreme rainfall that resulted in extreme flooding across Rio Grande do Sul, two event definitions are analysed in this study: the 4- and 10-day rainfall accumulations, averaged over the state of Rio Grande do Sul (Clarke et al., 2024b). The 4-day window captures the most severe single event in which record rainfall fell across several consecutive days, while the 10-day window (encompassing 26th April – 5th May, inclusive) captures the succession of heavy rainfall events, including the very wet individual days on either side of the major 4-day peak (Figure 2). Both rainfall events, the 10-day and 4-day events were found to be extremely rare in the current climate, with return periods of 100-250 years. Given the relatively short data records, we use the 1 in 100-year event for the analysis in this study to increase the statistical stability of the analysis. This return period is also typically considered a benchmark for risk analysis. ENSO was found to be important in explaining the variability in the observed rainfall, consistent with previous research. Most previous heavy rainfall events in the area occurred during El Niño years. The role of El Nino alone is comparably large. In observations, compared to a neutral ENSO phase, the current (December-February) El Niño resulted in a consistent increase across all datasets and for both events: by a factor of 2-3 in likelihood and 4-8% in intensity for the 10-day event, and a factor of 2-5 in likelihood and 3-10% in intensity for the 4-day event.

To assess the role of human-induced climate change, we combine observation-based products and climate models that include the observed ENSO relationship and assess changes in the likelihood and intensity for the 10-day and 4-day heavy rainfall over Rio Grande do Sul and find an increase in likelihood for both events of more than a factor of 2 and intensity increase of 6-9% due to the burning of fossil fuels. These findings are corroborated when looking at a climate of 2oC of global warming since pre-industrial times, where we find a further increase in the likelihood of a factor of 1.3-2.7 and an increase in intensity of about 4% compared to the present day. Again, results are similar for both event definitions. The unprecedented 2024 April-May floods in Rio Grande do Sul have affected over 90% of the state, an area equivalent to the UK, displacing 581,638 people and causing 169 deaths. While Rio Grande do Sul is often perceived as a well-off region, it still has significant pockets of poverty and marginalisation. Low income has been identified as a significant driver of flood impact. Informal settlements, indigenous villages, and predominantly quilombola (descendants of enslaved Africans) communities have been severely impacted.

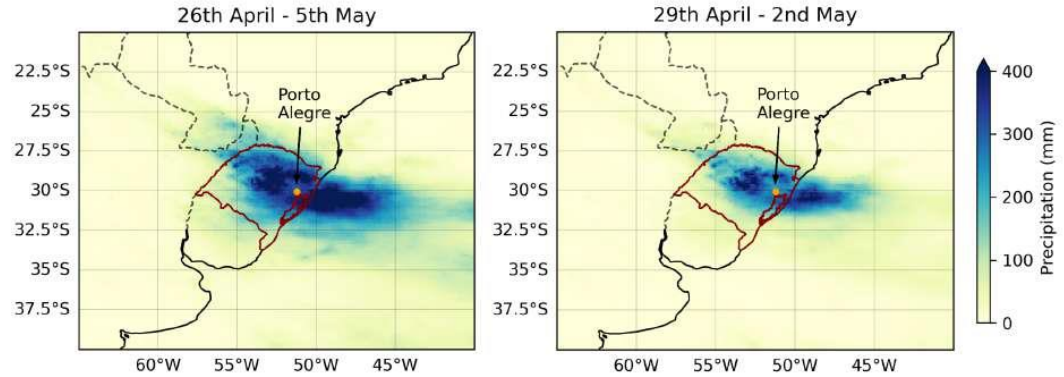


Fig. 5.6.2 – Accumulated rainfall over Rio Grande do Sul, the southernmost state of Brazil, in late April and early May 2024. The longer 10-day period (left) represents a succession of 3 rainfall events, the shorter 4-day period (right) covers the single largest multi-day pulse of rainfall. Data from MSWEP.

2024 Pantanal Fires

Fire weather is a critical driver of wildfires, although changes in vegetation (wildfire fuel) and fire management strategies also contribute to future wildfire risk. To understand the extent and

duration of extreme fire weather in the region, we use the cumulative Daily Severity Rating (DSR) for June, averaged over the Brazilian Pantanal (indicated by the solid black outline in Figure 3 left). The DSR indicates how difficult it is to control a fire once it starts, and it is commonly used to assess fire weather over monthly or longer periods. The DSR is derived from the Fire Weather Index (FWI), which uses meteorological information (temperature, humidity, wind speed and precipitation over the preceding weeks and days) to predict the expected energy release per length of the fire-front if a wildfire occurs (Barnes et al. 2024). We focus on the Brazilian Pantanal, where nearly all active fires in June occurred; however, including the wider region, which extends into Bolivia and Paraguay, would likely yield similar results.

Observations show that similar June fire weather conditions, as defined by DSR, are about 3 times more impactful than they would have been in a 1.2°C cooler climate. They would have been about a factor 100 rarer had the climate not been warmed by humans. To determine the role of climate change, we combine fire weather observations with climate models. Human-induced warming from burning fossil fuels made the June 2024 DSR about 40% more impactful and 4-5 times more likely. These trends will continue with future warming. If warming reaches 2°C, similar June fire weather conditions will become around twice as likely, expected to occur on average about once every 17 years, and will become 17% more impactful.

To understand how human-induced climate change affects June fire-weather conditions, we also investigate the weather variables comprising the DSR: maximum temperature, relative humidity, wind speed, and rainfall. Most of these variables broke records in June 2024: it was the driest, hottest, and windiest June since observations began. Only relative humidity was the second lowest on record. Next, we analyse how climate change alters the likelihood and intensity of these four main weather variables. In the observations, there is a strong drying trend and, as expected, increasingly high temperatures (Figure 3 right) accompanied by a reduction in relative humidity, while there is no clear trend in wind speeds. Thus, the increase in DSR can be explained by increasing temperatures – driven by climate change – and decreasing rainfall. Yearly rainfall in the Pantanal has been decreasing for over forty years. While natural decadal variability and deforestation in large ecosystems are known to affect rainfall patterns across South America, climate change may also be influencing the drying trend.

In the Pantanal, land use and land cover changes, such as clearing natural vegetation for pasture or agriculture, contribute to drier conditions and increase the availability of flammable vegetation. The June 2024 fires spawned multi-ministry response actions to try to contain fires and save wildlife and livelihoods, such as the establishment of 13 new bases to accelerate the deployment of firefighters to remote areas. However, while significant steps have been taken to address the Pantanal wildfires, there are still substantial challenges to containment and extinguishment efforts. It is imperative that government agencies at all levels act swiftly and prepare for increasingly critical situations, as projections indicate a rise in such events.

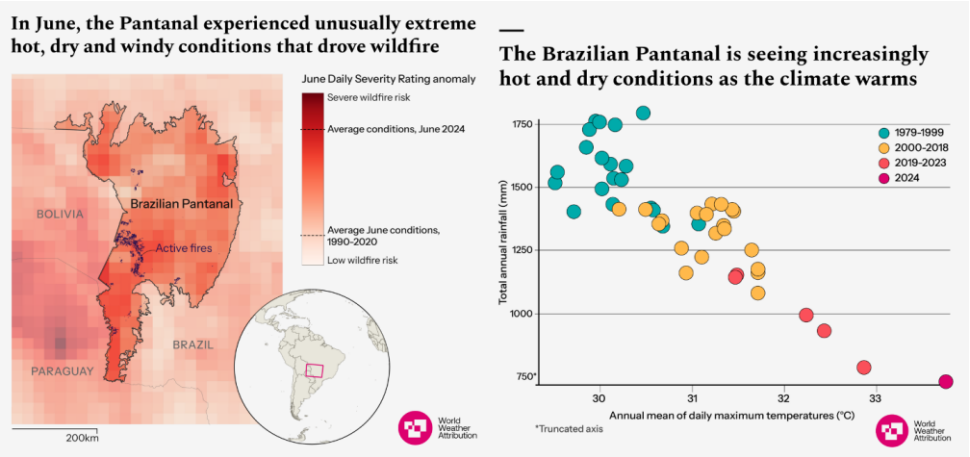


Fig. 5.6.3 – Map of June 2024 DSR anomaly over the study region wrt 1990-2020 June climatology (ERA5), showing active fire pixels as red dots (right). Accumulated annual mean rainfall vs annual mean of daily maximum temperatures over the last 45 years showing the drying and warming trend in different decades as well as the record in 2024 (left).

5.6.2 Inundation mapping using hydraulic modeling with high-resolution remote sensed data: a case study in the Acre River Basin, Brazil

The impacts of climate change in recent decades have exacerbated the frequency and intensity of floods worldwide, and especially in the Amazon region. The city of Rio Branco, located in the southwest of Brazil's Amazon region, has been severely affected by a combination of urbanization in flood-prone areas and increasing floods in the Acre River. In addressing this challenge, accurate inundation mapping plays a pivotal role in shaping effective flood risk reduction strategies. In the present study, it was employed hydraulic modeling using the HECRAS 1D model combined with a LIDAR-based high-spatial resolution DEM to generate an accurate flood extent mapping. The modeling process used dataset encompassing conventional and unconventional information from the three most significant historical floods in Rio Branco in 2012, 2015, and 2023. The geometry of the river channel and the floodplain were extracted from the terrain surface, and the riverbed was adjusted based on the bathymetry data of a single cross section measured where the stream gauge is located. The Manning's roughness coefficient "n" values for river channel and floodplain were calibrated considering flow levels, and the "n" values ranged from 0.039 to 0.052, for flows in the order of 600 m^3/s and 3200 m^3/s, respectively.

Steady flow simulations of the peak flow of each historical flood event were performed with an accuracy of 0.01 m in water surface elevation. Unsteady flow simulation was performed to simulate the flow hydrographs from 2012, 2015, and 2023 floods. Validation of the hydraulic model (Figure 4) was carried out using conventional data from stream gauge observations, aerial images of flood extent, and unconventional data from observed high-water marks. The RMSE was 0.22 m for the 2012 flood, 0.25 m for the 2015 flood, and 0.26 m for the 2023 flood. Flooding extent simulation (Figure 5) was assessed using the Critical Success Index (C) from two optical aerial survey images recorded during the 2012 and 2015 floods and one optical satellite image recorded during the 2023 flood. The C index for flood extension was evaluated from an aerial image of the 2012 flood (February 27th), a day after the peak flow condition; an aerial image of the 2015 flood (March 8th), four days after the peak flow conditions; and a satellite image of the 2023 flood (March 30th), four days before the peak flow conditions. The C index was 0.88, 0.84, and 0.97, respectively, for each flood event.

Finally, the model evaluation for the water depth simulation in the floodplain was performed for the steady flow simulation of the peak flow conditions (Figure 5). The water depth simulation from the 2012 flood was performed based on observed depth derived from high-water marks on the façade of buildings provided by the Google Street View imagery acquired a few months after the flood and presented a mean error of 0.17 m. The depth of the peak flow condition of the 2023 flood simulation was evaluated from a high-water mark in a staff gauge draw on the wall by a resident of Rio Branco and presented a discrepancy of 0.2 m.

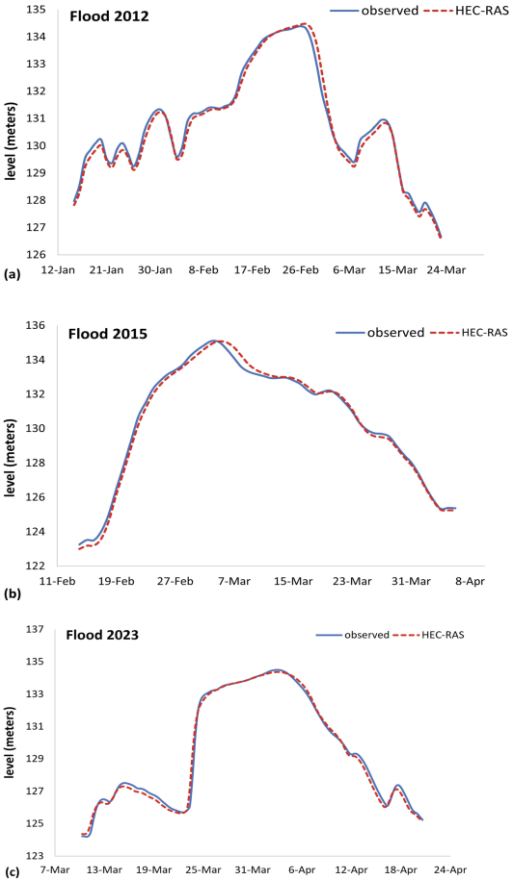


Fig. 5.6.4 – Stage hydrographs of the unsteady simulations in red dashed lines and observations at the stream gauge site in blue lines for the (a) 2012, (b) 2015 and (c) 2023 floods.

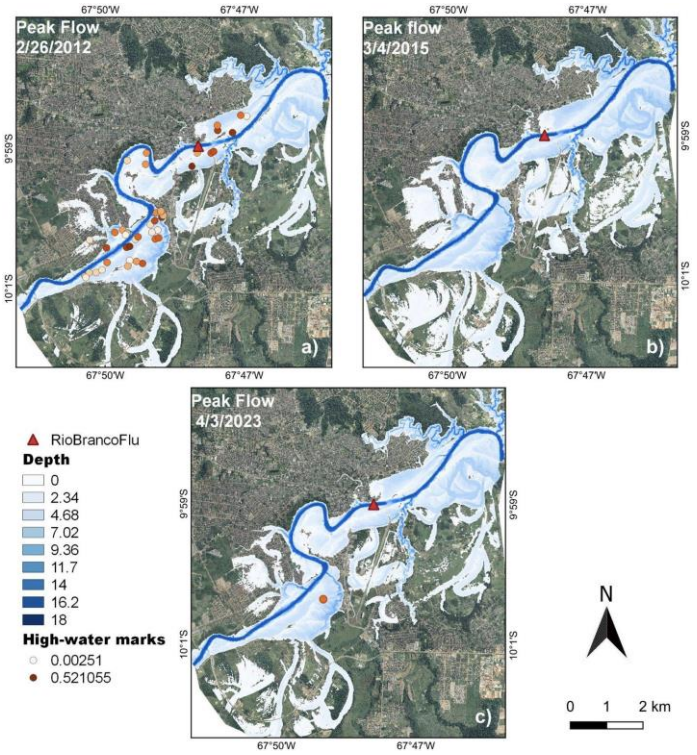


Fig. 5.6.5 – Flood mapping of maximum flow of Acre River in Rio Branco reach from 2012 flood (2880 m3/s) and distribution of high-water marks location along the floodplain (a). Flood mapping of maximum flow of Acre River in Rio Branco reach from 2015 flood (3175 m3/s) (b), Flood mapping of maximum flow of Acre River in Rio Branco reach from 2023 flood (2959 m3/ s) and a high-water mark location (c).

In conclusion, this study showed that it is possible to obtain an accurate simulation even in the absence of bathymetric data of the entire river channel when there is a high-spatial-resolution DEM with an accurate representation of the flood plain. Also, good-quality historical observed data and different sources of information from past historical events can result in hydraulic modeling with good accuracy for water elevation, flood extent, and flood depth. Besides the numerical reconstruction of historical events being useful for validating the hydraulic model, it can also be useful for flood hazard mapping and assessment of risk areas in different scenarios of river flooding, providing support for flood risk assessment and management. This is essential for effective decision-making in flood prevention and mitigation strategies, supporting flood warning systems natural disasters for reducing total loss of life and property.

5.6.3 Hydrometeorological drought analysis through Two-variate Standardized Index for the Paraná River Basin, Brazil

This study aimed to provide a significant advancement in the understanding and characterization of hydrometeorological droughts, particularly in Brazil's hydroelectric sector, which heavily relies on water resources for electricity generation. By introducing the Two-variate Standardized Index (TSI), which consider jointly precipitation and streamflow data, and comparing it with established indices like SPI and SSFI, the research highlights TSI's superior ability to characterize drought events across large-scale basins. Notably, TSI effectively captures the onset and persistence of droughts (Figure 6), making it a valuable tool for monitoring and managing drought conditions in regions with well-defined rainy and dry seasons. The results also demonstrate that TSI is particularly effective in monitoring droughts at 12- and 24-month scales (Figure 7), making it a promising operational tool for decision-making in water resource management. Our results emphasize the importance of incorporating multiple variables, such as

terrestrial water storage, ground water and reservoir levels, to gain a comprehensive understanding of drought dynamics. Given Brazil's vulnerability to extreme drought events, especially in the Paraná River Basin, this research contributes valuable insights into improving drought monitoring and prediction, which are crucial for sustaining the nation's hydroelectric power supply.

Moreover, our findings highlighting its potential for broader applicability of TSI beyond Brazil, suggesting that it can be effectively utilized in various basins with distinct climate patterns, highlighting its potential as a globally applicable operational tool for decision-making in water resource management. Given its ability to incorporate multiple variables, such as precipitation and streamflow data, TSI offers a comprehensive approach to drought assessment that can be adapted to different time and spatial scales. This global relevance positions TSI as a promising candidate for widespread use in monitoring and mitigating drought impacts, enabling timely interventions in diverse climatic contexts.

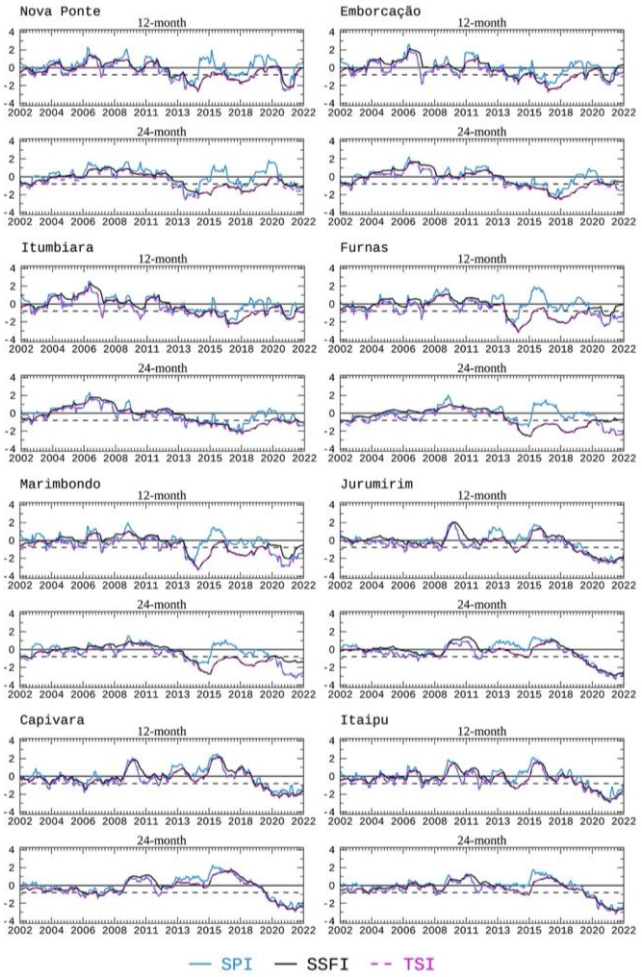


Fig. 5.6.6 – Comparison of SPI, SSFI and TSI indices at time scales of 12- and 24-month for several basins. The dashed black line is - 0.8, below which a drought condition is considered.

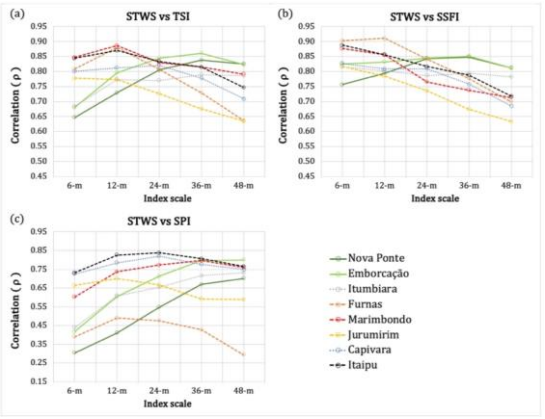


Fig. 5.6.7 – Correlation (ρ) among standardized terrestrial water storage (STWS) from GRACE and (a) Two-variate Standardized Index (TSI), (b) Standardized Streamflow Index (SSFI) and (c) Standardized Precipitation Index (SPI), at 6-, 12-, 24-, 36-, 48- and 60-month time scales.

5.6.4 Analysis of indicators for drought impacts in urban areas

Urban drought is a crucial theme to be approached, especially in Brazil, a country so large and heterogeneous. According to a study carried out in Brazil, from 1991 to 2020 there was a 15.7% reduction (3.1 million ha) in the water surface (Mapbiomas Project, 2021), while for the same period the urban population increased by 45% (IBGE, 2011). As example, highlighted impacts on urban water supply, such as that recorded in São Paulo in 2014 (Deusdará-Leal et al., 2020) and in Campina Grande from 2012 to 2017 (Meneses et al., 2022).

The result of a drought event combined with other variables such as large populations, increased consumption, lower water volume, among others, can cause deficiencies in urban water supply. More resilient cities or those with lower vulnerability tend to feel fewer impacts caused by drought. In this context, understanding vulnerability in terms of urban water supply can help identify the municipalities and regions most vulnerable to urban drought.

According to Wilches-Chaux (1993), vulnerability can be classified as natural, physical, economic, social, political, ideological, cultural, educational, ecological and institutional. The lower the vulnerability, that is, the more structured and prepared a location is for climatic events, such as drought, for example, the lower the impact will be. Therefore, this component aims to provide a preliminary analysis of a literature review of the main indicators used in studies on water consumption, access and supply.

To identify the indicators that have been used in water supply and related studies, the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) methodology was used, which is a systematic, replicable and transparent review (Page et al., 2021; Galvão et al., 2022). The methodology has a step-by-step process divided into seven main topics: title, abstract, introduction, methods, results, discussion and other information.

Thus, the platform chosen for the search was the Web of Science (WOS), one of the main and best-known in the academic environment, in addition to having the option of exporting a table with a large amount of information, including the abstracts of the articles in the search. The analysis was carried out on June 29, 2023 considering the following three keywords water, vulnerability, and urban, which were mentioned only in the abstract.

In addition, some filters were applied, such as year of publication (between 2019 and 2023); type of document restricted to article (review article, conference article, early access, book

chapter, data article, editorial material); and languages (Portuguese and English). The search returned a total of 489 documents.

In the second phase, the 489 documents were evaluated in terms of adherence to the theme, with the titles and abstracts being assessed. In this phase, studies related to Hydrology and hydraulics; Groundwater; Water quality; Seismic events; Urban heat; Floods and storms; Cooperative Management; and Mining, were excluded. After the exclusion process, 17 works remained, which were downloaded. All of them were read in full and the variables used for vulnerability analysis were identified.

The studies analyzed were quite diverse in terms of their applications, which focused on economic (Haak and Pagilla, 2020), conceptual (Deng et al., 2022), climate extremes (Dong et al., 2020; Grasham et al., 2019), and different spatial-temporal scales (Qiao et al., 2022; Waly et al., 2021), among others. The word cloud (Figure 8), elaborated from the Abstracts, provides more information about the main topics of discussion, reflecting not only the mentioned keywords (water, vulnerability, and urban) but also other central themes and issues.

The terms water security, water supply, infrastructure, social vulnerability, and water resources also stood out, indicating that they are more recurrent in the research (Figure 6). However, it is worth highlighting terms that are less prominent in Figure 8 and that are equally important, such as drought, disaster, scarcity, risk and impact. In total, 192 variables were identified and used in the 17 articles, which were divided into 13 large groups: Socioeconomic Indicators; Water Management and Use; Infrastructure; Water Quality and Treatment; Risk and Disaster; Land Use and Cover; Water and Water Stress Indices; Others; Precipitation; Environmental Indicators; Public Policies; Health Indicators; and Temperature (Figure 8).

Economic Indicators were the most frequently used, and the main variables used were population data. In total, seven articles used population or population density (Figure 8). Data on education, employability, GDP, income and employability in the industrial sector were also used as vulnerability indicators (Figure 8). It is understood that sectors such as industry and agriculture require greater water consumption, whether through direct use or by energy demand. Therefore, such sectors can generate an increase in demand and in drought situations this can lead to a reduction in the volume of water available for supply and conflicts over use.

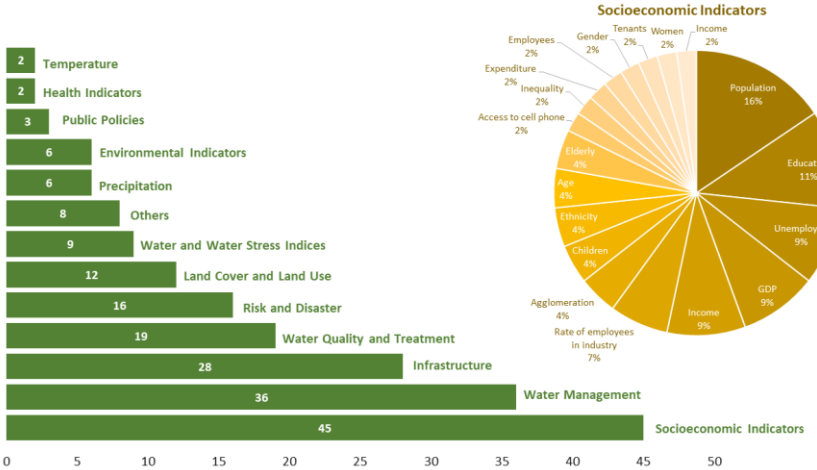


Fig. 5.6.8 – Word cloud base on Abstracts.

Among the variables classified in the Water Management and Use category, the highlights are the variables of consumption, demand, water availability and cost of water. In the infrastructure category, variables such as basic sanitation, access to water, bathrooms, reservoirs and distribution networks were the ones that had the greatest recurrence among the studies, as well as sewage treatment and water quality. In the Land Use and Cover item, information on built-up

area, soil impermeability, vegetation in urban areas and vegetation cover were used. Regarding indicators with climate variables, it can be said that precipitation is frequently used, either directly, through average or accumulated data, or indirectly in the Water and Water Stress Indexes. Less frequently, but very interesting, are variables such as Temperature, Health Indicators (number of hospitals and health professionals), Public Investment Policies and regulations related to water supply. And, finally, we can highlight relief and altitude as Environmental Indicators as vulnerability factors (Figure 9).

Fig. 5.6.9 – Word Cloud based on Recurrence of variables.

In order to obtain local data set about urban drought impacts, a fieldwork was carried out in the Brazilian semiarid region of Brazil from May 15, 2024 to May 31, 2024. The municipalities of Juazeiro do Norte (CE); Campina Grande (PB); Garanhuns (PE); and Caruaru (PE) were selected in reason to have a population of over 100,000 inhabitants, and are considered tourist municipalities. The objective of the fieldwork was collect information aimed to understand the water supply systems in the municipalities. Also, it aimed to evaluate the impacts of infrastructure on access to water distribution, mainly focused on periods of drought when water availability may be reduced.

Based on the field work, the results showed that water supply in the state of Ceará is entirely through reservoirs and wells. In Juazeiro do Norte, 100% of water is collected through wells, and due to the type of soil, it is not feasible to build reservoirs in the municipality (Figure 10). There are currently 70 collection wells that distribute water to the entire urban area.

Fig. 5.6.10 – a) Control system of reservoirs; b) Disposal in yellow color is the wells' water treatment 'station'; c) Well water pumping station; d) Water reservoir.

In Campina Grande (PB) city, the water supply comes from reservoir Epitácio Pessoa, located in Boqueirão (PB) municipality, 46 km far from Campina Grande. Water is transported from one

municipality to another through pipelines and during the period from 2012 to 2017 the supply was affected due to the low level of the reservoir, as quoted by Meneses et al. (2022). After the transposition of São Francisco River, the level of Epitácio Pessoa reservoir was stabilized (Figure 11a), although the level never reached more than approximately 65% of its capacity (Figure 11b).

In Pernambuco (PE), even though Caruaru and Garanhuns collect water from springs, in Caruaru it comes from another municipality, while in Garanhuns has two main sources of water. It is worth noting that Garanhuns did not face difficulties with water supply during the 2012-2017 drought, with few impacts, most of which were caused by infrastructure (Figures 12a and 12b). In contrast, Caruaru has both problems (drought and poor water infrastructure) that were evident during the great drought (2012-2017). It is worth noting that in 2024 the city will still have water rationing; on average, residents alternate between 8 days with water and 8 days without water (Figures 12c and 12d).

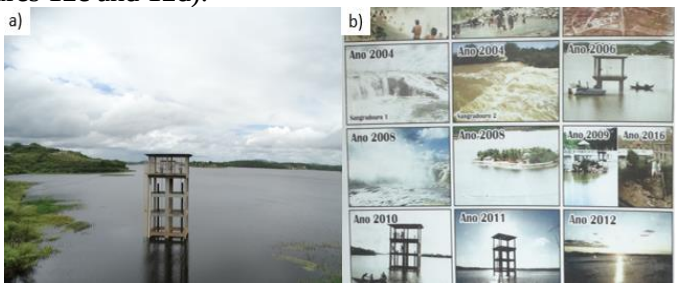


Fig. 5.6.11 – a) Epitácio Pessoa reservoir; b) Level of Epitácio Pessoa reservoir across the years.

Fig. 5.6.12 – a and b) Alternative market sale of drinking water in Garanhuns municipality; c) Storage tank for water. d) Water truck for supplying cisterns, commonly used in commercial establishments, condominiums, and middle-to-upper-class homes.

Water security and water supply are relevant topics in vulnerability studies regarding water supply in urban areas; however, only two studies highlight their assessments in the context of climate extremes. Socioeconomic indicators are the most diverse and also widely used, although the most common variables are access to water, population and income/GDP indicators.

On the other hand, there are some less used but relevant indicators, such as (i) elevation, considering that the higher the altitude, the greater the difficulty in distributing water; (ii) the cost of water; (iii) data on industries – consumption, employees – since industries that demand greater water consumption in one or more stages of their production systems require a greater volume of water and, therefore, are preferentially located in places with greater water availability.

Therefore, to better understand the variables and their uses, it is recommended to classify them according to the risk equation, considering variables such as precipitation and temperature as hazard and not vulnerability. Furthermore, based on fieldwork, variable elevation has been shown to be relevant, especially when the water distribution station (WDS) is available, since the greater the elevation gains from the WDS to the home or neighbor, the greater the vulnerability to water distribution.

5.6.5 Heavy rains and hydrogeological disasters in the city of São Sebastião on the Northern coast of the State of São Paulo, Brazil

Hundreds of families were hit by heavy rains recorded in the northern coastal region of the State of São Paulo, in southeastern region, Brazil, at the beginning of the second half of February 2023. Specifically, between February 18th and 19th, a cold front crossed the subtropical Atlantic Ocean, which was warmer on the coast of the state of São Paulo, causing intense rains that triggered landslides and floods in the municipality of São Sebastião, the oldest city on the north coast (a town founded in 1636) and one of the 15 municipalities in São Paulo considered seaside resorts by the state. The population of the municipality, according to the 2022 Census, is 81,595 inhabitants, with a demographic density of 202.77 inhabitants/km^2 and a total area of 402.395 km^2.

A detailed study of the causes and impacts of the rain resulting from the cold front, combined with the orographic effect of Serra do Mar, which culminated in an unprecedented volume of rain of 683 mm and which reached the city in less than 15 hours was conducted by Marengo et al al. (2024). It is noteworthy that on February 16th, early warnings were provided about the possibility of a critical event occurring that could trigger floods and landslides in municipalities in the Metropolitan Region and on the coast of São Paulo. Subsequently, on February 17th, forecast of extreme rains for the weekend were confirmed. Furthermore, the geo-hydrological risk forecast, released by CEMADEN, valid for February 18th, indicated a “very high” risk of hydrological processes and mass movements in municipalities in the eastern portion of the state of São Paulo. The following day, February 19th, the risk forecast continued to indicate a very high risk of geo-hydrological processes in a region that included the north coast of São Paulo (Figures 13 and 14) (Alvalá et al., 2024a). Therefore, specific alerts of hydrological and geological risks that should trigger the contingency plan of the municipality of São Sebastião were issued days in advance.

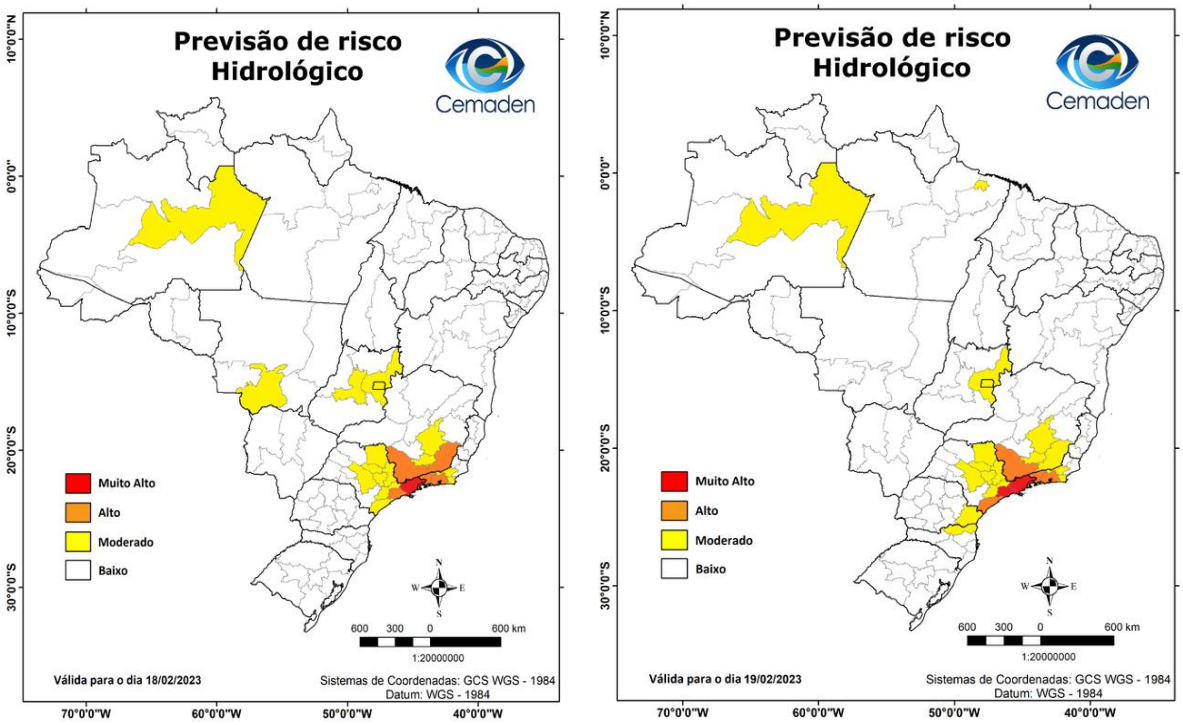


Fig. 5.6.13 – Possibility of occurrence of hydrological events at least in one municipality located in highlighted mesoregions. Map prepared by a multidisciplinary team, taking into account current hydrological risk scenarios added to the rainfall forecast.

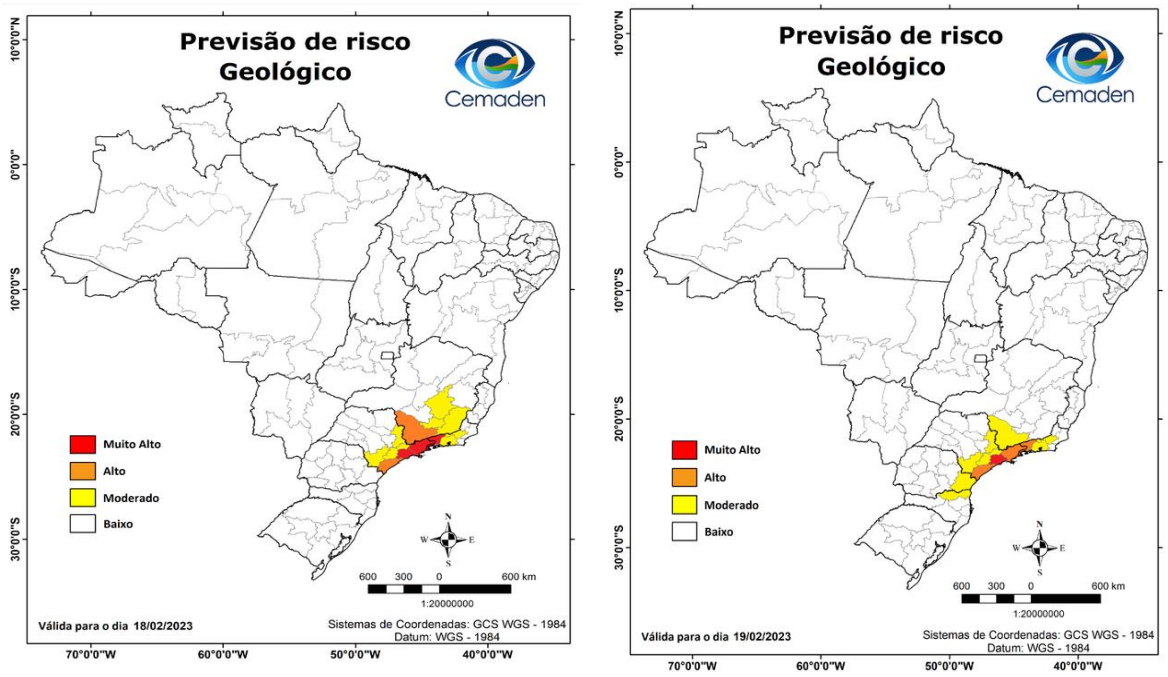


Fig. 5.6.14 – Possibility of occurrence of landslides events at least in one municipality located in highlighted mesoregions. Map prepared by a multidisciplinary team, taking into account current hydrological risk scenarios added to the rainfall forecast.

In the above context, the effectiveness of the disaster early warning system used to alert authorities and residents, as well as the detailed warnings of very high hydrological and

geological risks sent to state and municipal emergency services several days in advance were not sufficiently to save lives. Thus, people in São Sebastião were either not warned of the approaching catastrophe or, if warned, were not prepared to understand the risk to which they were subjected. In both cases, actions were not taken in time so that 65 lives were not lost and damage to infrastructure was minimized. It is noteworthy that the extreme rains recorded during the event caused a widespread collapse of slopes that were concentrated in a continuous strip approximately 40 km long and approximately 10 km wide, encompassing areas of high hills adjacent to the coast of São Sebastião and including small islands and mountainous areas (Figure 15). Therefore, there were specific clusters of landslides and flows, which resulted in extraordinary volumes of material mobilized and the consequent impacts were more severe on the beaches of Barra de Boiçucanga (434 residences in risk areas), Camburi (608 residences), Baleia (185 residences), Barra do Sahy (162 residences) and Juquehy (575 residences), totaling almost 200 residences affected. In the study, the need to improve communication in the event of an imminent disaster was also discussed, highlighting that early warning systems against multiple risks are vital for adaptation and risk reduction in areas susceptible to disasters, as well as policies must be implemented effective public policies to save lives.

Fig. 5.6.15 – Scars from the landslides that occurred in São Sebastião, SP, Brazil, on February 19, 2023.

5.6.6 Analysis of the hydrological disaster occurred in the state of Rio Grande do Sul, Brazil in September 2023: Vulnerabilities and risk management capabilities

Understanding disaster risk in all its dimensions is a priority on global agendas. This study developed an integrated analysis of flood risk drivers using a methodology based on meteorological and hydrological analyses, population vulnerability assessment, and municipal risk management capabilities from public data sources. Rio Grande do Sul, Brazil, was selected due to extreme rainfall that affected more than 400,000 people in September 2023. The hypothesis was that the vulnerability characteristics of populations and municipal disaster risk management capabilities influence the impacts of floods in affected municipalities. For this purpose, the specific objectives were developing a comprehensive analysis of the meteorological and hydrological events that affected the municipalities, with a detailed focus on the Taquari-Antas River, since this region concentrated the municipalities that presented the most deaths from the floods (Figure 16); and evaluate population vulnerability, as well as the municipal disaster risk management capabilities (Alvalá et al., 2024b).

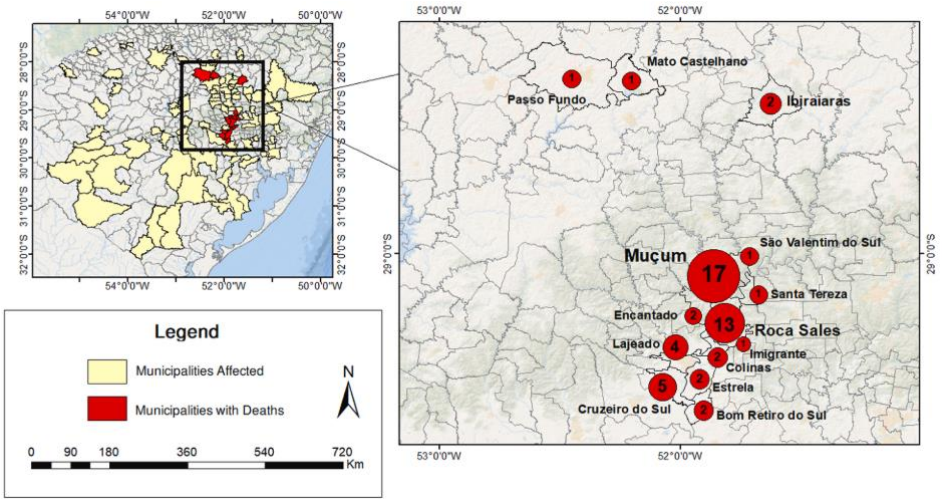


Fig. 5.6.16 – Municipalities with recorded fatalities affected by the hydrological disaster from September 1st to 7th, 2023 in RS state. The numbers represent the total deaths registered in the municipalities.

For the analysis of the meteorological information, accumulated rainfall from September 1st to 7th, 2023 recorded by instruments from the CEMADEN environmental observational network was used. Additionally, gridded data for regional domains (Satellite-based Global Precipitation Measurement - GPM) – Integrated Multi-satellite Retrievals for GPM (IMERG) combined with data from surface observations – MERGE, from the Center for Weather Forecasts and Climate Studies – CPTEC (Rozante et al., 2010) were evaluated. The hydrological data, obtained from the National Water and Sanitation Agency (ANA) and Brazilian Geological Survey (SGB), were used to estimate the return period of the peak flood according to Gumbel distribution. To evaluate the severity of the flood event, the HEC-RAS software version 5.0.7 was used, and the input data were the digital terrain model of Copernicus (30 m horizontal resolution) and the peak flood level at Muçum, estimated through High-water marks, to simulate the flood extent in the municipality. Due to the gauge station in Muçum being covered by water during the peak flood, the HEC-RAS software, developed by the US Army Corps of Engineers (BRUNNER, 1995; US ARMY CORPS OF ENGINEERS, 2021), version 6.1.0 for two-dimensional (2D) unsteady flood (US Army corps of Engineers, 2016) was used to estimate the peak flood in Muçum. The hydrodynamic modeling is based on a Digital Elevation Model (DEM) to represent the topography of the floodplain to simulate the water flow end water stage. The input data were the digital terrain model of Copernicus (30 m horizontal resolution) and the peak flood level estimated through High-water marks.

Data from the Brazilian Institute of Geography and Statistics were used to characterize the vulnerability of the region studied. Vulnerability indicators and capacities represent several dimensions, such as social, economic, infrastructure, community and institutional development. Therefore, an evaluation was conducted using data from the 2010 census, encompassing quantitative indicators related to population characteristics associated with social, economic, occupational, and infrastructural dimensions. For the evaluation of risk management capacities qualitative indicators associated with the infrastructure and institutional dimensions were selected, derived from the Profile of Brazilian Municipalities 2021 (IBGE, 2022). These indicators represent aspects that increase or decrease the population's vulnerability and the municipal disaster risk management capacities. A factorial analysis (Principal Component Analysis – PCA) using Varimax rotation, were performed. The Principal Component Analysis (PCA) as a statistical method for assessing vulnerability is widely employed in studies (Cutter et al., 2003; Hummell et al., 2016; Ribeiro et al. 2022). Its objective was to extract information from numerous variables and express it in sets of variables known as principal components (PC). PCA reduces the dimensionality of multivariate data into two or three PCs, which can be

graphically visualized with minimal loss of information. In a dataset, PCA identifies the main direction of variables, if the primary linear directions in the data exhibit the greatest variance Abdi and Williams, 2010; Asadzadeh et al., 2017; Cutter et al., 2014).

The results showed that a stationary frontal system caused unprecedented rain and floods between September 1 and 4, 2023. A quasi-stationary cold front from Argentina intensified precipitation, exacerbated by an upper-level low-pressure area. Attributed to the 2023 El Niño, these events resulted in heavy rainfall exceeding normal levels by 200–300 mm, leading to floods that affected 107 municipalities, resulting in 54 deaths and extensive property damage. The Caí and Taquari-Antas river basins were particularly affected, with river levels exceeding critical limits, causing severe floods and most deaths. Vulnerability was higher among populations of low socioeconomic status living in housing with precarious infrastructure, especially in small municipalities dependent on agriculture (Figure 17).

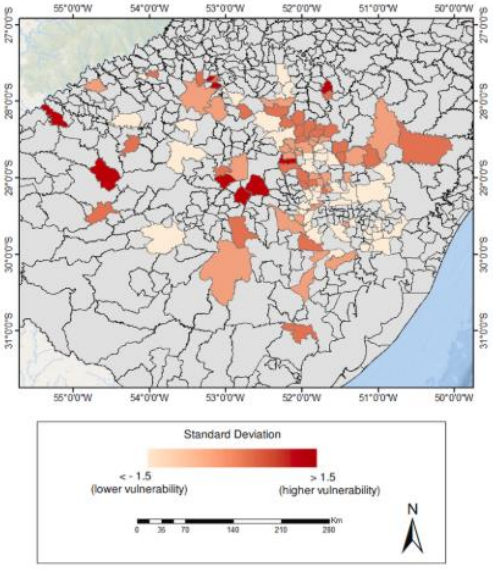


Fig. 5.6.17 – Vulnerability index for the analyzed municipalities

The high vulnerability is due to the lack of public policies that improve socioeconomic conditions, such as social action policies for agricultural workers, combating educational delays, and improvements in household infrastructure. Furthermore, municipal administrations must invest in strengthening tools, actions, and policies focused on risk response and management, and promoting educational activities in civil protection and defense, with special attention to the elderly population.

5.6.7 Community disaster resilience in Brazilian small urban centers

Approximately 94% of the Brazilian municipalities presented a population under 100.000 according to estimative provided in 2021, accounting for 42,3 % of the country's population (IBGE, 2022). These localities could be classified as small cities (Andrade e Serra, 2001). Due to the heterogeneity of these areas and considering the Brazilian urban hierarchy, these locations can be determined as small urban centers - SUCs. Brazilian small urban centers face several disasters impacts due to their singular environmental, economic, and social characteristics. The comprehension of disaster risk, capacities, and resilience of Brazilian SUCs requires an approach beyond solely considering socioeconomic indicators. Therefore, it is necessary to analyze the different dimensions contributing to the municipalities' resilience. Thus, these factors can be related to the community resilience concept. Community disaster resilience - CDR encompasses a process that addresses both a community's capacity to deal with adverse events and its adaptive capabilities in the face of uncertainties imposed by climate change (Aldunce et al., 2014; Amirzadeh and Barakpour, 2021; Kulig et al., 2013). In this study, CDR

was defined as a dynamic process by which social systems respond to and recover from risk events, drawing on inherent conditions that enable them to absorb impacts and cope with changes; as well as characteristics that support them to reorganize, change, and learn in response to an event, contributing to adaptation.

This research focused on analyzes the community disaster resilience of 213 small urban centers in the Brazilian Southeast region, affected by recurrent events, such as floods, flash floods, and landslides (Figure 18).

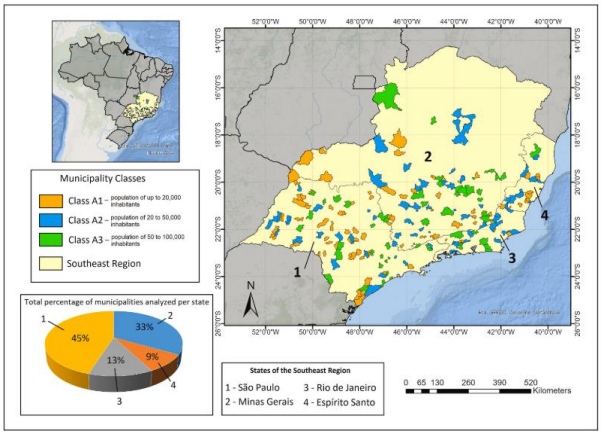


Fig. 5.6.18 – Municipalities selected for community resilience assessment. The chart presents the percentage of analyzed municipalities by state in the region.

The assessment of CDR in Brazilian SUCs is crucial in the current context. These areas may react and recover differently from large and medium-sized municipalities due to their smaller size and limited resources (Ribeiro et al., 2022). In contrast, larger municipalities tend to present more diverse and robust economic sectors, the availability of superior urban infrastructure, and specific municipal laws focused on disaster risk management, contributing to their ability to recover from disasters (Saito et al., 2021). Furthermore, in relation to the total number of municipalities affected by climate related disasters from 1991 to 2012, 75 % corresponded to municipalities with a population of less than 100,000 inhabitants (CEPED/UFSC, 2013).

The study adopted a mixed-methods approach. First, a quantitative analysis was conducted at the municipal level using statistical techniques to develop a community disaster resilience index, incorporating the follow dimensions (i) social, focused on sociodemographic aspects, such as educational level; (ii) economic, related to the financial power characteristics of populations; (iii) infrastructure, reflecting the conditions of households and urban services; iv) institutional, represented by public policies contributing to social and urban development and risk reduction; and (v) community, related to social capital, which refers to the connections and social networks formed among individuals through relationships with family, neighbors, and friends, as well as through participation and cooperation in various organizations.

Simultaneously, a qualitative assessment evaluated the levels of social capital at the intra-municipal scale among populations affected by disasters through an online questionnaire. The municipalities of Santos Dumont (MG) and Mongaguá (SP) were selected since presented the following characteristics: low CDRI levels, disaster occurrences from 2013 to 2021; and more than ten individuals directly affected by disasters.

The results demonstrated a direct correlation between community disaster resilience levels and the economic and urban development of the assessed municipalities. Lower levels of CDRI were associated with higher vulnerability of the population, characterized by limited socioeconomic

development, inadequate housing conditions, insufficient urban infrastructure for transportation, healthcare, leisure, and social support services, and ineffective implementation of public development policies. Moreover, the absence and limited diversity of leisure spaces that foster social connections contributed to reduced community engagement and participation, resulting in lower levels of social capital (Ribeiro et al, 2024).

5.6.8 Spatial **and temporal evaluation of social vulnerability in Rio Grande do Sul, Brazil**

An ongoing study is under development to conduct a spatiotemporal analysis of social vulnerability across the 497 municipalities of Rio Grande do Sul, which was recently impacted by an unprecedented disaster and over 95% of the state was affected by floods and landslides in 2024. The primary objective is to track the evolution of social vulnerability in these municipalities over the past 30 years, exploring whether the levels of social vulnerability are correlated with the impacts experienced by the municipalities over time. The study is currently in its final phase, with the results being analyzed.

The methodology adopted comprises four key steps (i) Selection and manipulation of variables for three periods 2000, 2010, and 2022; (ii) Normalization of the variables using the Adjusted Mazziotta-Pareto Index method; (iii) Development of a Principal Component Analysis, proposition of a Social Vulnerability Index, and mapping of the index for each analyzed period; (iv) Application of univariate and bivariate Moran's I index and local indicator of spatial autocorrelation analysis.

5.6.9 Identification of the vulnerable population to disasters in Brazilian capitals in the context of the early warning system

The knowledge about the population exposed in risk areas and their socioeconomic characteristics is essential to support risk reduction actions and responses to emergencies. Furthermore, it directly contributes to the definition of strategic guidelines for expanding mitigation and adaptation capabilities to climate change. Vulnerability indices are valuable tools for supporting disaster risk management and are primarily used to reduce human losses. In a previous research work, an unprecedented methodology was developed to create a population vulnerability index to support monitoring and issuing early warnings of disaster risk in Brazil (Assis Dias et al, 2020).

To improve the Brazilian early warning system, the study conducted within the scope of these study aims to update an intra-urban vulnerability population index to support the monitoring and issuance of early warnings of disaster risk for Brazilian capitals which have mapping of risk areas and are monitored by CEMADEN/MCTI. It was found that 12 Brazilian capitals are monitored by CEMADEN and have mapping data on hydrological risk areas. Considering the 12 capitals identified, the objective was to develop an index of population vulnerability to hydrological processes, named as InOV-Hidro, considering demographic data from 2010.

The first stage of the methodology for obtaining InOV-Hidro comprised the selection and processing of vulnerability indicators, while the second stage refers to the calculation of the vulnerability index. In the present study, vulnerability in the context of the BEWS is considered a guiding principle for indicating the areas that are most critically at-risk in the municipality, given the combination of residents' low capacity for response and their conditions characterized by high exposure. In other words, the synthetic vulnerability index aims to identify the areas in which the highest number of vulnerable people in the most critical conditions is concentrated in each municipality.

The population in these conditions may require the assistance and priority action of civil defense professionals during an emergency. The proposed synthetic index is based on vulnerability indicators and characterizes the conditions of residents' physical exposure in at-risk areas and their capacity for response following a disaster. Four theoretical indicators were selected that identified exposure to critical conditions and the response capacity of residents in risk areas. The four indicators are (i) the total number of exposed individuals; (ii) the total number of children and elderly who are exposed; (iii) the total number of exposed individuals who are without income or with an income per capita of less than half the minimum wage and; (iv) the total number of individuals in households with inadequate sanitation.

As a result, it was estimated that 1,029,171 people were vulnerable to hydrological processes in the 12 Brazilian capitals highlighted, based on data from 2010. In Table 1 the vulnerable population data for each Brazilian capital is available, according to the class of vulnerability is available, as well as in Figure 19 is illustrate an example of the InOV-Hidro generated for the municipality of Belo Horizonte, state of Minas Gerais.

Table 5.6.1 – List of the Brazilian Capitals with the Operational Index of Vulnerability of the population to hydrological processes and the quantitative of the exposed population by degree of vulnerability.

Municipality	**Very High vulnerability and percentage in relation to the total population at-risk**	**High vulnerability and percentage in relation to the total population at-risk**	**Medium vulnerability and percentage in relation to the total population at-risk**
Porto Velho - RO	4.168 (79.28%)	168 (3.20%)	921 (17.52%)
Rio Branco - AC	17.442 (53.11%)	6.848 (20.85%)	8.550 (26.04%)
Macapá – AP	1.047 (44.48%)	254 (10.79%)	1.053 (44.73%)
Teresina - PI	10.919 (43.85%)	8.619 (34.61%)	5.362 (21.53%)
Fortaleza – CE	38.299 (41.52%)	32.829 (35.59%)	21.116 (22.89%)
Natal - RN	51.918 (63.49%)	10.343 (12.65%)	19.509 (23.86%)
João Pessoa – PB	8.407 (67.55%)	258 (2.07%)	3.781 (30.88%)
Salvador – BA	387.391 (96.30%)	649 (0.16%)	14.247 (3.54%)
Belo Horizonte – MG	80.706 (59.82%)	39.587 (29.34%)	14.628 (10.84%)
São Paulo – SP	28.994 (12.53%)	129.801 (56.11%)	72.529 (31.35%)
Porto Alegre – RS	2.188 (27.16%)	3.426 (42.53%)	2.441 (30.30%)
Cuiabá - MT	86 (11.13%)	687 (88.87%)	0

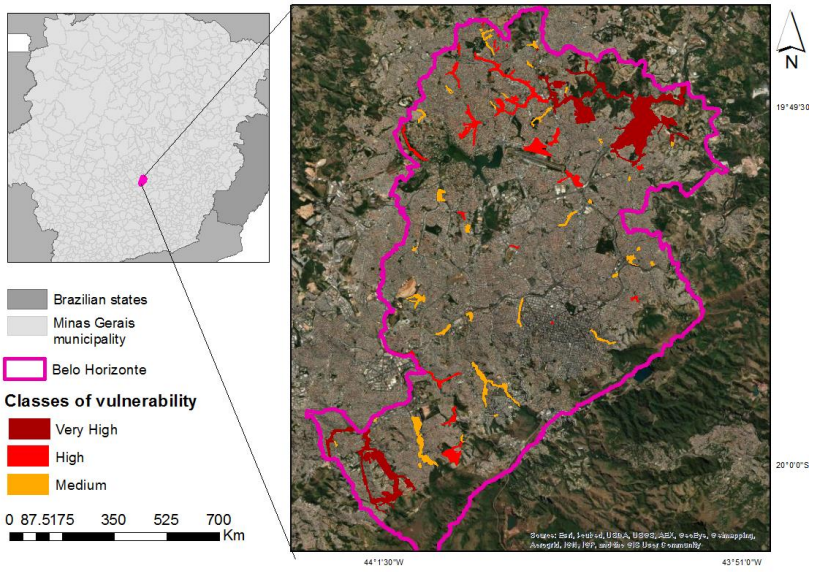


Fig. 5.6.19 – Spatial distribution of the InOV-Hidro for the city of Belo Horizonte, MG.

5.6.10 The exposure of schools and the education sector to flooding in the public calamity scenario of May 2024 in municipalities of Rio Grande do Sul, Brazil.

The floods and landslides that occurred between late April and early June 2024 in the state of Rio Grande do Sul (RS), the southernmost region of Brazil, left a trail of destruction on society, the environment, and the economy of the entire state (INPE, 2024), with repercussions for the rest of the country (Rio Grande do Sul, 2024a). The global climate emergency suggests an increase in the intensity and frequency of heavy rainfall in southern Brazil (Debone et al., 2023), which simultaneously trigger multiple types of geo-hydro-meteorological threats such as floods, flash floods, and wet mass landslides, creating complex multi-hazard scenarios (UNGA, 2016). That is already being highlighted in the region (Alvalá et al., 2024b). In particular, the significant adverse impacts of these events on schools and school communities have highlighted the vulnerability of the education sector in this state, like represented in the Table 2 in terms of damages, losses and economic cost.

Table 5.6.2 – Damages and losses of the education sector by the 2024 Rio Grande do Sul, Brazil disaster.

Mesoregion	Damaged Facilities	Destroyed Facilities	Material Damage (R$)	Public Losses (R$)
Centro Ocidental Rio Grandense	10	1	200,000.00	-
Centro Oriental Rio Grandense	26	0	17,067,492.88	69,087,263
Metropolitana Porto Alegre	129	0	277,637,665.00	14,610,000
Nordeste Rio Grandense	10	0	22,001.00	32,000
Noroeste Rio Grandense	14	0	297,500.00	12,500
Sudeste Rio Grandense	0	0	-	200,000
Sudoeste Rio Grandense	0	0	-	-
TOTAL	**189**	**1**	**BRL 295,224,658.88**	**BRL 83,941,763.05**

Source: Prepared by the authors from the S2iD disaster damage and loss database

Education needs to be understood by public authorities and other actors responsible for disaster risk management as one of the social pillars most sensitive to the effects of socio-environmental threats and as a fundamental link in climate change adaptation programs. The disaster vulnerability in this sector encompasses human factors, as emphasized by Bothe et al. (2018), which emphasized that child and youth population is at a crucial stage of physical and mental development, with limited autonomy; people under 18, especially younger people, still make up half of the disaster victims; schools accommodate a large number of students who are overseen by a smaller team of dedicated adults; the impact on the mental health and emotional well-being of the school community can lead to long-term challenges that affect multiple generations; the effects on education can extend throughout society, as the school community encompasses students, teachers, administrative staff, outsourced service providers, families connected to these individuals, and the surrounding neighborhood.

The disaster sensitivity of the Education sector also involves material aspects, such as those highlighted by Marchezini et al. (2018), whose highlighted that schools, along with hospitals, health centers, city halls, fire departments, civil defense, and essential service networks such as transportation, energy, gas, and water, are crucial infrastructures for the effective functioning of society; school buildings and equipment are vulnerable to damage and loss due to disasters; during emergency situations or public calamities, school facilities and equipment are frequently repurposed as shelters, disrupting the regular teaching and learning processes; rebuilding after a disaster can be a lengthy process, and there is no assurance that the resilience of infrastructure and equipment will be enhanced. Consequently, school communities may ultimately need to shoulder a portion of the rebuilding costs.

5.6.10 Exposure, damage and impact

This study revisits the concept of exposure as part of school vulnerability analyses and is based on the premise that there is a positive correlation between exposure, damage, and impact. Thus, the objective is to propose a methodology for estimating the degree of exposure of schools in Rio Grande do Sul state to rain-triggered events. Additionally, it aims to assess the potential damage and likely impacts of these events on both the schools and the school community. The initial analyses focused on flooding in municipalities monitored by CEMADEN and municipalities that had declared a State of Public Calamity due to the disaster in May 2024 (Rio Grande do Sul, 2024b).

The concept of "Exposure" refers to the condition in which individuals, infrastructure, residences, production processes, and other tangible human assets are situated in areas vulnerable to latent hazards. On the other hand, “Damage” describes the total or partial destruction of physical assets, impact on basic services, and disruption of livelihoods. Finally, “Impact” is the overall effect of a hazardous event or disaster, encompassing both negative and positive outcomes. It encompasses economic, environmental, and human aspects and may result in death, injury, illness, and impacts on physical, mental, and social well-being (UNGA 2016, P.13 e 19).

Concerning to material and method, firstly, the exposure is analyzed using map algebra in geographic information systems to calculate the minimum distance between the school building and the hydrological risk area (BRASIL, 2014) or the flood polygon (Antunes et al., 2024; CEMADEN, 2024). The school data is extracted from the School Census INEP (2022). The Census data preprocessing involves extracting geographic coordinates from addresses provided as attributes and selecting active schools situated in municipalities monitored by CEMADEN, as well as in municipalities that have declared a state of public calamity related to the May 2024 event (Rio Grande do Sul, 2024b). The hydrological risk mapping of the National Geological Service (BRASIL, 2014) includes the number of homes and populations located in hydrological risk areas (HRA); this information is added to the school attributes, together with the minimum

distance to the corresponding HRA. The flood zone for the extreme event of 2024, as mapped by CEMADEN, includes the name of the corresponding basin. This information is also included in the school attributes, along with the minimum distance to the corresponding polygon.

The distances obtained are categorized to express a specific level of exposure of each building. Once the fully exposed schools have been identified (distance is equal to zero), information corresponding to assets and equipment included in the INEP School Census (2022) is extracted to estimate potential material damage. Human damage to the school is estimated using information on the number of staff and students. Human damage to the school community is estimated based on data from the census sectors where the school is located, using information available in the IBGE Census (2022). The calculation of public loss considers the number of school days missed and the cost per student/day, categorized by municipality and state. Finally, the "school impact estimate" refers to an index that combines the estimated damages and losses.

As highlights, the methodology presented corresponds to the first relevant result of this study. It integrates multiple official databases to compile detailed information for aggregate to the school census, which in turn can be utilized in disaster risk management in the scope of the education sector. The preliminary results are related to the phase of categorizing the degree of exposure of schools to distances to risk areas (Table 3) and flood polygon (Table 4). From Table 3 it can be inferred that, during typical flood conditions, 42% (1278) of the schools in CEMADEN-monitored municipalities are situated within 1 km far from of the hydrological risk areas. The schools facing the most critical situation are those located in the municipalities being monitored by CEMADEN in a state of public calamity during the 2024 disaster (Figures 20 and 21).

Table 5.6.3 – Degree of exposure of schools of monitoring municipalities according to distance to risk areas

	E	**PC**	**NM**	**TOTAL**	**%**	**% Accumulated**
N° Municipalities	13	23	2	39		
N° Total of schools	387	2551	100	3038		
N° Schools in HRA	19	93	6	118	4%	4%
> 0 to 100 m	19	97	7	123	4%	8%
100 to 200m	28	121	5	154	5%	13%
200 to 500m	62	279	18	359	12%	25%
500 to 1000m	113	389	22	524	17%	42%
> 1000m	146	1572	42	1760	58%	100%

E: Municipalities in Emergency; PC: Municipalities in Public Calamity.
NM: Municipalities in Normality; HRA: Hydrologic Risk Area

In the context of the disaster occurred in 2024, the schools facing the most critical situation are those located in the distances between 0 and 100 m, approximately 608 schools. The next steps to be taken from the detailed exposure data are to estimate damages and losses and integrate the data into the proposed impact index, as outlined in the materials and methods.

Table 5.6.4 – Degree of exposure of schools of municipalities in public calamity according to distance to flood polygon, grouped by basin

Basin	**N° MUN**	**0 m**	**> 0 to 100 m**	**100 to 200 m**	**200 to 500 m**	**500 to 1000 m**	**> 1000 m**	**Total x Basin (0 m to 1 km)**

Cai	8	15	35	26	27	11	411	114
Gravatai	4	37	31	18	57	104	1018	247
Guaiba	8	114	109	73	129	253	640	678
Jacui	16	7	20	27	47	60	215	161
Jaguari	1	0	1	1	4	2	2	8
Litoraneas	5	45	67	68	120	49	79	349
Maquiné	1	5	8	0	1	0	0	14
Pardo	11	16	14	16	43	67	199	156
Sinos	15	191	103	68	171	112	406	645
Taquari	38	81	94	58	104	124	656	461
Toropi	1	0	1	0	0	0	3	1
Uruguai	3	2	1	1	3	0	2	7
Total x Distance	**95**	**513**	**484**	**356**	**706**	**782**	**3631**	**2841**

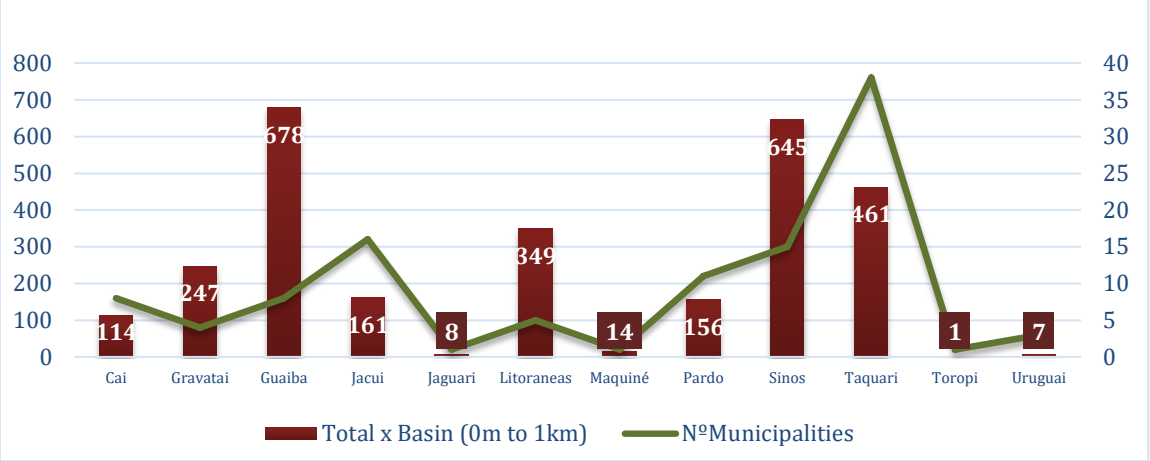


Fig. 5.6.20 – Degree of the exposure of schools in several municipalities declared in public calamity according to the distance to flood polygon, grouped by basin (left axis) and number of municipalities (right axis).

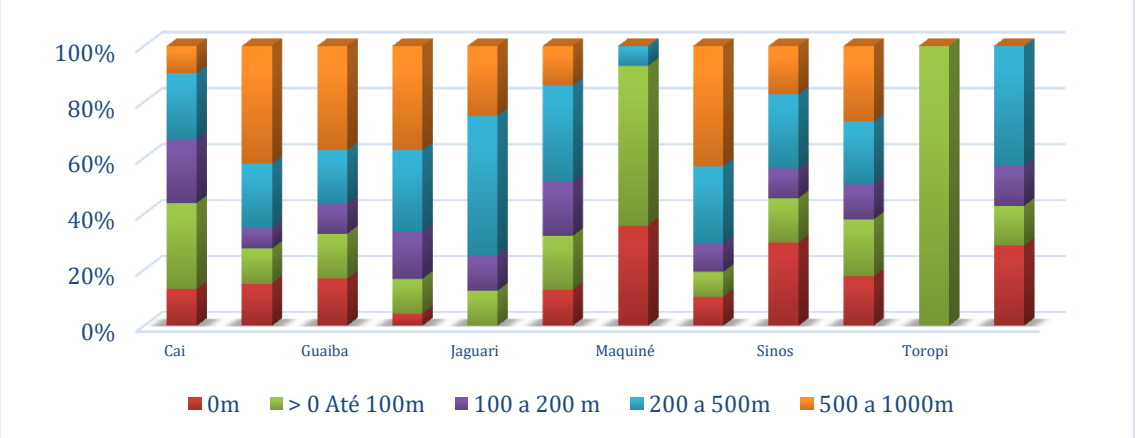


Fig. 5.6.21 – Percentage of the exposure of schools in several municipalities declared in public calamity according to distance to flood polygon, grouped by basin.

To confirm the accuracy of the results for each municipality, we will rely on impact data provided by the state and federal governments. Validating the data at the local level presents a more complex challenge, as it involves reaching out to all the affected schools. The work received support from several schools, facilitated by teachers from the National Network of Solidarity with Schools in Rio Grande do Sul Affected by the Socio-Environmental Tragedy (**Há-Braços**). This network was established in response to the disaster as a nationwide effort to provide solidarity and help with the repair and reconstruction of schools in the area.

After analyzing the exposure data and drawing from the practical experience and guiding principles of the CEMADEN Education Program, we discussed the potential capabilities that could be integrated into the "School-Centered Disaster Monitoring and Alert System". These capabilities aim to mitigate the current impact of disasters, promote adaptation to climate change, and increase the resilience of the education sector in RS, particularly in the face of extreme events.

5.6.11 – Additional contribution to the INCT-MC-II

Throughout the INCT-MC-II project, several studies were developed focusing on the municipality of Blumenau, especially in the assessment of risks related to landslides, as well as other studies carried out on a national scale that highlighted the state of Santa Catarina as a one of the states with the highest climate risk, in the present and future, associated with landslides. These contributions were fundamental to compose the proposal for the project "Multiscale early warning system for landslides integrating high-resolution meteorological products, geotechnical and population characteristics", submitted to the CNPq/MCTI Call Nº. 15/2023 "Extreme Meteorological Events: Prevention of Natural Disasters and Minimization of Damage", under the coordination of Dr. Pedro Camarinha, member of the INCT-MC-II. The aforementioned project was approved in December 2023 and aims to develop a multi-scale landslide early warning system for the entire state of Santa Catarina, with Blumenau being one of the municipalities chosen to apply the module with risk analysis on an intra-municipal scale (high resolution). Therefore, the mentioned research project will contribute to advances related to the INCT-MC-II project.

REFERÊNCIAS

Abdi, H.; Williams, L. J. Principal component analysis. Wiley Interdisciplinary Reviews: Computational Statistics, [S. l.], v. 2, n. 4, p. 433–459, 2010. DOI: 10.1002/wics.101. Disponível em: https://wires.onlinelibrary.wiley.com/doi/abs/10.1002/wics.101.

Aldunce, P.; Beilin, R.; Handmer, J.; Howden, M. Framing disaster resilience: The implications of the diverse conceptualisations of "bouncing back". Disaster Prevention and Management, [S. l.], v. 23, n. 3, p. 252–270, 2014. DOI: 10.1108/DPM-07-2013-0130. Disponível em: https://www.emerald.com/insight/content/doi/10.1108/DPM-07-2013-0130/full/html.

Alvalá, R. C. S.; M. C. Assis Dias, S. M. Saito, C. Stenner, C. Franco, P. Amadeu, J. Ribeiro, R. A. S. M. Santana, C. A. Nobre. Data for: Mapping characteristics of at-risk population to disasters in the context of Brazilian early warning system. Mendeley data, v1, (2019). http://dx.doi.org/10.17632/36zkrpjs7z.1

Amirzadeh, M.; Barakpour, N. Strategies for building community resilience against slow-onset hazards. International Journal of Disaster Risk Reduction, [S. l.], v. 66, p. 102599, 2021. DOI: 10.1016/j.ijdrr.2021.102599. Disponível em: https://linkinghub.elsevier.com/retrieve/pii/S2212420921005604.

Andrade, T. A.; Serra, R.V. Cidades Médias Brasileiras. Rio de Janeiro: IPEA - Instituto de Pesquisa Econômica Aplicada, 2001.

Asadzadeh, A.; Kötter, T.; Salehi, P.; Birkmann, J. Operationalizing a concept: The systematic review of composite indicator building for measuring community disaster resilience. International Journal of Disaster Risk Reduction,

[S. l.], v. 25, p. 147–162, 2017. DOI: 10.1016/j.ijdrr.2017.09.015. Disponível em: https://linkinghub.elsevier.com/retrieve/pii/S2212420917302364.

Assis Dias, M.; Saito, S. M.; Alvalá, R. C. S.; Seluchi, M. E.; Bernardes, T.; Camarinha, P. I. M.; Stenner, C.; Nobre, C. A. Vulnerability index related to populations at-risk for landslides in the Brazilian Early Warning System (BEWS). International Journal of Disaster Risk Reduction, v. 49, p. 101742, 2020. https://doi.org/10.1016/j.ijdrr.2020.101742.

Bothe, D. A.; Olness, K. N.; Reyes, C.; (2018). Overview of Children and Disasters. Journal of Developmental & Behavioral Pediatrics 39:652–662, (2018). DOI: 10.1097/DBP.0000000000000600. PMID: 30059416.

BRASIL. MINISTÉRIO DA INTEGRAÇÃO E DO DESENVOLVIMENTO REGIONAL. SECRETARIA NACIONAL DE PROTEÇÃO E DEFESA CIVIL. (2024a). Sistema Integrado de Informações sobre Desastres – S2iD. Relatório Gerencial - Danos Informados. Disponível em https://www.gov.br/mdr/pt-br/assuntos/protecao-e-defesa-civil/sistema-integrado-de-informacoes-sobre-desastres. Acesso em 16 de junho de 2024.

BRASIL. MINISTÉRIO DE MINAS E ENERGIA. GESTÃO TERRITORIAL. PREVENÇÃO DE DESASTRES. (2024b). Setorização de Riscos. Produtos por Estado. Setorização de Riscos Geológicos. Período de elaboração 2011 - 2024. Disponível em https://www.sgb.gov.br/produtos-por-estado-setorizacao-de-riscos-geologicos. Acesso em 16 de junho de 2024.

Brunner, G. W. HEC-RAS River Analysis System. Hydraulic Reference Manual. [s.l: s.n.].

CEPED/UFSC. Atlas Brasileiro de Desastres Naturais 1991 a 2012Centro Universitário de Estudos e Pesquisas Sobre Desastres, Universidade Federal de Santa Catarina. Florianópolis. Disponível em: https://s2id.mi.gov.br/paginas/atlas/.

Cutter, S. L.; Ash, K. D.; Emrich, C. T. The geographies of community disaster resilience. Global Environmental Change, [S. l.], v. 29, p. 65–77, 2014. DOI: 10.1016/j.gloenvcha.2014.08.005.

Cutter, S. L.; Boruff, B. J.; Shirley, W. L. Social Vulnerability to Environmental Hazards. Social Science Quarterly, [S. l.], v. 84, n. 2, p. 242–261, 2003. DOI: 10.1111/1540-6237.8402002. Disponível em: https://onlinelibrary.wiley.com/doi/10.1111/1540-6237.8402002.

Debone, D.; Tavella, R. A.; Colombo, A. L.; Gales, A. C.; Da Silva Júnior, F. M. R.; Miraglia, S. G. E. K. Is It Time to Build an Ark? The Reality of Climate Change in One of the Worst Climate Tragedies in Brazil. Preprints 2024, 2024061702. https://doi.org/10.20944/preprints202406.1702.v1

Deng, H., Song, X., Li, C., Li, Y., Diao, H., and Xu, J. Comprehensive Evaluation on Urban Water Security Based on the Novel DPEBLR Concept Model and the Cloud Matter-Element Model: A Case Study of Chongqing, China, Water (Switzerland), 14, https://doi.org/10.3390/w14213486, 2022.

Deusdará-Leal, K. R., Cuartas, L. A., Zhang, R., Mohor, G. S., de Castro Carvalho, L. V., Nobre, C. A., Mendiondo, E. M., Broedel, E., Seluchi, M. E., and dos Santos Alvalá, R. C.: Implications of the New Operational Rules for Cantareira Water System: Re-Reading the 2014-2016 Water Crisis, J. Water Resour. Prot., 12, 261–274, https://doi.org/10.4236/jwarp.2020.124016, 2020.

Dong, X., Jiang, L., Zeng, S., Guo, R., and Zeng, Y.: Vulnerability of urban water infrastructures to climate change at city level, Resour. Conserv. Recycl., 161, 104918, https://doi.org/10.1016/j.resconrec.2020.104918, 2020.

Galvão, T. F., Tiguman, G. M. B., Sarkis-Onofre, R., Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuinness, L. A., Stewart, L. A., Thomas, J., Tricco, A. C., Welch, V. A., Whiting, P., and Moher, D.: A declaração PRISMA 2020: Diretriz atualizada para relatar revisões sistemáticas, Epidemiol. e Serv. Saude, 31, 1–20, https://doi.org/10.5123/S1679-49742022000200033, 2022.

Grasham, C. F., Korzenevica, M., and Charles, K. J.: On considering climate resilience in urban water security: A review of the vulnerability of the urban poor in sub-Saharan Africa, Wiley Interdiscip. Rev. Water, 6, 1–11, https://doi.org/10.1002/WAT2.1344, 2019.

Haak, L.; Pagilla, K. The Water-Economy Nexus: a Composite Index Approach to Evaluate Urban Water Vulnerability, Water Resour. Manag., 34, 409–423, https://doi.org/10.1007/s11269-019-02464-9, 2020.

Hummell, B. M. de L.; Cutter, S. L.; Emrich, C. T. Social Vulnerability to Natural Hazards in Brazil. International Journal of Disaster Risk Science, [S. l.], v. 7, n. 2, p. 111–122, 2016. DOI: 10.1007/s13753-016-0090-9.

IBGE – Instituto Brasileiro de Geografia e Estatística. Censo Demográfico 2022. Disponível em: https://www.ibge.gov.br/estatisticas/sociais/trabalho/22827-censo-demografico-2022.html

IBGE. Perfil dos Municípios Brasileiros: 2021. Rio de Janeiro: IBGE, Coordenação de População e Indicadores Sociais, 2022.

IBGE: Sinopse do Censo Demográfico 2010, Instituto Brasileiro de Geografia e Estatística - IBGE, Rio de Janeiro, 2011.

Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira, INEP. (2024). Censo Escolar 2023. Microdados. Disponível em https://www.gov.br/inep/pt-br/assuntos/noticias/censo-escolar/mec-e-inep-divulgam-resultados-do-censo-escolar-2023. Acesso em 16 de junho de 2024.

Instituto Nacional de Pesquisas Espaciais, INPE (2024). Evento extremo no Rio Grande do Sul entre final de abril e início de maio de 2024. Relatório Técnico. Disponível em: https://www.gov.br/inpe/pt-br/assuntos/ultimas-noticias/relatorio-do-inpe-explica-evento-meteorologico-que-causou-a-tragedia-no-rs/chuvas-rio-grande-do-sul.pdf/view

Kulig, J. C.; Edge, D. S.; Townshend, I.; Lightfoot, N.; Reimer, W. Community Resiliency: Emerging Theoretical Insights. Journal of Community Psychology, [S. l.], v. 41, n. 6, p. 758–775, 2013. DOI: 10.1002/jcop.21569. Disponível em: https://onlinelibrary.wiley.com/doi/10.1002/jcop.21569.

Marchezini, V.; Aguilar Muñoz, V.; Trajber, R. (2018). Vulnerabilidade escolar frente a desastres no Brasil. **Territorium** 2018-01-25 DOI: 10.14195/1647-7723_25-2_13

Meneses, R. A.; Martins de Andrade, R.; Brito, H. C. De; Alves, P. B. R.; Rufino, I. A. A. Operação De Sistemas De Abastecimento Em Épocas De Crise Hídrica: O Caso De Campina Grande (2012-2017), XVI Simpósio Recur. Hídricos do Nord. 15o Simpósio Hidráulica e Recur. Hídricos dos Países Língua Port., 10, 2022.

Page, M. J.; McKenzie, J. E.; Bossuyt, P. M.; Boutron, I.; Hoffmann, T. C.; Mulrow, C. D.; Shamseer, L.; Tetzlaff, J. M.; Akl, E. A.; Brennan, S. E.; Chou, R.; Glanville, J.; Grimshaw, J. M.; Hróbjartsson, A.; Lalu, M. M.; Li, T.; Loder, E. W.; Mayo-Wilson, E.; McDonald, S.; McGuinness, L. A.; Stewart, L. A.; Thomas, J.; Tricco, A. C.; Welch, V. A.; Whiting, P.; Moher, D. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews, BMJ, 2021, n71, https://doi.org/10.1136/bmj.n71

Projeto Mapbiomas: A dinâmica da superfície de água do território brasileiro, 2021.

Qiao, Y.; Chen, Y.; Lu, H.; Zhang, J. Integrating water-related disaster and environment risks for evaluating spatial–temporal dynamics of water security in urban agglomeration, Environ. Sci. Pollut. Res., 29, 58240–58262, https://doi.org/10.1007/s11356-022-19832-5, 2022.

Ribeiro, D. F.; Saito, S. M.; Alvalá, R. C. S. Disaster vulnerability analysis of small towns in Brazil. International Journal of Disaster Risk Reduction, [S. l.], v. 68, p. 102726, 2022. DOI: 10.1016/j.ijdrr.2021.102726. Disponível em: https://linkinghub.elsevier.com/retrieve/pii/S2212420921006877.

Rio Grande do Sul. Defesa civil do Rio Grande do Sul (2024a). Balanço das enchentes no RS – 10/7. 2024. Disponível em: https://defesacivil.rs.gov.br/defesa-civil-atualiza-balanco-das-enchentes-no-rs-10-7

Rio Grande do Sul (2024b). Decreto N°57.646. Diário Oficial [do] Estado do Rio Grande do Sul, Governador do Estado, Porto Alegre, 30 mai. 2024. 12p.

Rozante, J. R; Moreira, D. S.; De Goncalves, L. G. G.; Vila, D. A. Combining TRMM and Surface Observations of Precipitation: Technique and Validation over South America. Weather and Forecasting, [S. l.], v. 25, n. 3, p. 885–894, 2010. DOI: 10.1175/2010WAF2222325.1.

Saito, S. M.; Assis Dias, M. C.; Ribeiro, D. F.; Alvalá, R. C. S.; Souza, D. B.; Santana, R. A. S. M.; Souza, P. A.; Ribeiro, J. V. M.; Stenner, C. Disaster risk areas in Brazil: outcomes from an intra-urban scale analysis. International Journal of Disaster Resilience in the Built Environment, [S. l.], v. 12, n. 2, p. 238–250, 2021. DOI: 10.1108/IJDRBE-01-2020-0008. Disponível em: https://www.emerald.com/insight/content/doi/10.1108/IJDRBE-01-2020-0008/full/html.

United Nations General Assembly. (2016). Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction. UNGA, 2016. 39p. Disponível em https://www.preventionweb.net/files/50683_oiewgreportenglish.pdf. Acesso em julho 2024.

US ARMY CORPS OF ENGINEERS. HEC-RAS River Analysis System, 2D Modeling User's Manual. Version 5.0. [s.l.] : Hydrologic Engineeering Center, 2016.

US ARMY CORPS OF ENGINEERS. HEC-RAS River Analysis System. Version 6.1.0. User's Manual. [s.l.] : Hydrologic Engineering Center, 2021.

Waly, N. M.; Ayad, H. M.; Saadallah, D. M. Assessment of spatiotemporal patterns of social vulnerability: A tool to resilient urban development Alexandria, Egypt, Ain Shams Eng. J., 12, 1059–1072, 2021.https://doi.org/10.1016/j.asej.2020.07.025

Wilche-Chaux, G. La Vulnerabilidad Global, in: Los desastres no son naturales, 166, 1993.

5.7 Economy and impacts in key sectors

The most important results achieved by the group during the seventh year of the project are related to continuing applications of different tools and databases developed throughout the project by various modeling initiatives. Given our international collaboration networks, some of such tools have been applied to other countries looking at the economic propagation of disruptive events. Some of such applications include (i) models for Egypt to access and better apply risk data, including hazard, vulnerability, and exposure data relating to complex climate futures (ii) multi-hazard probabilistic risk assessments for Costa Rica and Eswatini modeling how cascading and compounding risks contribute to inter-connected socio-economic impacts in the respective risk landscape of these countries, the objective of which was to inform national budgeting and planning priorities as well as options for risk reduction and risk sharing, and (iii) an integrated modeling framework developed to provide an economic assessment of the economic impacts of the 2023 earthquake in Morocco including the potential effects of the reconstruction plan.

Moreover, researchers quantified blue economy contributions in Brazil and analyzed coast-hinterland economic interdependence through interregional linkages The study advances by adopting a multi-level approach, analyzing municipality and state-level data of ocean-related activities. Using an interstate input-output model, they estimated the blue economy's value chains, enhancing the understanding of its systemic impacts. The study addresses gaps in national, regional, and local blue economy assessments, providing insights for tailored policies in Brazil's diverse coastal regions as Brazil aims for UN Sustainable Development Goal 14 by 2030.

Finally, we started a new modeling research project to apply an integrated environment-economic modeling approach to calculate the net effect of the Brazilian tax reform on land-use change in the Legal Aamazon. The model will also provide estimates for national and regional economic indicators such as GDP, employment, and other usual macroeconomic variables over time. A bottom-up spatial CGE model, calibrated for Brazil, serves as the core of the integrated modeling system. The results will inform policymakers of the potential impacts of the current tax reform focusing on its national and regional economic effects and unintended consequences on deforestation (Figure 1).

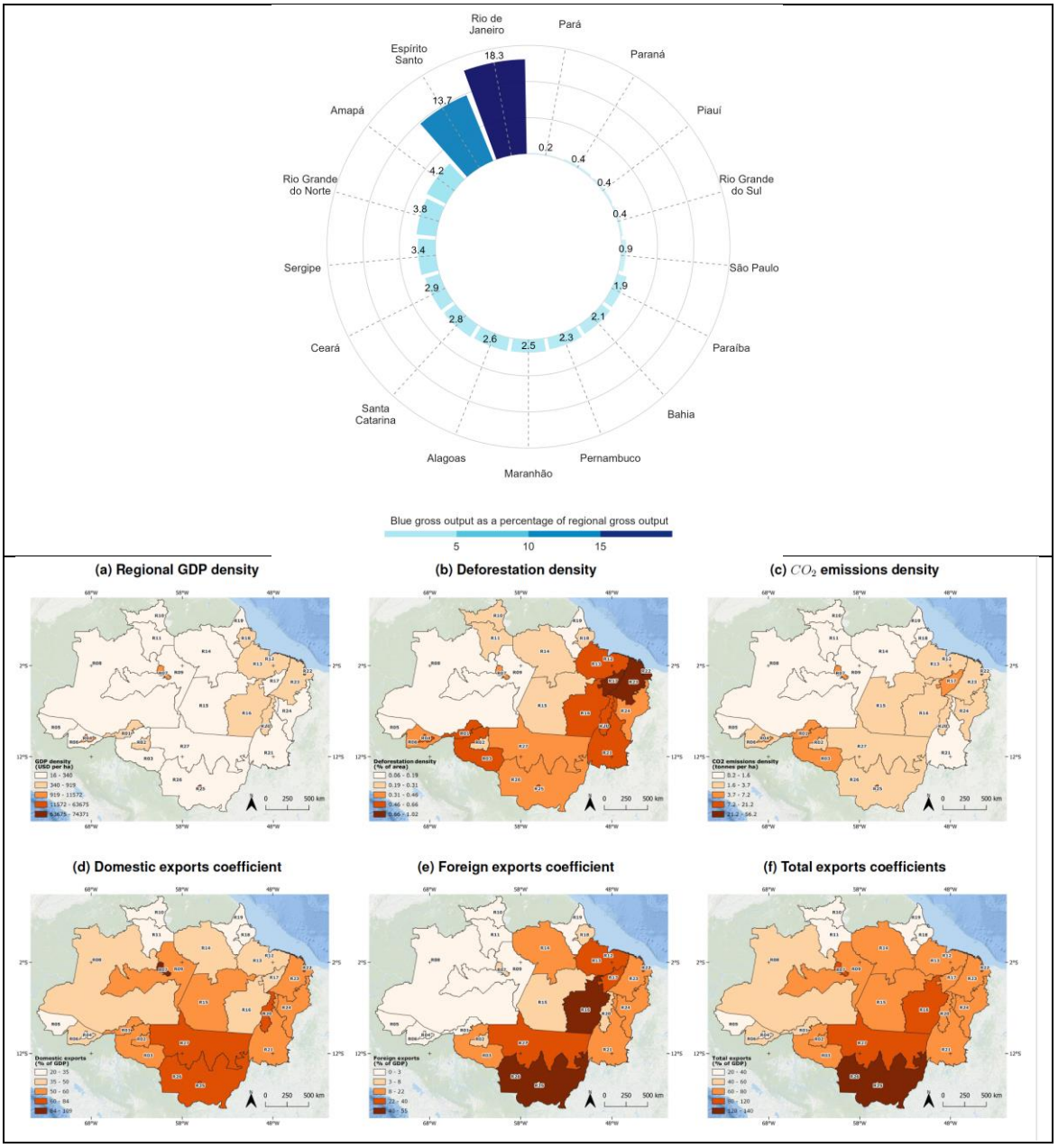


Figure 5.7.1. Estimates for national and regional economic indicators such as GDP, employment, and other usual macroeconomic variables over time.

5.7.1 **Summary of activities**

The objective of the subcomponent remains the same:

- *"To provide policymakers and society in general with quantitative results of rating studies of the economic costs associated with impacts of climate change, to subsidize a more systematic way, the design of sectoral and global public policies aimed at reducing climate vulnerability."*

Activities of Work Package # 1 (Integrated modeling) have focused on developing integrated modeling approaches to generate quantitative results associated with the impacts of climate change. We continued to focus on one of the areas that received more attention in years 1-6, namely, dealing with uncertainty in physical models and the implications for economy-wide impacts.

We have also reinforced our efforts in two other key areas, developed since years 3-6, which include: (i) the water and economic modeling integration; and (ii) modeling uncertainty and risk assessment in the context of unexpected events. In the latter case, we have teamed up with colleagues from Cornell Universit (USA), led by Prof. Kieran Donaghy, to devise alternative methodological approaches to integrate risk assessment models and CGE models. Using modeling of conflicts in Iraq, this partnership has advanced in bringing additional insights and understanding of the economic consequences of unscheduled events. We learn from this modeling experience and try to inform groups from the INCT better and elsewhere dealing with the economic impacts of floods, sea-level rise and other climate-related effects. In this respect, a project with the World Bank ("Egypt's Sustainable Cities Review: Assessing the Impacts of Climate Shocks and Policy Reform in Egypt") has been concluded to examine the economic contribution of the cities to the overall regional Gross Domestic Product (GDP) based on climate change scenarios (i.e., RCP 4.5 and RCP 8.5), and how it varies under different climate shocks scenarios, such as extreme weather events (e.g., heat wave, drought, flash flood) or changes (e.g., sea level rise). A first joint paper entitled "Geographical Propagation of the Economic Impacts of Extreme Events" has been submitted for publication to *Nature Communications* (NCOMMS-24-34033).

During the seventh year of INCT MC 2, the activities related to Work Package #2 focused on two main themes: (i) development of land-use models related to economic drivers of deforetation in the Amazon; and (ii) development of econometric models to assess adaptation to climate shocks through chemical technologies.

5.7.2 Related projects

We have also continued developing specific projects within the INCT Climate Change Project, complementing the funding received. In this context, the following projects funded by Fapesp should be mentioned: (i) "Urbanização e Mudanças Climáticas: Análises de Impacto na Região Metropolitana de São Paulo" (Doctorate, 2018/08833-5, granted); (ii) "Agricultural and Agro-Industrial Sustainability in Chile: Modeling the Impacts of Climate Change and Natural Disasters in an Integrated Framework" (CONICYT - Regular Research Project, 2018/08337-8, granted); (iii) "Fertility and Inequality: Evidence from Brazil " (Fellowship Abroad, 2018/06782-4, granted); (iv) "Uma Análise Espacial de Impacto da Acessibilidade à Água na Produção Agropecuária do Semiárido Brasileiro" (Scientific Initiation, 2018/11799-3, granted); (v) "The Economics of Low Carbon Markets – 2018" (Scientific Event Organization, 2018/17781-9, granted); (vi) "Assessing the Climate and Weather Effects in Brazil using Panel Data" (Fellowship Abroad, 2018/02081-1, granted); (vii) "The Economics of low Carbon Markets" – 2019 (Scientific Event Organization, 2019/13756-2, granted)

Recent Fapesp projects associated with the INCT include: (i) "The impact assessment of extreme events: an integrated approach with computable general equilibrium and risk analysis" (Fellowship Abroad, 23/06525-0, granted); (ii) "National crises, regional economic cycles, and disparities" (Visiting Researcher Grant – International, 23/01483-7, granted), (iii) "Impact of gender diversity on several approaches" (Doctorate, 22/05452-6, granted).

Throughout the past seven years, we have also succeeded in receiving additional funding from other sources, such as:

Instituto Escolhas: (i) "O impacto da crise hídrica no sistema público de saúde da Região Metropolitana de São Paulo", Tales Rozenfeld (Ariaster Chimeli); (ii) "Transição florestal e instituições: evidências dos últimos 50 anos no estado de São Paulo", Keyi Ando Ussami (Ariaster Chimeli); (iii) "Choque China: efeitos sobre saúde e meio ambiente no Brasil", Victor Simões Dornelas (Ariaster Chimeli); and (iv) "Mudanças Climáticas e Secas no Brasil: Uma

Análise Espacial Integrada a partir de Modelos IEGC e Monitoramento Climático no Semi-Árido Brasileiro", Bruno Proença Pacheco Pimenta (Eduardo A. Haddad).

CNPq: call "CNPq/MCTI Nº 23/2020 – PESQUISA E DESENVOLVIMENTO EM SUSTENTABILIDADE URBANA E REGIONAL", with the project "MODELAGEM INTEGRADA E PROPOSIÇÃO DE INDICADORES PARA SUSTENTABILIDADE REGIONAL E URBANA NO BRASIL", led by Prof. Roberto Schaeffer (COPPE-UFRJ) with the participation of members of this component as PIs. The Project is related to *Adapta-Brasil*.

CNPq: call "59/2022 - Linha 3 - Simulações Econômicas para Propostas de Crescimento Verde", with the project "Rede de Modelagem em Simulações Econômicas para Propostas de Crescimento Verde", led by Prof. Eduardo Haddad (FEAUSP). The project started during the sixth year.

Other sources: Finally, we succeeded in other initiatives for additional fundraising, including a project funded by the World Resources Institute, the New Economy for the Amazon (NEA) project; and collaborations with COPPE-UFRJ in projects for the states of Minas Gerais and Pernambuco.

In 2024, we have started negotiations with the **Bezos Earth Fund** to be part of the Green Macroeconomic Modeling Initiative (GMMI). GMMI is bringing together leading economic modeling and analysis teams from around the world to analyze the economy-wide impacts of green economic transitions; test new analytical approaches; and compare results in a rigorous, organized, and collaborative process. The GMMI is a forum for leading practitioners to learn from one another and build the collaborations needed to support policy making around green economic transitions.

Teams participating in the GMMI will analyze the economy-wide implications of one or more national policies or strategies of their choosing that are meant to drive a green economic transition in their own country or regional context. For diagnostic purposes, teams will also analyze one or more stylized policies (e.g., technology subsidies).

5.8 Modelling the earth system and production of future climate scenarios to study Vulnerability, Impacts and Adaptation

5.8.1 Development of the Brazilian Earth System Model – BESM

- BESM3.0.2 - (Global Atmos BAM1.2 sigma coupled to Global Ocean MOM6 via FMS coupler from NOAA/GFDL) version has been tested with a 230-year-long integration. Figure 1a shows the AMOC strength, while Figure 1b depicts salinity and temperature time series over the northern Atlantic for the BESM3.0.2 model configuration.

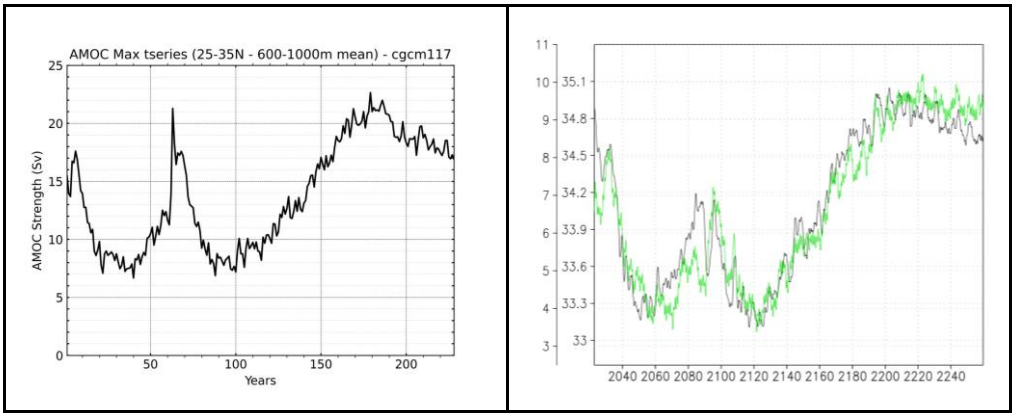


Figure 5.8.1 - Time series of (a) AMOC strength and (b) surface salinity (black) and temperature (green) over the North Atlantic for the BESM3.0.2 centennial run, experiment cgcm117. Source: Emanuel Giarolla and Paulo Nobre, personal communication (2024).

- BESM 3.0.2 - BESM 3.0.2 has been tested for seasonal predictability for 30 years (1993-2023) one year seasonal predictions initialized from MERCATOR ocean products, with ten member ensembles of November 1-10 IC. Figure 3 shows the anomaly correlation increase over the South Atlantic Convergence Zone (SACZ) due to the new initialization method, relative to the previous initialization procedure based on MOM solo spin up run, forced by observed winds.

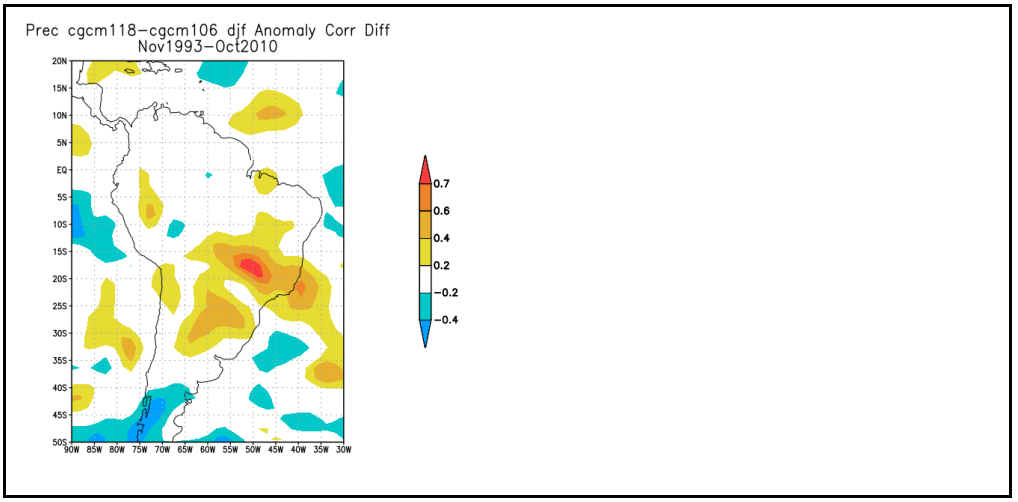


Figure 5.8.2 - Seasonal skill gain due to ocean initialization. In this case, DJF forecast period for Initial Conditions from 1-10 November of each year between 1993 and 2023.

- BESM 3.0 - low level MPI programing has been upgraded for both the low resolution **T062L42** (i.e. 200 Km horizontal grid and 42 levels in the vertical), median resolution T126L42 (i.e. 100 Km grid spacing) and the high resolution **T666L64** (i.e. 20 Km horizontal grid resolution and 64 levels in the vertical). Also, concurrent parallelism and the increase on the number of processing units has been implemented for BESM3.0. with a combined effect of up to 30% increase in the efficiency of computation in the CPU machine CRAY XC-50 at INPE.

Table 5.8.1 - BESM performance table.

Model	Resolution	Passo de tempo (sec)	No. Cores	No. task	No. threads	No. nodes	CPU (sec)/ day	CPU (hours)/month
BESM3.0_L	T062L42 (200 km)	720	280	280	1	7	40	0,33
BESM3.0_M	T126L42 (100 km)	400	400	400	1	10	118	0,98
BESM3.0_H	T666L64 (20 km)	225	2400	1200	2	60	890	7,42

- MOM6 regional grid - MOM6 ocean model has been configured to run a regional grid over southweste

rn South Atlantic. Test runs of ten years have been completed in a 7 km horizontal grid resolution.

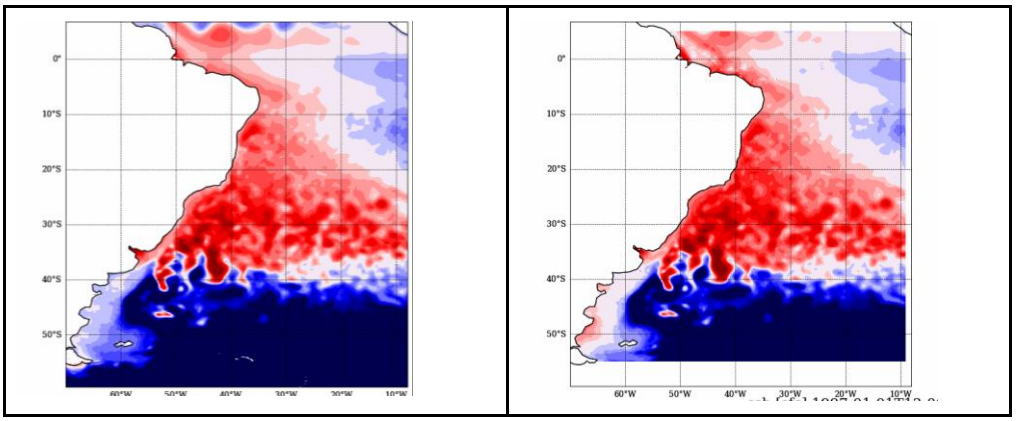


Figure 5.8.3 Sea surface height animation from (a) Glorys reanalysis and (b) MOM6 simulation on a 7 Km horizontal grid at INPE. Source: Nicole Laureanti (2024 personal communication).

5.8.2 Development of the Regional Earth System Model – Contribution to INCT-MC2

Model development

a.2.1.1 **Eta version 1.4.2** has been compiled and tested at the Lovelace supercomputer of CENAPAD-SP (Centro Nacional de Processamento de Alto Desempenho em São Paulo). One of the main features of the v1.4.2 version is the ability to run the model on multiple temporal scales (time, subseasonal, and climate change) and different spatial resolutions, being able to use non-hydrostatic or hydrostatic mode. The model is able to perform long-term simulations in a reasonable time using only one computer node with 128 processors. The Eta model has been tested with boundary conditions from ERA5 reanalysis and conditions from CMIP6 global models such as BESM and EC-EARTH3. This version of the model is documented in Gomes et al. (2023).

-Land-surface - radiation interaction: Improvements in the albedo

The Eta model's previous albedo map was based on climatological values. The new albedo depends on the model's vegetation type and with a monthly variation. In the tests for long-term runs with Eta at 20 km of horizontal resolution, the new albedo modified the interactions between the land surface and the radiative interaction; as a result, the 2-m temperature biases were reduced in some regions of the Amazon and northern Argentina (Figure E1).

a b,

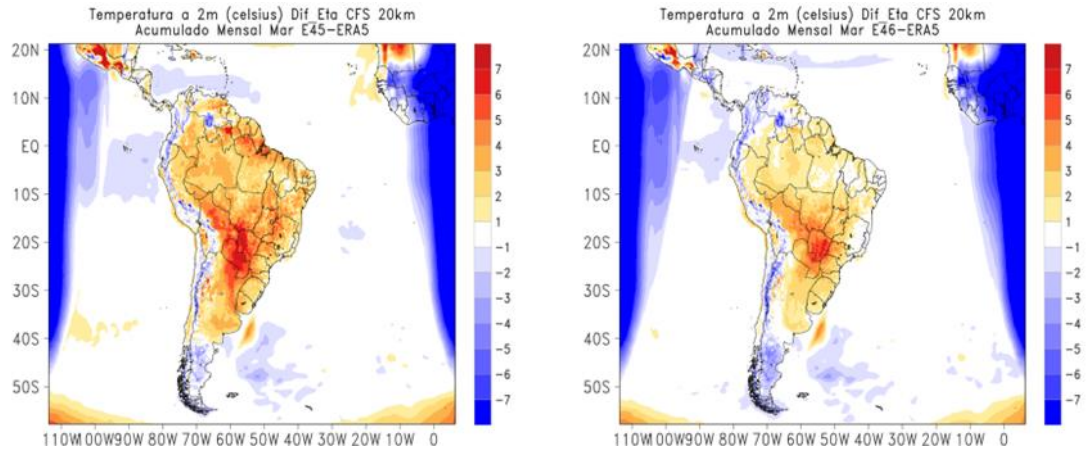


Figure 5.8.4 - 2-m temperature error (^{o}C) using climatological albedo (a) and vegetation-dependent albedo (b) forecast for March 2022. Discard the strong blue shading values, which are outside the model integration domain.

-Coupling to regional ocean model: **Eta-MOM6**

The Eta model code has been modified as preparation for the coupling to the regional ocean model MOM6. Various steps are needed to achieve the coupled system. The regional model and the ocean model become routines and are both called by the coupler FMS (Flexible Modeling System). FMS is a software framework for controlling model runs and becomes the major driver of the coupled ocean-atmosphere modeling system. The development was based on modifying the Eta code according to the FMS coding rules, and a routine was constructed named ATMOS.f90. Tests were carried out to guarantee that the output was reproduced after each set of modifications. This activity is ongoing.

5.9 Communication, dissemination of knowledge and education for sustainability.

5.9.1 Introduction

The transversal theme “Communication, dissemination of knowledge, education for sustainability” develops its actions within the scope of the Latin American Network for Scientific Dissemination and Climate Change (Rede Latinoamericana de Divulgação Científica e Mudanças Climáticas - Rede DCMC), which is composed of researchers and research institutions from Brazil, Argentina, Chile, Colombia, and Mexico. The group comprises historians, anthropologists, educators, communicators, philosophers, and natural science researchers who work in interface with the arts and humanities. In addition to academic research and publications, the group's activities make use of different languages, such as cinema, drawing, sculpture, and work with communication in many aspects – in the form of magazines, books, and the production of objects with variable materialities. In academic texts and in the production of these other materials, the main objective is to encourage reflections about our present time, marked by climate change, its causes and consequences, and how these elements mobilize new narratives, new ways of existing, new concepts and ideas, constituting relationships with varying degrees of effectiveness.

A central platform for the team's work is the ClimaCom journal, which is now eleven years old. It is a journal that combines academic production in the fields of arts, social sciences, and humanities in an interface with environmental themes, especially with the new climate regime. In addition to textual production, the publication features works by Brazilian and Latin

American artists. It also has a news and science dissemination section, besides including educational materials. In 2023, two dossiers were published at ClimaCom: Ciência.Vida.Educação (no. 24) and Desastres (no. 25). This second dossier was produced collaboratively with representatives of the disaster (José Marengo and Viviana Munhoz) and water security (Mário Mendiondo) components of INCT-MC phase 2, in addition to Gabriel Cid Garcia, member of the communication & education transversal theme and researcher at UFRJ. It was the first time that different components of INCT-MC phase 2 participated directly in the organization of a dossier. The Desastres dossier is the largest one ever published by ClimaCom, with more than four hundred pages, half dedicated to research and half to scientific dissemination and artistic productions.

Many of the works featured at ClimaCom reflect the perspective developed by the researchers over the years of taking the public as a creative power in communication and education. In other words, the public is not seen as a container, something that is given, ready, and finished, awaiting an encounter with something – scientific information – already produced in advance. Instead, the public came to be understood as a strategic creative force, with all its heterogeneity and singularities. Such an approach demands rethinking what it means to communicate and educate, calling into question, once again, the already widely criticized (but still persistent) old model of communication called the sender-receiver model, or knowledge deficit model, which presupposes the idea that there are absolute spaces and times of knowledge production which are distinct from the spaces and times in which this information is received and processed, while the structural and stylistic characteristics of the message are maintained. This model is still widely used, even if empirically, it has been proven to be ineffective. The assumption of "lack of information" disregards that all individuals have relatively complex ideas about the functioning of the world and, therefore, the environment and ecosystems. In some contexts, there is great collective investment in the development and circulation of such ideas, as in the case of the periodicity of rains in the semi-arid Northeast and its relationship with popular and traditional knowledge about the environment. Naturally, these issues also become part of political discourses and power relations. When scientific information arrives, it does not occupy empty spaces but interacts with these existing ideas. It is sucked into the whirlpool of cultural, social, and political life on different scales. For this reason, academic literature on scientific communication shows that it is more effective when the public can participate in the construction of the meanings attributed to messages. Such participation enables information to be contextualized, thus making it understandable.

There is, however, a deeper dimension to this issue. A few years ago, thinker and writer Ailton Krenak stated in an interview that we need to start "producing forests as subjectivity," as a mode of existence, not just physical forests. One way to understand what Krenak encourages us to do is to reproduce in other contexts - in different spaces, times, activities, practices, and even modes of thought - the forms of relations and actions through which life is produced and reproduced in a forest. One way in which several researchers of the transversal theme incorporated this was by adopting the perspective that communicating and educating is, among many things, producing encounters between heterogeneous actors. The goal is to replicate in diversity of thought what the forest does to diversity in relation to life – biodiversity. It is about generating active, mutual collaborations and dealing with all the problems that involve meetings as active political exercises, which are sometimes difficult. It's thinking about which encounters are possible, which are necessary, and which are effective. In terms of activities, this took shape through experimentation in the form of artistic residencies. Artistic residencies create the possibility for new encounters and experiences. These are moments of immersion in different forms of relationships outside of the scope of everyday experience.

5.9.2 Main activities

Over the past year, two artist residencies have been exceptionally powerful and productive. The first was a pilot residence called *Perceber-fazer-floresta I*. A transversal theme team went to the Amazon and visited the AmazonFace project, which is also an INCT-MC phase 2 partner, and

Parque das Tribos, in Manaus, where work was developed with a community of the Baré Indigenous people. The event resulted in the Tierra exhibition at the Gaia gallery in Campinas. The works that compose the exhibition are a small example of what happened in the residency. The second artistic residency was an experience called *Perceber-fazer-floresta II* - walking, cooking, singing, counting, and…, which took place in Campinas in May 2024, with forty people coming from various Brazilian states and South American countries, and with the participation of members of other components of INCT-MC phase 2. The event brought together researchers from the physical and natural sciences and from the humanities, Baré, Karapãna, and Guarani Kaiowá Indigenous leaders, a Quilombola community from Campinas, and artists and cultural professionals from the region. Based on these two successful experiences, new residencies will be planned for next year.

A third important activity developed last year, in a distinct line of work, was the holding of a cycle of seminars organized in collaboration with the University of Buenos Aires and Unicamp and dedicated to the work of the philosopher Bruno Latour, one of the most important contemporary authors, in the field of humanities, to address the issue of climate change. The cycle was called Ecopoetics: Education, Art and the Anthropocene, and it unfolded in ten online gatherings, where the thinker's concepts and main contributions were discussed. The meetings were broadcast live at the Youtube channel of the ClimaCom journal, where they remain available.

Researchers on the transversal theme also held many workshops, meetings, and working tables with students and teachers in the Campinas region. In these meetings, we worked with the idea of looking at the activities of science done by the other components of INCT-MC phase 2 from a different perspective beyond the idea that such work deals with resources and research objects: rivers, plants, clouds, people, stones, animals, etc. One orientation used was reframing the relationships with such beings and objects so that they came to be understood as companions in research, understanding, description, and construction of the world. In a way, research constitutes an effort to make these beings speak and express their ways of existing through mathematical models, equations, or maps. This was a strategy of building bridges of existence and thought, of sharing the perspectives of science with people. For example, just like science, native peoples, educators, and students all have their ways of dealing with reality and their different practices. Looking at the world as a large ecology of practices, we can access the ways in which each person, based on their practices, gains intimacy in their relationships with other beings and how effective and connected these practices are. One example concerns the act of *measuring* something in the world, a fundamental activity of scientific practice. An element that has been used in the meetings is the exploration of the different possibilities of the act of measuring. Everyone, in one way or another, measures something and works to produce data. A person who cooks, cleans, embroiders, measures things all the time, and, in doing so, connects things in the world. From this gesture, one can explore the many pedagogical possibilities of the act of measuring, of understanding through measurement – be it in how to construct an embroidery stitch or how to determine the probability of a catastrophic event.

Within the context of creating alliances and working on the relationships that constitute people in the world and that constitute worlds, the need arose to build a more consistent dialogue with the technologies and knowledge of Indigenous peoples, to establish relationships with their sciences, arts, and philosophies, produced in different instances, spaces and times, beyond the recognition of the existence and relevance of such forms of knowledge and action in the world. Based on the proposal of researchers on the transversal theme who have been working for many years with Indigenous thinkers and researchers, it was decided that the next dossier to be published in the ClimaCom journal will have the theme “Climate, territories and Indigenous peoples,” to be edited by the Indigenous intellectuals Valdelice Veron, Edson Kayapó, Bárbara Flores and Kellen Vilharva, together with Alik Wunder, Renzo Taddei, Emanuely Miranda and Susana Dias.

Another work front initiated this past year is a study of how the Anthropocene and climate

change have been approached and developed in undergraduate and graduate courses in Brazil and other countries in Latin America. This is an ongoing line of research.

In the journalistic field, the fellows of the transversal theme team produced a series of articles, published in ClimaCom (see list of publications). Some INCT-MC phase 2 scientists, such as Paulo Nobre and José Marengo, were recently interviewed. More interviews will be conducted in the future.

Within the academic production of researchers on the transversal theme team, a prominent item is the article *Artistic Practices in the Anthropocene*, written under the leadership of Marina Guzzo and accepted for publication in the journal Annual Review of Environmental and Resources. This is a publication that summarizes and conceptually elaborates a large number of conceptual principles and subjects with which researchers on the transversal theme have been working across the years. In the publication, however, such themes are presented in a language adjusted to the journal's target audience, mostly linked to natural sciences and engineering. The article deals with the role of artistic practices and experiments in the context of climate change and the existential challenges it brings. An important dimension of the climate environmental crisis is the way in which certain ideas crystallized around forms of social organization, economic models, political models, and ideas about the world end up materializing dysfunctional processes that generated the crisis. In this context, although the availability of scientific information is important, it proved insufficient. The question here, then, is to understand how collective patterns of perception and action in the world are constituted and how they are transformed. Academic literature shows that the visual arts played an important role in how historical transformations in the perception of the environment and its relationship with humans occurred. Landscape painting, for example, is strongly linked to social transformations that resulted in the creation of national parks in the United States. What the article argues is that, in the context of the climate and environmental crisis of the Anthropocene, what engaged artists have done is produce works that put people in the position of being able to perceive and feel the world differently and, from that, imagine the future in alternative ways.

Understanding scientific information's logical and analytical content is important but insufficient in producing the social transformations that the IPCC reports say are necessary. Artistic practices do not deal with all aspects of the problem, but they address a fundamental question, which concerns how we perceive issues, and which forms of sensitivity are fostered or disarticulated in the processes of everyday life. The argument is built around the idea that engaging in the construction of social transformations that result in a different future implies the development of different perceptions about reality. Here, the aforementioned dialogue with Indigenous peoples is particularly relevant. Authors like Ailton Krenak make us understand and think about nature and the relationship we have with it in completely counterintuitive ways. While 20th-century technical paradigms established that the Pinheiros River in São Paulo could have its course reversed for the convenience of humans and without major consequences, Krenak refers to the Doce River in Minas Gerais as his grandfather. In doing so, he offers no technical solution to the problems we have. However, this is not his intention. The idea that changing the perception of nature from a reservoir of economic resources to a context in which there are possibilities for the reproduction of life – including our own – is a necessary process is no longer controversial. However, we are incapable of managing this self-transformation through self-induction in the vast majority of cases. The unusual association of elements of the world, in the form of philosophical narratives in the case of indigenous authors such as Krenak, or experiences of sensorial immersion, as in the production of contemporary artists, seems more effective in creating the necessary ruptures and reframings that are seen as preconditions for imagining alternative futures. In many contexts, the arts more effectively induce transformations in our patterns of perception and our thoughts about the world.

Another activity developed in the last year was a collaboration with Ildenê Guimarães Loula and Rosamélia Queiroz da Cunha, researchers from the Cultural Center of the Brazilian Ministry of Health. The seminar Modes of Inhabiting the Anthropocene was organized by Renzo Taddei in

collaboration with the two researchers and took place in the Botanical Gardens of Rio de Janeiro, as an event of the 2023 National Science and Technology Week. The seminar featured speeches by Sandra Benitez, an Indigenous intellectual who is a specialist in education and the arts; Cláudio Medeiros, a philosopher at the Fluminense Federal University; Rafael Pena Rodrigues, ecologist and director of the Rio de Janeiro Botanical Garden; and Renzo Taddei, anthropologist at Unifesp and one of the coordinators of this transversal theme. The presentations were put together in the form of a book manuscript, which was submitted to the Editora da Fundação Oswaldo Cruz.

Two other ongoing research activities deserve mention. The first consists of a cartography of Brazil's communication ecosystem on climate change, developed by Debora Pires Jeronymo at Unifesp as a Master's thesis. The other is a survey on the attitudes and perceptions of opinion makers in the country regarding solar geoengineering. This research, coordinated by Júlia Guivant, received funding from The Degrees Initiative.

- We launched two dossiers of Revista ClimaCom with articles, essays, reviews, op-ed columns, news, interviews, reports, and artistic and cultural productions.

1) "Ciência.Vida.Educação" (June 2023, organized by Tiago Amaral Sales, Alice Copetti Dalmaso and Fernanda Monteiro Rigue);

2) "Disasters" (December 2024, organized by Gabriel Cid de Garcia, Viviana Aguilar-Muñoz, Jose Antonio Marengo Orsini, Eduardo Mario Mendiondo and Susana Oliveira Dias; edited by Susana Oliveira Dias, Leo Arantes Lazzerini, Natan Rafael Neves da Silva and Rayane Barbosa and with cover by Beá Meira. This dossier was organized in partnership with the transversal theme of Communication & Education and researchers from the Disasters (Cemaden) and Water Security (USP) subcomponents.

-We produced articles, summaries, expanded summaries, books, and conference presentations based on the research carried out individually or in groups.

-The project "Revista ClimaCom - arts, sciences and communications in the face of the Anthropocene," coordinated by Susana Dias, was approved in the BAS scientific initiation scholarship program at Unicamp, and we now have three scholarship holders - Rayane Barbosa, an Indigenous Kaingang student from Faculty of Education at Unicamp; Leo Arantes Lazzerini, from the Faculty of Applied Sciences at Unicamp; and Natan Rafael, from the Institute of Chemistry at Unicamp, who worked at ClimaCom magazine between June 2023 and July 2024;

-The project "Perceiving-making a forest - alliances between arts, sciences, and communications in the face of the Anthropocene," coordinated by Susana Dias, was approved by FAPESP and allowed the development of two artistic residencies, one in Manaus and the other in Campinas.

We produced a series of online seminars, "Latin American Variations in the Anthropocene" and "Ecopoetics: education, Art and Anthropocene," with the participation of researchers from Brazil, Argentina, Colombia, and Mexico.

-We organized the book "Modes of Existing in the Face of the Anthropocene", with texts by José Marengo, Mário Mendiondo, Paulo Nobre, Donna Haraway, Natasha Myers, and Ailton Krenak, among other researchers and artists. The book is in the final phase of publication.

5.10 Impacts on Brazilian ecosystems in view of changes in land use and biodiversity for sustainability

The activities developed in Year 7 focused on objectives related to advancing the knowledge of Cerrado's responses to climate change and Amazonia. They relate to the compilation of Cerrado functional traits to support the construction of a Cerrado Plant Functional Type to be included in global climate-vegetation models. A second activity was the evaluation of the contribution of

protected areas to the functioning of hydrological fluxes in the Cerrado Ecosystem. We continued the monitoring of greenhouse gases and aerosols in Amazonia, with continuous measurements in the ATTO tower, as well as other sites.
In the coming sections, the activities are presented in more detail.

5.10.1 **Contributing to the construction of a Cerrado Plant Functional Type**

Introduction

Plant Functional Type is the grouping of plants that have a similar response to environmental conditions and cause a similar effect on ecosystem functioning. In the context of climate change impacts, it allows an assessment with fewer variables by creating a functional profile of the vegetation of a given climatic domain, advancing the understanding of vegetation diversity in functional terms. A functional attribute is defined as a morphological, physiological, or phenological characteristic that affects an individual's fitness (i.e., growth, reproduction, and survival) (Violle et al., 2007).

Climate change could cause the extinction or decline in abundance of some PFTs, impacting ecosystems along regional gradients through the loss of key species with key functional traits. Therefore, it is urgent to classify the Cerrado as a PFT and monitor how climate change may cause the loss of this profile. Changes in mean annual temperature and precipitation can lead to the mortality of PFTs that are not adapted to the new climatic conditions imposed. The Brazilian Cerrado, which is already experiencing a 1ºC increase in average annual temperature (Rodrigues et al., 2022), has phytophysiognomies with the presence of a coexisting herbaceous-shrub layer. Some seminal studies have already defined the TFP of savannas, but only considering the herbaceous stratum. The PFT needs to represent the most important plant types on a global scale. These plant types need to be characterized according to their behavior and functional traits. The set of PFTs should provide complete and geographically representative information on the most important functional types.

Objective

Our objective was to obtain, summarize, make available and analyze canopy architecture data from Cerrado restricted sense tree species to feed into a PFT (Plant Functional Type) model of the Brazilian Cerrado.

UnB's Ecosystems Laboratory is collaborating with the Potsdam Institute for Climate Impact Research (PIK) to compile canopy architecture traits from different Cerrado locations to define a global Cerrado PFT.

Methods

We compiled data from 3618 individuals of 121 Cerrado woody species with measured traits.

The traits compiled were diameter at 30 cm from the ground, height, crown height, crown ratio, crown volume and crown area.

These observations refer to the years 2022, 2013 and 2009, in eigth different locations.

Results and Discussion

Assessing canopy structure is a way of evaluating the patterns and processes of a given region at an ecosystem level. This structure is affected by genetic and environmental factors, reflecting the survival strategy of the tree stratum.

The traits of canopy architecture can therefore be considered integrative (Miranda, 2012 and Lenti, 2014). These traits are related to light capture, minimization of hydraulic damage, competitive interactions with other individuals and efficiency in photosynthesis and use of nutrients and water (Lenti, 2014).

The complexity of the formation of the herbaceous-shrub layer makes it challenging to define a representative canopy architectural type for the Cerrado.

As well as being a proxy for evaluating the ecosystem processes mentioned above, canopy architecture traits can be analysed from the perspective of functional diversity (Figures 1, 2), which allows the impacts of the loss of Cerrado PFT to be assessed in terms of functional diversity in addition to taxonomic diversity.

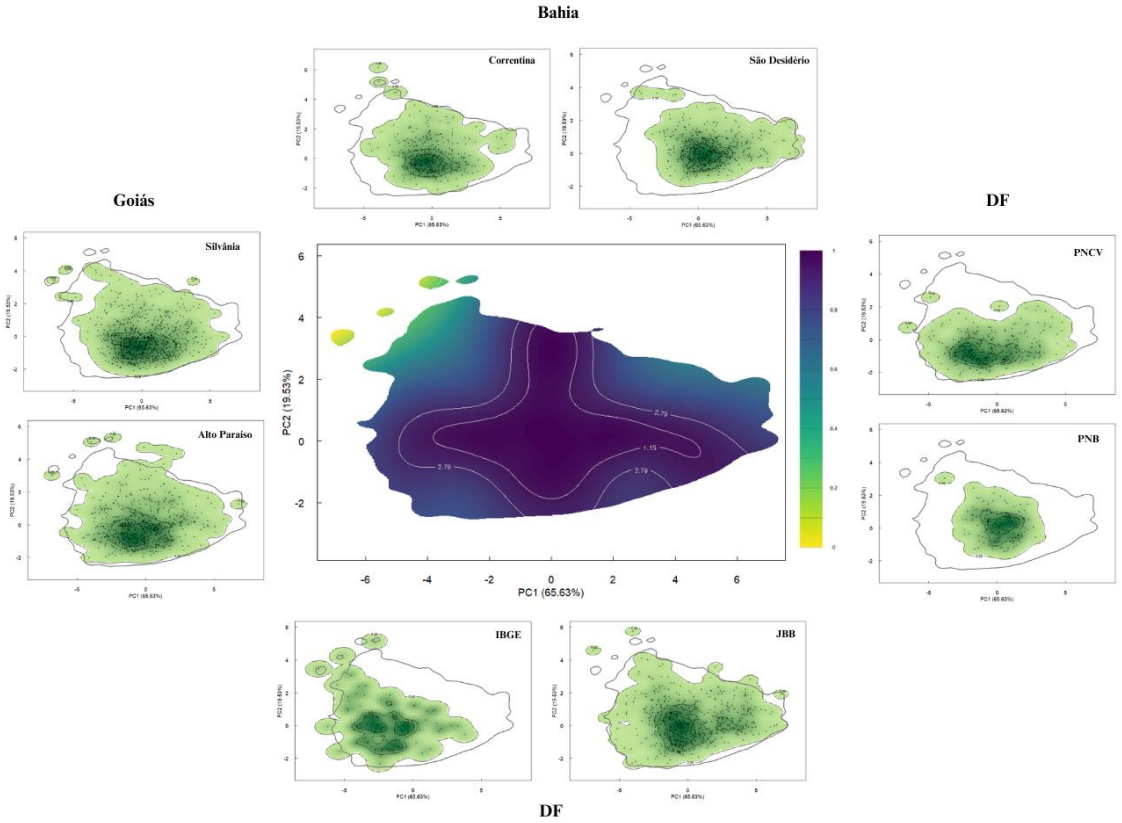


Figure 5.10.1. Functional diversity of compiled canopy architecture traits.
Light green = probability of occupying the functional space according to the traits collected.
Dark green = higher probability and density of occupying the functional space.
Black dots = functional traits distributed in the functional space.
Heatmap = probability of occupying points in the functional space.

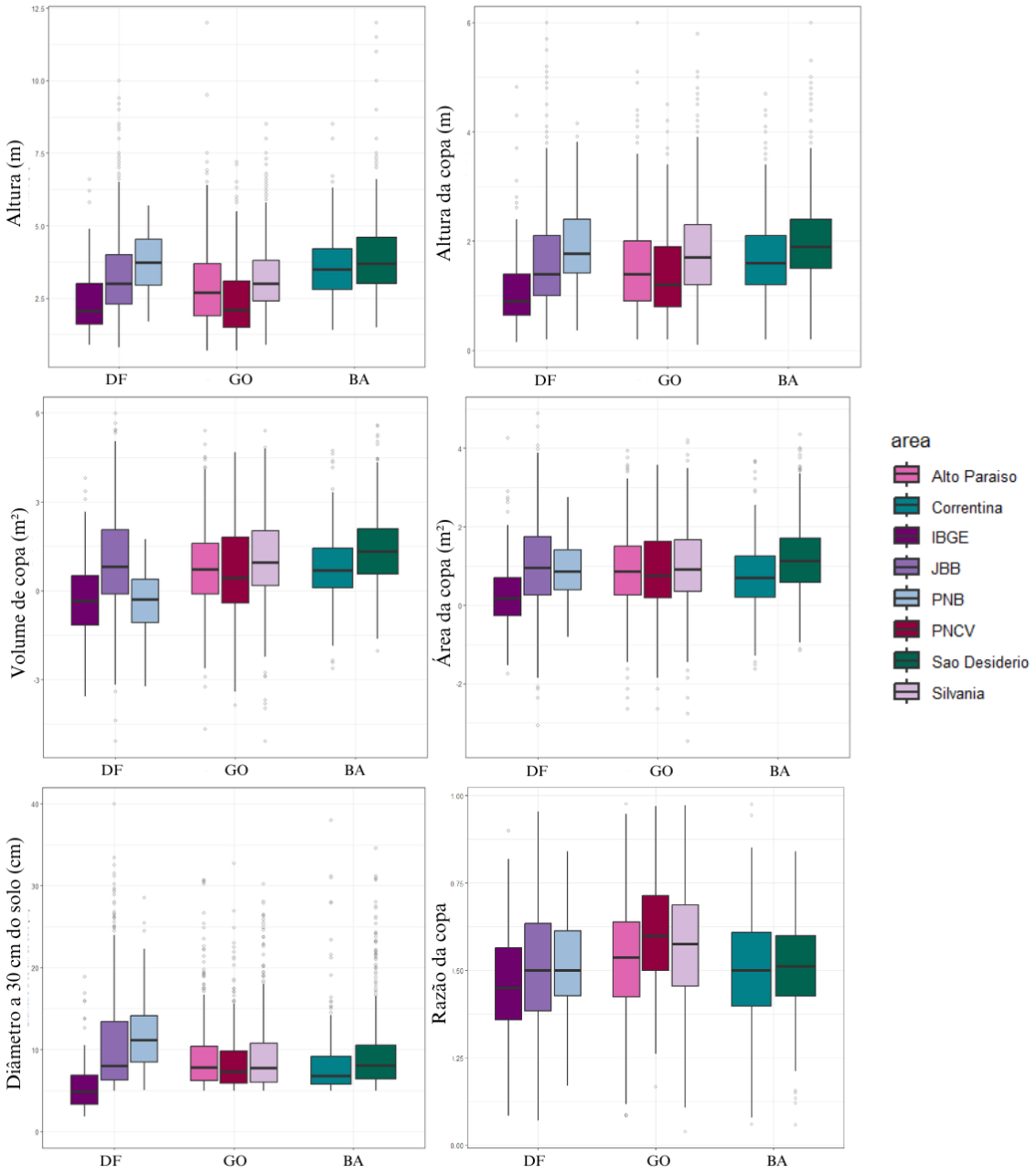


Figure 5.10.2: Canopy structure traits compiled in the states of Goiás, Bahia and the Federal District. Shades of purple = areas in the Federal District, shades of pink = areas in Goiás, and shades of green = areas in Bahia.

5.10.2 **The role of protected areas in regulating water fluxes in anthropized basins in the Cerrado**

Introduction

Changes in the water regime have an impact on human and natural systems. Periods of prolonged drought, for example, stimulate the temporary transition of the electricity matrix to high-carbon sources, since the burning of fossil fuels and biomass is an alternative to preserving water in reservoirs, thus intensifying climate change. Other possible effects of drought are an increase in the risk and severity of forest fires, deregulation of ecological interactions, for example between plants and pollinators, and the transition from perennial to intermittent rivers.

Increased precipitation and/or the concentration of precipitation in fewer, more intense events accentuates the transport of sediments and solutes into watercourses, with potential damage to biodiversity and energy generation. Some of these impacts interact and even act in positive feedback, potentially intensifying over time.

Objective

To assess the role of protected areas as a tool for the conservation of water ecosystem services on a local scale, using hydrological modelling and spatial analysis.

Methods

We evaluated water dynamics using the Soil and Water Assessment Tool (SWAT) hydrological model. This is a well-established model that has been in use since the 1990s and has a large community of users in Brazil and around the world, who offer accessible and democratic support.

SWAT was developed to 'predict the impact of land management practices on the production of water, sediment and agricultural chemicals in large, complex basins with various soils, land uses and management conditions over a long period of time'.

Initially, the model separates the basin into sub-basins and hydrological units, which are aggregated areas in each sub-basin with a unique combination of slope, soil, cover and management.

The driving force behind the model is the water balance and it operates in two phases: the land phase, which controls the amount of water, sediment and chemicals moving from the land to the channels, and the routing phase, which evaluates the transport of all these elements through the tributaries to the outflow.

The Rio Farinha basin in Maranhão and a sub-basin of the Alto Jequitinhonha in Minas Gerais were selected for the study. In addition to the presence of conservation units and the availability of long historical series of flow and precipitation, these basins were chosen because they are in a hotspot region for increasing evapotranspiration (ET) and surface temperature (LST), respectively, due to land use transition patterns, as assessed by Rodrigues et al. (2022). In addition, the basins are also located in transition areas between the Cerrado and other biomes (Amazon, Caatinga and Atlantic Forest), which implies more site-specific conditions.

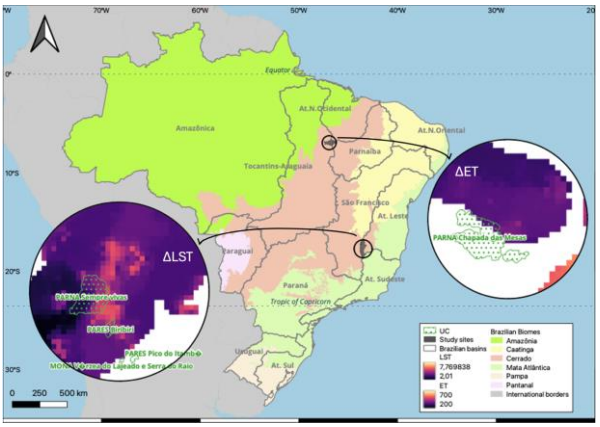


Figure 5.10.3: Study areas: the Farinha River basin in the Tocantins Araguaia hydrographic region and the Alto Jequitinhonha basin in the Eastern Atlantic hydrographic region. The circles indicate data from Rodrigues et al. (2022) relating to changes in evapotranspiration (Farinha) and surface temperature (Alto Jequitinhonha).

Results and Discussion – Cerrado component

The calibration and validation of both models achieved adequate statistics. This result confirms the suitability of the input data set used (including the soils refined in this work for the states of Minas Gerais and Maranhão) and gives reliability to the other analyses in this work that use the model results as a basis.

Soils explained a large part of the variance (R2) in ET and percolation, which mobilize most of the precipitation in the Alto Jequitinhonha basin. There is a lot of lateral flow (fast, in the unsaturated part) and little basal flow (slow, in the saturated part) due to the mountainous terrain with extensive areas of high slope. The basal flow is responsible for maintaining the flow in the dry season (Bart & Hope, 2014; Dralle et al., 2016) and a limitation in this flow means less water security.

The most abundant soil in the basin (Neossolo Litólico) seems to limit ET. This result is in line with Rodrigues et al. (2022) who identified the region as a site susceptible to an increase in surface temperature - as opposed to an increase in ET, in response to land and climate change.

In the north, there is less precipitation, which is divided more into ET than subsurface flow. Consequently, there is also less water production, with little contribution from slow flow (basal flow). To the south there is more precipitation, which is divided more into subsurface flow than ET. Therefore, there is also more water production, with comparatively more contribution from slow flow - even so, there is a major contribution from lateral flow to water production in practically the entire basin, because of its soils and relief.

The southern sub-basins are close to the climate of the Atlantic Rainforest, which is adjacent to the basin, as opposed to the northern sub-basins, which are closer to the Caatinga. In the largest sub-basins (to the north-west), there is an extensive flat area with (deep) red latosol and planted eucalyptus forests, all of which contribute to high ET and low water production.

Protected areas (PA) are further upstream (south) and concentrate a large part of non-vegetated areas and litholic neosols, so they have less ET and more percolation, basal flow and water production compared to non-protected areas (NP) (Figure 6). Protected areas are concentrated in regions that favor more basal flow and therefore contribute to water security, but only 10% of the basin is protected. On the other hand, they contribute little to ET, which plays a role, for example, in climate regulation (Hofmann et al., 2023).

In this basin, protected areas have been allocated to non-vegetated areas with very shallow soils. At the same time, areas favorable to ET are occupied with high-demand vegetation, which can unbalance the demand vs. supply of water locally (Silva, 2022).

The main anthropogenic use in the Rio Farinha basin - pasture - is concentrated in Latosol and Nitosol areas, mainly on flat terrain. As in Alto Jequitinhonha, there is a spatial relationship between shallower soils and lower ET rates, albeit to a lesser extent. Soils explain a large part of the variance (R2), but in this basin, there is also a more obvious contribution from land cover. This is in line with Rodrigues et al. (2022), who indicate that the region is susceptible to an increase in ET and, to a lesser extent, an increase in surface temperature in response to climate change.

Also identified in the water dynamics of this basin is the role of water transmission from the canals to the soils. The loss of water from the channels by transmission to the bed and percolation supplies the shallow aquifer, which, with the return of the rainy season, contributes again to basal flow to the channels. This process has a spatial relationship with Quartzarenic Neosol (RQo). This dynamic is characteristic of intermittent channels, which are potentially more sensitive to anthropogenic impacts (Vander Vorste et al., 2020).

Water production in the basin is mostly governed by basal flow, mainly in the centre-east of the basin, and by runoff in other areas, including PAs.

The protected areas (15% of the basin) concentrate extensive native vegetation cover, but also shallow soils (Quartzarenic Neosol - RQo and Litholic Neosol), so they have more runoff and less percolation and basal flow, which results in similar water production compared to non-protected areas. Water production, then, is quantitatively similar but qualitatively different: PA's have a predominance of fast flow, so their role in water security in the basin may be limited and reinforces the importance of sustainable management in non-protected areas.

There is a predominance of shallow soils in the AP, but the most abundant class (RQo) is different from the Upper Jequitinhonha, and the whole area is vegetated. Thus, ET is not as limited as in the Upper Jequitinhonha PAs. This shows how the interaction of the different characteristics of the basin is relevant to hydrological dynamics and emphasizes the importance of carrying out site-specific assessments to enhance mitigation and adaptation responses to climate change at a local level.

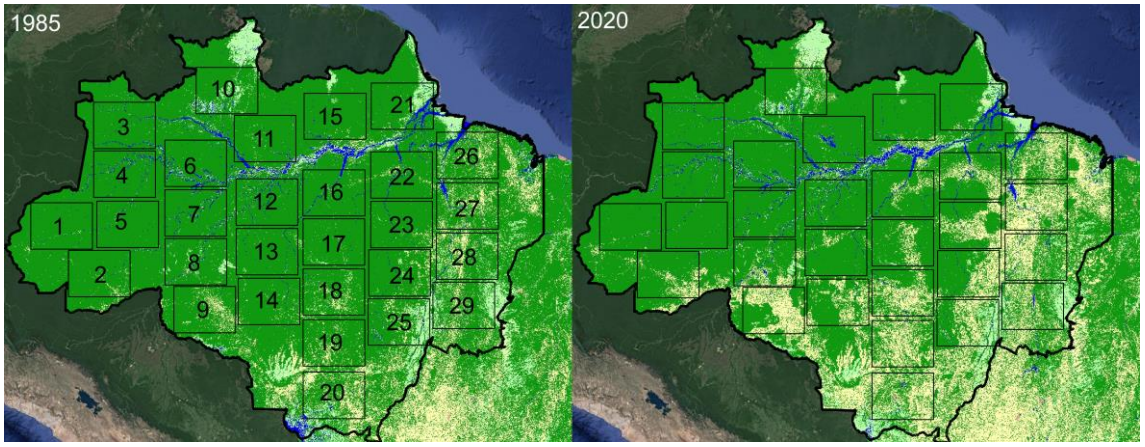
5.10.3 Disentangling the Influence of Deforestation and Global Climate Change on the Amazonian Atmosphere

The Amazon rainforest, one of the planet’s most significant and critical tropical forest ecosystems, is pivotal in preserving global climate stability. Nonetheless, over the past 35 years, land cover and climate change have perturbed the biosphere-atmosphere interactions in the Amazon region, resulting in significant shifts in water, energy, and greenhouse gas cycles. These disturbances may have far-reaching consequences, impacting the Earth’s climate system. This study presents a comprehensive quantitative analysis that untangles the relative contributions of deforestation and global climate change to the observed changes in the Amazonian climate. It specifically investigates the increasing concentrations of greenhouse gases (GHG), methane (CH4), and carbon dioxide (CO2), the rising surface maximum air temperature, and the decline of annual rainfall in the Amazonian Basin. Moreover, the analysis discerns the seasonal patterns of these changes and determines their significance. The changes in CH4 and CO2 concentrations primarily arise from global climate change, with deforestation contributing to less than 1% of the concentration increase. However, deforestation emerges as a significant factor when it comes to surface daily maximum air temperature and total annual rainfall. In the past 35 years, deforestation has accounted for 64.1% of the ~ 153 mm total annual rainfall reduction, and 18.9% of the total increase of 2.1°C in maximum temperature during the dry season. Deforestation modifies seasonal patterns and significantly drives climate change in the Amazon. Unlike the nearly linear changes caused by global climate change, the effects of deforestation exhibit a non-linear behavior. This trend has the potential to transform the Amazon climate completely, as well as the global climate, within a few decades.

To disentangle the regional effects of deforestation from the global effects of climate change in the Brazilian Amazonia, data on 29 areas measuring ~300 by 300 km2 were considered. This

area size was selected for several reasons. First, they encompass a sufficiently large area that includes the actual path length of deforestation, as indicated by previous studies27. This ensures that the effects of deforestation within a given region are adequately captured and analyzed. Second, the dimension of 300 km is within the mesoscale range, enclosing atmospheric phenomena like thunderstorms, squall lines, fronts, and deep 50 convection. The average size of cloud systems in this region is between 75 and 150 km in radius28, so this area size ensures that a cloud system, on average, lies entirely within its boundaries. The Brazilian Amazon was segmented into 29 sectors and statistics were computed for each year between 1985 and 2020. Figure 1 visually presents the 29 sectors analyzed within the Brazilian legal Amazon. The land-use classification (see Methods - Land Use and Land Cover Data for a detailed description) for 1985 (a) and 2020 (b) is overlaid on the sectors, providing a 55 clear representation of the deforestation that has taken place in each sector over time. In the Amazonian region, the northwest sectors stand out for their high fraction of natural forest cover, while the southern and eastern sectors face alarming levels of deforestation, commonly referred to as the arc of deforestation. The deforestation area for each sector in the period of 1985 to 2020 is presented in Supplement Figure S1. Upon analyzing the variation in forest cover across sectors, it was observed that the 75th and 25th quantiles of vegetation loss corresponded to 19% and 0.6%, respectively. These findings underscore the 60 substantial spatial variations in the pattern of deforestation across different regions.

Figure 5.10.4. The selected sectors were specifically chosen to examine the relationship between land use change and its impact on essential climate variables. The black line indicates the boundary of the Brazilian Legal Amazon region. The green color represents the forest fraction, corresponding to areas with intact forest cover, while the remaining colors denote deforested regions encompassing various land cover types.



This study emphasizes the substantial impact of global changes and land use on the variables examined. Deforestation strongly drives the variability of meteorological variables during the dry season. When considering all sectors across the Brazilian Amazonian region, deforestation substantially increases maximum surface temperature by approximately 18.9%, equivalent to 155 a temperature rise of 0.41°C. Deforestation also has a dominant influence on the reduction in total annual rainfall by 64.1%, resulting in a net effect of a -84.3 mm reduction in annual rainfall. On the other hand, deforestation had a small impact on GHG concentrations, which were driven predominantly by global changes.

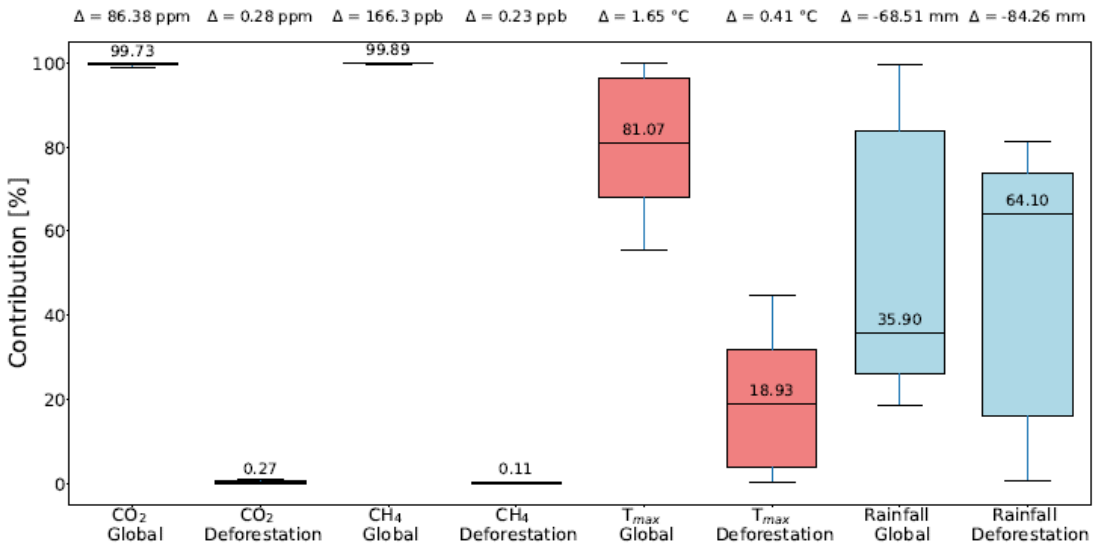


Figure 5.10.5. Boxplots of the deforestation and global contributions to CH4, CO2, maximum surface temperature, and total annual rainfall between 1985 and 2020, obtained with the parametric equations from Table 1, considering all 29 sectors. Values near the bars indicate the median contributions, whereas deltas at the chart top denote the variable mean value.

By comparing the sectors most and least impacted by deforestation, the effects of forest cover loss become even more apparent. The sectors experiencing higher levels of deforestation are particularly vulnerable to increased temperatures and reduced rainfall, 160 underscoring the crucial role of forest cover in regulating the meteorological dynamics of the biome. The results further highlight the critical importance of forest cover in maintaining rainfall patterns and controlling air temperature. The parametric equations derived from the study indicate that the most significant effects occur during the initial stages of forest cover removal, with substantial changes occurring within the first 10%-40% of coverage. While the changes become relatively smaller beyond this threshold, they remain noticeable as the region becomes more deforested.

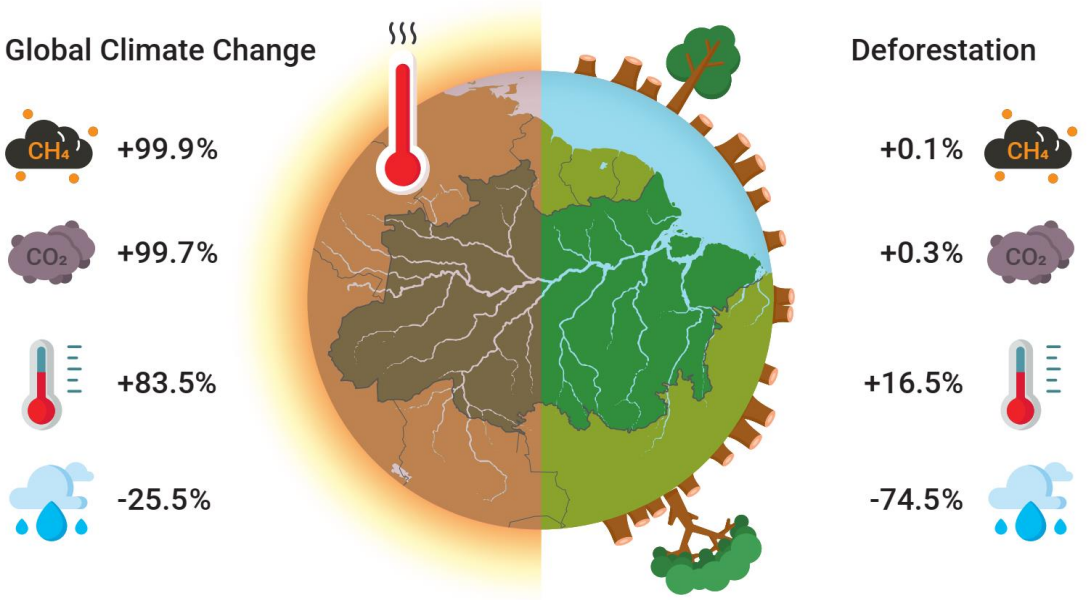


Figure 5.10.6 shows an overview of the results about the attribution of environmental changes versus deforestation for Amazonia, including all regions from figure 1. It is important to emphasize the impact of deforestation on precipitation.

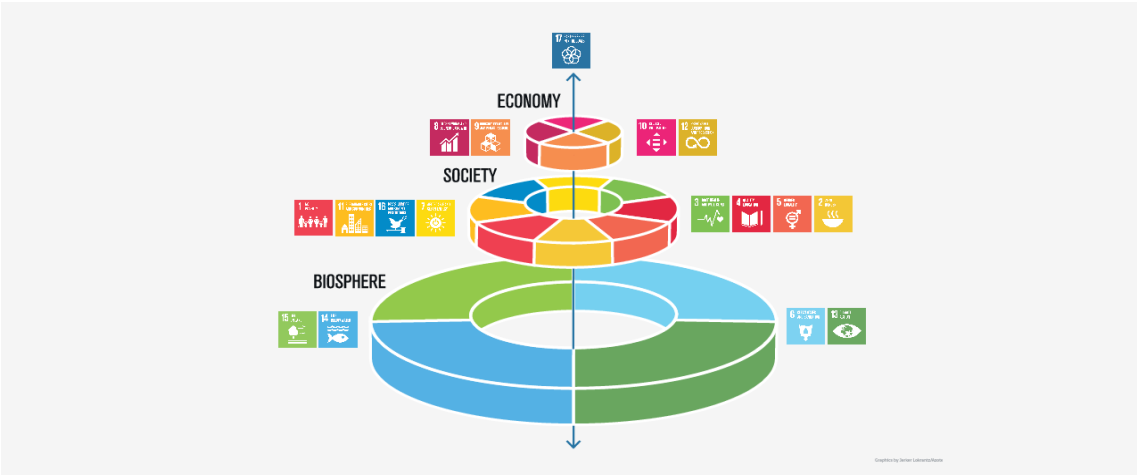
5.11 Synthesis and integration phase

Introducao

Promoting sustainable development is dependent on facing the challenges generated by climate change. The complex and strongly interconnected nature of such challenges demands the generation of knowledge and the strengthening of interdisciplinary research networks, in connection with institutional governance. Brazilian funding agencies play a vital role in this process, encouraging collaboration between researchers and the formation of research groups that can influence public policies and return knowledge to society to combat extreme events, especially global warming, with actions of mitigating greenhouse gas emissions and adapting to climate change. INCT-Climate Change, phase 2, with its six thematic lines and three integrating themes, provides a deep understanding of the interactions between different aspects of climate change and sustainable development. The emphasis is on impacts on water, energy and food security, health, ecosystems and urban development. These central themes are covered by climate and economic modeling, with permanent and updated communication of impacts and solutions to different audiences, in an integrated approach. The article presents an analysis of the contribution of INCT-MC2's scientific production to the Sustainable Development Goals based on a conceptual model that advocates that the economy and society are dependent on the biosphere, and that the integrity of the biosphere is fundamental to global sustainability .

The SDGs were formulated through a participatory process, including civil society, the private sector and local bodies, forming part of the so-called 2030 Agenda of the United Nations (UN) as it encompasses the period between 2016 and 2030 and applies to signatory countries. There are 17 individual objectives that represent different elements of sustainability, demonstrating the complexity of each one and their interdependencies. These objectives are part of a global agenda, with a set of goals for sustainable development and a monitoring structure to be carried out through annual reports to the UN. In 2016, Johan Rockstrom and Pavan Sukhdev presented a new way of seeing the economic, social and environmental aspects of the Sustainable Development Goals (SDGs) so that the economy and society should be seen as integral and dependent parts of the biosphere.

Fonte: Creative Commons CC BY-ND 3.0.



Rockström et al (2021) introduced the concept of "planetary boundaries" to define a safe space for humanity to operate. These limits are critical points that, if exceeded, can lead to catastrophic environmental changes.
The integrity of the biosphere is one of nine identified planetary boundaries. It is crucial to

human well-being and global economic stability. Healthy ecosystems provide a wide range of ecosystem services that are vital for human survival, including food, clean water, clean air, and building materials and medicines. Furthermore, they contribute to the resilience of human communities in the face of natural disasters and climate change.
Although the links between the impacts of climate change, climate action and sustainable development are widely known, there is little research on how science and technology institutes, which bring together researchers from different areas, contribute in an interdisciplinary and integrated way to these themes.
Understanding the relationships between the environmental agenda, in particular the broad sustainable development agenda, and the climate agenda requires interdisciplinary collaboration, with commitment from government spheres, at different levels, to mitigation and adaptation programs and processes in the face of climate change.

ODS	O1	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
	36	44	50	11	00	87	26	23	02	05	43	16	144	23	109	02	07

We highlight the contribution of INCT-MC2 to SDG 15 (life on land) and SDG 6 (drinking water and sanitation), with a focus on SDG 13 (action against global climate change), which constitute central base elements for the integrity of biosphere. The theme of SDG 14 (life in water) has a smaller representation among the group's production.
Health and well-being (SDG 03), zero hunger and sustainable agriculture and sustainable cities and communities (SDG 11), are themes present in a large part of INCT-MC2 research, whether directly in the specific components of the themes, or in other components in which the themes are in some way related to the consequences of good or bad water management, for example.

7. Integration among components of the project in Year 7

During this year various component of the project held weekly face-to-face meetings of the Communication sub-component to create journalistic materials, study materials produced by INCT Climate Change scientists, as well as study theoretical references from the philosophy of science that inspire our thinking and writing. We also held monthly online meetings with researchers from the Latin American Network for Scientific Dissemination and General Climate Change, online, to study authors, evaluate results, and define the actions that we would develop together this year. The components have also been working in the extension of the project by CNPq and FAPESP and started to work on integrated papers among components.

Certain food production practices and raw materials often cause significant impacts on natural resources. Sustainable agricultural management systems, considering the maintenance of ecosystem services, can help adapt to climate change (Cohen-Shacham et al, 2016). SDG 6 assumes a prominent position as an integrative dimension, whose research within the scope of INCT-MC2 involves studies on water security.

Water security refers to the ability to ensure the sustainable availability of quality water to sustain human health, economic development and the integrity of ecosystems. This perspective is related to an integrated approach, with water availability playing a preponderant role in the relationship between water-energy-food security. More frequent and severe extreme weather events, rising sea levels, droughts, intense flooding and other environmental changes can also lead to water scarcity and insecurity.Furthermore, water, energy and food production are essential to achieving other sustainable development goals, such as health and well-being, poverty reduction, gender equality, economics and resource conservation, ecosystems and biodiversity.

For cities and municipalities, sustainable planning and instruments are needed to ensure the protection of ecosystem services and biodiversity due to the expansion of urban areas. Priority should be given to expanding green belts for urban agriculture, which mitigate GHG emissions and contribute to the maintenance of permeable areas around cities; urban afforestation, which promotes thermal comfort, lower energy expenditure and reduces the effect of heat islands; and green infrastructures, which maintain soil permeability and contribute to reducing the impacts of flooding. Planned cities are more resilient to the effects of natural disasters

To reduce disaster risks, there is a need to improve and modernize risk and disaster management and communication systems, with the strengthening of competent bodies, such as Cemaden, Cenad, INMET, among others, as well as emergency training for state civil defenses and municipal health care teams, among others.

Building a resilient future is a key component of the Paris Agreement and the 2030 Agenda for Sustainable Development (SDGs), along with the Sendai Framework for Disaster Risk Reduction, and the main benefits of integrating these agendas involve development and integration research on related topics.

INCT-MC2's contribution to practically all SDGs can be observed and, in addition, the themes of each component consider integration with several others. The structure of the components was planned to encompass both research on topics related to the integrity of the biosphere, as well as topics that may affect it, or are or could be affected by it.

These factors highlight the scientific contribution of INCT-MC2 to the advancement of these agendas.

8. Plans for Year 8 of the project

Plans for the eight years include further approximation with researchers from the subcomponent's natural disasters, water Security and human health, to further develop joint projects. The contribution of the INCT MC2 was fundamental for the development of the studies on impacts, vulnerabilities and adaptation for the upcoming 5th National Communication (5CN) to UNFCCC.

-Food security

Research into food and nutrition security in Brazil is mainly focused on the quality of food and the nutritional status of the population, and a little on the political, economic and social aspects. As a multidisciplinary area, investments are needed to bring integration closer.

Animal protein plays an important role in addressing macro and micronutrient deficiencies in diets in many regions of the world. The target for 2050 is 435M tons of meat and 843M tons of dairy products. Modern animal production techniques have greatly improved the ability to provide protein for humans. Livestock farming is one of the contributors to climate change and has impacts on biodiversity and freshwater depletion. In the case of small ruminants, they have been resilient in high environmental temperatures for a long time. However, there is no consensus on the most effective way to tackle climate change in small ruminant farming, whether the intensive system with high-performance animals or the traditional production system with local breeds.

A preliminary analysis of small animal herds and rainfall in Brazil showed that there is no direct correlation, something like an association between longer periods of drought and fewer ruminants. However, physical geography and socio-economic factors could explain the oscillation of the small animal population in the northeast between 1960 and 1980. It is not yet clear whether there is a relationship between livestock numbers and severe famine events.

Goa
ls

- EVALUATE the relationship between climatic variables (temperature increase and CO2 concentration), food supply to animals (quality of pasture and feed) and the growth in the number of animals over time.
- MEASURE the direct and indirect impact of climate change on the number of animals (cattle and small ruminants) over time.
- EVALUATE the economic impacts on cattle and small ruminant livestock farming due to changes in pasture availability, management techniques and technology, and their implications for family farmers and the global food supply.
- MEASURE the impacts of climate change on global food security and Brazil's role as a global supplier of animal protein.

Objectives:

-Evaluate the direct and indirect socio-economic impacts of changes in temperature and rainfall on the supply of food of animal origin;
-Evaluate GHG emissions from small animals and their contribution to Brazil's overall GHG emissions

-Economy

Plans for the eight (last) year include continuing and further approximation with researchers from the subcomponents “Natural Disasters” and “Water Security” to wrap up joint projects.

There are two post-doc scholarships, already approved by Fapesp and CNPq, to be granted to researchers to develop projects integrating different subcomponents. The call for the Fapesp scholarship focused on the development of a project related to water charge and insurance as strategies for adapting to climate change and one candidate has been selected. The one for the CNPq will focus on the effects of climate shocks on socioeconomic indicators.

Ongoing projects with colleagues from Croatia (“Croatia’s Tourism Sector: An Environmental Analysis Through an Interregional CGE Model”), Chile (“UPDATE OF THE INTERREGIONAL INPUT-OUTPUT TABLE OF CHILE AND INCORPORATION OF WATER RESOURCES”), Paraguay (“Systemic impacts of climate change in Paraguay from business agriculture”), Egypt, Morocco and Portugal are to be further developed during the last year.

Finally, an array of recent FIPE projects allowed the discussion of the recent tax reform considering a “Green Tax Reform”. We also plan to continue devoting time to integrating the land use findings with the computable general equilibrium model, as mentioned in the previous report

Activities	**Survey and organizing information on small animal herds**	**Organization information on production systems for small animals**	**Definition and testing of models and protein supply in**	**Analysis of the adaptation of production systems**	**Analysis and defining impacts on food security**
1.0 month	**X**				
2.0 month		**X**	**X**		
3.0 month		**X**	**X**		
4.0 month		**X**	**X**		
5.0 month			**X**		
6.0 month				**X**	
8.0 month				**X**	
9.0 month				**X**	
10.0 month				**X**	
11.0 month					**X**
12.0 month					**X**

-Energy security

The energy security component aims to continue focusing on the impacts of climate change on wind and solar resources. Studies on climate change indicate the occurrence of desertification in Northeast Brazil, increased precipitation in the South region, and a rise in extreme events throughout of the Brazilian territory. Changes will occur in precipitation regimes, cloud cover, and wind speed, among other shifts. In this context, it becomes important to quantify future risks to the energy sector. During the next year, the energy security team aims to assess the climatology of low energy production events in wind and solar matrices across Brazilian territory, as well as to observe the occurrence of these events in the near future (2031-2060) and distant future (2061-2090). Two scenarios, SSP2-4.5 and SSP5-8.5, were chosen, and the extreme minimum event of daily wind speed, drought wind, was defined by the persistence of three consecutive days below the minimum energy generation threshold for wind turbines at a height of 100 meters, i.e., between 5 and 7 m/s. From the solar perspective, the extreme event is defined by daily solar incidence remaining below half of the seasonal climatological solar incidence for two consecutive days in each pixel. ERA5 reanalysis data (the fifth generation of ECMWF global climate atmospheric reanalyses) are used to evaluate observations from 1980 to 2014, while future scenarios are indicated by models from the NEX-GDDP (NASA Earth Exchange Global Daily Downscaled Projections) and CORDEX (Coordinated Regional Downscaling Experiment) experiments. Comparing both experiments is advantageous because NEX-GDDP applies statistical downscaling, while CORDEX applies dynamic downscaling. Preliminary results indicate that the NEX-GDDP models for wind speed variable have the highest agreement with observations, while for the solar component, some inconsistent behavior appears over the Northeast (April to September), Central-West (October), and South (April). Regardless of the experiment, results indicate two regions with a tendency for drought wind occurrence: i) the region between northern Bahia, eastern Piauí, and all the states in the Northeastern hinterland; and ii) northwestern, western, and southern Rio Grande do Sul state. In the solar matrix, extreme events in summer are indicated between the coast of Espírito Santo to the east of Mato Grosso. The main justification is the influence of the South Atlantic Convergence Zone (SACZ). We expect the results will indicate the frequency of scenarios with low energy production.

Climate change can affect the potential of renewable energy, resulting in the inappropriate deployment of new infrastructures at certain locations. To comprehensively explore these complexities, we propose utilizing the 'modeling to generate alternatives' (MGA) method embedded within Calliope, a linear programming-based energy model that minimizes the cost.

MGA explores the alternatives near the single optimal solution, not exceeding 5% (according to the modeler assignment) from the least cost. By combining five key layers – demand, policy, climate change, weather data, and alternative options – we will generate 1,600 long-term energy scenarios for Brazil. The model and the scenarios rely on an extensive data approach prepared in a pre-processing step. First, we will conduct a simulation and bias correction of wind and solar energy to have reliable data on renewable energy. For hydropower, we will use Affluent Energy Data, which is given by the National Operator (ONS). Second, we will use geospatial data to calculate the availability of lands and, consequently, the maximal capacity of the infrastructure that can be deployed at the zone. Third, we will investigate the impacts of climate change on the Brazilian power system by applying factors (CCF) in the wind and solar time series.

The former results produced by Energy Security team evaluated the CCFs for wind and solar, which will be adjusted for the Brazilian energy model. Finally, each scenario will be analyzed and categorized according to sustainability and energy indicators, including land use, water

consumption, emissions, biofuel production, and green hydrogen output. We aim to publish two papers in top international journals.

-Communication

- Two new ClimaCom dossiers will be published with articles, essays, journalistic materials and artistic productions with the themes: "Territories, Indigenous Peoples, and Climate" and "Environmental deviations". The participation of researchers from the various INCT components in the magazine will be encouraged through the production of texts, interviews, participation in news, etc.
- We will produce publications (for conferences, articles, books, etc.) by researchers on this transversal theme.
- We will launch the book "Modes of existing in the face of the Anthropocene" with articles by INCT researchers and guest researchers and artists.
- We will hold 6 workshops with teachers from the Campinas municipal network.
- We will hold 2 artistic residencies with the theme "Anticipating the disaster" in partnership with Cemaden and another to be defined, theme and location.

We will produce the exhibition "Vegetable Cosmopolitics" at Espaço Marco do Valle in Campinas, SP.

-Water Security

The planned future activities by the UC include:

- Expansion of Hydrological Modeling Studies: The group plans to continue developing and refining hydrological models to better understand and predict the impacts of climate change on local and regional water resources. This includes improving model accuracy and integrating more comprehensive climate data;
- Enhanced Remote Sensing Applications: The focus will be on advancing the use of remote sensing technologies to monitor water resources, soil moisture, and vegetation health. This will involve the development of new methodologies for data collection and analysis to support water management strategies;
- Climate Change Impact Assessments: The unit will conduct further studies to assess the potential impacts of climate change on water availability and quality. This includes evaluating the effects of extreme weather events, such as droughts and floods, on hydrological systems and developing adaptation strategies;
- Collaboration and Partnerships: The group aims to strengthen collaborations with national and international research institutions to leverage expertise and resources. This will involve participating in joint research projects, sharing data and findings, and contributing to global water security initiatives.

By pursuing these activities, the group aims to contribute significantly to the advancement of water security and the mitigation of climate change impacts on water resources.

-Disasters

The next steps to be developed during year 8 of the subcomponent are detailed below.

-Apply the methodology developed for mapping flood risk areas in priority municipalities monitored by CEMADEN.
- Apply the TSI methodology for all basins in Brasil.
- Develop methods for predicting hydrological droughts using hydrometeorological sub-seasonal and seasonal forecasts.

-Develop a multivariate index for monitoring and forecasting hydrometeorological drought events.
-Carry out the statistical analysis of supply data and indicators, as well as the validation of indicators for the Municipality of Juazeiro do Norte based on water supply data collected at field for the period from 2008 to 2018.

-Development of a study focused on the risk management capabilities of municipalities affected by disasters in the state of Rio Grande do Sul.
-Develop a study focused on characterizing disaster-related deaths occurred in Rio Grande do Sul municipalities aimed to determine appropriate measures for risk perception.
-Identifying social infrastructures in Rio Grande do Sul municipalities that can support the development of educational activities aimed at enhancing risk perception.
-Update the territorial base related to population exposed in risk areas for the year 2022, initially considering the update for the Brazilian capitals monitored by CEMADEN. Vulnerability indicators will be associated with the territorial base, in order to quantify the population exposed to disasters. Next, the vulnerability index will be calculated considering the methodology previously developed for the year 2010 and already validated according to Assis Dias et al (2020), as well as a validation of the results generated for the year 2022. A comparison will be made between the data on the exposed and vulnerable population between 2010 and 2022.
-Estimate damages and losses and integrate the data into the proposed impact index related to the exposure of schools and the education sector.

-Health

Neglected Tropical Diseases (NTDs) are part of goal 3 of the Sustainable Development Goals (SDGs), which aims to: “ensure healthy lives and promote well-being for all at all ages”. Positive progress is needed in relation to goal 3.3, which deals with the control of NTDs by 2030, especially those transmitted by vectors. The SDGs translate into a new perspective on tackling NTDs and Brazil is responsible for prioritizing health surveillance actions, which must be aligned with agendas committed to assessing climate and environmental changes. Thus, environmental changes, both of climate origin and deforestation, imply current risks and their impacts on human health must be analyzed and discussed according to the different epidemiological scenarios.

Continuing the studies related to the southeast region, the analyses of the spatial distribution of *Lu*. *longipalpis* and *Mg*. *migonei* will be completed. in future scenarios regarding climate change, these data may provide important information to fill gaps related to the adaptation of vector species to these changes. These results will be produced through ecological modeling and probability of occurrence maps. This work will contribute to robust data related to climate change and the significant impact on the spread of vector-borne diseases, such as leishmaniasis, since these changes can alter precipitation and temperature patterns, as well as the greater frequency of extreme climate factors, which directly influences the geographic distribution, reproduction and survival of these vectors and, consequently, the diseases associated with them.

-Modelling

- Due to the reduced availability of supercomputer power at INPE still in the year 6, the CMIP6 SSP's scenarios planned for year 6 of the project are postponed for the year 8. The climate scenarios shall encompass the period of 1985-2100, with BESM3.0, same for the RESM- Eta Model.
- Development of the Coupled Eta based model with MOM6 ocean model (RESM – Eta Model);
- Improve the coupling of the Radiation scheme in the RESM through tests and evaluation of the inclusion of aerosol (Eta Model)
- Coupling of the lake model FLake to the Eta Model

- Finish Coupling and evaluation of the dynamic vegetation + Carbon cycle in the RESM (Eta Model)
- Evaluation with the new model version of the Eta Model - continuation
- Generation of projections using new model version and new SSP's emission scenarios.
- developing AI/ML tools to improve climate simulations of the extreme events

8. Events organized by the INCT MC2 and its components with interaction among subcomponents of the project in Year 7 and when results of the project were presented

NEREUS at FEAUSP hosts a weekly seminar, on Mondays, during the academic year. There were different presentations on topics related to the INCT-MC. The complete program with the names of the presenters and titles of the presentations can be accessed at (http://www.usp.br/nereus/?p=3989)

TORRES, B E, B. R; HOUCHSPRUNG, J. C. M.; MARTINS, F. R. *Transição energética para a sustentabilidade no Brasil: narrativas e imaginários dos stakeholders*. **Congresso Brasileiro de Energia Solar**. 27 a 31 de maio de 2024. Natal, Rio Grande do Norte, Brazil.

ARRUDA, F. V.; ALMEIDA, M. P.; MARTINS, F. R.. *Estudo de caso de lstm e autoencoder lstm para previsão a curto prazo utilizando múltiplas séries temporais.* **Congresso Brasileiro de Energia Solar**. 27 a 31 de maio de 2024. Natal, Rio Grande do Norte, Brazil.

LIMA, F. J. L.; GONÇALVES, A. R.; COSTA, R. S.; PEREIRA, E. B.; MARTINS, F. R. *Impacto das mudanças climáticas na geração de energia solar: uma análise multimodelo utilizando CMIP6.* **Congresso Brasileiro de Energia Solar**. 27 a 31 de maio de 2024. Natal, Rio Grande do Norte, Brazil.

BORBA, P. C. S.; GONÇALVES, A. R.; MARTINS, F. R.; COSTA, R. S. *Modelagem de sistemas altamente renováveis: integração da energia eólica e solar no brasil em 2050.* **Congresso Brasileiro de Energia Solar**. 27 a 31 de maio de 2024. Natal, Rio Grande do Norte, Brazil.

TIPPETT, A., GONÇALVES, A. R.; PEREIRA, E. B.; MARTINS, F. R.; FISCH, G. F.; COSTA, R. S. *Ano meteorológico típico solar: sensibilidade à base de dados para cinco regiões diferentes do Brasil.* **Congresso Brasileiro de Energia Solar**. 27 a 31 de maio de 2024. Natal, Rio Grande do Norte, Brazil.

COSTA, R. S.; ZARZUR, A. M.; GONÇALVES, A. R.; MARTINS, F. R.; SIQUEIRA, R. A.; LIMA, F. J. L.; CASAGRANDE, M. S. G.; DA ROCHA, V. R.; NETO, H. B. L.; PES, M. P.; MACHADO, G. B. M.; PEREIRA, E. B. *Nova base de irradiação solar do Brasil - resultados preliminares.* **Congresso Brasileiro de Energia Solar**. 27 a 31 de maio de 2024. Natal, Rio Grande do Norte, Brazil.

CUMPLIDO, M. A.; GONÇALVES, A. R.; PEREIRA, E. B.; RUTHER, R. *Energia solar fotovoltaica combinada com hidrogênio verde: uma estratégia para redução das emissões e da vulnerabilidade na Amazônia.* **Congresso Brasileiro de Energia Solar**. 27 a 31 de maio de 2024. Natal, Rio Grande do Norte, Brazil.

SIQUEIRA, R. A.; GONÇALVES, A. R.; COSTA, R. S. *Avaliação de modelos de decomposição de irradiância global sobre o Brasil.* **Congresso Brasileiro de Energia Solar**. 27 a 31 de maio de 2024. Natal, Rio Grande do Norte, Brazil.

SOUZA, F. G.; LONDOÑO PABÓN, N. Y.; RODIO, N.; KRAMBECK, L.; COSTA, R. S.; GONÇALVES, A. R.; MANTELLI, M. B. H. *Uso da energia termossolar no Brasil: panorama atual e potencial de desenvolvimento.* **Congresso Brasileiro de Energia Solar**. 27 a 31 de maio de 2024. Natal, Rio Grande do Norte, Brazil.

AMORIM, A. C.; DIAS, S. O.; WUNDER, A.; OLIVEIRA JÚNIOR, W. M. Organização do IX Seminário Conexões: Deleuze e Linhas e Cosmos e Educação e…, realizado na Unicamp entre 27 a 29 de maio de 2024.

ARANHA, N. "Save the frogs", evento promovido pelo Laboratório de História Natural de Anfíbios Brasileiros (LaHNAB), na Unidade de Conservação ARIE Mata de Santa Genebra. 2023.

CANGI, A. Variações Latino-Americanas diante do Antropoceno 3. Poética de las piedras-Una Cartografía y Decolonizar el paisaje patagónico, com participação de Con Jeremías Castro

(UNDAV) e Alejandro Miroli (UBA/UNDAV). 28/04/2023. Disponível em: https://www.youtube.com/watch?v=To8uxpN-vSQ&t=3s

CANGI, A. Variações Latino-americanas diante do Antropoceno 4 - Descolonización del paisaje patagônico, com Com Martín Bolaños (Undav) e Alejandra Adela González (Uba/Undav). 29/05/2023. Disponível em: https://www.youtube.com/watch?v=BQBf8_oLaJE&t=3072s

DIAS, S. O; CANGI, A.; GONÇALVES, M; AMORIM, A.. 2o. Seminário do Ciclo "Ecopoéticas: educação, arte e Antropoceno - uma homenagem a Bruno Latour" | com Santiago Arcila e Alyne Costa. YouTube da ClimaCom, 02/06/2023. Sobre os temas: "Gaia: uma figura (enfim profana) da natureza" e "O Antropoceno e a destruição (da imagem) do Globo".

DIAS, S. O. Variações Latino-Americanas diante do Antropoceno 1,2,5 e 6, 2023.

COPETTI, A.; SALES, T. A.; TURANO, N.; DIAS, S. O. Variações Latino-Americanas diante do Antropoceno 6 - 2023.

COPETTI, A.; DIAS, S. III multiTão Pesquisas, no Laboratório de Estudos Avançados em Jornalismo (Labjor) da Universidade Estadual de Campinas, 2023.

DIAS, S. Palestra "Una constelación de imágenes monstruosas" com Maia Gattás Vargas no Labjor-Unicamp. http://climacom.mudancasclimaticas.net.br/una-constelacion/.

GARCIA, G.C. Pedagogias da Imagem. Sessão de 20/06/2023. Filme: 'Dr. Fantástico', de Stanley Kubrick. Convidado: Herli Joaquim de Menezes. Título da palestra: 'Estranhamor e os fins do mundo'.

GARCIA, G.C. Pedagogias da imagem. Sessão de 30/08/2023. Filme: 'Ôrí', de Raquel Gerber. Convidados: Nastassja Pugliese (FE/UFRJ e Cátedra UNESCO para a História das Mulheres na Filosofia, Ciências e Cultura) e Diego Matos Gondim (PPGE-UFRJ). Título da mesa: 'Pensar as vozes do currículo: gênero, raça e território'.

GUZZO, M. Série de seminários: Antropoceno: arte, cuidado e invenção. 2023. (Encontro).

QUEIROZ FILHO, Antonio Carlos. Webinário Internacional "Aulas Abertas do Rasuras" - Terceira Edição. (Sessão 1: sobre gamificação, vida urbana significativa e o aprender lúdico). 2023.

QUEIROZ FILHO, Antonio Carlos. Webinário Internacional "Aulas Abertas do Rasuras" - Terceira Edição. (Sessão 2: sobre linguagens artísticas e suas geo-grafias possíveis). 2023.

MINERVINI , M. Charla – Taller Narrativas para pensar los conflictos socio-ambientales. El caso del Corredor Sierras Chicas: Mgter. Mariana Minervini (Docente FCC- Administración de Parques Nacionales) – Mgter. Luciana Nicola e Ing. Marcos Ferioli (Administración de Parques Nacionales), Rocío Juncos (Subsecretaría de Cultura SEU-UNC) y Claudia Rodríguez (Docente FCC). En la IV Bienal de Periodismo y Comunicación.Facultad de Cs de la Comunicación.Universidad Nacional de Cordoba. jun. 2023.

VIDAL, E. Taller de Lenguaje I y Producción Gráfica A. Taller de Lenguaje III y Producción Audiovisual - Ver para comprender. Desafíos del periodismo visual en la cobertura de la crisis climática-Presentación del portal Sonda Internacional. Pablo Tosco (Argentina) Mikel Konate (España), Lili Meyer (Australia) Modera: Elizabeth Vidal https:// sondainternacional.com.Disponible en https://www.youtube.com/watch?v=c9f-NCGfP5I En la IV Bienal de Periodismo y Comunicación.Facultad de Cs de la Comunicación.Universidad Nacional de Cordoba. jun. 2023.

WUNDER, Alik; Fórum Permanente: Por uma justiça epistêmica e outras propostas decoloniais dos currículos. 2023. (Congresso).

OLIVEIRA, T.; WUNDER, A.; DIAS, S. Agrofloresta em festa. Vivência de 3 dias em Pocinhos do Rio Verde, Minas Gerais, 2023.

Monitoramento e Alertas. Oficina Emergência Climática. As ações federais diante de crescentes desafios. 29/09/2023. Sede do ICMBio, Brasília, DF.

Expressão Nacional – Resposta aos desastres ambientais. Câmara dos Deputados, 04/10/2023 (TV Câmara). https://www.youtube.com/watch?v=VfSiqJPFcR4&list=PLitz1J-q25kMymhpIEmtQjjm1LqZ9gkjz

Eventos extremos de chuvas no presente e seus impactos no contexto de desastres – Caso São Sebastião. Palestra no VII Seminário sobre Desastres Naturais – Semana Internacional para a

Redução de Risco de desastres, Palácio dos Bandeirantes, SP, 10/10/2023. https://www.youtube.com/watch?v=7RynWhgzbeg

Impactos dos Eventos Extremos, Palestra no Seminário on-line "Eventos Climáticos Extremos em Ano de El Niño", FAPESP, 17/10/2023. https://youtu.be/_1ddjHDQhNk

Senado debate fenômenos climáticos e desastres naturais – Sessão de Debates - Senado Federal, 26/10/2023. https://www12.senado.leg.br/noticias/videos/2023/10/ao-vivo-senado-debate-fenomenos-climaticos-e-desastres-naturais-2013-26-10-23

Monitoramento da situação da seca na Região Nordeste. Apresentação na Reunião Extraordinária – Audiência Pública sobre Severa seca que incidirá sobre o Nordeste do Brasil em 2024. Comissão de Meio Ambiente e Desenvolvimento Sustentável - Câmara dos Deputados. Brasília, 14/11/2023. https://www.camara.leg.br/noticias/1024205-comissao-discute-medidas-contra-seca-atipica-que-deve-afetar-o-nordeste-no-1o-semestre-de-2024/

Mesa-redonda: Crise climática e El Niño. Academia Brasileira de Ciências (ABC), 17/11/2023. https://www.youtube.com/watch?v=nAdMeiZGNNQ

Especialistas reforçam alertas de seca severa e riscos de desertificação no Nordeste. Portal da Câmara dos Deputados (Agência Câmara de Notícias), 14/12/2023. https://www.camara.leg.br/noticias/1026668-especialistas-reforcam-alertas-de-seca-severa-e-riscos-de-desertificacao-no-nordeste

Monitoramento e Alertas de Riscos de Desastres Geohidroclimáticos. Palestra apresentada na Mesa 2 – Gestão de riscos e de desastres hidrológicos, meteorológicos, climatológicos e geológicos. Workshop Interministerial: Abordagem Interinstitucional do Primeiro Plano Nacional de Proteção e Defesa Civil. MIDR, 01/02/2024. https://www.youtube.com/watch?v=IkJvTEd8U8s

Bate-papo com a Defesa Civil - como as mulheres transformam a gestão de riscos e desastres. 28/03/2024. Mediado pela diretora de Articulação e Gestão da Secretaria Nacional de Proteção e Defesa Civil Nacional (Sedec), Karine Lopes, pela diretora do Cemaden, Regina Alvalá; participação da gerente de Atenção Social da Defesa Civil do Recife (PE), Maria Afra Guedes, e da professora do Instituto Federal do Rio de Janeiro (IFRJ) e da Universidade Veiga de Almeida (UVA), Viviane Japiassú. **https://www.gov.br/mdr/pt-br/noticias/bate-papo-com-a-defesa-civil-debate-como-as-mulheres-transformam-a-gestao-de-riscos-e-desastres**

Conferencia Livre sobre Eventos Extremos no Contexto de Monitoramento e Alertas de Desastres: Estratégias em C&T para o Brasil, 11/04/2024. Realizada pelo CEMADEN, em parceria com o CENAD/MIDR, COMAL/SC; INPE/MCTI; UNESP-SJC; UNIFEI.

Palestra sobre o tema "Relação entre as mudanças climáticas e a ocorrência dos desastres". Audiência na câmara dos deputados, 14/05/2024. Comissão Especial sobre Prevenção e Auxílio a Desastres e Calamidades Naturais. Regina Alvalá, Ana Toni, Delton Carvalho, Fábio Feldmann, Suely Mara Guimarães Araújo. **https://www.camara.leg.br/evento-legislativo/72874**

https://www.youtube.com/watch?v=yFW5N7vZuzg

Palestra no Fórum de Meio Ambiente, Painel 2: Mudanças Climáticas, Desastres e Adaptação no Festival Internacional de Cinema e Vídeo Ambiental 2024 (FICA 2024), na cidade de Goiás, GO, 14/06/2024. Participantes do painel: Regina Alvalá, Candice Ballester, Fernando Rocha Nogueira e José Frederico Lyra Netto.

Palestra sobre Vulnerabilidade dos biomas brasileiros às mudanças climáticas, no Seminário Finep – Tragédia no RS: um alerta para os Biomas Brasileiros, Sessão A situação do Rio Grande do Sul e desafios para os biomas brasileiros. Rio de Janeiro, 25/06/2024. http://www.finep.gov.br/noticias/todas-noticias/6811-seminario-na-finep-com-foco-nas-cheias-do-rio-grande-do-sul-debate-biomas-brasileiros-e-politicas-efetivas-para-eventos-climaticos-extremos

5ª Conferencia Nacional de CT&I. Eixo III – Sessão especial: Na era dos desastres climáticos: a importância de ouvir a Ciência. Coordenação (Regina Célia dos Santos Alvalá - CEMADEN); Palestrantes (Flávia Costa – INPA; Fábio Feldman – Consultor CBC; Sérgio Portella – Fiocruz; Mercedes Bustamante – UnB); Relatoria (Julia Cohen – UFPA). Sala Porto Seguro 1. **https://5cncti.org.br/conferencia-nacional/**

Painel Mudanças Climáticas. Adaptação, resiliência e controle de riscos. Moderação: Joaquim Guedes Correa Gondim Filho; Contextualização: Saulo Aires de Souza, Palestrantes: Jordana Girardelo, Regina Célia dos Santos Alvalá, 1º Fórum Brasil das Águas, Foz do Iguaçu, 05/08/2024, 09:15 – 10:30 horas. https://www.forumbrasildasaguas.org/

EPE marca presença no 6º Seminário: O futuro do setor elétrico-energético brasileiro: Mudanças climáticas e seus efeitos sobre os desligamentos do sistema, Empresa de Pesquisa Energética, 15/08/2024. https://www.epe.gov.br/pt/imprensa/noticias/epe-marca-presenca-no-6-seminario-o-futuro-do-setor-eletrico-energetico-brasileiro-mudancas-climaticas-e-seus-efeitos-sobre-os-desligamentos-do-sistema

CHOU, S. C. 2024 :Considerando informações climáticas no planejamento da gestão hídrica na RMRJ. Oficina "INTEGRAÇÃO PELAS ÁGUAS: Governança, Planos e Territórios" no XI Encontro Estadual de Comiês de Bacias Hidrográficas do Rio de Janeiro. Rio de Janeiro, 2024.

CHOU, S.C. 2024 "PROJEÇÕES DE MUDANÇAS CLIMÁTICAS NO BRASIL" UFSCar, Pós-Graduação em Ecologia e Recursos Naturais.

CHOU, S.C. 2024 "Webinar AESABESP: Modelagem Numérica do Sistema Terrestre, Impacto, vulnerabilidade e adaptação das cidades às mudanças climáticas"

CHOU, S. C. 2023: Projeções em alta resolução da chuva durante eventos de El Niño em cenários de mudanças climáticas globais & Previsões sazonais em alta resolução da estação chuvosa 2023- 2024. Em "Crise climática e desastres como consequência do El Niño 2023-2024: impactos observados e esperados no Brasil". Academia Brasileira de Ciências, 16 de novembro de 2023. https://www.abc.org.br/evento/mesa-redonda-crise-climatica-e-el-nino/

Chou, S. C. "Climate variability and change on timescales of seasons to millennia". Componente da Mesa Redonda 6 com apresentação da palestra intitulada "Simulações de mudanças climáticas & Previsões climáticas de chuva para a próxima estação". XXV Simpósio Brasileiro de Recursos Hídricos, Aracajú - SE, 2023.

Chou, S. C. 2024: Previsão Climática Sazonal e Projeções de Mudanças Climáticas: Subsídio a planejamento de curto prazo (meses à frente) e longo prazo (décadas a frente). Workshop Sistema de Previsão de Secas e Enchentes para a Bacia do Rio Madeira, Universidade do Estado do Amazonas - Manaus, 18 e 19 de junho de 2024.

BALTAZAR, R. L. S.; CHOU, S. C.; DERECZYNSKI, P. Desempenho das previsões sazonais do modelo Eta aninhado ao modelo BESM do INPE. In: 12ª SIAc – Semana de Integração Acadêmica da UFRJ, Rio de Janeiro, 2023.

Laureanti, N. C. 2024: Extremos Climáticos na Bacia do Rio Madeira: O papel dos oceanos Pacífico e Atlântico. Workshop Sistema de Previsão de Secas e Enchentes para a Bacia do Rio Madeira, Universidade do Estado do Amazonas - Manaus, 18 e 19 de junho de 2024.

Tavares, M.G.; Chou, S.C. 2024: Reserva de Desenvolvimento Sustentável do Rio Madeira. Workshop Sistema de Previsão de Secas e Enchentes para a Bacia do Rio Madeira. Universidade do Estado do Amazonas - Manaus, 18 e 19 de junho de 2024.

Other publications (op-eds, abstracts in proceedings, etc.)

GARCÍA, D.; MENEGAZ, A. Elaboración de 3 documentos destinados a docentes interculturales sobre Cambio Climático. Desarrollo de contenidos para la sensibilización y

difusión de la adaptación al cambio climático y Pueblos Indígenas; conocimiento de la ley n°. 27.520 de presupuestos mínimos de adaptación y mitigación del cambio climático global; instrumentos de acceso al conocimiento para ejercer el derecho a participar y decidir. Editado por Dirección Nacional de Cambio climático. **Ministerio de Ambiente y Desarrollo Sostenible de la Nación**, 2023. (no prelo)

Miranda, E. A relação entre consumo de carne e mudanças climáticas no âmbito coletivo. **Climacom Cultura Científica**, 15 de maio de 204;

Miranda, Emanuely. Como contar o incontável. **Climacom Cultura Científica**, 14 mar. 2024.

MIRANDA, Emanuely. Quando a crise climática esbarra no racismo. **Climacom Cultura Científica**.

PELLEJERO, E. A.. Virginia Buitrón: Laços vitais. **ClimaCom**, v. 25, p. 1-8, 2023. Analisando a obra de Virginia Buitrón, este ensaio estabelece a possibilidade de relações simbióticas não limitadas ao biológico, dando lugar a formas da imaginação que excedem os limites de humano e permitem pensar numa ecologia alargada.

RAMMIG, A. ; LAPOLA, D. M. ; BACHEGA, L. R. ; LEITE, P. P. ; PEREIRA, A. C. ; PEREIRA, I. ; GUEDES, A. ; GARCIA, S. ; SANTANA, F. ; ALEIXO, I. ; PORTELA, B. T. ; DAMASCENO, A. ; USHIDA, G. ; FERRER, V. ; SOUZA, C. ; MORAES, A. C. ; QUESADA, C. A. ; FUCHSLUEGER, L. ; VALVERDE-BARRANTES, O. ; MONTEIRO, Marko Synésio Alves . AmazonFACE: A large-scale Free Air CO2 Enrichment Experiment in the Amazon rainforest. In: **EGU General Assembly 2024**, 2024, Viena. EGU General Assembly 2024, 2024. p. 1.

RAMMIG, A. ; LAPOLA, D. M. ; BACHEGA, L. R. ; MARTINS, N. ; LEITE, P. P. ; PEREIRA, A. C. ; PEREIRA, I. ; GUEDES, A. ; GARCIA, S. ; SANTANA, F. ; ALEIXO, I. ; PORTELA, B. T. ; DAMASCENO, A. ; USHIDA, G. ; FERRER, V. ; SOUZA, C. ; MORAES, A. C. ; QUESADA, C. A. ; FUCHSLUEGER, L. ; MONTEIRO, Marko Synésio Alves . AmazonFACE: A Free Air CO2 Enrichment Experiment in the Amazon rainforest is ready to launch. In: **EGU General Assembly 2023**, 2023, Viena. EGU General Assembly 2023, 2023. p. 1.

TADDEI, R. R.. Como planejar um futuro que não é mais o que era no passado. **Jornal da Ciência (SBPC)**, São Paulo, p. 16 - 16, 12 dez. 2023.

OLIVEIRA JUNIOR, WENCESLAO MACHADO; RIGOTTI, Gabriela Fiorin. DEVIRES NÃO HUMANOS DO CINEMA NO LUGAR-ESCOLA DE EDUCAÇÃO INFANTIL - alguns dispositivos de pesquisa e formação de educadoras em exercício. In: 7 Colóquio Internacional, 2023, Natal. **Anais do VII Colóquio Internacional A educação pelas imagens e suas geografias**, 2023. v. 1. p. 1-5.

ALVAREZ, T. O. Mediadora do evento Variações Latino-Americanas diante do Antropoceno 2 - Pedagogias da imagem: cineclubismo e educação, com Gabriel Cid Garcia, 2023.

AMORIM, A. C. R.. 2 Fragmentos de vidas em deslocamentos. 2023. (Apresentação de Trabalho/Congresso). I Colóquio Internacional de Infâncias Migrantes e Refugiadas; Inst. promotora/financiadora: Programa de Pós-Graduação em Educação da UFJF.

AMORIM, A. C. R.. Ensinar trans-versando os signos do acontecimento. 2023. (Apresentação de Trabalho/Conferência ou palestra). II Congresso do Programa de Pós-Graduação em Ensino de Ciências e Humanidades; Inst. promotora/financiadora: Pós-Graduação em Ensino de Ciências e Humanidades UFAM.

ARANHA, N; DIAS, S.. Apresentação oral "Os cantos dos anfíbios e a comunicação diante do Antropoceno" no X Simpósio Nacional de Ciência, Tecnologia e Sociedade – Ciência em Tempos Sombrios: Descolonizando pensamento e territorializando as disputas, realizado nos dias 25, 26 e 27 de outubro de 2023 na Universidade Federal de Alagoas.

ARANHA, N. Participação como ouvinte no X Simpósio Nacional de Ciência, Tecnologia e Sociedade – Ciência em Tempos Sombrios: Descolonizando pensamento e territorializando as disputas, realizado nos dias 25, 26 e 27 de outubro de 2023 na Universidade Federal de Alagoas.

ARANHA, N. Apresentação oral “A bioacústica dos sapos e os estudos multiespécies: experimentos comunicacionais em mesas de trabalho” no X Congresso Brasileiro de Herpetologia, realizado de 11 a 15 de setembro de 2023, na cidade de Porto Seguro/BA.

ARANHA, N. Participação como ouvinte no X Congresso Brasileiro de Herpetologia, realizado de 11 a 15 de setembro de 2023, na cidade de Porto Seguro/BA.

ARANHA, N. Apresentação oral "Os cantos dos anfíbios e a comunicação diante do Antropoceno" no evento multiTÃO Pesquisas 2023, realizado no dia 29/11/2023, de forma remota, com carga horária de 06 horas.

ARANHA, N. Participação como ouvinte no evento multiTÃO Pesquisas 2023, realizado no dia 29/11/2023, de forma remota, com carga horária de 06 horas.

ARANHA, N.; DIAS, S. Trabalho apresentado no IX Seminário Conexões: Deleuze e Linhas e Cosmos e Educação e…, Unicamp, 27 a 29 de maio de 2024.

CANGI, A.. Apresentação no 1o. Seminário do Ciclo "Ecopoéticas: educação, arte e Antropoceno - uma homenagem a Bruno Latour" com Adrián Cangi e Carolina Cantarino. YouTube da ClimaCom., 2023.

CANGI, A.; GONZÁLEZ, A. Mediadores do 2o. Grupo de Estudos do Ciclo "Ecopoéticas: educação, arte e Antropoceno - uma homenagem a Bruno Latour" | com Alik Wunder. YouTube da ClimaCom, 05/05/2023. Sobre os temas: "Sobre a instabilidade (da noção de) natureza" e "Como não (des)animar a natureza".

CANTARINO, C. Apresentação no 1o. Seminário do Ciclo "Ecopoéticas: educação, arte e Antropoceno - uma homenagem a Bruno Latour" com Adrián Cangi e Carolina Cantarino. YouTube da ClimaCom., 2023.

DALMASO, A. C.. Mediação Variações Latino-Americanas diante do Antropoceno 6, 2023.

DIAS, S. O. Apresentação do livro: DIAS, S; BARATA, G.; BARBAI, M.; CARREON, R. de O.; ALDAY, A. Divulgação científica e cultural: 16 anos de um curso de pós-graduação. São Paulo: Pontes, na Casa do Lago, 2024.

DIAS, S. O. Apresentação "ClimaCom e Bruno Latour" no 1o. Seminário do Ciclo "Ecopoéticas: educação, arte e Antropoceno - uma homenagem a Bruno Latour". YouTube da ClimaCom., 2023.

DIAS, S. O. Palestra na série de seminários: Antropoceno: arte, cuidado e invenção. Título da palestra: Companhia como modo de atenção à Terra. 2023. (Encontro).

DIAS, S. O. Palestra na disciplina: Naturezas, Culturas e Educação, na UFSC. Título da palestra: Espécies companheiras: desdobramentos de um conceito-prática. 2023. (Outra).

DIAS, S. O. Palestra "Como ser afetada por um rio?", UFBA, 2023.

DIAS, Susana. Mediação Variações Latino-Americanas diante do Antropoceno 5 - 2023.

ESQUIVEL MARIN, S. Conferencia magistral de investigación en filosofía de la comunicación "modernidad capitalista", en el coloquio de investigaciones de invierno del 2023 en la MIHE de la UAZ.

ESQUIVEL MARIN, S. Conferencia magistral: La memoria absoluta de las cosas (Cioran, Yourcenar, (alasso: Repensar: la finitud yel tiernpo), Estrasburgo, Université de Strasbourg, 21 de junio del 2023.

ESQUIVEL MARIN, S. Conferencia: Deleuze y Antroceno en Mesa redonda Cosmopolítica y Estéticas aberrantes, 9 Seminario de Conexões, Campinas, UNICAMP, 27-29 de mayo del 2024.

ESQUIVEL MARIN, S. Conferencia magistral: Orfandad humana y alteridad divina. Bajo la crisis de la modernidad capitalista y el Antropoceno, Praga, Université Charles de Prague, 26 de juniol del 2024.

GARCÍA, D. Conferencista invitada en la actividad de apertura: La formación de educadores ambientales en el horizonte de la educación superior. Semana UNIPE virtual 2023 / Edición Verano.

GARCÍA, D. Conferencia "Pedagogía Ambiental: La EA como práctica política transformadora". Espacio de Formación. Foro Provincial Estrategia de Educación Ambiental de la provincia de Buenos Aires. La Plata. Octubre 2023.

GARCÍA, D.; MENEGAZ. A. Condicionantes sociales del uso de agrotóxicos en la horticultura familiar: aportes conceptuales para la transición agroecológica. III Congreso Argentino de agroecología. El Bolsón. Noviembre 2023.

GARCÍA, D.; MENEGAZ, A. Taller de técnicas de investigación territorial. SEMANA DEL AMBIENTE. Instituto de Ciencias Sociales y Administración-UNAJ. Junio 2023.

GARCÍA, D.; MENEGAZ, A. Agrotóxicos y salud, ¿que expresan y que ocultan las bandas de color toxicológicas? Mesa de Trabajo XI Jornadas de Agricultura familiar. Facultad de Agronomia. UNLP. La Pata Agosto 2023.

GARCIA, G. C. Participante do encontro Variações Latino-Americanas diante do Antropoceno (ClimaCom/Fapesp), com a intervenção 'Pedagogias da imagem: cineclubismo e educação', online – 31/03/2023.

GARCIA, G. C. Mediação do 2º Seminário do Ciclo 'Ecopoéticas: educação, arte e Antropoceno - uma homenagem a Bruno Latour' (Unicamp/Rede DCMC/UFSC/Undav-Argentina/Fapesp), online - 02/06/2023.

GARCIA, G. C. X Simpósio Nacional de Ciência, Tecnologia e Sociedade – X ESOCITE.BR. Apresentação do trabalho oral: "Cinema, artifício e nomadismo: figurações do desastre no Antropoceno". Maceió, Alagoas. 25/10/2023.

GARCIA, G.C. Debatedor no evento 'multiTÃO Pesquisas 2023', Labjor-Unicamp, 29/11/2023, de forma remota.

GUIVANT, JULIA S. Participação no debate As Humanidades ante o Antropoceno. 11/05/2023. Organização IEA/USP.

GUZZO, MARINA SOUZA LOBO. Mistura: alianças coreográficas entre mulheres e plantas. 2023. (Apresentação de Trabalho/Outra).

GUZZO, MARINA SOUZA LOBO. Choreographing the mixture: alliances between woman and plant. 2023. (Apresentação de Trabalho/Comunicação).

GUZZO, MARINA SOUZA LOBO. Diante da catástrofe: alianças afetivas para coreografar no Antropoceno. 2023. (Curso de curta duração ministrado/Outra).

GUZZO, MARINA SOUZA LOBO; GIELEN, P. ; NICOLAU, G. . Sentir a Terra: conversa sobre arte e ecologia. 2023. (Palestra).

HATRICK, P.; GARCÍA, D.. Ponencia en el eje 1: desarrollo social, organizacional y humano. Horticultura y agrotóxicos: potencial impacto sobre la salud en familias de La Capilla, Florencio Varela. II Encuentro Latinoamericano de Experiencias Investigativas RED COMPA-INSTITUCION UNIVERSITARIA COLEGIO MAYOR DE ANTIOQUIA. Colombia. Modalidad mixta. Mayo 2023.

MENEGAZ, Adriana; GARCÍA, d. Interpelando las prácticas: desafíos y oportunidades de la construcción participativa de conocimiento. Simposio: Co-producción de conocimiento y enfoque etnográfico: apuestas y tensiones en el trabajo con organizaciones y movimientos populares. X Jornadas sobre Etnografía y Métodos Cualitativos, ciudad de Posadas, Misiones, Argentina. Septiembre de 2023.

MENEGAZ, A.; GARCÍA, D.; TORRENS, S. "La cartografía de problemáticas socioambientales locales en el diseño de un itinerario de Formación docente situada. La experiencia en Oliden" Foro Provincial Estrategia de Educación Ambiental de la Provincia de Buenos Aires. La Plata. Octubre 2023

MIRANDA, E. Apresentação oral: "Histórias em tempos de crise climática: um desafio que fica para o jornalismo" no evento Intercom Sudeste 2024, realizado no dia 31/05/2024

MIRANDA, E. Apresentação oral: "O Cântico dos Cânticos: como as espécies companheiras chegaram para pensar o feminino" no evento multiTÃO Pesquisas 2023, realizado no dia 29/11/2023, de forma remota, com carga horária de 06 horas.

MIRANDA, E. Participação como ouvinte no XII Colóquio Internacional de Filosofia e Educação, realizado nos dias 6 a 10 de maio de 2024, na Universidade Estadual do Rio de Janeiro.

MORALES,S.; VIDAL, E. y Equipos de Producción del ISEP (2023). Módulo "La comunicación como objeto de enseñanza", para el Instituto Superior de Estudios Pedagógicos, Dirección General de Educación Superior. Ministerio de Educación de la Provincia de Córdoba.

MURRIELLO, S. Presentación del libro A diez años de la erupción del Puyehue-Cordón Caulle, compilado por Murriello, S. y Barrios García, G. publicado por la Editorial de la UNRN en 2023.

MURRIELLO, S. Charla abierta a cargo del Dr. Marcelo Lagos López, de la Universidad Católica de Chile, Santiago de Chile. https://www.youtube.com/watch?v=n_-T0U2t2xU

OLIVEIRA, Tatiana P., LAYRARGUES, Philippe P., BERTACHI, Marcos V.; VAZ DA SILVA, Patricia P.. Colapso ambiental e os desafios sociopolíticos da agroecologia no Brasil. 11º Encontro de Agroecologia, IFSULDEMINAS – Campus Machado, Machado/MG, Dez./2023. (Mesa Redonda).

OLIVEIRA, Tatiana P. Em/entre corpos e solos: cultivos de gestos e práticas. Jornadas de Antropologia John Monteiro, IFCH, Universidade Estadual de Campinas, Campinas/SP, Nov./2023. (Apresentação de Trabalho/Comunicação Oral).

OLIVEIRA, Tatiana P. Escritas de biointeração. MultiTÃO Pesquisas 2023, Laboratório de Estudos Avançados em Jornalismo, Universidade Estadual de Campinas, Campinas/SP, Nov./2023. (Apresentação de Trabalho/Comunicação Oral).

OLIVEIRA JÚNIOR, Wenceslao Machado. Participação, como palestrante, na live "Natureza, Conexidade e Cultura: o ser-no-mundo", lançamento da formação "Perceber-fazer floresta" da Secretaria Municipal de Educação-Campinas, no dia 07 de maio. o título de minha fala foi: "PAISAGENS (DES)(RE)FLORESTADAS DA EDUCAÇÃO ESCOLAR: três movimentos da escola como terra de cultivo".

RIGUE, F. M. ; SALES, TIAGO AMARAL. Trabalho apresentado no IX Seminário Conexões: Deleuze e Linhas e Cosmos e Educação e…, Unicamp, 27 a 29 de maio de 2024: Seres mais que humanos e territórios acadêmicos: espécies companheiras em coabitação na universidade.

RIGUE, F. M. ; SALES, TIAGO AMARAL; DALMASO, Alice.. Trabalho apresentado no IX Seminário Conexões: Deleuze e Linhas e Cosmos e Educação e…, Unicamp, 27 a 29 de maio de 2024: Fabulando estórias com os vírus: educações em criações de mundos.

TADDEI, Renzo. Apresentação do trabalho “The challenges of integrating Indigenous knowledge in the construction of climate knowledge at the IPCC”, na reunião anual da American Anthropological Association (AAA), realizada em conjunto com a Canadian Anthropological Society, em Toronto, em painel intitulado “Anthropology & Climate Change: Transitions”, para o qual o pesquisador foi convidado pelo Climate Change Interest Group da AAA. 15 a 19 de novembro de 2023, Toronto, Canadá.

TADDEI, Renzo. Apresentação do trabalho “Há espaço para o conhecimento indígena nos esforços globais de construção de sistemas de informação sobre ciência climática?”, na reunião anual da Asociación Latinoamericana de Antropologia (ALA), em painel intitulado “MR.27: O lugar dos povos tradicionais, de seus conhecimentos e cosmovisões no debate sobre mudanças climáticas”, para o qual o pesquisador foi convidado pela Associação Brasileira de Antropologia (ABA), organizadora da sessão. 11 a 15 de março de 2024, Rosário, Argentina.

VARGAS, Maia Gattás. Palestra “Una constelación de imágenes monstruosas” no Labjor-Unicamp. http://climacom.mudancasclimaticas.net.br/una-constelacion/.

VIDAL, E. LOYOLA I. ILARDO C. Taller de Lenguaje I y Producción Gráfica A y Taller de Lenguaje III y Producción Audiovisual - Ver para comprender. Desafíos del periodismo visual en la cobertura de la crisis climática-Presentación del portal Sonda Internacional. Pablo Tosco (Argentina) Mikel Konate (España), Lili Meyer (Australia) Modera: Elizabeth Vidal https:// sondainternacional.com. Disponible en https://www.youtube.com/watch?v=c9f-NCGfP5I En la IV Bienal de Periodismo y Comunicación. Facultad de Cs de la Comunicación. Universidad Nacional de Córdoba. jun. 2023.

VILELA, M.. Palestra: Criação e arte em questionamentos do antropoceno. Organização Amplia rede/UFU. Uberlânida, 2023.

WUNDER, A.; PEDAGOGIAS DE LA PERCEPCIÓN Y LA IMAGINACIÓN. 2023. (Apresentação de Trabalho/Conferência ou palestra).

WUNDER, Alik;?Ecopoéticas: educação, arte e Antropoceno?. 2023. (Apresentação de Trabalho/Conferência ou palestra).

ARCILA, S. Palestra no evento Variações Latino-Americanas diante do Antropoceno 5 - 2023.

ARCILA, S. Palestra no evento “Ecopoéticas: educação, arte e Antropoceno”, 2023.

SOARES, ANNA ELIS PAZ; SILVA, S. R.; MONTENEGRO, S. G. L. Reúso de efluentes sanitários e a revitalização de rios no semiárido: uma revisão sistemática da literatura. In: Proceedings of the I Latin American Symposium on City, Architecture and Sustainability, 2023,

São Paulo. https://www.even3.com.br/city-architecture-and-sustainability-314170/, 2023. v. 1. p. 1206-1217.

CARVALH, M. E. F. S.; MEDEIROS, E. L. C.; COUTINHO, A. P.; MONTENEGRO, SUZANA MARIA GICO DE LIMA; CABRAL, JAIME JOAQUIM DA SILVA PEREIRA. ABORDAGEM SOCIO-HIDROLÓGICA NA REVITALIZAÇÃO DE RIOS URBANOS: ESTUDO DE CASOS PELO MUNDO. In: XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023, Sergipe. Anais - XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023.

BRESSIANI, D. A.; SRINIVASAN, R.; MIRANDA, R. Q.; Galvíncio, J. D.; MONTENEGRO, SUZANA MARIA GICO DE LIMA; MENDIONDO, E. M.. AN OPEN COLLABORATIVE WEB-BASED BRAZILIAN ECOHYDROLOGICAL SIMULATION TOOL - BEST. In: XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023, SERGIPE. Anais - XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023.

SILVA, P. G. C.; BENSO, M. R.; SILVA, G. J.; JESUALDO, G.; COSTA, R. S.; GONCALVES, A. R.; MIRANDA, I. P.; BRESSIANI, D. A.; PEREIRA, E. B.; Galvíncio, J. D.; CUARTAS, L. A.; MONTENEGRO, SUZANA MARIA GICO DE LIMA; KROL, M. S.; MENDIONDO, E. M.. DESAFIOS E OPORTUNIDADES DA TRANSIÇÃO PARA A ENERGIA SOLAR FOTOVOLTAICA NA GESTÃO DOS RECURSOS HÍDRICOS NO BRASIL. In: XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023, Sergipe. Anais - XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023.

CARVALH, M. E. F. S.; CABRAL, JAIME JOAQUIM DA SILVA PEREIRA ; SANTANA, A. P. C.; MEDEIROS, E. L. C.; MONTENEGRO, SUZANA MARIA GICO DE LIMA; SANTOS, N. B. C.; COUTINHO, A. P.. EVENTOS CULTURAIS COMO FORMA DE INCENTIVO PARA REVITALIZAÇÃO DE RIOS URBANOS: O CASO DO CAPIBARIBE FESTIVAL. In: XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023, Sergipe. Anais - XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023.

TAVARES, D. M. F.; FARIAS, V. E. M.; DE ANDRADE, J. M.; MONTENEGRO, S. M. G. L. AVALIAÇÃO DO DESEMPENHO DE PRODUTOS DE SENSORIAMENTO REMOTO PARA ANÁLISE DE SECA NA BACA HIDROGRÁFICA DO RIO PAJEÚ. In: XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023, Sergipe. Anais - XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023.

URSULINO, B. e S.; FARIAS, V. E. M.; SILVA, S. F.; MONTENEGRO, S. M. G. L. RESPOSTAS DA VEGETAÇÃO À DINÂMICA DE VARIÁVEIS HIDROCLIMATOLÓGICAS UTILIZANDO SENSORIAMENTO REMOTO NA BACIA DO RIO CAPIBARIBE-PE. In: XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023, Sergipe. Anais - XXV SBRH - Simpósio Brasileiro de Recursos Hídricos, 2023.

Vieira VR, Afonso MMS, Costa SM, Magalhães MAFM, Souza IAA, Rangel EF. Municipal Vulnerability of American Visceral Leishmaniasis and Prediction of Future Scenarios in the face of Climate Change in the State of Minas Gerais, Brazil. In: 59° Congresso da Sociedade Brasileira de Medicina Tropical, 2024, São Paulo.

Margarete Martins Santos Afonso, Bruno Moreira Carvalho, Arthur Augusto Velho Mendes Júnior, Cristina Maria Giordano Dias, Lucas Keidel, Patrícia Soares Meneguete, Sandro Antônio Pereira, Elizabeth Ferreira Rangel. Distribution of vectors of American Visceral Leishmaniasis in the state of Rio de Janeiro/ Brazil: municipal vulnerability for transmission, ecological niche modelling and predicted geographic distribution. In: 59° Congresso da Sociedade Brasileira de Medicina Tropical, 2024, São Paulo.

Simone Miranda da Costa, Mônica Avelar Figueiredo Mafra Magalhães e Elizabeth Ferreira Rangel. Leishmaniose Tegumentar Americana (LTA) em associação com a distribuição espacial de *Nyssomyia whitmani*, frente as alterações ambientais nos estados da Amazônia Legal, Brasil). In: 59° Congresso da Sociedade Brasileira de Medicina Tropical, 2024, São Paulo.

Simone Miranda da Costa, Monica de Avelar Figueiredo Mafra Magalhães, Renata de Saldanha da Gama Gracie Carrijo, Elizabeth Ferreira Rangel. Using geoprocessing techniques to analyze the geographic distribution of *Nyssomyia whitmani* (Diptera: Psychodidae: Phlebotominae)

associated with vegetation cover, and the impacts on the expansion of American Cutaneous Leishmaniasis (ACL) in Brazil). In: 59° Congresso da Sociedade Brasileira de Medicina Tropical, 2024, São Paulo.

9. List of publications (articles, books and book chapters)

Health

Costa SM, Magalhães MAFM, Gracie Carrijo RSG, Rangel EF. Using geoprocessing techniques to analyze the geographic distribution of *Nyssomyia whitmani* (Diptera: Psychodidae: Phlebotominae) associated with vegetation cover, and the impacts on the expansion of American Cutaneous Leishmaniasis (ACL) in Brazil. Journal Archives of Health, 2024.

Agriculture

Estevam, C.G.; Pavão, E.M.; Assad, ESTEVAM, C.,G., PAVÃO, E., ASSAD, E. (2023). QUANTIFICATION OF GHG EMISSIONS IN THE Agriculture Industry. Emissions factors, metrics and methodologies . Bioeconomy Knowledge and Innovation Observatory. Getulio Vargas Foundation, SP. Brazil. 2023

Estevam, C.G. ; PAVAO, E. M. ; **Assad, E.D.** . DISTORTIONS IN THE MEASUREMENT OF GHG EMISSIONS FROM AGRIBUSINESS. AGROANALYSIS (FGV), v. 7, p. 28-31, 2024.

Assad.E.D.:Filho,F.M.G ; El-Memari Neto, A,C. ; Braga, H. ; Poppi, A.C.O. ; Wassal, A.A. . Emissions balance of one hundred Brazilian farms. AGROANALYSIS (FGV), v. 7, p. 25-29, 2024

Modelling

Bottino, M. J., and Coauthors, 2024: Amazon savannization and climate change are projected to increase dry season length and temperature extremes over Brazil. *Sci. Rep.*, **14**, 5131, https://doi.org/10.1038/s41598-024-55176-5.

Makarieva, A. M., and Coauthors, 2023: Water Lifting and Outflow Gain of Kinetic Energy in Tropical Cyclones. *J. Atmospheric Sci.*, **80**, 1905–1921, https://doi.org/10.1175/JAS-D-21-0172.1.

Nobre, P., and Coauthors, 2023: AMOC decline and recovery in a warmer climate. *Sci. Rep.*, **13**, 15928, https://doi.org/10.1038/s41598-023-43143-5.

Sherwood, S. C., and Coauthors, 2024: Uncertain Pathways to a Future Safe Climate. *Earths Future*, **12**, e2023EF004297, https://doi.org/10.1029/2023EF004297.

da Silva Tavares, P., R. Acosta, P. Nobre, N. C. Resende, S. C. Chou, and A. de Arruda Lyra, 2023: Water balance components and climate extremes over Brazil under 1.5 °C and 2.0 °C of global warming scenarios. *Reg. Environ. Change*, **23**, 40, https://doi.org/10.1007/s10113-023-02042-1.

Veiga, S. F., and Coauthors, 2023: Climate change over South America simulated by the Brazilian Earth system model under RCP4.5 and RCP8.5 scenarios. *J. South Am. Earth Sci.*, 104598, https://doi.org/10.1016/j.jsames.2023.104598.

Xue, Y., and Coauthors, 2023: Remote effects of Tibetan Plateau spring land temperature on global subseasonal to seasonal precipitation prediction and comparison with effects of sea surface temperature: the GEWEX/LS4P Phase I experiment. *Clim. Dyn.*, https://doi.org/10.1007/s00382-023-06905-5.

Tavares, P. S.; Pilotto, I. L.; Chou, S. C.; Souza, S. A.; Fonseca, L. M. G.; Chagas, D. J. (2024). A dataset of high-resolution climate change projections over South America with bias correction. DERBYANA, accepted.

Campos DA, Chou SC, Bottino MJ, Gomes JL, Lyra AA. Inclusion of the radiative effect of deep convective clouds in the Eta model simulations. Quarterly Journal of the Royal Meteorological Society, 1–12. 2024. Available from: https://doi.org/10.1002/qj.4673.

Farfán, H. H., Tcheou, M. P., Lovisolo, L., Chou, S. C., Gomes, J. L., & Nobre, P. (2024). Correção de viés em previsão climática global da temperatura da superfície do mar por meio de filtros adaptativos no domínio da frequência. Revista Brasileira De Climatologia, 34(20), 620–642. https://doi.org/10.55761/abclima.v34i20.17005

Afonso, E.O.; Chou, S.C. Modeling the Effects of Local Atmospheric Conditions on the Thermodynamics of Sobradinho Lake, Northeast Brazil. Climate 2023, 11, 208. https://doi.org/10.3390/cli11100208

Sondermann, M.; Chou, S.C.; Tavares, P.; Lyra, A.; Marengo, J.A.; Souza, C.R.d.G. Projections of Changes in Atmospheric Conditions Leading to Storm Surges along the Coast of Santos, Brazil. Climate 2023, 11, 176. https://doi.org/10.3390/cli11090176

Ferreira, N. C. R., Tavares, P. S., Medeiros, G. S., Ferreira, L. N., Borges, P., Chou, S. C., & Rodrigues, M. L. (2023). Projeções de tempo severo e impactos em torres de linhas de transmissão em Santa Catarina, Brasil, sob cenários futuros de mudanças climáticas globais. Derbyana, 44. https://doi.org/10.14295/derb.v44.808

Economia

CALLEGARI, CAMILA ; TANURE, TARIK ; FIORINI, ANA CAROLINA OLIVEIRA ; Haddad, Eduardo ; DOMINGUES, EDSON ; MAGALHÃES, ALINE ; PEROBELLI, FERNANDO ; PORSSE, ALEXANDRE ; LUCENA, ANDRÉ F. P. ; VASQUEZ-ARROYO, EVELINE ; IMPÉRIO, MARIANA ; BAPTISTA, LUIZ BERNARDO ; SCHAEFFER, ROBERTO . The Role of Cities: Linking Integrated Assessment Models to Urban Solutions. Sustainability, v. 15, p. 4766, 2023.

Haddad, Eduardo A.; ARAÚJO, INÁCIO F. ; PEROBELLI, FERNANDO S. . Geographical Proximity and Technological Similarity. Structural Change and Economic Dynamics, 2024.

Haddad, E. A., Bonet, J. and Hewings. G. J. D. (Eds.) (2023). The Colombian Economy and Its Regional Structural Challenges: A Linkages Approach. Springer.

Haddad, Eduardo A.; ARAÚJO, INÁCIO F. ; CHAWKI, CHAIMAA ; EL-MANSOUM, RACHIDA ; MASNAOUI, MAROUANE . Analysis of Economic and Environmental Impacts of Shutting Down the Moroccan Refinery Samir: An Interregional Input-Output Approach. Scientific African, v. 20, p. e01690, 2023.

MARQUES, CRÍSTOFER H. ; PEREDA, PAULA C. ; LUCCHESI, ANDREA ; RAMOS, RAMIRO F. ; FIKSDAHL, OLAV ; ASSIS, LUIZ F. ; PEREIRA, NEWTON N. ; CAPRACE, JEAN-DAVID . Cost and environmental impact assessment of mandatory speed reduction of maritime fleets. MARINE POLICY, v. 147, p. 105334, 2023.

Morchid,W.; Haddad, E.A.; Savard, L. Measuring the Cost of the European Union's Carbon Border Adjustment Mechanism on Moroccan Exports. Sustainability 2024, 16, 4967. https://doi.org/10.3390/su16124967

ROCHA, ADEMIR ; Haddad, Eduardo ; LEAL, ALAN ; CORRÊA, JOÃO . Water charge and conservation of natural areas: An ex¿ante assessment of a policy proposal for the Mantiqueira region, Brazil. WATER RESOURCES RESEARCH, v. 59, p. 1-21, 2023.

RODRIGUES, Weslem ; VALE, V. A. ; Perobelli, Fernando Salgueiro ; BETARELLI JUNIOR, Admir Antonio . Assessment of issues related to international trade and environmental impacts (Emissions): an analysis for Brazil. International Journal Of Environment And Sustainable Development, v. 22, p. 134-166, 2023.

Energy security

TIPPETT, A. C. V. ; GONÇALVES, A. R. ; PEREIRA, E.B. ; MARTINS, F. R. ; FISCH, G. F. ; COSTA, R. S. . *Data Source Sensitivity in Solar Radiation Typical Meteorological Year (TMY) for Five Different Regions of Brazil*. TELLUS SERIES A-DYNAMIC METEOROLOGY AND OCEANOGRAPHY, v. 76, p. 29-41, 2024. doi: 10.16993/tellusa.3261

BET, L. G. ; ROSÁRIO, N. M. E. ; ZILLES, R. ; MARTINS, F. R. . *Estudo sobre o impacto dos aerossóis atmosféricos no fator espectral de módulos fotovoltaicos em São Paulo*. Revista Brasileira de Energia Solar, v. 13, p. 146-156, 2023. doi: 10.59627/rbens.2022v13i2.393

TORRES, B E, B. R; HOUCHSPRUNG, J. C. M.; MARTINS, F. R. Transição energética para a sustentabilidade no Brasil: narrativas e imaginários dos stakeholders. In: Congresso Brasileiro de Energia Solar, 2024, Natal/RN. Anais do X Congresso Brasileiro de Energia Solar. São Paulo: Associação Brasileira de Energia Solar, 2024.

ARRUDA, F. V.; ALMEIDA, M. P.; MARTINS, F. R.. Estudo de caso de lstm e autoencoder lstm para previsão a curto prazo utilizando múltiplas séries temporais. In: Congresso Brasileiro de Energia Solar, 2024, Natal/RN. Anais do X Congresso Brasileiro de Energia Solar. São Paulo: Associação Brasileira de Energia Solar, 2024.

LIMA, F. J. L.; GONÇALVES, A. R.; COSTA, R. S.; PEREIRA, E. B.; MARTINS, F. R. Impacto das mudanças climáticas na geração de energia solar: uma análise multimodelo utilizando CMIP6. In: Congresso Brasileiro de Energia Solar, 2024, Natal/RN. Anais do X Congresso Brasileiro de Energia Solar. São Paulo: Associação Brasileira de Energia Solar, 2024.

BORBA, P. C. S.; GONÇALVES, A. R.; MARTINS, F. R.; COSTA, R. S. Modelagem de sistemas altamente renováveis: integração da energia eólica e solar no Brasil em 2050. In: Congresso Brasileiro de Energia Solar, 2024, Natal/RN. Anais do X Congresso Brasileiro de Energia Solar. São Paulo: Associação Brasileira de Energia Solar, 2024.

TIPPETT, A., GONÇALVES, A. R.; PEREIRA, E. B.; MARTINS, F. R.; FISCH, G. F.; COSTA, R. S. Ano meteorológico típico solar: sensibilidade à base de dados para cinco regiões diferentes do Brasil. In: Congresso Brasileiro de Energia Solar, 2024, Natal/RN. Anais do X Congresso Brasileiro de Energia Solar. São Paulo: Associação Brasileira de Energia Solar, 2024.

COSTA, R. S.; ZARZUR, A. M.; GONÇALVES, A. R.; MARTINS, F. R.; SIQUEIRA, R. A.; LIMA, F. J. L.; CASAGRANDE, M. S. G.; DA ROCHA, V. R.; NETO, H. B. L.; PES, M. P.; MACHADO, G. B. M.; PEREIRA, E. B. Nova base de irradiação solar do Brasil - resultados preliminares. In: Congresso Brasileiro de Energia Solar, 2024, Natal/RN. Anais do X Congresso Brasileiro de Energia Solar. São Paulo: Associação Brasileira de Energia Solar, 2024.

CUMPLIDO, M. A.; GONÇALVES, A. R.; PEREIRA, E. B.; RUTHER, R. Energia solar fotovoltaica combinada com hidrogênio verde: uma estratégia para redução das emissões e da vulnerabilidade na Amazônia. In: Congresso Brasileiro de Energia Solar, 2024, Natal/RN. Anais do X Congresso Brasileiro de Energia Solar. São Paulo: Associação Brasileira de Energia Solar, 2024.

SIQUEIRA, R. A.; GONÇALVES, A. R.; COSTA, R. S. Avaliação de modelos de decomposição de irradiância global sobre o Brasil. In: Congresso Brasileiro de Energia Solar, 2024, Natal/RN. Anais do X Congresso Brasileiro de Energia Solar. São Paulo: Associação Brasileira de Energia Solar, 2024.

SOUZA, F. G.; LONDOÑO PABÓN, N. Y.; RODIO, N.; KRAMBECK, L.; COSTA, R. S.; GONÇALVES, A. R.; MANTELLI, M. B. H. Uso da energia termossolar no Brasil: panorama atual e potencial de desenvolvimento. In: Congresso Brasileiro de Energia Solar, 2024, Natal/RN. Anais do X Congresso Brasileiro de Energia Solar. São Paulo: Associação Brasileira de Energia Solar, 2024.

Communication

AMORIM, A. C. R. de; FONSECA, F. S. R. da. Um currículo que guarde um pouco da terra nas mãos. **Revista de Ensino de Biologia da SBEnBio**, v. 16, p. 1189-1208, 2023.

ASAYAMA, S. ; DE PRYCK, K. ; BECK, S. ; COINTE, B. ; EDWARDS, P. N. ; GUILLEMOT, H. ; GUSTAFSSON, K. M. ; HARTZ, F. ; HUGHES, H. ; LAHN, B. ;

LECLERC, O. ; LIDSKOG, R. ; LIVINGSTON, J. E. ; LORENZONI, I. ; MACDONALD, J. P. ; MAHONY, M. ; MIGUEL, JEAN C.H. ; MONTEIRO, MARKO ; O?REILLY, J. ; TADDEI, Renzo . Three institutional pathways to envision the future of the IPCC. **Nature Climate Change**, v. 13, p. 01, 2023.

CANGI, A; HERE, G.; GONÇALVES, M. Poéticas do rastejar: por modos educativos do instável e da transformação na era do Antropoceno. **Revista ClimaCom**: Ciência. Vida. Educação, ano 10, no. 23, 2023.

DALMASO, A. C.; RIGUE, F. M. ; SALES, T. A.. Ciências, diferença e educação: experimentações, possibilidades. **ReDiPE: Revista Diálogos e Perspectivas em Educação**, v. 5, p. 14, 2023. https://periodicos.unifesspa.edu.br/index.php/ReDiPE/article/view/2337/1098

DIAS, S. O.. Alianças vegetais - espécies companheiras de ensino diante do Antropoceno. **Educação e Realidade** Edição eletrônica, v. 48, p. 1-27, 2023. https://doi.org/10.1590/2175-6236125011vs01

DIAS, S. O. Plant Alliances: companion species in teaching in the face of the Anthropocene. **Educ. Real**. v. 48, p. 1-27, 2023 https://doi.org/10.1590/2175-6236125011vs02

DIAS, S. O.. Um caminhar multiespécies: mesas de trabalho como modos de habitar artes, educações e comunicações diante do Antropoceno. **Revista Digital do Laboratório de Artes Visuais ?** UFSM/RS, v. 16, p. 1, 2023.

FONSECA, F. S. R.; KROEF, A. B. G.. Moscas transgênicas: quando o laboratório de genética torna-se ateliê de criação artística. **Revista Digital do LAV**, v. 16, n. 1, p. e3/1-26, 2023.

GARCIA, D y A. MENEGAZ. Producción hortícola, agrotóxicos y salud colectiva en Florencio Varela: la extensión crítica y el desafío de la co-construcción de conocimiento. **Territorio. Revista de vinculación y curricularización**, n°4, Vinculación y Salud, 2024. https://territorio.unaj.edu.ar/numero-4

GUZZO, MARINA SOUZA LOBO. Coreografar a crise - uma dramaturgia do contexto presente. **Urdimento-Revista De Estudos Em Artes Cenicas**, v. 3, p. 1-19, 2023.

GUZZO, MARINA SOUZA LOBO. -Se não posso dançar, não é minha revolução-: autocuidado e hapticalidade como práticas políticas. **QUADERNS DE PSICOLOGIA. INTERNATIONAL JOURNAL OF PSYCHOLOGY**, v. 25, p. e1778, 2023.

GRUBER, G.; MIRANDA, E. O cosmos das línguas indígenas perante a barbárie do antropoceno**. REVISTA ÑANDUTY**, v. 11, p. 89-117, 2023.

HERE, G., CANGI, A,. Retóricas y políticas del arrastre: por una estética de lo inestable en la era del Antropoceno. Cartografías del Sur. **Revista multidisciplinaria en Ciencias, Arte y Tecnología**, indexada en DOAJ y Lantindex, y editada por la Secretaría de Investigación y Vinculación Tecnológica e Institucional de la Universidad Nacional de Avellaneda. 17, Cds, Nº 17, 2023.

IBARRA, Jorge Ignacio y ESQUIVEL MARÍN, Sigifredo. (2024). De la mirada médica a la rostricidad médica. Aproximaciones ecosóficas a la pandemia del COVID–19. **Revista digital FILHA**. Enero-julio. Número 30. Publicación semestral. Zacatecas, México: Universidad Autónoma de Zacatecas. Disponible en: http://www.filha.com.mx ISSN: 2594-0449

LEITE, Douglas De Albuquerque ; MONTEIRO, Marko Synésio Alves . Gerenciamento de discursos hídricos: A comunicação da crise de abastecimento de água na RMSP (2014-2015). **AMBIENTE & SOCIEDADE** (ONLINE), v. 26, p. 1-26, 2023.(https://doi.org/10.1590/1809-4422asoc2021079r1vu2023L4AO)

MAUS, L.; TOMASINI, S.. Do Jardim à paisagem (e vice-versa). In: **Revista Valise**, Porto Alegre, Vol. 13, n. 1 (jul. 2023), p. 312-330 , il.

MARIN, S. E.. Ante la catástrofe: arte, cuerpo y pensamiento. **ClimaCom – Desastres** [online], Campinas, ano 10, n.25., nov . 2023. Available from: https://climacom.mudancasclimaticas.net.br/ante-la-catastrofe/

MASSARO, T. "Berta Ribeiro: enlace de saberes, plantas e antropologia". 2023. **Mana** journal. 2023; 29:02. DOI: https://doi.org/10.1590/1678-49442023v29n2e2023022.pt.

MENEGAZ A.; TERRACCINO, M. C. Aproximaciones a la EAI desde una mirada renovada sobre la huerta. **Revista Novedades Educativas** N° 388, Julio 2023, pp 28 – 37, 2023.

MIRANDA, E. A ciência para além da razão: um dever de reflorestamento espiritual e decolonial. **ReDiPE: Revista Diálogos e Perspectivas em Educação,** v. 5, p. 1, 2023

OLIVEIRA JUNIOR, WENCESLAO MACHADO. Reparar (n)o lugar através do cinema: como fazer do lugar-escola uma floresta?. **Punto Sur - Revista de Geografía de la UBA**, 2023.
OLIVEIRA JUNIOR, WENCESLAO MACHADO. "Porvires não humanos do cinema no lugar-escola de educação infantil: entre relatos, imagens e dispositivos de criação". **Leitura: Teoria & Prática**, Campinas, São Paulo, v.42, n.90, p.33-51, 2024.
OTERO, S., RIVAS L., VILLA,M. Y GARCIA, D Una experiencia desde la integralidad: educación popular, agroecología y salud colectiva. **Territorio. Revista de vinculación y curricularización**, n°4, Vinculación y Salud, 2024. https://territorio.unaj.edu.ar/una-experiencia-desde-la-integralidad-educacion-popular-agroecologia-y-salud-colectiva/
PELLEJERO, E. A.. Além de si - A arte como fazer coletivo. **MARGENS** (UFPA), v. 17, p. 227-244, 2023.
PELLEJERO, E. A.. O acontecimento poiético - A arte em vias de se fazer. **ARTEFILOSOFIA** (UFOP), v. 18, p. 1-17, 2023.
PELLEJERO, E. A.. El acontecimiento poiético: el arte en vías de hacerse. **Artes en Filo**, v. 4, p. 24-35, 2023.
PELLEJERO, E. A.. Fantasmas, visiones, estática. Metáforas en sentido literal. **Escritura E Imagen**, v. 19, p. 1-9, 2023.
QUEIROZ FILHO, A. C.. Exercícios de sentir-paisagem: fotografias e notas poéticas sem finalidade alguma. **RUA**, v. 29, p. 237-265, 2023.
RIGUE, F. M. ; SALES, TIAGO AMARAL ; DALMASO, ALICE COPETTI . Metaformoses em Emanuele Coccia: composições para habitar a educação e a formação docente. **EDUCAÇÃO E FILOSOFIA** (ONLINE), v. 37, p. 1465-1496, 2024.
SALES, T. A.; RIGUE, F. M.. Entre o cuidado de si e o bem viver: porvires possíveis para a vida e a educação em meio às pedagogias pandêmicas. **HUMANIDADES & INOVAÇÃO**, v. 9, p. 111-128, 2023.
SALES, T. A.; DALMASO, A. C.; RIGUE, F. M.. Ciência. Vida. Educação. **CLIMACOM CULTURA CIENTÍFICA - PESQUISA, JORNALISMO E ARTE**, v. 10, p. 1-9, 2023.
SALES, T. A.. O Que Podem as Educações Menores em HIV/aids? Caminhos possíveis à educação em ciências e biologia. **REVISTA DA FAEEBA- EDUCAÇÃO E CONTEMPORANEIDADE**, v. 32, p. 391-410, 2023.
SALES, TIAGO AMARAL. Poéticas de uma casa povoada em sua solidão. **LEITURA: TEORIA E PRÁTICA**, v. 41, p. 81-96, 2024.
SALES, T. A.. Corações... na escola: amor em cotidianos estudantis. **TEMAS EM EDUCACAO**, v. 33, p. 1-30, 2024.
SALES, TIAGO AMARAL; SILVA, GABRIEL ANDRADE . Gênero e sexualidade em devires e afetos no chão da escola: experiências e resistências entre arte e educação. **REVISTA INTERTERRITÓRIOS**, v. 10, p. 1-29, 2024.
TADDEI, R. Is there Room for Other-than-Human Agency in Transdisciplinary Research? An Ethnographic Reflection. **REVISTA IBEROAMERICANA DE CIENCIA TECNOLOGÍA Y SOCIEDAD (EN LÍNEA)**, v. 18, p. 247-264, 2023.
VARGAS, M. G.. Escombros, resíduos e cinzas no final da paisagem do norte da Patagônia argentina. Uma análise material cinematográfica de Los muertos dos de Manque La Banca e Puyehue de Victoria Sayago e Bruno Stecconi. **ClimaCom** – Desastres [online], Campinas, ano 10, n.25., nov . 2023. Available from:https://climacom.mudancasclimaticas.net.br/escombros-residuos-e-cinzas/
VIDAL, E. “Experiencias de gestión cultural desde el ámbito universitario: dispositivos itinerantes para el trabajo educativo”. **Revista Pragmatizes**, no. 25, Set/2023. Universidade Federal Fluminense. http://periodicos.uff.br/pragmatizes
VIDAL, E. La convergencia de medios y la enseñanza del lenguaje audiovisual en el ámbito universitario. **Cuadernos del CiPeCo**: Escenarios contemporáneos del periodismo: convergencia, disrupciones, reconfiguraciones y desafíos, enero-junio 2023. Universidad Nacional de Córdoba.
VIDAL, E.; LOYOLA, M.I.; VIADA, M.M.; MINERVINI, M.A. (2023): Experiencias situadas en la enseñanza de la comunicación: el foco en el ambiente. **Revista ClimaCom,**

Ciência.Vida.Educação | pesquisa – artigos | ano 10, no. 23, 2023. Disponible en: https://climacom.mudancasclimaticas.net.br/experiencias-situadas/

VILELA, M.; DIAS, S.. ESGUEDELHAR: trazendo à vida um corpo-linha-selvagem. **InterFaces -** "Emaranhados, tramas e escutas: práticas artísticas para resistir e agir em meio ao Antropoceno", UFRJ, vol. 33, N. 2, 2024. (no prelo)

GUZZO, M., DIAS, S., MORAES, A., FAGUNDES, G., RIBEIRO, W., ALVES, K., TADDEI, R.. "Artistic practices in the face of the Anthropocene". *Annual Review of Environmental and Resources* (ARER), 2024. *Accepted for publication:*

DADA, O. O. O. D. O.; OBÀTÁLÁ ILÉ-IFỊ̀, O. O.; FREITAS, M. da G.; DIAS, S. O. **Obàtálá - criador de criaturas e criadores**. Campinas, Casa dos Saberes Ancestrais - Unicamp, 2024.

SANTOS, B., FILO, B.; FRADE, M.; DIAS, S. **Companhia como modo de atenção à Terra**. Belém: Programa de Pós-graduação em Artes - UFPA, 2023.

DIAS, S; BARATA, G.; BARBAI, M.; CARREON, R. de O.; ALDAY, A. **Divulgação científica e cultural: 16 anos de um curso de pós-graduação**. São Paulo: Pontes, 2024.

FUREGATTI, Sylvia. (Org.). **Paisagem sob inventário**. 1ed.Campinas: BCCL/UNICAMP, 2023, v. 1, p. 77-87.

GARCÍA D.; A. MENEGAZ (Coord.). **Introducción crítica al desarrollo sustentable.** Editorial Universidad Nacional Arturo Jauretche. Florencio Varela, 2023.

MAUS, Lilian; POLIDORO, Marina Bortoluz; SCHENKEL, Camila. **Histórias e práticas artísticas: catálogo de atividades 2020-2023**. Porto Alegre: UFRGS, 2023.

MAUS, Lilian; Polidoro, Marina Bortoluz. **Lilian Maus: obras**. Porto Alegre: UFRGS, 2023.

MURRIELLO, S.; BARRIOS, G. (Comp.). **A 10 años de la erupción del Puyehue-Cordòn Caulle.** Viedma: Editorial UNRN, 2023.

PELLEJERO, E. A.. Lusco-fusco. 1. ed. Natal: **Serpentibus Plena**, 2023.

In preparation:

DIAS, S, DALMASO, A., RODRIGUES, C., OLIVEIRA, T., GONÇALVES, M., GUZZO, M., MURRIELLO, S., TADDEI, R. Modos de existir diante do Antropoceno. 2024.

ÁLVAREZ, T. O. Trayectos formativos: Experiencias de co-creación con Lenguajes Contemporáneos. In: **Mutaciones de la Educación corporal**, 2024. (no prelo)

ÁLVAREZ, T. O.; CADAVID, L. E. G.; D´AVILA, A.. BioMapameamientos de sí: una experiencia de aula con materialidades. In: **Cuerpos y Corporalidades en Movimiento**. Editorial bonaventuriana. Universidad de San Buenaventura – Medellín, 2023 .Págs. 91-112.

ÁLVAREZ, T. O.; CASTRO, J. D. V. Experiencias formativas en el encuentro en un espacio áulico rural. In: **Mutaciones de la Educación corporal**, 2024. (no prelo)

ÁLVAREZ, T. O.; RAMIREZ, L. Y. V.. Cartografías gestuales de las manos: unas coreografías ficciográficas. In: **Cuerpos y Corporalidades en Movimiento**. Editorial bonaventuriana. Universidad de San Buenaventura – Medellín, 2023.

AMORIM, A. C. R.. (Trans)passagens do educativo na exposição Paisagem sob Inventário. In: Sylvia Furegatti. (Org.). **Paisagem sob Inventário**. 1ed.Campinas: BCCL/UNICAMP, 2023, p. 77-87.

AMORIM, A. C. R.. Imágenes para una educación sin unidad. In: **Luchas minoritarias y líneas de fuga en América Latina**. 1ed. Santiago: Metales Pesados, 2023, v. 1, pp. 169-190.

CANGI, A. "Cosmopolíticas de los modos y maneras plurimodales". In: Maria dos Remédios de Brito, Lindomberto Ferreira Alves e Dhemersson Warly Santos Costa. (Org.). **Desejar o menor dos mundos, escrever corporeidades outras desde aí.** 1ed.Belém: Programa de Pós-Graduação em Artes/UFPA, 2023, v. 1, p. 16-33.

DIAS, S. A autocompostagem que emerge das ecologias de práticas em "Les glaneurs et la glaneuse" de Agnès Varda - pensando diante de tempos de catástrofes. In: GARCIA, G. C.. **Pegadogias da imagem**, 2024. (no prelo)

DIAS, S. O.; BRITO, M. R. . "Fazer o papel falar" ou de como cultivar florestas em tempos de catástrofes. In: Maria dos Remédios de Brito, Lindomberto Ferreira Alves e Dhemersson Warly Santos Costa. (Org.). **Desejar o menor dos mundos, escrever corporeidades outras desde aí.** 1ed.Belém: Programa de Pós-Graduação em Artes/UFPA, 2023, v. 1, p. 85-103.

ESQUIVEL MARIN, S. "Arte, educación y biocapitalismo desde los márgenes e intersticios. In: **Pensar la técnica. Vida, cultura, educación.** México, Juan Pablo Editor, México, 2023.

ESQUIVEL MARIN, S. Creación sin fin. In: **Castoriadis y la condición humana**. Juárez, CELAPEC-UAZ, 2023.

FRANCHINI, M.; VIOLA, E. J.; GUIVANT, J. S.. Brazilian Agriculture and the International Political Economy of Climate Change. In: **Sustainability Challenges of Brazilian Agriculture Governance, Inclusion, and Innovation**. Springer, 2023, v.1, p. 67 - 84.

GARCÍA D.; RECK, I. La idea de desarrollo. In: **Introducción crítica al desarrollo sustentable** García D. y A. Menegaz (comp) pp 11 – 28. Editorial Universidad Nacional Arturo Jauretche. Florencio Varela, 2023.

GARCÍA, D. Desarrollo Sustentable: revisión crítica del concepto. In: **Introducción crítica al desarrollo sustentable**. García D. y A. Menegaz (comp) pp 157 -204. Editorial Universidad Nacional Arturo Jauretche. Florencio Varela, 2023.

GARCÍA, D.; MENEGAZ, A.; POCH, L. Educación ambiental: desafíos e inéditos en contextos disruptivos y cambiantes -Capítulo 2-. In: **Experiencia de Educación Ambiental Integral**. Ed. Novedades Educativas CABA, 2023.

GUIVANT, JULIA S.; FROMER, M. Interdisciplinaridade na pesquisa sobre mudança climática: o caso do Inct-MC Fase 2. In: Autran, A.; Andrade, T.(orgs). **Interdisciplinaridade está em jogo?**. Campinas: Pontes Editora, 2023, p. 1-317. Referências adicionais: Brasil/Português. Meio de divulgação: Meio digital, ISBN: 9786556376721, Home page: https://www.ponteseditores/

GUIVANT, Julia Silvia. A virada cosmopolita e as inovações de baixo carbono: o caso da certificação da soja. In: **Ambiente, saúde e sociedade. Interdependências e diálogos**., ed.1. São Leopoldo: Oikos, 2024, p. 1 - 45.

IWAKAMI, Victor Hugo. WUNDER, Alik, Encontro, diferença e retomada? partilhas criativas com o povo Kariri-Xocó. **Revista de Ensino de Biologia da SBEnBio**, 2024. (no prelo)

MAUS, Lilian; SCHENKEL, Camila; Junqueira, POLIDORO, Marina. Procurando conexões : sobre divulgação artística e acadêmica a partir do blog do PEHPA. In: **Histórias e práticas artísticas: catálogo de atividades 2020-2023**. Porto Alegre: UFRGS, 2023. p. 12-15.; Waquil, Isabel Leivas. Entrevista de Isabel Waquil com Lilian Maus. In: Junqueira, Lilian Maus (Org.). Lilian Maus [recurso eletrônico]. Porto Alegre: UFRGS, 2023. p. 4-8.

MAUS, Lilian; WAQUIL, Isabel. Entrevista de Isabel Waquil com Lilian Maus . In: MAUS, Lilian (Org.). **Lilian Maus: obras** [recurso eletrônico]. Porto Alegre : UFRGS, 2023. p. 4-8.

MENEGAZ, A. y G. JAURÉ. Crisis capitalista y hegemonía neoliberal. In: **Introducción crítica al Desarrollo Sustentable.** García D. y A. Menegaz (comp) pp 79 -102. Editorial Universidad Nacional Arturo Jauretche. Florencio Varela, 2023.

MENEGAZ, A.; ALEKSA, A.. La cuestión ambiental. In: **Introducción crítica al desarrollo sustentable**. García D. y A. Menegaz (comp) pp 131 -138. Editorial Universidad Nacional Arturo Jauretche. Florencio Varela, 2023.

MIGUEL, J. C. H. ; TADDEI, R. ; MONTEIRO, M. S. . Civic Epistemologies. In: De Pryck, Kari; Hulme, Mike. (Org.). **A Critical Assessment of the Intergovernmental Panel on Climate Change**. Cambridge: Cambridge University Press, 2023, p. 217-224.

MONTEIRO, Marko. Ethnography and the Circulation of Knowledge. In: Wiebke Keim; Leandro Rodriguez Medina; Rigas Arvanitis; Natacha Bacolla; Chandni Basu; Stéphane Dufoix; Stefan Klein; Mauricio Nieto Olarte; Barbara Riedel; Clara Ruvituso; Gernot Saalmann; Tobias Schlechtriemen; Hebe Vessuri. (Org.). **Routledge Handbook of Academic Knowledge Circulation**. London: Routledge, 2023, p. 485-495.

MURRIELLO, S. y MARILUAN, A. Del silenciamiento a los procesos de visibilización de lenguas y sonidos. En: Malvestitti, M. y Farro,M. (comp.). **Documentos inéditos en lenguas fuegopatagónicas (1880-1950).** Viedma: Editorial de la Universidad Nacional de Río Negro, 2023.

MURRIELLO, S. y PIERUCCI, L. (2023) "Memorias del Puyehue-Cordón Caulle" (Capítulo 1) En: Murriello,S- y Barrios García,G. (Comp) **A diez años de la última erupción del Puyehue-Cordón Caulle**. Viedma: Editorial de la Universidad Nacional de Río Negro.

OLIVEIRA JUNIOR, Wenceslao Machado. Devenires vegetales en cuerpos y cameras - hacer cine, hacer comunidad, hacer lugar. In: Azucena Castro. (Org.). **Futuros multiespecies - prácticas vinculantes para un planeta en emergencia**. 1ed.: Bartlebooth, 2023, v. , p. 229-246.
OLIVEIRA JUNIOR, Wenceslao Machado. Pelo espaço: desasfixiar pensamentos, desfigurar lugares em imagens. In: Aldo Gonçalves de Oliveira; Ana Giordani; Ivaine Tonini; Ludmila Losada da Fonseca; Suzana Campos. (Org.). **Geografias e Educação: singulares mãos docentes**. 1ed.Rio de Janeiro: Letra Capital, 2023, v. 1, p. 177-200.
OLIVEIRA, T. P.; DIAS, S. Potências de fabulação em exercícios de escrita e pesquisa. In: DIAS, S; BARATA, G.; BARBAI, M. CARREON, R. de O.; ALDAY, A. **Divulgação científica e cultural: 15 anos de um curso de pós-graduação**. São Paulo: Pontes, 2024.
QUEIROZ FILHO, Antonio Carlos; BORGES, R. H. M. F. . Estamos em aula: Geografias de afeto, encontro e devir. In: Aldo Gonçalves de Oliveira; Ana Claudia Giordani; Ivaine Maria Tonini; Ludmila Losada da Fonseca; Suzana Campos. (Org.). **Geografias e educação: singulares mãos docentes**. 1ed.Rio de Janeiro: Letra Capital, 2023, v. 1, p. 387-411.
TADDEI, R. O Antropoceno exige pensar o cuidado de novas formas. In: Brasil. Ministério da Saúde. Secretaria-Executiva. Superintendência Estadual do Rio de Janeiro. (Org.). **Encontros de cultura e saúde: como a antropologia pode ajudar a pensar o SUS hoje**. Rio de Janeiro: Ministério da Saúde, 2024, p. 79-91.
TADDEI, RENZO ROMANO. Kopenawa and the environmental sciences in the Amazon. In: Nils Bubandt, Thomas Schwarz Wentzer. (Org.). **Philosophy on Fieldwork: Case Studies in Anthropological Analysis**. London: Routledge, 2023, p. 353-372.
WUNDER, Alik; BANIWA, L. ; APYKA, L. ; WAUJA, M. ; GUARANI, L. S. ; TUKANO, M. . ULEI, KAINI, MANDI?O, KI?I, MANDIOCA: MEMÓRIAS, SABORES E SABERES DE UMA RAIZ-CORPO. In: Nilda Alves, Rosa Helena Mendonça e Noale Toja. (Org.). **Cozinhas e conversas: cheiros e gostos, sons e imagens e afetos**. Petrópolis: DP et Alli, 2023, v. 1, p. 1-275.
WUNDER, Alik; Ouvir palavras, ler imagens, desenhar escritas: sopros indígenas em uma universidade. In: Daniel Munduruku, Isabella Rosado nunes, Darlene Taukane e Maurício Negro. (Org.). **Jenipapos: diálogos sobre viver**. 1ed.Rio de Janeiro: Mina Comunicações, 2022, v. 1, p. 52-62.
WUNDER, Alik; WIEDEMANN, S. ; NARITA, M. . Dasaturaciones de la razón y lo humano: cultivando cielos vacantes para tierras y naturalezas por venir. In: Patricio Landaeta Mardones e Antonio Carlos Rodrigues de Amorim. (Org.). **Afectos e Visibilidades comparadas entre Chile e Brasil**. 1ed.Santiago de Chile: metales Pesados, 2023, v. 1, p. 1-297.
ESQUIVEL MARIN, S. Proseguir el diálogo entre filosofía, literatura, psicoanálisis y disciplinas afines. ***Revista Reflexiones Marginales*** https://reflexionesmarginales.com
SALES, T. A.; DALMASO, A. C.; RIGUE, F. M. R (Orgs). Dossiê 'Ciência.Vida.Educação". **ClimaCom,** no. 23. Ed. Campinas: Labjor- Unicamp, 2023.
DALMASO, A. C.; RIGUE, F. M.; SALES, T. A. (Orgs). Ciências, diferença e Educação: experimentações, possibilidades. **ReDiPE: Revista Diálogos e Perspectivas em Educação**, v. 5, 2023.
GARCIA, G.; AGUILAR-MUÑOZ, V.; MARENGO, J. A.; MENDIONDO, E. M.; DIAS, Susana "Desastres". **ClimaCom**, n. 25, Unicamp, 2023.
GUZZO, M.; RIBEIRO, W. Emaranhados, tramas e escutas: práticas artísticas para resistir e agir em meio ao Antropoceno. **Interfaces**, UFRJ, vol. 33, n. 2, 2024. (no prelo)

Water Security

ALMEIDA, DEBORA NATÁLIA OLIVEIRA DE; ARAÚJO, DIÊGO CEZAR DOS SANTOS; SOARES, DÉBORA RODRIGUES; MAIA, FRANCISCO MARCELO DE ALENCAR; MONTENEGRO, SUZANA MARIA GICO LIMA; SANTOS, SYLVANA MELO DOS; OLIVEIRA, LEIDJANE MARIA MACIEL DE . Delimitation of water areas using remote sensing in Brazil semiarid region. Revista Brasileira de Ciências Ambientais (Online), v. 58, p. 20-29, 2023.

Alves, M.L.P.R., Oliveira, R.G.L., Rocha, C.A.A. *et al.* Assessing flood susceptibility with ALOS PALSAR and LiDAR digital terrain models using the height above nearest drainage (HAND) model. *Environ Dev Sustain* (2024). https://doi.org/10.1007/s10668-024-04785-1

ANDRADE, J. M.; RIBEIRO NETO, A.; NÓBREGA, R. L. B.; RICO-RAMIREZ, M. A.; MONTENEGRO, S. M. G. L. Efficiency of global precipitation datasets in tropical and subtropical catchments revealed by large sampling hydrological modelling. Journal of Hydrology, v. 633, p. 131016, 2024.

ANDRADE, JOÃO M. ; RIBEIRO NETO, ALFREDO ; NÓBREGA, RODOLFO L.B. ; RICO-RAMIREZ, MIGUEL A. ; MONTENEGRO, SUZANA M.G.L. . Efficiency of global precipitation datasets in tropical and subtropical catchments revealed by large sampling hydrological modelling. JOURNAL OF HYDROLOGY, https://doi.org/10.1016/j.jhydrol.2024.131016

ANTONIO CAMELO CID, DANIEL ; de Assis de Souza Filho, Francisco ; DA SILVA ALVES, RAFAELA ; DEHON ARAÚJO PONTES FILHO, JOÃO ; COSTA DA SILVA, DANIELE ; SÁVIO PASSOS RODRIGUES MARTINS, EDUARDO . Drought in play: A grounded socio-hydrological tool to increase social participation in drought plans. JOURNAL OF HYDROLOGY(2024),

Ballarin, A Mijael Rodrigo Vargas Godoy, Masoud Zaerpour, Hebatallah M Abdelmoaty, Shadi Hatami, Yohanne L Gavasso-Rita, Edson Wendland, and Simon Michael Papalexiou (2024) Drought intensification in Brazilian catchments: implications for water and land management, Environ. Res. Lett. 19 054030, https://doi.org/10.1088/1748-9326/ad3e18

CAROLINA DA ENCARNAÇÃO PAIVA, ANA ; MARTINS, MINELLA ; CANAMARY, ERICA ACIOLI ; RODRIGUEZ, DANIEL ANDRES ; TOMASELLA, JAVIER . Inter-basin water transfers under changing climate and land use: Assessing water security and hydropower in the Paraíba do Sul River basin, Brazil. JOURNAL OF SOUTH AMERICAN EARTH SCIENCES (2024) https://doi.org/10.1016/j.jsames.2023.104707

Cepeda, E et al (2024) Impact of rapid anthropogenic environmental change on water security in a tropical Andean basin , Wat. Security, https://doi.org/10.1016/j.wasec.2024.100175

da Silva, G.J.F., Silva, R.M., Brasil Neto, R.M. *et al.* (2024) Multi-datasets to monitor and assess meteorological and hydrological droughts in a typical basin of the Brazilian semiarid region. *Environ Monit Assess* 196, 368. https://doi.org/10.1007/s10661-024-12461-0

DA SILVA, SAMARA FERNANDA; DOS SANTOS ARAÚJO, DIEGO CEZAR; FREIRE DE SOUZA VIANA, JUSSARA; SOUSA FONTES, ANDREA; DANTAS PINTO MEDEIROS, YVONILDE; GICO LIMA MONTENEGRO, SUZANA MARIA. Analysis of the correlation between land use and surface runoff in a Brazilian savanna basin. JOURNAL OF SOUTH AMERICAN EARTH SCIENCES, v. 133, p. 104724, 2024.\

De Oliveira, B. Et al (2024) Low-Impact Development Scenarios in Terms of Construction Costs and Runoff Reduction , J. Hydrol. Eng., https://doi.org/10.1061/jhyeff.heeng-6059

DOS SANTOS ARAUJO, DIEGO CEZAR; GICO LIMA MONTENEGRO, SUZANA MARIA; RIBEIRO NETO, ALFREDO; DA SILVA, SAMARA FERNANDA. Evaluation of satellite-based soil moisture for agricultural drought monitoring in the Brazilian semiarid region. Remote Sensing Applications-Society And Environment, v. 1, p. 101111, 2023.

FARIAS, CAROLYNE WANESSA LINS DE ANDRADE; VIANA, JUSSARA FREIRE DE SOUZA; MIRANDA, RODRIGO DE QUEIROGA; SILVA, SAMARA FERNANDA DA; VASCO, GABRIEL; MONTENEGRO, SUZANA MARIA GICO LIMA; GALVÍNCIO, JOSICLÊDA DOMICIANO. Técnica de calibração para modelagem da bacia hidrográfica do Rio São Francisco, Brasil, utilizando o SWAT. REVISTA BRASILEIRA DE GEOGRAFIA FÍSICA, v. 16, p. 1621-1628, 2023.

FARIAS, CAROLYNE; MIRANDA, RODRIGO; VIANA, JUSSARA; LINS, FREDERICO; PEREIRA, JOÃO ANTONIO; URSULINO, BRUNO; MONTENEGRO, SUZANA; GALVÍNCIO, JOSICLÊDA DOMICIANO; MONTENEGRO, ABELARDO ; SRINIVASAN, RAGHAVAN. Calibration of SWAT model in the Pernambuco state watersheds to support the SUPer system. REVISTA BRASILEIRA DE GEOGRAFIA FÍSICA, v. 16, p. 3572-3592, 2023.

Gomes Jr., M. N., Castillo, L., Lago, C. A., Oliveira, P. T., Giacomoni, M., Mendiondo, E M (2023) HydroPol2D — Distributed hydrodynamic and water quality model: Challenges and

opportunities in poorly-gauged catchments, J. Hydrol., https://doi.org/10.1016/j.jhydrol.2023.129982

Gomes Jr. et al (2024a) Global optimization-based calibration algorithm for a 2D distributed hydrologic-hydrodynamic and water quality model, Environ. Mod. & Software, https://doi.org/10.1016/j.envsoft.2024.106128

Gomes Jr. et al (2024b) Increasing flood awareness through dam-break serious games, Int. J. Dis. Risk Red., https://doi.org/10.1016/j.ijdrr.2024.104543

Kolling Neto, A.; Siqueira, V.A.; Gama, C.H.d.A.; Paiva, R.C.D.d.; Fan, F.M.; Collischonn, W.; Silveira, R.; Paranhos, C.S.A.; Freitas, C. Advancing Medium-Range Streamflow Forecasting for Large Hydropower Reservoirs in Brazil by Means of Continental-Scale Hydrological Modeling. *Water* 2023, *15*, 1693. https://doi.org/10.3390/w15091693

Lago, C. A. Et al (2023) Generalizing rapid flood predictions to unseen urban catchments with conditional generative adversarial networks, *J. Hydrol*., 618 (129276), https://doi.org/10.1016/j.jhydrol.2023.129276

Lago, C. A., Giacomoni, M. H., Gomes Jr., M. G., Mendiondo, E M (2023) Simulation and optimization framework for evaluating the robustness of low-impact development placement solutions under climate change in a small urban catchment, *Hydrol. Sci. J.*, https://doi.org/10.1080/02626667.2023.2248137

Macedo, M B et al (2024) Brief communication: Lessons learned and experiences gained from building up a global survey on societal resilience to changing droughts , Nat. Haz. Earth Sys. Sci., https://doi.org/10.5194/nhess-24-2165-2024

Moura Brasil Neto, R. ; Santos, C A (2024) The NIFT index: A new approach to assessing meteorological drought exposure. JOURNAL OF HYDROLOGY 632 (130857) https://doi.org/10.1016/j.jhydrol.2024.130857

NISHIWAKI, ADRIANA APARECIDA MEGUMI; MOURA, MAGNA SOELMA BESERRA DE; GALVÍNCIO, JOSICLÊDA DOMICIANO; OLIVEIRA, CINTHIA PEREIRA DE; SILVA, EMANUEL ARAÚJO; LIMA, JOSÉ ROMUALDO DE SOUSA; ANTONINO, ANTONIO CELSO DANTAS; SOUZA, EDUARDO SOARES DE; MENEZES, RÔMULO SIMÕES CEZAR; MONTENEGRO, SUZANA MARIA GICO LIMA; DOMINGUES, TOMAS FERREIRA. Uso do LiDAR na Estimativa de Atributos Florestais: Uma Revisão. REVISTA BRASILEIRA DE GEOGRAFIA FÍSICA, v. 16, p. 505-527, 2023.

NUNES CARVALHO, TAÍS MARIA ; Souza Filho, Francisco de Assis ; MADRUGA DE BRITO, MARIANA . Unveiling Water Allocation Dynamics: A Text Analysis of 25 Years of Stakeholder Meetings. Environmental Research Letters, https://doi.org/10.1088/1748-9326/ad37cd

Rocha, P.I.O., Dantas, A.P.X., Santos, C.A.G. *et al.* Assessing urban forest decline and predicting future expansion: a spatial analysis and modeling approach in João Pessoa City, Brazil. *Model. Earth Syst. Environ.* 10, 3923–3940 (2024). https://doi.org/10.1007/s40808-024-01983-8

RODRIGUES JUNIOR, JOCIMAR COUTINHO; TAVARES, DANIELA MARIA FERNANDES ; PAIVA, ANDERSON LUIZ RIBEIRO ; FARIAS, VANINE ELANE MENEZES ; SANTANA, ALEXANDRE CARLOS ARAÚJO ; OLIVEIRA, LEIDJANE MARIA MACIEL ; MONTENEGRO, SUZANA MARIA GICO LIMA . Análise estatística multivariada de variáveis hidrológicas na bacia hidrográfica do rio Pajeú - PE. REVISTA BRASILEIRA DE GEOGRAFIA FÍSICA, v. 16, p. 3246-3262, 2023.

SASS, K. Et al (2024) Enhancing Drought Resilience and Vulnerability Assessment in Small Farms: A Global Expert Survey on Multidimensional Indicators , Int. J. Dis. Risk Red., https://doi.org/10.1016/j.ijdrr.2024.104616

SILVA, R. M. ; Lopes, A. G. ; Santos, C.A.G. . Deforestation and fires in the Brazilian Amazon from 2001 to 2020: Impacts on rainfall variability and land surface temperature. JOURNAL OF ENVIRONMENTAL MANAGEMENT (2024) https://doi.org/10.1016/j.jenvman.2022.116664

Tomasella, J., Cunha, A.P.M.A., Simões, P.A. *et al.* Assessment of trends, variability and impacts of droughts across Brazil over the period 1980–2019. *Nat Hazards* 116, 2173–2190 (2023). https://doi.org/10.1007/s11069-022-05759-0

TOMASELLA, JAVIER; CUNHA, ANA PAULA M. A. ; SIMÕES, PALOMA ANGELINA ; ZERI, MARCELO . Assessment of trends, variability and impacts of droughts across Brazil over the period 1980-2019. NATURAL HAZARDS, v. 116, p. 2173-2190, 2023.
VIANA, JUSSARA FREIRE DE SOUZA; MONTENEGRO, SUZANA MARIA GICO LIMA; SRINIVASAN, RAGHAVAN; SANTOS, CELSO AUGUSTO GUIMARÃES; MISHRA, MANORANJAN; KALUMBA, AHMED MUKALAZI; DA SILVA, RICHARDE MARQUES. Land Use and Land Cover Trends and Their Impact on Streamflow and Sediment Yield in a Humid Basin of Brazil Atlantic Forest Biome. DIVERSITY, v. 15, p. 1220-1243, 2023.

Disasters

Luz Adriana Cuartas, Thais Fujita, Juliana Andrade Campos, Cintia Bertacchi Uvo, Gholamreza Nikravesh, Jonas Olsson, Johanna Sörensen, José Antonio Marengo, Diogo Amore, Elisangela Broedel, Jerusa Peixoto, Hydrometeorological drought analysis through Two-variate Standardized Index for the Paraná River Basin, Brazil, **J. of Hydrology: Regional Studies**, Volume 54, 2024, 101886, ISSN 2214-5818, https://doi.org/10.1016/j.ejrh.2024.101886

Marengo, J. A.; Cunha, A. P.; Seluchi, M. E.; Camarinha, P. I.; Dolif, G.; Sperling, V. B.; Alcântara E. H.; Ramos, A. M.; Andrade, M. M.; Stabile, R. A.; Mantovani, J.; Park, E.; Alvalá, R. C.; Moraes, O. L.; Nobre, C. A. Heavy rains and hydrogeological disasters on February 18th-19th, 2023 in the city of São Sebastião, São Paulo, Brazil: from meteorological causes to early warnings. Natural Hazards 120, 7997–8024 (2024). https://doi.org/10.1007/s11069-024-06558-5

Ribeiro, D. F.; Saito, S. M.; Alvalá, R. C. S. Community disaster resilience in Brazilian small urban centers. **International Journal of Disaster Risk Reduction**, December 13, 2023. Manuscript Number: IJDRR-D-23-02768R1. https://doi.org/10.1016/j.ijdrr.2023.104200

Antunes, L.; Rudorff, C.; Ovando, A.; Pimentel, A.; Cuartas, L. A.; Alvalá, R. C. S. Inundation mapping using hydraulic modeling with high-resolution remote sensed data: a case study in the Acre River Basin, Brazil. **Modeling Earth Systems and Environment**, January 24, 2024. MESE-D-23-01266R1. https://doi.org/10.1007/s40808-024-01972-x

Regina Célia dos Santos Alvalá; Daniela Ferreira Ribeiro; José Marengo; Marcelo Enrique Seluchi; Demerval Aparecido Gonçalves; Larissa Antunes da Silva; Luz Adriana Cuartas Pineda; Silvia Midori Saito. Analysis of the hydrological disaster occurred in the state of Rio Grande do Sul, Brazil in September 2023: vulnerabilities and risk management capabilities. **International Journal of Disaster Risk Reduction**. 110, August 2024, 104645. https://doi.org/10.1016/j.ijdrr.2024.104645

Alvalá, R. C. S.; Nogueira, F. R.; Dutra, Caroline; Vieira, Maluci; Alves, Roberta, Valle, Victor. Desastres climáticos no Brasil e o papel do poder público no seu gerenciamento. Revista ClimaCom, 2023, Vol. N25, Págs 1-9, ISSN- 2359-4705. **https://climacom.mudancasclimaticas.net.br/desastres-climaticos1/**

Barnes, C., Santos, F.L.M., Libonati, R., Keeping, T., Rodrigues, R. and co-authors (2024). Hot, dry and windy conditions that drove devastating Pantanal wildfires 40% more intense due to climate change, World Weather Attribution Report, 08/08/2024, Grantham Institute for Climate Change, https://doi.org/10.25561/113726

Clarke, B., Barnes, C., Rodrigues, R., Zachariah, M., and co-authors (2024a). Climate change, not El Niño, main driver of extreme drought in highly vulnerable Amazon River Basin, World Weather Attribution Report, 24/01/2024, Grantham Institute for Climate Change, https://doi.org/10.25561/108761

Clarke, B., Barnes, C., Rodrigues, R., Zachariah, M., and co-authors (2024b). Climate change, El Niño and infrastructure failures behind massive floods in southern Brazil, World Weather Attribution Report, 03/06/2024, Grantham Institute for Climate Change, https://doi.org/10.25561/111882

Regina C. S. Alvalá; Jose A. Marengo Orsini, Marcelo E. Seluchi. Desafíos de la Gestión y Reducción de Riesgos de Desastres geo-hidro-meteorológicos en Brasil: Estudio de un Caso**. Pg 37-42.** Revista Digital del Grupo de Trabajo de Gestión de Riesgo de desastres de FELACBEJA. (Coord. Delgado Pérez). Forjando um Futuro Más Resiliente Ante Desastres: La Conexión entre Japón, Latinoamérica y el Caribe. 2024. DOI 10.5281/zenodo.10867146.

Antunes, L.; Cuartas, L. A.; Gonçalves, D. A.; Alvalá, R. C. dos S. (2024). "Mapeamento das áreas impactadas pela inundação de maio de 2024 na região hidrográfica **Anais** [...]. Associação Brasileira de Recursos Hidricos, ABRHidro; Universidade Federal do Paraná, UFPR do Guaíba". Anais IV Encontro Nacional de Desastres, END., 2024, Curitiba., 2024. ISSN: 2764-9040.

CENTRO NACIONAL DE MONITORAMENTO E ALERTA DE DESASTRES NATURAIS, CEMADEN. NOTA TÉCNICA Nº 279/2024/SEI-CEMADEN. Nº do Processo 01242.000199/2024-71: Mapeamento das manchas de inundações e enxurradas e das cicatrizes dos movimentos de massa, associadas ao desastre do estado do Rio Grande do Sul em maio de 2024. Brasília, SEI/MCTI - 11973914 - Nota Técnica, 21/05/2024.

Ecosystems

Allen, D., Pickering, K., Avery, M., Li, Z., Shan, S., Morales Rodriguez, C. A., & Artaxo, P. (2024). A CloudSat and CALIPSO-based evaluation of the effects of thermodynamic instability and aerosol loading on Amazon Basin deep convection and lightning. Journal of Geophysical Research: Atmospheres, 129, e2023JD039818. https://doi. org/10.1029/2023JD039818.

Blichner, S.M., Yli-Juuti, T., Mielonen, T., C. Pöhlker, E. Holopainen, L. Heikkinen, C. Mohr, P. Artaxo, S. Carbone, B. B. Meller, C. Quaresma Dias-Júnior, M. Kulmala, T. Petäjä, C. Scott, C. Svenhag, L. Nieradzik, M. Sporre, D. Partridge, E. Tovazzi, A. Virtanen, H. Kokkola, and I. Riipinen. Process-evaluation of forest aerosol-cloud-climate feedback shows clear evidence from observations and large uncertainty in models. Nature Communications, 15, 969 (2024) https://doi.org/10.1038/s41467-024-45001-y.

Brown, F., Folberth, G., Sitch, S., Artaxo, P., Bauters, M., Boeckx, P., Cheesman, A. W., Detto, M., Komala, N., Rizzo, L., Rojas, N., dos Santos Vieira, I., Turnock, S., Verbeeck, H., and Zambrano, A.: Performance evaluation of UKESM1 for surface ozone across the pan-tropics, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-2937 , 2024.

Caravan, R.L., T. J. Bannan, F. A. F. Winiberg, M. A. H. Khan, A. C. Rousso, A. W. Jasper, S. D. Worrall, A. Bacak, P. Artaxo, J. Brito, M. Priestley, J. D. Allan, H. Coe, Y. Ju, D. L. Osborn, N. Hansen, S. J. Klippenstein, D. E. Shallcross, C. A. Taatjes & C. J. Percival. Observational evidence for Criegee intermediate oligomerization reactions relevant to aerosol formation in the troposphere. Nat. Geosci. 17, 219–226 (2024). https://doi.org/10.1038/s41561-023-01361-6.

Unfer, G. R., Machado, L. A. T., Artaxo, P., Franco, M. A., Kremper, L. A., Pöhlker, M. L., Pöschl, U., and Pöhlker, C.: Amazonian aerosol size distributions in a lognormal phase space: characteristics and trajectories, Atmos. Chem. Phys., 24, 3869–3882, https://doi.org/10.5194/acp-24-3869-2024, 2024.

Franco, M.A., Morais, F.G., Rizzo, L.V., Rafael Palácios, Rafael Valiati, Márcio Teixeira, Luiz A. T. Machado, Paulo Artaxo. Aerosol optical depth and water vapor variability assessed through autocorrelation analysis. *Meteorol Atmos Phys* **136**, 15 (2024). https://doi.org/10.1007/s00703-024-01011-5 .

Artaxo, Paulo; Rizzo, Luciana Varanda; Machado, Luiz Augusto Toledo. Inteligência artificial e mudanças climáticas. Revista USP, São Paulo, Brasil, n. 141, p. 29–40, 2024. DOI: 10.11606/issn.2316-9036.i141p29-40. https://www.revistas.usp.br/revusp/article/view/225205. Acesso em: 15 maio. 2024.

Louis Lu, Longlei Li, Sagar Rathod, Peter Hess, Carmen Martínez, Nicole Fernandez, Christine Goodale, Janice Thies, Michelle Wong, Maria Alaimo, Paulo Artaxo, Francisco Barraza, Africa Barreto, David Beddows, Shankararman Chellam, Ying Chen, Patrick Chuang, David Cohen, Gaetano Dongarrà, Cassandra Gaston, Darío Gómez, Yasser Morera-Gómez, Hannele Hakola, Jenny Hand, Roy Harrison, Phillip Hopke, Christoph Hueglin, Yuan-wen Kuang, Katriina Kyllonen, Fabrice Lambert, Willy Maenhaut, Randall Martin, Adina Paytan, Joseph Prospero, Yenny González, Sergio Rodriguez, Patricia Smichowski, Daniela Varrica, Brenna Walsh, Crystal Weagle, Yi-hua Xiao, and Natalie Mahowald. Characterizing the Atmospheric Mn Cycle and Its Impact on Terrestrial Biogeochemistry. Global Biogeochemical Cycles, 38, e2023GB007967. https://doi.org/10.1029/2023GB007967, 2024.

Machado, L. A. T., Kesselmeier, J., Botía, S., van Asperen, H., O. Andreae, M., de Araújo, A. C., Artaxo, P., Edtbauer, A., R. Ferreira, R., Franco, M. A., Harder, H., Jones, S. P., Dias-Júnior, C. Q., Haytzmann, G. G., Quesada, C. A., Komiya, S., Lavric, J., Lelieveld, J., Levin, I., Nölscher, A., Pfannerstill, E., Pöhlker, M. L., Pöschl, U., Ringsdorf, A., Rizzo, L., Yáñez-Serrano, A. M., Trumbore, S., Valenti, W. I. D., Vila-Guerau de Arellano, J., Walter, D., Williams, J., Wolff, S., and Pöhlker, C.: How rainfall events modify trace gas mixing ratios in central Amazonia, Atmos. Chem. Phys., 24, 8893–8910, https://doi.org/10.5194/acp-24-8893-2024, 2024.

Franco, M. A., Valiati, R., Holanda, B. A., Meller, B. B., Kremper, L. A., Rizzo, L. V., Carbone, S., Morais, F. G., Nascimento, J. P., Andreae, M. O., Cecchini, M. A., Machado, L. A. T., Ponczek, M., Pöschl, U., Walter, D., Pöhlker, C., and Artaxo, P.: Vertically resolved aerosol variability at the Amazon Tall Tower Observatory under wet-season conditions, Atmos. Chem. Phys., 24, 8751–8770, https://doi.org/10.5194/acp-24-8751-2024, 2024.

Rathod, S., Douglas S. Hamilton, Lance Nino, Sonia M. Kreidenweis, Emily Bian, Natalie M. Mahowald, Jeffrey R. Pierce, Andres Alastuey , Xavier Querol, Adina Paytan, Ying Chen, Paulo Artaxo, Barak Herut, Cassandra Gaston, Joseph Prospero, Shankararaman Chellam, Christoph Hueglin, Daniela Varrica, Gaetano Dongarra, David Cohen, Patricia Smichowski, Dario Gomez, Fabrice Lambert, Francisco Barraza, Gilles Bergametti, Sergio Rodríguez, Yenny Gonzalez-Ramoz, Jenny Hand, Katriina Kyllonen, Hannele Hakola, Patrick Chuang, Philip Hopke, Roy M. Harrison, Randall Martin, Brenna Walsh, Crystal Weagle, Willy Maenhaut, Yasser Morera-Gómez, Yu-Cheng Chen, and Tami C. Bond. Constraining present-day anthropogenic total iron emissions using model and Observations. Journal of Geophysical Research Atmospheres, 129, Issue 17, e2023JD040332. https://doi.org/10.1029/2023JD040332 .

Adriana Gioda, Paulo Artaxo, et al., Chemical characterization and source apportionment of rainwater in the Amazon region. Submitted to Acta Amazonica, AA-2023-0131.R2.

Alexander Cheesman, Flossie Brown, Paulo Artaxo, Mst Nahid Farha, Gerd Folberth, Felicity Hayes, Viola Heinrich, Tim Hill, Lina Mercado, Rebecca Oliver, Michael O'Sullivan, Johan Uddling, Lucas Cernusak, Stephen Sitch. Impact of ground-level ozone on tropical forests. Accepted for publication in Nature Geosciences, July 2024.

Luiz Augusto Machado, Gabriela Unfer, Sebastien Brill, Stefanie Hildmann, Christopher Pöhlker, Jonathan Williams, Harder Harder Hartwig, Meinrat Andreae, Paulo Artaxo, Yafang Cheng, Joachim Curtius, Marco Franco, Micael Cecchini, Achim Edtbauer, Thorsten Hoffmann, Bruna Holanda, Theodore Khadir, Radovan Krejci, Leslie Kremper, Bruno Meller, Mira Pöhlker, Carlos Quesada, Akima Ringsdorf, Ilona Riipinen, Susan Trumbore, Stefan Wolff, Jos Lelieveld, Ulrich Pöschl. Frequent nanoparticle bursts in the Amazon rainforest. Submitted to Nature, Manuscript number 2023-10-18462.

Mahowald, N. M., Li, L., Vira, J., Prank, M., Hamilton, D. S., Matsui, H., Miller, R. L., Lu, L., Akyuz, E., Meidan, D., Hess, P. G., Lihavainen, H., Wiedinmyer, C., Hand, J., Alaimo, M. G., Alves, C., Alastuey, A., Artaxo, P., Barreto, A., Barraza, F., Becagli, S., Calzolai, G., Chellam, S., Chen, Y., Chuang, P., Cohen, D. D., Colombi, C., Diapouli, E., Dongarra, G., Eleftheriadis, K., Engelbrecht, J., Galy-Lacaux, C., Gaston, C., Gomez, D., González Ramos, Y., Harrison, R. M., Heyes, C., Herut, B., Hopke, P., Hüglin, C., Kanakidou, M., Kertesz, Z., Klimont, Z., Kyllönen, K., Lambert, F., Liu, X., Losno, R., Lucarelli, F., Maenhaut, W., Marticorena, B., Martin, R. V., Mihalopoulos, N., Morera-Gomez, Y., Paytan, A., Prospero, J., Rodríguez, S., Smichowski, P., Varrica, D., Walsh, B., Weagle, C., and Zhao, X.: AERO-MAP: A data compilation and modelling approach to understand spatial variability in fine and coarse mode aerosol composition, Earth Syst. Sci. Data Discuss., 37 (2024), 10.5194/essd-2024-1.

Pereira, G. M., Yoshiaki Kamigauti, L., Pereira, R. F., Monteiro dos Santos, D., da Silva Santos, T., Martins, J. V., Alves, C., Gonçalves, C., Casotti Rienda, I., Kováts, N., Nogueira, T., Rizzo, L., Artaxo, P., Maura de Miranda, R., Yamasoe, M. A., Dias de Freitas, E., de Castro Vasconcellos, P., and de Fatima Andrade, M.: Source apportionment and ecotoxicity of particulate pollution events in a Major Southern Hemisphere Megacity: influence of biomass burning and a biofuel impacted fleet, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-2212, 2024.

Louis Lu, Longlei Li, Sagar Rathod, Peter Hess, Carmen Martínez, Nicole Fernandez, Christine Goodale, Janice Thies, Michelle Y. Wong, Maria Alaimo, Paulo Artaxo, Francisco Barraza, Africa Barreto, David Beddows, Shankarararman Chellam, Ying Chen, Patrick Chuang, David D. Cohen, Gaetano Dongarrà, Cassandra Gaston, Darío Gómez, Yasser Morera-Gómez, Hannele Hakola, Jenny Hand, Roy Harrison, Phillip Hopke, Christoph Hueglin, Yuan-wen Kuang, Katriina Kyllönen, Fabrice Lambert, Willy Maenhaut, Randall Martin, Adina Paytan, Joseph Prospero, Yenny González, Sergio Rodriguez, Patricia Smichowski, Daniela Varrica, Brenna Walsh, Crystal Weagle, Yi-hua Xiao, and Natalie Mahowald. Characterizing the Atmospheric Mn Cycle and Its Impact on Terrestrial Biogeochemistry. Submitted to Global Biogeochemical Cycles, Manuscript 2023GB007967R. fevereiro 2024.

Diego Aliaga, Victoria A. Sinclair1, Radovan Krejci2, Marcos Andrade3,4, Paulo Artaxo5, Luis Blacutt3, Runlong Cai1,6, Samara Carbone7, Yvette Gramlich8, Liine Heikkinen1,2, Dominic Heslin-Rees2, Wei Huang1, Veli-Matti Kerminen1, Alkuin Maximilian Koenig3,9, Markku Kulmala1,10,11, Paolo Laj1,12, Valeria Mardoñez-Balderrama3,13, Claudia Mohr2,8, Isabel Moreno3, Pauli Paasonen1, Wiebke Scholz14, Karine Sellegri15, Laura Ticona3, Gaëlle Uzu15, Fernando Velarde3, Alfred Wiedensohler16, Douglas Worsnop1,17, Cheng Wu18, Chen Xuemeng19,20, Qiaozhi Zha10, Federico Bianchi1New Particle Formation dynamics in the central Andes: Contrasting urban and mountain- top environment. Submitted for publication at Atmospheric Chemistry and Physics, Preprint at Aerosol Research Discussions https://doi.org/10.5194/ar-2024-15 , August 2024.

Santos, Celso; de Oliveira, Gabriel; Mataveli, Guilherme; Stark, Scott; Jones, Matthew; Carmenta, Rachel; Brunsell, Nathaniel; Silva, Richarde; da Silva Junior, Carlos Antonio; Cunha, Helenilza; da Cunha, Alan; dos Santos, Carlos Antonio; Stewart, Hannah; Fuchs, Vanessa; Hellenkamp, Skye; Artaxo, Paulo; Alencar, Ane; Moutinho, Paulo; Shimabukuro, Yosio. Safeguarding the Amazon: A Unified Strategy. Submetido em Frontiers in Ecology and the Environment paper number FEE24-0124. 24 de maio de 2024.

Aliaga, D., Sinclair, V. A., Krejci, R., Andrade, M., Artaxo, P., Blacutt, L., Cai, R., Carbone, S., Gramlich, Y., Heikkinen, L., Heslin-Rees, D., Huang, W., Kerminen, V.-M., Koenig, A. M., Kulmala, M., Laj, P., Mardoñez-Balderrama, V., Mohr, C., Moreno, I., Paasonen, P., Scholz, W., Sellegri, K., Ticona, L., Uzu, G., Velarde, F., Wiedensohler, A., Worsnop, D., Wu, C., Xuemeng, C., Zha, Q., and Bianchi, F.: New Particle Formation dynamics in the central Andes: Contrasting urban and mountain-top environments, Aerosol Research Discuss. [preprint], https://doi.org/10.5194/ar-2024-15, in review, 2024.

10.Other activities and web sites of reports, art exhibitions and courses/seminars online and videos

Martins, F. R. *Podcast – Com Quantos Paus se faz uma canoa:* Um planeta cada vez mais extremo. https://open.spotify.com/episode/1oTiDzohqPROHy6I9Zu7ol?si=8dywo2XKQPG5TGMMAI9xRA.

Martins, F. R. *Podcast – Estação 953 – Radio UFSCAR. Frequência de temperaturas extremas na costa brasileira.* Episódio 48. Maio, 2023. https://open.spotify.com/episode/38vKpwmu6edvhcCcS9niVq?si=8a09c102df574671Martins,

F. R. *Podcast – Estação 953 – Radio UFSCAR: Ondas de calor e as recentes catastrofes no Brasil e no Mundo.* Episódio 140. Setembro, 2023. https://open.spotify.com/episode/59ETOY7MgpgW9cztCMtyd4?si=9bfa13e41b0a4ca6

BACHIR, M. Série de entrevistas "O futuro é feminista e vegetal" - Entrevista com Marlene Pereira, que atua com agroecologia e culinária em São Paulo, setembro de 2023. Disponível no Instagram da Inadequada.

BACHIR, M. Série de entrevistas "O futuro é feminista e vegetal" - Entrevista com Aline Rios, gestora de projetos do movimento campones, outubro de 2023. Disponível no Instagram da Inadequada.

BACHIR, M.; DIAS, S.. Série de entrevistas "O futuro é feminista e vegetal" - Entrevista com Kellen Vilharva, indígena Guarani-Kaiwoá, graduada e mestra em Biologia, doutoranda em na Unicamp, setembro de 2023. Disponível no Instagram da Inadequada.

BACHIR, M.; DIAS, S.. Série de entrevistas "O futuro é feminista e vegetal" - Entrevista com Tatiana Plens, assessora de comunicação, fotógrafa e doutoranda da Unicamp, outubro de 2023. Disponível no Instagram da Inadequada.

BACHIR, M; DIAS, S.. Série de entrevistas "O futuro é feminista e vegetal" - Entrevista com Alessandra Ribeiro, historiadora, líder da Comunidade Jongo Dito Ribeiro e gestora da Casa de Cultura Fazenda Roseira, novembro de 2023. Disponível no Instagram da Inadequada.

GARCIA D. y A. MENEGAZ Programa radial Dimensión Ambiental 2030. Un diálogo de saberes sustentables. Entrevista sobre agrotóxicos, producción y consumo de hortalizas. Radio Mestiza UNAJ. abril 2024. https://www.instagram.com/reel/C5jxTPuNTT_/?igsh=dGw1cXJraHF0ZmRi

GARCIA D. y A. MENEGAZ Programa radial Estación Sur. La Plata FM 91.7 Entrevista radial sobre uso de agrotóxicos en horticultura y salud. https://www.youtube.com/watch?v=voPnFx1eGTQ. Octubre 2023[G8] MAUS, L.; NICOLODI, A.. Entrevista com Lilian Maus sobre produção artística e pesquisa no Podcast Panorama Crítico. 11/10/2023. Disponível em: https://open.spotify.com/episode/6AtErRa3rwNmHB9ZAIVBAz?si=RxtbnCdeQlaakJ9PzmRQpw

GUIVANT, JULIA S.. A interdisciplinaridade na pesquisa sobre mudança climática: reflexões a partir da experiência do Instituto Nacional de Ciência e Tecnologia no Brasil. Blogue Shift, Universidade de Lisboa, p.1 - 4, 2024.

MIRANDA, Emanuely. Entrevista com José A. Marengo - Estamos avançando e novamente ganhando terreno na agenda ambiental. **Climacom,** 14 de março 2024.

MIRANDA, Emanuely. "Podemos sim mudar e revitalizar a terra" – Entrevista com Valdelice Verón, liderança indígena Guarani Kaiowá. **Climacom**, 15 de abril de 2024

QUEIROZ FILHO, Antonio Carlos. Áudio-aula: por que estudar linguagem é geográfico? (parte um). 2022 (Projeto de Extensão).

QUEIROZ FILHO, Antonio Carlos. Áudio-aula: por que estudar linguagem é geográfico? (parte dois). 2022 (Projeto de Extensão).

TADDEI, R. R.. Ciência Fundamental: O Antropoceno dá um passo à frente (menção). 2023. (Programa de rádio ou TV/Entrevista).

TADDEI, R. R..; GRAZIOSI, I. . Entrevista concedida à revista digital Lucy sulla Cultura. 2023. (Programa de rádio ou TV/Entrevista).

TADDEI, R. R.; GUAL, J. R. . El espíritu que promete evitar que el mal tiempo arruine un show en Brasil y firma contratos oficiales. 2023. (Programa de rádio ou TV/Entrevista).

TADDEI, R. R.; BUCCI, S. . Accudite il mondo. L'antropologo chiama gli artisti. 2023. (Programa de rádio ou TV/Entrevista)

DIAS, S.; BARÉ, C.; VILHARVA, K.; GUZZO, M.; TELES, P.; FUREGATTI, S.; MAUS, L.. Organização da Residência artística perceber-fazer floresta I. Campinas e Manaus, 2023.

DIAS, S.; MIRANDA, E.; BARÉ, C.; VILHARVA, K.; GUZZO, M.; RIBEIRO, A.; PAULINO, M. A.; FUREGATTI, S.; MAUS, L., WUNDER, A. Organização da Residência artística Perceber-fazer floresta II: caminhar, cozinhar, cantar, contar…. 23 a 26 de maio de 2024 em Campinas.

ARANHA, N.; BARBOSA, R.; DIAS, S. O. Oficina "Seguir os sapos" para professores da rede municipal de ensino de Campinas, 2024.

ARANHA, N.; FAUTH, W.; MIRANDA, E.; BARBOSA, R.; LAZZERINI, L. A.; DIAS, S. O. Mesa de trabalho "Perceber-fazer floresta", para estudantes do PPG Divulgação Científica e Cultural, no Labjor-Unicamp, 8 de maio de 2024.

MAUS, Lilian Maus. Curadoria das ações educativas e oficinas da exposição PAMPA SINGULAR (Projeto Contemplado por edital CNPQ). Museu de Ciências Naturais Carlos Ritter, Pelotas/RS, 2023;

ARANHA, N.; FAUTH, W.; MIRANDA, E.; GUZZO, M.; FUREGATTI, S.; ESQUIVEL MARIN, S.; GARCIA, G. C.; MURRIELLO, S.; COTAIMICH, V.; VIDAL, E.; GARCÍA, D,; MENEGAZ, A.; PELLEJERO, E.; WUNDER, A.; OLIVEIRA JÚNIOR, W. M.; OLIVEIRA, T. P., MASSARO, T.; LEITÃO, M. V.; TELES, P., VILHARVA, K.; BARÉ. C.; PAULINO, M. A.; CANGI, A.; ARCILA, S.; OSPINA, T.; MAUS, L.; RIBEIRO, A.; DIAS, S. O. Participação na residência em Manaus Perceber-fazer floresta II, realizada em maio de 2024. (Projeto de Pesquisa Perceber-fazer floresta - FAPESP)

GUZZO, M.; FUREGATTI, S.; VILHARVA, K.; BARÉ, C.; PAULINO, M. A.; MAUS, L.; DIAS, S. O. Participação na residência em Manaus Perceber-fazer floresta I, realizada entre junho e outubro de 2023. (Projeto de Pesquisa Perceber-fazer floresta - FAPESP)

OLIVEIRA, T.; DIAS, S. O. Oficina "Corpos-solos-vivos para professores da rede municipal de ensino de Campinas, 2024.

RIBEIRO, A.; MIRANDA, E; DIAS, S. Oficina "Plantas companheiras" para professores da rede municipal de ensino de Campinas, 2024.

[J13] VILELA, Mariana. Cabeça vegetal, uma experiência para além dos sentidos. Oficina-vivência. Casa de Cultura Fazenda Roseira. Campinas, 2023.

DIAS, S. O. Curadoria da exposição "Tierra", Galeria Gaia da Unicamp, Campinas, de 23 de maio a 28 de junho.

DIAS, S. O. Curadoria da exposição "A Carne de Gaia", Espaço Cultural Pavão, Campinas, de 02 de maio a 29 de junho.

SANTOS, B.; FILO, B.; FRADE, M.; DIAS, S.. Emaranhados vegetais I. Mostra realizada no Casarão do boneco em Belém, Pará. **ClimaCom – Desastres** [online], Campinas, ano 10, Nov. 2023. Available from: https://climacom.mudancasclimaticas.net.br/emaranhados-vegetais/

SANTOS, B.; FILO, B.; FRADE, M.; DIAS, S.. Emaranhados vegetais II. Mostra realizada na Galeria do Centro de Conveções da Unicamp, Campinas, entre 27 e 29 de maio de 2024.

MAUS, Lilian Maus. Participação artista expositor em Exposição coletiva (convite). Artistas da Galeria Aura, stand da feira ARTRIO 2023, Pavilhão principal Marina da Glória, Rio de Janeiro/RJ, 2023;

MAUS, Lilian Maus. Participação artista expositor em Exposição coletiva (convite). Participação em exposição coletiva (seleção) XII Leilão MOVE RIO (curadoria: Manuela Parrino e Vanda Klabin), ARTRIO 2023, Pavilhão externo Marina da Glória, Rio de Janeiro, 2023;

MAUS, Lilian Maus. Participação artista expositor em Exposição coletiva (seleção). Participação em exposição coletiva (convite) Arquiteturas Improváveis (curadoria: Gabriel Kogan), Galeria Aura, São Paulo, 2023;

MAUS, Lilian Maus. Participação artista expositor em Exposição coletiva (seleção). Participação em exposição coletiva (convite). Exposição coletiva dos artistas da galeria Aura, stand feira SP-ARTE 2023 São Paulo/SP;

MAUS, Lilian Maus. Participação como artista expositor em exposição coletiva PAMPA SINGULAR (curadoria: João Iganci). Projeto contemplado em edital CNPQ-RS. Museu de Ciências Naturais Carlos Ritter - UFPel, Pelotas/RS;

MAUS, Lilian Maus. Curadoria em exposição coletiva Quando a casa estremece, Galeria A SALA (coordenação Lizângela Torres e Ricardo Mello), UFPEL, Pelotas/RS. Artistas participantes: Elida Tessler, Adauany Zimovski, Adriene Coelho, Aline Farias, Betina Nilsson, Bruna Salamin, Carmem Salazar, Elissa Seadi, duo Fernanda Gassen e Michel Zózimo, Isabelle Baiocco, James Zortéa, Jess S. S., Juliana Gonzalez, Laura Fagundes, Leonardo Lopes, Lia Menna Barreto, Luciane Bucksdricker, Marcela Pardo, Marla Pritsch, Maya Bardini, Milena Castro, Pedro Dalla Rosa e Sol, 2023;

MAUS, Lilian Maus. Curadoria em exposição coletiva dos formandos de Artes Visuais 2021/2 Constelar Corpos e materialidades (curadoria: Lilian Maus), Galeria Barão de Santo Ângelo, Porto Alegre, IA/UFRGS. Artistas integrantes: Aldren Venes, Ana Flávia Garcia, Anurb Izquierdo, Dantara Ordovás, Gabriela Berghan, Juliana Gonzalez, Juliana Justino, Luísa Guazzelli Sirangelo, Luiza Horn, Maria Ana e Pedro Rocha Martin;

MAUS, Lilian Maus. Curadoria em exposição individual da artista Zoravia Bettiol Iemanjá e os Deuses Olímpicos, Galeria Habitart, Porto Alegre/RS. Concepção da performance "Ode à Sereia", com atuação da atriz Verônica Becker e Francisco Marshall ao piano;

MAUS, Lilian Maus; MASTROBERTI, Paula. Curadoria em exposição coletiva Ilustraê!, curadoria Lilian Maus e Paula Mastroberti, (Editora da Revista Sextante: Thaís Furtado), Espaço Evelyn Ioschpe, 5º andar, Casa de Cultura Mario Quintana, Porto Alegre. Artistas participantes: Alex Rezende, Ana Claudia de Moura Cabral, Ana Luiza Freire, Aster Cézar, Ayla Dresch, Beatriz Collares, Camila Chaves, Cerise Gomes, Carolina Esteves, Dayana Flores, Denise Moraes Costa, Eduarda Dalavechia, Eliseu Sauthier, Enzo Koch, Esther Jaeger, Gabriel Anjos, Gabriela Bittencourt, Gabriele Baptista, Giullia Brahm, Isabela Olerich, Isabelle Baiocco, Jeniru, Júlia Dolores, Kelin Agnes, Luísa Crepaldi, Maria Eduarda Alegre, Nicolas Fedrizzi, Kézia Mausolf, Luci Pinheiro, Magnólia Leão, Marina Brandão, Mariana Lemmertz, Pedro Stelmach, Rafaela Müller, Sérgio Dias, Sofia Kerr, Thainá Gabriela e Yasmin Marchant, 2023

NORES J. et al. BIODIVERSA. MIRADAS SOBRE BOSQUES NATIVOS. EXPERIENCIA INMERSIVA. una experiencia inmersa que invita a jugar con los sentidos y sumergirse en el bosque nativo para reflexionar sobre la importancia de su conservación. El Museo Botánico acerca esta propuesta producida por un equipo interdisciplinario de investigadoras/es y artistas. Organización: Museo Botánico Córdoba. Instituciones involucradas: - Universidad Nacional de Córdoba. Junio 2023

VILELA, Mariana. Participação artista expositor em Exposição coletiva (convite). Vitaloceno: para uma cabeça vegetal. Exposição A-fiar. Curadoria de Isabel Portella e Filipe Chagas. Rio de Janeiro, 2023.
VILELA, Mariana. Participação artista expositor em Exposição coletiva (convite). Vitaloceno: para uma cabeça vegetal. Exposição Entrelinhas. Curadoria de Sylvia Wernek. São Paulo, 2023.
VILELA, Mariana. Participação artista expositor em Exposição coletiva (convite). Novo-elo. Exposição Entrelinhas. Curadoria de Sylvia Wernek. São Paulo, 2023.
ARCILA, S; ATRACTOR STUDIO. **Los Migrantes.** Vídeo-game exposto na exposição Tierra, Galeria Gaia da Unicamp.
MARTINS, A. C.; PAULINO, M. A.; VILHARVA, K.; SCORNAIENCHI, V.; DIAS, S. O. **Kaá Wasú**. Livro-objeto. 2024, exposto na exposição Tierra, Galeria Gaia da Unicamp.
MAUS, L. **Políptico Leite da Floresta e Autorretrato Floresta.** Série de pinturas expostas na exposição Tierra, Galeria Gaia da Unicamp.
VILHARVA, K.; SCORNAIENCHI, V.; TERENA, S.; PEREIRA, Z.; DIAS, S. O. **Seyro Morotĩ- a sabedoria de uma árvore**, Instalação, 2024, exposta na exposição Tierra, Galeria Gaia da Unicamp.
DIAS, Susana. Instalação artística "**Mesa de trabalho fazer floresta**". Sesc Paulista. 2023.
GUZZO, MARINA SOUZA LOBO; DAMASCENO, L. L. . **Fotografia. Mistura #4**. 2023.
GUZZO, Marina, Joilson da Silva Paulino Karapãna, Marilda Da Silva Paulino, Maria Alice da Silva Paulino Karapãna, Manoela Paulino da SIlva Karapãna, Odair da Silva Paulino Karapãna, Joilson Wakenai Tomas Paulino Karapãna. **338 Kangataras**. Vídeo e instalação. 2024, exposta na exposição Tierra, Galeria Gaia da Unicamp.
GUZZO, Marina. **brilhar com o rio negro, dançar com o rio negro.** Vídeo-instalação. 2024, exposta na exposição Tierra, Galeria Gaia da Unicamp.
MAUS, Lilian; GOMES, Biel. **Ygápéba**. 5min, 2023 (no prelo, a ser exibido em Berlin em pesquisa da Cátedra Arte e Natureza: Processos Híbridos. Disponível em: https://www.ufrgs.br/catedra-arte-natureza/
MURRIELLO, S. ***Desgajado***. Fotografía seleccionada en el Concurso fotográfico "La tierra tiembla. Cambio climático y territorio". UNRN , Sede Andina, Bariloche, RN,Argentina. 2022 .
MURRIELLO, S. Dirección de ***La voz del planeta***, video arte instalación de Apa, María Elena. Trabajo Final de Licenciatura en Diseño Artístico Audiovisual, UNRN, El Bolsón, RN, Argentina.Junio 2022.
NORES, María Jimena; MONTECCHIESI, Silvana; BERNARDELLO, Gabriel. Mirabilis Ilustración botánica. **ClimaCom – Políticas vegetais** [online], Campinas, ano 9, n. 22. dez. de 2022. Available from: http://climacom.mudancasclimaticas.net.br/mirabilis/
PLENS, Tatiana. DIAS, Susana. Práticas de agroflorestar imagens. **ClimaCom – Políticas vegetais** [online], Campinas, ano 9, dez. 2022. Available from: http://climacom.mudancasclimaticas.net.br/agroflorestar-imagens/
QUEIROZ FILHO, Antonio Carlos. Fotografias para a capa e ilustrações da Master Thesis 'Revitalising through interaction: using community values to turn vacant heritage in a place for intergenerational interactions'.. 2023. Fotografia.
QUEIROZ FILHO, A. C.. Fotografias para ilustrações da Master Thesis 'Values and attachment: social and ecological spaces in value-based redesign of former milling factory, Estação, Faro'.. 2023. Fotografia.
QUEIROZ FILHO, Antonio Carlos. Fotografias para ilustrações da Master Thesis 'Capture Nature: Exploring emotional attachment towards nature with a photographic walking tour for a nature-inclusive redesign of two former warehouses in Faro, Portugal'.. 2023. Fotografia.
QUEIROZ FILHO, Antonio Carlos. Fotografias para ilustrações da Master Thesis 'An architecture of possibilities Co-creation design as a tool for embracing well-being in creating alternative futures for vacant heritage in Estação neighborhood, Faro, Portugal'.. 2023. Fotografia.
QUEIROZ FILHO, Antonio Carlos. Série fotográfica para o livro 'Além do que a vista alcança: sobre paisagem como dobras de sentidos'.. 2022. Fotografia.
QUEIROZ FILHO, Antonio Carlos; CAMARGO, G..Criação de performance em vídeo para o livro 'Geografias e(em) artes: diálogos e afetações mútuos.. 2022. Performance.

QUEIROZ FILHO, Antonio Carlos. Montagem fotográfica para a capa do livro 'Geografias e(em) artes: diálogos e afetações mútuas'.. 2022. Fotografia.
FONSECA, F. S. R. **Como falar com formigas**. Videoarte.
VARGAS, M. G. **Taxonomía de la desmesura: laboratorio Isla Victoria.** Vídeo-instalação. 2024, exposta na exposição Tierra, Galeria Gaia da Unicamp.
VILELA, M. **Vitaloceno - para uma cabeça vegetal**. 2022.
https://www.abes-dn.org.br/previsibilidade-de-eventos-extremos-e-destaque-em-sessao-do-terceiro-dia-da-brazil-water-week-2024/
UOL, Economia, "Sem metas, reconstrução do RS levará décadas", diz especialista em desastres, jun.2024
Folha de São Paulo, "Brasil não avança em integração de saneamento e de Defesa Civil para combater eventos extremos", maio 2024
Folha de São Paulo, "Canal não deve ser prioridade no RS, dizem especialistas", junho 2024
BBC - Amazon's record drought driven by climate change: https://www.bbc.com/news/science-environment-6803236
The Guardian - Devastating drought in Amazon result of climate crisis, study shows: https://www.theguardian.com/environment/2024/jan/24/devastating-drought-in-amazon-result-of-climate-crisis-study-shows
Financial Times – Climate change was big driver of historic Amazonian drought, study finds: https://www.ft.com/content/d3aa4444-0362-4afb-9228-df5e6dd41d8d
Al Jazeera - Global warming drove record Amazon rainforest drought, study finds: https://www.aljazeera.com/news/2024/1/25/global-warming-drove-record-amazon-rainforest-drought-study-finds
The New York Times - Climate Change Drove Drought in the Amazon: https://www.nytimes.com/2024/01/24/climate/amazon-drought-low-water.html
Reuters - Climate change drives Amazon rainforest's record drought, study finds: https://www.reuters.com/business/environment/climate-change-drives-amazon-rainforests-record-drought-study-finds-2024-01-24/
El País - El principal responsable de la sequía inédita en la Amazonia fue el cambio climático, no 'El Niño': https://elpais.com/america-futura/2024-02-08/el-principal-responsable-de-la-sequia-inedita-en-la-amazonia-fue-el-cambio-climatico-no-el-nino.html
Mongabay - Climate change made 2023 Amazon drought 30 times more likely, scientists say: https://news.mongabay.com/2024/01/climate-change-made-2023-amazon-drought-30-times-more-likely-scientists-say/
Jornal Nacional Globo - Mudanças climáticas tiveram peso maior do que o El Niño na seca da Amazônia em 2023, aponta estudo: https://g1.globo.com/jornal-nacional/noticia/2024/01/24/mudancas-climaticas-tiveram-peso-maior-do-que-o-el-nino-na-seca-da-amazonia-em-2023-aponta-estudo.ghtml
The Guardian - Devastating Brazil floods made twice as likely by burning of fossil fuels and trees: https://www.theguardian.com/world/article/2024/jun/03/devastating-brazil-floods-made-twice-as-likely-by-burning-of-fossil-fuels-and-trees
The New York Times - Deadly Floods in Brazil Were Worsened by Climate Change, Study Finds: https://www.nytimes.com/2024/06/03/climate/brazil-floods-climate-change.html
France 24 - Climate change made historic Brazil floods twice as likely: scientists: https://www.france24.com/en/live-news/20240603-climate-change-made-historic-brazil-floods-twice-as-likely-scientists
A Folha de SP - Mudança climática tornou chuva no RS duas vezes mais provável, aponta estudo: https://www1.folha.uol.com.br/ambiente/2024/06/mudanca-climatica-tornou-chuva-no-rs-duas-vezes-mais-provavel-aponta-estudo.shtml?utm_source=sharenativo&utm_medium=social&utm_campaign=sharenativo
O Globo - Mudanças climáticas tornaram a tragédia no Rio Grande do Sul duas vezes mais provável, indica estudo internacional: https://oglobo.globo.com/brasil/noticia/2024/06/03/mudancas-climaticas-tornaram-a-tragedia-no-rio-grande-do-sul-duas-vezes-mais-provavel-indica-estudo-internacional.ghtml

O Estado de SP - Quanto El Niño e mudanças climáticas pioraram as chuvas no Rio Grande do Sul? Estudo traz resposta: https://www.estadao.com.br/sustentabilidade/mudancas-climaticas-chuvas-rio-grande-do-sul-el-nino/

MCTI Notícias - Mudança climática dobrou a probabilidade de ocorrência de chuvas extremas no Sul do Brasil: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2024/06/mudanca-climatica-dobrou-a-probabilidade-de-ocorrencia-de-chuvas-extremas-no-sul-do-brasil

Conexão Globo News (Registros de enchentes e deslizamentos em 2023 já representam 75% do total de 2022), 06/09/2023. https://g1.globo.com/globonews/conexao-globonews/ https://g1.globo.com/globonews/conexao-globonews/video/registros-de-enchentes-e-deslizamentos-em-2023-ja-representam-75-do-total-de-2022-11925703.ghtml

El Niño atípico liga alerta para eventos extremos no verão. O Globo, 15/09/2023. https://infoglobo.pressreader.com/article/281526525655117

Muçum é o símbolo de uma nova era climática, diz coordenador do Cemaden sobre tragédia do RS e que El Niño chega ainda mais avassalador no fim do ano. Jornal O Globo, 15/09/2023. https://oglobo.globo.com/brasil/noticia/2023/09/15/el-nino-ganha-forca-e-aumenta-risco-de-chuvas-extremas-no-sul-mais-calor-no-sudeste-e-seca-no-norte-e-nordeste.ghtml

Áreas elevadas e água abaixo do joelho: especialistas apontam o que fazer para se proteger das tempestades de verão. O Globo, 21/01/2024. https://oglobo.globo.com/brasil/noticia/2024/01/21/areas-elevadas-e-agua-abaixo-do-joelho-especialistas-apontam-o-que-fazer-para-se-proteger-das-tempestades-de-verao.ghtml

Oito cidades do país somaram 1.485 alertas de risco, aponta centro nacional de monitoramento. O Globo, 26/02/2024. https://oglobo.globo.com/brasil/noticia/2023/02/oito-cidades-do-pais-somaram-1485-alertas-de-risco-aponta-centro-nacional-de-monitoramento.ghtml

Descubra quanto calor faz na sua cidade: mapa mostra os locais mais quentes do Brasil em ano de recorde mundial. O Globo, 27/02/2024. https://oglobo.globo.com/brasil/meio-ambiente/noticia/2024/02/27/descubra-quanto-calor-faz-na-sua-cidade-mapa-mostra-os-locais-mais-quentes-do-brasil-em-ano-de-recorde-mundial.ghtml

Alerta máximo: com previsão de chuva extrema, governos e prefeituras dispensam servidores e universidades fecham. O Globo, 22/03/2024. https://oglobo.globo.com/rio/noticia/2024/03/22/alerta-maximo-com-previsao-de-chuva-extrema-governos-e-prefeituras-dispensam-servidores-e-universidades-fecham.ghtml

Lanternas, velas e celulares carregados... veja dicas de especialista para não ser pego de surpresa pela chuva no Rio. O Globo, 22/03/2024. https://oglobo.globo.com/rio/noticia/2024/03/22/lanternas-velas-e-celulares-carregados-veja-dicas-de-especialista-para-nao-se-pego-de-surpresa-pela-chuva-no-rio.ghtml

Especialistas defendem que alerta sobre o risco de tempestade sejam feitos à população com antecedência. O Globo, 23/03/2024. https://oglobo.globo.com/rio/noticia/2024/03/23/especialistas-defendem-que-alertas-sobre-o-risco-de-tempestade-sejam-feitos-a-populacao-com-antecedencia.ghtml

Econômico, 25/03/2024. https://valor.globo.com/brasil/noticia/2024/03/23/prefeito-do-rio-espera-piora-da-chuva-no-domingo-petrpolis-decreta-emergncia.ghtml

Corredores verdes e cidades-esponja, as soluções que vêm da natureza. O Globo, 24/05/2024. **https://oglobo.globo.com/mundo/g20-no-brasil/noticia/2024/05/24/corredores-verdes-e-cidades-esponja-as-solucoes-que-vem-da-natureza.ghtml**

Chuvas no RS: entenda a combinação de fenômenos climáticos que provoca o dilúvio sobre o estado. O Globo, 03/05/2024. https://oglobo.globo.com/brasil/noticia/2024/05/03/chuvas-no-rs-entenda-a-combinacao-de-fenomenos-climaticos-que-provoca-o-diluvio-sobre-o-estado.ghtml

Brasil não avança em integração para combater desastres. Folha de São Paulo, 04/05/2024. https://www1.folha.uol.com.br/cotidiano/2024/05/brasil-nao-avanca-em-integracao-de-saneamento-e-de-defesa-civil-para-combater-eventos-extremos.shtml

Decisões sobre extremos climáticos devem incorporar a ciência, enfatizam especialistas, Academia Brasileira de Ciências, 02/08/2024. https://www.abc.org.br/2024/08/02/decisoes-sobre-extremos-climaticos-devem-incorporar-a-ciencia-enfatizam-especialistas/

Estudo analisa enchentes de setembro de 2023 no RS para mapear vulnerabilidade de municípios a desastres ambientais. Jornal da Unesp, 06/08/2024. https://jornal.unesp.br/2024/08/06/estudo-analisa-enchentes-de-setembro-de-2023-no-rs-para-mapear-vulnerabilidade-de-municipios-a-desastres-ambientais/

1641 municípios no país têm risco a chuvas alto; o que cabe aos prefeitos? APública, 15/08/2024. **https://apublica.org/2024/08/1-641-municipios-no-pais-tem-risco-a-chuvas-alto-ou-muito-alto-o-que-cabe-aos-prefeitos/**

Papel da gestão municipal no controle de desastres. Revista Poli (Saúde, educação, Trabalho). Ano XVII, No. 96, Julho/Outubro 2024, Páginas 20-22, ISSN 1983-909X. **https://www.epsjv.fiocruz.br/sites/default/files/poli_96_web.pdf**

Cátia Guimaraes, Maria Fernanda Lemos, Carlos Machado.

Cidades resilientes: planos de governo revelam descompasso entre propostas e emergência climática. O Globo, 25/08/2024. **https://oglobo.globo.com/politica/eleicoes-2024/noticia/2024/08/25/cidades-resilientes-planos-de-governo-revelam-descompasso-entre-propostas-e-emergencia-climatica.ghtml**

Seca e Incêndios no Estado de São Paulo. Entrevista para a Rádio CBN - Noite Total (Tania Morales), 26/08/2024. https://www.youtube.com/watch?v=azgFslDqkkk

Aquecimento global faz surgir primeira zona árida e expande clima semiárido e áreas secas no Brasil. https://revistapesquisa.fapesp.br/aquecimento-global-faz-surgir-primeira-zona-arida-e-expande-clima-semiarido-e-areas-secas-no-brasil/

Seca histórica atinge Goiás e mais 15 estados, além do Distrito Federal, aponta Cemaden https://www1.diariodeaparecida.com.br/2024/08/29/seca-historica-atinge-goias-e-mais-15-estados-alem-do-distrito-federal-aponta-cemaden/

Mais da metade dos estados no país enfrenta o pior período de seca em 44 anos, diz Cemaden. https://g1.globo.com/meio-ambiente/noticia/2024/08/26/mais-da-metade-dos-estados-no-pais-enfrentam-a-pior-periodo-de-seca-em-80-anos-diz-cemaden.ghtml

Seca e incêndios batem recordes no Brasil em 2024**.** https://oantagonista.com.br/brasil/seca-e-incendios-batem-recordes-no-brasil-em-2024/#google_vignette

Clima na Amazônia está perto de se equiparar à seca histórica de 2015/2016. https://radios.ebc.com.br/tarde-nacional-amazonia/2024/07/clima-na-amazonia-esta-perto-de-se-equiparar-a-seca-historica-de-2015-2016

Alerta: previsão de seca no Amazonas pode se agravar nos próximos meses. https://realtime1.com.br/alerta-previsao-de-seca-no-amazonas-pode-se-agravar-nos-proximos-meses/

Seca na Amazônia pode bater recorde e se estender até janeiro; situação de rios estratégicos é crítica. https://g1.globo.com/meio-ambiente/noticia/2023/09/30/seca-na-amazonia-pode-bater-recorde-e-se-estender-ate-janeiro-situacao-de-rios-estrategicos-e-critica.ghtml

Seca histórica explica parte do aumento das queimadas no Brasil. https://olhardigital.com.br/2024/08/28/ciencia-e-espaco/seca-historica-pode-explicar-aumento-das-queimadas-mas-onde-ha-fumaca/

Seca na Amazônia: municípios tem mais de 80% das áreas agroprodutivas afetadas. https://agenciagov.ebc.com.br/noticias/202310/seca-aumenta-numero-de-municipios-com-mais-de-80-das-areas-agroprodutivas-afetadas-pela-estiagem-na-amazonia

Quase 40% das terras indígenas foram afetadas por seca severa ou moderada, aponta Cemaden. https://www.cnnbrasil.com.br/nacional/quase-40-das-terras-indigenas-foram-afetadas-por-seca-severa-ou-moderada-aponta-cemaden/

Cidades brasileiras registraram temperaturas até 5°C mais altas que o normal em 2023. https://www.terra.com.br/planeta/noticias/cidades-brasileiras-registraram-temperaturas-ate-5c-mais-altas-que-o-normal-em-2023,902a842311c46171d7e5ff1ccc4b6d40svnubpoo.html

Seca histórica por falta de chuva atinge 16 estados e o DF. https://radaramazonico.com.br/seca-historica-por-falta-de-chuva-atinge-16-estados-e-df/

Interview on Climate and Health at FIOCRUZ
Elizabeth Ferreira Rangel.
Published on the Climate and Health Observatory website
12/20/2023

https://climaesaude.icict.fiocruz.br/entrevista-com-pesquisadora-elizabeth-rangel-chefe-do-laboratorio-interdisciplinar-em-vigilancia
Mini-conference: Climate Change and its impacts on health
58th Congress of the Brazilian Society of Tropical Medicine
Elizabeth Ferreira Rangel
12/09/2023
https://medtrop2023.com.br/evento/medtrop2023/programacao/lista?grades%5B%5D=10
Oral presentation of the paper: Distribuição Espacial dos Vetores das Leishmanioses em Associação com os Casos Humanos de Leishmaniose Tegumentar Americana (LTA) e Leishmaniose Visceral Americana (LVA) no Município de Barbalha, Estado do Ceará, Brasil
Simone Miranda da Costa, Alfredo Carlos Rodrigues de Azevedo, Monica de Avelar Figueiredo Mafra Magalhães, Ulisses Mariano da Silva, Lindemberg Caranha, Elizabeth Ferreira Rangel.
ChagasLeish Satellite Meeting 2023
09/13/2023
Apresentação na 7th International Conference on Environmental Sustainability and Climate Change, Las Vegas, USA. 19-20/08/2024
Elizabeth Ferreira Rangel
Distribution of vector of American visceral leishmaniasis in the state of Rio de Janeiro/Brazil: Municipal vulnerability for transmission, ecological, niche modelling and predicted geographic distribution

11 Summary Reports

Summary of scientific production 2023-2024 (Year 7)

Activity	Quantity
Events organized by the INCT MC2 and its components with interaction among subcomponents of the project in Year 7, Participation in scientific events relevant to the INCT MC2 with accepted abstracts or presentations (with partial or total funding from the INCT MC2, or virtual participation)	190
List of publications and book chapters	193
Other publications (Reports, abstracts)	98
Other activities and web sites of reports, art exhibitions and courses/seminars online and videos, interviews, pod casts	150

12 Fellowships (bolsas) granted by FAPESP and other funding agencies in Year 7 (including students)

Economy

Paula Carvalho Pereda
"Assessing the climate and weather effects in Brazil using panel data"
Scholarships abroad - Research
Paula Carvalho Pereda
Link: https://bv.fapesp.br/en/bolsas/179293/assessing-the-climate-and-weather-effects-in-brazil-using-panel-data/
Michael Tulio Ramos de França
"Fertility and Inequality"

Scholarships abroad - Research Internship - Doctorate
Columbia University in the City of New York (United States)
Eduardo Amaral Haddad
Link: https://bv.fapesp.br/en/bolsas/177969/fertility-and-inequality/

Michael Tulio Ramos de França
"Fertility and inequality: evidence from Brazil"
Scholarships in Brazil - Doctorate
Eduardo Amaral Haddad
Link: https://bv.fapesp.br/en/bolsas/174909/fertility-and-inequality-evidence-from-brazil/

Eduardo Amaral Haddad
"Agricultural and agro-industrial sustainability in Chile: modeling the impacts of climate change and natural disasters in an integrated framework"
Regular Research Grants
Eduardo Amaral Haddad
Link: https://bv.fapesp.br/en/auxilios/102276/agricultural-and-agro-industrial-sustainability-in-chile-modeling-the-impacts-of-climate-change-and/

François Claude Prado Boris
"A spatial impact analysis of water accessibility on farming in the Brazilian semiarid"
Scholarships in Brazil - Scientific Initiation
Eduardo Amaral Haddad
Link: https://bv.fapesp.br/en/bolsas/181818/a-spacial-impact-analysis-of-water-accessibility-on-farming-in-the-brazilian-semiarid/

Karina Simone Sass
"Urbanization and climate change: impact evaluation in the Metropolitan Region of São Paulo"
Scholarships in Brazil - Doctorate
Eduardo Amaral Haddad
Link: https://bv.fapesp.br/en/bolsas/183721//

Inácio Fernandes de Araújo Junior
"Agricultural and agro-industrial sustainability in Chile: modeling the impacts of climate change and natural disasters in an integrated framework"
Scholarships in Brazil - Technical Training Program - Technical Training
Eduardo Amaral Haddad
Link: https://bv.fapesp.br/en/bolsas/184227/agricultural-and-agro-industrial-sustainability-in-chile-modeling-the-impacts-of-climate-change-and/

Inácio Fernandes de Araújo Junior
"Extreme events impact assessment: an integrated approach with computable general equilibrium and risk analysis"
Scholarships in Brazil - Post-Doctorate
Link: https://bv.fapesp.br/en/bolsas/202198/extreme-events-impact-assessment-an-integrated-approach-with-computable-general-equilibrium-and-risk/

Inácio Fernandes de Araújo Junior
"The impact assessment of extreme events: an integrated approach with computable general equilibrium and risk analysis"
Scholarships abroad - Research Internship - Post-doctor
Link: https://bv.fapesp.br/en/bolsas/210308/the-impact-assessment-of-extreme-events-an-integrated-approach-with-computable-general-equilibrium-a/

Eduarda Miller de Figueiredo
"Impact of gender diversity on several approaches"
Scholarships in Brazil – Doctorate
Link: https://bv.fapesp.br/en/bolsas/206701/impact-of-gender-diversity-on-several-approaches/

Carlos Roberto Azzoni
"National crises, regional economic cycles and disparities"
Research Grants - Visiting Researcher Grant – International
Link: https://bv.fapesp.br/en/auxilios/112214/national-crises-regional-economic-cycles-and-disparities/

Energia

Degree	Researcher Project Title	Funded researcher	Scholarship period
MSc.	Application of the Auto-LSTM model for solar energy forecasting in photovoltaic power systems. (FAPESP number: 2022/10281-6)	Fernando Vasconde de Arruda	From 01/07/2023 to 31/12/2024
TT4-A	Statistical Downscaling Methods of Climate Projections for Quantifying Solar and Wind Potentials in Brazil (FAPESP number: 2020/15754-4)	Francisco José Lopes de Lima	Concluded
TT4-A	Statistical Downscaling Methods of Climate Projections for Quantifying Solar and Wind Potentials in Brazil (FAPESP number: 2023/13978-0)	Hallan Souza de Jesus	
DTI-A	The impacts of offshore wind power on the stability of the electric system for the present and future climate (CNPq)	Marcelo Pizzuti Pes	Concluded
DTI-B	Data Quality evaluation of environmental quantities used in trend analysis of extreme weather events impacting the electric sector (CNPq)	Guilherme Bággio Martins Machado	Concluded
DTI-A	Strategies to strengthen energy security in highly renewable energy systems considering water stress scenarios (CNPq number: 383635/2023-3)	Paula Conde Santos Borba	From 01/08/2023 to 30/06/2024
PD	Multiple near-optimal solutions for the long-term sustainable energy development (FAPESP number: 2024/02007-7)	Paula Conde Santos Borba	From 01/07/2024 to 31/12/2026

Communication

TT Fapesp
Iniciação científica BAS-Unicamp
Título - Revista ClimaCom - artes, ciências e comunicações diante do Antropoceno
Bolsista - Priscila Cristina Dourado Salvadeo
Orientadora – Susana Dias
Tipo de bolsa: Bolsa BAS Unicamp / Duração - 1 ano / Dedicação - 40 horas / Valor mensal R$ 678,00
Título - Revista ClimaCom - artes, ciências e comunicações diante do Antropoceno
Bolsista - Rayane Barbosa
Orientadora – Susana Dias
Tipo de bolsa: Bolsa BAS Unicamp / Duração - 1 ano / Dedicação - 40 horas / Valor mensal R$ 678,00
Título - Revista ClimaCom - artes, ciências e comunicações diante do Antropoceno
Bolsista - Leo Arantes Lazzerini
Orientadora – Susana Dias
Tipo de bolsa: Bolsa BAS Unicamp / Duração - 1 ano / Dedicação - 40 horas / Valor mensal R$ 678,00
Pós-doutorado
Posdoctorado CONICET- Argentina
Título: Formas audiovisuales del paisaje en la Patagonia argentino-chilena (últimas décadas)

Becario: Maia Gattas Vargas
Co-orientadora: Sandra Murriello
Posdoctorado:CONICET- Argentina
Beca: Posdoctorado CONICET.
Plazo : 2022-2025
Doutorado CNPq
Título - Corpo-solo-vivo: entre linhas de cultivo
Bolsista - Tatiana Plens Oliveira
Orientadores - Wenceslao Machado de Oliveira Júnior e Susana Oliveira Dias
Tipo de bolsa - 2019-2022. Universidade Estadual de Campinas, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior.
Mestrado FAPESP
Título - Comunicação e estudos multiespécies diante do Antropoceno: o caso do sapo cururu.
Bolsista - Natália Aranha de Azevedo
Orientadora - Susana Oliveira Dias
Tipo de bolsa - Mestrado (2023/03090-2), vigência: 01/04/2023 a 29/02/2024. Pós-graduação em Divulgação Científica e Cultural no Laboratório de Estudos Avançados em Jornalismo (Labjor) da Universidade Estadual de Campinas.
Mestrado Capes
Título - A inadequação de uma terra/Terra viva: dimensão do feminino e as práticas diante da intrusão de Gaia
Bolsista - Milena Bachir
Orientadora - Susana Oliveira Dias
Tipo de bolsa - Mestrado (2023/03090-2), vigência: 01/04/2023 a 29/02/2024. Pós-graduação em Divulgação Científica e Cultural no Laboratório de Estudos Avançados em Jornalismo (Labjor) da Universidade Estadual de Campinas.

Disasters

BOLSISTA DE DESENVOLVIMENTO TECNOLÓGICO INDUSTRIAL - DTI – CNPq
PROCESS NUMBER: 380991/2023-3
TITLE: Modelagem da seca urbana: avaliação dos impactos na saúde, abastecimento de água e turismo.
NAME: Lidiane Cristina Oliveira Costa
PERIOD: 01/03/2022 to 02/2025
INSTITUTION: CEMADEN/MCTI

TECHNICAL TRAINING - FAPESP
PROCESS NUMBER: 2023/05950-9
TITLE: Identificação da população vulnerável a desastres nas capitais brasileiras no contexto do sistema de monitoramento e alertas
NAME: Mariane Carvalho de Assis Dias
PERIOD: 01/07/2023 to 30/06/2025
INSTITUTION: CEMADEN/MCTI

POST-DOCTORAL FELLOWSHIP - FAPESP

PROCESS NUMBER: 2023/1517-0 - fapesp
TITLE: Índice de vulnerabilidade de escolas e estudantes no contexto das mudanças climáticas e alertas de desastres
NAME: Viviana Munõz Aguilar
PERIOD: 01/02/2024 to 31/12/2025
INSTITUTION: CEMADEN/MCTI

Health

Vanessa Rendeiro Vieira, PhD, bolsista CNPq
Integridade do Subcomponente
Distribuição Espacial da Leishmaniose Visceral Americana em Associação com Impactos Ambientais, Clima, Desmatamento e sua Expansão nos Estados da Região Sudeste, no Brasil
Simone Miranda da Costa, PhD. colaborador de pesquisa
Integridade do Subcomponente
A importância das "Áreas Sentinela" associadas às mudanças climáticas no contexto da vigilância epidemiológica da Leishmaniose Tegumentar Americana no Brasil.
Margarete Martins Afonso dos Santos, PhD. colaborador de pesquisa
Integridade do subcomponente
Vigilância e Controle da Leishmaniose Visceral Americana no Estado do Rio de Janeiro: distribuição espacial e análise da vulnerabilidade municipal.
Distribuição Espacial da Leishmaniose Visceral Americana em Associação com Impactos Ambientais, Clima, Desmatamento e sua Expansão nos Estados da Região Sudeste, Brasil - Chamada Pública MCTI/CNPQ/CAPES/FAPS Nº 16/2014 - PROGRAMA INCT. Vanessa Rendeiro Vieira
Projeções futuras da distribuição geográfica de *Nyssomyia whitmani*, principal vetor de Leishmaniose Tegumentar Americana (LTA), com foco na Amazônia Legal - Chamada Pública MCTI/CNPQ/CAPES/FAPS Nº 16/2014 - PROGRAMA INCT. Simone Miranda da Costa
Distribuição Espacial da Leishmaniose em Associação com Impactos Ambientais, Clima, Desmatamento e sua Expansão nos Estados da Região Sudeste, no Brasil - FAPERJ, Programa Científico do Nosso Estado - 2020. Elizabeth Ferreira Rangel
Impactos das Mudanças Climáticas e do Desmatamento na Expansão da Leishmaniose no Brasil - Chamada Pública CNPq nº 11/2020 - Bolsas de Produtividade em Pesquisa SENIOR - PQ-Sr 2020. Elizabeth Ferreira Rangel

13. Changes in Personnel

There were changes in the team of the communications component. The new members are:

- Débora Pires Jerônymo – Mestranda, Universidade Federal de São Paulo
- Tatiana Massaro – Dra., Bolsista DTI-A, INCT Mudanças Climáticas fase 2

In the food security component:

Team	Institution
Eduardo Delgado Assad	FGV/GVagro and Cepagri/Unicamp
Jurandir Zullo Junior	Cepagri/Unicamp
Cecilia Fagan	FGV/GVagro
Talita P. Pinto	FGV/GVagro
Cicero Zanetti	FGV/GVagro CNPq scholarship holder)
Eduardo de Moraes Pavão	FGV/GVagro
Camila G. Estevan	FGV/GVagro
Sabrina Carlos Matos	FGV/GVagro

In the disaster's component, exclusion of a researcher in the CEMADEN team: Carolina Galhardo, Carolina Gomes Vergetti Amim

Modelling

Diego de Andrade Campos, Inclusion of the RRTMG radiative scheme in the Eta climate change version and study of radiation-aerosol interactions. October 2022 - February 2025

Resources from the CNPq project led by Paulo Nobre awarded funds from CNPq call for proposals 6/2020 allowed the hiring of one PostDoc researcher to develop the coupling of Eta-MOM6, with the support of members of the INCT-MC2 Modeling component.
Paulo Nobre received a grant from the CNPq/MCTI/BRICS-STI No 04 call for proposals to develop joint research with researchers from the Indian Institute of Tropical Meteorology - IITM in India, and the Chinese Academy of Sciences - CAS, in China, to develop high-resolution earth system modeling aided by Artificial Intelligence algorithms to study the development of extreme climatic events in a warmer world. The project has a scheduled meeting to happen between October 8-13, with the participation of 6 Brazilian, 8 Chinese and 2 Indian researchers, at INPA in Manaus and INPE in São José dos Campos.
The RESM - Eta Model had received grant no.406591/2022-9 from CNPq. This supports generating new downscaling scenarios from BESM and EC-Earth climate models. .

list of students indicating if they are IC, MS or doctoral

Marcely Sondermann, Doctoral Student. Eta Model evaluation in rapid cyclogenesis.

Eliseu Oliveira Afonso, Doctoral Student. The regional climate around the Sobradinho Lake from numerical simulations with the FLake model coupled to the Eta model

João Figueiredo, Doctoral Student. Global Climate Model in eta coordinates

Roberto Baltazar, IC student. Evaluating Eta forecasts driven by BESM.

14. Financial report: Use of the RT and BC (summary)

The Communication component reported these expenses used BC and RT funds in the period:

- Revision of grammar and orthography (English) in a scientific article authored by Renzo Taddei, done by Kay Celter: R$ 499,98.
- Participation of Renzo Taddei in the annual meeting of the American Anthropological Association in Toronto, session on "Anthropology & Climate Change: Transitions".
    - Registration: R$ 1.243,32
    - Air ticket: R$ 7.070,50
    - Travel allowances: R$ 9.759,40
- Payment of two daily travel allowances, for Renzo Romano Taddei (São Paulo-Campinas-São Paulo) and Tatiana Plens Oliveira (Sorocaba-Campinas-Sorocaba), of R$ 285 each, on 19/09/2022, for research activities at Unicamp.
- Purchase of printer tonners: R$ 760,00
- Purchase of office materials: R$ 181,10
- Participation of Renzo Taddei in the annual meeting of the Latin-American Anthropological Association (ALA), in Rosário, session "MR.27: O lugar dos povos tradicionais, de seus conhecimentos e cosmovisões no debate sobre mudanças climáticas."
    - Air ticket: R$ 4.723,29
    - Travel allowances: R$ 9.065,91
- Payment of transcription and revision services to Diogo Campos dos Santos of the text of the book Modos de Habitar o Antropoceno, currently being organized by Renzo

Taddei and colleagues: R$ 1.650,00.
Total: R$ 35.523,50

15 Collaboration with other INCTs, projects and Research networks

This INCT MC2 works very closely with the Rede Clima, the Brazilian Panel on Climate Change PBMC, and the INCLINE program at USP. We are already interacting or plan to interact with these INCTs and projects due to common interests and collaboration:

Process 465680/2014-3
INCT da Criosfera
Coordinator: Jefferson Cardia Simões
UFRGS - Universidade Federal do Rio Grande do Sul

Process 465764 / 2014-2
INCT-Observatório Nacionalidade da Dinâmica da Água e do Carbono no Bioma Caatinga
Coordinator: Antônio Celso Antonino
UFPE-Universidade Federal de Pernambuco

Process: 465319/2014-9
INCT do Bioetanol
Coordinator: Marcos Silveira Buckeridge
USP - Universidade de São Paulo

Process: 2015/03804-9
INCT MacroAmb-Environmental Governance in São Paulo Macro Metropolis in a climate variability context
Coordinator: Pedro R. Jacobi
USP - Universidade de São Paulo

Process - CNPq nº 58/2022 (Novo INCT)
INCT Observatório Nacional de Segurança Hídrica e Gestão Adaptativa-ONSEAdapta, Coordinator: Suzana Montenegro
UFPE

UK-CSSP Climate Service Science Project
Newton Fund UK
CEMADEN, INPE, INPA, UKMO

RED-CLIMA (Red Española e Iberoamericana sobre Variabilidad Climática y Servicios Climáticos en Ecosistemas Terrestres y Marinos) Project, under Grant INCCLO0023 from the Consejo Superior de Investigaciones Científicas LINCGLOBAL CSIC from Spain.

Pantanal Research Network MCTI (Rede de Pesquisas do Pantanal do MCTI)

The project “Companion plants: herbs and rites of the Jongo Dito Ribeiro community”, coordinated by Susana Dias, won the Art and Culture award - DCULT Unicamp in the amount of R$ 14,000.00 to produce a collective book-object.

The “Tierra” project, coordinated by Susana Oliveira Dias, won the Preac-Unicamp tender worth R$20,000.00 to produce the “Tierra” exhibition at Galeria Gaia at Unicamp and 200 units of the exhibition catalog.

The project “Revista ClimaCom - arts, sciences and communications in the face of the Anthropocene”, under the coordination of Susana Dias, was approved granting 3 scientific initiation scholarships from Unicamp's SAE from 03/01/2023 to 02/28/2025.

The project “Agroecological Holidays ‘Km. 0’”, coordinated by Gabriela Aloras, was approved in the call for Puntos de Cultura in Argentina.

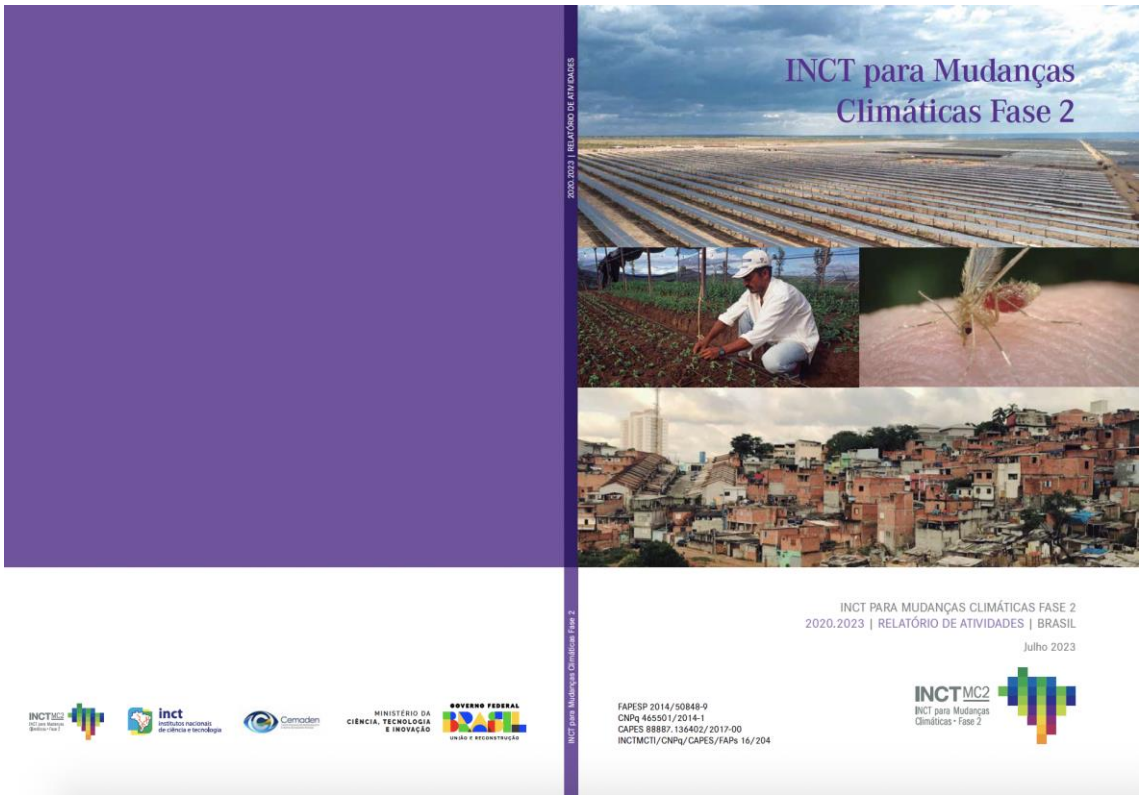
Pesticides, toxicological classification, color bands and communication: Social mapping of effects on health in contexts of conventional horticultural production in Florencio Varela and La Plata. Type of Project: UNAJ Investiga 2023-Modalidad 1-Type A. Director: GARCIA, Daniela and Codirector: MENEGAZ, Adriana

INCT ONSEAdapta - National Observatory on Water Security and Adaptive Management (406919/2022-4):

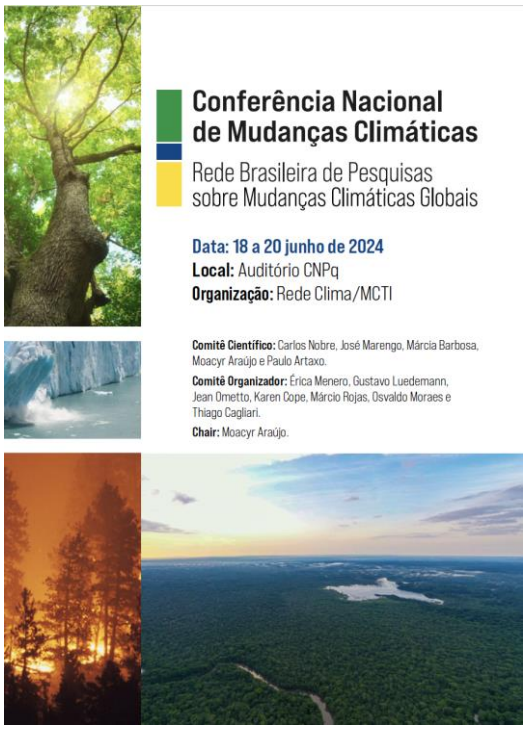
National Observatory on Water Security and Adaptive Management (ONSEADAdapta) is an interdisciplinary network of national and international researchers who develop research on different topics related to the central theme. It is a subject that requires great knowledge integration and an integrated, systemic, and transdisciplinary vision. The INCT aims to combine the efforts to conduct long-term research on different scales, systematize the generated knowledge, train human resources, and subsidize the formulation of public policies. This initiative is pioneering and essential for the different regions, their problems, and the country.

Annexes

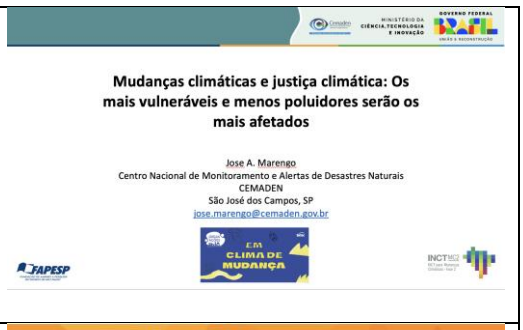
Second INCT MC2 Report 2020-2023



Conferencia Internacional da Rede Clima



Presentations of the INCT MC2 at meetings and conferences (presential and virtual)




Eldorado Brasil
SAVE THE DATE
23 Fevereiro 2024 | 8h30
Como será o Clima em 2024?
Melhores Previsões e Eventos Extremos na Região de Atuação da Eldorado
PALESTRANTES
MSc. NADIARA PEREIRA – Meteorologista da Climatempo
Palestra: Tendência Climática com retorno de La Niña em 2024
Dr. JOSÉ MARENGO – Coordenador Geral de P&D do CEMADEN
Palestra: Eventos Climáticos extremos na região de atuação da Eldorado devem se acentuar em 2024?
MEDIADORA
Vágna Pereira – Especialista em Ecofisiologia e Meteorologia Florestal – Eldorado Brasil


Cidades e águas urbanas
Dia 03 de maio de 2024 19h30 (horário de Brasília)
Suzana Montenegro
Carlos Tucci
YouTube


tve
GIRO NORDESTE
JOSÉ MARENGO
COORDENADOR DE PESQUISA CEMADEN E CLIMATOLOGISTA
TERÇA 19:00
Na TVE, redes sociais e www.tve.ba.gov.br
/TVEBAHIA
/TVEBAHIA
/TVEBAHIA
/TVEBAHIA

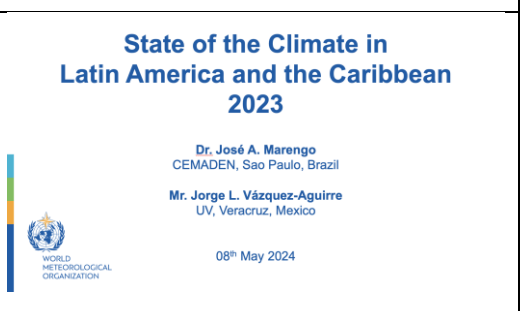

Efeitos do El Niño na América do Sul e Brasil
Jose A. Marengo
CEMADEN/MCTI
São José dos Campos, SP, Brasil
www.cemaden.gov.br
jose.marengo@cemaden,gov.br
Unifal


II WEBINÁRIO
PRODUTOS DO CEMADEN / MCTI PARA O MONITORAMENTO GEO-HIDRO-METEOROLÓGICO NO BRASIL
MONITORAMENTO DE SECAS E RISCO DE FOGO
Abertura
Regina Alvalá
Diretora Substituta
José Marengo
Coordenador-geral de Pesquisa e Desenvolvimento
Alan Pimentel
Pesquisador colaborador
Moderador
Ana Cunha
Sistema de Monitoramento de Secas do Cemaden e Avaliação de Impactos
Marcelo Zeri
Indicadores de Secas desenvolvidos no CEMADEN Definições e Aplicações
Adriana Cuartas
Monitoramento e Previsão de Seca Hidrológica
Liana Anderson
Concepção do produto de probabilidade de fogo
13/11/2023
14h00 Horário de Brasília
Acompanhe pelo YouTube
reuniaodeimpactoscemaden


Profa. Danielle Bressiani
UFPel
Instrutora
ABRHidro 45 anos
Associação Brasileira de Recursos Hídricos
Comissão de Educação
ONSEAdapta
CONVITE:
Curso de Capacitação Acadêmica:
"Modelo SWAT para Segurança Hídrica e Gestão Adaptativa"
Vagas Limitadas
Informações e Inscrições :
29-31/05/2023, 14-17h
Presencial: USP São Carlos
Remoto Online: Instruções
Realização e Apoio:
FAPESP
CAPES
CNPq
@TheWadiLab


"MODELING CLIMATE CHANGE: AN OVERVIEW OF THE CRISIS AND RECONSTRUCTION PLANS IN SOUTHERN BRAZIL"
join the Zoom meeting
MAY 24, 2024 - 3PM UK / 11AM BR
PANELISTS:
Márcia Barbosa
Federal University of Rio Grande do Sul, Brazil
Moderator: Carolina Brito
Federal University of Rio Grande do Sul, Brazil
Rob Chadwick
Met Office, UK
Andrew Hartley
Met Office, UK
José Marengo
National Centre for Monitoring and Early Warning of Natural Disasters, Brazil
University of Exeter
UFRGS
Cemaden
Environmental Intelligence

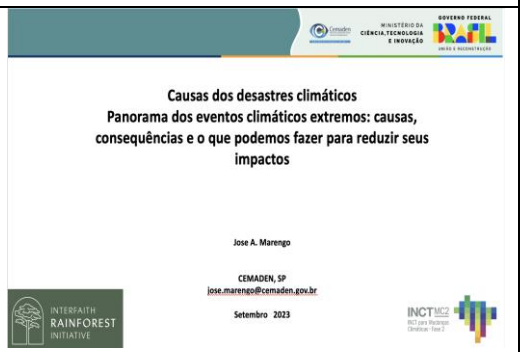

CONFERÊNCIA NACIONAL DE 5ª CT&I
Conferências Livres da 5a. CNCTI
Eventos Extremos no Contexto de Monitoramento e Alertas de Desastres: Estratégias em C&T para o Brasil
11/04/24 - 09h às 17h
PROGRAMAÇÃO


State of the Climate in Latin America and the Caribbean 2023
Dr. José A. Marengo
CEMADEN, Sao Paulo, Brazil
Mr. Jorge L. Vázquez-Aguirre
UV, Veracruz, Mexico
08th May 2024
WORLD METEOROLOGICAL ORGANIZATION

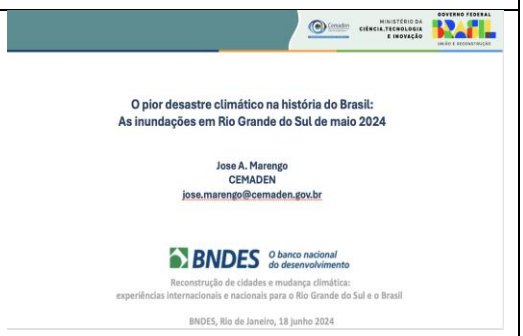

EXTREMES OF HYDROMETEOROLOGY AND DRY SEASON LENGTH IN AMAZONIA ASSOCIATED WITH THE DROUGHT OF 2023
Jose A. Marengo, Rong Fu, Ana P. Cunha, Jhan C. Espinoza, Jochen Shongart, Juan C. Jimenez-Muñoz, Mabel Costa
CEMADEN/MCTI, IRD-PUCP UV, INPA, UCLA
2024
UKMO, University of Exeter
January 28-Februay 3 2024


PARA UM BRASIL JUSTO, SUSTENTÁVEL E DESENVOLVIDO
5ª CONFERÊNCIA NACIONAL DE CT&I
Sessão 1:
El Niño/La Niña e Desastres no Brasil
Risco de Desastres no Brasil: El Niño como deflagrador
Jose A. Marengo
CEMADEN/São Paulo, Brasil
jose.marengo@cemaden.gov.br
São Paulo, 11 Abril 2024


Conferência Nacional de Mudanças Climáticas
Rede Brasileira de Pesquisas sobre Mudanças Climáticas Globais
Ministério da Ciência, Tecnologia e Inovações
AVALIAÇÃO À VULNERABILIDADE E MEDIDAS DE ADAPTAÇÃO-4CN
Jose A. Marengo
CEMADEN


Causas dos desastres climáticos
Panorama dos eventos climáticos extremos: causas, consequências e o que podemos fazer para reduzir seus impactos
Jose A. Marengo
CEMADEN, SP
jose.marengo@cemaden.gov.br
Setembro 2023
INTERFAITH RAINFOREST INITIATIVE

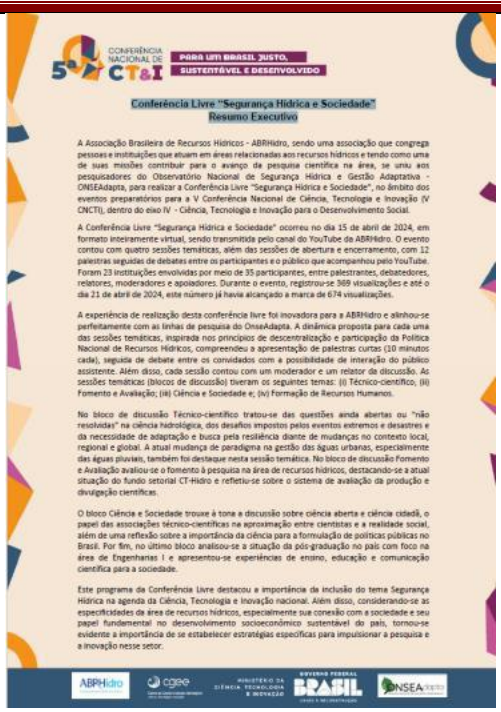

CBN na Rede
Dr. José Marengo - Climatologista
Marcelo Rocha
CBN (12) 99603 5234


O pior desastre climático na história do Brasil:
As inundações em Rio Grande do Sul de maio 2024
Jose A. Marengo
CEMADEN
jose.marengo@cemaden.gov.br
BNDES O banco nacional do desenvolvimento
Reconstrução de cidades e mudança climática:
experiências internacionais e nacionais para o Rio Grande do Sul e o Brasil
BNDES, Rio de Janeiro, 18 junho 2024


CONPEMET
II CONGRESO PERUANO DE METEOROLOGÍA
LA MOLINA
Estrategias de adaptación al cambio climático en Brasil en el contexto Sudamericano
Jose A. Marengo
CEMADEN
São Paulo, Brasil
Junio 2024


Entrevista com Eduardo Mendiondo I Diana Zatz


Apac
1:00 / 5:34
Entrevista com Suzana Montenegro I Diana Zatz


CONFERÊNCIA NACIONAL DE CT&I
PARA UM BRASIL JUSTO, SUSTENTÁVEL E DESENVOLVIDO
Conferência Livre "Segurança Hídrica e Sociedade"
Resumo Executivo
A Associação Brasileira de Recursos Hídricos - ABRHidro, sendo uma associação que congrega pessoas e instituições que atuam em áreas relacionadas aos recursos hídricos e tendo como uma de suas missões contribuir para o avanço da pesquisa científica na área, se uniu aos pesquisadores do Observatório Nacional de Segurança Hídrica e Gestão Adaptativa - ONSEAdapta, para realizar a Conferência Livre "Segurança Hídrica e Sociedade", no âmbito dos eventos preparatórios para a V Conferência Nacional de Ciência, Tecnologia e Inovação (V CNCTI), dentro do eixo IV - Ciência, Tecnologia e Inovação para o Desenvolvimento Social.
A Conferência Livre "Segurança Hídrica e Sociedade" ocorreu no dia 15 de abril de 2024, em formato inteiramente virtual, sendo transmitida pelo canal do YouTube da ABRHidro. O evento contou com quatro sessões temáticas, além das sessões de abertura e encerramento, com 12 palestras seguidas de debates entre os participantes e o público que acompanhou pelo YouTube. Foram 23 instituições envolvidas por meio de 35 participantes, entre palestrantes, debatedores, relatores, moderadores e apoiadores. Durante o evento, registrou-se 369 visualizações e até o dia 21 de abril de 2024, este número já havia alcançado a marca de 674 visualizações.
A experiência de realização desta conferência livre foi inovadora para a ABRHidro e alinhou-se perfeitamente com as linhas de pesquisa do OnseAdapta. A dinâmica proposta para cada uma das sessões temáticas, inspirada nos princípios de descentralização e participação da Política Nacional de Recursos Hídricos, compreendeu a apresentação de palestras curtas (10 minutos cada), seguida de debate entre os convidados com a possibilidade de interação do público assistente. Além disso, cada sessão contou com um moderador e um relator da discussão. As sessões temáticas (blocos de discussão) tiveram os seguintes temas: (i) Técnico-científico, (ii) Fomento e Avaliação; (iii) Ciência e Sociedade e; (iv) Formação de Recursos Humanos.
No bloco de discussão Técnico-científico tratou-se das questões ainda abertas ou "não resolvidas" na ciência hidrológica, dos desafios impostos pelos eventos extremos e desastres e da necessidade de adaptação e busca pela resiliência diante de mudanças no contexto local, regional e global. A atual mudança de paradigma na gestão das águas urbanas, especialmente das águas pluviais, também foi destaque nesta sessão temática. No bloco de discussão Fomento e Avaliação avaliou-se o fomento à pesquisa na área de recursos hídricos, destacando-se a atual situação do fundo setorial CT-Hidro e refletiu-se sobre o sistema de avaliação da produção e divulgação científicas.
O bloco Ciência e Sociedade trouxe à tona a discussão sobre ciência aberta e ciência cidadã, o papel das associações técnico-científicas na aproximação entre cientistas e a realidade social, além de uma reflexão sobre a importância da ciência para a formulação de políticas públicas no Brasil. Por fim, no último bloco analisou-se a situação da pós-graduação no país com foco na área de Engenharias I e apresentou-se experiências de ensino, educação e comunicação científica para a sociedade.
Este programa da Conferência Livre destacou a importância da inclusão do tema Segurança Hídrica na agenda da Ciência, Tecnologia e Inovação nacional. Além disso, considerando-se as especificidades da área de recursos hídricos, especialmente sua conexão com a sociedade e seu papel fundamental no desenvolvimento socioeconômico sustentável do país, tornou-se evidente a importância de se estabelecer estratégias específicas para impulsionar a pesquisa e a inovação nesse setor.
ABRHidro
cgee
BRASIL
ONSEA


IOC
Instituto Oswaldo Cruz
Informes do IOC
IMPACTOS DAS MUDANÇAS CLIMÁTICAS NA SAÚDE HUMANA
Elizabeth Ferreira Rangel
EVENTO NA FGV
DIAS
14 a 16/9/2023
20 de setembro de 2023
IOC
Instituto Oswaldo Cruz
Ministério da Saúde
BRASIL

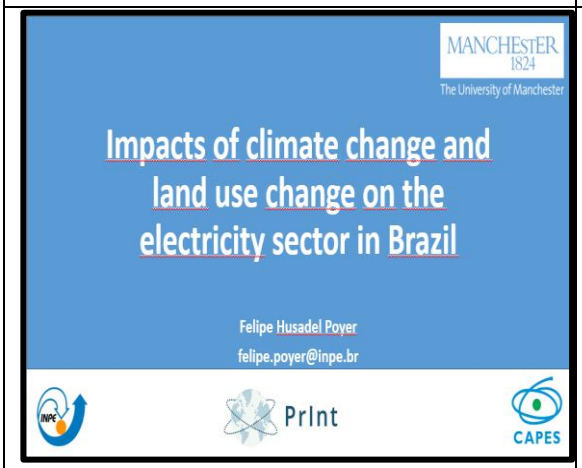

CLIMATE &
HEALTH 2023
OCT 21-22, 20
Zucker School of Medicin
Hofstra/Northwell • Hempst
www.climatehealth2023.


Impacto das Mudanças Climáticas na Geração de Energia Solar: Uma Análise Multimodelo Utilizando CMIP6
Francisco José Lopes de Lima
André Rodrigues Gonçalves
Rodrigo Santos Costa
Enio Bueno Pereira
Fernando Ramos Martins
UNIFESP

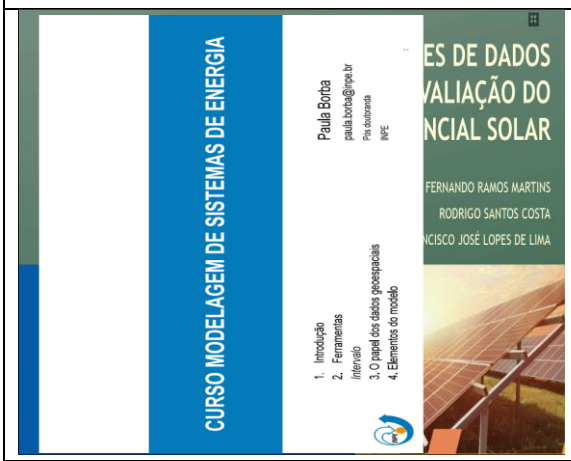

Energia solar fotovoltaica combinada com hidrogênio verde: uma estratégia para redução das emissões e da vulnerabilidade na Amazônia
Meiriele Alvarenga Cumplido
André Rodrigues Gonçalves
Enio Bueno Pereira
Ricardo Rüther (UFSC/Fotovoltaica)
LABREN


X CONGRESSO BRASILEIRO DE ENERGIA SOLAR • 2024
27 A 31 DE MAIO • NATAL • RN
TRANSIÇÃO ENERGÉTICA PARA A SUSTENTABILIDADE NO BRASIL: NARRATIVAS E IMAGINÁRIOS DOS STAKEHOLDERS
Bruno Eduardo Baptista Rodrigues Torres[1]
Jean Carlos Hochsprung Miguel[2]
Fernando Ramos Martins[1]
[1]Instituto do Mar - Universidade Federal de São Paulo, Campus Baixada Santista
[2] Universidade Estadual de Campinas


IMPACTOS DE EVENTOS EXTREMOS NA PREVISÃO DO RECURSO SOLAR
FERNANDO RAMOS MARTINS
X CONGRESSO BRASILEIRO DE ENERGIA SOLAR • 2024


MANCHESTER 1824
The University of Manchester
Impacts of climate change and land use change on the electricity sector in Brazil
Felipe Husadel Poyer
felipe.poyer@inpe.br
PrInt
CAPES

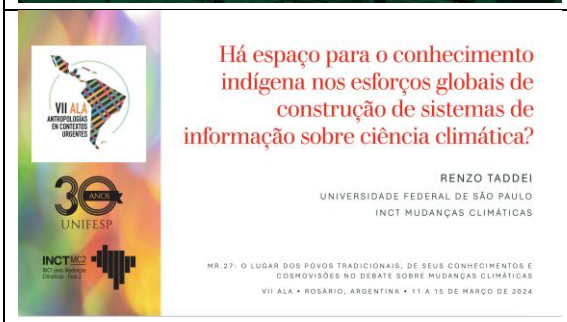

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS
Descarbonização de Sistemas Isolados na Amazônia: uma análise prospectiva para uso do hidrogênio verde
Meiriele Alvarenga Cumplido
Orientadores:
Enio Bueno Pereira(INPE) e
Ricardo Rüther (UFSC)

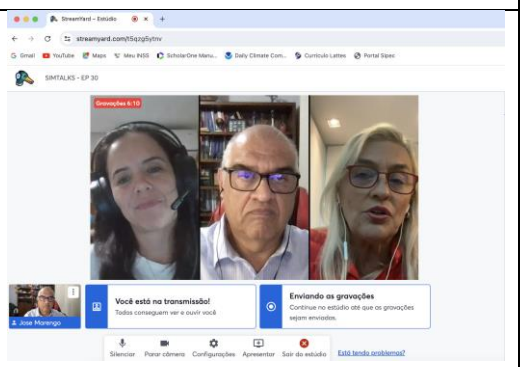

CURSO MODELAGEM DE SISTEMAS DE ENERGIA
Paula Borba
paula.borba@inpe.br
Pós doutoranda
INPE
1. Introdução
2. Ferramentas
Intervalo
3. O papel dos dados geoespaciais
4. Elementos do modelo
ES DE DADOS
VALIAÇÃO DO
NCIAL SOLAR
FERNANDO RAMOS MARTINS
RODRIGO SANTOS COSTA
NCISCO JOSÉ LOPES DE LIMA

O MAIOR DESASTRE CLIMÁTICO DO BRASIL: CHUVAS E INUNDAÇÕES NO ESTADO DO RIO GRANDE DO SUL EM ABRIL-MAIO 2024

José Marengo e todo o CEMADEN

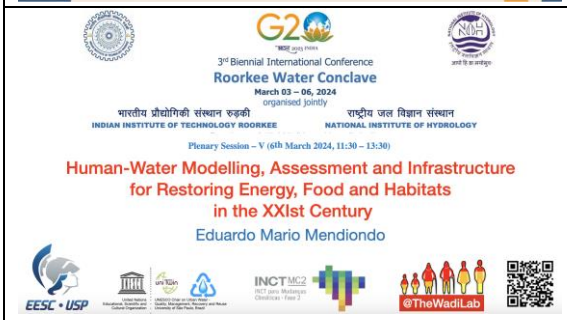
Julho 2, 2024

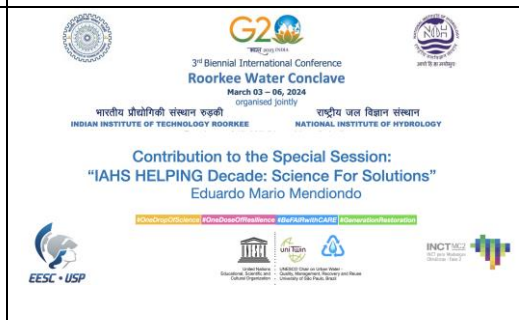


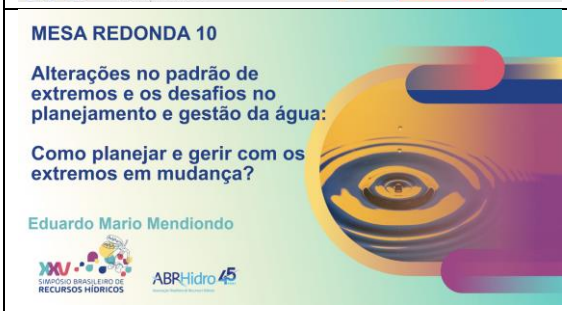



5ª
CONFERÊNCIA NACIONAL DE
CT&I
PARA UM BRASIL JUSTO, SUSTENTÁVEL E DESENVOLVIDO
Conferência Livre Segurança Hídrica e Sociedade
Abertura
ONSEAdapta
ABRHidro
cgee
GOVERNO FEDERAL
BRASIL


EGU General Assembly
Oral | Thursday, 18 Apr, 14:55–15:05 (CEST) Room 2.31
On promoting education and community adaptation in Global South's studies populating the Digital Water Globe: the DREAMS project for the HELPING Science Decade
EESC • USP
@TheWadiLab


G20
3rd Biennial International Conference
Roorkee Water Conclave
March 03 – 06, 2024
organised jointly
भारतीय प्रौद्योगिकी संस्थान रुड़की
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
राष्ट्रीय जल विज्ञान संस्थान
NATIONAL INSTITUTE OF HYDROLOGY
Plenary Session – V (6th March 2024, 11:30 – 13:30)
Human-Water Modelling, Assessment and Infrastructure for Restoring Energy, Food and Habitats in the XXIst Century
Eduardo Mario Mendiondo
EESC • USP
INCT MC2
@TheWadiLab


G20
3rd Biennial International Conference
Roorkee Water Conclave
March 03 – 06, 2024
organised jointly
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
NATIONAL INSTITUTE OF HYDROLOGY
Contribution to the Special Session:
"IAHS HELPING Decade: Science For Solutions"
Eduardo Mario Mendiondo
EESC • USP
INCT MC2


MESA REDONDA 10
Alterações no padrão de extremos e os desafios no planejamento e gestão da água:
Como planejar e gerir com os extremos em mudança?
Eduardo Mario Mendiondo
SIMPÓSIO BRASILEIRO DE RECURSOS HÍDRICOS
ABRHidro 45


XI WMCRHPE | VIII WISMCB
Ciência, Sustentabilidade e Solidariedade
Recife, PE, Brasil, 25 a 27 de outubro de 2023
Mudanças globais e adaptações sustentáveis com viabilidade hidro-energética e solvência econômica
Eduardo Mario Mendiondo
EESC • USP
ONSEAdapta
INCT MC2
@TheWadiLab


Mesa-redonda: Recursos Hídricos
Alguns dos principais desafios científicos e tecnológicos para garantirmos segurança hídrica no cenário de aquecimento global acelerado?
E. Mario Mendiondo, Escola de Engenharia de São Carlos, Universidade de São Paulo
INCT MC2


INCT MC2
INCT para Mudanças Climáticas - Fase 2
ESOCITE.LA
CAMPINAS BRASIL 2024
Práticas Artísticas e Tecnociências no Antropoceno
Profa. Dra. Marina Souza Lobo Guzzo


Scientific colloquium
3 June 2024, Room X
Hybrid mode from UNESCO HQ, Paris
Join the meeting via Zoom here
50 years of Evolution of Science of Hydrology:
From Science to Application and Way Forward
"Coalignment of Legacies"
Co-creation of Water Knowledge for Transboundary Cooperation
Eduardo Mario Mendiondo
IAHS Digital Water Globe
@TheWadiLab


Ciencias del Agua para la Paz
y el Desarrollo en América
Latina y el Caribe
en el marco de las celebraciones del
Día Mundial de la Ciencia para la
Paz y el Desarrollo
10 de Noviembre 2023
Ciencias del Agua para el Desarrollo
Eduardo Mario Mendiondo
Waters for Our World
#OnlyOneEarth
#OneDropOfScience
#OneDoseOfResilience
#ScienceForPeace
@TheWadiLab


SEGUNDO TALLER DEL PROCESO
REGIONAL DE LAS AMÉRICAS
10° FORO MUNDIAL DEL AGUA
FORMACIÓN DE
CAPACIDADES
Sr. Eduardo
Mendiondo
Sra. Virginia
Barbancho
Sra. Lucía
Samaniego
Sra. Marta
París
OLAS
BID
OEA
CONAGUA


Cidadãos Resilientes
Apoiados em C&T&I
do Saneamento
em Tempos de Mudança
Eduardo Mario Mendiondo
27 de outubro
Prefeitura de
SÃO CARLOS
@TheWadiLab


1ª CONFERÊNCIA
CIÊNCIA,
TECNOLOGIA
e INOVAÇÃO
16 a 27 de outubro
PROGRAMAÇÃO NA CIDADE
CNPq
Prefeitura de
SÃO CARLOS
Cidadãos Resilientes
Apoiados em C&T&I
do Saneamento
em Tempos de Mudança
Eduardo Mario Mendiondo


Scientific colloquium
3 June 2024, Room X
Hybrid mode from UNESCO HQ, Paris
Join the meeting via Zoom here
50 years of Evolution of Science of Hydrology:
From Science to Application and Way Forward
"Coalignment of Legacies"
Co-creation of Water Knowledge for Transboundary Cooperation
Eduardo Mario Mendiondo
IAHS Digital Water Globe
@TheWadiLab

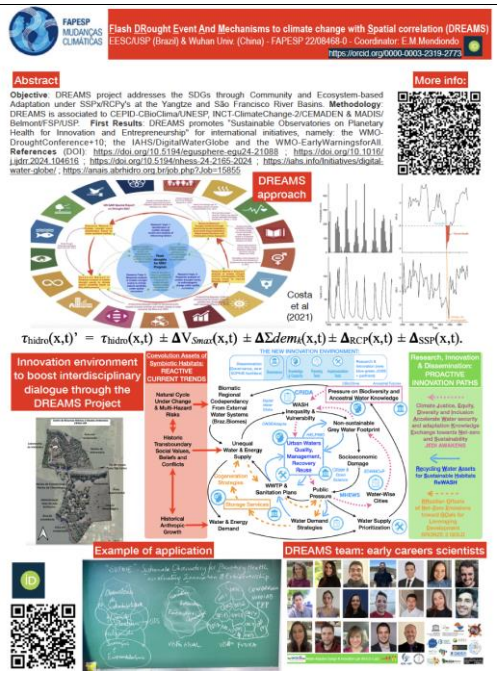

Taller Regional sobre Calidad de las Masas de Agua,
Gestión de vertidos y Valorización de las Aguas Residuales
30 octubre – 1 de noviembre 2023, Montevideo, Uruguay
El valor comparativo del reuso y reutilización de aguas residuales tratadas:
Una visión desde la aversión a los riesgos de los cambios globales
EESC • USP
Eduardo Mario Mendiondo


Cemaden
Ministério da Ciência,
Tecnologia e
Inovações
GOVERNO FEDERAL
BRASIL
Panorama Atual Sobre as Mudanças
Climáticas e Projeções Climáticas e seus
Impactos no Setor Elétrico Brasileiro
Jose A. Marengo
CEMADEN
Agosto 15 2024
INCT MC2
O Futuro do Setor
Elétrico-Energético
Brasileiro

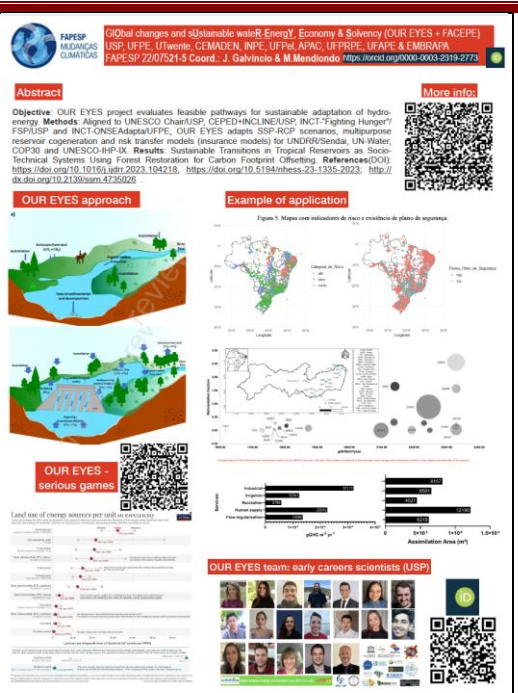
ATUAÇÃO DO CEMADEN DIANTE DO DESASTRE NO ESTADO DO RIO GRANDE DO SUL EM ABRIL-MAIO 2024

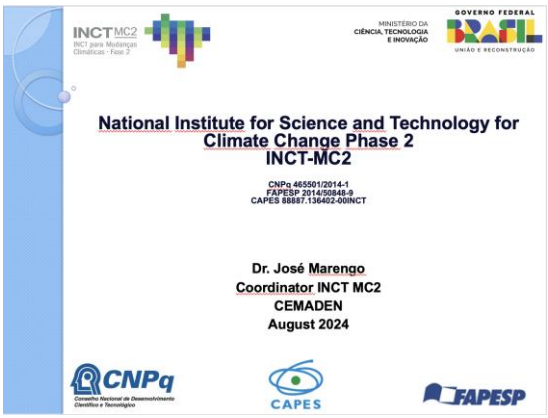
José Marengo e todo o CEMADEN

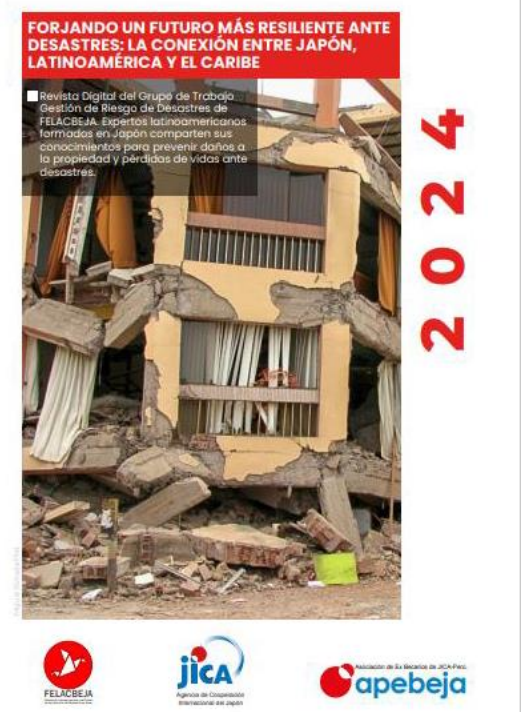
Julho 2, 2024




1ª CONFERÊNCIA
CIÊNCIA, TECNOLOGIA e INOVAÇÃO
16 a 27 de outubro
PROGRAMAÇÃO NA CIDADE
Prefeitura de SÃO CARLOS
Cidadãos Resilientes
Apoiados em C&T&I
do Saneamento
em Tempos de Mudança
Eduardo Mario Mendiondo
EESC • USP
@TheWadiLab


GlObal changes and sUstainable wateR EnergY, Economy & Solvency (OUR EYES + FACEPE)
USP, UFPE, UTwente, CEMADEN, INPE, UFPel, APAC, UFPRPE, UFAPE & EMBRAPA
FAPESP 22/07521-5 Coord.: J. Galvincio & M.Mendiondo https://orcid.org/0000-0003-2319-2773
Abstract
More info:
OUR EYES approach
Example of application
OUR EYES - serious games
OUR EYES team: early careers scientists (USP)


INCT MC2
INCT para Mudanças Climáticas - Fase 2
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO
National Institute for Science and Technology for Climate Change Phase 2
INCT-MC2
CNPq 465501/2014-1
FAPESP 2014/50848-9
CAPES 88887.136402-00INCT
Dr. José Marengo
Coordinator INCT MC2
CEMADEN
August 2024
CNPq
CAPES
FAPESP


FORJANDO UN FUTURO MÁS RESILIENTE ANTE DESASTRES: LA CONEXIÓN ENTRE JAPÓN, LATINOAMÉRICA Y EL CARIBE
Revista Digital del Grupo de Trabajo Gestión de Riesgo de Desastres de FELACBEJA. Expertos latinoamericanos formados en Japón comparten sus conocimientos para prevenir daños a la propiedad y pérdidas de vidas ante desastres.
2024
FELACBEJA
JICA
apebeja

Archives of Health, Curitiba, v.X, n.X, p.XXX-XXX, 202X. ISSN 2675-4711

Using geoprocessing techniques to analyze the geographic distribution of *Nyssomyia whitmani* (Diptera: Psychodidae: Phlebotominae) associated with vegetation cover, and the impacts on the expansion of American Cutaneous Leishmaniasis (ACL) in Brazil

DOI: 10.46919/archvXnX-

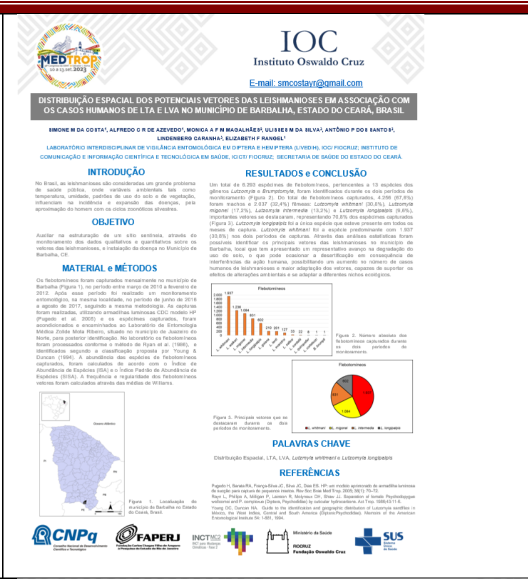
Originals received: 01/29/2024
Acceptance for publication: 02/21/2024

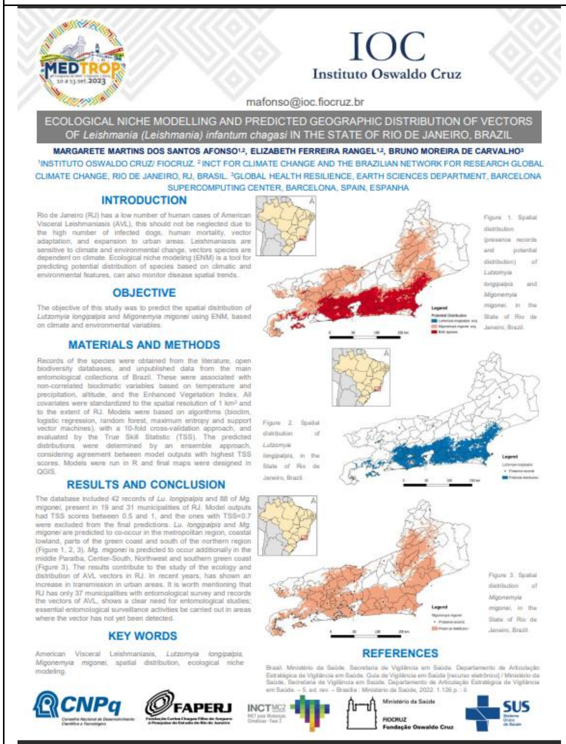
Simone Miranda da Costa
Doctor of Biodiversity and Healt, Instituto Oswaldo Cruz, FIOCRUZ
Institution: Instituto Oswaldo Cruz, FIOCRUZ
Institutional address: Av. Brasil, 4365 – Manguinhos, Rio de Janeiro, Brazil
E-mail: smcostayr@gmail.com

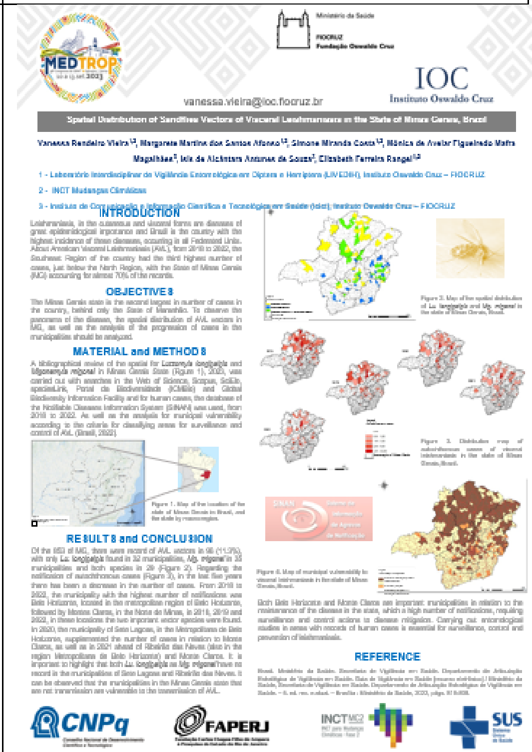
Monica de Avelar Figueiredo Mafra Magalhães
Doctor of Public Health, Universidade Federal do Rio de Janeiro, UFRJ
Instituto de Comunicação e Informação Científica e Tecnológica em Saúde, ICICT, Fiocruz
Av. Brasil, 4365 – Manguinhos, Rio de Janeiro, Brazil
E-mail: monica.avelar.magalhaes@gmail.com

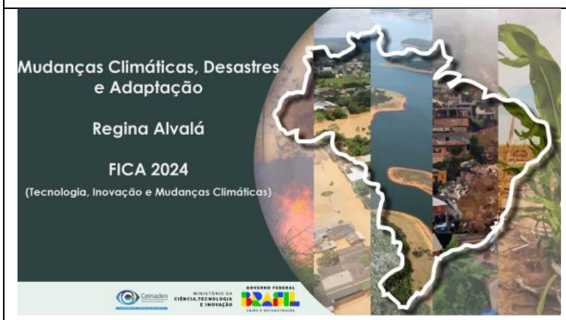
Renata de Saldanha da Gama Gracie Carrijo
Doctor of Public Health, Instituto de Estudos de Saúde Coletiva
Instituto de Comunicação e Informação Científica e Tecnológica em Saúde, ICICT, Fiocruz
Av. Brasil, 4365 – Manguinhos, Rio de Janeiro, Brazil
E-mail: gracierenata@gmail.com

Elizabeth Ferreira Rangel
Doctor of Zoology, Universidade de São Paulo, USP
Institution: Instituto Oswaldo Cruz, FIOCRUZ
Institutional address: Av. Brasil, 4365 – Manguinhos, Rio de Janeiro, Brazil
E-mail: efrangel@ioc.fiocruz.br



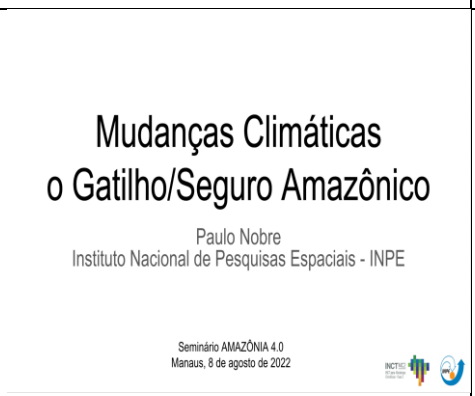


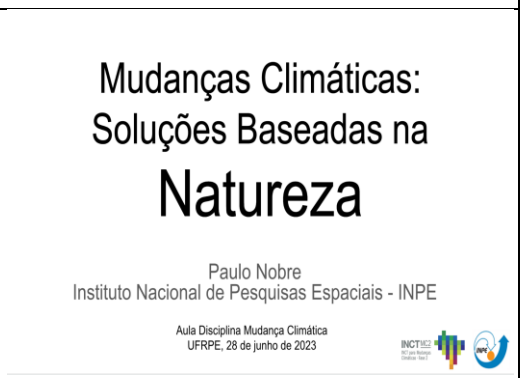





Relação entre as mudanças climáticas e a ocorrência dos desastres
Regina Alvalá
Câmara dos Deputados
14 de maio 2024


Mudanças Climáticas, Desastres e Adaptação
Regina Alvalá
FICA 2024
(Tecnologia, Inovação e Mudanças Climáticas)


Mudanças Climáticas
o Gatilho/Seguro Amazônico
Paulo Nobre
Instituto Nacional de Pesquisas Espaciais - INPE
Seminário AMAZÔNIA 4.0
Manaus, 8 de agosto de 2022


Mudanças Climáticas:
Soluções Baseadas na
Natureza
Paulo Nobre
Instituto Nacional de Pesquisas Espaciais - INPE
Aula Disciplina Mudança Climática
UFRPE, 28 de junho de 2023


WORKSHOP
PROJETO FAPESP - FAPEAM
FAPESP
FAPEAM
Sistema de Previsão de Secas e Enchentes para a Bacia do Rio Madeira
Manaus, 18-19 de junho de 2024.
PREVISÃO CLIMÁTICA SAZONAL e
PROJEÇÕES DE MUDANÇAS CLIMÁTICAS:
SUBSÍDIO AO PLANEJAMENTO A CURTO PRAZO (meses a frente) E A LONGO PRAZO (décadas a frente)
Chou Sin Chan
chou.chan@inpe.br


AESABESP
Webinar AESABESP
Mês do Meio Ambiente
25 de junho de 2024
Modelagem Numérica do Sistema Terrestre,
Impacto, vulnerabilidade e adaptação das cidades às mudanças climáticas
Chou Sin Chan
chou.chan@inpe.br


PROJEÇÕES DE MUDANÇAS CLIMÁTICAS NO BRASIL
Chou Sin Chan
INPE
chou.chan@inpe.br
UFSCar, Pós-Graduação em Ecologia e Recursos Naturais
ONLINE, 05 de junho de 2024
Disciplina Conservação da Biodiversidade
Prof. Augusto Piratelli


XIECOBRJ
INTEGRAÇÃO PELAS ÁGUAS:
Governança, Planos e Territórios
FGV, 17 de abril de 2024, 13:00 h – 17:00 h
Oficina
Considerando informações climáticas no planejamento da gestão hídrica na RMRJ
Chou Sin Chan
INPE
chou.chan@inpe.br
FÓRUM FLUMINENSE
DE COMITÊS DE BACIAS HIDROGRÁFICAS


Mesa 6: Variabilidade e Mudanças Climáticas na escala sazonal a milênios
Aracaju, 21/11/2023
Simulações de mudanças climáticas
&
Previsões climáticas de chuva para a próxima estação
Chou Sin Chan
chou.chan@inpe.br
Instituto Nacional de Pesquisas Espaciais (INPE)
Ministério da Ciência, Tecnologia e Inovações
SIMPÓSIO BRASILEIRO DE RECURSOS HÍDRICOS
ABRHidro 45


ACADEMIA BRASILEIRA DE CIÊNCIAS
SBPC
Sociedade Brasileira para o Progresso da Ciência
Educação e Ciência sempre
Cemaden
Mesa-redonda: Crise climática e El Niño
Projeções em alta resolução da chuva durante eventos de El Niño em cenários de mudanças climáticas globais
Chou Sin Chan
chou.chan@inpe.br
Instituto Nacional de Pesquisas Espaciais
Ministério da Ciência, Tecnologia e Inovações


Cemaden
5TA
CONFERENCIA INTERNACIONAL SOBRE EL NIÑO OSCILACIÓN DEL SUR (ENOS)
O DESASTRE CLIMATICO NO ESTADO DO RIO GRANDE DO SUL EM ABRIL-MAIO 2024
Jose A. Marengo
CEMADEN/MCTI
São Paulo, Brasil
GESTIONANDO EL RIESGO Y CONSTRUYENDO RESILIENCIA PARA LA VARIABILIDAD CLIMÁTICA


Sessão de Debates Temáticos para "Discutir os incêndios florestais e mudanças climáticas
Jose A. Marengo
CGPDE-CEMADEN
Senado Federal-Brasília
25 Setembro 2024

Reports, meetings, interviews, pod casts, and press communications where results of the INCT MC2 were mentioned

MÍRIAM LEITÃO

blogs.oglobo.globo.com/miriam-leitao
miriamleitao@oglobo.com.br
Com Ana Carolina Diniz

O que Porto Alegre ensina para Belém

O cientista José Marengo do Cemaden, Centro de Monitoramento e Alertas de Desastres Naturais, usa uma expressão forte para explicar o que está acontecendo agora no clima, após o aquecimento simultâneo do Pacífico e do Atlântico. "A América Latina está como num sanduíche entre dois oceanos quentes". É o retrato do tempo atual que tem provocado a inundação tão prolongada do Rio Grande do Sul. Marengo acha que a situação no território gaúcho deve durar um mês ainda para se normalizar e, depois, o clima pode ir para o extremo oposto. "Da enchente para a seca".

— O clima no Sul é meio radical, pode-se ter um ano muito úmido e depois um muito seco. Sabemos que La Niña está se configurando e isso deve aparecer em agosto e poderemos dizer se será intensa. Se for intensa haverá uma situação de estiagem. O Sul pode sair de um período de enchente para o oposto, a estiagem, a seca.

As chuvas no Rio Grande do Sul, que começaram a cair pesadamente em 30 de abril, foram previstas no dia 26 de abril. Ele lembra que o pior foi até o dia 5 de maio. Na quinta-feira da semana passada, voltou a chover forte. Segundo Marengo, ainda que as chuvas parem agora, as águas vão continuar altas. Pode demorar um mês até essa água toda baixar.

Ele define também com uma expressão eloquente a falta de compromissos do mundo com as metas de redução das emissões.

— O Acordo de Paris já foi para o ralo. Em algumas regiões do mundo, passamos de um grau e meio. Então os países estão preparando planos de adaptação, como o Brasil neste momento. Está em processo de elaboração porque o assunto ficou parado por quatro anos no governo anterior.

O que o mundo está vendo agora é o resultado em grande parte do aquecimento global, que levou os oceanos Atlântico e Pacífico a ficarem quentes ao mesmo tempo durante esse período do El Niño. No La Niña, que está para entrar agora, haverá o esfriamento dos oceanos e a consequência no Brasil será chuva no Norte e Nordeste e seca no Sul do Brasil.

Há outras situações extremas previstas, como uma "temporada extraordinária de furacões no hemisfério norte", com pelo menos 25 furacões. Há, também, o que Marengo define como "uma irregularidade das chuvas". Em tudo isso, como ele diz, "o sinal humano está presente" como uma das causas.

Ouvir os cientistas do clima sempre impressiona, porque mostra que temos feito uma marcha insensata em direção a um desequilíbrio que não podemos consertar. Pode-se atenuar os efeitos dessa gangorra do clima com medidas de preparação dos locais onde vivem as populações.

Cientista José Marengo, do Cemaden, diz que Rio Grande do Sul pode sair de um período de enchente para o oposto, a estiagem

— A chuva não mata.

A chuva não mata as pessoas. Se a chuva cai num lugar onde as pessoas estão vulneráveis, expostas, aí acontece o desastre. O Cemaden trabalha com os extremos, emite os alertas de risco de desastres que são deflagrados pelos extremos, das chuvas intensas à falta de chuvas, as secas severas. O desastre é a mistura dos eventos extremos e a vulnerabilidade e a exposição da população.

Então, a solução parece óbvia, trabalhar para reduzir essa vulnerabilidade. Não é simples como parece.

— A agenda ambiental começa em um governo e só vê resultados bons em dois ou três governos adiante. Não aparece o produto em quatro anos de mandato. A prevenção, um governo começa, mas quem leva crédito é a próxima administração. Já a reconstrução, pode-se terminar a obra em um período de quatro anos.

O Cemaden monitora 1.133 municípios considerados os mais vulneráveis e expostos a desastres e agora pediu à Casa Civil para elevar esse número para 1.942. São esses que o Ministério do Meio Ambiente está considerando os municípios-piloto para um plano de prevenção contra desastres provocados pela mudança do clima. Mas há muita coisa que poderia melhorar imediatamente.

— Precisa haver a profissionalização da Defesa Civil. Em alguns municípios, há vagas ocupadas por parentes do prefeito, por exemplo. E tem que haver mais investimento, só que as estatísticas mostram que o investimento federal tem caído. O Brasil deveria ser proativo, mas parece que está cada vez mais reativo. E no mundo também é assim. Nas COPs, todo mundo vira ambiental, se veste de verde, tem apertos de mão e poses para as fotos.

Que Porto Alegre sirva de alerta para Belém. Na COP 30, o mundo precisa sair daqui com compromissos de realmente enfrentar a tragédia climática mundial.

Agência FAPESP NOTÍCIAS VÍDEOS AGENDA OPORTUNIDADES ASSINE

Eventos extremos

Reconstrução de cidades gaúchas precisa considerar adaptação climática e é alerta para outros municípios

23 de maio de 2024

Em evento no Instituto de Estudos Avançados da USP, pesquisadores lembram como mudanças no clima já estão exigindo preparação dos espaços urbanos e da necessidade de gestores públicos protegerem ainda mais populações vulneráveis

José Marengo, pesquisador do Cemaden, em evento realizado no dia 21 de maio (*imagem: reprodução*)

André Julião | Agência FAPESP – A reconstrução das cidades afetadas pelas chuvas no Rio Grande do Sul terá de considerar o aspecto das mudanças climáticas, o que inclui mesmo realocar cidades inteiras para lugares diferentes. A avaliação foi feita por **José Marengo**, pesquisador do Centro Nacional de Monitoramento e Alertas de Desastres Nacionais (Cemaden), em evento realizado pelo Instituto de Estudos Avançados da Universidade de São Paulo (IEA-USP) na última terça-feira (21/05).

"Não temos como parar as chuvas, mas podemos salvar a população", disse.

Agência FAPESP NOTÍCIAS VÍDEOS AGENDA OPORTUNIDADES ASSINE

Eventos extremos

Chuvas extremas no Sul do Brasil têm aumentado desde 1950, aponta estudo

23 de maio de 2024

Análises de dados coletados por estações de observações meteorológicas terrestres indicam que grandes áreas contíguas da região registraram dias de chuva intensa nas últimas sete décadas

"É preciso maior prevenção e melhora na preparação para essas chuvas intensas, que vão continuar aumentando", alerta pesquisador (*foto: Gustavo Mansur/Palácio Piratini*)

Elton Alisson | Agência FAPESP – A região Sul do Brasil vem apresentando, desde 1950, tendência de aumento de extremos de chuvas, como as que têm atingido os Estados do Rio Grande do Sul e de Santa Catarina.

As constatações são de um estudo liderado por pesquisadores do Centro Nacional de Monitoramento e Alertas de Desastres Naturais (Cemaden) em colaboração com o Met Office – o serviço nacional de meteorologia do Reino Unido.

Os resultados do trabalho, apoiado pela FAPESP no âmbito do Instituto Nacional de Ciência e Tecnologia para Mudanças Climáticas (INCT-MC), foram

Agência FAPESP NOTÍCIAS VÍDEOS AGENDA OPORTUNIDADES ASSINE

Eventos extremos

Sistemas de alerta e planos para evitar desastres por chuvas extremas ainda são falhos, aponta estudo

02 de maio de 2024

Pesquisadores do Cemaden analisaram deslizamentos de terra provocados por tempestade em São Sebastião no ano de 2023, quando pelo menos 65 pessoas morreram; cientistas sugerem envolvimento dos moradores em programas de contingência

Além do grande volume de chuva concentrado em poucas horas, houve em São Sebastião uma combinação de crescimento urbano não planejado em encostas com a remoção de vegetação (*foto: Prefeitura de São Sebastião*)

Luciana Constantino | Agência FAPESP – Com a elevação constante das temperaturas e o aumento da frequência de eventos climáticos extremos, especialmente chuvas, os municípios brasileiros precisam desenvolver planos de contingência, com monitoramento eficiente e rápida resposta. Além de um eficaz sistema de alerta local, é necessário que a população entenda a real ameaça e saiba o que fazer ao receber o aviso de desastre iminente emitido pelos órgãos responsáveis. O planejamento urbano, com infraestruturas adequadas, também desempenha importante papel para evitar perdas econômicas e de vidas.

10 MONDE ENVIRONNEMENT

Libération **Mercredi** *8 et* **Jeudi** *9 Mai 2024*

BRÉSIL Le Rio Grande do Sul face à un désastre météo sans précédent

Au moins 85 personnes sont mortes dans des crues jamais vues jusqu'ici, dont les autorités fédérales et locales peinent à gérer les conséquences.

Par
CHANTAL RAYES
Correspondante à São Paulo

RÉCIT

Toute la nuit de samedi, Herbert Poersch, habitant de Canoas, ville du Rio Grande do Sul, fut tourmenté par des pleurs d'enfants s'échappant des toits des maisons, dernier refuge d'une population piégée par les inondations qui frappent depuis plus d'une semaine cet Etat méridional du Brésil. «*Je ne veux pas mourir*», les entend sangloter ce père de famille, qui a lui-même trouvé refuge sur le toit de son domicile avec sa femme et ses deux garçons. Et lorsque surgit un intrépide *gaucho* (nom donné aux habitants de la région) qui a enfourché son jet-ski pour prêter main-forte aux secours débordés, «*il a fallu décider lequel de nos enfants sauver en premier*», raconte, encore atterré, Herbert Poersch au média en ligne *UOL*, puisque le bolide aquatique ne comporte qu'une seule place passager.

«SCÉNARIO DE GUERRE»

Entre le 29 avril et le 4 mai, les pluies torrentielles qui se sont abattues sur ce prospère Etat brésilien de 11,3 millions d'habitants, frontalier de l'Argentine et de l'Uruguay, représentaient déjà la moitié du volume des précipitations attendues pour toute l'année. Mardi, le bilan provisoire des inondations s'établissait à 85 morts, 361 blessés et 132 disparus, tandis que près de 204 000 personnes ont dû quitter leur domicile. Les trois quarts des 497 villes et communes de l'Etat sont touchées. Isolées par la violence des courants, provoquée par des crues jamais vues des cours d'eau traversant la région, certaines de ces localités ont parfois attendu jusqu'à soixante-douze heures pour être évacuées. L'armée de l'air a dû mobiliser des hélicoptères. On a même vu de riches particuliers cédant

leur propre appareil dans un élan de solidarité. Même la capitale d'Etat, Porto Alegre, devenue célèbre pour avoir accueilli, dans les années 2000, la grand-messe altermondialiste du Forum social mondial, est sous l'eau. Le niveau de l'estuaire de Guaíba, qui baigne la ville, et où se déversent les eaux d'autres régions, a atteint son record depuis la crue de 1941 : 5,29 mètres, soit 2,3 mètres au-delà de son niveau normal. Les images du centre historique, du stade de foot érigé pour le Mondial 2014 et de l'aéroport international inondés ont frappé les esprits. Gouvernée à droite, la mairie de Porto Alegre, dont les caisses sont pourtant pleines, n'a pas investi le moindre centime l'an dernier dans le dispositif anti-inondations.

Face à la plus grave catastrophe météo de l'histoire de son Etat, le jeune gouverneur Eduardo Leite (droite) parle d'un *«scénario de guerre»* et appelle à un *«plan Marshall»* pour reconstruire une zone qui fut victime, il y a seulement quelques mois, en septembre, d'un cyclone extratropical qui avait déjà fait 47 morts. Pour sa part, le président Lula da Silva (gauche), qui s'est déjà rendu deux fois sur place, ne lésine pas sur les moyens. Non seulement le chef de l'Etat brésilien a mobilisé plus de 13 000 militaires, mais il a également signé un texte accélérant les démarches en vue du déblocage de moyens financiers. Sa ministre de l'Environnement, Marina Silva, prépare quant à elle un plan de prévention des désastres climatiques, de plus en plus fréquents et extrêmes au Brésil en raison, selon les experts, du réchauffement du climat provoqué par l'action humaine : sécheresse historique en Amazonie l'année dernière ; *«déficit de précipitations»* cette année dans les riches prairies du Pantanal ; vagues de chaleur à répétition sur tout le sud-est du pays, soit sa région la plus peuplée, où les températures dépassent actuellement de 5 degrés la moyenne saisonnière.

La capitale de l'Etat brésilien du Rio Grande do Sul, Porto Alegre, sous les eaux, samedi. PHOTOS CARLOS FABAL. AFP

«ZONES NATURELLES SUPPRIMÉES»

Le Rio Grande do Sul est particulièrement vulnérable en raison de sa situation de point de rencontre entre courants d'air froid et chaud. Or, une masse d'air chaud et sec, qui s'est formée, la chaleur aidant, sur le centre du Brésil, aurait empêché le passage vers le nord du pays d'un courant froid venu d'Argentine, provoquant les intempéries *(lire ci-dessous)*. Grand producteur de riz et de soja, *«le Rio Grande do Sul est le premier Etat brésilien à avoir couvert tout son territoire d'exploitations agricoles,* explique pour sa part l'écologiste Clóvis Borges. *Les zones naturelles ont été pratiquement supprimées, ce qui a réduit sa résilience aux événements climatiques. Si la classe politique continue de fermer les yeux sur le non-respect de la législation environnementale, nous allons subir des situations encore plus dures».* Une allusion aux négationnistes climatiques, ce puissant lobby agricole qui détient deux tiers des sièges au Parlement brésilien et fait obstruction aux mesures de protection de l'environnement. ◂▸

Un cocktail climatique qui favorise les pluies diluviennes

https://infoamazonia.org/2024/06/20/rio-em-fluxo/

PT ES EN

INFOAMAZONIA

Notícias Mapas Projetos Podcast Sobre nós EXPLORAR

REPORTAGEM ESPECIAL / MUDANÇA CLIMÁTICA

Rio em fluxo: o impacto das mudanças do clima na Amazônia

Enquanto a média da temperatura do planeta aumenta, as cidades da Amazônia brasileira sentem as estações chuvosas e secas cada vez mais intensas, com ameaça à segurança alimentar e à própria sobrevivência de muitas comunidades ribeirinhas, além do aumento da mortalidade de peixes e botos.

Por Daniel Grossman 20 junho 2024 at 8:00

Leu static.cloudflareinsights.com


ESTUDO DO NEREUS REVELA O IMPACTO DA ECONOMIA DO MAR NOS ESTADOS E MUNICÍPIOS DO BRASIL
POR EDUARDO AMARAL HADDAD
NEREUS
FEAUSP


BRASIL
Simplifique!
Comunica BR
Participe
Acesso à informação
Legislação
Canais
FIOCRUZ
Fale com a Fiocruz
FUNDAÇÃO OSWALDO CRUZ
ICICT
English Português Français
Dislexia
Inverter
Observatório
de CLIMA e SAÚDE
Início
Apresentação
Temas e Indicadores
Áreas de Vigilância
Notícias e Agenda
Mapas, Gráficos e Tabelas
Publicações
Multimídia
Doenças e Perguntas
You are here »Home
» Entrevista Com a Pesquisadora Elizabeth Rangel. Chefe Do Laboratório Interdisciplinar Em Vigilância Entomológica do IOC Do Instituto Oswaldo Cruz
Entrevista com a pesquisadora Elizabeth Rangel. Chefe do Laboratório Interdisciplinar em Vigilância Entomológica do IOC do Instituto Oswaldo Cruz

Coalesce Research Group

7TH INTERNATIONAL CONFERENCE ON

ENVIRONMENTAL SUSTAINABILITY AND CLIMATE CHANGE

August 19-20, 2024

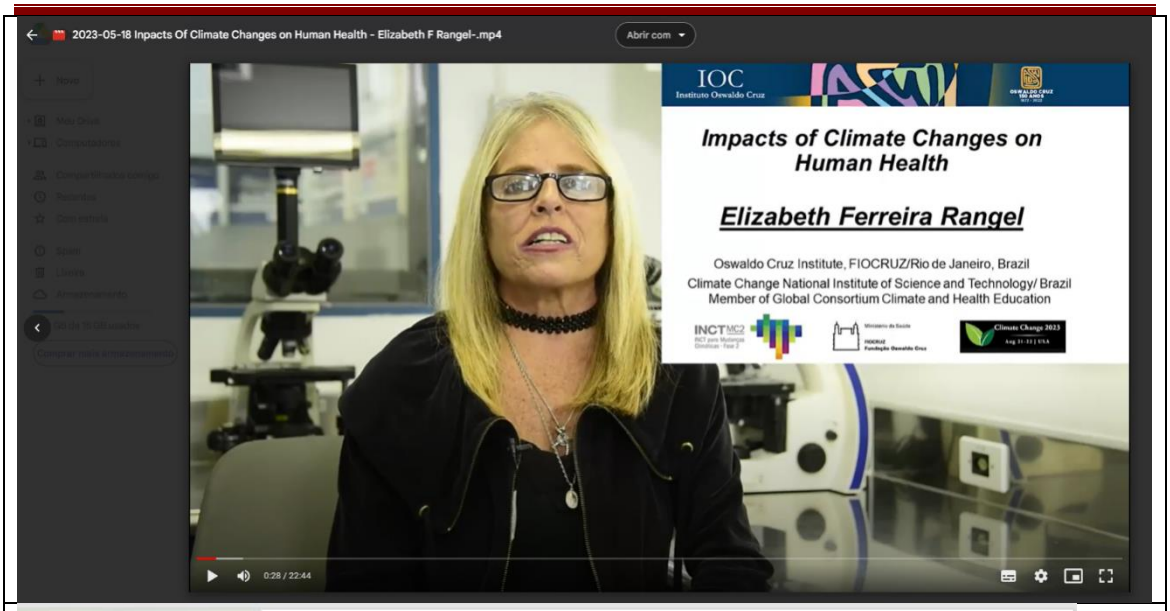
SOUTH POINT HOTEL, CASINO & SPA, LAS VEGAS, USA

Theme: "Current Research on Environmental Sustainability and Climate Change"

https://crgconferences.com/environmental

14:20 - 14:40 Distribution of Vectors of American Visceral Leishmaniasis in the State of Rio De Janeiro/ Brazil: Municipal Vulnerability for Transmission, Ecological Niche Modelling and Predicted Geographic Distribution

Elizabeth Ferreira Rangel, Instituto Oswaldo Cruz, FIOCRUZ, Rio de Janeiro, Brazil



Desafíos de la Gestión y Reducción de Riesgos de Desastres geo-hidro-meteorológicos en Brasil: Estudio de un Caso

Regina C. S. Alvalá
José A. Marengo Orsini
Marcelo E. Seluchi
Centro Nacional de Monitoramento e Alertas de Desastres Naturais/Ministério da Ciência, Tecnologia e Inovação (CEMADEN/MCTI)

La conexión entre Sepsis, Latinoamérica y El Caribe

Introducción

En los últimos 30 años, el número de desastres ha aumentado en todo el planeta debido a la intensificación de los eventos geodinámicos, hidrometeorológicos y climáticos, o por el aumento de la población que vive en zonas de riesgo. El reciente informe del Panel Intergubernamental (AR6) destacó que los cambios climáticos antropogénicos han contribuido con el aumento de los eventos meteorológicos y climáticos extremos que culminan en muertes e impactos significativos causados por inundaciones y deslizamientos de tierra.

Según un informe de la Organización Meteorológica Mundial (OMM, 2023), los gobiernos, las comunidades, la sociedad civil y las Naciones Unidas deben estar preparados en todos los niveles para fortalecer la resiliencia climática y reducir eficazmente el riesgo de desastres. También según la OMM (2023), las principales prioridades deben incluir esfuerzos de preparación, sistemas de alerta temprana y preparación para emergencias. Por ello, la iniciativa "Alertas Tempranas para Todos" fue lanzada por el Secretario General de la ONU en marzo de 2022, con el objetivo de garantizar, hacia finales de 2027, que todas las personas en el planeta estén protegidas contra los fenómenos meteorológicos, hídricos o climáticos perjudiciales, a través de sistemas de alerta temprana centrados en salvar vidas.

Particularmente en Brasil, en 2011, poco después de la ocurrencia del desastre histórico que afectó gravemente la región serrana de Río de Janeiro, y luego de una sucesión de desastres anteriores que provocaron importantes impactos socioeconómicos y ambientales, se realizaron esfuerzos para garantizar que Brasil cuente con un sistema de alerta temprana para situaciones de deslizamientos de tierra, inundaciones, crecidas e inundaciones repentinas. En el sistema diseñado en 2011 se dio prioridad a la creación de un programa multisectorial destinado a gestionar de manera integrada los riesgos de desastres hidrológicos y geodinámicos provocados por extremos de lluvia, incluyendo la prevención. También en 2011 se creó el Centro Nacional de Monitoreo y Alertas de Desastres Naturales (CEMADEN) y, en 2012, se implementó el "Plan Nacional de Gestión de Riesgos y Respuesta a Desastres", centrando la acción gubernamental en el área de prevención y priorizando la gestión en cuatro ejes: 1-mapear las áreas de riesgo, 2-establecer un sistema de monitoreo y alerta, 3-realizar obras públicas y 4-en el medio plazo, fortalecer los órganos de Defensa Civil y apoyar la planificación urbana con miras a evitar la ocupación de áreas de riesgo (Alvalá y Barbieri, 2017).

El sistema de monitoreo y alerta diseñado para Brasil en 2011 tuvo en cuenta las premisas del Marco de Acción de Hyogo (2005-2015) en el sentido de aumentar la resiliencia del país y de las comunidades con el fin de lograr, hasta 2015, una reducción considerable de las pérdidas provocadas por desastres geodinámicos e hidrológicos, tanto en el número de vidas humanas como en los aspectos sociales, económicos y ambientales. Además, este sistema consideró posteriormente las metas del Marco de Acción de Sendai (2015-2030), priorizando la incorporación del conocimiento generado entre 2011 y 2015 para contribuir con la reducción del riesgo de desastres. En este contexto, el CEMADEN/MCTI, organismo de monitoreo y envío de alertas, viene realizando acciones tendientes a promover y difundir la ciencia en las comunidades escolares, defensas civiles y comunidades locales, desarrollando estrategias educativas para la investigación/acción, la comunicación y la movilización para la gestión y reducción de la vulnerabilidad a los desastres, con el objetivo de construir sociedades sostenibles y resilientes.

Monitoreo y Alertas de Riesgo de Desastres en Brasil

En el contexto de la gestión de riesgos y respuesta a desastres, especialmente en lo que respecta a los sistemas de alerta temprana, el CEMADEN/MCTI tiene la misión fundamental de monitorear y emitir alertas de la probable ocurrencia de desastres asociados a fenómenos naturales para los órganos de Defensa Civil. Para ello, utiliza tecnologías modernas de monitoreo de condiciones ambientales precursoras de desastres, combinadas con pronósticos numéricos meteorológicos, hidrológicos y geodinámicos, que culminan con el desarrollo de un sistema de pronóstico para riesgo de deslizamientos de tierra y/o de eventos hidrológicos, siendo éstos los fenómenos que provocan los mayores impactos económicos y humanos en Brasil (Dias et al., 2018; Alvalá et al., 2019).

El CEMADEN monitorea (24 horas por día, 7 días por semana) y emite, caso sea necesario, alertas de riesgo de desastre, para 1038 municipios definidos como prioritarios. Para estos municipios, ubicados en su mayoría en las regiones Nordeste, Sudeste y Sur de Brasil, el Centro cuenta con mapas georreferenciados de las áreas de riesgo y con una red de observación ambiental para medir la precipitación, humedad del suelo y niveles de los ríos, especialmente en las cercanías de las áreas de riesgo de los municipios prioritarios. Cabe destacar también que el monitoreo es realizado por profesionales especializados en las áreas de geología, hidrología, meteorología y vulnerabilidad social.

Además de monitorear eventos de lluvia que pueden provocar inundaciones y/o deslizamientos de tierra, el CEMADEN/MCTI (i) diagnostica y evalúa impactos de sequías en actividades estratégicas; (ii) asesora instituciones gubernamentales y tomadores de decisiones, realizando diagnósticos, brindando escenarios futuros y evaluando los impactos relacionados al estado del tiempo y los extremos climáticos, relevantes para subsidiar

37

Prefeitura Municipal de São Carlos

São Carlos, Capital da Tecnologia

Secretaria Municipal de Ciência, Tecnologia e Inovação

Minuta – DECRETO

GRUPO DE TRABALHO EM MUDANÇAS CLIMÁTICAS GLOBAIS

- CONSIDERANDO o impacto que as mudanças climáticas globais causam nas áreas urbanas com efeitos graves na infraestrutura, saúde humana e economia;

- CONSIDERANDO que São Carlos "*Capital da Tecnologia*", tem suficiente e competente corpo de pesquisadores, cientistas, engenheiros e administradores, com capacidade para apresentar projetos, promover seminários, convidar especialistas para discutir e propor soluções mitigadoras e adequação à mudanças climáticas no município;

- Fica criado o "GRUPO DE TRABALHO EM MUDANÇAS CLIMÁTICAS GLOBAIS", que tratará do problema no âmbito municipal, em todas as suas dimensões econômicas, ecológicas e sociais.

COMPONENTES DO GRUPOS DE TRABALHO EM MUDANÇAS CLIMÁTICAS

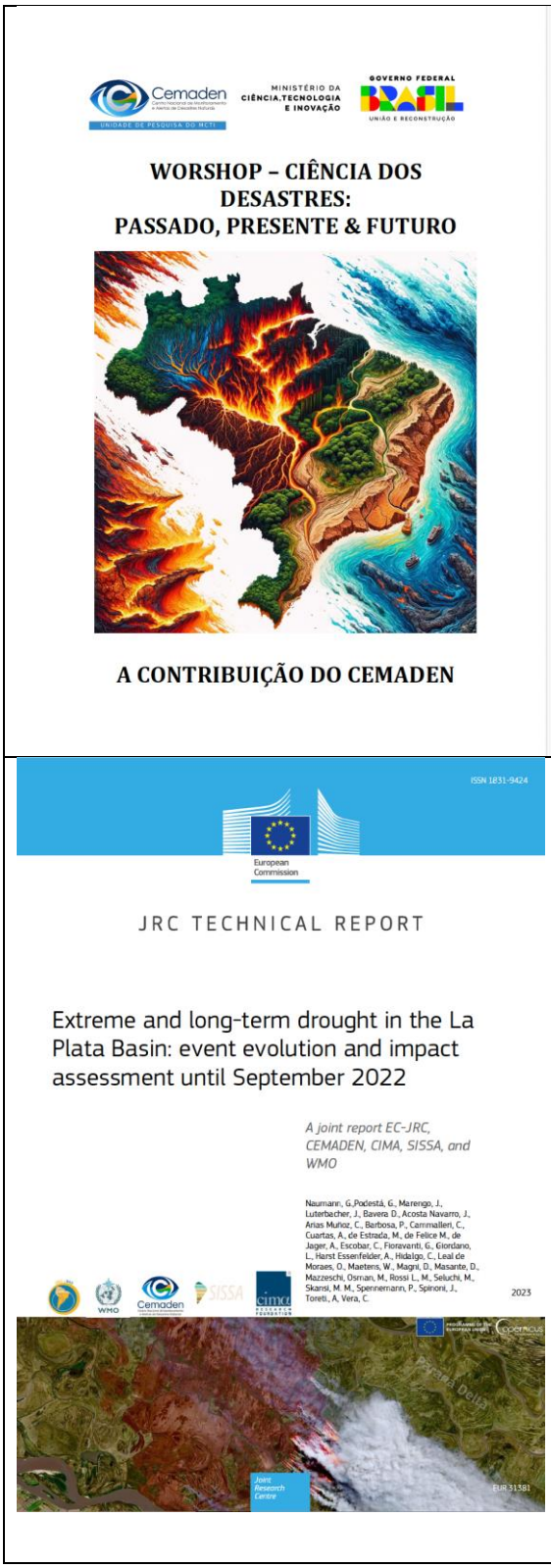
- Dr. Silvio Crestana – EMBRAPA Instrumentação
- Dr. Paulo Estevão Cruvinel – EMBRAPA Instrumentação
- Dra. Odete Rocha – UFSCar
- Dr. Eduardo Mario Mendiondo – EESC/USP
- Dra. Silvia Claudia Semensato Povinelli – UFSCar
- Dr. Sergio Henrique Vannucci Leme de Mattos – UFSCar
- Dr. Edson Cezar Wendland – SCTI-SP
- Dr. José Galizia Tundisi – SMCTI / PM
- MsC. Thamiris Cristina Costa Basilio – SMCTI / PM
- Engo. Francisco Porto Filho – SMCTI / PM
- 01 membro – Secretaria Municipal de Segurança Pública e Defesa Social
- 01 membro – Defesa Civil

São Carlos, ... de ..... de 2024.

Rua 13 de Maio, 2272 – Centro – CEP 13.560-647 São Carlos, SP

Fone: 16 3413 3057 / 3413 3054 / 3413 2979

Some papers and other publications derived from the project



Cemaden

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL BRASIL UNIÃO E RECONSTRUÇÃO

WORSHOP – CIÊNCIA DOS DESASTRES: PASSADO, PRESENTE & FUTURO

A CONTRIBUIÇÃO DO CEMADEN

BOLETIM CNM

Publicação da Confederação Nacional de Municípios • agosto de 2023

DESASTRES NATURAIS

MAIS DE 4,2 MILHÕES DE PESSOAS DEIXARAM SUAS CASAS EM 10 ANOS

CNM CONFEDERAÇÃO NACIONAL DE MUNICÍPIOS

Nesta edição:

Com o Censo 2022, Confederação aponta impacto nos coeficientes do FPM

Encontro dos Fóruns de Vice-prefeitos e Consórcios Públicos acontecem em setembro

Prazo para se adaptar à nova Lei de Licitações vai até 29 de dezembro

ISSN 1831-9424

European Commission

JRC TECHNICAL REPORT

Extreme and long-term drought in the La Plata Basin: event evolution and impact assessment until September 2022

A joint report EC-JRC, CEMADEN, CIMA, SISSA, and WMO

Naumann, G.,Podestá, G., Marengo, J., Luterbacher, J., Bavera D., Acosta Navarro, J., Arias Muñoz, C., Barbosa, P., Cammalleri, C., Cuartas, A., de Estrada, M., de Felice M., de Jager, A., Escobar, C., Fioravanti, G., Giordano, L., Harst Essenfelder, A., Hidalgo, C., Leal de Moraes, O., Maetens, W., Magni, D., Masante, D., Mazzeschi, Osman, M., Rossi L., M., Seluchi, M., Skansi, M. M., Spennemann, P., Spinoni, J., Toreti, A, Vera, C.

2023

Joint Research Centre

EUR 31581

Scientific Research Publishing

American Journal of Climate Change, 2023, 12, 140-171
https://www.scirp.org/journal/ajcc
ISSN Online: 2167-9509
ISSN Print: 2167-9495

More Erratic and More Extreme: Trends in Precipitation in the State of São Paulo, Brazil

Luci Hidalgo Nunes[1], Guilherme Henrique Gabriel[2], Jose A. Marengo[3]

[1]Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, Brasil
[2]Universidade Estadual de Campinas (UNICAMP), São Paulo, Brasil
[3]Centro Nacional de Monitoramento e Alertas de Desastres Naturais (CEMADEN), São José dos Campos, Brazil
Email: lucihidalgo@gmail.com, guihg@hotmail.com, jose.marengo@cemaden.gov.br

How to cite this paper: Nunes, L. H., Gabriel, G. H., & Marengo, J. A. (2023). More Erratic and More Extreme: Trends in Precipitation in the State of São Paulo, Brazil. *American Journal of Climate Change, 12*, 140-171.
https://doi.org/10.4236/ajcc.2023.121008

Received: May 19, 2022
Accepted: March 24, 2023
Published: March 27, 2023

Abstract

The study assessed changes in rainfall variability and the frequency of extreme events (very wet and very dry) in the state of São Paulo, Brazil, for a 40-year period that divided into two sub-groups: 1973-1992 (P1) and 1993-2012 (P2). Data of 79 rain gauge stations were selected to represent the different climatic and geomorphological domains of the state. The annual pattern was evaluated through the scale and the shape parameters of the gamma distribution and the 95th and the 5th percentiles thresholds, the latter also employed to evaluate the seasonal spatial patterns (rainy season, Oct.-Mar. and sub-humid to dry season, Apr.-Sep.). Results showed that the average precipitation was similar in P1 and P2, but São Paulo evolved to a pattern of increased irregularity in the rainfall distribution, with a rise of approximately 10% in the number of extremes between 1973 and 2012, especially in the very dry occurrences, and in the north and west of the state, which are the least rainy regions. Moreover, while 55% of the evaluated rain gauges recorded more extreme wet episodes in P2, 76% registered more dry extreme episodes in the same period. Some very dry or very wet events recorded after the 40-year period evaluated were discussed in terms of the associated weather patterns and their impacts on society and attested to the validity of the results found in the quantitative assessment. The qualitative analysis indicates that if the trends of more irregular distribution of rain and increase in extreme events persist, as pointed out by the gamma and percentile analyses, they would continue to bring serious effects on the natural and social systems in the state, which is the most populous and has the strongest and most diversified economy in Brazil.

Keywords

Rainfall, Extremes, São Paulo, Gamma Distribution, Percentiles, Impacts

OPEN ACCESS Freely available online

Journal of Geography & Natural Disasters

Research Article

Refinement of Precipitation Distribution in Southern Brazil under the Conditions of the Pacific Ocean Temperature Anomaly

Osvaldo Luiz Leal de Moraes[1*], Jose Marengo Orsini[2]

[1]Department of Climate and Sustainability, Brazilian Ministry of Science and Technology, Brasília, Brazil; [2]National Early Warning and Monitoring Centre for Natural Disasters, São José dos Campos, São Paulo, Brazil

ABSTRACT

The role of the Pacific Decadal Oscillation (PDO) and the El Niño-Southern Oscillation (ENSO) was investigated in relation to anomalous precipitation in Southern Brazil. A daily precipitation dataset was used, covering the period 1961 to 2016 from 106 monitoring stations. In addition, a direct comparison was made between El Niño plus positive PDO events and La Niña plus negative PDO events to discover any correlations between these phenomena in regional precipitation. Our results indicate that significant monthly favorable anomalous precipitation across the region occurred only during intense or extreme El Niño events, and PDO had no modulating effect regardless of its intensity. However, monthly negative precipitation anomalies at higher latitudes ranged from low to moderate during robust La Niña periods, suggesting some association with adverse PDO events.

Keywords: El Niño-Southern oscillation; Pacific decadal oscillation; Precipitation in Southern Brasil

INTRODUCTION

Rainfall has great social and economic importance in Southern Brazil, which has more than 25 million inhabitants and is responsible for 40%, 40%, and 80% of national production of soybeans, corn, and rice, respectively [1]. Mid-latitude systems greatly influence this region, and its geographic location is characterized by well-distributed rainfall throughout the year [2]. However, precipitation variability is considerable, and the effects of large-scale circulation anomalies are evident. The climate of southern Brasil is strongly associated with El Niño–Southern Oscillation (ENSO) phases and the effects of these events on precipitation in the region have been studied in recent decades [3-10]. These studies, confirmed by model experiments, showed that warm episodes of ENSO (El Niño) in Southern Brazil produce precipitation above the climatological mean, while cold episodes (La Niña) produce values below the mean [11-17]. Cai et al. [16] showed that the effects of ENSO are very different due to ENSO diversity and the types of variability within and outside the Pacific Ocean with different ENSO types and the effects of SST variability in the South Atlantic.

The effects of ENSO are complicated by other forms of natural climate variability. These interact and modify the effects and trends of ENSO, such as the Southern Annular Mode (SAM), the Indian Ocean Dipole (IOD), the Pacific Decadal Oscillation (PDO), the Atlantic multidecadal variability, and warming due to the greenhouse effect [18-25]. Overall, Southeastern South America, including Southern Brazil and the northern sector of the northern and Northeastern regions of Brazil, is most affected by teleconnection patterns [26].

ENSO and PDO have a significant impact on global climate and precipitation patterns. Schoennagel et al. [27] analyzed the relationship between ENSO and PDO and fire occurrence due to drought in subalpine forests in the Rocky Mountains. McCabe et al. used first leaf data at 850 sites across North America from 1900–2008 to examine how ENSO and PDO individually and together can influence the timing of spring [28]. Limestone and Goodrich examined the effects of ENSO and PDO on winter air pollution in Phoenix, while Henson et al. conducted an analysis of crop yields in Missouri to determine if there is interannual or multidecadal variation due to ENSO and PDO [29]. Mariano et al. showed strong correlations between ENSO and PDO influences and the likelihood of occurrence of extreme physical conditions that altered fish communities in a shallow lake due

Correspondence to: Osvaldo Luiz Leal de Moraes, Department of Climate and Sustainability, Brazilian Ministry of Science and Technology, Brasília, Brazil, E-mail: osvaldo.moraes@mctt.gov.br

Received: 20-Oct-2023, Manuscript No. JGND-23-27730, **Editor assigned:** 23-Oct-2023, PreQC No. JGND-23-27730 (PQ), **Reviewed:** 07-Nov-2023, QC No. JGND-23-27730, **Revised:** 14-Nov-2023, Manuscript No. JGND-23-27730 (R), **Published:** 21-Nov-2023, DOI: 10.35841/2167-0587.23.13.283

Citation: Moraes OLL, Orsini JM (2023) Refinement of Precipitation Distribution in Southern Brasil under the Conditions of the Pacific Ocean Temperature Anomaly. J Geogr Nat Disasters. 13: 283.

Check for updates

AGU ADVANCING EARTH AND SPACE SCIENCES

Earth's Future

COMMENTARY

10.1029/2023EF003857

Tackling Growing Drought Risks—The Need for a Systemic Perspective

M. Hagenlocher[1], G. Naumann[2], I. Meza[1,3], V. Blauhut[4], D. Cotti[1], P. Döll[5,6], K. Ehlert[7,8], F. Gaupp[9], A. F. Van Loon[10], J. A. Marengo[11], L. Rossi[2], A.-S. Sabino Siemons[2], S. Siebert[12], A. T. Tsehaye[13], A. Toreti[2,14], D. Tsegai[15], C. Vera[16,17], J. Vogt[18], and M. Wens[18]

[1]Institute for Environment and Human Security (UNU-EHS), United Nations University, Bonn, Germany, [2]CIMA Research Foundation, Savona, Italy, [3]WWF Germany (WWF DE), Berlin, Germany, [4]Faculty of Environment and Natural Resources, Environmental Hydrological Systems, University of Freiburg, Freiburg, Germany, [5]Institute of Physical Geography, Goethe University Frankfurt, Frankfurt am Main, Germany, [6]Senckenberg Leibniz Biodiversity and Climate Research Centre Frankfurt (SBiK-F), Frankfurt am Main, Germany, [7]World Meteorological Organization (WMO), Genève, Switzerland, [8]Bundesamt für Meteorologie und Klimatologie MeteoSchweiz, Zürich-Flughafen, Switzerland, [9]Potsdam Institute for Climate Impact Research (PIK), Potsdam, Germany, [10]Institute for Environmental Studies, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands, [11]National Center for Monitoring and Early Warning of Natural Disasters (Cemaden), São José dos Campos, Brazil, [12]Department of Crop Sciences, University of Göttingen, Göttingen, Germany, [13]Intergovernmental Authority on Development (IGAD), IGAD Climate Prediction and Application Centre (ICPAC), Nairobi, Kenya, [14]European Commission, Joint Research Centre (JRC), Ispra, Italy, [15]United Nations Convention to Combat Desertification (UNCCD), Bonn, Germany, [16]Department of Atmospheric and Ocean Sciences, CIMA, University of Buenos Aires, CONICET, Buenos Aires, Argentina, [17]Sistema se Información sobre Sequías para el Sur de Sudamérica (SISSA), Buenos Aires, Argentina, [18]Retired from European Commission, Joint Research Centre (JRC), Ispra, Italy

Key Points:

- Drought risks are on the rise and their effects are increasingly felt across communities, economic sectors, ecosystems, borders and entire societies
- To effectively assess and manage drought risks, a systemic perspective is needed
- We propose a novel systemic framework to better inform drought risk research and policy

Correspondence to:

M. Hagenlocher,

hagenlocher@ehs.unu.edu

Citation:

Hagenlocher, M., Naumann, G., Meza, I., Blauhut, V., Cotti, D., Döll, P., et al. (2023). Tackling growing drought risks—the need for a systemic perspective. *Earth's Future*, *11*, e2023EF003857. https://doi.org/10.1029/2023EF003857

Received 31 MAY 2023

Accepted 13 JUL 2023

Author Contributions:

Conceptualization: M. Hagenlocher, G. Naumann, I. Meza, V. Blauhut, D. Cotti, P. Döll, F. Gaupp, A. F. Van Loon, A. S. Sabino Siemons, S. Siebert, J. Vogt, M. Wens

Visualization: M. Hagenlocher, G. Naumann, I. Meza, D. Cotti, F. Gaupp, A. F. Van Loon, A. S. Sabino Siemons, J. Vogt

Writing – original draft: M. Hagenlocher, G. Naumann, I. Meza, D. Cotti, A. S. Sabino Siemons

Abstract In the last few years, the world has experienced numerous extreme droughts with adverse direct, cascading, and systemic impacts. Despite more frequent and severe events, drought risk assessment is still incipient compared to that of other meteorological and climate hazards. This is mainly due to the complexity of drought, the high level of uncertainties in its analysis, and the lack of community agreement on a common framework to tackle the problem. Here, we outline that to effectively assess and manage drought risks, a systemic perspective is needed. We propose a novel drought risk framework that highlights the systemic nature of drought risks, and show its operationalization using the example of the 2022 drought in Europe. This research emphasizes that solutions to tackle growing drought risks should not only consider the underlying drivers of drought risks for different sectors, systems or regions, but also be based on an understanding of sector/system interdependencies, feedbacks, dynamics, compounding and concurring hazards, as well as possible tipping points and globally and/or regionally networked risks.

Plain Language Summary In recent years, the world has faced severe and frequent droughts, resulting in significant direct and indirect impacts. However, our understanding and assessment of drought risks are still limited which has important implications for risk management. Here, we propose a new approach—a systemic perspective on drought risks—to effectively assess and manage drought risks. Our framework highlights the interconnected nature of drought risks, impacts and responses. We demonstrate the framework's application by analyzing the 2022 drought in Europe. This research emphasizes the need for a comprehensive understanding of drought risks and offers a practical tool for policymakers and researchers to guide future drought risk research and policy.

1. Introduction

Droughts are temporary, recurring, usually slow-onset water deficits that can lead to devastating impacts on many sectors and systems and, eventually, affect ecosystems, entire societies and economies (Chiang et al., 2021; IPCC, 2022; Pokhrel et al., 2021; UNDRR, 2021). These water deficits are caused by the interaction of meteorological imbalances propagating through the hydrological cycle and human activities (Bartholomeus et al., 2023; Van Loon et al., 2022). Drought impacts, resulting from an imbalance between water availability and water needs, are severe, spatially and temporally complex, interlinked, and often slowly evolving, rendering their assessment a challenge. Between 2001 and 2021, droughts affected on average about 67 million people globally every year, with variations across the years, and caused global economic losses of USD 146 billion (CRED, 2022). While

sustainability

MDPI

Article

Flood Risk Mapping during the Extreme February 2021 Flood in the Juruá River, Western Brazilian Amazonia, State of Acre

José Mantovani [1,2], Enner Alcântara [1,2,*], José A. Marengo [1,3], Luciana Londe [1,3], Edward Park [4], Ana Paula Cunha [1,3] and Javier Tomasella [1,3]

[1] Institute of Science and Technology, São Paulo State University (Unesp), São José Dos Campos 12245-000, SP, Brazil; j.mantovani@unesp.br
[2] Graduate Program in Natural Disasters, (Unesp/CEMADEN), São José Dos Campos 12247-004, SP, Brazil; jose.marengo@cemaden.gov.br (J.A.M.); luciana.londe@cemaden.gov.br (L.L.); ana.cunha@cemaden.gov.br (A.P.C.); javier.tomasella@unpe.br (J.T.)
[3] National Center for Monitoring and Early Warning of Natural Disasters (CEMADEN), São José Dos Campos 12247-016, SP, Brazil
[4] National Institute of Education, Earth Observatory of Singapore and Asian School of the Environment, Nanyang Technological University (NTU), Singapore 639798, Singapore; edward.park@nie.edu.sg
[5] National Institute for Space Research (INPE), Cachoeira Paulista12630-000, SP, Brazil
* Correspondence: enner.alcantara@unesp.br

Abstract: Cruzeiro do Sul, a municipality in Northwestern Brazil is recurrently impacted by floods, particularly along the Juruá River. This study presents a comprehensive flood risk analysis by integrating geoprocessing, remote sensing, and hydraulic modeling techniques. Our objectives are to simulate flood extents, identify high-risk areas, and guide sustainable territorial management. Our findings illustrate that the flood impacts are distributed across urban (27%), agricultural (55%), and forest/grassland (17%) landscapes. Historical records and literature reviews also underscore a recurring pattern of extreme floods in the municipality, notably during February's La Niña events. Some vulnerable urban neighborhoods were identified: Vila Cruzeirinho, Centro, Miritizal, and Da Várzea. These areas are especially susceptible due to their proximity to the river and increased surface runoff during high flood events. By amalgamating various data sources and methods, this research aids decision making for flood mitigation and urban development, fostering resilience against recurrent flooding events in Cruzeiro do Sul.

Keywords: natural hazards; floods; remote sensing; environmental modeling; Brazil

Citation: Mantovani, J.; Alcântara, E.; Marengo, J.A.; Londe, L.; Park, E.; Cunha, A.P.; Tomasella, J. Flood Risk Mapping during the Extreme February 2021 Flood in the Juruá River, Western Brazilian Amazonia, State of Acre. *Sustainability* **2024**, *16*, 2999. https://doi.org/10.3390/su16072999

Academic Editor: Tommaso Caloiero

Received: 1 March 2024
Revised: 26 March 2024
Accepted: 1 April 2024
Published: 3 April 2024

1. Introduction

The need to address the global challenges presented by disasters has never been more urgent. Out of these, floods stand out as the most common and damaging natural events, affecting billions of people and causing enormous economic losses worldwide [1]. In Brazil, flooding is a particularly pressing issue that often results in irreparable losses for affected populations [2,3]. The country's unique geographical and climatic variables contribute to a landscape inherently prone to such catastrophes. The rainy season in the northern region of Brazil varies depending on the subregion, but it typically occurs from December to May, during which flood events become more frequent. Rivers swell due to increased rainfall, impacting human settlements along their banks. The situation is further complicated in the Amazon region, where large scale climatic phenomena like the Intertropical Convergence Zone (ITCZ) and the La Niña climatic phenomena play a significant role in exacerbating flood risks [4–6]. This increased susceptibility raises questions about best practices to manage flood risks and protect vulnerable communities in a region of such environmental and climatic complexity.

Natural Hazards

https://doi.org/10.1007/s11069-024-06558-5

ORIGINAL PAPER

Check for updates

Heavy rains and hydrogeological disasters on February 18th–19th, 2023, in the city of São Sebastião, São Paulo, Brazil: from meteorological causes to early warnings

Jose A. Marengo[1,2,3] · Ana P. Cunha[1,2] · Marcelo E. Seluchi[1] · Pedro I. Camarinha[1] · Giovanni Dolif[1] · Vinicius B. Sperling[1] · Enner H. Alcântara[2] · Andrea M. Ramos[4] · Marcio M. Andrade[1,2] · Rodrigo A. Stabile[1] · José Mantovani[2] · Edward Park[5] · Regina C. Alvala[1,2] · Osvaldo L. Moraes[1,2] · Carlos A. Nobre[6,2] · Demerval Goncalves[1]

Received: 14 November 2023 / Accepted: 7 March 2024

Abstract

This study provides a thorough analysis of the landslides that occurred in the city of São Sebastião, on the northern coast of São Paulo state, Brazil, in February 18th–19th, 2023. The meteorological condition during this event was characterized by a cold front crossing over a warmer-than-normal subtropical South Atlantic, off the coast of São Paulo. Combined with the orographic effect of the Serra do Mar Mountain, the front remained stationary over the northern coastal areas of the state of São Paulo, causing an extreme and historic heavy precipitation event. An unprecedented volume of rain, amounting to 683 mm in less than 15 h, triggered landslides that generated 65 casualties and damages. Although alerts were clearly issued in advance, response among the communities was minimal, indicating the ineffectiveness of current early warning system in place. This calls for improved public policies, communication and the possible adoption of multi-hazard early warning systems to reduce risk in vulnerable areas.

Keywords Heavy rainfall · Landslides · Early warning systems · Adaptation · Rainfall and risk forecasts

1 Introduction

Disasters triggered by heavy rainfall exacerbate preexisting socioeconomic crises and disrupt people's lives and properties (e.g. Moraes 2023). Recent reports by the International Disaster Database of the Centre for Research on the Epidemiology of Disasters CRED EMDAT (www.emdat.be) suggests that Central and South America are among the region's most vulnerable to landslide risk (Nadim et al. 2013). Of the 180,000 disaster-related deaths recorded in South America from 1960 to 2009, 60% were caused by earthquakes or volcanic activity, and 32% of the deaths were due to meteorological or climatic events, such as heavy and intense rainfall (Nunes et al., 2015). In recent years, Brazil have experienced numerous deadly landslides triggered by heavy rainfall (Mendes et al. 2017, Cabral et al. 2022, Alcantara et al.,

Extended author information available on the last page of the article

Published online: 28 March 2024

Springer

Climate Dynamics
https://doi.org/10.1007/s00382-023-06937-x

Changes in compound drought-heat events over Brazil's Pantanal wetland: an assessment using remote sensing data and multiple drought indicators

Ana Paula M. A. Cunha[1] · Wolfgang Buermann[2] · José A. Marengo[1]

Received: 1 March 2023 / Accepted: 19 August 2023

Abstract
Brazil's Pantanal wetland is one of the most threatened Brazilian ecosystems from direct anthropogenic pressures and climate change. In this study, the overarching research question is to explore whether compound drought-heat events (CDHEs) have become more recurrent, intense, and widespread over Brazil's Pantanal wetland in recent decades. For this, we purpose and tested two different approaches using validated long-term time series of monthly precipitation, temperature, and the satellite-based Vegetation Health Index (VHI) to characterize the spatiotemporal pattern of CDHEs over Pantanal. Firstly, we assessed global gridded precipitation and temperature data sets against ground measurements to choose an appropriate dataset for this study. Then, we calculated the Standardized Precipitation Index (SPI), Standardized Temperature Index (STI), and Standardized Precipitation Evapotranspiration Index (SPEI) from 1981 to 2021. The results showed that using both approaches (CDHE-M1 and CDHE-M2), the frequency of events is higher considering the moderate category, which is expected since the criteria are less restrictive. In addition, the highest frequency of CDHE events occurs between September and November (the end of the dry season). The results also indicated that CDHE events have been more recurrent and widespread since 2000 in Pantanal. Besides, considering all methods for identifying the CDHEs, the probability density function indicates a shift pattern to warmer and drier conditions in the last 40 years. The Mann–Kendall tests also confirmed the assumption that there is a significantly increasing trend in the compound drought-heat events in the Pantanal. Developing methodologies for monitoring compound climate events is crucial for assessing climate risks in a warming climate. Besides, it is expected that our results contribute to the convincing of the urgent need for environmental protection strategies and disaster risk reduction plans for the Pantanal.

Keywords Compound drought-heat event · Pantanal wetland · Climate extremes · Drought indicators

1 Introduction

The frequency of extreme climate events has increased under the influence of global warming leading to an intensification of disasters, particularly those associated with hydrometeorological hazards (IPCC 2021). Along with the rise in extreme climate events, the simultaneous occurrence of multiple climate hazards has also increased and is projected to further increase in this century (Zscheischler et al. 2018, 2020; Vogel et al. 2020; IPCC 2021). Such simultaneous occurrences of two or more extreme events are generally defined as compound extremes (Hao et al. 2018b; Bezak and Mikoš 2020; Sutanto et al. 2020; Zscheischler et al. 2020; Ganguli 2022).

Compound drought-heat events (CDHEs), characterized by low water availability with coinciding high temperatures,

✉ Ana Paula M. A. Cunha
ana.cunha@cemaden.gov.br
Wolfgang Buermann
wolfgang.buermann@uni-a.de
José A. Marengo
jose.marengo@cemaden.gov.br
[1] National Center for Monitoring and Early Warning of Natural Disasters (CEMADEN), São José dos Campos, Brazil
[2] Augsburg University, Augsburg, Germany

Published online: 05 September 2023

ISSN 1831-9424

European Commission

JRC Technical Report

Drought in the Amazon basin November 2023

GDO Analytical Report

Copernicus
Europe's eyes on Earth

Emergency Management Service

Toreti, A., Bavera, D., Acosta Navarro, J., Arias Muñoz, C., Barbosa, P., Branco, A., Cunha, A. P.,de Jager, A., Fioravanti, G., Grimaldi, S., Hrast Essenfelder, A., Libertà, G., Maetens, W., Magni, D., Marengo, J.A., Masante, D., Mazzeschi, M., McCormick, N., Meroni, M., Dorn, D., Rembold, F., Salamon, P., San Miguel, J.

2023

EUR 31777 EN

Check for updates

AGU ADVANCING EARTH AND SPACE SCIENCES

Earth and Space Science

RESEARCH ARTICLE
10.1029/2023EA003279

Observed Global Changes in Sector-Relevant Climate Extremes Indices—An Extension to HadEX3

Robert J. H. Dunn[1], Nicholas Herold[2], Lisa V. Alexander[3,4], Markus G. Donat[5,6], Rob Allan[7], Margot Bador[8], Manola Brunet[9], Vincent Cheng[10], Wan Maisarah Wan Ibadullah[11], Muhammad Khairul Izzat Bin Ibrahim[12], Andries Kruger[13,14], Hisayuki Kubota[15], Tanya J. R. Lippmann[16], Jose Marengo[17], Sifiso Mbatha[13], Simon McGree[18], Sandile Ngwenya[13], Jose Daniel Pabon Caicedo[19], Andrea Ramos[20,21], Jim Salinger[22], Gerard van der Schrier[23], Arvind Srivastava[24], Blair Trewin[18], Ricardo Vásquez Yáñez[25], Jorge Vazquez-Aguirre[26], Claudia Villarroel Jiménez[25], Russ Vose[27], Mohd Noor'Arifin Bin Hj Yusof[12], and Xuebin Zhang[28]

[1]Met Office Hadley Centre, Exeter, UK, [2]Applied Climate Science Pid Ltd., Adelaide, SA, Australia, [3]Climate Change Research Centre, UNSW Sydney, Kensington, NSW, Australia, [4]ARC Centre of Excellence for Climate Extremes, UNSW Sydney, Kensington, NSW, Australia, [5]Barcelona Supercomputing Center, Barcelona, Spain, [6]Catalan Institution for Research and Advanced Studies (ICREA), Barcelona, Spain, [7]Centre for Maritime Historical Studies, University of Exeter, Exeter, UK, [8]CECI Université de Toulouse, CERFACS/CNRS, Toulouse, France, [9]Department of Geography, Centre for Climate Change, University Rovira I Virgili, Tarragona, Spain, [10]Climate Research Division, Environment and Climate Change Canada, Toronto, ON, Canada, [11]Malaysian Meteorological Department, Kuala Lumpur, Malaysia, [12]Brunei Darussalam Meteorological Department, Ministry of Transport and Infocommunications, Brunei, Brunei Darussalam, [13]Climate Service, South African Weather Service, Pretoria, South Africa, [14]Department of Geography, Geoinformatics and Meteorology, Faculty of Natural and Agricultural Sciences, University of Pretoria, Pretoria, South Africa, [15]Department of Earth and Planetary Sciences, Hokkaido University, Sapporo, Japan, [16]Department of Earth Sciences, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands, [17]National Center for Monitoring and Early Warning of Natural Disasters CEMADEN, Sao Paulo, Brazil, [18]The Bureau of Meteorology, Melbourne, VIC, Australia, [19]Departamento de Geografía, Universidad Nacional de Colombia, Bogotá, Colombia, [20]Instituto Nacional de Meteorologia—INMET, Brasília, Brazil, [21]Fundação de Desenvolvimento Científico e Cultural, Lavras, Brazil, [22]School of Geography, Environmental and Earth Sciences, Victoria University of Wellington, Wellington, New Zealand, [23]Royal Netherlands Meteorological Institute, De Bilt, The Netherlands, [24]Climate Research and Services, IMD Pune, Pune, India, [25]Dirección Meteorológica de Chile, Santiago, Chile, [26]WMO Expert Team on Climate Information for Decision-Making (ET-CID), Xalapa, Mexico, [27]NOAA/NCEI, Asheville, NC, USA, [28]Pacific Climate Impacts Consortium, University of Victoria, Victoria, BC, Canada

Key Points:
- We present a sector specific extension to a data set of gridded temperature and precipitation extremes
- This first quasi-global product of these indices will support decision makers in a wide range of sectors
- Long-term changes show increases in intensity, frequency, and duration of warm extremes, and corresponding decreases in cool extremes

Supporting Information:
Supporting Information may be found in the online version of this article.

Correspondence to:
R. J. H. Dunn,
robert.dunn@metoffice.gov.uk

Citation:
Dunn, R. J. H., Herold, N., Alexander, L. V., Donat, M. G., Allan, R., Bador, M., et al. (2024). Observed global changes in sector-relevant climate extremes indices—An extension to HadEX3. *Earth and Space Science, 11*, e2023EA003279. https://doi.org/10.1029/2023EA003279

Received 7 SEP 2023
Accepted 15 JAN 2024

Author Contributions:
Conceptualization: Robert J. H. Dunn, Lisa V. Alexander, Markus G. Donat
Data curation: Robert J. H. Dunn
Formal analysis: Robert J. H. Dunn
Investigation: Robert J. H. Dunn

Abstract Global gridded data sets of observed extremes indices underpin assessments of changes in climate extremes. However, similar efforts to enable the assessment of indices relevant to different sectors of society have been missing. Here we present a data set of sector-specific indices, based on daily station data, that extends the HadEX3 data set of climate extremes indices. These additional indices, which can be used singly or in combinations, have been recommended by the World Meteorological Organization and are intended to empower decision makers in different sectors with accurate historical information about how sector-relevant measures of the climate are changing, especially in regions where in situ daily temperature and rainfall data are hard to come by. The annual and/or monthly indices have been interpolated on to a 1.875° × 1.25° longitude-latitude grid for 1901–2018. We show changes in globally-averaged time series of these indices in comparison with reanalysis products. Changes in temperature-based indices are consistent with global scale warming, with days with T_{max} > 30°C (TXge30) increasing virtually everywhere with potential impacts on crop fertility. At the other end of the scale, the number of days with T_{min} < −2°C (TNltm2) are reducing, decreasing potential damage from frosts. Changes in heat wave characteristics show increases in the number, duration and intensity of these extreme events in most places. The gridded netCDF files and, where possible, the underlying station indices are available from https://www.metoffice.gov.uk/hadobs/hadex3 and https://www.climdex.org.

Plain Language Summary To be able to assess changes in extreme temperature and rainfall events across the globe, data sets which capture characteristics of these extreme events are required. The use of indices for these characteristics further enables both data sharing and the comparison of events across the world. Extreme events have impacts across human health, our infrastructure and the natural environment. So far there has not been a global product which presents indices which are relevant for different sectors of our society.

Theoretical and Applied Climatology
https://doi.org/10.1007/s00704-023-04655-2

RESEARCH

Multiscale analysis of drought, heatwaves, and compound events in the Brazilian Pantanal in 2019–2021

Mabel Calim Costa[1] · Jose A. Marengo[1] · Lincoln M. Alves[2] · Ana Paula Cunha[1]

Received: 14 September 2022 / Accepted: 11 September 2023

Abstract
In this study, a comprehensive multiscale analysis of compounding drought-heat events in the Pantanal region is presented. The goal is to assess the multiscale nature of drought and determine whether the combined effects of drought and heatwaves, as driving factors, are more relevant than the effects of each event separately. The study describes a persistent interannual extreme event characterized by drought and heatwaves in the Pantanal, lasting from 2019 to 2021. The extreme event involved a prolonged dry season, a shortened and delayed rainy season, and persistent heatwaves, resulting in the emergence of drought-heat compound events. Despite experiencing consecutive months of increasing drought hazards and a delayed rainy season in late 2020 to 2021, the northern Pantanal region was unable to recover from the water deficit accumulated due to water stress in the previous year. This emphasizes the long-lasting impacts of compound events on water availability and ecosystem health. Furthermore, the study suggests that interannual water stress played a crucial role in explaining the context that led to record-breaking daily maximum temperatures during the austral spring of 2020. The regions most at risk for such compound extreme events are the northern and central Pantanal. Looking at longer timescales, the analysis of compound drought-heat events can provide insights essential for understanding and preventing their impacts, particularly those that could trigger fire outbreaks.

Highlights
- Despite consecutive months of increasing drought hazards and a delayed rainy season in late 2020–2021, recovery from the water deficit caused by water stress in 2020 was insufficient.
- Interannual water stress plays a crucial role in explaining the context behind the record-breaking daily maximum temperatures during the austral spring of 2020.
- Interannual compound drought-heatwave effects persisted even during the rainy season.
- Compound events on a broader scale (scale 12) encompassed 80% of the study area in 2019 and expanded to 89% in 2020.
- The study emphasized the significance of drought effects and compound events on longer timescales (>3 months). It also identified a strong seasonal pattern in accumulative heatwave coverage, with a scale of 6 months.
- Partial and multiple coherence analyses indicated that conducting single-factor assessments in isolation at a single scale can undermine results and lead to a misunderstanding of the overall complexity of extreme event contexts.
- The study advocates for analyzing drought-heat events as compound occurrences rather than isolated extremes, as this approach offers the most accurate insight into the multifaceted nature of such events.

✉ Mabel Calim Costa
mabelcalim@gmail.com
[1] National Center for Monitoring and Early Warning of Natural Disasters, São José dos Campos, Brazil

Published online: 26 September 2023

1 Introduction

A complex interplay among several contributing factors, including meteorological and hydrological conditions, the availability of fuel material (dry biomass-vegetation from legal or illegal land use practices), and human ignition sources (accidental and intended), can cause unprecedented fire outbreaks. The catastrophic fires in California in 2020 and the unusual fire activity in regions such as Oceania, Euro-Asia, North America, and Central South America were no exception (Thielen et al. 2021). In 2020, the Pantanal biome faced the most devastating fires in the last two decades (Silva et al. 2022a). Around a third of the Brazilian section of the Pantanal was affected, including several indigenous territories and conservation units (Abram et al. 2021; Canadell 2021; Dowdy et al. 2022; Libonati et al. 2022). Between January and August 2020, 7,727 fires were detected. This number represents an increase of 211% compared to the same period in 2019.

[2] National Institute for Space Research (INPE), São José dos Campos, Brazil

Nat. Hazards Earth Syst. Sci., 23, 1–19, 2023
https://doi.org/10.5194/nhess-23-1-2023

Natural Hazards and Earth System Sciences

Deadly disasters in southeastern South America: flash floods and landslides of February 2022 in Petrópolis, Rio de Janeiro

Enner Alcântara[1], José A. Marengo[1,2], José Mantovani[1], Luciana R. Londe[1,2], Rachel Lau Yu San[3], Edward Park[3], Yunong Nina Lin[4], Jingyu Wang[5], Tatiana Mendes[1,5], Ana Paula Cunha[1,2], Luana Pampuch[1,5], Marcelo Seluchi[2], Silvio Simões[1], Luz Adriana Cuartas[1,2], Demerval Gonçalves[2], Klécia Massi[1,5], Regina Alvalá[1,2], Osvaldo Moraes[1,2], Carlos Souza Filho[6], Rodolfo Mendes[1,2], and Carlos Nobre[1,7]

[1]Graduate Program in Natural Disasters, Unesp/CEMADEN, São José dos Campos, Brazil
[2]National Center for Monitoring and Early Warning of Natural Disasters (CEMADEN), São José dos Campos, Brazil
[3]National Institute of Education, Earth Observatory of Singapore and Asian School of the Environment, Nanyang Technological University (NTU), Singapore
[4]Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan
[5]Department of Environmental Engineering, Institute of Science and Technology, São Paulo State University (Unesp), São José dos Campos, Brazil
[6]Institute of Geosciences (IG/Unicamp), University of Campinas, Campinas, Brazil
[7]Institute of Advanced Studies, University of São Paulo (IEA/USP), São Paulo, Brazil

Correspondence: Enner Alcântara (enner.alcantara@unesp.br)

Received: 2 June 2022 – Discussion started: 10 June 2022
Revised: 15 February 2023 – Accepted: 5 March 2023 – Published:

Abstract. On 15 February 2022, the city of Petrópolis in the highlands of the state of Rio de Janeiro, Brazil, received an unusually high volume of rain within 3 h (258 mm), generated by a strongly invigorated mesoscale convective system. It resulted in flash floods and subsequent landslides that caused the deadliest landslide disaster recorded in Petrópolis, with 231 fatalities. In this paper, we analyzed the root causes and the key triggering factors of this landslide disaster by assessing the spatial relationship of landslide occurrence with various environmental factors. Rainfall data were retrieved from 1977 to 2022 (a combination of ground weather stations and the Climate Hazards Group InfraRed Precipitation – CHIRPS). Remotely sensed data were used to map the landslide scars, soil moisture, terrain attributes, line-of-sight displacement (land surface deformation), and urban sprawling (1985–2020). The results showed that the average monthly rainfall for February 2022 was 200 mm, the heaviest recorded in Petrópolis since 1932. Heavy rainfall was also recorded mostly in regions where the landslide occurred, according to analyses of the rainfall spatial distribution. As for terrain, 23 % of slopes between 45–60° had landslide occurrences and east-facing slopes appeared to be the most conducive for landslides as they recorded landslide occurrences of about 9 % to 11 %. Regarding the soil moisture, higher variability was found in the lower altitude (842 m) where the residential area is concentrated. Based on our land deformation assessment, the area is geologically stable, and the landslide occurred only in the thin layer at the surface. Out of the 1700 buildings found in the region of interest, 1021 are on the slope between 20 to 45° and about 60 houses were directly affected by the landslides. As such, we conclude that the heavy rainfall was not the only cause responsible for the catastrophic event of 15 February 2022; a combination of unplanned urban growth on slopes between 45–60°, removal of vegetation, and the absence of inspection were also expressive driving forces of this disaster.

1 Introduction and background

The municipality of Petrópolis is nestled in the mountains, 68 km from the city of Rio de Janeiro. It presents a rugged relief with numerous cliffs, and it is populated by approximately 305 687 inhabitants. The city is predominantly

Published by Copernicus Publications on behalf of the European Geosciences Union.

IOP Publishing Environ. Res. Lett. 19 (2024) 054030 https://doi.org/10.1088/1748-9326/ad3e10

ENVIRONMENTAL RESEARCH
LETTERS

LETTER

Drought intensification in Brazilian catchments: implications for water and land management

André S Ballarin[1,*], Müsel Rodrigo Vargas Godoy[2,3], Masoud Zaerpour[4], Hebatallah M Abdelmoaty[2], Shadi Hatami[2,4], Yohanne I. Gavasso-Rita[2], Edson Wendland[1] and Simon Michael Papalexiou[2,4]

[1] Department of Hydraulics and Sanitary Engineering, São Carlos School of Engineering, University of São Paulo, São Carlos, Brazil
[2] Department of Civil Engineering, University of Calgary, Calgary, Canada
[3] Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Prague, Czech Republic
[4] Department of Bioresources Engineering, McGill University, Ste-Anne-de-Bellevue, Quebec, Canada
* Author to whom any correspondence should be addressed.
E-mail: sballarin@gmail.com

Keywords: meteorological droughts, global warming, Brazil, extreme events, water security
Supplementary material for this article is available online

Abstract
Droughts exert widespread impacts on both natural and social systems, and there is accumulating evidence that this situation may worsen in the context of global warming. Despite the importance of assessing changes in droughts to understand their potential future impacts on society, studies are unevenly distributed worldwide. In this study, utilizing bias-corrected CMIP6 simulations and a standard precipitation-evaporation index based approach, we quantified expected changes in future drought properties across 735 Brazilian catchments under SSP2-4.5 and SSP5-8.5 scenarios. Beyond evaluating the statistical properties of future droughts, we assessed their occurrence under both land use and water demand perspectives and propose a new framework to better understand their link with changes in long- and short-term conditions of precipitation (P) and potential evapotranspiration (PET). Our results indicate that drought events are projected to become more frequent and severe in the future, with high CMIP6 model agreement. According to the SSP5-8.5 scenario, at least half of Brazilian cropland and pasture areas will experience an increase of over 30% in drought properties by the end of the century. Furthermore, among the 85% of catchments expected to experience more severe droughts, nearly 90% are also projected to exhibit increased water demand, which will likely exacerbate future water scarcity. The investigation of the relationship between droughts changes and climate variables suggests that catchments with augmented droughts in the future will likely exhibit increased long-term average PET and P-variability, but not necessarily long-term average P. For instance, over 50% of evaluated Brazilian catchments are expected to experience an intensification of drought properties even with increases in P_{mean}. We believe this study may contribute (a) to improve Brazilian water resiliency by helping achieve the objectives of the National Water Security Plan and (b) to deepen our understanding of droughts in an uncertain future.

1. Introduction

Among climate-related hazards, droughts emerge as the most challenging for natural and social systems (De Luca and Donat 2023), as they might disrupt a myriad of facets, including food production, power generation, and water resources (Vicente-Serrano *et al* 2022, Cardenas Belleza *et al* 2023). Hence, understanding and predicting drought properties are essential to address their potential impacts on society and develop mitigation strategies, especially in the context of global warming, which is expected

www.nature.com/scientificreports

scientific reports

OPEN

Amazon savannization and climate change are projected to increase dry season length and temperature extremes over Brazil

Marcus Jorge Bottino[1✉], Paulo Nobre[1], Emanuel Giarolla[1], Manoel Baptista da Silva Junior[1], Vinicius Buscioli Capistrano[1], Marta Malagutti[1], Jonas Noboru Tamaoki[1], Beatriz Fátima Alves de Oliveira[2] & Carlos Afonso Nobre[1]

Land use change and atmospheric composition, two drivers of climate change, can interact to affect both local and remote climate regimes. Previous works have considered the effects of greenhouse gas buildup in the atmosphere and the effects of Amazon deforestation in atmospheric general circulation models. In this study, we investigate the impacts of the Brazilian Amazon savannization and global warming in a fully coupled ocean-land-sea ice-atmosphere model simulation. We find that both savannization and global warming individually lengthen the dry season and reduce annual rainfall over large tracts of South America. The combined effects of land use change and global warming resulted in a mean annual rainfall reduction of 44% and a dry season length increase of 69%, when averaged over the Amazon basin, relative to the control run. Modulation of inland moisture transport due to savannization shows the largest signal to explain the rainfall reduction and increase in dry season length over the Amazon and Central-West. The combined effects of savannization and global warming resulted in maximum daily temperature anomalies, reaching values of up to 14 °C above the current climatic conditions over the Amazon. Also, as a consequence of both climate drivers, both soil moisture and surface runoff decrease over most of the country, suggesting cascading negative future impacts on both agriculture production and hydroelectricity generation.

In addition to being the habitat of a great number of vegetal and animal species[1], the Amazon rainforest is also known to be an important player in the global climatic system. Several works have demonstrated its role in modulating rainfall and air temperature, both locally (e.g., [2–5]) and remotely[6,7]. One role of the Amazon rainforest is to regulate the hydrological cycle both over the forest itself and in distant areas[8,9]. Via intense evapotranspiration, the tropical forest pumps latent heat deep into the atmosphere to balance the strong surface radiative heating[10]. Furthermore, moisture recycling processes are an important mechanism for the advection of water vapor towards the interior of the continent[11,12,4]. Water vapor originating from the tropical Atlantic Ocean is transported over South America by the Trade Winds, feeding into the precipitation processes over the Amazon basin[13,14]. A portion of the transported water vapor reaches the western portion of the basin with replenishing water vapor content supplied by Amazon rainforest evapotranspiration[15]. However, we have yet to investigate to what extent two competing factors induce rainfall reductions over the Amazon Basin and elsewhere in South America, namely savannization (i.e. the substitution of the original Amazonian broadleaf evergreen trees by broadleaf trees with ground cover) and global warming. Additionally, it is of interest to gauge the dependence of the agricultural growing season in Central-West and elsewhere in Southern Brazil on the upstream water vapor transport contribution from the Amazon rainforest[16]. A study using satellite-based and rain gauge observations from 1981 to 2019 found that a large fraction of this agriculturally important region has experienced reduced dry season rainfall[18]. Over the state of Rondônia in Brazil, water vapor originating from ocean evaporation accounts for 58% of the mean dry season precipitation while continental recycling contributes 42%[17]. One mechanism

[1]National Institute for Space Research – INPE, Rodovia Presidente Dutra SP-RJ Km 40, Cachoeira Paulista, São Paulo 12630-000, Brazil. [2]Federal University of Mato Grosso Do Sul (UFMS), Campo Grande, Mato Grosso do Sul, Brasil. [3]Fiocruz Regional Office of Piauí, National School of Public Health, Oswaldo Cruz Foundation, Teresina, Piauí, Brazil. [4]Institute of Advanced Studies (IEA), São Paulo University, São Paulo, São Paulo, Brazil. ✉email: mjbottino@gmail.com

International Journal of Disaster Risk Reduction 104 (2024) 104396

Contents lists available at ScienceDirect
International Journal of Disaster Risk Reduction
journal homepage: www.elsevier.com/locate/ijdrr

The prevalence of objectivist risk in official DRR terminology and a consistent mathematical equation to define it

Osvaldo Luiz Leal de Moraes[a,*], Renato Santos Lacerda[b]

[a] Climate and Sustainability Department, Ministry of Science, Technology and Innovation, Brasília, DF, Brazil
[b] National Early Warning and Monitoring Centre of Natural Disaster, Estrada Dr. Altino Bondesan 500, São José Dos Campos, SP, Brazil

ARTICLE INFO

Keywords:
DRR terminology
Disaster risk
Probability theory
Anthropic hazards

ABSTRACT

In this article, we show that the objectivist school of risk prevails in the terminology of disasters used in the DRR structures created by the UN since the 1990s. In particular, the concept of risk has gained prominence in all updates and revisions of terminology and is included in more than 30% of the concepts in the most recent terminology. The concept of risk adopted by the UNDRR is closely associated with the theory of probability developed by Pascal and Fermat in the 17th century. This association is used in this article to present a definition of risk in which threats from nature are placed on the same hierarchical level as the other elements that make up objectivist risk. Such a structure not only simplifies the definition of risk, but also serves as a guide for risk mitigation measures that can be taken by decision makers.

1. Introduction

Over the centuries, the meaning of the word "risk" has changed and its use has become widespread and is applied to a variety of situations. The origin of the word and the concept of risk goes back to early seafaring and was used to describe the dangers that could jeopardize a voyage. At that time, the concept of risk excluded the idea of human fault and responsibility. The change in the meaning and use of the term risk is linked to the advent of modernity, which began in the 17th century. In the eighteenth century, the concept of risk was scientifically reappraised, using new ideas from mathematics in relation to probability [1].

According to Beck [2], the term "risk" has two completely different meanings. On the one hand, it refers to a world that is completely governed by the laws of probability; on the other hand, this word is also used for non-quantifiable uncertainties. This second view is based on the fact that our decisions entail consequences and dangers, and this is in stark contrast to the institutionalized language of control. The first view of risk described above is that of the objectivist school of thought, while the second is held by the constructivist school of thought. In the objectivist school, risk is a way of imagining what might happen in the future, based on knowledge of some underlying factors, whereas in the constructivist school, risk is a result of individual perception, as risk lies in singular observation rather than objective reality.

According to Peter Bernstein [3], the central idea of the objectivist school, i.e. the concept of risk in the probabilistic sense, is one of the ideas that distinguishes modernity from the ancient past. "Against the Gods" [3] describes the remarkable intellectual adventure that has freed humanity from oracles and prophets by using the powerful tools of risk management available to us today.

It is fascinating to realize that modern society's urge to use numbers to calculate probabilities has its origins in the adoption of the Hindu-Arabic system in Italy in the early thirteenth century. Risk and probabilities have thus been associated with our daily lives since the Renaissance [3]. However, the development of the probabilistic concept of risk was born when Antoine Gombaud, who was

* Corresponding author.
E-mail addresses: osvaldo.moraes@mcti.gov.br (O.L. Leal de Moraes), renato.lacerda@cemaden.gov.br (R. Santos Lacerda).

https://doi.org/10.1016/j.ijdrr.2024.104396
Received 20 July 2023; Received in revised form 8 March 2024; Accepted 9 March 2024
Available online 11 March 2024
2212-4209/

Analysis

Critical transitions in the Amazon forest system

https://doi.org/10.1038/s41586-023-06970-0
Received: 29 August 2022
Accepted: 13 December 2023
Published online: 14 February 2024
Open access
Check for updates

Bernardo M. Flores[1,2], Encarni Montoya[3], Boris Sakschewski[4], Nathália Nascimento[5], Arie Staal[6], Richard A. Betts[4,7], Carolina Levis[1], David M. Lapola[8], Adriane Esquivel-Muelbert[9,10], Catarina Jakovac[11], Carlos A. Nobre[8], Rafael S. Oliveira[12], Laura S. Borma[13], Da Nian[14], Niklas Boers[15,16], Susanna B. Hecht[17], Hans ter Steege[18,19], Júlia Arieira[20], Isabella L. Lucas[20], Erika Berenguer[20,21], José A. Marengo[22,23,24], Luciana V. Gatti[25], Caio R. C. Mattos[26] & Marina Hirota[27,28] ✉

The possibility that the Amazon forest system could soon reach a tipping point, inducing large-scale collapse, has raised global concern[1–3]. For 65 million years, Amazonian forests remained relatively resilient to climatic variability. Now, the region is increasingly exposed to unprecedented stress from warming temperatures, extreme droughts, deforestation and fires, even in central and remote parts of the system[4]. Long existing feedbacks between the forest and environmental conditions are being replaced by novel feedbacks that modify ecosystem resilience, increasing the risk of critical transition. Here we analyse existing evidence for five major drivers of water stress on Amazonian forests, as well as potential critical thresholds of those drivers that, if crossed, could trigger local, regional or even biome-wide forest collapse. By combining spatial information on various disturbances, we estimate that by 2050, 10% to 47% of Amazonian forests will be exposed to compounding disturbances that may trigger unexpected ecosystem transitions and potentially exacerbate regional climate change. Using examples of disturbed forests across the Amazon, we identify the three most plausible ecosystem trajectories, involving different feedbacks and environmental conditions. We discuss how the inherent complexity of the Amazon adds uncertainty about future dynamics, but also reveals opportunities for action. Keeping the Amazon forest resilient in the Anthropocene will depend on a combination of local efforts to end deforestation and degradation and to expand restoration, with global efforts to stop greenhouse gas emissions.

The Amazon forest is a complex system of interconnected species, ecosystems and human cultures that contributes to the well-being of people globally[1]. The Amazon forest holds more than 10% of Earth's terrestrial biodiversity, stores an amount of carbon equivalent to 15–20 years of global CO_2 emissions (150–200 Pg C), and has a net cooling effect (from evapotranspiration) that helps to stabilize the Earth's climate[1–5]. The forest contributes up to 50% of rainfall in the region and is crucial for moisture supply across South America[6], allowing other biomes and economic activities to thrive in regions that would otherwise be more arid, such as the Pantanal wetlands and the La Plata river basin[7]. Large parts of the Amazon forest, however, are projected to experience mass mortality events due to climatic and land use-related disturbances in the coming decades[3,8], potentially accelerating climate change through carbon emissions and feedbacks with the climate system[2,3]. These impacts would also involve irreversible loss of biodiversity, socioeconomic and cultural values[2,7–9]. The Amazon is home to more than 40 million people, including 2.2 million Indigenous peoples of more than 300 ethnicities, as well as afrodescendent and local traditional communities[9]. Indigenous peoples and local communities (IPLCs) would be harmed by forest loss in terms of their livelihoods, lifeways and knowledge systems that inspire societies globally[2,10].

[1]Graduate Program in Ecology, Federal University of Santa Catarina, Florianopolis, Brazil. [2]Geosciences Barcelona, Spanish National Research Council, Barcelona, Spain. [3]Potsdam Institute for Climate Impact Research, Member of the Leibniz Association, Potsdam, Germany. [4]Institute of Advanced Studies, University of São Paulo, São Paulo, Brazil. [5]Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, The Netherlands. [6]Met Office Hadley Centre, Exeter, UK. [7]Global Systems Institute, University of Exeter, Exeter, UK. [8]Center for Meteorological and Climatic Research Applied to Agriculture, University of Campinas, Campinas, Brazil. [9]School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, UK. [10]Birmingham Institute of Forest Research, University of Birmingham, Birmingham, UK. [11]Department of Plant Sciences, Federal University of Santa Catarina, Florianopolis, Brazil. [12]Department of Plant Biology, University of Campinas, Campinas, Brazil. [13]Division of Impacts, Adaptation and Vulnerabilities (DIAV), National Institute for Space Research, São José dos Campos, Brazil. [14]Earth System Modelling, School of Engineering and Design, Technical University of Munich, Munich, Germany. [15]Luskin School for Public Affairs and Institute of the Environment, University of California, Los Angeles, CA, USA. [16]Naturalis Biodiversity Center, Leiden, The Netherlands. [17]Quantitative Biodiversity Dynamics, Utrecht University, Utrecht, The Netherlands. [18]Science Panel for the Amazon (SPA), São José dos Campos, Brazil. [19]Sustainable Development Solutions Network, New York, NY, USA. [20]Environmental Change Institute, University of Oxford, Oxford, UK. [21]Centro Nacional de Monitoramento e Alerta de Desastres Naturais, São José dos Campos, Brazil. [22]Graduate Program in Natural Disasters, UNESP/CEMADEN, São José dos Campos, Brazil. [23]Graduate School of International Studies, Korea University, Seoul, Korea. [24]Program in Atmospheric and Oceanic Sciences, Princeton University, Princeton, NJ, USA. [25]Group IpES, Department of Physics, Federal University of Santa Catarina, Florianopolis, Brazil. ✉e-mail: mflores.bernardo@gmail.com; marinahirota@gmail.com

Theoretical and Applied Climatology
https://doi.org/10.1007/s00704-024-04857-2

RESEARCH

Analysis of extreme rainfall and landslides in the metropolitan region of the Paraiba do Sul River Valley and North Coast of Sao Paulo, Brazil

Rodrigo Cesar da Silva[1,2] · José Antônio Marengo[3,4] · Murilo Ruv Lemes[5,6]

Received: 30 October 2023 / Accepted: 21 January 2024

Abstract
The impact of hydrological and geological disasters has resulted in significant social, economic, and human losses, which added climate change impacts, and such events have become more frequent and intense. Therefore, our objective is to analyze the extreme rainfall (trends) in the Metropolitan Region of the Paraíba do Sul Valley and North Coast of Sao Paulo (RMVPLN). This analysis will support the most affected areas by landslides identification, which mainly impact roads and their population. In addition, evaluate the atmosphere conditions that supported these extreme rainfall events. To achieve our objectives, we have surveyed historical landslide data reported by the Brazilian government and information related by press and media. The precipitation evaluation used CHIRPS v.2 data and ETCCDI indices and the vertically integrated moisture flow and wind speed were calculated by ERA5 reanalysis. Our results show that the frequency and intensity of rainfall indicators such as seasonal PRCPTOT, R20mm, R30mm, and SDII have increased, particularly in the coastal and mountainous regions of São Paulo. This is due to positive anomalies of moisture transport and an increase of ocean winds influenced by the intense South Atlantic Subtropical Anticyclone (SASA). The region with the highest susceptibility to landslides triggered by extreme rainfall is the one that combines deforested areas, high slope topography, and excessive anthropic intervention. The presence of mountainous regions increases the risk of landslides, which can damage local infrastructure and expose the vulnerability of populations in these risk areas.

1 Introduction

The two most economically important Brazilian cities are São Paulo (SP) and Rio de Janeiro (RJ), which are in the Southeast region. Their estimated population in 2021 is around 12,396,372 and 6,775,561 inhabitants for SP and RJ, respectively (IBGE 2023). Between these two cities is located the Metropolitan Region of the Paraíba Valley. This region is the natural connection between SP and RJ and both cities are connected by Dutra Highway, which crosses the Paraíba do Sul River Valley. While the North Coast of Sao Paulo is not located here, we decided to include it in our analysis due to its elevated risk of extreme rainfall-triggered disasters. We refer to these regions as RMVPLN (in Portuguese). The RMVPLN shows a population of 2,506,181 inhabitants, and an urbanization rate of 94.8% (Waldvogel et al. 2021).

From the 1950s onwards, there was an option to adopt road transport in Brazil (Barat 1978), which should not occur in a country of continental dimensions. In this same period, there was an intense process of urbanization in urban centers (Santos 2008; Baer 2002), a period called the "rural exodus." Such fluxes occurred from medium-sized cities to state and federal capitals (Ricci 2006; Alves et al. 2011) without planning of the governments. Associated with the lack of environmental and urban planning (Rolnik 2011), these have resulted in disorderly urban expansion and occupation of risk areas (Mendes et al. 2018a). These are reflected in the installation of highways in areas of high

✉ Rodrigo Cesar da Silva
rodrigo.silva9378@etec.sp.gov.br

[1] Graduate Program in Natural Disasters, UNESP/CEMADEN, São José dos Campos, SP, Brazil
[2] Paula Souza State Technological Education Center, CEETEPS, São Paulo, SP, Brazil
[3] CEMADEN, National Center for Monitoring and Early Warning of Natural Disasters, São José dos Campos, SP, Brazil
[4] Graduate School of International Studies, Korea University, Seoul, South Korea
[5] University of Manchester, Manchester, UK
[6] Earth System Science Post-Graduation, INPE, São José dos Campos, SP, Brazil

Published online: 01 February 2024

Springer

Earth's Future
RESEARCH ARTICLE
10.1029/2023EF004053

Frequency Rather Than Intensity Drives Projected Changes of Rainfall Events in Brazil

André S. Ballarin[1,2], Edson Wendland[1], Masoud Zaerpour[3], Shadi Hatami[2,3], Antônio A. Meira Neto[4], and Simon Michael Papalexiou[2,3]

[1]Department of Hydraulics and Sanitary Engineering, São Carlos School of Engineering, University of São Paulo, São Carlos, Brazil, [2]Department of Civil Engineering, University of Calgary, Calgary, AB, Canada, [3]Department of Bioresources Engineering, McGill University, Ste-Anne-de-Bellevue, QC, Canada, [4]Department of Civil and Environmental Engineering, Colorado State University, Fort Collins, CO, USA, [5]Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Prague, Czech Republic

Abstract Extreme rainfall events are expected to intensify with global warming, posing significant challenges to both human and natural environments. Despite the importance of such assessments, they are unevenly widespread across the globe. Here, using bias corrected climate simulations of the latest phase of the Coupled Model Intercomparison Project (CMIP6), we provide a comprehensive assessment on how different rainfall events are expected to change across Brazil. Specifically, (a) we explored the projected changes in both intensity and frequency of rainfall events belonging to the right-tail of the rainfall distribution using a non-parametric approach, and (b) quantified how rainfall events associate with different return periods are expected to intensify, using a parametric approach. We found that extreme rainfall events will become more frequent and intense by the end of the century, with averaged projected changes for rainfall exceeding the historical rainfall quantile $q_{0.99}$ of nearly 100% and 10% on frequency and intensity, respectively. Non-extreme rainfall events, in contrast, are expected to be less frequent, aligning with the compensation hypothesis. For instance, Brazilian 100-year rainfall are anticipated to intensify, on average, 17% and 31% under the moderate and the highest CMIP6 emissions scenarios, respectively. Finally, our findings reveal that frequency, rather than intensity, dictates the projected changes of rainfall. We believe that the evidence gathered here will certainly contribute to not only an improved understanding of Brazilian rainfall events but also to a better comprehension of the different rainfall properties, their interplay and how the different ways of assessing them may affect climate studies.

Plain Language Summary The dynamics of rainfall events are expected to change in the future due to global warming. Understanding how this is likely to happen is extremely important for society, since this information is usually required for water resources management and for the design of infrastructure systems. To this end, studies commonly rely on climate models simulations, as they can offer a preview of forthcoming scenarios, helping us to understand the potential effects of such changes to society. Here, using the last generation of climate model projections, we propose an alternative way to explore how rainfall events might change in Brazil. Our results show that heavy rainfall events will be much more frequent and stronger in the future. For example, heavy rain that usually happens once in 100 years in Brazil could become nearly 31% stronger by the end of the century. Less intense rainfall events, on the other hand, might happen less often. Our results also indicated that changes in the frequency of rainfall events, rather than in their intensity, rules how they are expected to change. This study helps us understand not only what might happen to rainfall events in Brazil but also to improve future climate change impact studies.

1. Introduction

Extreme precipitation events underlie many of the most significant challenges society faces (Kirchmeier-Young & Zhang, 2020). Their negative impacts on both natural and human environments are responsible for billions of dollars in economic damages and immeasurable human losses (Doocy et al., 2013; McBean & Rodgers, 2010; Nissen & Ulbrich, 2017). Consequently, the understanding of extreme rainfall has gained considerable attention in recent decades, being recognized as one of the scientific Great Challenges by the World Climate Research Programme (Diffenbaugh et al., 2017; Sillmann et al., 2017). Despite significant advancements in characterizing such events, there remain unresolved questions that underscore the need for an enhanced understanding of their

Key Points:
- Coupled Model Intercomparison Project 6-based assessment of projected changes in the distribution of rainfall events in Brazil
- Extreme and light/moderate rainfall events are expected to increase and decrease in the country, respectively
- Frequency, rather than intensity, dictates the projected changes in future rainfall events

Supporting Information:
Supporting Information may be found in the online version of this article.

Correspondence to:
A. S. Ballarin,
andre.ballarin@usp.br

Citation:
Ballarin, A. S., Wendland, E., Zaerpour, M., Hatami, S., Meira Neto, A. A., & Papalexiou, S. M. (2024). Frequency rather than intensity drives projected changes of rainfall events in Brazil. *Earth's Future*, *12*, e2023EF004053. https://doi.org/10.1029/2023EF004053

Received 16 AUG 2023
Accepted 22 DEC 2023

Author Contributions:
Conceptualization: André S. Ballarin, Shadi Hatami, Antônio A. Meira Neto, Simon Michael Papalexiou
Funding acquisition: Edson Wendland
Investigation: André S. Ballarin
Methodology: André S. Ballarin, Masoud Zaerpour
Supervision: Edson Wendland, Simon Michael Papalexiou
Validation: André S. Ballarin
Visualization: André S. Ballarin
Writing – original draft: André S. Ballarin
Writing – review & editing: André S. Ballarin, Edson Wendland, Masoud Zaerpour, Shadi Hatami, Antônio A. Meira Neto, Simon Michael Papalexiou

Scientific Research Publishing

International Journal of Geosciences, 2023, 14, 1146-1159
https://www.scirp.org/journal/ijg
ISSN Online: 2156-8367
ISSN Print: 2156-8359

The SNAKE System: CEMADEN's Landslide Early Warning System (LEWS) Mechanism

Marcio Roberto Magalhães de Andrade[1*], Cassiano Antonio Bortolozo[1], Adenilson Roberto Carvalho[1], Harideva Marturano Egas[1], Klaifer Garcia[1], Daniel Metodiev[1], Tulius Dias Nery[1], Carla Prieto[1], Tristan Pryer[2], Silvia Midori Saito[1], Graziela Scofield[1]

[1]CEMADEN—National Center for Monitoring and Early Warning of Natural Disasters, General Coordination of Research and Development, São José dos Campos, Brazil
[2]Department of Mathematical Sciences, University of Bath, Bath, UK
Email: *marcio.andrade@cemaden.gov.br

How to cite this paper: de Andrade, M.R.M., Bortolozo, C.A., Carvalho, A.R., Egas, H.M., Garcia, K., Metodiev, D., Nery, T.D., Prieto, C., Pryer, T., Saito, S.M. and Scofield, G. (2023) The SNAKE System: CEMADEN's Landslide Early Warning System (LEWS) Mechanism. *International Journal of Geosciences*, 14, 1146-1159.
https://doi.org/10.4236/ijg.2023.1411058

Received: October 7, 2023
Accepted: November 27, 2023
Published: November 30, 2023

Abstract
In Brazil, the prominent climate-induced disasters are floods and mass movements, with the latter being the most lethal. The spate of major landslide events, especially those in 2011, catalyzed the creation of CEMADEN (National Center for Monitoring and Early Warning of Natural Disasters). This article introduces one of CEMADEN's pivotal systems for early landslide warnings and traces its developmental timeline. The highlighted SNAKE System epitomizes advancements in digital monitoring, forecasting, and alert mechanisms. By leveraging precipitation data from pluviometers in observed municipalities, the system bolsters early warnings related to potential mass movements, like planar slides and debris flows. Its deployment in CEMADEN's Situation Room attests to its suitability for overseeing high-risk municipalities, attributed primarily to its robustness and precision.

Keywords
Natural Disasters, Landslide Early Warning System (LEWS), SNAKE System, CEMADEN, Brazil

1. Introduction

The disaster risks in Brazil stemming from excessive rainfall primarily manifest as floods and mass movements, such as landslides [1] [2]. In fact, landslides are the deadliest hazard in the country [3]. Notably, a significant landslide event in the mountainous region of the state of Rio de Janeiro took place in 2011, resulting in over 900 deaths and 300 missing individuals [4]. Following this tragedy,

www.nature.com/scientificreports

scientific reports

OPEN

The new record of drought and warmth in the Amazon in 2023 related to regional and global climatic features

Jhan-Carlo Espinoza[1,2]✉, Juan Carlos Jimenez[3], José Antonio Marengo[4,5,6], Jochen Schongart[7], Josyane Ronchail[8], Waldo Lavado-Casimiro[9] & João Vitor M. Ribeiro[4]

In 2023 Amazonia experienced both historical drought and warm conditions. On October 26th 2023 the water levels at the port of Manaus reached its lowest record since 1902 (12.70 m). In this region, October monthly maximum and minimum temperature anomalies also surpassed previous record values registered in 2015 (+3 °C above the normal considering the 1981–2020 average). Here we show that this historical dry and warm situation in Amazonia is associated with two main atmospheric mechanisms: (i) the November 2022–February 2023 southern anomaly of vertical integrated moisture flux (VIMF), related to VIMF divergence and extreme rainfall deficit over southwestern Amazonia, and (ii) the June–August 2023 downward motion over northern Amazonia related to extreme rainfall deficit and warm conditions over this region. Anomalies of both atmospheric mechanisms reached record values during this event. The first mechanism is significantly correlated to negative sea surface temperature (SST) anomalies in the equatorial Pacific (November–February La Niña events). The second mechanism is significantly correlated to positive SST anomalies in the equatorial Pacific, related to the impacts of June–September El Niño on the Walker Circulation. While previous extreme droughts were linked to El Niño (warmer North Tropical Atlantic SST) during the austral summer (winter and spring), the transition from La Niña 2022–23 to El Niño 2023 appears to be a key climatic driver in this record-breaking dry and warm situation, combined to a widespread anomalous warming over the worldwide ocean.

Amazonia hosts the Earth's largest tropical forests characterized by a unique biodiversity. The Amazon basin represents the largest hydrological basin on Earth (about 6.87 million km²) with 16–18% of the global freshwater discharge to the oceans. It is the largest and most intense terrestrial convective centre in the Earth system, coupled to global atmospheric circulations[1]. Approximately 13% of global precipitation over the continental areas is concentrated in the Amazon basin, which just accounts for 4.6% of the world's land area[2]. Due to climate change and deforestation this biome is moving towards a "tipping point", especially in those regions affected by large-scale deforestation, forest fragmentation and degradation over the last decades[3]. Particularly in those regions a warming trend[4,5], the lengthening of the dry season[6–8], and a decline of carbon sink[9] are observed.

At the Port of Manaus (Central Amazonia; Fig. 1a), where daily water level measurements of the Rio Negro exist since September 1902, a state of emergency is declared when the water level is below 15.8 m (a threshold

[1]Institut des Géosciences de l'Environnement, IRD, CNRS, Université Grenoble Alpes, 70 Rue de La Physique, Bat. OSUG- B. Domaine Universitaire, 38400 Saint Martin d'Hères, France. [2]Instituto de Investigación Sobre la Enseñanza de las Matemáticas (IREM PUCP), Pontificia Universidad Católica del Perú, Lima 15088, Peru. [3]Global Change Unit (GCU) of the Image Processing Laboratory (IPL), Universitat de València Estudi General (UVEG), C/ Catedrático José Beltrán 2, 46980 Paterna, Valencia, Spain. [4]National Centre for Monitoring and Early Warning of Natural Disasters CEMADEN, Estrada Doutor Altino Bondesan, 500 - Distrito de Eugênio de Melo, São José dos Campos, SP CEP:12.247-060, Brazil. [5]Institute of Science and Technology, São Paulo State University, UNESP, São José dos Campos, SP, Brazil. [6]Graduate School of International Studies, Korea University, Seoul, South Korea. [7]Department of Environmental Dynamics, National Institute for Amazon Research (INPA), 2936, Av. André Araújo, Manaus, Amazonas 69067375, Brazil. [8]Laboratoire d'Océanographie et du Climat, LOCEAN-IPSL, IRD, CNRS, MNHN, Sorbonne Université, Paris, France. [9]Servicio Nacional de Meteorologia e Hidrologia (SENAMHI), Lima, Peru. ✉email: jhan-carlo.espinoza@ird.fr

AGU ADVANCING EARTH AND SPACE SCIENCES

Water Resources Research

RESEARCH ARTICLE

10.1029/2023WR034510

Water Charge and Conservation of Natural Areas: An Ex-Ante Assessment of a Policy Proposal for the Mantiqueira Region, Brazil

Ademir Rocha[1], Eduardo Haddad[1,2], Alan Leal[1], and João Corrêa[1]

[1]Department of Economics, University of São Paulo, São Paulo, Brazil, [2]Policy Center for the New South, Rabat, Morocco, [3]PGSES, Mohammed VI Polytechnic University, Rabat, Morocco

Key Points:
- Mantiqueira region houses a singular forest biome and provides fresh water to densely populated regions in Brazil
- Pigouvian water charge instrument can achieve economic and environmental benefits
- Interregional computable general equilibrium economic models have the flexibility to evaluate ex-ante water resources management policies

Correspondence to:
A. Rocha,
aarc.eco@gmail.com

Citation:
Rocha, A., Haddad, E., Leal, A., & Corrêa, J. (2023). Water charge and conservation of natural areas: An ex-ante assessment of a policy proposal for the Mantiqueira region, Brazil. *Water Resources Research*, *59*, e2023WR034510. https://doi.org/10.1029/2023WR034510

Received 22 JAN 2023
Accepted 22 SEP 2023

Author Contributions:
Conceptualization: Ademir Rocha, Eduardo Haddad, Alan Leal, João Corrêa
Formal analysis: Ademir Rocha, Alan Leal, João Corrêa
Funding acquisition: Eduardo Haddad
Methodology: Ademir Rocha, Eduardo Haddad
Writing – original draft: Ademir Rocha, Eduardo Haddad, Alan Leal, João Corrêa
Writing – review & editing: Ademir Rocha, Eduardo Haddad

Abstract Water plays a central role in several socioeconomic and environmental nexuses. Faced with various anthropogenic pressures that act as water scarcity drivers and knowing that the unavailability of water can be a limiting factor for economic development, there is an urgent need for the design and evaluation of economic instruments that help in the management of water resources. This article presents a proposal and assessment for a Pigouvian water charge instrument. The instrument suggests imposing a charge based on the amount of water consumed, targeting the agriculture, livestock, forest extraction, and aquaculture sectors. The revenue generated from this charge could be utilized to fund reforestation initiatives and support government expenditures, thereby creating both environmental and economic advantages. Based on a calibrated static computable general equilibrium economic model for the Brazilian Mantiqueira region, it was possible to estimate that a water charge policy at a rate of R$ 0.10/m³ (US$ 0.026/m³) could lead to an increase in the Brazilian GDP in the benchmark year by US$ 10.7 million. Economic benefits could also be verified at the regional level, especially in those areas where there are water-intensive economic activities. On the environmental side, the water charge could incentivize actions capable of recovering approximately 80 km² of natural areas.

1. Introduction

Water plays a central role in several socioeconomic and environmental nexuses (Vogel et al., 2015). In the water-society nexus, water is used for daily consumption activities, and hygiene is perceived as an element of human dignity. Access to clean water and sanitation leads to benefits for public health (Bisung & Elliott, 2014; Elliott, 2011; Gunda et al., 2019). In the water-economy nexus, water is input to economic activities, and its availability determines the cultivation of irrigated crops, forestry production, livestock, fishing, energy generation, industrial production, transport services, tourism and water distribution and sewage treatment (Bhaduri et al., 2015; Conway et al., 2015; De Amorim et al., 2018; Hamiche et al., 2016; C. Zhang et al., 2018; Zhao et al., 2021). In the water-environment nexus, water supports several ecological components, such as the preservation of aquatic and terrestrial biodiversity and the regulation of natural physical cycles (Melo et al., 2021). Faced with various anthropogenic pressures that act as drivers of water scarcity (intensive agriculture, urbanization, population change, pollution, and climate change) (Alcamo et al., 2007), and knowing that a shortage of water can be a limiting factor for development, there is an urgent need for the design and evaluation of economic instruments that help in the management of water resources (Da Motta, 2004; Grimble, 1999; Kessler, 1997; Rey et al., 2019; Tundisi et al., 2015).

In Brazil, the National Water Resources Policy (Law No. 9433/97) institutionalized the introduction of charges for water use (Brazil, 1997). The water charge is an economic instrument that aims to (a) rationalize the use of water resources; (b) recognize that water has an economic value; (c) reduce environmental damage related to excessive water use; and (d) minimize conflicts between users. Thus, charging for water is expected to enable better management of this resource, ensuring its sustainability in the short and long run. Despite this legal framework, the application of charging for water resources in Brazil remains incipient, as it is considered unpopular, and the idea of water scarcity is perceived as a long-run problem. In addition to conventional problems of water resource management, such as the spatial scale of water regulation (national, subnational, and hydrographic regions), there is also strong resistance to paying for this natural resource on the part of political-economic groups, mainly those related to agribusiness (agriculture and livestock), which are the largest consumers of water

sustainability MDPI

Article

Measuring the Cost of the European Union's Carbon Border Adjustment Mechanism on Moroccan Exports

Wissal Morchid [1], Eduardo A. Haddad [1,2] and Luc Savard [1,*]

[1] Africa Institute for Research in Economics and Social Sciences (AIRESS), Faculté de Gouvernance, Sciences Économiques et Sociales (FGSES), Université Mohammed VI Polytechnique, Campus Rabat-Salé, Rabat 11103, Morocco; wissal.morchid@um6p.ma (W.M.); ehaddad@fipe.br (E.A.H.)
[2] Núcleo de Economia Regional e Urbana da USP (NEREUS), University of Sao Paulo, Sao Paulo 05508-900, Brazil
* Correspondence: savard.luc@um6p.ma

Abstract: The 'Fit for 55' policy package was presented in the European Commission's Green Deal framework, comprising a set of proposals to improve existing energy and climate legislation. Among its main proposals was a revision of the European Union's Emission Trading System to expand its sectoral coverage. Anticipating the possible loss of competitiveness with carbon pricing within the EU—which may lead to 'carbon leakage'—a carbon border adjustment mechanism (CBAM) was included in the package. This scheme takes the form of an export tax levied by the European Union on some goods manufactured in non-carbon-taxing countries. In this paper, we provide a first-order estimate of the potential impact of CBAM on Morocco's exports using an input–output approach. Our main findings suggest that the scheme would yield a carbon bill ranging from USD 20 to 34 million annually to Moroccan exporters in its initial phase. Morocco can mitigate such economic losses by instituting a national Emission Trading System, a tax reform, or speeding up the decarbonization of its economy.

Keywords: European Green Deal; carbon leakage; carbon border adjustment mechanism; Morocco; input–output approach

JEL Classification: C64; D57; F18; F14; H23

check for updates

Citation: Morchid, W.; Haddad, E.A.; Savard, L. Measuring the Cost of the European Union's Carbon Border Adjustment Mechanism on Moroccan Exports. *Sustainability* **2024**, *16*, 4967. https://doi.org/10.3390/su16124967

Academic Editor: Junnian Song

Received: 19 March 2024
Revised: 31 May 2024
Accepted: 3 June 2024
Published: 11 June 2024

1. Introduction

In December 2019, the European Commission announced its "Green Deal", an overarching environmental strategy to achieve climate neutrality across the European Union by 2050. This ambitious plan includes a broad spectrum of policies and actions dedicated to addressing climate change, promoting sustainable development, and improving living standards for citizens within the EU. Following this initiative, in July 2021, the Commission launched "Fit for 55", a crucial subset of policy measures under the Green Deal's umbrella aimed at significantly reducing greenhouse gas emissions—targeting at least a 55% reduction from 1990 levels by the year 2030. This policy package includes a proposal to implement a carbon border adjustment mechanism [1]. The purpose behind CBAM is mainly to tackle carbon leakage's economic and environmental risks by applying charges on select imports into Europe. The scheme takes the form of a levy and ensures that goods imported are subjected to equivalent carbon constraints as those produced domestically under the EU's Emission Trading System (ETS)—thereby shielding EU industries against inequitable competition while motivating global emission reductions [1–3].

While CBAM is promoted as part of an ambitious climate policy to counteract carbon leakage, some authors view it as disguised protectionism that could sabotage climate policy endeavors and development prospects [4,5]: the CBAM is likely to impose higher export

sustainability MDPI

Article

The Role of Cities: Linking Integrated Assessment Models to Urban Solutions

Camila Callegari [1,*], Tarik Tanure [2], Ana Carolina Oliveira Fiorini [1], Eduardo Haddad [3], Edson Domingues [2], Aline Magalhães [2], Fernando Perobelli [4], Alexandre Porsse [5], André F. P. Lucena [1], Eveline Vasquez-Arroyo [1], Mariana Império [1], Luiz Bernardo Baptista [1] and Roberto Schaeffer [1]

[1] Energy Planning Program, Graduate School of Engineering, Universidade Federal do Rio de Janeiro (UFRJ), Centro de Tecnologia, Cidade Universitária, Ilha do Fundão, Rio de Janeiro 21941-914, Brazil
[2] Center for Development and Regional Planning, Faculty of Economic Sciences, Universidade Federal de Minas Gerais (UFMG), Av. Presidente Antônio Carlos, 6627, Belo Horizonte 31270-901, Brazil
[3] Department of Economics, Faculty of Economics, Administration, Accounting and Actuarial Science, Universidade de São Paulo (USP), Av. Prof. Luciano Gualberto, 908, FEA I, São Paulo 05508-900, Brazil
[4] Department of Economics, Faculty of Economic Sciences, Universidade Federal de Juiz de Fora (UFJF), Campus Universitário, Juiz de Fora 36036-330, Brazil
[5] Department of Economics, Faculty of Economic Sciences, Universidade Federal do Paraná (UFPR), Av. Prefeito Lothario Meissner, 632, Jardim Botânico, Curitiba 80060-000, Brazil
* Correspondence: ludovique@ppe.ufrj.br

Abstract: Cities play a fundamental role in reducing greenhouse gas emissions and advancing the 2030 Agenda for Sustainable Development. In this context, public authorities need tools to help in identifying the best set of available solutions for the urban environment. Here, we developed an approach to help decision makers in evaluating sustainable solutions, considering aspects such as emission rate, economic attractiveness, job creation, and local competitiveness in an intersectoral fashion. To rank the best solutions, we developed a new methodology that links integrated assessment models (IAMs) to the available solutions at the Innovation Observatory for Sustainable Cities (OICS) database and applied it to Brazil. Our results show that the solutions with the greatest impact were often related to new technologies, for example, renewable energy, which depends on institutional and financial arrangements that are beyond the administrative capacity of the vast majority of municipalities. Despite these limitations, Brazilian cities can act as regulators or provide financial incentives and advocacy to promote sustainable solutions in the urban environment.

Keywords: climate commitments; sustainable development goals; IAMs; indicators; ranking; urban solutions

check for updates

Citation: Callegari, C.; Tanure, T.; Fiorini, A.C.O.; Haddad, E.; Domingues, E.; Magalhães, A.; Perobelli, F.; Porsse, A.; Lucena, A.F.P.; Vasquez-Arroyo, E.; et al. The Role of Cities: Linking Integrated Assessment Models to Urban Solutions. *Sustainability* **2023**, *15*, 4766. https://doi.org/10.3390/su15064766

Academic Editor: Miguel Amado

Received: 14 December 2022
Revised: 8 February 2023
Accepted: 19 February 2023
Published: 8 March 2023

1. Introduction

Cities are responsible for around 70% of the global carbon dioxide (CO_2) emissions and global gross domestic product (GDP) while comprising about 50% of the global population [1,2]. The urban population is expected to nearly double by 2050 [1]. As a consequence, cities have increasingly concentrated populations, economic activities, social and cultural interactions, and environmental and humanitarian impacts [1]. Cities are both key emission sources and where climate change's consequences are felt most severely [3]. Climate change has already impacted human health, livelihoods, and key infrastructure in urban settings, and climate change risks are expected to increase in the mid and long term [4]. Therefore, cities face challenges to deal with and opportunities to mitigate climate change.

Thus, cities play a crucial role in mitigating greenhouse gases (GHGs) and need to adapt to reduce the impact of climate change. Growing public and political awareness of climate impacts and risks has led many cities to include adaptation and mitigation in their policies and planning processes [4,5]. Several cost-effective technologies are available for urban climate action [6,7].

Structural Change and Economic Dynamics 70 (2024) 302–318

Contents lists available at ScienceDirect

Structural Change and Economic Dynamics

journal homepage: www.elsevier.com/locate/strueco

Geographical proximity and technological similarity*

Eduardo A. Haddad [a,b,c,*], Inácio F. Araújo [a], Fernando S. Perobelli [d]

[a] Department of Economics, University of São Paulo, Brazil
[b] Faculty of Governance, Economic and Social Sciences of the Mohammed VI University, Morocco
[c] Policy Center for the New South, Morocco
[d] Department of Economics, Federal University of Juiz de Fora, Brazil

ARTICLE INFO

Keywords:
Input-output analysis
Spatial analysis
Technological convergence
Economic structure
Global databases

ABSTRACT

From a time-space perspective, we assess the effects of geographical proximity on technological convergence over time identifying proximity dimensions associated with countries' technological similarities. We compare a time series of input-output coefficients for 66 different countries extracted from the 2021 edition of OECD Inter-Country Input-Output to verify whether nearby countries are more likely to share similar technologies. Our results reveal that geographical technological spillovers are important since closer economies tend to be more similar than distant ones. This is particularly evident for the European economies in the sample, suggesting that institutional proximity also matters for technological convergence. Over time, closer economies are becoming structurally more similar; however, this trend seems to have slowed down after the 2008–9 financial crisis. Conjectures on how informational gaps are filled in the consolidation of the databases – encountered in an environment of limited information – based on known practices of using regional and global average structures may add a layer of uncertainty to our results.

1. Introduction

Regional input-output (IO) analysis is often anchored under national input-output systems. Despite recognizing that regional production recipes differ, researchers assume, without any embarrassment, that national technology prevails everywhere. In a world of limited information, the usual justification considers that the lack of appropriate data at the regional level can be surpassed by the assumption that the available technology for regional firms is given nationally. From a practitioner's perspective, it translates into the assumption of national sectoral technology at the regional level leading to the prevalence of the same input mix for a given sector everywhere with differences only in the degree of interregional dependence on input sources.

Shared technology is a plausible working assumption for practitioners dealing with isolated or integrated subnational systems. Technological convergence in input-output technical coefficients, defined as high similarity between A matrices, is more likely to be observed across regions within a country than across different countries, given the existing relative homogeneity in sub-national economic spaces.

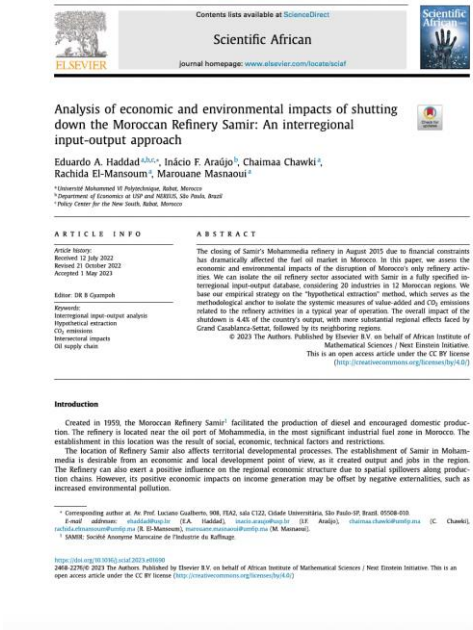
However, input-output practitioners also face conditions of limited information when dealing with national input-output models for countries with poor statistical institutions. Although many countries produce their supply and use tables (SUT) with different publication frequencies and levels of detail, there are still many countries for which SUTs are dated or not available. To circumvent this problem, researchers sometimes adjust existing input-output tables from elsewhere to one or various of such countries by estimating or inferring the parts of the system that are undetermined – usually the technical coefficients (A matrix) –, or even replicating the structure of a "similar" country.

Different experiences with developing Global Multi-Regional Input-Output (GMRIO) share the common challenge of estimating individual country IO tables based on limited information. Different versions of the GTAP Project (Hertel, 1997) database, for instance, develop the concept of representative IO tables as a linear combination of IO tables from regions representing a broad economic and geographic spectrum for which good quality IO data are available. Representative tables are used for different purposes, including the adaptation of the production structure, intermediate usage, and consumption for sectors that are not split in the original IO table of a given country. The GTAP database also encompasses the concept of composite regions, constructing for them IO

* The data that support the findings of this study are available in OECD Inter-Country Input-Output (ICIO) Tables at http://oe.cd/icio. These data were derived from the following resources available in the public domain: - OECD, https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm

* Corresponding author.
E-mail address: ehaddad@usp.br (E.A. Haddad).

https://doi.org/10.1016/j.strueco.2024.02.007
Received 20 July 2023; Received in revised form 31 January 2024; Accepted 13 February 2024
Available online 22 February 2024



Scientific African 20 (2023) e01690

Contents lists available at ScienceDirect

Scientific African

journal homepage: www.elsevier.com/locate/sciaf

Analysis of economic and environmental impacts of shutting down the Moroccan Refinery Samir: An interregional input-output approach

Eduardo A. Haddad [a,b,c,*], Inácio F. Araújo [b], Chaimaa Chawki [a], Rachida El-Mansoum [a], Marouane Masnaoui [a]

[a] Université Mohammed VI Polytechnique, Rabat, Morocco
[b] Department of Economics at USP and NEREUS, São Paulo, Brazil
[c] Policy Center for the New South, Rabat, Morocco

ARTICLE INFO

Article history:
Received 12 July 2022
Revised 21 October 2022
Accepted 1 May 2023

Editor: DR B Gyamfoh

Keywords:
Interregional input-output analysis
Hypothetical extraction
CO_2 emissions
Intersectoral impacts
Oil supply chain

ABSTRACT

The closing of Samir's Mohammedia refinery in August 2015 due to financial constraints has dramatically affected the fuel oil market in Morocco. In this paper, we assess the economic and environmental impacts of the disruption of Morocco's only refinery activities. We can isolate the oil refinery sector associated with Samir in a fully specified interregional input-output database, considering 20 industries in 12 Moroccan regions. We base our empirical strategy on the "hypothetical extraction" method, which serves as the methodological anchor to isolate the systemic measures of value-added and CO_2 emissions related to the refinery activities in a typical year of operation. The overall impact of the shutdown is 4.4% of the country's output, with more substantial regional effects faced by Grand Casablanca-Settat, followed by its neighboring regions.

Introduction

Created in 1959, the Moroccan Refinery Samir[1] facilitated the production of diesel and encouraged domestic production. The refinery is located near the oil port of Mohammedia, in the most significant industrial fuel zone in Morocco. The establishment in this location was the result of social, economic, technical factors and restrictions.

The location of Refinery Samir also affects territorial developmental processes. The establishment of Samir in Mohammedia is desirable from an economic and local development point of view, as it created output and jobs in the region. The Refinery can also exert a positive influence on the regional economic structure due to spatial spillovers along production chains. However, its positive economic impacts on income generation may be offset by negative externalities, such as increased environmental pollution.

* Corresponding author at: Av. Prof. Luciano Gualberto, 908, ITA2, sala C122, Cidade Universitária, São Paulo-SP, Brazil. 05508-010.
E-mail addresses: ehaddad@usp.br (E.A. Haddad), inacio.araujo@usp.br (I.F. Araújo), chaimaa.chawki@um6p.ma (C. Chawki), rachida.elmansoum@um6p.ma (R. El-Mansoum), marouane.masnaoui@um6p.ma (M. Masnaoui).
[1] SAMIR: Société Anonyme Marocaine de l'Industrie du Raffinage.

https://doi.org/10.1016/j.sciaf.2023.e01690
2468-2276/© 2023 The Authors. Published by Elsevier B.V. on behalf of African Institute of Mathematical Sciences / Next Einstein Initiative. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/)

Marine Policy 147 (2023) 105334

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Full length article

Cost and environmental impact assessment of mandatory speed reduction of maritime fleets

Cristofer H. Marques [a,1], Paula C. Pereda [b,2], Andrea Lucchesi [a,3], Ramiro F. Ramos [d,4], Olav Fiksdahl [a,5], Luiz F. Assis [d,6], Newton N. Pereira [c,7], Jean-David Caprace [d,*,8,9]

[a] School of Engineering, Federal University of Rio Grande – FURG, Brazil
[b] Department of Economics, University of São Paulo – USP, Brazil
[c] School of Arts, Science and Humanities, University of São Paulo – USP, Brazil
[d] Department of Ocean Engineering, Federal University of Rio de Janeiro – UFRJ, Brazil
[e] Department of Marine Technology, Norwegian University of Science and Technology – NTNU, Norway
[f] Department of Production Engineering, Federal Fluminense University – UFF, Brazil

ARTICLE INFO

Keywords:
Shipping
Ship speed
Greenhouse gas
Effect on cost
Maritime CO_2 emissions
Cost effectiveness analysis

ABSTRACT

To reduce greenhouse gas emissions from maritime transport, the International Maritime Organization has been studying measures to be implemented in the short term. However, there is a need to carefully analyze the impact of these measures on transport costs. The present work presents an assessment of cost and CO_2 emissions from mandatory speed reductions on the world merchant ship fleet. Considering the product usually transported by each ship type and the distance navigated, expenditures and CO_2 emissions are calculated to perform a cost-effectiveness analysis. Results reveal that a given speed reduction is more beneficial for some regions and ship types than for others. Higher speed reductions were found to be environmentally beneficial but significantly increase the annual seaborne transport cost. Finally, the cost-effectiveness analysis shows that the cost per avoided ton of CO_2 emission ranges between USD 23 and USD 50, in 30% and 40% speed reduction scenarios, respectively.

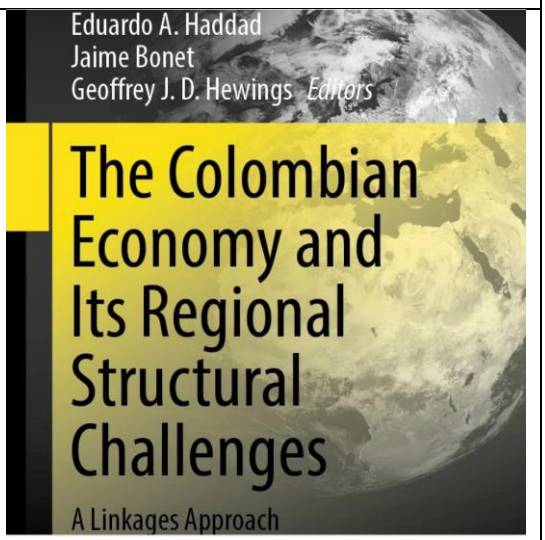
1. Introduction

The global average temperature was 1°C higher in 2018 compared with the pre-industrial age. This temperature rise is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the same rate [19]. Global warming is partially caused by greenhouse gas (GHG) emissions, and the burning of fossil fuels in the transport sector is one of the main contributors to GHG emissions. Specifically, maritime transport is responsible for generating over 1.0 gigaton (Gt) of CO_2 per year, accounting for about 3% of global GHG emissions [13]. Almost all this emission is due to international long-haul shipping [12,14], and this amount is comparable to the total emissions of countries like Germany, and Japan [28].

In this context, in April 2018, the International Maritime

* Corresponding author.
E-mail addresses: cristofelhmood@furg.br (C.H. Marques), pereda@usp.br (P.C. Pereda), andrea.lucchesi@usp.br (A. Lucchesi), ramirofr@oceanica.ufrj.br (R.F. Ramos), olavfiksdahl@hotmail.com (O. Fiksdahl), felipe@oceanica.ufrj.br (L.F. Assis), newtonpereira@id.uff.br (N.N. Pereira), jdcaprace@oceanica.ufrj.br (J.-D. Caprace).
[1] ORCID ID: 0000-0003-0178-5666
[2] ORCID ID: 0000-0002-8717-9522
[3] ORCID ID: 0000-0002-0813-245X
[4] ORCID ID: 0000-0001-5730-3158
[5] ORCID ID: 0000-0001-6330-9310
[6] ORCID ID: 0000-0001-5602-3779
[7] ORCID ID: 0000-0003-3432-7063
[8] ORCID ID: 0000-0002-1014-9357
* Address: Centro de Tecnologia, Av. Athos da Silveira Ramos, 000-852 - Cidade Universitária da Universidade Federal do Rio de Janeiro, Rio de Janeiro - RJ, 21941-972

https://doi.org/10.1016/j.marpol.2022.105334
Received 1 July 2022; Received in revised form 23 September 2022; Accepted 6 October 2022
Available online 21 October 2022



Tellus A

Data Source Sensitivity in Solar Radiation Typical Meteorological Year (TMY) for Five Different Regions of Brazil

REVIEW ARTICL

ANNA TIPPETT
ANDRÉ RODRIGUES GONÇALVES
ENIO BUENO PEREIRA
FERNANDO RAMOS MARTINS
GILBERTO FISCH
RODRIGO SANTOS COSTA
*Author affiliations can be found in the back matter of this article

STOCKH UNIVERSITY

ABSTRACT

In this article, we examine how sensitive the methodology for calculating a "Typical Meteorological Year" (TMY) is to changes in the source of the meteorological data series and the weighting factors used. Three different sources of meteorological data – ground-based observations, modeled satellite-derived data, and ERA5 reanalysis data – were used to determine the sensitivity of the TMY to the data source. The TMY was created for five different climatic regions in Brazil using 13 years of hourly data for meteorological indices consisting of maximum, minimum, and average air temperature, relative humidity, wind speed, global total horizontal radiation, and normal direct solar radiation. The study shows that the source of the meteorological data plays little role in determining the "most typical" months. The typicality of the months was consistent even when data sources as diverse as in situ and modeled data were used. The study also shows that the exact choice of weighting scheme for the meteorological data source is relatively arbitrary, if not irrelevant. This is because meteorological parameters are not independent variables and therefore often represent redundant information. A few independent parameters are sufficient to produce a good TMY and adding several interdependent parameters does not improve the quality of the TMY produced.

CORRESPONDING AU
Anna Tippett
Department of Physics
Undergraduate Progra
University of Oxford, O
3PU Oxford, UK; Nation
Institute for Space Res
– INPE, Division of Imp
Adaptation and Vulner
12227-010 São José d
Campos – SP, Brazil
acvtippett@gmail.com

KEYWORDS:
TMY; Typical Meteorolo
Year; Meteorological D
Solar Energy; Solar Rad

TO CITE THIS ARTICL
Tippett, A, Gonçalves, A
Pereira, EB, Martins, FR,
Fisch, G and Costa, RS.
Data Source Sensitivity
in Solar Radiation Typic
Meteorological Year (T

Integrating renewable energy for power security in water stress scenarios: strategies and opportunities

Paula Conde Santos Borba[a,*], André Rodrigues Gonçalves[a], Rodrigo Costa Santos[a], Meiriele Alvarenga[a], Fernando Ramos Martins[a,b]

[a]*LABREN - Laboratory of Modeling and Studies on Renewable Energy Resources – National Institute for Space Research (INPE), São José dos Campos, , São Paulo, Brazil*
[b]*Federal University of São Paulo, Sea Science Department, Santos, São Paulo, Brazil*

Abstract

Hydropower systems are vulnerable to climate change effects, mainly in the Southern Hemisphere, risking energy security and investments in emerging markets. With Brazil as our representative case, we explore strategies to enhance the power system's reliability and opportunities amid water stress scenarios in 2050. We use a high-resolution power model, which optimizes capacity and dispatch simultaneously while minimizing the costs. Findings indicate a major role of wind energy and a decline in natural gas in water stress scenarios. However, extensive wind penetration is only possible when combined with storage systems, which remain mainly reservoir-based. Also, severe cases of water stress can increase the power system cost by up to 14.9% when combined with 100% renewable systems. The moderate cost scenarios have similar optimal results to advanced costs (less costly), indicating the high competition between wind and solar alternatives. Furthermore, expanding the wind farms portfolio may lead to surplus wind energy, particularly

*paula.borba@inpe.br

Preprint submitted to Elsevier *June 13, 2024*

State of the Climate in Latin America and the Caribbean 2023

WEATHER CLIMATE WATER

WORLD METEOROLOGICAL ORGANIZATION

WMO-No. 1351

BERKELEY EARTH. Camoden CIIFEN Climate Change Service Deutscher Wetterdienst Wetter und Klima aus einer Hand DWD FAO IAI 気象庁 Japan Meteorological Agency LEGOS Met Office NASA NOAA PAHO wgms

For more information, please contact:

World Meteorological Organization
7 bis, avenue de la Paix – P.O. Box 2300 – CH 1211 Geneva 2 – Switzerland

Strategic Communications Office
Cabinet Office of the Secretary-General
Tel: +41 (0) 22 730 83 14 – Fax: +41 (0) 22 730 80 27
Email: cpa@wmo.int

wmo.int

Decarbonizing isolated minigrids in the Brazilian Amazon: a prospective analysis for green hydrogen adoption

Meiriele A. Cumplido[a], André R. Gonçalves[a], Enio B. Pereira[a], Ricardo Rüther[b]

[a]*Laboratory for Modeling and Studies of Renewable Energy Resources - http://labren.ccst.inpe.br/, National Institute for Space Research (INPE), Av. Astronautas, 1758, São José dos Campos, 12227010, São Paulo, Brazil*
[b]*Strategic Research Group on Solar Energy - www.fotovoltaica.ufsc.br, Federal University of Santa Catarina (UFSC), Sapiens Parque, Av. Luiz Boiteux Piazu, 1302, Florianópolis, 88056000, Santa Catarina, Brazil*

Abstract

Most of the isolated communities in the Brazilian Amazon are supplied with electricity through isolated generation-distribution systems (minigrids) using oil and gas. The logistical difficulties of supplying fossil fuels, combined with their high cost and greenhouse gas (GHG) emissions, indicate that the current electricity supply model needs to be rethought to ensure environmental and socioeconomic benefits for the local population. In this context, this paper presents a prospective analysis that considers the use of locally produced green hydrogen from photovoltaic solar electricity (PV-green H_2) and water as a substitute for fossil fuels to supply isolated systems in the Amazon region. Although some barriers linger on for green hydrogen technology deployment, such as high costs and concerns about water requirements, several benefits can be identified in terms of sustainable energy transition, leading to positive socioeconomic impacts and improved energy security. This work departs from the whole energy demand of the Amazon minigrids and performs an emissions analysis for hybrid electric systems. The GHG lifecycle of the proposed solution is estimated based on performance data from the literature. According to a preliminary assessment, the PV-green H_2 system could avoid about 83% of the emissions, with negligible water impacts in the Amazon region.

Keywords: Renewable energy, Complementarity, Hybrid generation,

Preprint submitted to Renewable Energy *April 7, 2024*

Sensitivity analysis of solar irradiance estimates over a tropical region by cloud index models.

Ricardo Almeida de Siqueira[a,*], André Rodrigues Gonçalves[a], Rodrigo Santos Costa[a], Fernando Ramos Martins[b]

[a]*Division of Impacts, Adaptations, and Vulnerability of the General Coordination of Earth Sciences at the National Institute for Space Research, Av. dos Astronautas, 1758, São José dos Campos, 1227-010, SP, Brazil*
[b]*Institute of Marine Science, Federal University of São Paulo (Unifesp), Rua Carvalho de Mendonça, 144, Santos, 11070-102, SP, Brazil*

Abstract

The downward global horizontal irradiance (*GHI*) modulates various physical processes on Earth and is an essential variable in climate, ecology, and renewable resources studies. In recent years, the use of geostationary satellites for estimating *GHI* has gained increasing interest due to their regional coverage and lower maintenance and calibration requirements. Clouds have long been considered to correlate well with measured *GHI* values in various scientific studies. Therefore, *GHI* estimates using cloud index models rely on calculating the cloud cover index (C_{eff}) that depends on the assumed reflectance for clouds (ρ_{cloud}). This work investigates how the spatial resolution of satellite imagery and ρ_{cloud} variability affect C_{eff} evaluation and the skill metrics of numerical models to estimate *GHI* over a tropical region. The results show the cloud index parameterization robustness against pixel resolution and solar geometry. Small detachment was observed when reducing resolution down to 1 km. Zenith and satellite phase angles induced no bias in the models. On low cloud cover conditions models tended to overestimate *GHI* while underestimating otherwise, suggesting an internal compensation to minimize the error on all cloud cover conditions. Nevertheless, the spread in skill metrics among stations was always higher than these variables. The choice of clear sky model and ρ_{cloud} maximum value was confirmed as the most sensitive parameters for model performance. In summary, the cloud index

*Corresponding author
Email address: ricardo.siqueira@inpe.br (Ricardo Almeida de Siqueira)

Preprint submitted to Solar Energy *April 25, 2024*

MODELAGEM DE SISTEMAS ALTAMENTE RENOVÁVEIS: INTEGRAÇÃO DA ENERGIA EÓLICA E SOLAR NO BRASIL EM 2050

Paula Conde Santos Borba – paula.borba@inpe.br
André Rodrigues Gonçalves
Instituto Nacional de Pesquisas Espaciais, LABREN
Fernando Ramos Martins
Universidade Federal de São Paulo, Campus Baixada Santista
Rodrigo Santos Costa
Instituto Nacional de Pesquisas Espaciais, LABREN

7.1. Estratégias e políticas para energias renováveis

Resumo. *Este estudo investigou soluções para o sistema elétrico considerando a demanda de 2050 e utilizando modelos de sistemas de energia que visam a minimização de custos. Aspectos físicos como a disponibilidade de área foram consideradas, além da inclusão de séries temporais de alta resolução. Os resultados obtidos indicam que a capacidade instalada no Brasil até 2050 deve variar entre 353 a 428 GW a depender do ano climático considerado, com uma predominância de parques eólicos e solares. No que tange à capacidade eólica, o estudo apresenta uma média que varia de 147 a 192 GW. Em relação à energia solar, os números variam entre 57 a 75 GW. Os resultados apontam que a maior parte da capacidade instalada de energia solar se concentra em São Paulo, seguido por Minas Gerais, Bahia e Rio de Janeiro, estados com grande demanda elétrica. O estudo também enfatiza a necessidade de diversidade tecnológica e espacial para garantir a segurança energética, destacando que não há um único caminho tecnológico para atingir sistemas altamente renováveis. A energia eólica é considerada a mais competitiva em termos de custo nivelado, devido a sua geração mais constante em comparação com os parques solares, porém, enfrenta desafios sazonais que são compensados com a energia solar.*

Palavras-chave: *Energia solar, Energia eólica, Sistema elétrico.*

1. INTRODUÇÃO

O desafio do século XXI é desenvolver um sistema energético mais sustentável, capaz de garantir o fornecimento de energia em um mundo com restrições de emissões de carbono (Bridge *et al.*, 2013). As energias renováveis têm sido uma das soluções para enfrentar o problema global das mudanças climáticas (Saganeiti *et al.* 2020) e também para cumprir os compromissos estabelecidos no Acordo de Paris na redução das emissões de Gases de Efeito Estufa (GEE) no setor energético.

O segundo desafio que o setor elétrico enfrenta é a capacidade de projetar uma expansão do sistema de forma sustentável até 2050 para atender à demanda futura de eletricidade, que deverá ser 2,8 vezes maior do que em 2019. Para isso, é crucial compreender o potencial individual de expansão das tecnologias no Brasil, considerando aspectos socioambientais, possíveis conflitos e competitividade. Além disso, promover um sistema com segurança de suprimento é fundamental para evitar apagões massivos e elevados custos sociais e econômicos (Min *et al.*,2018).

Embora as usinas hidrelétricas sejam altamente eficientes e tenham baixos custos de operação e manutenção (Dranka e Ferreira, 2018), sua expansão ainda é incerta. Primeiro, porque existe a dificuldade de estabelecer segurança energética devido ao aumento da frequência de eventos extremos de seca e, em segundo lugar, há um impacto negativo no meio ambiente, principalmente associado aos grandes reservatórios e barragens. A Empresa de Pesquisa Energética (EPE) apontou 52 GW de potencial hidráulico que ainda não foi explorado, principalmente na bacia Amazônica e Tocantins-Araguaia. No entanto, 77% desse potencial está em áreas protegidas ou em território indígena. Além disso, a maioria dos projetos na bacia Amazônica deverão ser a fio d'água (Corrêa da Silva et al.,2016), que possui capacidade de armazenamento limitada e poderá sofrer impactos mais expressivos devido às alterações climáticas se comparado com outros tipos de empreendimentos.

Diante das barreiras de expansão do principal recurso brasileiro atualmente, já existe um grande número de novas instalações eólicas e solares, recursos também muito abundantes no Brasil. Porém, a integração de novas fontes renováveis variáveis no sistema existente é de grande complexidade devido à natureza flutuante dos recursos. A demanda também é variável, exigindo sinergia temporal e espacial simultânea entre tecnologias e localizações para garantir a segurança energética (Zeyringer, 2018).

A dificuldade torna-se ainda maior no planejamento a longo prazo, uma vez que espera-se um aumento considerável da demanda até 2050 no Brasil (EPE, 2020). Tal aumento exigirá uma expansão da capacidade instalada significante. A expansão massiva dos parques eólicos e solares e de outras infraestruturas (por exemplo, estradas e linhas de transmissão) exige uma grande extensão territorial, o que também pode trazer problemas sociais como conflitos de uso de terras com as comunidades locais (Brannstrom et al., 2017) e problemas ambientais como a perda da biodiversidade ao interferir nos ecossistemas locais (Guan, 2023).

ENERGIA SOLAR FOTOVOLTAICA COMBINADA COM HIDROGÊNIO VERDE: UMA ESTRATÉGIA PARA REDUÇÃO DAS EMISSÕES E DA VULNERABILIDADE NA AMAZÔNIA

Meiriele Alvarenga Cumplido – meiriele.cumplido@inpe.br
André Rodrigues Gonçalves
Enio Bueno Pereira
Instituto Nacional de Pesquisas Espaciais - INPE, Divisão de Impactos, Adaptação e Vulnerabilidades
Ricardo Rüther
Universidade Federal de Santa Catarina - UFSC, Departamento de Engenharia Civil - Laboratório Fotovoltaica

6.8. Hidrogênio verde

Resumo. *O óleo diesel é a principal fonte para a geração de energia elétrica nos Sistemas Isolados (SISOL) na Amazônia. Para além do aspecto econômico (elevados custos do diesel, de logística e de subsídios) e do aspecto ambiental (elevada emissão específica), a logística de transporte do combustível é um limitante para a confiabilidade no fornecimento de eletricidade às localidades atendidas pelo SISOL. O suprimento de combustível se dá principalmente por transporte fluvial e eventos de seca severa, como o ocorrido ao final de 2023, eleva o risco de desabastecimento e a necessidade de racionamento de energia nas localidades. Um exemplo dessa ocorrência foi em São Gabriel da Cachoeira, no estado do Amazonas, que possui o Rio Negro como principal meio de acesso. Em novembro de 2023, o rio atingiu o seu menor nível ao longo da série histórica avaliada, havendo impacto sobre a navegação. Eventos de seca mais intensos e frequentes tendem a ocorrer por efeito das mudanças climáticas, o que sinaliza para maior vulnerabilidade dos sistemas isolados a estes eventos e da população à falta de energia. Diante desse contexto, este trabalho avalia a substituição de combustíveis fósseis por recursos energéticos renováveis locais na matriz elétrica do SISOL. Para esta avaliação, considera-se uma planta híbrida solar fotovoltaica e hidrogênio verde (PV-H2V) suprindo a potência gerada por diesel e gás natural. Os resultados indicam que o uso combinado das fontes renováveis pode ser uma estratégia de mitigação, em que ao menos 5,67 $MtCO_{2eq}$ poderiam ser evitados no ano. Também, uma medida de adaptação dos sistemas naturais e humanos aos impactos das mudanças climáticas sobre os recursos naturais e energéticos. A demanda de água para a produção do hidrogênio não deverá ser um limitante para sua adoção na região amazônica, e poderá contribuir com a resiliência da região na geração de eletricidade.*

Palavras-chave: *Energia de Fontes Renováveis, Descarbonização, Sistemas Isolados*

1. INTRODUÇÃO

No Brasil, a maior parte da produção e transmissão de energia elétrica se dá por meio do Sistema Interligado Nacional (SIN). Trata-se de um sistema hidro-solar-eólico-térmico de grande porte sob coordenação e controle do Operador Nacional do Sistema Elétrico (ONS), o qual é fiscalizado e regulado pela Agência Nacional de Energia Elétrica (ANEEL). O sistema é constituído por quatro subsistemas elétricos - Sul, Sudeste/Centro-Oeste, Nordeste e Norte, interconectados por meio da malha de transmissão. Isso permite atender aos consumidores conectados ao SIN com maior confiabilidade, vista a complementaridade entre regiões que reduz riscos de interrupção de energia (ONS, 2023). Já na região Norte do país, compreendendo vários estados que compõem a Amazônia Legal, razões técnicas e econômicas e até de natureza socioambientais, inviabilizam que algumas localidades sejam interligadas ao SIN, incluindo Boa Vista, capital do estado de Roraima. A essa capital e demais localidades não interligadas, a energia elétrica é então fornecida pelos chamados Sistemas Isolados (SISOL), conforme definido no Art. 2º do Decreto nº 7.246/2010 (Brasil, 2010).

Enquanto a fonte hidráulica predomina na oferta de eletricidade pelo SIN, o óleo diesel é a fonte de eletricidade predominante no SISOL. Além da elevada emissão específica do diesel (emissões de gases de efeito estufa (GEE) por unidade de energia, em gCO_{2eq}/kWh), o abastecimento do SISOL com esse combustível possui também elevado custo. Em parte devido ao próprio custo do diesel, mas também devido à logística de transporte e ao subsídio da Conta de Consumo de Combustíveis (CCC) - encargo pago pelos consumidores do SIN para subsidiar os custos da energia elétrica do SISOL (CCEE, 2022; ONS, 2022). Relativo à logística de transporte, o acesso para fornecimento do combustível se dá principalmente, ou exclusivamente, pelo modal de transporte fluvial. De modo a evitar a comprometer o suprimento de energia elétrica durante os períodos de estiagem, quando o acesso pelas vias fluviais fica comprometido, certas localidades precisam dispor de tanques de armazenamento de grande porte para estoque do combustível (EPE, 2022b).

ICDC11

GREEN HYDROGEN: SUSTAINABLE ENERGY TRANSITION IN THE ISOLATED ELECTRICITY SYSTEMS OF THE AMAZON REGION

ABSTRACT

Fossil-fired thermal power plants prevail in isolated electricity systems (SISOL) in the Brazilian Amazon region. These systems are not connected to the national generation and transmission grid due to technical or economic constraints, and generate electricity mainly by burning oil and gas. As a result, they depend on these imported fuels to provide electricity to a population of 3.1 million at SISOL communities. This current power system arrangement is defined by logistical difficulties in the fuel supply, as they are mainly delivered by river transport, making it expensive due to the cost of fuel, logistics and subsidies. Quite often, more than 1 liter of diesel is spent to deliver 1 liter of diesel to these isolated communities. SISOL is also characterized by a high emission factor due to the preponderance of fossil fuels. In this context, this work aims to evaluate the energy transition from fossil fuels to local renewable energy sources in the Amazonian SISOL. The analysis quantifies the avoided emissions when a hybrid power generation system using photovoltaics, green hydrogen and fossil fuels (PV-GH2-FF) is established as an alternative to replace the total installed capacity of fossil fuel thermal plants. The lifecycle GHG emissions of each technology are considered, and the emissions benchmark considers the baseline configuration (with no renewable share in the SISOL electricity mix). By varying the shares of renewable and non-renewable sources in the hybrid system, reducing fossil fuels up to the scenario where they are completely banned from the mix, the results indicate that green hydrogen -produced from and combined with photovoltaic solar energy (PV-GH2)- is a potential mitigation strategy that can achieve expressive reductions in current GHG emission levels and contributing to a more reliable energy supply. The great uncertainty remains in the economical feasibility due to the future costs of GH2 electrolysers.

Keywords: Renewable Energy; Solar Photovoltaics; Hybrid Generation Systems; Fossil Fuels; GHG Emissions.

THE AMAZON WE WANT
Science Panel for the Amazon

STATEMENT ON THE 2023 AMAZON DROUGHT AND ITS UNFORESEEN CONSEQUENCES

Flávia Costa[1] & José Marengo[2]

The 2023 drought has been characterized by greatly reduced rainfall and four heatwaves, which occurred during the pre-rainy season, reducing river levels. These alterations caused increased mortality of fish and aquatic mammals, scarcity of potable water and food for river-dwelling communities, halted river transportation, increased risk of waterborne disease, and strong defoliation of vegetation along river margins due to surface fires. Middle- and long-term impacts include forest degradation near deforested areas; increased tree mortality and decreased growth, reducing forest carbon sinks, and negative impacts on community-based socio-bioeconomies. Extreme drought in the Amazon is also expected to reduce atmospheric moisture transport to the southern part of South America, worsening the water and energy crisis both inside and beyond the Amazon region.

Historical patterns and uniqueness of the 2023 drought:

Recent decades are the warmest of the observational period, with severe droughts occurring in the Amazon in 2005, 2010, 2015/2016, a smaller one in 2020, and this very strong in 2023-2024. The current drought is the most extreme ever seen in the historical record, and somewhat unique since it started during the pre-rainy season, while in previous events, drought occurred during the peak of the rainy season (austral summer). This drought combines widespread reduction of rainfall over most of the western-central Amazon Basin – 100 to 300 mm below average in the Bolivian Amazon and in the Brazilian states of Amazonas, Acre, Roraima, and Rondônia – with a warmer austral winter due to El Niño, and four heat waves with air temperatures 2-5ºC warmer than usual in the austral winter and spring. As a result, several large rivers experienced the most extreme reductions in water levels since 1902. None of the previous droughts were affected by all those characteristics together.

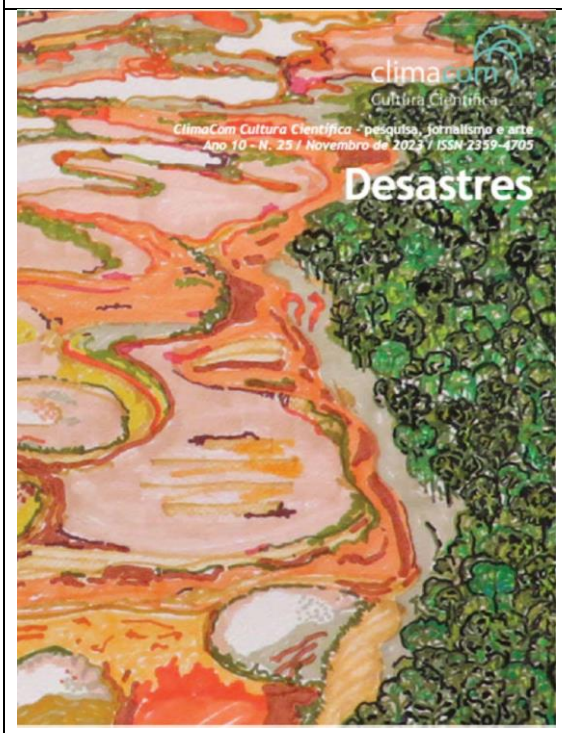
What can happen in 2024 and in the long term:

The El Niño 2023 is expected to continue its evolution during the first part of 2024, and, together with a warmer Tropical North Atlantic, it is very likely that the Amazon's rainy season will be weaker than normal, and river levels will be lower than normal. This drought illustrates the possible effects of warming on the Amazon and may represent a 'new-normal' if no action is taken to stop climate change.

Consequences and Impacts:

The consequences and impacts of the drought are already large and will continue in the medium term. They have affected aquatic and terrestrial systems (Table 1), and human populations in both rural and urban areas. Among the most striking effects are high fish and aquatic mammal mortality in the Solimões-Amazonas River, images of leafless trees along riverbanks, and surface fires in dry forests. The total lack of access to safe drinking water, disruptions to crop production, and fish

[1] Researcher at the National Institute of Amazonia Research, INPA, Manaus, Brazil. Coordination PELD Manaus - Floresta Amazônica.
[2] Director of Research and Development, National Center for Monitoring and Early Warning of Natural Disaster, CEMADEN, São José dos Campos, Brazil.



SEÇÃO TEMÁTICA: A FAUNA, A FLORA, OS OUTROS SERES VIVOS E OS AMBIENTES NO ENSINO DE CIÊNCIAS E DE BIOLOGIA

Educação & realidade

Alianças Vegetais: espécies companheiras de ensino diante do Antropoceno

Susana Oliveira Dias[I]
[I]Universidade Estadual de Campinas (Unicamp), Campinas/SP – Brasil

RESUMO – Alianças Vegetais: espécies companheiras de ensino diante do Antropoceno. O que as alianças com as árvores podem ativar em experiências de ensino diante do Antropoceno? Partindo dessa pergunta, analisa-se encontros entre biologias e artes nas práticas da disciplina "Arte, ciência e tecnologia". Mobilizado pelo conceito de "espécies companheiras" de Haraway (2021) e em diálogos com obras de artistas, autores da educação e filosofia, este texto se interessa por pensar no que acontece entre as relações materiais e os regimes de signos envolvidos em exercícios que resultaram em dois livros-objeto criados na disciplina: Floresta de Luz e Floresta². As árvores convocam as pessoas a pensarem o ensino como um laboratório-ateliê de perceber-fazer floresta e a darem atenção às fabulações que brotam pelas frestas, entre biologias e artes.
Palavras-chave: **Árvores. Ensino. Espécies Companheiras. Estudos Multiespécies. Arte e Ciência.**

ABSTRACT – Plant Alliances: companion species in teaching in the face of the Anthropocene. What can alliances with trees bring about when it comes to teaching experiences in the face of the Anthropocene? This text analyzes the encounters between biological sciences and the arts as seen throughout the "Art, science and technology" course. Having been provoked by Haraway's (2021) concept of "companion species" and established a connection with works by artists and with authors of education and philosophy, its interest in thinking about what happens between material relations and the systems of signs involved in those exercises which have resulted in two book-objects produced within the course: *Floresta de luz* and *Floresta*². The trees call upon people to think of teaching as a laboratory-atelier of perceiving-creating forests and to pay attention to the fabulations between biological sciences and the arts.
Keywords: **Trees. Teaching. Companion Species. Multispecies Studies. Art and Science.**

ENTRE O CUIDADO DE SI E O BEM VIVER: PORVIRES POSSÍVEIS PARA A VIDA E A EDUCAÇÃO EM MEIO ÀS PEDAGOGIAS PANDÊMICAS

BETWEEN CARE OF THE SELF AND GOOD LIVING: POSSIBLE FUTURES FOR LIFE AND EDUCATION IN THE MIDST OF PANDEMIC PEDAGOGIES

Tiago Amaral Sales [1]
Fernanda Monteiro Rigue [2]

Resumo: *Este texto é escrito ensaisticamente (LARROSA, 2003) e busca tangenciar e tensionar as pedagogias pandêmicas que vêm atravessando as nossas vidas ao longo dos últimos anos, como também pensar em porvires possíveis para esses tempos. Ao percebermos que, antes mesmo da emergência pandêmica, já nos encontrávamos em uma sociedade neoliberal e com as suas diferentes estratégias e dispositivos de excesso de positivação da vida, produção de cansaço, hiper atenção curta e rápida, contribuindo para uma auto-exploração do existência e da convivialidade, estonamos possibilidades para escapar dessas táticas que despotencializam a vida. Por intermédio das ferramentas conceituais de cuidado de si (FOUCAULT, 2010a) e da dimensão do Bem Viver (KRENAK, 2020), abrimos vias que nos auxiliam o pensar-habitar-mobilizar as porvires possíveis nestes territórios pandêmicos e, ao mesmo tempo, em pistas de potencializar o corpo, a vida e a educação.*

Palavras-chave: *Covid-19. Educação. Michel Foucault. Ailton Krenak. Pandemia.*

Abstract: *This text is written essayistically (LARROSA, 2003) and seeks to tangent and tension the pandemic pedagogies that have been crossing our lives over the last few years, as well as thinking about possible futures at these times. When we realize that, even before the pandemic emergency, we were already in a neoliberal society and with its different strategies and apparatus of excess positivation of life, production of fatigue, short and rapid hyperattention, contributing to a self-exploration of existence and conviviality, we activate possibilities to escape these tactics that depotentiate life. Through the conceptual tools of care of the self (FOUCAULT, 2010a) and the dimension of Bem Viver (Good Living) (KRENAK, 2020), we open paths that help us to think-inhabit-mobilize the possible futures in these pandemic territories and, at the same time, in clues to potentialize the body, life and education.*

Keywords: *Covid-19. Education. Michel Foucault. Ailton Krenak. Pandemic.*

1 Doutor em Educação (UFU). Mestre em Educação (UFU). Graduado em Ciências Biológicas (UFU). Professor na Escola Municipal Stella Saraiva Peano e na Escola Estadual da Cidade Industrial, Uberlândia, Minas Gerais, Brasil. Lattes: http://lattes.cnpq.br/2295345372533795. ORCID: https://orcid.org/0000-0002-3555-8026. E-mail: tiagoamaralsales@gmail.com

2 Doutora em Educação (UFSM). Mestre em Educação (UFSM). Graduada em Química (IFF). Professora na Universidade Federal de Uberlândia (UFU). Lattes: http://lattes.cnpq.br/1523364228695308. ORCID: https://orcid.org/0000-0003-2403-7513. E-mail: fernanda_rigue@hotmail.com

Fantasmas, visões, estática: metáforas em sentido literal

EDUARDO PELLEJERO
PROFESSOR DO DEPARTAMENTO DE FILOSOFIA DA UFRN

Bem-vindos, sonhadores acordados!
VARDA, Agnès.[1]

Sabemos que, assim como não existe uma teoria da imagem, também não existe um método para olhar. A proliferação incomparável do sensível encontra no caráter polimorfo da atenção um suplemento inesperado. E, contudo, *conduzir uma experiência* no sensível não é uma expressão vazia. Conhecemos práticas e procedimentos, casos que merecem a nossa atenção e aconselham o estudo – digamos: modos de ver e dar a ver.

O deslocamento da atenção é seguramente o procedimento mais simples, o mais imediato, o mais comum de todos. Não o único passo em direção à experiência estética, mas sem lugar para dúvidas um passo seguro. Os gregos cunharam um conceito para ele, um conceito que perpassaria toda a história da arte ocidental: a *metáfora*. Colocar fora de lugar aquilo que de ordinário damos por assente ou instalar o extraordinário no âmbito do familiar são modos exemplares desse procedimento que por vezes parece confundir-se com a atividade

[1] Varda, Agnès. "Un minuto para una imagen". In: *L'Atalante*, jul.-dez., 2011, p. 75.

ARTEFILOSOFIA
ISSN:2526-7892

O ACONTECIMENTO POIÉTICO: A ARTE EM VIAS DE SE FAZER

Eduardo Pellejero*

Resumo: Em 1937, no College de France, Paul Valéry introduzia de maneira provocativa uma nova ciência, cujo objeto – as relações que se estabelecem entre a obra e o artista no momento da criação – desafiava a obscuridade que tradicionalmente vela as condutas criativas. A 'poiética', enquanto perspectiva crítica sobre a instauração da arte, envolve a fenomenologia e a ontologia, a sociologia e a psicologia, a antropologia e a história, numa tentativa de atingir o gesto sempre renovado, sempre singular, de compor figuras capazes de resistir ao tempo. O presente artigo aspira a problematizar algumas dimensões fundamentais desse campo de pesquisa a partir de uma aproximação à perspectiva original sobre o ato de criação na obra de Gilles Deleuze e dos processos criativos de Francis Bacon e outros artistas que manifestam pontos em comum no momento da produção da obra de arte.

Palavras-chave: Poiética; Paul Valéry; Gilles Deleuze; Francis Bacon; Criação artística.

Abstract: In 1937, Paul Valéry provocatively introduced a new science, whose object – the relationships established between the work and the artist at the moment of creation – challenged the obscurity that traditionally veils creative behaviors. 'Poietics', as a critical perspective on art, involves phenomenology and ontology, sociology and psychology, anthropology and history, in an attempt to achieve the ever-renewed gesture or creation. This paper aims to problematize some fundamental dimensions of this field of research, in dialogue with the work of Gilles Deleuze and the creative processes of Francis Bacon and other artists who manifest common points at the moment of production of the artwork.

Keywords: Poietics; Paul Valéry; Gilles Deleuze; Francis Bacon; Artistic creation.

* Eduardo Pellejero. Universidade Federal de Rio Grande do Norte. E-mail: estetica.ufrn@gmail.com Lattes: http://lattes.cnpq.br/1224372202417906. Orcid: https://orcid.org/0000-0001-9203-6147.

Submissão: 14/03/2023 | Aprovação: 11/06/2023
https://periodicos.ufpa.br/index.php/revistamargens/article/view/13916
http://dx.doi.org/10.18542/rmi.v17i28.13916
Margens: Revista Interdisciplinar | e-ISSN:1982-5374 | V. 17 | N. 28 | Jan-Jun, 2023, pp. 205-227

ALÉM DE SI: A ARTE COMO FAZER COLETIVO

BEYOND YOURSELF: ART AS A COLLECTIVE ENTERPRISE

Eduardo PELLEJERO
Universidade Federal do Rio Grande do Norte (UFRGN)[1]

Resumen: Autores fundamentais da literatura e da filosofia como Blanchot, Zambrano o Cortázar, associaram de maneira essencial a criação artística à solidão. Mas no encontro e na colaboração com os outros a arte muitas vezes manifestou uma potência incomparável de invenção. Essas experiências, que abrem um horizonte de pesquisas, colocam em causa a herança romântica do gênio e a noção do artista como indivíduo privilegiado. A partir de alguns casos da música e da dança, da pintura e da literatura, o presente ensaio procura explorar algumas dimensões da criação enquanto empresa coletiva.

Palabras-clave: Arte coletiva. Colaboração. Criação artística.

Abstract: *Central authors of literature and philosophy such as Blanchot, Zambrano and Cortázar, associated artistic creation with solitude. But in collaboration art often manifested an incomparable power of invention. These experiences, which open up a horizon of research, call into question the romantic heritage of genius and the notion of the artist as a privileged individual. Based on some cases of music and dance, painting and literature, this essay seeks to explore some dimensions of creation as a collective enterprise.*

Keywords: *Collective art. Collaboration. Artistic creation.*

[1] Doutor em Filosofia Contemporânea pela Faculdade de Letras da Universidade de Lisboa (Portugal, 2006). Desde 2009 é professor de Estética, do Departamento de Filosofia da Universidade Federal do Rio Grande do Norte (UFRN) e do Programa de Pós-Graduação em Estudos da Linguagem e do Programa de Pós-Graduação em Filosofia (UFRN). *E-mail:* edupelejero@gmail.com

DO JARDIM À PAISAGEM (E VICE-VERSA)

Lilian Maus Junqueira
Sérgio Luiz Valente Tomasini

Resumo: O artigo traz reflexões sobre a atividade artística enquanto estratégia de ativação, revelação e ressignificação do patrimônio cultural e natural. São analisadas duas experiências que refletem sobre os conceitos de jardim e paisagem a partir da perspectiva de possíveis intercâmbios simbólicos, perceptivos e afetivos gerados pela arte em contato com o campo do paisagismo urbano. Enquanto a primeira se inspira na prática do paisagismo para explorar a imaterialidade do jardim por meio de um jogo poético, a segunda constrói um percurso alegórico do jardim à paisagem pelo viés da representação pictórica e da produção de imagens. Discute-se o potencial da arte contemporânea para a sensibilização e o reconhecimento de patrimônios vulneráveis.

Palavras-chave: Patrimônio Cultural. Patrimônio Natural. Paisagem. Jardim. Arte Contemporânea e Natureza.

FROM THE GARDEN TO THE LANDSCAPE (AND VICE VERSA)

Abstract: The article presents reflections on artistic activity as strategy for activating, revealing and reframing cultural and natural heritage. Two experiences that reflect on the concepts of garden and landscape from the perspective of possible symbolic, perceptive and affective exchanges generated by art in contact with the field of urban landscape design are analyzed. While the first one is inspired by the practice of landscape design to explore the immateriality of the garden through a poetic game, the second one constructs an allegorical journey from the garden to the landscape through the bias of pictorial representation and image production. The potential of contemporary art for raising awareness and recognizing vulnerable heritage is discussed.

Keywords: Cultural Heritage. Natural Heritage. Landscape. Garden. Contemporary Art and Nature.

Urdimento
REVISTA DE ESTUDOS EM ARTES CÊNICAS
E ISSN 2358.6958

Coreografar a crise - uma dramaturgia do contexto presente

Marina Souza Lobo Guzzo

Para citar este artigo:

GUZZO, Marina Souza Lobo. Coreografar a crise - uma dramaturgia do contexto presente. **Urdimento** – Revista de Estudos em Artes Cênicas, Florianópolis, v. 3, n. 48, set. 2023.

DOI: 10.5965/1414573103482023e0103

Este artigo passou pelo *Plagiarism Detection Software* | iThenticate

REnBio
Revista de Ensino de Biologia da SBEnBio
SBEnBio
DOI: 10.46667/renbio.v16inesp.1.1063

UM CURRÍCULO QUE GUARDE UM POUCO DA TERRA NAS MÃOS

A CURRICULUM THAT HOLDS A LITTLE OF THE EARTH/LAND IN THE HANDS

UN CURRICULUM QUE TIENE UN POCO DE LA TIERRA EN LAS MANOS

Antonio Carlos Rodrigues de Amorim[1], Fabiola Simões Rodrigues da Fonseca[2]

Resumo
Este ensaio deriva da necessidade latente de criar educações possíveis em tempos de mudanças climáticas, na urgência de olharmos nossas formas de estar no mundo e de fazer nossas composições. É deflagrado por reconhecer que a paisagem das mudanças climáticas é marcada por um legado colonizador de estar no mundo, em que nossas formas de sentir e de conviver estão bastante contaminadas por isso. Desenvolveu-se uma pesquisa-criação na qual Biologia e Arte são linhas para composição de currículos, em atravessamentos com perspectivas da crítica à representação. Os espaços e tempos de inventar currículos são um ateliê virtual de experimentação com palavras e imagens. Geram-se territórios educativos pulsantes para outros possíveis de viver e morrer em uma terra arruinada.

Palavras-chave: currículo-experimentação; Antropoceno; biologia e arte.

Abstract
This essay derives from the latent need to create possible educations in times of climate change, in the urgency of looking at our ways of being in the world and making our compositions. It is triggered by recognizing that the landscape of climate change is marked by a colonizing legacy of being in the world, in which our ways of feeling and living together are quite contaminated by this. A research-creation was developed in which Biology and Art are lines for the composition of curricula, in crossings with perspectives of criticism of representation. The spaces and times of inventing curricula are a virtual workshop for experimentation with words and images. Pulsating educational territories are generated for others possible to live and die in a ruined land.

Keywords: curriculum-experimentation; Anthropocene; biology and art.

[1] Doutor em Educação - Universidade Estadual de Campinas (UNICAMP). Campinas, SP - Brasil. Pós-Doutorado - Goldsmiths Collège - Universidade de Londres. London, UK. Professor Titular - Faculdade de Educação - Universidade Estadual de Campinas (UNICAMP). Campinas, SP - Brasil. E-mail: amoracorde@gmail.com

[2] Doutora em Educação - Universidade Federal de Uberlândia (UFU). Uberlândia, MG - Brasil. Pós-doutorado em Educação - Universidade Estadual de Campinas (UNICAMP). Campinas, SP - Brasil. Especialista em Conteúdo no Museu do Amanhã. Rio de Janeiro, RJ - Brasil. E-mail: fsrfonseca@gmail.com

SCIENCE PANEL FOR THE AMAZON

POLICY BRIEF

THE AMAZON WE WANT

DROUGHTS IN THE AMAZON

Flávia R.C. Costa, José Antonio Marengo*, Ana Luisa M. Albernaz, Ana Paula Cunha, Nicolás Cuvi, Jhan-Carlo Espinoza, Joice Ferreira, Juan Carlos Jimenez-Muñoz, María Belén Páez, Luciano Carramaschi de Alagão Querido, Jochen Schöngart* | *Co-lead authors

KEY MESSAGES

- Strong droughts in the Amazon have been increasing in frequency and intensity, from four in a century to four in less than 25 years, in concert with increasing deforestation and global warming. The synergy of droughts, deforestation, fire, and forest degradation have the potential to drive the Amazon to a tipping point where this globally important ecosystem may significantly reduce its capacity to provide critical services such as water recycling, carbon storage, and provision of goods for human well-being.
- Droughts increase tree mortality, and thus biomass loss, imperiling the functioning of the carbon sink provided by tree growth. Droughts also increase animal mortality, especially when river levels decrease abruptly and when forests are disturbed by fire and forest degradation.
- Droughts increase the risk of fires, with direct impacts such as carbon emissions and the loss of biodiversity and ecosystem services, while also threatening human health and food security and feedbacking to global warming.
- The socioeconomic impacts of droughts are large, and result in social, cultural and economic vulnerability. The impacts include threats to water security and quality, food security, public health, human rights, local-to-large scale economies, mobility, energy production, river bank stability, and human migrations.
- The impacts of droughts vary in nature and intensity across social communities (e.g., Indigenous, afro-descendant, *ribeirinhos, caboclos*, etc.), predominant economic activities (e.g., fishing, farming, extractivism, urban services), gender, age, and the regional differences between countries and the Amazon regions (e.g., lowlands, Amazonian Andes, and foothills).
- There are critical gaps to the knowledge required for planning future and immediate responses to climate crises. These include the lack of comprehensive monitoring of Amazonian forests, climate, and hydrology to inform adaptation programs, and the lack of social, economic, cultural, and demographic data at local and regional scales, especially concerning vulnerable populations.

DOI00.0000XXXXXXXX

UFSM LAV

Revista Digital do Laboratório de Artes Visuais
ISSN 1983-7348
Acesso aberto

Submissão: 18/06/2023 • Aprovação: 23/06/2023 • Publicação: 13/09/2023

Um caminhar multiespécies: mesas de trabalho como modos de habitar artes, educações e comunicações diante do Antropoceno

A multispecies walk: working tables as ways of inhabiting arts, education and communications in the face of the Anthropocene

Un caminar multiespecie: las mesas de trabajo como modos de habitar las artes, la educación y la comunicación ante el Antropoceno

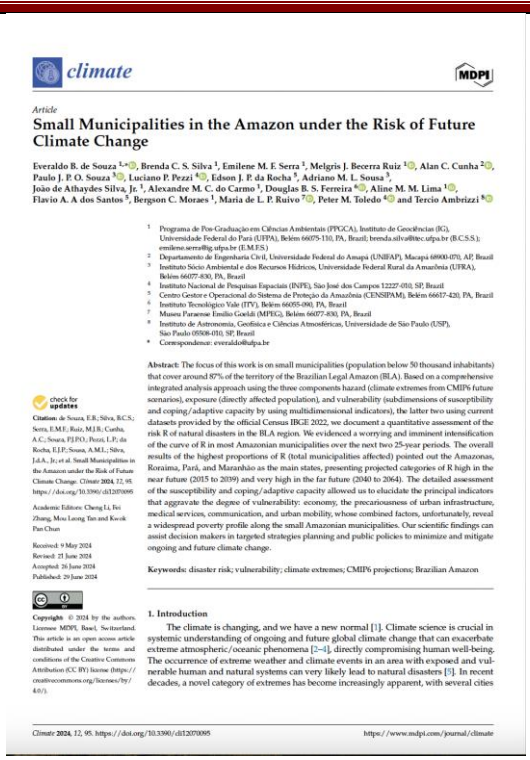
Susana Dias
Universidade Estadual de Campinas

Resumo
Neste artigo busca-se pensar a potência de duas mesas de trabalho, desenvolvidas em diferentes contextos e denominadas de "Encontros com potências frágeis" e "Modos de atenção à Terra". As mesas de trabalho são, ao mesmo tempo, uma intervenção artística urbana e uma metodologia de pesquisar-criar entre artes e ciências, desenvolvidas no âmbito do grupo multiTÃO (CNPq) e Revista ClimaCom. Interessa pensar como tais mesas de trabalho instauram um certo caminhar multiespécies e como geram novas possibilidades de habitar a educações e comunicações diante do Antropoceno.
Palavras-chave: Estudos multiespécies; Arte-Ciência; Caminhar; Plantas.

Abstract
The purpose of this article is to think about the potencialities of two working tables, developed in different contexts and called "Meetings with fragile potencies" and "Modes of attention to the Earth". The working tables are, at the same time, an urban artistic intervention and a research-creating methodology between arts and sciences, developed within the scope of the multiTÃOgroup and ClimaComJournal. It is interesting to think about how such working tables establish a certain multispecies walk and how they generate new possibilities for inhabiting education and communications in the face of the Anthropocene.
***Keywords**. Multispecies studies, Art-Science, To walk, Plants.*

Resumen
Este artículo pretende reflexionar sobre el potencia de dos mesas de trabajo, desarrolladas en contextos diferentes y denominados "Encuentros con poderes frágiles" y "Formas de prestar atención a la Tierra". Las mesas de trabajo son tanto una intervención artística urbana como una metodología de investigación y creación entre las artes y las ciencias, desarrollada en el ámbito del grupo multiTÃO (CNPq) y de la Revista ClimaCom. Me interesa pensar cómo estas mesas de trabajo establecen un cierto caminar multiespecie y cómo generan nuevas posibilidades de habitar la educación y la comunicación frente al Antropoceno.
***Palabras clave:** Estudios multiespecies; Arte-Ciencia; Caminar; Plantas.*

[1] Susana Oliveira Dias tem pós-doutorado em artes pela Universidade Federal do Pará (UFPA). É pesquisadora (PqA) do Laboratório de Estudos Avançados em Jornalismo (Labjor), da Universidade Estadual de Campinas (Unicamp) e editora da Revista ClimaCom. E-mail: susana@unicamp.br.



climate

MDPI

Article

Small Municipalities in the Amazon under the Risk of Future Climate Change

Everaldo B. de Souza [1,*], Brenda C. S. Silva [1], Emilene M. F. Serra [1], Melgris J. Becerra Ruiz [1], Alan C. Cunha [2], Paulo J. P. O. Souza [3], Luciano P. Pezzi [4], Edson J. P. da Rocha [5], Adriano M. L. Sousa [3], João de Athaydes Silva, Jr. [1], Alexandre M. C. do Carmo [1], Douglas B. S. Ferreira [6], Aline M. M. Lima [1], Flavio A. A dos Santos [5], Bergson C. Moraes [1], Maria de L. P. Ruivo [7], Peter M. Toledo [8] and Tercio Ambrizzi [8]

[1] Programa de Pos-Graduação em Ciências Ambientais (PPGCA), Instituto de Geociências (IG), Universidade Federal do Pará (UFPA), Belém 66075-110, PA, Brazil; brenda.silva@itec.ufpa.br (B.C.S.S.); emilene.serra@ig.ufpa.br (E.M.F.S.)
[2] Departamento de Engenharia Civil, Universidade Federal do Amapá (UNIFAP), Macapá 68900-070, AP, Brazil
[3] Instituto Sócio Ambiental e dos Recursos Hídricos, Universidade Federal Rural da Amazônia (UFRA), Belém 66077-830, PA, Brazil
[4] Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos 12227-010, SP, Brazil
[5] Centro Gestor e Operacional do Sistema de Proteção da Amazônia (CENSIPAM), Belém 66037-420, PA, Brazil
[6] Instituto Tecnológico Vale (ITV), Belém 66055-090, PA, Brazil
[7] Museu Paraense Emílio Goeldi (MPEG), Belém 66077-830, PA, Brazil
[8] Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo (USP), São Paulo 05508-010, SP, Brazil
* Correspondence: everaldo@ufpa.br

Abstract: The focus of this work is on small municipalities (population below 50 thousand inhabitants) that cover around 87% of the territory of the Brazilian Legal Amazon (BLA). Based on a comprehensive integrated analysis approach using the three components hazard (climate extremes from CMIP6 future scenarios), exposure (directly affected population), and vulnerability (subdimensions of susceptibility and coping/adaptive capacity by using multidimensional indicators), the latter two using current datasets provided by the official Census IBGE 2022, we document a quantitative assessment of the risk R of natural disasters in the BLA region. We evidenced a worrying and imminent intensification of the curve of R in most Amazonian municipalities over the next two 25-year periods. The overall results of the highest proportions of R (total municipalities affected) pointed out the Amazonas, Roraima, Pará, and Maranhão as the main states, presenting projected categories of R high in the near future (2015 to 2039) and very high in the far future (2040 to 2064). The detailed assessment of the susceptibility and coping/adaptive capacity allowed us to elucidate the principal indicators that aggravate the degree of vulnerability: economy, the precariousness of urban infrastructure, medical services, communication, and urban mobility, whose combined factors, unfortunately, reveal a widespread poverty profile along the small Amazonian municipalities. Our scientific findings can assist decision makers in targeted strategies planning and public policies to minimize and mitigate ongoing and future climate change.

Keywords: disaster risk; vulnerability; climate extremes; CMIP6 projections; Brazilian Amazon

check for updates

Citation: de Souza, E.B.; Silva, B.C.S.; Serra, E.M.F.; Ruiz, M.J.B.; Cunha, A.C.; Sousa, P.J.P.O.; Pezzi, L.P.; da Rocha, E.J.P.; Sousa, A.M.L.; Silva, J.d.A., Jr.; et al. Small Municipalities in the Amazon under the Risk of Future Climate Change. *Climate* **2024**, *12*, 95. https://doi.org/10.3390/cli12070095

Academic Editors: Cheng Li, Fei Zhang, Mou Leong Tan and Kwok Pan Chun

Received: 9 May 2024
Revised: 21 June 2024
Accepted: 26 June 2024
Published: 29 June 2024

1. Introduction

The climate is changing, and we have a new normal [1]. Climate science is crucial in systemic understanding of ongoing and future global climate change that can exacerbate extreme atmospheric/oceanic phenomena [2–4], directly compromising human well-being. The occurrence of extreme weather and climate events in an area with exposed and vulnerable human and natural systems can very likely lead to natural disasters [5]. In recent decades, a novel category of extremes has become increasingly apparent, with several cities

International Journal of Disaster Risk Reduction 108 (2024) 104543

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

ELSEVIER

DISASTER RISK

Check for updates

Increasing flood awareness through dam-break serious games

Marcus Nóbrega Gomes Jr. [a,b,*], Maria de Andrade Rocha Alencar Castro [a], Pedro Gustavo Câmara da Silva [a], Marcio Hofheinz Giacomoni [b], Eduardo Mario Mendiondo [a]

[a] University of São Paulo, Department of Hydraulic Engineering and Sanitation, São Carlos School of Engineering, Av. Trab. São Carlense, 400 - Centro, São Carlos, 13566-590, São Paulo, Brazil
[b] The University of Texas at San Antonio, College of Engineering and Integrated Design, School of Civil & Environmental Engineering and Construction Management, One UTSA Circle, BSE 1.310, San Antonio, 78249, TX, United States of America

ARTICLE INFO

Keywords:
Flood hazard
Serious games
Risk perception
Hydrodynamic forces
Hydrodynamic modeling

ABSTRACT

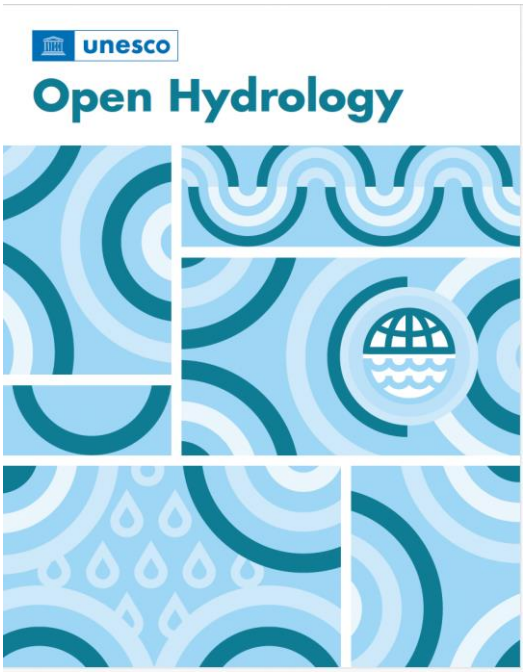
Dams are one of the most important human-made structures ever conceptualized and allow the development of society by providing multiple uses, such as the development of hydroelectric plants and as a source of water supply. A dam break problem is a catastrophic event that evolves rapidly, causing uncontrollable large floods downstream. In this paper, we develop a simplified modeling approach to assess flood characteristics associated with dam-break problems. The method offers a useful tool to improve the perception of dam safety in terms of the hydrodynamic impacts associated with a dam break. We apply our framework to 20 dams in Brazil, in addition to the Brumadinho dam failure at Córrego do Feijão. This event occurred in Brazil in 2019 leading to almost 300 fatalities. The second case study demonstrates the use of the modeling framework developed in this paper through the simulation of 20 dams in Brazil. The modeling approach uses GIS databases, Google Earth, and National Water Agency (ANA) databases and can be replicated whenever GIS information on dam characteristics, downstream channel, and downstream community is available. The results of this modeling approach indicate that several dams in the northeast of Brazil have relatively large flood hazards. A simplified dam-break hazard index was developed to establish a relative hazard impact that considers only deterministic factors such as the hydrodynamic force, velocity, and depth, as well as the arrival time of the maximum values of these states. These values are determined by a 1-D full momentum solver model (HydroHP-1D).

1. Introduction

Dams have contributed significantly to the development of civilization and are one of the most important human-made infrastructure. With a relatively high stored volume and relatively high depths, a dam break problem is a catastrophic event that evolves shortly and rapidly, causing uncontrollable large floods downstream. Despite the associated potential damages, dams are a versatile strategy used for multiple uses such as waste disposal, energy generation, and flood control [1–3].

* Corresponding author at: University of São Paulo, Department of Hydraulic Engineering and Sanitation, São Carlos School of Engineering, Av. Trab. São Carlense, 400 - Centro, São Carlos, 13566-590, São Paulo, Brazil.
E-mail addresses: marcusnobrega.engcivil@gmail.com (M.N. Gomes Jr.), maria.alencar@usp.br (M.d.A.R.A. Castro), pedrogc.silva@usp.br (P.G.C.d. Silva), marcio.giacomoni@utsa.edu (M.H. Giacomoni), emm@ce.usp.br (E.M. Mendiondo).
URL: http://www.engenheirosplanilhetes.com.br (M.N. Gomes Jr.).

https://doi.org/10.1016/j.ijdrr.2024.104543
Received 15 October 2023; Received in revised form 18 February 2024; Accepted 8 May 2024
Available online 16 May 2024
2212-4209/



unesco

Open Hydrology

Nat. Hazards Earth Syst. Sci., 24, 2165–2173, 2024
https://doi.org/10.5194/nhess-24-2165-2024

Natural Hazards and Earth System Sciences

Brief communication: Lessons learned and experiences gained from building up a global survey on societal resilience to changing droughts

Marina Batalini de Macedo[1], Marcos Roberto Benso[2], Karina Simone Sass[3], Eduardo Mario Mendiondo[2], Greicelene Jesus da Silva[2], Pedro Gustavo Câmara da Silva[2], Elisabeth Shrimpton[4], Tanaya Sarmah[4], Da Huo[5], Michael Jacobson[6], Abdullah Konak[3], Nazmiye Balta-Ozkan[6], and Adelaide Cassia Nardocci[1]

[1]Institute of Natural Resources, Federal University of Itajubá, Itajubá, Brazil
[2]São Carlos School of Engineering, University of São Paulo, São Carlos, Brazil
[3]School of Public Health, University of São Paulo, São Paulo, Brazil
[4]Department of Ecosystem Science and Management, The Pennsylvania State University, State College, PA, USA
[5]College of Information Sciences and Technology, The Pennsylvania State University, State College, Berks, PA, USA
[6]School of Water, Energy and Environment, Cranfield University, Wharley End, UK

Correspondence: Marina Batalini de Macedo (marinamacedo@unifei.edu.br)

Received: 6 September 2023 – Discussion started: 13 September 2023
Revised: 22 April 2024 – Accepted: 5 May 2024 – Published: 1 July 2024

Abstract. This paper describes the process of creating a global survey of experts to evaluate drought resilience indicators. The lessons learned include five main points: (1) the heterogeneity in the conceptual background should be minimized before the construction of the survey; (2) large numbers of indicators decrease the engagement of respondents through the survey, and ways to apportion indicators whilst maintaining reliability should be considered; (3) it is necessary to design the survey to balance response rate and accuracy; (4) the survey questions should have clear statements with a logical and flowing structure; and (5) reaching experts with different domain experience and representing different regions is difficult but crucial to minimize biased results.

1 Introduction

The formulation of a global survey is a complex process that poses several challenges in both the preparation (a priori) and the evaluation of results (a posteriori) phases. In general, studies focusing on surveys and expert elicitation address a posteriori challenges, such as the data analysis tools used for samples of different sizes and compositions. However, a priori challenges are rarely addressed and represent an important and defining step in the process. For example, Baker et al. (2014) state that "while there is a rich literature on expert elicitation approaches and protocols, there is less information available on the specifics of how an elicitation is carried out".

Harzing et al. (2013) have reviewed the issues faced in global surveys and identified cultural and language differences, which may lead to different interpretations of questions or loss of meaning, and varying response rates between countries as significant sources of bias in global surveys. ProductLab (2023) also discusses the difficulties of global surveys and provides best practices for their formulation. They also mention the challenges due to cultural and language differences and finally recommend appropriate survey timing for all countries. However, both studies focus on business and product development.

Therefore, our main motivation for writing this brief communication is due to the scarcity of papers and other materials discussing the challenges of creating global surveys on complex subjects where we face conceptual and definitional divergences – such as resilience. We believe that the challenges and problems faced during the survey-building process are often not discussed by the researchers, as doing so may weaken confidence in their final results. However, it is

Published by Copernicus Publications on behalf of the European Geosciences Union.

IOP Publishing Environ. Res. Lett. 19 (2024) 044066 https://doi.org/10.1088/1748-9326/ad37cd

ENVIRONMENTAL RESEARCH
LETTERS

LETTER

OPEN ACCESS

Unveiling water allocation dynamics: a text analysis of 25 years of stakeholder meetings

Taís Maria Nunes Carvalho[1,*], Francisco de Assis de Souza Filho[2] and Mariana Madruga de Brito[3]

[1] Center for Scalable Data Analytics and Artificial Intelligence (ScaDS.AI) Dresden/Leipzig, Universität Leipzig, Leipzig, Germany
[2] Helmholtz Center for Environmental Research, Leipzig, Germany
[3] Hydraulics and Environmental Engineering Department, Federal University of Ceara, Fortaleza, Brazil
* Author to whom any correspondence should be addressed.

E-mail: tais.carvalho@informatik.uni-leipzig.de

Keywords: water allocation, text mining, participatory management
Supplementary material for this article is available online

Abstract

Managing water resources in regions with high climate variability and frequent extreme weather events poses challenges for policymakers. To facilitate water allocation in these cases, participatory and collaborative decision-making approaches have become common. However, the evaluation of these approaches is hindered by the lack of structured methods and data to understand them. To address this knowledge gap, we propose a novel methodology that leverages text data to identify key topics, conflicts, and influential actors that shape water allocation dynamics. Our methodology is tested using records of 1020 water basin committee meetings held between 1997 and 2021 across 12 basin committees in Ceará, Brazil—a region known for its extensive history of droughts that have impacted water governance. To uncover key water management issues discussed during these meetings, we employed a three-step topic modeling framework: (1) sentence embedding, (2) dimensionality reduction, and (3) sentence clustering. Furthermore, we used entity recognition, dependency parsing, and network graphs to identify powerful actors influencing these meetings and, ultimately, the decisions taken. Our findings revealed stakeholders' heightened concern for urban water supply over agricultural demand during droughts. We found that 'reservoir operation' was the most recurring topic, especially in basins where the strategic reservoirs are located. Discussions related to 'climate information' became significantly more important over time, which indicates that water allocation decisions are increasingly based on the seasonal forecast and data on oceanic indices provided by the meteorology agency. Despite the presence of local users in the committees, governmental representatives dominated the discussions and were central in all river basins. In conclusion, our proposed approach harnesses existing text data to uncover spatiotemporal patterns related to participatory water allocation. This study opens new avenues for investigating water governance using text-based analysis.

1. Introduction

Managing water resources in scenarios where their availability is uncertain and their uses are conflicting requires a coordinated response from stakeholders and decision-makers [1]. Water management is a complex and political task, so its social context cannot be disengaged [2, 3]. Acknowledging this challenge, frameworks such as integrated water resources management (IWRM) [4] and adaptive management [5, 6] have been developed. The IWRM framework [7] focuses on integrating management across multiple scales and resources (i.e. water and land) while attending to the needs of multiple users. Adaptive management, on the other hand, incorporates uncertainty assessment by promoting a flexible, continuous learning approach [8, 9].

In recent decades, collaborative and participatory approaches have been widely applied to promote IWRM and adaptive management. However, their utilization in the Global South [10, 11] has been limited compared to the United States and Europe [12].

HYDROLOGICAL SCIENCES JOURNAL
https://doi.org/10.1080/02626667.2024.2325653

IAHS AISH Taylor & Francis

Water security in an Andean basin: an integrated socio-hydrological, multi-scenario and allocation assessment

Edisson Cepeda Arias*, Julio Cañón Barriga* and Eduardo Mario Mendiondo[a,c]

[a]Grupo de Gestión y Modelación Ambiental – GAIA, Escuela Ambiental, Facultad de Ingeniería, Universidad de Antioquia, Medellín, Colombia; [b]São Carlos School of Engineering, University of São Paulo, São Carlos, Brazil; [c]Center for Education and Research of Disasters, University of São Paulo, São Carlos, Brazil

ABSTRACT
The concept of water security encompasses dynamic objectives in various socio-hydrologic contexts. This study examines the pressures on several dimensions of water security and water usage in an Andean basin utilizing an integrated water security index (IWS), the Water Evaluation and Planning System (WEAP) model, and 10 composite scenarios for the period 2021–2099. The results show 60% of the scenarios result in a "fair" IWS score, with 40% classified as "good" trending towards "fair" coverage. Competition in terms of demand coverage for equal and different water usage priorities indicates that mining, thermoelectric, and service-related uses cover their needs, whereas other human uses are unable to cope with the demand, domestic use being the most affected. The findings highlight the difficulty of ensuring water security for all users and reveal that population dynamics and controlled human interventions and trade-offs will have a substantial impact on the provision of water services.

ARTICLE HISTORY
Received 30 March 2023
Accepted 8 February 2024

EDITOR
R. Singh

ASSOCIATE EDITOR
S. Lyon

KEYWORDS
Water security; climate change; climate models; WEAP model; water allocation

1 Introduction

The concept of water security has emerged as a response to the multifaceted global water crisis (Srinivasan *et al.* 2017) and remains one of the most significant challenges of the 21st century. Research on water security indicates that, as population growth continues, humanity faces the potential for an uncertain future in terms of water availability for both human use and the environment due to factors such as climate change and rising water demand (Wagener *et al.* 2010, Mishra *et al.* 2021, van Hateren *et al.* 2023). As human demand for water increases and the value of ecosystem services becomes more apparent, competition for limited water resources intensifies between humans and the environment, as well as between different sectors of the economy and different segments of society (Kurian 2017).

Despite the increasing number of scientific publications pertaining to water security, there is still a lack of clarity regarding how the concept is conceptualized, understood, operationalized, and applied in various contexts and at different spatial scales worldwide (Srinivasan *et al.* 2017, Gerlak *et al.* 2018, Mishra *et al.* 2021). While the concept of water security may be central and general, its meaning and use as a framing mechanism are not consistently shared, applied, or even articulated across different contexts (Gerlak *et al.* 2018, Mishra *et al.* 2021, Octavianti and Staddon 2021). The recognition of water security as a conceptual framework is typically limited to case studies that evaluate specific dimensions or attributes of the concept (Cook and Bakker 2011, Gerlak and Mukhtarov 2015, Zeitoun *et al.* 2016, Gerlak *et al.* 2018, Mishra *et al.* 2021).

Researchers such as Srinivasan *et al.* (2017) argue that water security is a multifaceted issue that goes beyond simply balancing water supply and demand, and they suggest that this is why many studies fail to provide a comprehensive and accurate definition of how the concept is understood or applied. Typically, various concepts of water security are not integrated in a comprehensive manner for the analysis of global, regional, or local water security (Cook and Bakker 2016).

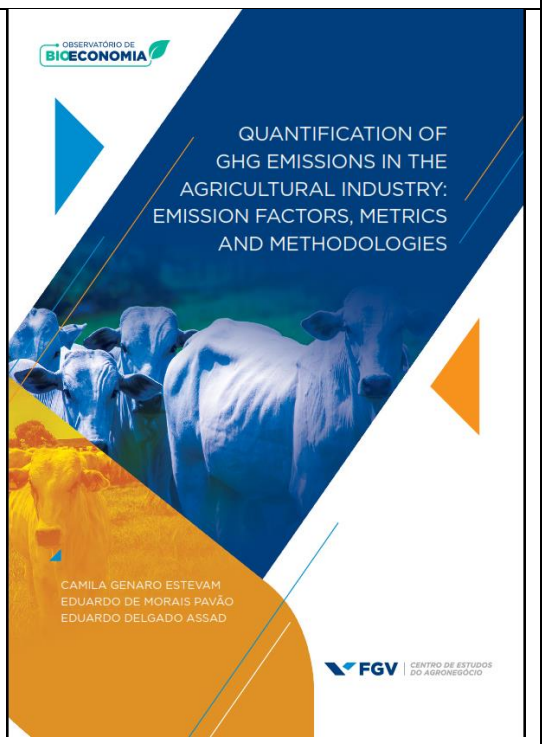
Climate change presents a significant challenge, but an even greater one is the lack of governance systems designed to manage the complex system of competing water uses (Braga *et al.* 2014). To address this issue, hydrology needs to advance the understanding and prediction of systems undergoing change and water services under pressure (Ehret *et al.* 2014, van Hateren *et al.* 2023). An integrated analysis of water security in scenarios of crisis, incorporating various dimensions of water security from the literature, considering water security for both humans and the environment, and including all types of water resources (such as surface water, groundwater, and rainwater), would be a valuable academic and policy contribution. This analysis should also incorporate appropriate metrics for assessing water security, considering socioeconomic, climate, and policy factors, and utilizing mathematical models from various disciplines to support climate, hydrological, ecological, socio-economic, political, competition, and allocation analyses.

Freshwater environments are facing unprecedented global and regional pressures that may lead to water insecurity (Wheater and Gober 2015). High Andean basins offer a potential laboratory for studying integral water security due

CONTACT Edisson Cepeda Arias edisson.cepeda@udea.edu.co Grupo de Gestión y Modelación Ambiental - GAIA, Escuela Ambiental, Facultad de Ingeniería, Universidad de Antioquia, 67th Street No. 53-108, Medellín 050010, Colombia
Supplemental data for this article can be accessed online at https://doi.org/10.1080/02626667.2024.2325653

OBSERVATÓRIO DE BIOECONOMIA

QUANTIFICATION OF GHG EMISSIONS IN THE AGRICULTURAL INDUSTRY: EMISSION FACTORS, METRICS AND METHODOLOGIES



CAMILA GENARO ESTEVAM
EDUARDO DE MORAIS PAVÃO
EDUARDO DELGADO ASSAD

FGV | CENTRO DE ESTUDOS DO AGRONEGÓCIO

SUSTENTABILIDADE

DISTORÇÕES NA MENSURAÇÃO DE EMISSÕES DE GEE DO AGRO

CAMILA GENARO ESTEVAM, EDUARDO DE MORAIS PAVÃO, EDUARDO DELGADO ASSAD*

Um dos elementos iniciais na implementação de metas de descarbonização é o inventário de emissões de carbono. No setor agropecuário, as principais calculadoras utilizadas focam, com frequência, no componente de emissões, negligenciando as remoções de carbono, relacionadas a práticas de manejo. Soma-se a isso a escolha usual por uma fonte de fatores de emissão generalista, não refletindo realidades específicas. Depois de comparar um cálculo com base nas Comunicações Nacionais à UNFCCC e outro com base no IPCC, este artigo recomenda como fundamentais as métricas e fontes locais para a contabilização de emissões e remoções.

NOS ÚLTIMOS anos, tem sido observado um crescente comprometimento por parte das corporações em estabelecer metas sustentáveis, abarcando dimensões sociais, de governança e ambientais. Entre estas, a questão ambiental destaca-se pela diversidade de abordagens possíveis, notadamente no que tange à redução das emissões de gases do efeito estufa (GEE). A implementação de metas de descarbonização, seja por meio de iniciativas como a Science Based Targets initiative (SBTi) ou por meio de objetivos internos, demanda, inicialmente, a realização de inventários de emissões de carbono, que servem como um diagnóstico preliminar dos impactos operacionais.

A etapa de delimitação dos inventários começa com a definição dos limites organizacionais a serem considerados. Pode-se optar por analisar exclusivamente as emissões diretas (escopo 1), que são aquelas originadas de atividades diretamente controladas pela organização, e indiretas (escopo 2), relativas à compra de energia elétrica e térmica. Alternativamente, pode-se expandir a análise para o escopo 3, que abrange todas as emissões indiretas associadas à cadeia produtiva, incluindo o transporte de colaboradores, viagens de negócios e o transporte de matéria-prima ou de produtos acabados.

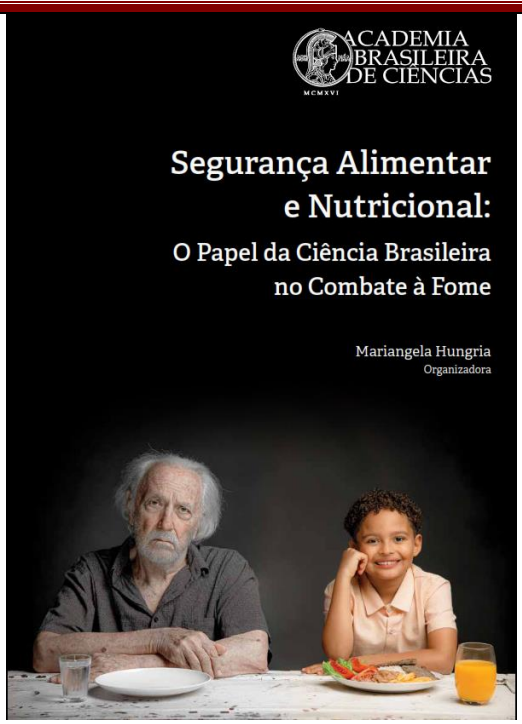
É importante destacar que, quando atividades agropecuárias estão incluídas na cadeia produtiva, suas emissões devem ser quantificadas criteriosamente. Para tanto, existem múltiplos métodos: algumas empresas recorrem a calculadoras independentes para mensurar as emissões ao longo de operações globais, visando padronizar os resultados para facilitar comparações. Outras desenvolvem internamente seus questionários para coletar dados sobre as fontes de emissão. Por fim, algumas adotam uma abordagem híbrida, combinando dados de múltiplas fontes para criar um modelo próprio de contabilização.

Posteriormente, os questionários são distribuídos ao longo da cadeia produtiva, com o objetivo de obter dados detalhados sobre os processos dos diferentes agentes da cadeia produtiva. Ao consolidar as informações coletadas, a empresa obtém uma visão dos seus processos operacionais sob a perspectiva dos impactos sobre as emissões, o que permite a identificação de etapas e processos de alta intensidade de emissão e o estabelecimento de metas de redução de emissões e planos de descarbonização, visando alcançar a neutralidade de carbono, conhecida como "*net-zero*".

FOCO EM EMISSÕES NEGLIGENCIA DADOS RELEVANTES DE REMOÇÕES

No entanto, quando se trata do setor agropecuário, um aspecto frequentemente negligenciado é que as principais ferramentas e calculadoras disponíveis no mercado focam exclusivamente no componente de emissões, sem considerar as remoções de carbono que podem ocorrer devido a práticas de manejo. É crucial reconhecer que os setores produtivos agropecuário e florestal operam como um sistema de fluxo bidirecional de carbono, envolvendo tanto a emissão, quanto a remoção de carbono. Desta forma, tais setores são únicos, já que podem fazer parte da solução no combate às mudanças climáticas.

Frequentemente, esses sistemas são criticados por seus impactos ambientais, particularmente em relação às emissões de GEE, apesar da adoção generalizada de práticas sustentáveis. A exclusão ou não consideração das remoções na avaliação das emissões gera uma distorção significativa no cálculo do balanço de carbono desses sistemas, causando uma



Capítulo 8

Mudanças climáticas e as injustiças sociais no combate à fome

Eduardo Delgado Assad

Cepagri/Unicamp; Observatório da Bioeconomia FGV/GVagro

SUSTENTABILIDADE

BALANÇO DE EMISSÕES EM CEM FAZENDAS BRASILEIRAS

EDUARDO DELGADO ASSAD[1], FÁBIO MARTINS GUERRA NUNES DIAS[2], ANTONIO CHAKER EL-MEMARI NETO[3], HELLEN BRAGA[4], AMANDA CAMILA DE OLIVEIRA POPPI[5], ALICE ASSAD WASSALL[6]

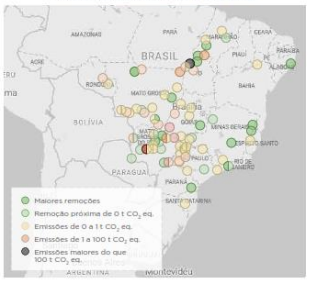
Em 2023, o Brasil tornou-se o maior exportador de carne bovina, o que colocou a atividade no foco dos debates globais, pelo seu papel nas mudanças climáticas. Em 2017, a Friboi e o Instituto Integra criaram o Programa FNI0 para melhorar a produtividade e a sustentabilidade de fazendas fornecedoras de carne. Com uma área geográfica bem distribuída, conquistou-se uma análise representativa da produção pecuária no País, sendo possível mensurar as emissões e as remoções de GEE em diferentes fazendas. Desse estudo, depreendeu-se que as fazendas mais eficientes emitem 46% menos GEE do que as menos eficientes. Portanto, o objetivo do FNI0 é identificar as ações realizadas nas fazendas que neutralizam e sequestram carbono e replicá-las em fazendas consideradas emissoras.

A PECUÁRIA brasileira, com um rebanho superior a 200 milhões de cabeças, desempenha um papel crucial na economia do País. Em 2023, o Brasil consolidou a sua posição como o maior exportador mundial de carne bovina, enviando 2,536 milhões de toneladas ao mercado global, enquanto a bovinocultura contribuiu significativamente para o Produto Interno Bruto (PIB) nacional, representando 6,6%, o equivalente a R$ 721 bilhões, segundo dados do Ministério da Agricultura e Pecuária (MAPA), do Centro de Estudos Avançados em Economia Aplicada da Escola Superior de Agricultura "Luiz de Queiroz" da Universidade de São Paulo (Cepea/Esalq/USP) e da Confederação da Agricultura e Pecuária do Brasil (CNA).

Com relações comerciais em 159 países, a pecuária não só tem relevância econômica, mas também é um foco de debates ambientais. As emissões de metano (CH_4), subproduto da digestão animal, e óxido nitroso (N_2O), proveniente do uso de fertilizantes nitrogenados e do manejo de esterco, colocam a atividade no centro das discussões, pelo seu papel nas mudanças climáticas e no aquecimento global.

DISTRIBUIÇÃO GEOGRÁFICA E INTENSIDADE DE EMISSÃO LÍQUIDA DAS FAZENDAS PARTICIPANTES (T CO_2 EQ. POR CABEÇA)

A partir de uma análise que teve resultados entre -2,89 e 152,54 t CO_2 eq., a distribuição geográfica e a intensidade de emissão líquida das fazendas foram representadas num espectro que vai das maiores remoções (verde-escuro) às maiores emissões (preto).



Fonte: elaboração pelos autores

International Journal of Disaster Risk Reduction 100 (2024) 104200

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

Community disaster resilience in Brazilian small urban centers

Daniela Ferreira Ribeiro *, Silvia Midori Saito, Regina Célia dos Santos Alvalá

National Center for Monitoring and Early Warning of Natural Disasters - CEMADEN, 500 Estrada Doutor Altino Bondensan, Distrito de Eugênio de Melo, São José dos Campos, SP, Brazil

ARTICLE INFO

Keywords:
Social capital
Small municipalities
Small towns
Vulnerability

ABSTRACT

Brazilian small urban centers are facing several disasters impacts due to their singular environmental, economic, and social characteristics. A comprehensive approach encompassing multiple dimensions of resilience and adaptation is essential to minimize material and human losses. This article analyzes the community disaster resilience of 213 small urban centers in the Brazilian Southeast region, affected by recurrent events, such as floods, flash floods, and landslides. The study adopts a mixed-methods approach. First, a quantitative analysis was conducted at the municipal level using statistical techniques to develop a community disaster resilience index, incorporating social, economic, infrastructure, institutional, and community dimensions. Simultaneously, a qualitative assessment evaluated the levels of social capital at the intra-municipal scale among populations affected by disasters through an online questionnaire. The results demonstrated a direct correlation between community disaster resilience levels and the economic and urban development of the assessed municipalities. Lower levels of community disaster resilience were associated with higher vulnerability of the population, characterized by limited socioeconomic development, inadequate housing conditions, insufficient urban infrastructure for transportation, healthcare, leisure, and social support services, and ineffective implementation of public development policies. Moreover, the absence and limited diversity of leisure spaces that foster social connections contributed to reduced community engagement and participation, resulting in lower levels of social capital. This study underscores the need for comprehensive strategies to enhance community resilience in small urban centers facing recurrent disasters. The findings provide insights for policymakers and practitioners to prioritize interventions and investments in economic development, infrastructure improvement, and social capital enhancement as crucial elements of disaster risk reduction and resilience-building efforts.

1. Introduction

The global urban population is expected to sharply rise, potentially comprising two-thirds of the world's population by 2050. Urbanization and population growth characteristics in cities vary across countries. Urban agglomerations, highly populated areas, are categorized as follows: megacities, with 10 million or more inhabitants; large cities, with 5–10 million inhabitants; medium-sized cities, with 1–5 million people; cities with 500,000 to 1 million; cities with 300,000 to 500,000; and urban settlements with less than 300,000 inhabitants [1]. Currently in Brazil, there is no standardized definition for the classification of urban areas. In accordance with the provisions of Decree-Law No. 311 of 1938, every municipal council, irrespective of its population size, is designated as a city.

As per the Brazilian Institute of Geography and Statistics (IBGE), in relation to the urban network's hierarchy, municipalities are recognized as urban centers and are classified according to their distinct governance functions and activities dedicated to service pro-

* Corresponding author.
E-mail addresses: daniela.ribeiro@cemaden.gov.br (D.F. Ribeiro), silvia.saito@cemaden.gov.br (S.M. Saito), regina.alvala@cemaden.gov.br (R.C.d.S. Alvalá).

https://doi.org/10.1016/j.ijdrr.2023.104200
Received 26 September 2023; Received in revised form 11 December 2023; Accepted 13 December 2023
Available online 17 December 2023

Modeling Earth Systems and Environment
https://doi.org/10.1007/s40808-024-01972-x

REVIEW ARTICLE

Inundation mapping using hydraulic modeling with high-resolution remote sensed data: a case study in the Acre River Basin, Brazil

Larissa Antunes da Silva[1] · Conrado Rudorff[1] · Alex Ovando[1] · Alan Pimentel[1] · Luz Adriana Cuartas[1] · Regina Célia dos Santos Alvalá[1]

Received: 17 November 2023 / Accepted: 24 January 2024

Abstract
Considering the impacts of climate change in recent decades that have exacerbated the frequency and intensity of floods worldwide and especially in the Amazon region. The city of Rio Branco, located in the southwest of Brazil's Amazon region, has been severely affected by a combination of urbanization in flood-prone areas and increasing floods in the Acre River. In addressing this challenge, accurate inundation mapping plays a pivotal role in shaping effective flood risk reduction strategies. This study employs hydraulic simulations of the Acre River, utilizing the HEC-RAS 1D model. The modeling process integrates a high-resolution digital terrain model, acquired through Light Detection and Ranging (LiDAR), and a rich dataset encompassing conventional and unconventional information from the three most significant historical floods in Rio Branco in 2012, 2015, and 2023. To ensure the precision of the simulations, calibration of the roughness coefficient was conducted for steady-state scenarios, drawing upon a diverse range of observed stream-gauge data. The evaluation of water elevation in steady state reveals an impressive mean error of just 0.01 m, underscoring the model's accuracy. Moving beyond steady-state simulations, the study evaluates unsteady-state scenarios by calculating the root mean square error (RMSE). Results showcase commendable accuracies of 0.22, 0.25, and 0.26 m for the 2012, 2015, and 2023 floods, respectively. Flooding extent simulation was assessed using the Critical Success Index (C) from two optical aerial survey images recorded during the 2012 and 2015 floods and one optical satellite image recorded during the 2023 flood. The accuracy was 0.88 (2012) and 0.84 (2015) for optical aerial survey images and 0.97 for the optical satellite image (2023). Images from Google Street View recorded after 2012 flood event containing high-water marks were used to evaluate the accuracy of maximum water depth simulation along the floodplain and presented a mean error of 0.17 m.

Keywords Flood events · Flood hazard mapping · High-water mark · HEC-RAS · Hydraulic model · LiDAR

Introduction

Larissa Antunes da Silva
antunesla86@gmail.com

Conrado Rudorff
Conrado.Rudorff@fmglobal.com

Alex Ovando
alex.ovando@cemaden.gov.br

Alan Pimentel
alan.gopimentel@gmail.com

Luz Adriana Cuartas
adriana.cuartas@cemaden.gov.br

Regina Célia dos Santos Alvalá
regina.alvala@cemaden.gov.br

[1] The National Center for Monitoring and Early Warning of Natural Disasters (CEMADEN), São José Dos Campos, São Paulo, Brazil

Floods constitute a substantial portion of the reported disasters, as highlighted by Freer et al. (2011) and Duan et al. (2022). According to the Emergency Events Database (EM-DAT) maintained by the Centre for Research on the Epidemiology of Disasters (CRED), a staggering 5,361 flood disasters were documented between 1980 and 2023. This accounts for a significant 37% of the total recorded disasters (14,556) during the same period, with an annual average economic loss exceeding $175 million. These figures underscore the pervasive impact of floods on a global scale and the substantial economic toll associated with such events (EM-DAT, CRED 2023).

The United Nations Office for Disaster Risk Reduction (UNDRR 2023) provides a comprehensive overview of disasters in Latin America and the Caribbean from 2000

Published online: 18 March 2024

www.nature.com/scientificreports

scientific reports

OPEN

Amazon savannization and climate change are projected to increase dry season length and temperature extremes over Brazil

Marcus Jorge Bottino[1✉], Paulo Nobre[1], Emanuel Giarolla[1], Manoel Baptista da Silva Junior[1], Vinicius Buscioli Capistrano[1], Marta Malagutti[1], Jonas Noboru Tamaoki[1], Beatriz Fátima Alves de Oliveira[2] & Carlos Afonso Nobre[1]

Land use change and atmospheric composition, two drivers of climate change, can interact to affect both local and remote climate regimes. Previous works have considered the effects of greenhouse gas buildup in the atmosphere and the effects of Amazon deforestation in atmospheric general circulation models. In this study, we investigate the impacts of the Brazilian Amazon savannization and global warming in a fully coupled ocean-land-sea ice-atmosphere model simulation. We find that both savannization and global warming individually lengthen the dry season and reduce annual rainfall over large tracts of South America. The combined effects of land use change and global warming resulted in a mean annual rainfall reduction of 44% and a dry season length increase of 69%, when averaged over the Amazon basin, relative to the control run. Modulation of inland moisture transport due to savannization shows the largest signal to explain the rainfall reduction and increase in dry season length over the Amazon and Central-West. The combined effects of savannization and global warming resulted in maximum daily temperature anomalies, reaching values of up to 11a °C above the current climatic conditions over the Amazon. Also, as a consequence of both climate drivers, both soil moisture and surface runoff decrease over most of the country, suggesting cascading negative future impacts on both agriculture production and hydroelectricity generation.

In addition to being the habitat of a great number of vegetal and animal species[1], the Amazon rainforest is also known to be an important player in the global climatic system. Several works have demonstrated its role in modulating rainfall and air temperature, both locally (e.g.,[2–4]) and remotely[5,6]. One role of the Amazon rainforest is to regulate the hydrological cycle both over the forest itself and in distant areas[6,10]. Via intense evapotranspiration, the tropical forest pumps latent heat deep into the atmosphere to balance the strong surface radiative heating[11]. Furthermore, moisture recycling processes are an important mechanism for the advection of water vapor towards the interior of the continent[12–14]. Water vapor originating from the tropical Atlantic Ocean is transported over South America by the Trade Winds, feeding into the precipitation processes over the Amazon basin[5,13,14]. A portion of the transported water vapor reaches the western portion of the basin with replenishing water vapor content supplied by Amazon rainforest evapotranspiration[15]. However, we have yet to investigate to what extent two competing factors induce rainfall reductions over the Amazon Basin and elsewhere in South America, namely savannization (i.e. the substitution of the original Amazonian broadleaf evergreen trees by broadleaf trees with ground cover) and global warming. Additionally, it is of interest to gauge the dependence of the agricultural growing season in Central-West and elsewhere in Southern Brazil on the upstream water vapor transport contribution from the Amazon rainforest[17]. A study using satellite-based and rain gauge observations from 1981 to 2019 found that a large fraction of this agriculturally important region has experienced reduced dry season rainfall[18]. Over the state of Rondônia in Brazil, water vapor originating from ocean evaporation accounts for 58% of the mean dry season precipitation while continental recycling contributes 42%[19]. One mechanism

[1]National Institute for Space Research - INPE, Rodovia Presidente Dutra SP-RJ Km 40, Cachoeira Paulista, São Paulo 12630-000, Brazil. [2]Federal University of Mato Grosso Do Sul (UFMS), Campo Grande, Mato Grosso do Sul, Brasil. [3]Fiocruz Regional Office of Piauí, National School of Public Health, Oswaldo Cruz Foundation, Teresina, Piauí, Brazil. *Institute of Advanced Studies (IEA), São Paulo University, São Paulo, São Paulo, Brazil. ✉email: mjbottino@gmail.com

www.nature.com/scientificreports

scientific reports

OPEN

AMOC decline and recovery in a warmer climate

Paulo Nobre[1✉], Sandro F. Veiga[2], Emanuel Giarolla[1], André L. Marquez[1], Manoel B. da Silva Jr.[1], Vinicius B. Capistrano[1], Marta Malagutti[1], Julio P. R. Fernandez[1], Helena C. Soares[1], Marcus J. Bottino[1], Paulo Y. Kubota[1], Silvio N. Figueroa[1], José P. Bonatti[1], Gilvan Sampaio[1], Fernanda Casagrande[1], Mabel C. Costa[1] & Carlos A. Nobre[1]

This study presents novel insight into the mechanisms of Atlantic Meridional Overturning Circulation (AMOC) reduction and its recovery under a warmer climate scenario. An one-thousand-year-long numerical simulation of a global coupled ocean–ice–atmosphere climate model, subjected to a stationary atmospheric radiative forcing, depict a coherent picture of the Arctic sea ice melting as a trigger for the initial AMOC reduction, along with decreases in the northward fluxes of salt and heat. Further atmospheric-driven ocean processes contribute to an erosion of the stable stratification of the fresher, yet colder waters in the surface layers of the North Atlantic, contributing to the recovery of a permanently altered AMOC.

The scientific scrutiny of the Atlantic Meridional Overturning Circulation (AMOC) as a driver of world climatic stability and change has sharply increased recently[1–7]. Several studies based on both paleoclimatic data and model simulations concur in proposing mechanisms for AMOC reduction[8–11] or eventual collapse[12–17] in a warmer climate. According to the concept of the AMOC being driven by density gradients associated with deep-water formation in the North Atlantic (NATL)[18,19], an eventual weakening of the AMOC can be seen as a direct result of the reduction of surface water density due to warming or salinity decreases of the upper ocean layers[1]. Yet, the AMOC recovery has been suggested by several studies. One among them, for example, attributes the recovery to a northward transport of anomalous warmer water at depth, into the NATL region, that results in a destabilization of ocean stratification, restarting then the convection[1]. Other study, on the other hand, suggest that the recovery is driven by ocean-only processes based on downward advection and mixing of freshwater by the still-active AMOC, that lead to an erosion of the stratification in the NATL, which generates convection[6].

Here we propose that the AMOC demise is caused by a Summer-Fall pulse of warm air/water temperature, followed by a Winter sea ice melting over the Arctic and a Spring southward advection of fresher/cooler waters by ocean currents. The recovery of the AMOC, on the other hand, is attributed to the vertical stratification erosion caused by the wind driven Ekman pumping, bringing denser (saltier) waters to the surface, by the AMOC itself, which is much weaker but not totally collapsed, and by the solar radiation warming of surface waters, slowly dissipating the cold surface anomaly. Those statements are based on a set of one-thousand-year-long numerical simulation of the Brazilian Earth System Model (BESM2.5)[20–23], with two stationary atmospheric forcings, the pre-industrial (piControl) and the abrupt four times atmospheric CO_2 concentration increase (Abrupt4xCO_2) of the CMIP5 protocol[24]. The Abrupt4xCO_2 stationary atmospheric forcing experimental design enables climate considerations of transient processes that act in the global climate system. The model, which demonstrated a bistable equilibria characteristic[21,23] (Supplementary Fig. 1), underwent four phases; fast reduction, slow recovery, fast recovery, and damped oscillations, depicted in Fig. 1 and discussed below.

The AMOC meridional mean profiles for control and perturbed conditions, the latter in the first and last 100 years of simulation, are shown in Fig. 2.

Results and discussion

AMOC weakening mechanisms

Links between Arctic sea ice loss and AMOC reduction have been pointed out by several studies. Consistent with the findings of previous studies[8,20,21], the Abrupt4xCO_2 BESM2.5 simulation predicts a time-evolving AMOC structure related to a concurrent decrease in Arctic sea ice volume and a reduced AMOC (Supplementary Fig. 2),

[1]Center for Weather Forecasting and Climate Studies (CPTEC), National Institute for Space Research (INPE), Cachoeira Paulista, São Paulo 12630-000, Brazil. [2]School of Atmospheric Sciences and Key Laboratory of Mesoscale Severe Weather/Ministry of Education, Nanjing University, Nanjing, China. [3]Institute of Physics, Federal University of Mato Grosso do Sul (UFMS), Campo Grande, Mato Grosso do Sul 79070-900, Brazil. *Institute for Advanced Studies, University of São Paulo, São Paulo, São Paulo 05508-050, Brazil. ✉email: paulo.nobre@inpe.br

AUGUST 2023 MAKARIEVA ET AL. 1905

Water Lifting and Outflow Gain of Kinetic Energy in Tropical Cyclones

ANASTASSIA M. MAKARIEVA,[a,b] VICTOR G. GORSHKOV,[a] ANDREI V. NEFIODOV,[a] ALEXANDER V. CHIKUNOV,[c] DOUGLAS SHEIL,[d,e] ANTONIO DONATO NOBRE,[f] PAULO NOBRE,[g] GÜNTER PLUNIEN,[h] AND RUBEN D. MOLINA[i]

[a] *Theoretical Physics Division, Petersburg Nuclear Physics Institute, Saint Petersburg, Russia*
[b] *Institute for Advanced Study, Technical University of Munich, Garching, Germany*
[c] *Princeton Institute of Life Sciences, Princeton, New Jersey*
[d] *Forest Ecology and Forest Management Group, Wageningen University and Research, Wageningen, Netherlands*
[e] *Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, Ås, Norway*
[f] *Centro de Ciência do Sistema Terrestre, Instituto Nacional de Pesquisas Espaciais, São José dos Campos, Brazil*
[g] *Center for Weather Forecast and Climate Studies, Instituto Nacional de Pesquisas Espaciais, São José dos Campos, Brazil*
[h] *Institut für Theoretische Physik, Technische Universität Dresden, Dresden, Germany*
[i] *Escuela Ambiental, Facultad de Ingeniería, Universidad de Antioquia, Medellín, Colombia*

(Manuscript received 25 June 2021, in final form 2 December 2021, accepted 7 December 2021)

ABSTRACT: While water lifting plays a recognized role in the global atmospheric power budget, estimates for this role in tropical cyclones vary from no effect to a major reduction in storm intensity. To better assess this impact, here we consider the work output of an infinitely narrow thermodynamic cycle with two streamlines connecting the top of the boundary layer in the vicinity of maximum wind (without assuming gradient-wind balance) to an arbitrary level in the inviscid free troposphere. The reduction of a storm's maximum wind speed due to water lifting is found to decline with increasing efficiency of the cycle and is about 5% for maximum observed Carnot efficiencies. In the steady-state cycle, there is an extra heat input associated with the warming of precipitating water. The corresponding positive extra work is of an opposite sign and several times smaller than that due to water lifting. We also estimate the gain of kinetic energy in the outflow region. Contrary to previous assessments, this term is found to be large when the outflow radius is small (comparable to the radius of maximum wind). Using our framework, we show that Emanuel's maximum potential intensity (E-PI) corresponds to a cycle where total work equals work performed at the top of the boundary layer (net work in the free troposphere is zero). This constrains a dependence between the outflow temperature and heat input at the point of maximum wind, but does not constrain the radial pressure gradient. We outline the implications of the established patterns for assessing real storms.

KEYWORDS: Hurricanes; Hurricanes/typhoons; Precipitation; Sea surface temperature; Tropical cyclones

1. Introduction

Reliable predictions of storm intensity are vital for improving human safety. These predictions require a robust account of the major physical factors that determine the maximum wind speed that can be developed by the storm. Tropical cyclones do not just generate kinetic energy; they also lift water that subsequently precipitates. This lifting can diminish the power available for winds. Nonetheless, available estimates of this impact are inconsistent (Makarieva et al. 2020; Emanuel and Rousseau-Rizzi 2020).

Table 1 summarizes the situation. In steady-state large-scale circulations, the water lifting power W_P (W m^{-2}) is within 20%–50% of total wind power. By analogy to hydropower, this lifting power is estimated from the known precipitation rate P and precipitation pathlength H_P (the mean height from which the hydrometeors are falling) (Gorshkov 1982, 1995; Pauluis et al. 2000; Pauluis and Dias 2012; Makarieva et al. 2013, 2017c).

For tropical cyclones, Emanuel (1988) estimated that water lifting reduces the central pressure drop in intense storms by about 5% and 20% for pseudoadiabatic and reversible ascent, respectively, and concluded that "the importance of water loading in limiting the hurricane intensity in the reversible case" is "very substantial." Without referring to this prior work, Emanuel and Rousseau-Rizzi (2020) recently agreed with Makarieva et al. (2020) that in real cyclones the reduction of the squared maximum velocity due to water lifting should not exceed 10%.

In contrast, Sabuwala et al. (2015)—quoted by Emanuel (2018) but neglected by Rousseau-Rizzi and Emanuel (2019) and by Emanuel and Rousseau-Rizzi (2020)—used satellite-derived precipitation data and Emanuel's potential intensity framework to report an approximately 50% reduction in the squared maximum velocity due to water lifting for pseudoadiabatic ascent. Unlike Sabuwala et al. (2015), who did not quote Emanuel (1988), Wang and Lin (2020) used the approach of Emanuel (1988) to account for the total water mixing ratio q_t in the pseudoadiabatic model of Emanuel and Rotunno (2011) and found that this reduces air velocity at the radius of maximum wind in a hurricane with reversible adiabats by about 10% (or squared velocity by 20%). At the same time, Emanuel and Rousseau-Rizzi (2020) indicated that the impact of the water lifting on storm intensity depends on the integral of dq_t/dt over a closed contour. For a reversible cycle, which conserves the total water content, this integral is exactly zero (Table 1).

Gorshkov: Deceased.

Corresponding author: Anastassia M. Makarieva, ammakarieva@gmail.com

DOI: 10.1175/JAS-D-21-0172.1

Access through your institution Purchase PDF

ELSEVIER Journal of South American Earth Sciences

Volume 131, November 2023, 104598

Climate change over South America simulated by the Brazilian Earth system model under RCP4.5 and RCP8.5 scenarios

Sandro F. Veiga [a b], Paulo Nobre [c], Emanuel Giarolla [d], Vinícius B. Capistrano [e], Manoel B. da Silva Jr. [c], Fernanda Casagrande [c], Helena C. Soares [c], Paulo Y. Kubota [c], Silvio N. Figueroa [c], Marcus J. Bottino [c], Marta Malagutti [c], Julio P.R. Fernandez [c], José P. Bonatti [c], Gilvan Sampaio [c], Carlos A. Nobre [f]

Show more

Add to Mendeley Share Cite

https://doi.org/10.1016/j.jsames.2023.104598 Get rights and content

climate MDPI

Article

Modeling the Effects of Local Atmospheric Conditions on the Thermodynamics of Sobradinho Lake, Northeast Brazil

Eliseu Oliveira Afonso [*,†] and Sin Chan Chou [†]

National Institute for Space Research-INPE, Rodovia Presidente Dutra, km 40 SP/RJ, Cachoeira Paulista, São Paulo CEP 12630-970, Brazil; chou.chan@inpe.br
* Correspondence: eliseuoafonso@gmail.com
† These authors contributed equally to this work.

Abstract: The objective of this work was to study climate variability and its impacts on the temperature of Sobradinho Lake in Northeast Brazil. Surface weather station data and lake measurements were used in this study. The model applied in this work is FLake, which is a one-dimensional model used to simulate the vertical temperature profile of freshwater lakes. First, the climate variability around Sobradinho Lake was analyzed. Observations showed a reduction in precipitation during 1991–2020 compared to 1981–2010. To study climate variability impacts on Sobradinho Lake, the years 2013, 2015, and 2020 were selected to characterize normal, dry, and rainy years, respectively. In addition, the months of January, April, July, and October were analyzed for rainy months, rainy–dry transitions, dry months, and dry–rainy transitions. Dry years showed higher incoming solar radiation at the surface and, consequently, higher 2 m air temperatures. A characteristic of the normal years was more intense surface winds. October presented the highest incoming solar radiation, the highest air temperature, and the most intense winds at the surface. The lowest incoming solar radiation at the surface was observed in January, and the lightest wind was observed in April. To assess the effects of these atmospheric conditions on the thermodynamics of Sobradinho Lake, the FLake model was forced using station observation data. The thermal amplitude of the lake surface temperature (LST) varied by less than 1 °C during the four months. This result was validated against surface lake observations. FLake was able to accurately reproduce the diurnal cycle variation in sensible heat fluxes (H), latent heat fluxes, and momentum fluxes. The sensible heat flux depends directly on the difference between the LST and the air temperature. During daytime, however, FLake simulated negative values of H, and during nighttime, positive values. The highest values of latent heat flux were simulated during the day, with the maximum value was simulated at 12:00 noon. The momentum flux simulated a similar pattern, with the maximum values simulated during the day and the minimum values during the night. The FLake model also simulated the deepest mixing layer in the months of July and October. However, our results have limitations due to the lack of observed data to validate the simulations.

Keywords: lake surface temperature; FLake model; Sobradinho Lake

1. Introduction

Sobradinho Lake is located along the São Francisco River, Brazil, centered at approximately latitude −9.67° and longitude −41.50°. It is considered one of the largest artificial lakes in the world. The lake was built mainly to regulate water flow from the São Francisco River [1]. The major activities related to the lake are energy production, crop irrigation, and fishing.

Sediment retention behind power generation dams, however, significantly impacts water turbidity, disrupting fish physiology. Decreases in water temperature, especially in the deeper parts of the reservoir, may cause disturbances in the reproduction and development of some fish species [2].

check for updates
Citation: Afonso, E.O.; Chou, S.C. Modeling the Effects of Local Atmospheric Conditions on the Thermodynamics of Sobradinho Lake, Northeast Brazil. *Climate* **2023**, *11*, 208. https://doi.org/10.3390/cli11100208
Academic Editors: Nektarios N. Kourgialas, Ioannis Anastopoulos and Alexandros Stefanakis
Received: 13 August 2023
Revised: 9 October 2023
Accepted: 11 October 2023
Published: 17 October 2023

climate MDPI

Article

Projections of Changes in Atmospheric Conditions Leading to Storm Surges along the Coast of Santos, Brazil

Marcely Sondermann [1,*], Sin Chan Chou [1], Priscila Tavares [1], André Lyra [1], José A. Marengo [2] and Celia Regina de Gouveia Souza [3]

[1] National Institute for Space Research, Cachoeira Paulista 12630-000, SP, Brazil; chou.chan@inpe.br (S.C.C.); priscila.tavares@inpe.br (P.T.); andre.lyra@inpe.br (A.L.)
[2] National Center for Monitoring and Early Warning of Natural Disasters (CEMADEN), São José Dos Campos 12247-016, SP, Brazil; jose.marengo@cemaden.gov.br
[3] Institute of Environmental Researches, Secretariat for the Infrastructure and Environment of the State of São Paulo, São Paulo 05508-090, SP, Brazil; aelia@sp.gov.br
* Correspondence: marcely.silva@inpe.br

Abstract: This study aims to assess the changes in the atmospheric conditions favorable to storm surges over the Santos Coast in Southeast Brazil. Storm surges can favor high sea level rises and coastal erosion, affecting people and strategic structures in coastal areas. The assessment of the atmospheric conditions was based on the downscaling of climate simulations of the Brazilian Earth System Model by the Eta regional climate model at higher spatial resolution. The detection scheme used by the model was able to reproduce the three observed atmospheric patterns favorable to storm surges found by recent studies: Pattern 1 is characterized by a cyclone on the synoptic scale over the ocean; Pattern 2 presents an intense wind fetch from the southeast; Pattern 3 is characterized by winds parallel to the coast. The simulations underestimated the number of cases in Patterns 1 and 2. However, it overestimated the number of days in Pattern 3. The model presented more intense winds in the three patterns. The storm surges characterized by Pattern 1 will become more intense. However, it will be equal to or less frequent. In Pattern 2, the number of events will decrease. Nevertheless, these episodes will be associated with more precipitation along the coastline. Pattern 3 will have a similar number of storm surges.

Keywords: Eta Model; climate change; coastal hazards

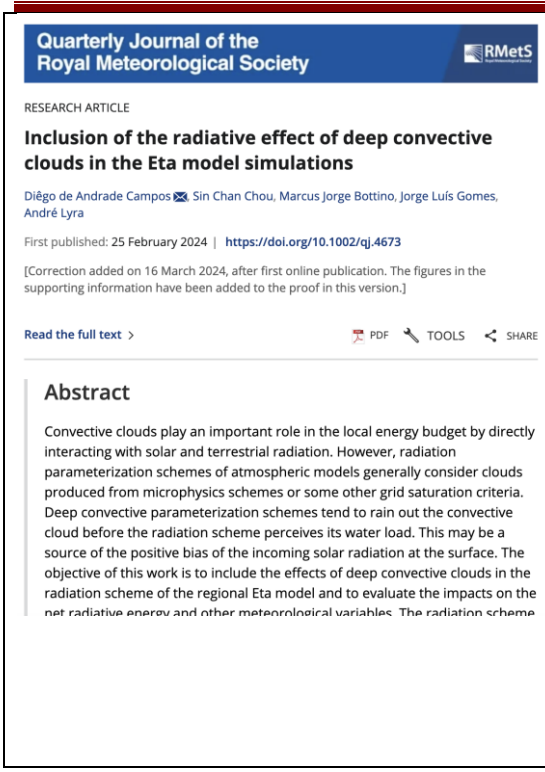
1. Introduction

Storm surge is the temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions, according to the Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC). The authors of [1] define storm surges as rising sea levels due to low atmospheric pressure and strong winds. In addition, these authors conclude that tropical cyclones drive the most extreme storm surges. However, extratropical cyclones can also be responsible for high sea levels, especially when they coincide with high tides [2].

Coastal zones are considered highly vulnerable to climate change effects, including sea level rise [3], changes in the frequency and intensity of storms [4], increases in precipitation, and warmer ocean temperatures. Furthermore, most of the world's coastal regions in which intense storms pass on a regular or occasional basis are affected by storm surges [5]. In addition, the concurrent events of heavy precipitation and storm surges are increasing in coastal areas worldwide, according to the analyses of past changes observed by the authors of [6].

In [7], the authors identify the atmospheric conditions favorable to causing storm surges on the coast of Santos from May 1981 to 2010. In addition, they verify that the number of storm surge events and the maximum monthly significant wave height is increasing during May. These diagnostics are obtained using ERA5 reanalysis data [8]. The choice of May is

check for updates
Citation: Sondermann, M.; Chou, S.C.; Tavares, P.; Lyra, A.; Marengo, J.A.; Souza, C.R.d.G. Projections of Changes in Atmospheric Conditions Leading to Storm Surges along the Coast of Santos, Brazil. *Climate* **2023**, *11*, 176. https://doi.org/10.3390/cli11090176
Academic Editor: Nir Y. Krakauer
Received: 27 June 2023
Revised: 16 August 2023
Accepted: 21 August 2023
Published: 26 August 2023



Quarterly Journal of the Royal Meteorological Society

RESEARCH ARTICLE

Inclusion of the radiative effect of deep convective clouds in the Eta model simulations

Diêgo de Andrade Campos, Sin Chan Chou, Marcus Jorge Bottino, Jorge Luís Gomes, André Lyra

First published: 25 February 2024 | https://doi.org/10.1002/qj.4673

[Correction added on 16 March 2024, after first online publication. The figures in the supporting information have been added to the proof in this version.]

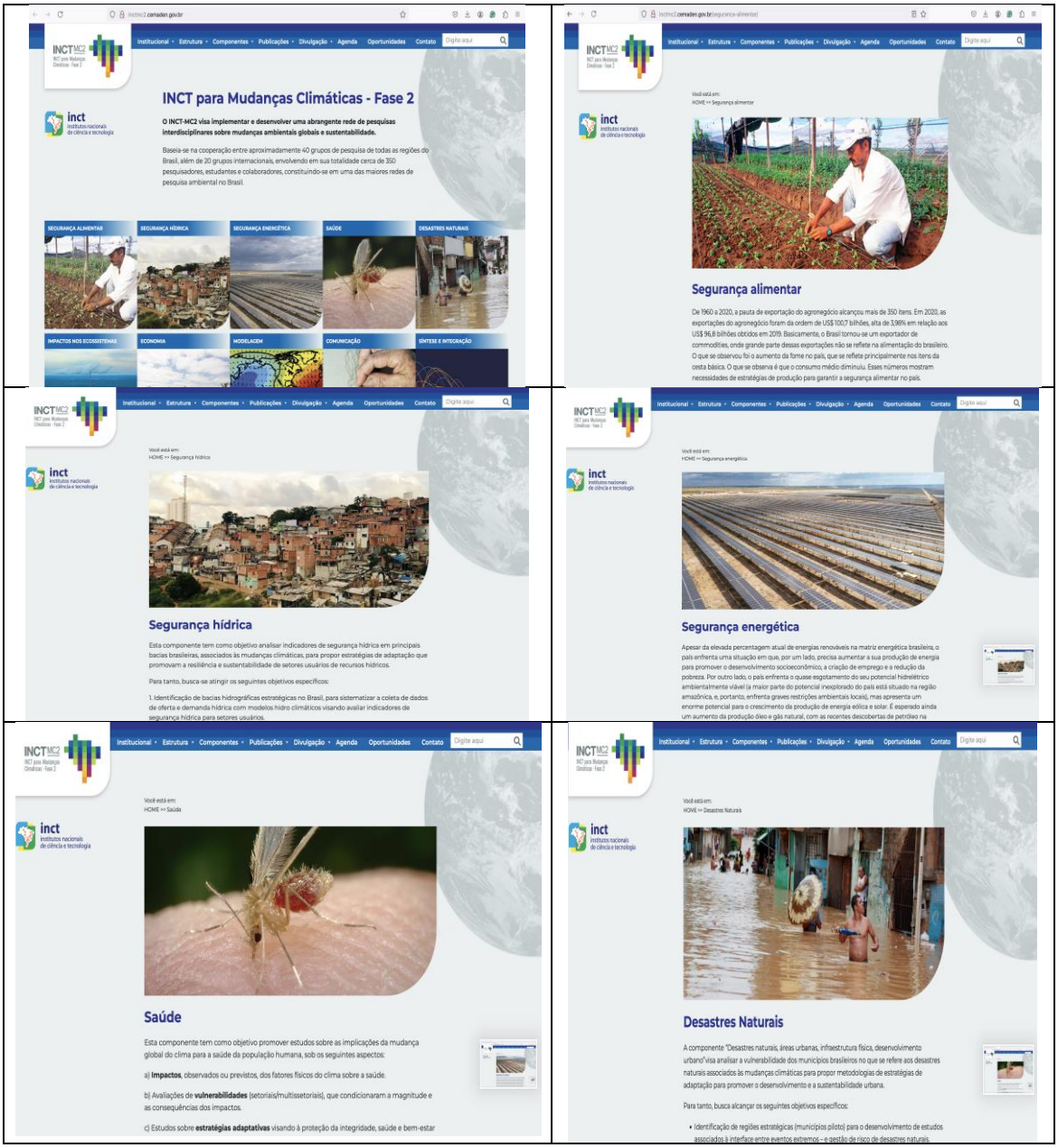
Read the full text > PDF TOOLS SHARE

Abstract

Convective clouds play an important role in the local energy budget by directly interacting with solar and terrestrial radiation. However, radiation parameterization schemes of atmospheric models generally consider clouds produced from microphysics schemes or some other grid saturation criteria. Deep convective parameterization schemes tend to rain out the convective cloud before the radiation scheme perceives its water load. This may be a source of the positive bias of the incoming solar radiation at the surface. The objective of this work is to include the effects of deep convective clouds in the radiation scheme of the regional Eta model and to evaluate the impacts on the net radiative energy and other meteorological variables. The radiation scheme

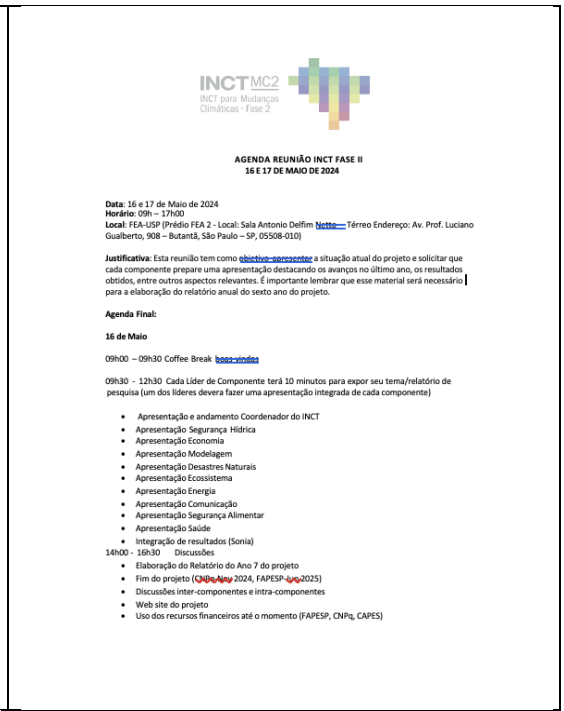
Pesquisa FAPESP – Interviews Agencia FAPESP; YouTube interviews

Design of the web site of the Project




Impactos nos ecossistemas
Economia
Modelagem
Comunicação
Síntese e integração
Quem somos

INCT meetings



INCT MC2
INCT para Mudanças Climáticas - Fase 2

AGENDA REUNIÃO INCT FASE II
16 E 17 DE MAIO DE 2024

Data: 16 e 17 de Maio de 2024
Horário: 09h – 17h00
Local: FEA-USP (Prédio FEA 2 - Local: Sala Antonio Delfim Netto— Térreo Endereço: Av. Prof. Luciano Gualberto, 908 – Butantã, São Paulo – SP, 05508-010)

Justificativa: Esta reunião tem como objetivo apresentar a situação atual do projeto e solicitar que cada componente prepare uma apresentação destacando os avanços no último ano, os resultados obtidos, entre outros aspectos relevantes. É importante lembrar que esse material será necessário para a elaboração do relatório anual do sexto ano do projeto.

Agenda Final:

16 de Maio

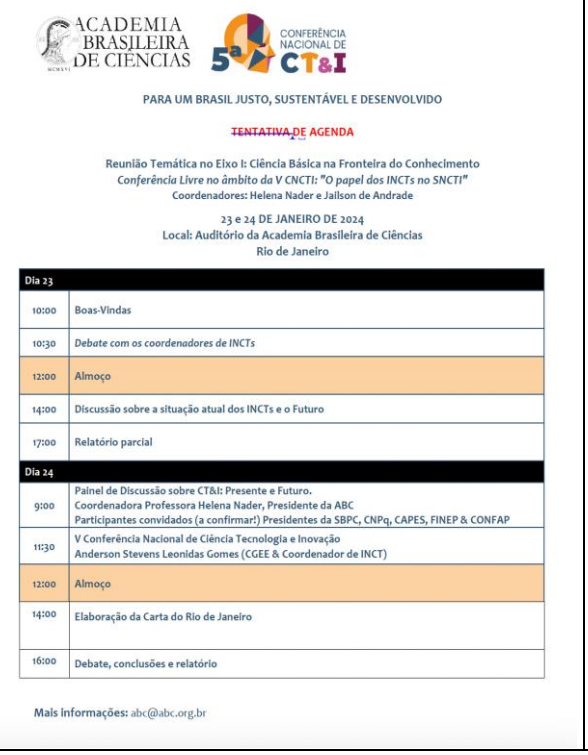
09h00 – 09h30 Coffee Break boas-vindas

09h30 - 12h30 Cada Líder de Componente terá 10 minutos para expor seu tema/relatório de pesquisa (um dos líderes devera fazer uma apresentação integrada de cada componente)

- Apresentação e andamento Coordenador do INCT
- Apresentação Segurança Hídrica
- Apresentação Economia
- Apresentação Modelagem
- Apresentação Desastres Naturais
- Apresentação Ecossistema
- Apresentação Energia
- Apresentação Comunicação
- Apresentação Segurança Alimentar
- Apresentação Saúde
- Integração de resultados (Sonia)

14h00 - 16h30 Discussões

- Elaboração do Relatório do Ano 7 do projeto
- Fim do projeto (CNPq-Nov 2024, FAPESP-Jun 2025)
- Discussões inter-componentes e intra-componentes
- Web site do projeto
- Uso dos recursos financeiros até o momento (FAPESP, CNPq, CAPES)



ACADEMIA BRASILEIRA DE CIÊNCIAS
CONFERÊNCIA NACIONAL DE 5ª CT&I

PARA UM BRASIL JUSTO, SUSTENTÁVEL E DESENVOLVIDO

~~TENTATIVA~~ DE AGENDA

Reunião Temática no Eixo I: Ciência Básica na Fronteira do Conhecimento
Conferência Livre no âmbito da V CNCTI: "O papel dos INCTs no SNCTI"
Coordenadores: Helena Nader e Jailson de Andrade

23 e 24 DE JANEIRO DE 2024
Local: Auditório da Academia Brasileira de Ciências
Rio de Janeiro

Dia 23	
10:00	Boas-Vindas
10:30	*Debate com os coordenadores de INCTs*
12:00	Almoço
14:00	Discussão sobre a situação atual dos INCTs e o Futuro
17:00	Relatório parcial
Dia 24	
9:00	Painel de Discussão sobre CT&I: Presente e Futuro. Coordenadora Professora Helena Nader, Presidente da ABC Participantes convidados (a confirmar!) Presidentes da SBPC, CNPq, CAPES, FINEP & CONFAP
11:30	V Conferência Nacional de Ciência Tecnologia e Inovação Anderson Stevens Leonidas Gomes (CGEE & Coordenador de INCT)
12:00	Almoço
14:00	Elaboração da Carta do Rio de Janeiro
16:00	Debate, conclusões e relatório

Mais informações: abc@abc.org.br