INCT Climate Change Phase 2
(INCT MC2)

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Year 5 Report

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CEMADEN

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 and 4 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.

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:

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

So far the INCT MC2 scientific agenda has been developed as planned, providing scientific excellence in various areas of global environmental change and its implications for sustainable development. The emphasis on the impacts of global climate change on agriculture, health, renewable energy, urban development, and natural disasters such as central themes integrated with environmental modelling, the economics and the communication of these impacts to the public, scientific community and academic sector, industry business and government can contribute to maintain excellence in activities in Science & Technology & Innovation as the axis of sustainable environmental development, with an integrative and innovative character. This project includes knowledge transfer using instruments that go beyond only scientific articles, but producing audio-visual, web tools, and other outlets that allow a scientific education of the population, improving the impact of Brazilian science and also a greater international integration of Brazil in environmental negotiations.

Different from the Report of Year 1, where only FAPESP funded components were explained, in Years 2, 3,4 and now in year 5 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 better holistic view of the project and its components.

Since March 2020, due to the COVID-19 pandemics, many meetings, conferences have been cancelled or moved to 2022, and participation in some international and national gatherings were cancelled because either the meeting were moved to 2022 or cancelled. In any case, participation in meetings and seminars by means or virtual platforms (Zoom, Goto Meeting, etc) made possible the interaction among participants. The scientific production and publication activities did not stop and continue as planned. Participation in many national and international meetings after March 2020 were in the form of Webinars, Lives, pod casts and other using the virtual platforms due to the impossibility to travel imposed by the pandemics. By now, we have slowly started to have presential meetings among leaders now that situations is improving. For

instance, we had on June 9-10 2022 the first presential meeting since the beginning of the pandemics. Other presential meetings have took place between the coordinators of the project in Sao Paulo and with other partners in Rio de Janeiro.

Outside the scope of the initial project, there is a proposal to include the in the Health Component theme COVID-19, since this condition has generated major social, economic, environmental changes, i.e., global and planetary changes, which can generate impacts on the results analyzed (See Annexes). Considering this context, it is possible that the seasonality of the new coronavirus (SARS-COv-2) may also rest in climatic aspects, given that its seasonality in the world and in Brazil is still practically unknown, but it can share similarities with other vARIS. Obviously, human behavior, globalization and control measures (ie wearing masks, social isolation, lockdown, among others) are non-climatic factors that, in fact, seem to have the greatest impact on the epidemiology of SARS-VOC-2, but the climatic factors should be better analyzed in the Brazilian context to help understand the epidemic in the country. This understanding can benefit both from vulnerability assessments that allow identifying the territories most susceptible to localized outbreaks, and from the climate approach in epidemiological models that provide a holistic view of the behavior of the new pathogen.

Therefore, the introduction of the COVID-19 theme in the Health component of the INCT is justified, as this condition has generated major social, economic, and environmental changes. The COVID-19 is also considered as a research activity in the components of energy and natural disasters. This has developed slowly since there is still some controversies on the link between climate and COVID-19 as reported by the components of the health component.

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). 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 July 2022 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 to present these initial findings and foster conversations between scientists and policymakers to advance sustainable development pathways in the Amazon.

Some other significant contributions of the INCT-MC2 appeared in the IPCC AR6 Working Group 2 released in March 22, the State of Climate Report for Latin America and Caribbean 2021 launched by the World Meteorological Organization on July 2022, and for the UKCSSP project funded by the Newton Fund in collaboration between UKMO-CEMADEN-INPE-INPA.

2. Objectives and aims

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, in order 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 for the IPCC AR6, special reports of the Brazilian Panel of Climate Change and the Fourth 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
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Eduardo Haddad	Economy of climate change	FEA USP	ehaddad@usp.br

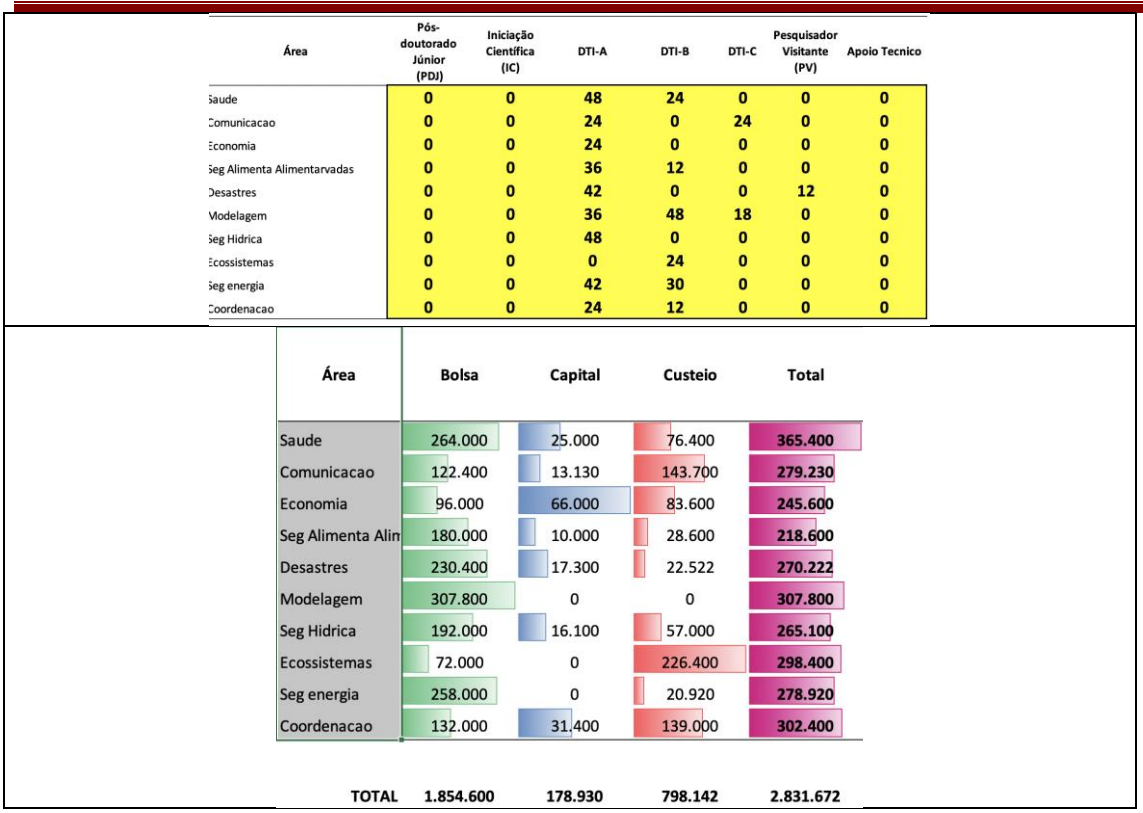
All members of the Steering Committee (CG) are also coordinators of the Associated Laboratories. The Federal University of the Sate of Santa Catarina (UFSC) and the State University of Campinas (UNICAMP) are also Associated Laboratories. Associated Laboratories are those centers whose members are part 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 sub components (themes) and from the cross cutting activities. We have meet virtually in March to see the progress of the project.

We have to inform that FAPESP approved the Report of Year 4.

4. New Developments on the future of the INCTs

In July 2021 there was a meeting of INCT coordinators, led by Prof. Jailson Andrade from the UFBA with the Ministry of CTI to discuss the future of the INCTs. The meeting was to discuss the harmful and continued attacks on Science and Scientists. The INCTs looked to act strategically and articulately, with the help of the ABC and SBPC to produce a manifesto in support of C,T&I, ready, articulated and demonstrating a vital Structuring Program of the INCTs for the country. There was an important meeting of presentations of the INCTs by Prof. Jailson representing all INCTs with the occasion of the 70th anniversary of CNPq. On May 2022 The ABC and CNPq organized s series of Webinars on themes relevant to the INCTs: "Os INCTs e o Futuro da CT&I no Brasil. O INCT MC2 was presented on the first webinar (see annexes for information. In July 22, during the 57th Annual Meeting of the Brazilian Society of progress of Science (SBPC) in Brasilia there will be a virtual meeting of coordinators of INCTs to discuss some of the common problems the IMNCT face amd also on the future of the INCT program.

By September 2021 we were informed of the intensions of the CNPq to extend the INCT for two more years, with capital and “custeio” resources as well as for bolsas. The resources provided were for about 30% of the requested total budget, and were provided by CNPq only, not for the FAPS nor CAPES. All information on the approved amounts for capital custeio and bolsas for the INCT MC2 are listed at the annex section. The project will continue until July 2025 funded by CNPq, but the funding from FAPESP will end in June 2023.



Área	Pós-doutorado Júnior (PDJ)	Iniciação Científica (IC)	DTI-A	DTI-B	DTI-C	Pesquisador Visitante (PV)	Apoio Tecnico
Saude	0	0	48	24	0	0	0
Comunicacao	0	0	24	0	24	0	0
Economia	0	0	24	0	0	0	0
Seg Alimenta Alimentarvadas	0	0	36	12	0	0	0
Desastres	0	0	42	0	0	12	0
Modelagem	0	0	36	48	18	0	0
Seg Hidrica	0	0	48	0	0	0	0
Ecossistemas	0	0	0	24	0	0	0
Seg energia	0	0	42	30	0	0	0
Coordenacao	0	0	24	12	0	0	0

Área	Bolsa	Capital	Custeio	Total
Saude	264.000	25.000	76.400	365.400
Comunicacao	122.400	13.130	143.700	279.230
Economia	96.000	66.000	83.600	245.600
Seg Alimenta Alin	180.000	10.000	28.600	218.600
Desastres	230.400	17.300	22.522	270.222
Modelagem	307.800	0	0	307.800
Seg Hidrica	192.000	16.100	57.000	265.100
Ecossistemas	72.000	0	226.400	298.400
Seg energia	258.000	0	20.920	278.920
Coordenacao	132.000	31.400	139.000	302.400
TOTAL	1.854.600	178.930	798.142	2.831.672

Figure 1. Resources granted buy CNPq for an extension of 2 years for the INCT MC2. Upper side: Number of months for each type of bolsa granted for each component, Lower side: distribution of resources (bolsas, capital and custeio) for two more years.

5. Reports by component

In the following we focus on the reports from each sub component 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 4. 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 4 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 dedicated 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 journal, magazines and the Revista Pesquisa FAPESP. This is being done since the beginning of the project and constitutes a background fall all components.

In the following we report some of the major studies developed by the coordination. As mentioned in Year 4, the coordination works on some comprehensive e studies dealing with 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 for 2 more years of the project.

5.1.1 State of Climate for Latin America and Caribbean 2021 (WMO document prepared by Jose A. Marengo and other representatives from the region)

Extreme weather and climate change impacts including mega-drought, extreme rainfall, land and marine heatwaves and glacier melt are affecting the Latin America and the Caribbean region, from the Amazon to the Andes and from Pacific and Atlantic Ocean waters to the snowy depths of Patagonia. The World Meteorological Organization (WMO) State of the Climate in Latin America and the Caribbean 2021 highlighted the far-reaching repercussions for ecosystems, food and water security, human health and poverty. Deforestation rates were the highest since 2009, in a blow for both the environment and climate change mitigation. Andean glaciers have lost more than 30 percent of their area in less than 50 years. The "Central Chile Mega drought" is the longest in at least 1,000 years. The report shows that hydrometeorological hazards, including droughts, heatwaves, cold waves, tropical cyclones and floods, have unfortunately led to the loss of hundreds of lives, severe damages to crop production and infrastructure and human displacement.

Increasing sea-level rise and ocean warming are expected to continue to affect coastal livelihoods, tourism, health, food, energy, and water security, particularly in small islands and Central American countries. For many Andean cities, melting glaciers represent the loss of a significant source of freshwater currently used for domestic use, irrigation, and hydroelectric power. In South America, the continued degradation of the Amazon rain forest is still being highlighted as a major concern for the region but also for global climate, considering the role of the forest in the carbon cycle.

The report was released during a WMO Regional Technical Conference for South American countries, organized by WMO in Cartagena, Colombia, on 22 July 2022.This is the second year that WMO has produced this annual regional report, which provides decision-makers more localized information to inform action. It is accompanied by an interactive Story Map (Figure 2)

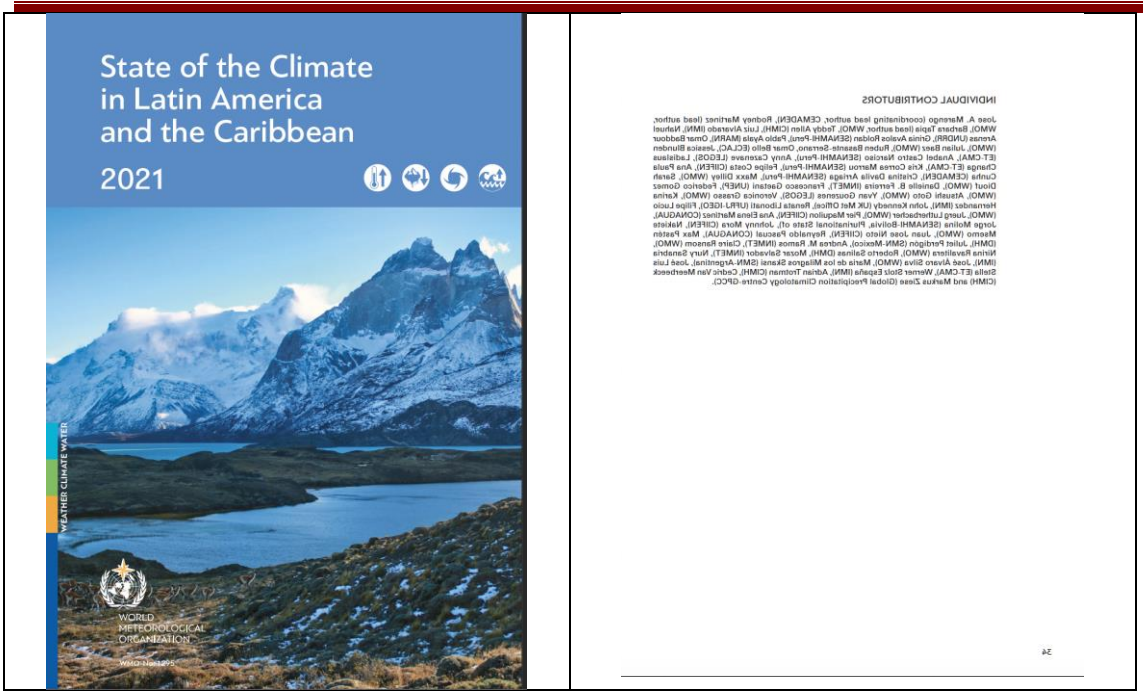


Figure 2. State of the Climate in Latin America and the Caribbean 2021 (WMO 2022)

Worsening climate change and the compounding effects of the COVID-19 pandemic have not only impacted the biodiversity of the region, but have also stalled decades of progress against poverty, food insecurity and the reduction of inequality in the region.
Addressing such interconnected challenges and their associated impacts will require an interconnected effort. No matter how it is taken, action must be informed by science. The State of the Climate in Latin America and the Caribbean report, the second of its kind, is a critical source of science-based information for climate policy and decision-making.

Key findings:

- **Temperature:** The warming trend continued in 2021 in Latin America and the Caribbean. The average rate temperature increase was around 0.2°C/decade between 1991 and 2021, compared to 0.1°C/decade between 1961 and 1990.
- **Glaciers** in the tropical Andes have lost 30% and more of their area since the 1980s, with a negative mass balance trend of -0.97 m water equivalent per year during the 1990-2020 monitoring period. Some glaciers in Peru have lost more than 50% of their area. Glacier retreat and the corresponding ice-mass loss has increased the risk of water scarcity for the Andean population and ecosystems.
- **Sea levels** in the region continued to rise at a faster rate than globally, notably along the Atlantic coast of South America south of the equator (3.52 ± 0.0 mm per year, from 1993 to 2021), and the subtropical North Atlantic and the Gulf of Mexico (3.48 ± 0.1 mm per year, from 1993 to 1991). Sea level rise threatens a large proportion of the population, which is concentrated in coastal areas—by contaminating freshwater aquifers, eroding shorelines, inundating low-lying areas, and increasing the risks of storm surges.
- **The "Central Chile Mega Drought"** continued in 2021, at 13 years to date, this constitutes the longest drought in this region in at least one thousand years, exacerbating a drying trend and putting Chile at the forefront of the region's water crisis. Additionally, a multi-year drought in the Parana-La Plata Basin, the worst since 1944, affected central-southern Brazil and parts of Paraguay and Bolivia.
- **The Parana-La Plata basin drought-induced damages to agriculture** reduced crop production, including soybean and corn, affecting global crop markets. In South

America overall, drought conditions led to a decline of -2.6% in the 2020-2021 cereal harvest compared with the previous season.

- **The 2021 Atlantic Hurricane season** had the third highest number of named storms on record, 21, including seven hurricanes, and was the sixth consecutive above-normal Atlantic hurricane season. Some of these storms directly impacted the region.
- **Extreme rainfall in 2021**, with record values in many places, led to floods and landslides. There were substantial losses, including hundreds of fatalities, tens of thousands of homes destroyed or damaged and hundreds of thousands of people displaced. Floods and landslides in the Brazilian states of Bahia and Minas Gerais led to an estimated loss of US$ 3.1 billion.
- **Deforestation in the Brazilian Amazon rainforest** doubled compared to the 2009-2018 average, reaching its highest level since 2009. 22% more forest area was lost in 2021 compared to 2020.
- A total of 7.7 million people, in Guatemala, El Salvador and Nicaragua, experienced high levels of **food insecurity** in 2021, with contributing factors including continuing impacts from hurricanes Eta and Iota in late 2020 and COVID-19 pandemic economic impacts.
- The Andes, northeast Brazil and the northern countries in Central America are among the most sensitive regions to climatic-related migrations and displacements, a phenomenon that has increased in last 8 years. **Migration and population displacement** have multiple causes. Climate change and associated extreme events are amplifying factors, which exacerbate social, economic and environmental drivers.
- South America is among the regions with the greatest documented need for strengthening **of early warning systems**. Multi-hazard early warning systems (MHEWS) are essential tools for effective adaptation in areas at risk from weather, water and climate extremes.

The two great oceans that flank the continent—the Pacific and the Atlantic—are warming and becoming more acidic as a result of carbon dioxide while sea level also rises. Unfortunately, greater impact is in store for the region as both the atmosphere and ocean continue to rapidly change. Food and water supplies will be disrupted. Towns and cities and the infrastructure required to sustain them will be increasingly at risk. Human health and welfare will be adversely affected, along with natural ecosystems. Amazonia, northeastern Brazil, Central America, the Caribbean, and some parts of Mexico will likely see increased drought conditions, while hurricanes impacts may increase in Central America and the Caribbean. Climate change is threatening vital systems in the region, such as the glaciers in the Andes, the coral reefs in Central America, the Amazon forest, that are already approaching critical conditions under risk of irreversible damage.

In addition to impacts from the COVID-19 pandemic, in the LAC region the United Nations Office for Disaster Risk Reduction registered a total of 175 disasters during the 2020-2022 period. Of these, 88% have meteorological, climatological and hydrological origins. These hazards accounted for 40% of recorded disaster-related deaths and 71% of the economic losses.

To reduce adverse impacts of climate-related disasters and support resource management decisions and improved outcomes, climate services, end-to-end early warning systems, and sustainable investments are required but are not yet adequately deployed in the LAC region. It is vital to strengthen the climate services value chain across its constituent components – including observing systems, data and data management, better forecasting, strengthening of weather services, climate scenarios, projections, and climate information systems While the report is regional most of the information from Brazil comes from results of the INCT MC2

5.1.2 Deadly disasters in Southeastern South America: Flash floods and landslides of February 2022 in Petrópolis, Rio de Janeiro

On February 15, 2022, the city of Petrópolis in Rio de Janeiro, Brazil, received an unusually high volume of rain within three hours (258 mm). It resulted in flash floods and subsequent landslides that caused 231 fatalities, the deadliest landslide disaster recorded in Petrópolis. In this paper, we analyzed the root cause 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, while other remote sensing data from 1985 to 2020, were utilized to map the landslide scars, soil moisture, terrain attributes, line-of-sight displacement (land surface deformation), and urban sprawling. The results showed that the average monthly rainfall for February 2022 was 200 mm, the heaviest recorded in Petrópolis since 1932.

From the rainfall spatial distribution, heavy rainfall was also recorded mostly in regions where the landslide occurred. 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. From our land deformation assessment, the area is geologically stable, and the landslide occurred only in the thin layer at the surface of the 1,700 buildings found in the region of interest, 1,021 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 February 15, 2022; a combination of unplanned urban growth on slopes between 45-60°, removal of vegetation, and the absence of inspection were also significant elements of this natural disaster.

The weather forecasts issued by INMET and CEMADEN for the mountainous region of Rio de Janeiro released earlier on February 14 warned about isolated convective rainfall, which could occur in some areas of the city. However, no meteorological model predicted such significant amounts of rainfall over the region. The heavy rainfall that occurred in the city of Petrópolis on February 15 was caused by the action of a meteorological phenomenon known as mesoscale convective cell, with extraordinary characteristics without known recorded antecedents. The situation was influenced by the presence of the South Atlantic Convergence Zone (SACZ), that at the time was positioned over the state of Rio de Janeiro and created a favorable environment for atmospheric convection.

The other key element that led to the extraordinary rains in the center of Petrópolis was the passage of a cold front, with very particular characteristics, which occurred at the exact moment when the rain showers began to form over the city. This cold front, on the one hand, was weak enough to not be able to dissipate the instability necessary to form the storm clouds and, on the other hand, it was strong enough to change the wind direction, which came from the south, exactly perpendicular to the Petrópolis mountain range. As a result of this combination of factors, the mesoscale convective cell cloud (technically called of cumulonimbus), which should have lasted a few minutes, lasted several hours due to the interaction of the southerly winds associated with the cold front with the mountain. Figure 12 shows the surface winds and temperature for the 18:00 UTC on February 15 (Figure 3). It is noticed the cold front with the temperature gradient and changes in wind direction. Southerly winds on the mountain region where the urban part of the of the city of Petrópolis (region prone to landslides) turned the "orographic cloud" (cloud that positions on the top of mountains for hours and that normally do not precipitate) into a convective cell, which is very rare. Due to the sudden formation and the null displacement of the storm, the weather radars also did not allow its anticipated tracking. It is noteworthy that the current state of knowledge and meteorological forecast does not allow predicting where each individual cloud will form, with which this event could not be predicted in advance.

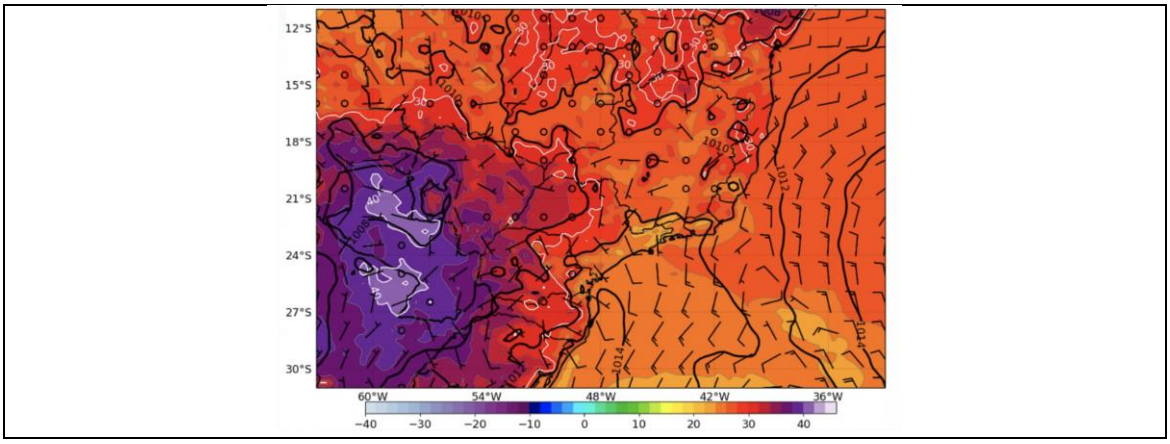


Figure 3. GFS analysis at 18:00 UTC for February 15 2022 for the Petrópolis region. Shades represent surface temperature, isolines represent sea level pressure and the barbs shows wind speed (in knots).

Figure 4 (lower side) shows the radar images of Pico do Couto site, where the formation of the cloud can be seen exactly above the center of the city of Petrópolis. It should be noted that only the residential area of the municipality was affected by the rain, which lasted more than three hours. The accumulated rainfall over the Petrópolis station (Figure 4 upper side) shows the most intense rain between 19:00 and 21:00 UTC. The highest record of 260 mm in just 4 hours, occurred between the afternoon and evening of February 15, is unprecedented in the city. It can also be noted the curvature of the storm produced by the southerly winds (represented by blue arrows in the figure) which resulted in its long persistence.

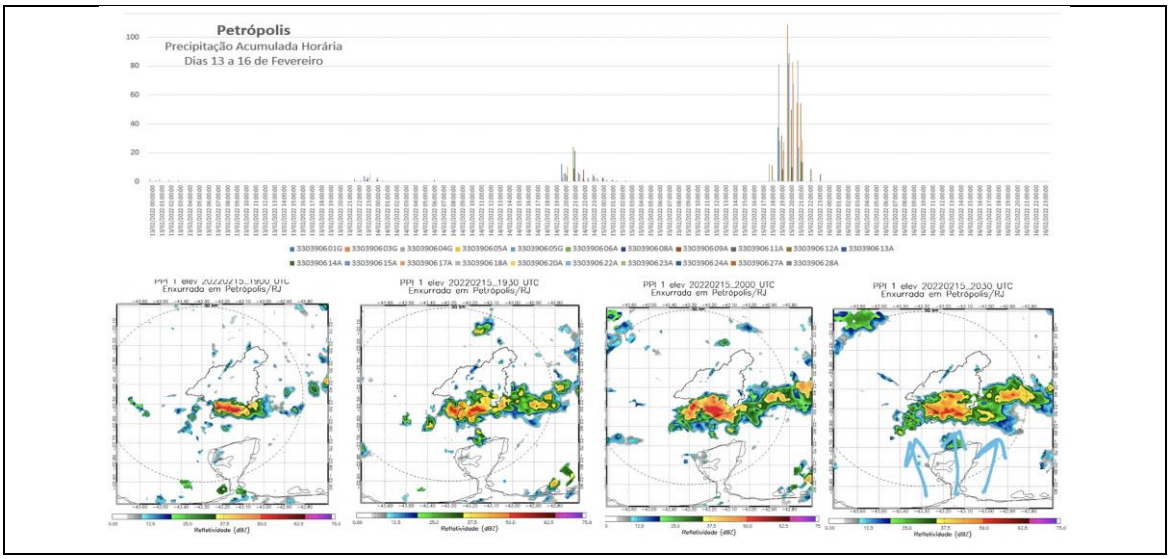


Figure 4. (upper side) Hourly rainfall for various CEMADEN's weather station in the city of Petropolis during February 13-16 2022; (lower side) radar images at the Pico do Couto site between 19:00 to 20:30 UTC for February 15 2022. (Source-=CEMADEN)

According to CEMADEN, from a hydrological point of view, the events recorded on February 15, 2022, in the city of Petrópolis were characterized as landslides, flood and flash flood typologies. The municipality's hydrography indicates the convergence of rivers and streams, which are in an anthropized hydrographic basin while its topographic characteristics resulted in high speed and energy surface runoff. Due to these characteristics and the meteorological event that hit the municipality, there was an increase in the levels of rivers and streams during the

intense and concentrated rains. The drainage systems were overloaded and, as a result, the rainwater runs off the surface, causing flash floods and floods.

Regarding the occurrence of landslides, the Geotechnical Stations of CEMADEN installed in the municipality of Petrópolis indicate that there was a significant increase in soil moisture during the rainfall event that occurred between 15:30 and 19:00 on February 15, 2022. The monitoring station also indicated that prior to the event, soil moisture was already high since the previous rains exceeded 220 mm/14 days and 350 mm/21 days (recorded in some of the CEMADEN stations). The preceding rise in soil moisture was an inducing, preparatory factor for the occurrence of landslides. The abrupt elevation of soil moisture in a short time interval, due to intense and concentrated precipitation and consequently, the oversaturation of the ground, provided the triggering of mass movement processes. On the other hand, it was also verified that very high soil moisture was not recorded at deep levels (sensors in depths 2.0 m, 2.5 m and 3.0 m). In other words, a priori, the processes were closely related to intense surface runoff and percolation with very high positive pressure in fractures. The high fracture density favors the formation of large blocks of rocks on the slopes. Blocks of rocks and colluvial soil deposits were incorporated into the mass of debris and deposited in valley bottom as a poorly sorted material (Alcantara et al 2022).

5.1.3 Cold Waves of Winter 2021 in central South America: Characteristics and impacts

During the austral winter of 2021, the meteorological services of Brazil, Argentina, Peru, Paraguay, Bolivia, and Chile all issued forecasts for unusually cold conditions. Record-low minimum temperatures and cold spells were documented, including two strong cold waves. In this study, we define a *cold wave* as a period in which daily maximum and minimum air temperatures are below the corresponding climatological 10th percentile for three or more consecutive days. From June–August 2021, two intense cold wave events: in the last week of June and again at the end of July, resulted in record-breaking minimum daily temperatures in several places in central South America and Chile. Several locations had temperatures about 10 °C below average, central South America had freezing conditions, and southern Brazil even saw snow. In both events, the cold air intrusion was characterized by an intense upper-air trough located close to 35 °S and 70 °W. The southerly flow to the west of this trough brought very cold air northward into subtropical and tropical South America. A northward flow between the cyclonic and anticyclonic perturbations caused the intense southerly flow between the ridge and trough. This condition facilitated the inflow of near-surface cold air from southern Argentina into southeastern Brazil and tropical South America east of the Andes. In the city of São Paulo, these cold waves killed 13 homeless people, from hypothermia. The frost and snowfall across southern and southeastern Brazil caused significant damage to coffee, sugarcane, oranges, grapes, and other fruit and vegetable crops. Wine and coffee production fell, the latter by 30%, and prices of food and commodities in the region rose.

To define cold waves, Figure 5 identifies cold episodes between June 1 and August 31, 2021. It features minimum and maximum temperature data from weather stations. The blue color indicates when daily minimum and maximum temperatures were both below the corresponding climatological 10th percentile, representing cold days. The red frame delimits the cold wave events. Cold waves were detected from June 27 to July 2, and from July 26 to August 2. The first was longer and affected four countries and reached lower latitudes. Figure 3 shows also that in addition to the cold waves, cold spells occurred in other periods and regions: around June 19, July 19-20, and August 12 and 26, where the minimum or maximum temperatures dropped below the 10^{th} percentile and the spatial coverage of the cooling was lower than the cold waves in the last week of June and July.

In Argentina, minimum temperature reached -6.2 ^{o}C in Catamarca on June 28 (LTM: 8.6 ^{o}C, with the previous record of -5.8 in June 15, 1961), and the station Presidente Roque Saenz Peña detected -2.5 ^{o}C in June 28 (previous record of -7.1 ^{o}C, LTM: 11.0 ^{o}C) and in Formosa

minimum temperature reached -1.3 °C (previous record of -2.3 °C, LTM: 12.0 °C) on the same day. On July 29 minimum temperatures of -7.4 °C and -2.5 °C were detected in Presidente Roque Saenz Peña and Formosa, respectively (LTM: 10.0 °C and 11.7 °C, respectively). Those were new monthly historical records, being the previous ones -7.1 °C on July 18, 2017, and -2.3 °C on July 1, 1976). In Formosa and Presidente Roque Saenz Peña the episodes of June 28-30 and July 27-29 were cold waves, while in Catamarca these cold events were classified as cold spells and not cold waves.

On July 29 the station of Bom Jardim da Serra in the State of Santa Catarina registered a minimum temperature of -8,6°C with snow. This was considered the coldest day in Brazil in 2021. On 28 June – 2 July, Vilhena, State of Rondônia, Brazil, reached 8.2 °C (1981-2010 monthly average: 19.2 °C). On 26 June, Campo Grande, State of Mato Grosso do Sul, experienced 4 °C (1981-2010 monthly average: 15.8 °C). (INMET).

In Paraguay, record low temperatures and cold waves were recorded at Pedro Juan Caballero on June 29 (1.0 °C, LTM : 8.4 °C), San Juan Bautista on June 30 (-1.0 °C, LTM: 11.9 °C) and Pilar on June 30 (0.4 °C, LTM: 12.2 °C). However, the cooling in Mariscal Estigarribia June 30 (-2.6 °C, LTM: 13.6 °C) was classified as cold spell (DMH). In Bolivia the all-time lowest temperatures were recorded in some stations of the Chiquitania and Pantanal regions and new historical minimum temperature records were established on 30 June (SENAMHI).

From June 26 to July 2, the anomalies extended from central and southern Brazil, central and northern Argentina and Paraguay to eastern Bolivia, western Brazil and the Peruvian Amazon, with maximum daily temperatures 3–4 °C below average. Minimum daily temperatures of at least -4 °C less than baseline occurred in the same regions and extended further into central and southern Chile. During the cold wave episode from July 27 to August 1, maximum daily temperature anomalies (at least -4 °C lower than baseline) arose in southeastern Brazil, northern Argentina, and Paraguay. Anomalies in Bolivia and western Amazonia were in the range of -1 to -3 °C. Minimum temperature anomalies (-4 ˚C or more) concentrated in southeastern Brazil, Uruguay, Paraguay, northern and central Argentina, and central Chile, extending further into those regions than the June cold wave had.

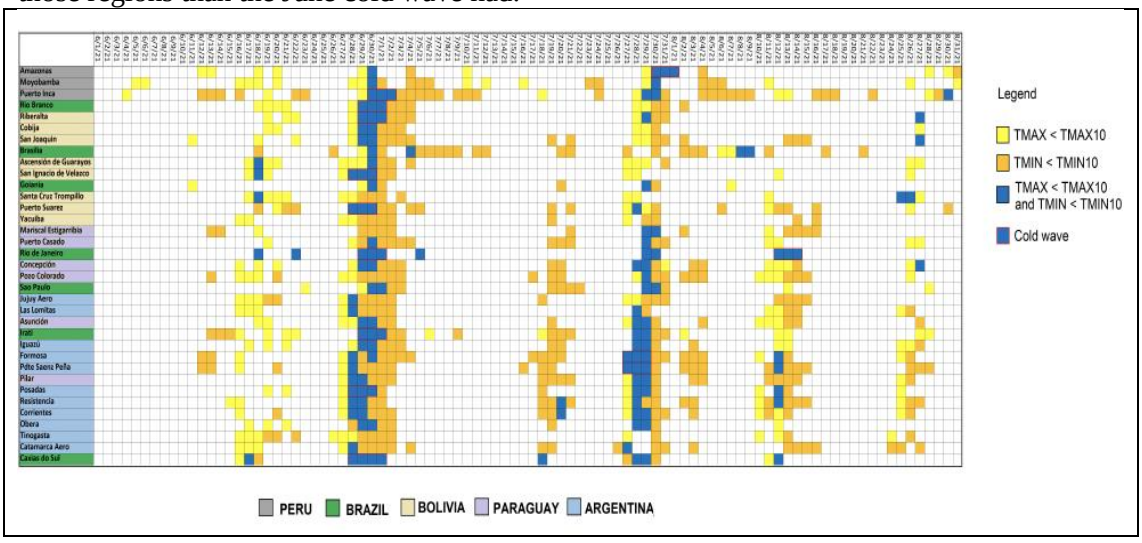


Figure 5. Identification of cold waves based on simultaneous occurrence of daily minimum and maximum temperatures below the corresponding climatological 10th percentile (blue) and cold wave event (red frame) for weather stations in the study area. Stations from Argentina, Bolivia, Brazil, Paraguay, and Peru are organized showing the northernmost stations at the top and southernmost station at the bottom. Countries are indicated by color boxes. (Marengo et al 2022b).

5.1.4 **Heavy rainfall associated with natural disasters in southeastern Brazil in November-December 2021: Meteorological context, trends in extremes and impacts**

In Southeast Brazil, floods and landslides are responsible for most of the loss of lives due to heavy precipitation events, mainly during summer. In November and December 2021, the northern area of the State of Minas Gerais and the southern part of Bahia were affected by disasters after periods of heavy rain. This study evaluated the meteorological conditions leading to December 22-29 th, when it rained up to 300 mm. Soil saturation reached higher levels in this period, resulting in landslides and floods exacerbated by extreme rainfall events in previous wet periods, November and December. While precipitation was heavy, they claimed fewer lives when compared with previously documented disasters in the region from 2011 and 2020 that caused more fatalities. The estimated losses in both states were about 3.1 billion dollars in November-December 2021. Monitoring and issuing risk alerts for these disasters helped minimize related damage and protect human lives and properties.

The South Atlantic Convergence Zone (SACZ) is one of the atmospheric system's components of the South American Monsoon System. The SACZ is a convective band that extends northwest-southeast from the Amazon Basin to the subtropical South Atlantic Ocean, being identifiable by persistent cloudiness and frequently configured in the austral summertime. These variations relate to the propagation of mid-latitude wave trains east of South America that modify circulation and moisture transport in the tropics and subtropics from the Amazon region by the South American Low-Level Jet east of the Andes LLJ. Various studies have shown that the regional distribution of extreme precipitation depends on both the intensity and form of the convection in the SACZ. In addition, the north-south Atlantic SST gradient influences SACZ, LLJ, and continental rainfall.

While rainfall peaks in December-January in NMG and SBA maximum occurs in March-April. So, the SBA's heavy rainfall events in November and December 2021 were atypical in terms of timing and intensity. As shown in Figure 6a-f, over the SBA-NMG region, November and December climatology should be between 150-200 mm. In December 2021, it rained more than 250 mm, and rainfall anomalies show more than 200 mm above average, meaning that rainfall in the region in December 2021 was several times above normal. Based on that, the study region is defined and shown in the red boxes in Figure 1 e-f, and further analyses will focus on that region for stations in SBA and NMG that surpassed 200 mm in December 2021.

Starting in November 2021, Brazil's SBA and NMG regions have been affected by heavy rains and subsequent floods and landslides. In SBA, According to INPE (www.cptec.inpe.br), SACZ episodes were detected on November 1 st to 8 th and 10 th to 17 th that affected the same region, plus the state of Espirito Santo in the latter event. Another SACZ episode by 27 th -30 th November 2021 affected Bahia Espirito Santo and Rio de Janeiro (Figure 2). According to the INMET (www.inmet.gov.br) and CEMADEN (www.cemaden.gov.br), in December 2021, three episodes (December 1 st -4 th, 7 th -11 th, 23 th -27 th) of the SACZ affected the region between the SBA and NMG. On December 7 th, storms caused by the passage of a subtropical cyclone formed near the coast of Rio de Janeiro that combined with moisture convergence and the SACZ produced heavy precipitation that affected several cities in the SBA (Figure 6).

According to INMET, in four days, it rained 491 mm in Itamaraju, 253.6 mm in Porto Seguro, 216.1 mm in Ilhéus, which are cities in SBA where the December rainfall climatology oscillates between 150-200 mm. In Itamaraju, according to CEMADEN, it rained 769.8 mm in December 2021 (climatology of 148 mm), the previous record in December 1989. In that year, abundant rainfall caused overflowing rivers and flooding, closing on highways, including the BR 101, near the city of Itamaraju. Consequently, 2 people died, 267 were injured, 6,371 were left homeless, 15,199 were displaced, and 220,297 were affected by the floods.

In Salvador, the capital of Bahia, it rained 175.65 mm from December 1st -10 th, where the climatology is 58.1 mm. On December 13 th, according to Noticias Agricolas (www.noticiasagricolas.com.br/noticias/soja/304834-excesso-de-chuvas-atinge-lavouras-de-soja-na-Bahia-com-alagamentos-e-plantas-mortas.html#.YfE7NWBvBI, last accessed on March 1st, 2022), the abundant rainfall affected soybean fields in the state of BA with floods and dead plants due to wet soil on the field. While the planting for 2021/2022 was benefited from early rainfall in October, rainfall increased and triggered floods. The rains persisted in significant volumes. On December 15 th, another ZACS episode provided high accumulated rainfall values such as 86.2 mm in Vitoria da Conquista, 70.8 mm in Salvador, and 57.0 mm in Cruz das Almas.

From December 22 th to 29 th, some atmospheric trough episodes occurred in the coast of the state of Bahia, in addition to the convergence of moisture in the middle and lower layers coming from Amazonia and evaporation from a warmer tropical South Atlantic off the coast of the State of Bahia (around 2-2.5°C warmer than average since November 2021) provided more rainfall to SBA. As a result, by December 26, greater daily rainfall totals were detected in locations in SBA: 127.6 mm in Itiruçu, 77.6 mm in Barreiras, 66.8 mm in Guanambi 63.8 mm in Salvador, and 58.6 mm in Ilhéus.

By December 27 th, in Itabuna, in SBA, the Cachoeira river that crosses the city raised by about 10 m, bridges were closed, energy was shut down, and the isolated population had to be rescued by helicopter (SBT News 2021-www.sbtnews.com.br/noticia/primeiro-impacto/191765-chuvas-na-Bahia-Rio-em-Itabuna-sobe-quase-10-metros, las accessed o January 27 th, 2022). During that period, the heavy rains in southern Bahia continued to claim victims across the state, two dams broke due to the storms, and dozens of cities are still entirely flooded. In addition, rescue and relief operations have been highly complex and time-consuming due to flooding on roads and the continuation of rains in the region.

In November, while the rainfall amount was much higher during the first two periods, it is noticed that rainfall started in NMG and later moved to SBA. This is more obvious on 10 th -17 th November when from 10 th -13 th intense rainfall affected NMG, and from 14 th to -17 th November the intense rainfall migrated SBA with the almost same intensity. CPTEC/INPE and INMET [42, 43] identified episodes of SACZ on 2 nd -7 th,12 th -15 th and 20 th -23 th November 2021, and on 7 th -11 th and 22 th -29 th December 2021. In the third period, the two regions experienced heavy rainfall almost simultaneously, even though less heavy than in the other periods. However, the impacts were much higher because the soil was wet due to the accumulated heavy rainfall in previous periods in November and early and middle December.

Based on these criteria, we have selected three periods with intense rainfall in the region for detailed analysis of rainfall distribution: 1 st -8 th, 10 th -17 th, and 27 th -30 th November 2021 and two from December 2021: 7 th -11 th and 22 th -29 th December, considering data from the CEMADEN network (Figures 2). In addition, some special analyses were performed for the 22 th -29 th December period, which was very wet in both regions. It was when the disasters triggered by heavy rainfall left more fatalities (Figure 6)

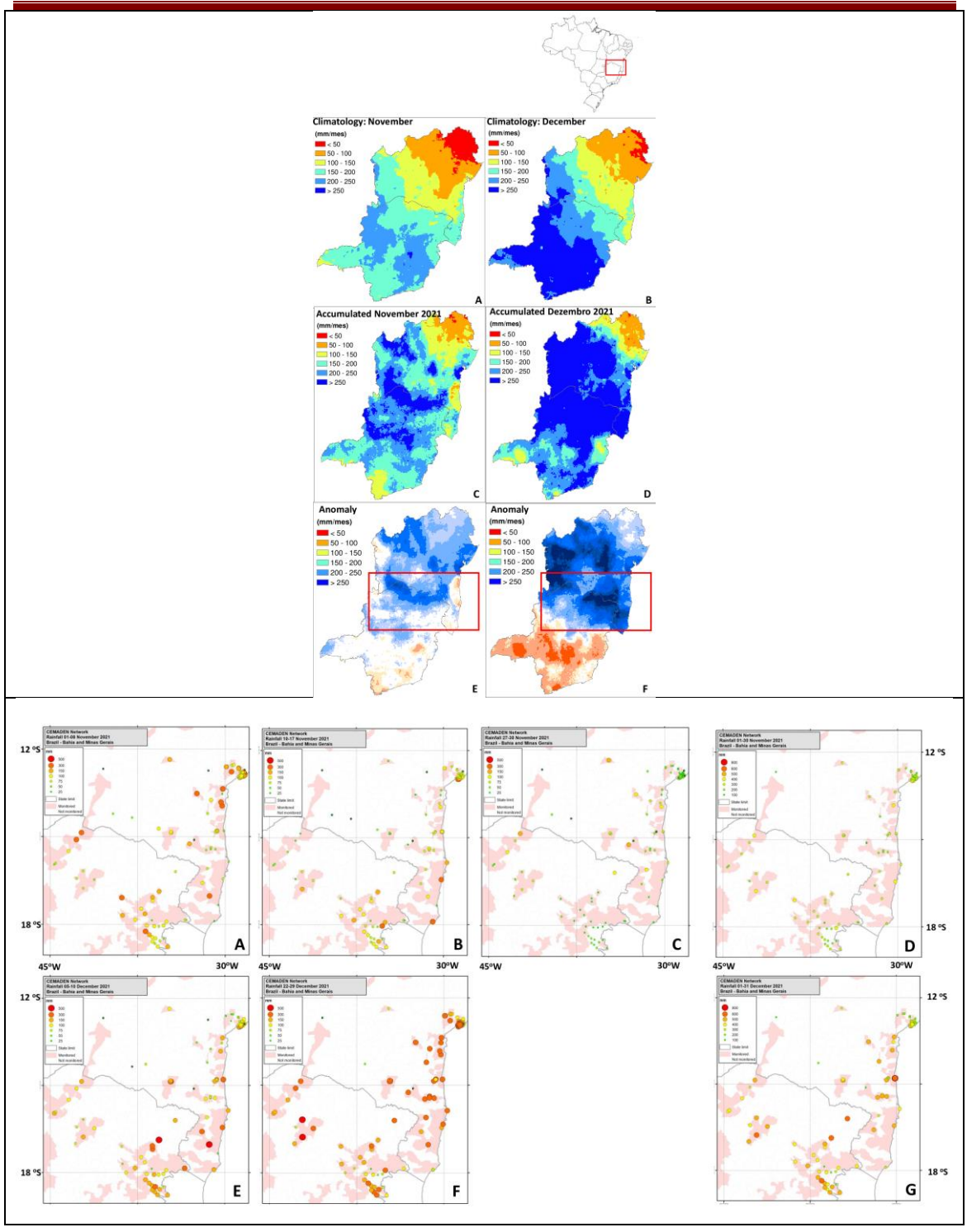


Figure. 6. (Upper panel) rainfall in the States of Bahia and Minas Gerais in southeast Brazil. A)Climatology for November, B) Climatology for December, C) Accumulated rainfall in November 2021, D) Accumulated rainfall in December 2021, E) Rainfall anomaly for November 2021, F) Rainfall anomaly for December 2021. Units in mm/month. The color scale is shown on the upper left side of each panel. Anomalies are relative to 1981-2010. The area of interest covering the southern part of the state o Bahia and the northern region of Minas Gerais is shown inside the red square. Source of data: CHIRPS. (Lower panel) Maps of accumulated rainfall for the Southern Bahia and the northern Minas Gerais States during the wet periods identified in Figure 2 for November (A, B, C) and December (E, F) in mm. Figures D and G show the monthly rainfall accumulated for November and December 2021, respectively. The

color scale is shown on the upper left side of each panel—Source of data: CEMADEN Network.

5.1.5 **Increased climate pressure on the agricultural frontier in the Eastern Amazonia-Cerrado transition zone**

Several large-scale drivers of both anthropogenic and natural environmental changes are interacting nonlinearly in the transition zone between eastern Amazonia and the adjacent Cerrado, considered to be another Brazilian agricultural frontier. Land-use change for agrobusiness expansion together with climate change in the transition zone between eastern Amazonia and the adjacent Cerrado may have induced a worsening of severe drought conditions over the last decade. Here we show that the largest warming and drying trends over tropical South America during the last four decades are observed to be precisely in the eastern Amazonia-Cerrado transition region, where they induce delayed wet-season and worsen severe drought conditions over the last decade. Our results evidence an increase in temperature, vapor pressure deficit, subsidence, dry-day frequency, and a decrease in precipitation, humidity, and evaporation, plus a delay in the onset of the wet season, inducing a higher risk of fire during the dry-to-wet transition season. These findings provide observational evidence of the increasing climatic pressure in this area, which is sensitive for global food security, and the need to reconcile agricultural expansion and protection of natural tropical biomes.

Land-use change for agrobusiness expansion together with underlying climate change may induce higher frequency of extreme climate events, increasing the exposure and vulnerability of tropical forests and Cerrado. The transition zone between the Eastern Amazon and the Cerrado (EAC) biomes comprises the largest area of contact between forest and savanna in the tropics, with the Cerrado recognized as the world's most biodiverse savanna. The hypothesis of "savannization" of Amazonia suggests that such a new equilibrium state becomes more likely as the climate gets warmer and drier, deforestation advances and fires become more frequent. The expected result of this interplay of processes is a contraction of the humid and dense forests giving way to a Cerrado-like biome. Modeling studies show that the Amazon may have "tipping points" linked to their exceeding of deforestation and temperature thresholds. Satellite-based observations have recently revealed that the area of degradation and natural disturbance there is surpassing that impacted by deforestation in the Amazon region. Acting synergistically with processes already in play in the Amazon, the deterioration described here may increase climate change pressure in the region, especially putting at risk productive areas responsible for supporting global food security.

Compound changes in hydrological and climate variables. Regions suffering a long-term warming and/or drying trend (1981-2020) are identified through the analysis of spatial patterns of these trends for different radiative, atmospheric, and hydrological variables (Fig. 7). EAC experienced a widespread and significant warming trend (0.38 ± 0.15ºC/decade, $p<0.05$) during the dry-to-wet transition season July-October (JASO) over last four decades (Fig. 1a). The observed actual evapotranspiration (EVP) reduction (Fig. 7b) tends to elevate temperature, which increases sensible flux to offset the net downward radiative flux. Generally, an increase of surface net radiation and consequent increase of temperature lead to an increase of EVP if there is sufficient moisture in plants and soil. The widespread increase of vapor pressure deficit (VPD, Fig. 1c) is in line with the spatial pattern of warming observed in air temperature. This also agrees with global increases of VPD leading to reductions in vegetation growth[46].

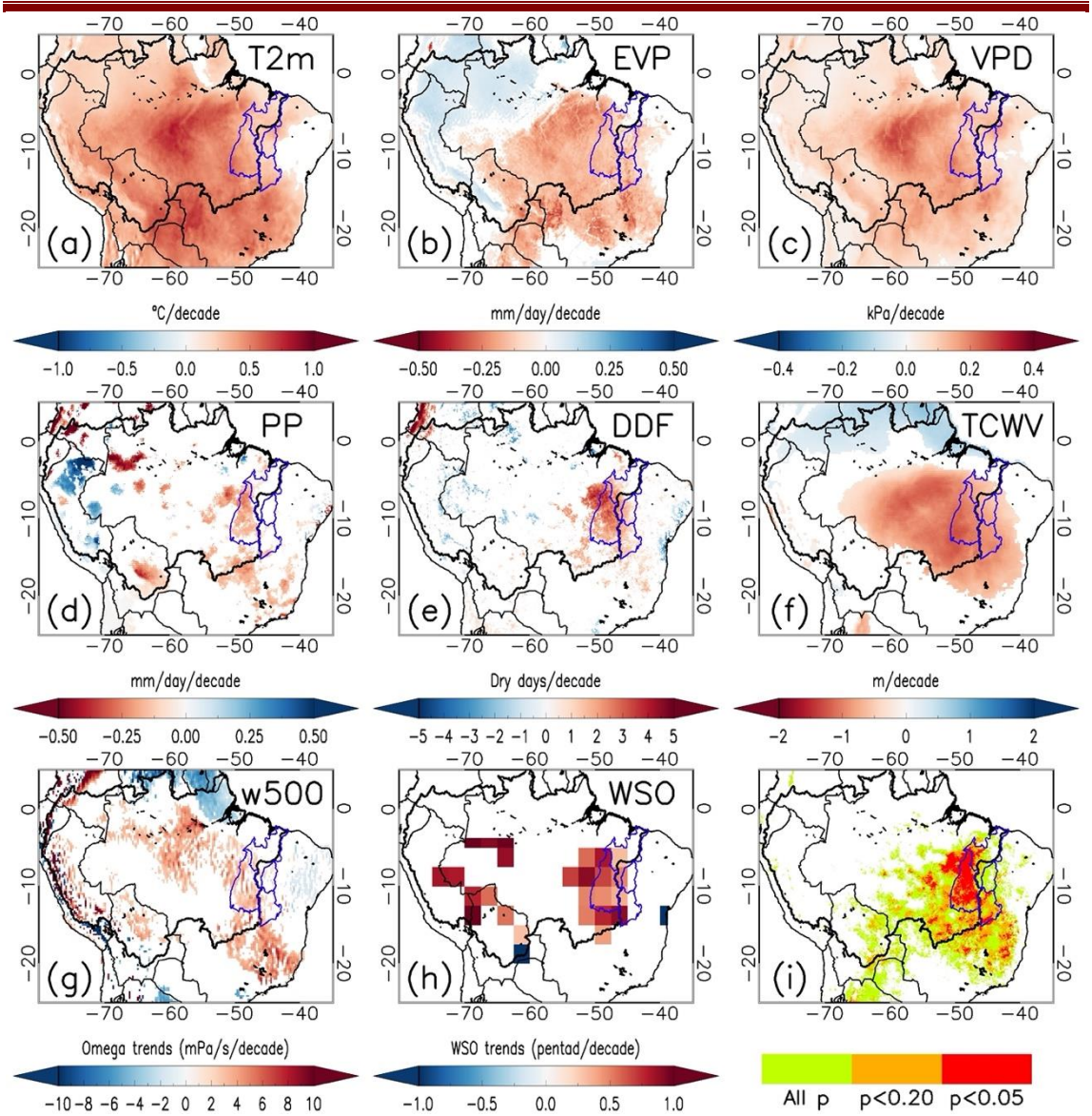


Figure 7. Spatial patterns of trends and compound changes. Trends (1981-2020) for the JASO seasonal period in air temperature T2m (a), actual total evapotranspiration EVP (b), vapor pressure deficit VPD (c), precipitation PP (d), frequency of dry days DDF (e), atmospheric water vapor content TCWV (f), omega at 500 hPa (g) and wet season onset WSO (h). Values of trends given in units per decade. Only pixels statistically significant at the $\alpha = 0.05$ level are displayed. Hydrological and climate changes are combined to display those pixels where positive trends in T2m, VPD and DDF, and negative trends in PP, EVP and TCWV are simultaneously observed (i). Compound trends are categorized into three levels: pixels without statistical significance (All p), pixels statistically significant at $p<0.2$, and pixels statistically significant at $p<0.05$. In all maps, the Amazon and MATOPIBA regions are marked by black and blue contour lines, respectively.

Overall, precipitation trends during the dry-to-wet transition season do not show a statistically significant widespread spatial pattern, but negative trends predominate over southern and southeastern Amazonia (Fig. 7d). A delayed wet season onset (WSO) is also noticed over eastern Amazonia (Fig. 7h), associated with an increase in atmospheric subsidence, as suggested by the positive trend in vertical velocity (omega) at 500 hPa over this region (Fig. 7g). Accordingly, EAC is characterized by a significant increase of the frequency of dry days (DDF, Fig. 7e). The observed DDF increases associated with increased subsidence over this region, are partially related to an intensification of the Hadley and Walker cells, and a higher

frequency of winter weather types during September-October. Moreover, the increase in DDF over this region is related to a warming of the northern tropical Atlantic Ocean and a weakening of moisture transport from the tropical Atlantic Ocean. This is consistent with previous findings demonstrating the increased dry season length, also observed through the delayed WSO (Fig. 7h). There is a reduction in the atmospheric water vapor content (TCWV) in eastern Amazonia (Fig. 7f), and a northwest to southeast gradient, wet over the north and dry over the south.

In water-limited areas such as the eastern Amazon, however, an increase of temperature is unlikely to increase EVP, especially in the dry and dry-to-wet seasons. Variation in water availability governs EVP in the seasonally dry tropical forests in the south and southeast Amazon, towards the transition with the Cerrado biome. Dry-adapted plants can control stomata opening or shed their leaves in response to water deficits, but unadapted plants cannot. If the stomata are closed for too long, an increase in plant mortality by carbon starvation is expected. On the other hand, if plants are unable to avoid water loss, mortality is likely to increase because of cavitation. All these processes are fundamentally linked to canopy–atmosphere coupling, with complex interactions between climate and plant phenology.

The analysis of long-term trends (Figs. 7a-h) evidenced that some of the hydrological and climate changes are already widespread in EAC, whereas other changes are focused on southern/southeastern Amazonia or even finer regional scales. By combining changes of all the variables into a single compound indicator (Fig. 7i), we show that EAC is suffering a combined dry and warming trend. The EAC sensitive region is mainly composed of Cerrado and encompasses roughly the MATOPIBA region. Therefore, the MATOPIBA region shows the strongest heating and drying trends observed across the whole of the Amazon and Tocantins basins and Cerrado biome. This agrees with the fire distribution focused across the southern boundary of the Amazon basin and in the EAC during the May-August dry season because the disturbed forests are more prone to burning in the dry-to-wet transition season than in the wet and dry seasons.

5.1.6 **Intraseasonal Drivers of the 2018 Drought Over São Paulo, Brazil**

Dry conditions occurred over São Paulo state (southeastern Brazil) from February to July 2018, causing the driest semester in 35 years. Socioeconomic impacts included a record number of fire spots, most adverse conditions to pollutant dispersion in 3 years and the winter's lowest water reservoirs stored volume in 17 years. This study discusses climate drivers to the onset and persistence of the dry conditions, with special attention to the intraseasonal forcing. Barotropic atmospheric circulations forced by the intraseasonal Pacific-South America teleconnection pattern (PSA), embedded in the lower frequency setup of the Pacific Decadal Oscillation and the Atlantic Multidecadal Oscillation, were identified as main large-scale forcings to reduce precipitation. Drought evolution was modulated by other intraseasonal drivers such as the Madden Julian Oscillation (MJO), Antarctic Oscillation (AAO) and 10–30 days Oscillations. A break in the 6-month dry condition, in March 2018, highlighted the important role of such oscillations in determining precipitation anomalies over São Paulo (SP). Results show that intraseasonal phenomena and their interactions control drought characteristics such as magnitude, persistence and spatial distribution within a setup determined by lower-frequency oscillations. The intraseasonal timescale seems to be key and must be considered for a complete description and understanding of the complex drought evolution process in São Paulo.

In order to summarize the finds described above, a schematic representation of the main climate drivers for the February 2018 and April 2018 dry conditions are presented in Fig.8. In both months, intraseasonal PSA and MJO signals were the most important drivers. A distinction between summer and autumn is seen in the role of South Atlantic Convergence Zone (SACZ) in the former, and South Atlantic Surface High (SASH) and Intertropical Convergence Zone (ITCZ) in the latter. The intraseasonal AAO also contributed to this scenario, enhancing the drought in February, during the positive phase, and weakening it in the following months. The

precipitation pattern change between February and March was in part due to the AAO turning from positive to neutral, illustrating the importance of this oscillation to characterize monthly dry conditions over SP. But the role of AAO in SP drought seems not limited to its intraseasonal variability. The Oscillation also presents an interannual variability that, albeit much smaller than the intraseasonal one, may contribute to longer wet and dry periods over SP.

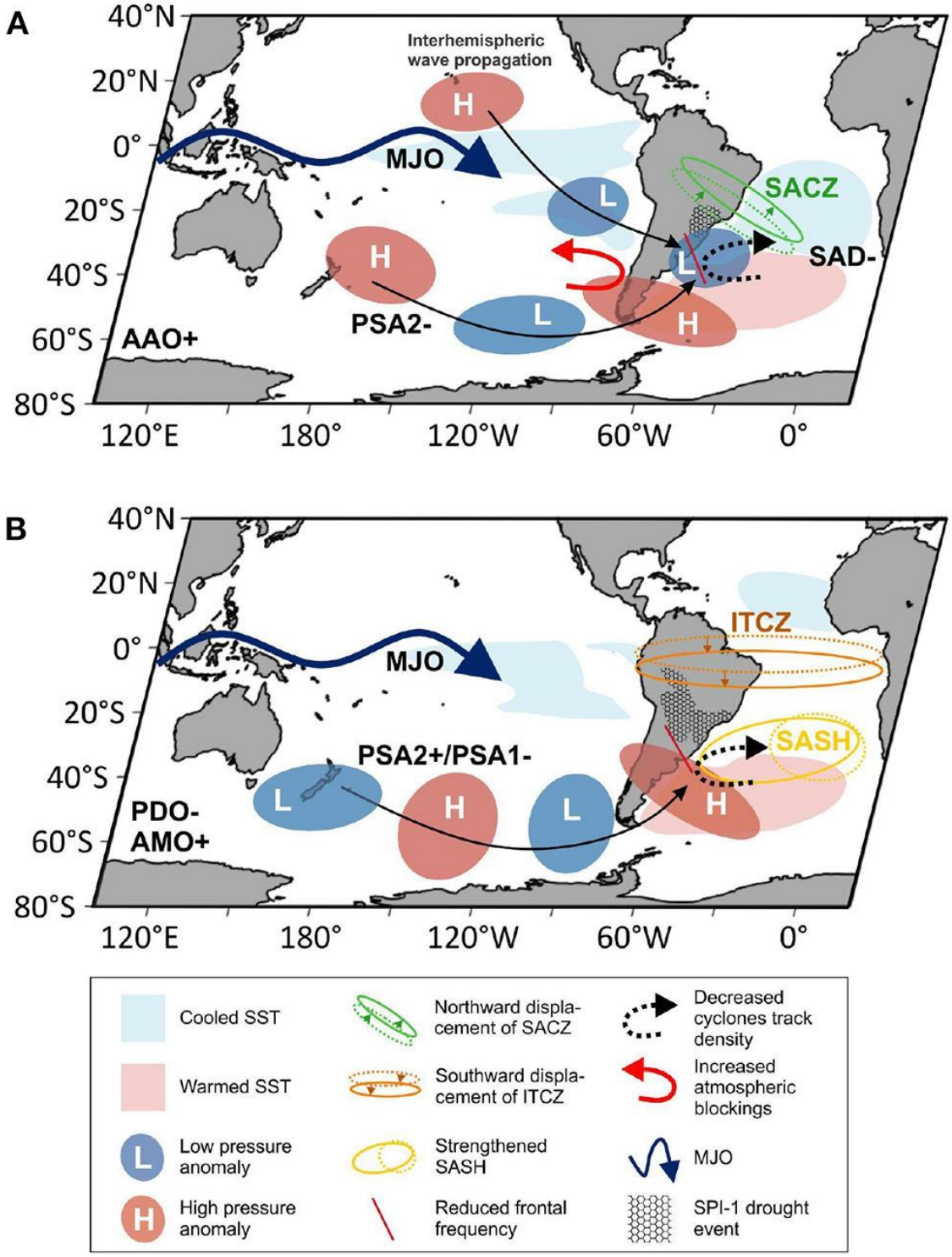


Figure 8: Schematic representation of the main climate drivers for the (A) February 2018 and (B) April 2018 dry conditions.

5.2 Food security

This subcomponent is divided into three activities

- Activity 1 - Climate, agriculture and implications for food security (Year 5)
- Activity 2 - Economy, Climate and implications for food security (Year 6)
- Activity 3 - Climate, livestock and implications for food security (Already reported in Year 4).

5.2.1 Activity 1 - Climate, agriculture and implications for food security

In this stage of the work, studies were developed to assess food security vulnerability due to changes in crops and pastures (such as new production systems and production intensification) - based on the estimate of land use change from 1985 to 2018 made by MAPBIOMAS In Figure 9 this variation between 1985 and 2020 is indicated agriculture and cattle-raising: 263 million hectares

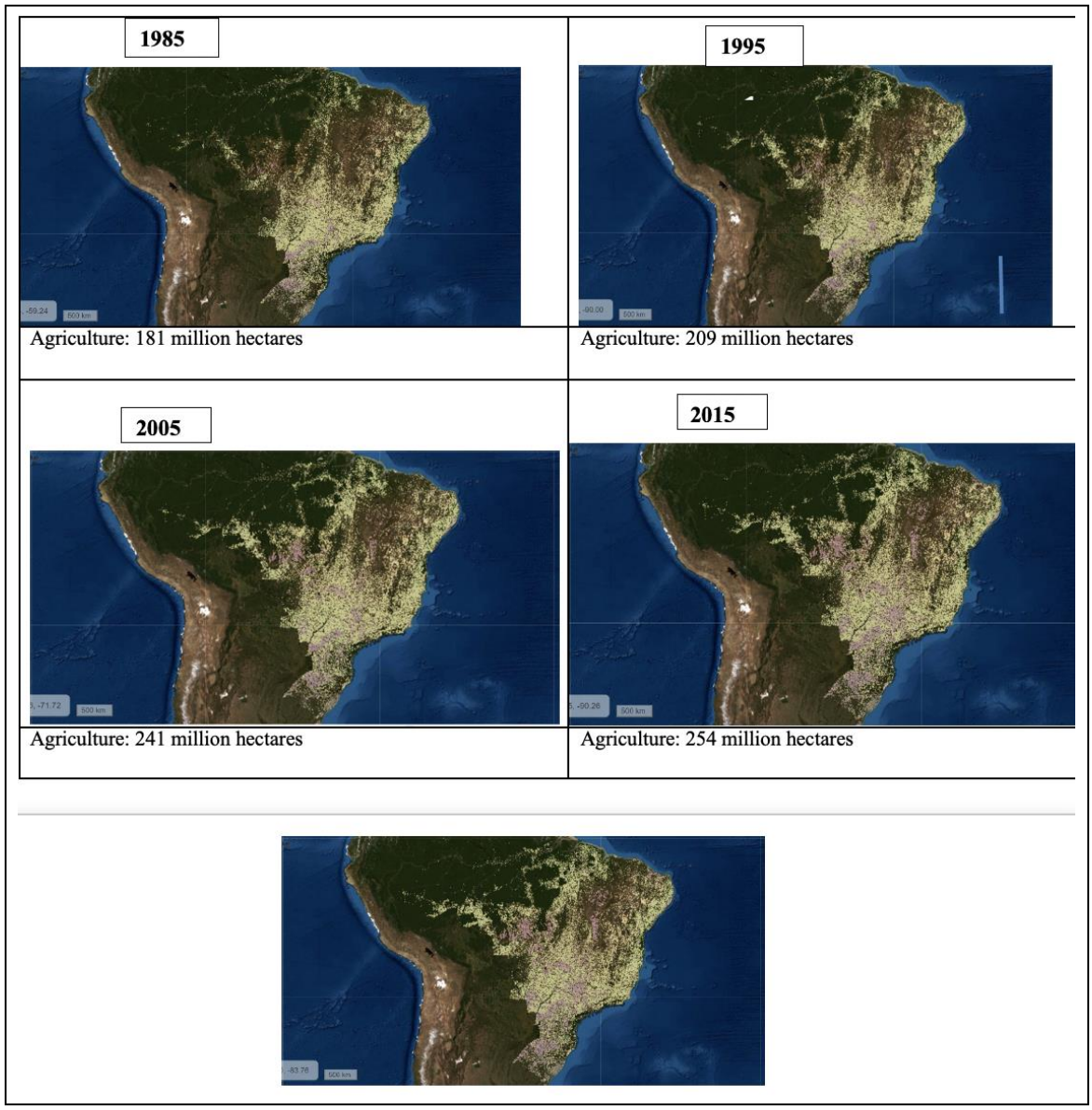


Figure 9. Variation of land use in Brazil, from 1985 to 2020.

The period concerned the occupied area grew by 68% and productivity by more than 200%. The country is the world's largest exporter of soy, coffee, sugar, orange juice, sugar cane ethanol, beef and chicken.

From 1960 to 2020, the agribusiness export agenda reached more than 350 items. In 2020, agribusiness exports were on the order of US$ 100.7 billion, increasing 3.98% from the US$ 96.8 billion obtained in 2019. Basically, Brazil has become an exporter of commodities, where a great part of these exports are not reflected in the Brazilian people's diet. What was observed was the increase in hunger in the country, which is reflected mainly in the basic food basket items. Table 1 shows the Brazilian consumption levels, in kilograms of food per inhabitant, over the last 35 years. What can be observed is that the average consumption has decreased. These figures may indicate production strategies to ensure food security in the country.

Table 1. Per capita consumption of 4 basic food basket items in the last 35 years, in kg/inhabitant.

	Rice	Bean	cassava	wheat
1985	67	19	171	32
1990	74	16	159	37
1995	65	21	151	13
2000	67	16	120	14
2005	71	16	129	31
2010	65	18	125	31
2015	60	16	114	26
2020	49	14	83	26

With the increase in temperature and rainfall, the food production situation can be affected. In recent years, climate change has had a strong impact on the production of soy and corn, reducing harvests by more than 25 million tons.

Assessment of climate change and agricultural impacts in the pilot area of the São Francisco River Basin.

This part of the work was done with the Federal University of Ceará, Civil Engineering Department and IFAL, Federal Institute of Alagoas. The main result of this interaction was at the end of the studies the publication of a book entitled "Nexus Recursos hídricos, Agricultura e Energia, na Bacia estendida do Rio São Francisco ", with 4 chapters, indicating the application of the relationship between food security, water security and energy security.

Main results

The main results of the work on the spatial-temporal characterization of the BESF using the MapBiomas products are presented; then aspects of drought perception will be addressed as a way of subsidizing water security and the impact of climate change on water levels in the BESF; results related to agricultural production are also presented. Assessments of greenhouse gas emissions (GHG), and carbon sequestration by soil will be presented in the next report.

Spatial-temporal characterization of the BESF

Starting from the need for LULC maps for the entire BESF, the proposal was to demonstrate the structuring, reclassification, and validation of the annual MapBiomas LULC maps for the Extended São Francisco Basin.

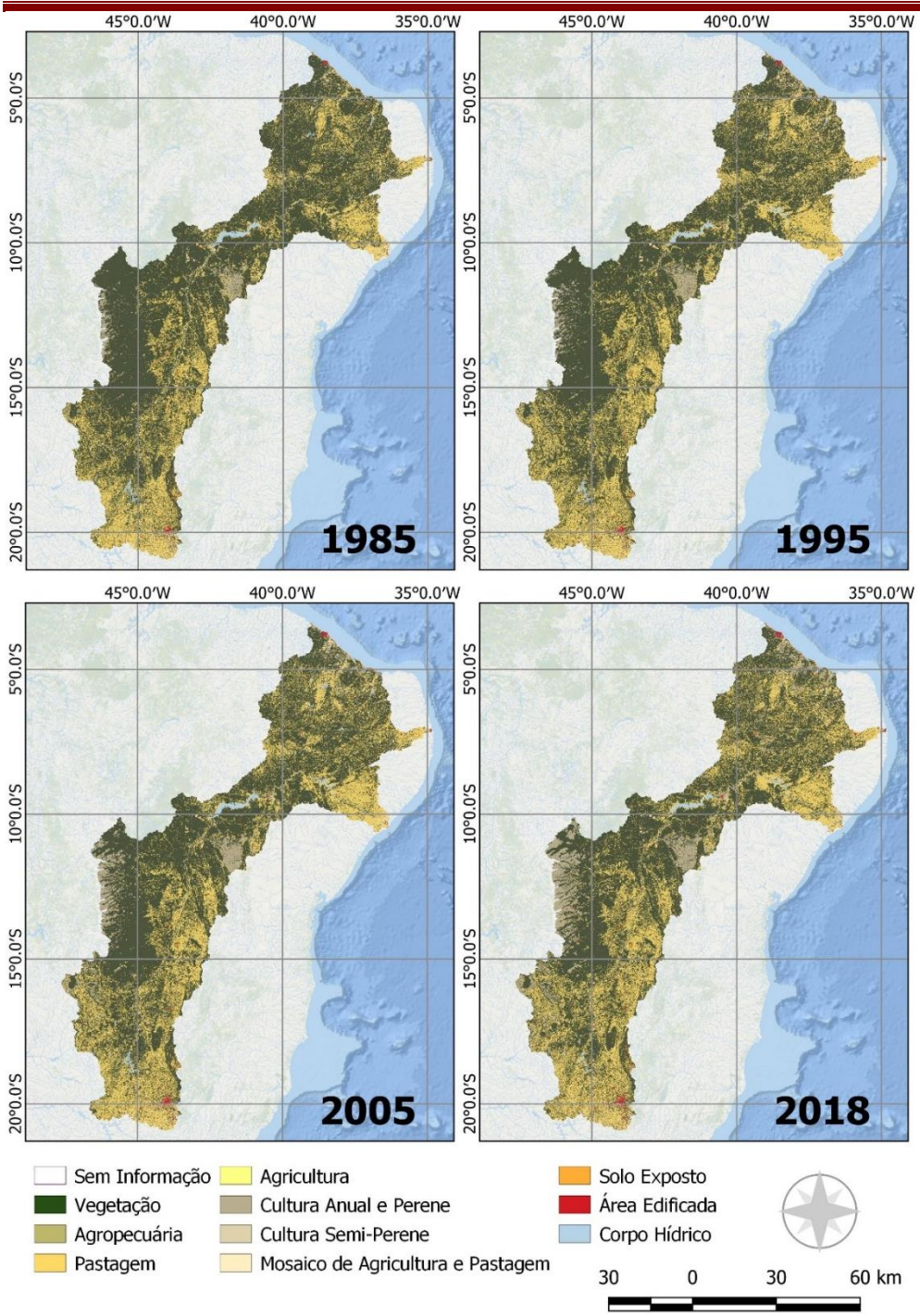
The data series used in the characterization of the BESF correspond to collections 3.1 and 4.1 (1984 to 2018). The classification adopted by MapBiomas is subdivided into 27 classes. However, since in the scope of the project the classifications would be used in simulations and diverse modeling, it was decided to group the classes into more comprehensive groups. Some groups were composed of only one class of interest to the project, such as the six agricultural use classifications and the urban infrastructure class. Figure 10 illustrates the adopted legend code and the composition of the LULC groups adopted in the reclassification operation.

Figure 10 - Legend codes after reclassification of MapBiomas products

CÓDIGO	GRUPO DE USO E COBERTURA DO SOLO	CLASSES MAPBIOMAS UTILIZADAS
0	Sem Informação	Área não observada
1	Vegetação	Floresta, floresta natural, formação florestal, formação savânica, mangue, floresta plantada, formação natural não florestal, formação campestre, apicum, outra formação natural não florestal
2	Agropecuária	Agropecuária
3	Pastagem	Pastagem
4	Agricultura	Agricultura
5	Cultura Anual e Perene	Cultura anual e perene
6	Cultura Semi-Perene	Cultura semi-perene
7	Mosaico de Agricultura e Pastagem	Mosaico de agricultura e pastagem
8	Solo Exposto	Área não vegetada, praia e duna, afloramento rochoso, mineração, outra área não vegetada
9	Área Edificada	Infraestrutura urbana
10	Corpo Hídrico	Corpos d'água, rio, lago, oceano, aquicultura

MapBiomas, through the availability of annual land use and land cover mapping data, allows interested parties to analyze changes and transitions in land use at various geographic scales, from a local micro scale to a regional or national scale. One can see that there are a number of complexities involved in both land use and land cover change and the newly formed BESF.
The study points out that between 1985 and 2018, the biggest change observed refers to the reduction of vegetation that reached just over 3% of the total area of the extended watershed. Agriculture and cattle ranching, on the other hand, grew just under 2% in area. Another factor worth noting is that as urban infrastructure expanded, water bodies reduced in the same proportion, around 0.08%.

Figure 11 - Land Use and Land Cover for the years 1985, 1995, 2005, and 2018 in the Extended São Francisco River Basin.


45°0.0'W
40°0.0'W
35°0.0'W
5°0.0'S
10°0.0'S
15°0.0'S
20°0.0'S
1985
1995
2005
2018
Sem Informação
Vegetação
Agropecuária
Pastagem
Agricultura
Cultura Anual e Perene
Cultura Semi-Perene
Mosaico de Agricultura e Pastagem
Solo Exposto
Área Edificada
Corpo Hídrico
30
0
30
60 km

All 34 maps extracted from MapBiomas were quantified and used by the various researchers of the project team as input for simulation models (carbon stock, hydrological models, etc.). The possibilities of use in subdivisions of the BESF as sub-basins allowed for diverse analyses as can be seen in several chapters of the book " Nexus Recursos hídricos, Agricultura e Energia, na Bacia estendida do Rio São Francisco (Figura 11)

Impact of climate change on the flow regime

Climate change is a global phenomenon, anthropically caused, with impacts that are likely to compromise the current form of economic production and social organization on the planet. Projecting and quantifying these impacts are necessary steps in the construction of mitigation strategies. In the São Francisco River Basin, the intricate Water-Energy-Food NEXUS makes the socio-environmental system even more sensitive to climate change. Among the projected impacts, changes in the flow regime have implications for the water supply for food and energy production.
In this component of the SHAE IP, the Global Climate Model (GCM) projections made available in the sixth cycle of the Coupled Model Intercomparison Project (CMIP6) were combined with rainfall-runoff modeling to assess the impacts of climate change on the flow regime in the São Francisco River Basin. The impacts were assessed specifically on the catchments of the tributaries of the Três Marias, Sobradinho, Retiro Baixo, and Queimado reservoirs.

In the IPCC6, the scenarios for climate change assessment combine the emission trajectories, represented by the RCPs, with possible socio-political dynamics of global development, which may rely on mitigation actions or result in intensified impacts. The socio-political trajectories are condensed into five scenarios called Shared Socioeconomic Pathways (SSPs) (Riahi et al., 2017), which correspond to narratives for global development.

In this study, the scenarios SSP 2 - 4.5 and SSP 5 - 8.5 were considered, which combine, respectively, the SSP 2 and SSP 5 scenarios with RCPs 4.5 and 8.5. In this way, two distinct trajectories were represented: a first more optimistic one and a second one considering the most intense impact level.

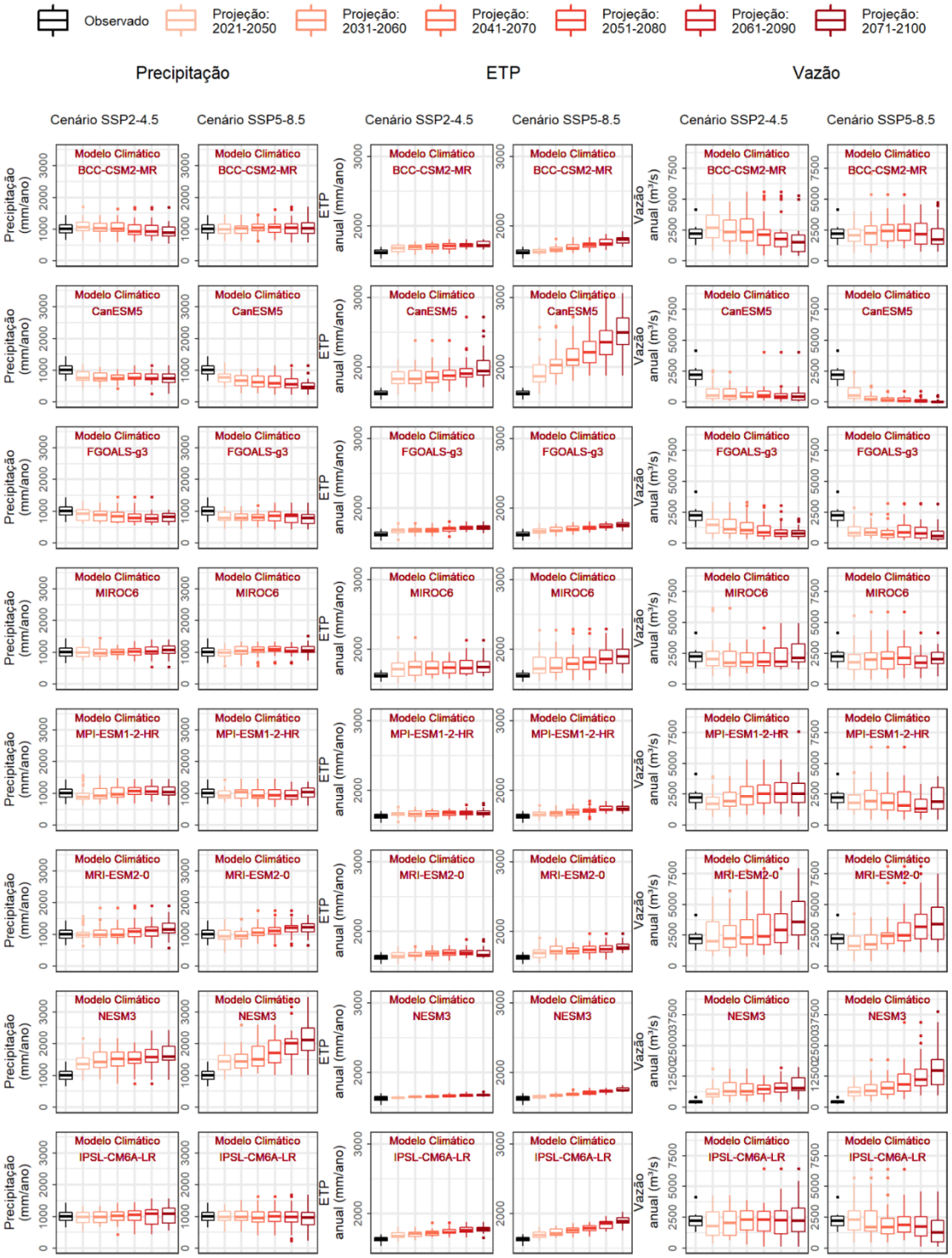
For each of these scenarios, the eight CMIP6 climate models were considered: BCC-CM2-MR, CanESM5, FGOALSg3, MIROC6, MPI-ESM1-2-HR, MRI-ESM2-0, NESM3, and IPSL-CM6A-LR. Precipitation and maximum and minimum temperature data were extracted from each model, in historical model simulations and in projections for the 21st century.
In the historical simulations, the period 1980-2015 was cut out for precipitation data and the period 1980-2013 for temperature data. For the projections, the period 2021-2100 was considered, which was broken down in the analysis into subperiods of 30 years (with a step of 10 years and overlapping of 20 years), that is, 2021-2050, 2031-2060, until 2071-2100.

The following will only present the results related to the Sobradinho reservoir (Figure 8), the others are available in the Book "Nexus Recursos hídricos, Agricultura e Energia, na Bacia estendida do Rio São Francisco"

The CMIP6 climate change models project for the São Francisco River Basin a consistent increase in temperature over the 21st century, following the global trend. Consequently, an increase in ETP is projected. On the other hand, the eight models evaluated do not agree regarding the direction of the projected trend for the region's precipitation regime. Yet, at least four models point to significant variations in average precipitation (between -48% and +119%).
The framework developed for assessing the effect of climate change on the flow regime showed that the projected trends for precipitation and ETP are combined and result in more intense variation trends in the flow regime, with the most extreme models showing variations as high as

-97% and 627%. Significant variations are observed already in the SSP2-4.5 scenario, with an intensification of the trends occurring in the SSP5-8.5 scenario (Figure 12).

Figure 12 - Time evolution of hydrological variables (precipitation, ETP and flow) projected by eight MCGs in the SSP2-4.5 and SSP5-8.5 scenarios in Sobradinho reservoir.



Even though the projections differ on the trend of the flow regime, implying great uncertainty in the evaluation of water supply, the projection of an increase in ETP implies an increase in demand per unit of planted area, considering the maintenance of irrigation techniques. If the

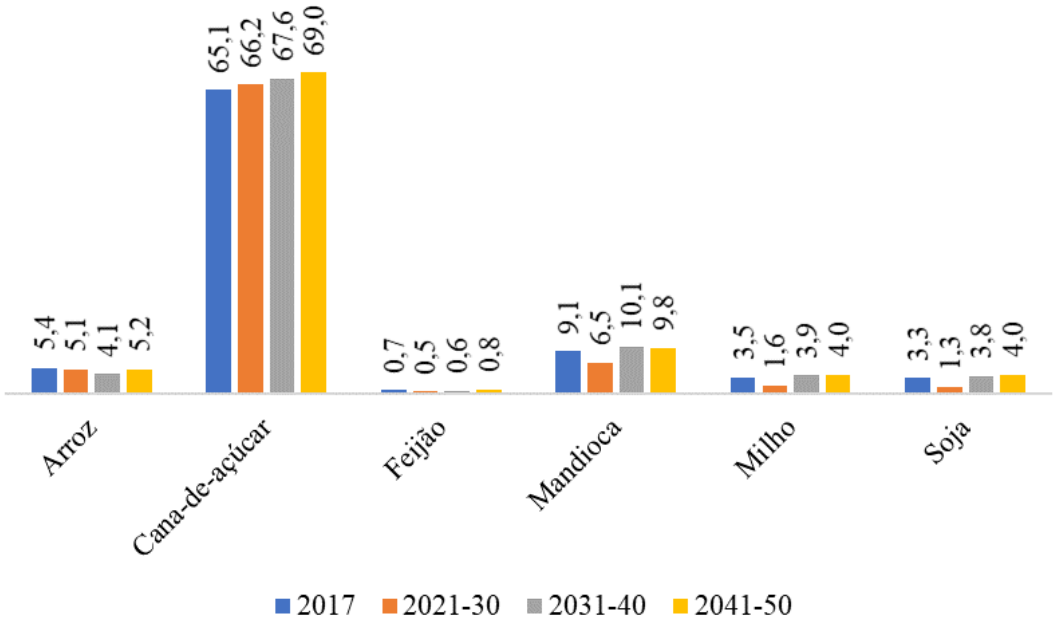
total irrigated area is maintained, there will be an increase in demand. In the worst of the projected scenarios, there will be a decrease in supply (which could reach -97%) accompanied by an increase in demand, intensifying competition among water uses in the region.

Agriculture and cattle ranching indicators: current data and future climate change scenarios

In the context of the SHAE IP, this component collected data related to livestock (cattle) and agriculture (harvested area, production and productivity of rice, sugarcane, beans, cassava, corn and soy crops) for the period 2005 to 2017, and generated projections of these variables under climate change scenarios. The survey of this data had two objectives: i) compile the primary data used in the estimates of greenhouse gas emissions in the BESF; ii) evaluate the dynamics of the activities of the agricultural and livestock sector in the period 2005 to 2017, and the impacts of climate change on the indicators of production and productivity in the BESF. To estimate productivity for the BESF, the climate databases from Xavier (2015) and the HadGEM2-ES global climate model were used. Both contain 11,299 points gridded at 0.25° and their importance lies in daily information on climate parameters such as maximum temperature, minimum temperature, and rainfall.

Only a few results about the productivity indicators for agricultural crops and pastures, as well as livestock projections will be presented here. Considering the average data for all the municipalities in the BESF, the simulations with climate change scenarios point to an increase in productivity for most crops in the region. Only the rice crop showed a reduction in productivity levels. For example, comparing the period 2041-2050 with 2017 (base year), an average reduction of 3.4% was estimated. The other crops are expected to show productivity gains of 5.9, 10.8, 8.2, 14.7, and 21.1% for sugarcane, beans, cassava, corn, and soybeans, respectively (Figure 13). The plants have their own adaptation to the prevailing climatic conditions in their environment, allowing for technological development that indicates new crop accommodations considering the new climate through climate risk zoning for agriculture in the BESF region.

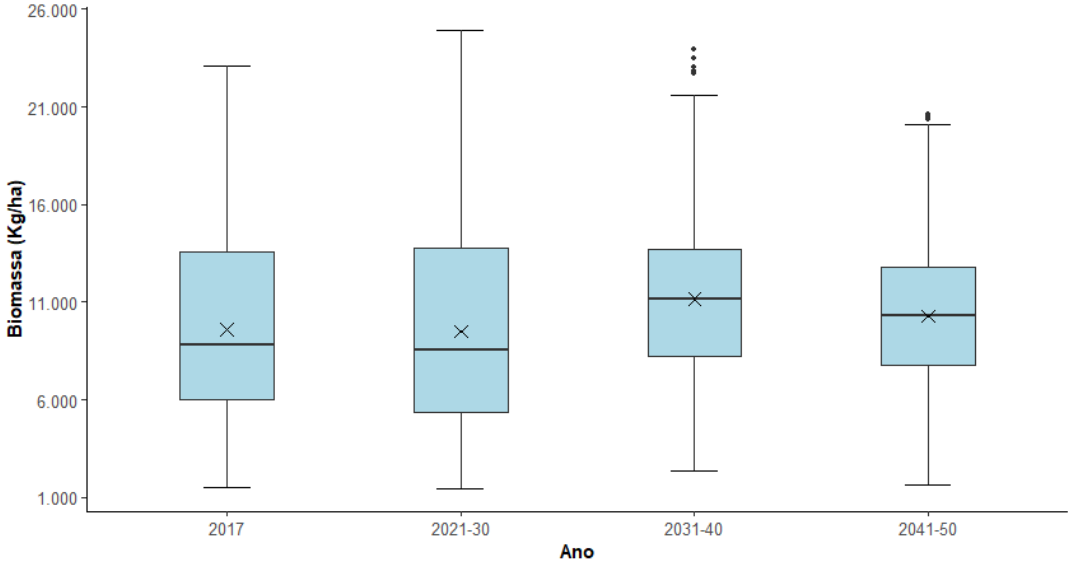
Figure 13 - Current and projected agricultural productivity (t ha-1) of the main crops in the BESF in 2017 and based on climate change scenarios.



The pastures, on the other hand, showed a tendency to increase biomass productivity in the period 2031-40, with a median indicating productivity of 11,159.31 kg ha-1, with a small reduction in the period 2041-50 in the BESF. The greatest variability in pasture biomass

productivity is observed in the period 2021-30, however, presenting the lowest median among the periods (8,527.83 kg ha-1) (Figure 14).

Figure 14 - Pasture biomass in different periods of climate change, considering all the municipalities in the BESF.



With the changes in pasture biomass simulated under different climate change scenarios, it was estimated that in the period 2041-50 the herd could be 36.7 million of heads, an increase of 24.6% compared to 2017 (Table 2). The largest increase were observed for beef cattle (+36.8%), dairy cattle (+33.0%) and bubalines (+33.3%), while sheep, goats and horses will have their herds increased by 6.1, 10.4 and 19.7%, respectively.

Table 2 - Animal population projection under future climate scenarios in the Extended São Francisco River Basin for the periods 2021-30, 2031-40 and 2041-50.

Herd	2017	2021-30	2031-40	2041-50
	Number of animals (in millions of heads)			
Beef Cattle	14,69	14,99	21,56	20,10
Dairy Cattle	2,15	2,38	2,97	2,86
Goats	5,36	4,76	6,09	5,92
Sheep	6,51	6,00	7,07	6,91
Equines	0,71	0,65	0,90	0,85
Bubalines	0,03	0,03	0,05	0,04
Total	29,45	28,80	38,64	36,69

The analysis of the dataset from the present period (2005-2017) allowed for the identification of important trends in the BESF. With regard to livestock, the results show that there has been an increase in the yield of several species, indicating that even in the face of the climate, soil, and socioeconomic limitations that characterize the region, producers have managed to improve productivity indicators. Clear examples of this change are: i) the 65.5% increase in the high productivity cattle herd; ii) the 46.4% increase in poultry raising; and iii) the approximately 38% increase in industrial swine raising in detriment of subsistence raising. There was also a

50.6% increase in the sheep herd, while the beef cattle and goat herds remained stable in the period studied.

In agriculture, considering the six crops studied, the results show productivity gains in the ESBS, since the area harvested with these crops grew only 2.9%, while production increased 40.5% in 12 years. The negative highlight comes from manioc, which showed significant reductions both in harvested area (-57.2%) and productivity (-22.5%).

Finally, the results of the climate change scenarios point to a tendency for an increase in the biomass production of pastures, which will allow for an increase in livestock activity. The same should occur with agricultural crops, since the results indicate increases in the average productivity of the crops covered in this study. However, it is necessary to take into consideration the prospect of an increase in the frequency and intensity of extreme events, which can mitigate the theoretical gains in productivity and agricultural production, and negatively impact water, energy and food security in the BESF.

Agricultural production losses and extreme weather events in the BESF

The data from the previous topic showed that between 2005 and 2017 there were significant increases in productivity and production of agricultural and livestock production in the ESFS, which is important to help ensure food security in the region. However, the increased frequency of occurrence and intensity of extreme events due to climate change is expected to be a challenge for the region. According to Carvalho et al. (2020), droughts hit the northeast region most intensely in the years 2010, 2012, 2014, and 2017, causing reductions in rainfall ranging from 15.0% to 70%. In this context, this chapter aimed to evaluate agricultural production losses from planting to pre-harvest in the Extended São Francisco River Basin (BESF) in the period 2005 to 2017, and correlate these data with extreme drought.

Figure 15 shows the results of loss rates from planting to pre-harvest of the main crops present in the BESF between 2005 and 2017. The results show that the loss rates can reach levels close to and above 30%, as occurred in the crops of beans, cassava, and corn, which obviously significantly impacts the entire production chain. It was also observed that the years 2012, and 2015 to 2017 were the most critical for almost all crops. The year 2012 had high losses in all crops (except soybeans), while the period between 2015 and 2017 was marked by significant losses, for example, in rice, beans, and corn. Among the crops evaluated, sugarcane was the least susceptible to losses until pre-harvest.

Figure 15 - Loss rates from planting to pre-harvest of the main crops present in the BESF between 2005 and 2017.

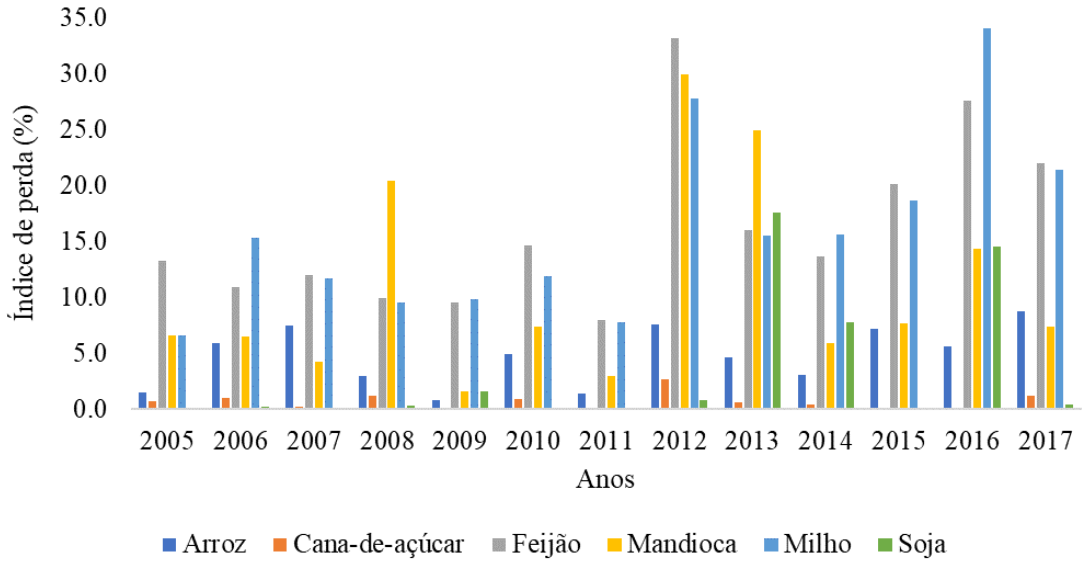
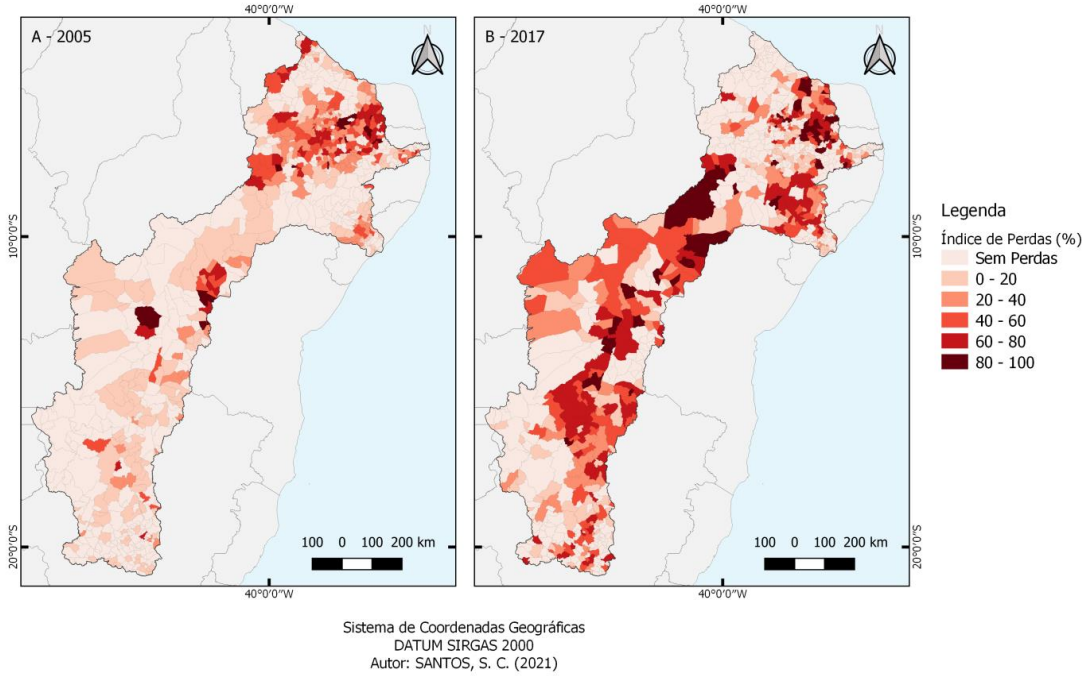


Figure 16 shows the spatialized results by municipality in the BESF. For the bean crop it is observed that there were losses of up to 96% in 2017. These losses presented in 2017 occurred in almost the entire length of the basin, reaching a greater number of municipalities when compared to 2005. The data for the other crops can be seen in Book Nexus Recursos hídricos, Agricultura e Energia, na Bacia estendida do Rio São Francisco. These results for the bean crop serve to illustrate the impact of droughts on agricultural production, demonstrating that the increased frequency and intensity of extreme events, in this case droughts, can substantially affect and hinder food security in the BESF.

Figure 16 - Index of agricultural losses (%) from planting to pre-harvest of beans in the years 2005 (A) and 2017 (B) in the municipalities that make up the Extended São Francisco River Basin.



Activity 3 was reported in Year 4.

5.3 Water security

5.3.1 Highlights

The noteworthy results achieved during the 5th year of the INCTMC2 project were the continuous promotion of INCTMC2 water security goals on (see Figure 17, 18 and Table 3, with a Summary and Appendix enclosed):

- COVID+IPCC/AR6 communication strategies for society and users,
- synergic alliances with other interdisciplinary groups, and
- accelerating action with UNESCO-IHP-IX for science-to-policy adaptation.

These achievements were developed through strategies of:

(1) water security-designed courses, workshops and webinars with InnSciD SP 2021 + TWAS Science Diplomacy LAC and UNESCO-IHP-IX (2022-2029);

(2) synergy and sharing knowledge with granted projects around INCTMC2's goals with FAPESP Research, Dissemination & Innovation Center (CeMEAI-"Applied Maths for Industry"), FAPESP Engineering Research Center (C4AI-"Artificial Intelligence"), and FAPESP-Belmont Forum (MADIS-"Management of Disaster Risk and Societal Resilience", new title)

(3) participation in co-authored publications in high-impact journals (*Nature*) with early-career

scientists and with comparative datasets promoting INCTMC2,

(4) updating INCTMC2 water security timeplan (see Table 1) with premises from the WMO State of the Climate in Latin America and the Caribbean and the UNESCO recommendation on open science

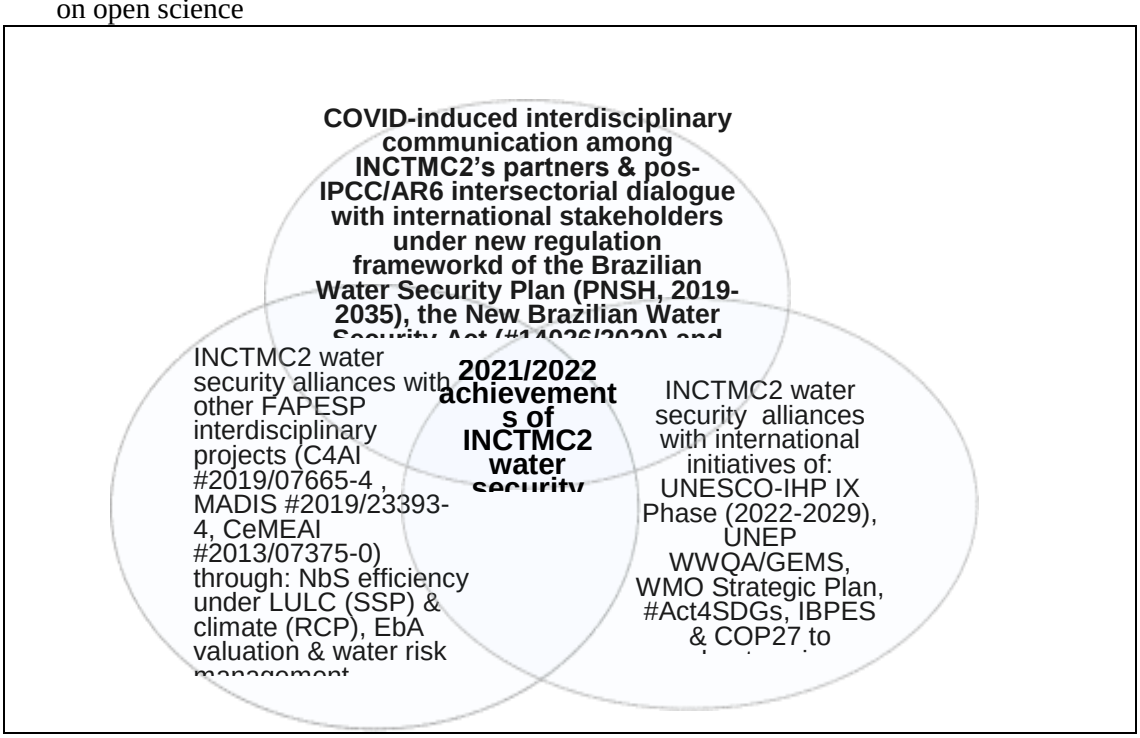


Figure 17. Summary of achievements of the INCTMC2 water security in the period 2021/2022.

Table 3. State of objetives and goals of INCTMC2-Water Security (adapted from Marengo, 2014). Shaded cells represent workable topics of CNPq DTI scholarships (CEMADEN + APAC)

10.2.3 Main objectives (page 34)	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
1. Identification of strategic river basins to systematize data collection of water supply	□□	□□	□□	□□	□□	
2. Calibration and validation, spatially-distributed, of hydrological processes, i.e. rainfall- evapotranspiration, and runoff, under	□□	□□	□□	□□	□□	
3. Simulation of calibrated models, coupling with climate models of medium-and long-term, for prospecting indicators of	□□	□□	□□	□□	□□	
4. Evaluation of new adaptation strategies for water security for multiple uses under	□□	□□	□□	□□	□□	
5. Proposition of strategies for improving water security communication among stakeholders, scientific community, policy		□□	□□	□□	□□	
10.2.5 Expected Goals (page 36)						
[1.] Strengthening information and databases for present and future climate-hydrology	□□	□□	□□	□□	□□	
[2.] Consolidation of a cooperative research network from institutions of excellence in	□□	□□	□□	□□	□□	
[3.] Promotion of adaptation strategy of climate-water-resilience for sustainable		□□	□□	□□	□□	

[4.] Providing technical tools for policies with strategies of adaptation to future changes		□□	□□	□□	□□	
[5.] New courses of water security in graduate programs, including interdisciplinary	□□	□□	□□	□□	□□	
[6.]Postgraduate Award of Brazilian researchers on the subject of water security with increased participation in national and	□□	□□	□□	□□	□□	
[7.] Publication of research results in media accessible to interested parties, as well as in	□□	□□	□□	□□	□□	
[8.] Expansion of participation of Brazilian researchers in international forums for	□□	□□	□□	□□	□□	
[9.] Promotion of a science-to-policy network for the 2019-2035 Brazilian Water Resources Plan (ANA), under the legal framework (9.433/97, Braz. Wat. Res. Act; 12.187/09: the	□□	□□	□□	□□	□□	

5.3.2 Scientific and Management Activities (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 affiliated networks from ABRHidro. Activities were subdivided into sections of advances in water security at local scales, climate change and trends in selected scales, earth observation for water management, and combined strategies with key stakeholders. Detailed information can be consulted in respective publications (section XX) After COVID, highlights of the 5th year 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). Moreover, being Brazil a global player in natural capital has the INCTMC2 water security subcomponent decided to include the Intergovernmental Science-Policy Platform on Biodiversity & Ecosystem Services (IPBES) and the Convention of Biological Diversity (CBD) as programs for linking INCTMC2-WS' science-for-policy goals.

The polycentric governance statement of the INCTMC2-WS is: *"how new sustainable, resilient PPPs 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, <u>through metrics and levels of</u>:*

- Nationally Determined Contributions of Parties (NDC) for UNFCCC,
- Nature's Contribution to People (NCP) for CDB & IPBES,
- Digital Sequence Information" (DSI) for Natural Capital from CBD,

with <u>flexible, adaptable and participatory mechanisms</u> of:

- 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 of Sustainable Insurance (PSI-UNEPFI) and Green Bonds,
- Waste Wise Cities from UN-Habitat,
- Water, Sanitation & Hygiene"(WASH) services from UN-Agenda 2030,

using <u>resilience-driven (absorptive, adaptive, transformative) methods</u> of:

- Nature-based Solutions (NbS),
- Ecosystem-based Adaptation(EbA),
- Community-based Adaptation(CbA),
- Participatory Action Research (PAR)".

Hence, this 5th year of the INCTMC2-WS was consolidated through relevant research-into-policy networks with the IAHS Panta Rhei benchmark dataset with socio-hydrological data of paired events of floods and droughts, the UNESCO-IHP-IX Operational Plan (2022-2029), the IWA 'Earth Observation for water management' Community of Practice, Brazilian open datasets on water security (PNSH/ANASB, CAMELS'BR & CABra).

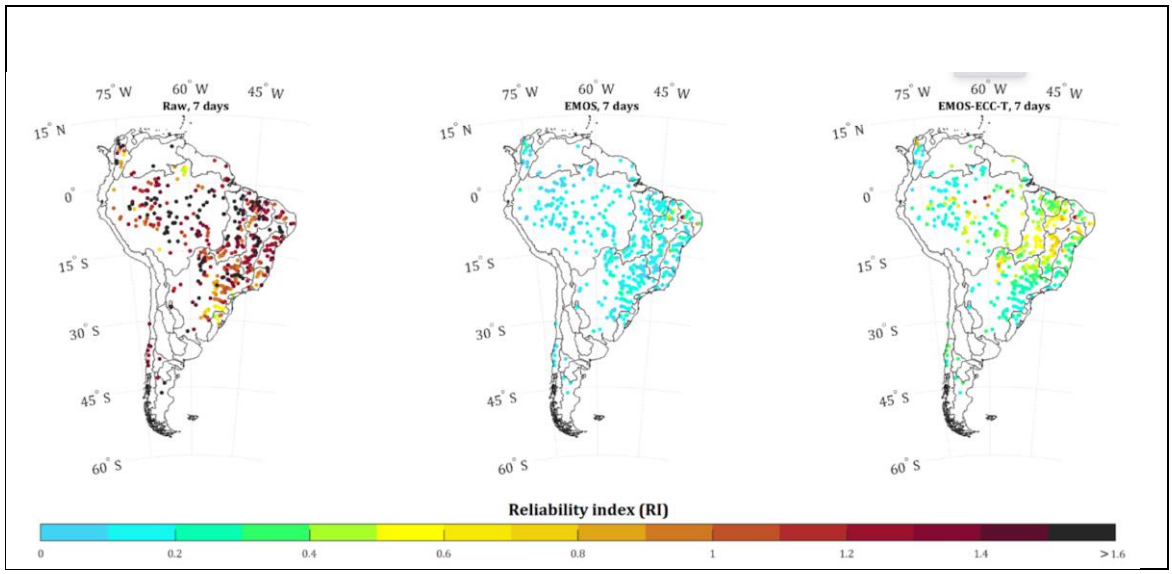
5.3.3 Advances at Multiple Scales of Water Security

In this 2021/2022 period, research groups of INCTMC2-Water Security have gained advances despite of COVID pandemic like continental river flows' datasets, forecasts and post-processing skills, when appropriate (A.1.1),

-Continental river flow datasets, forecast and post-processing

In early 2022, the first Brazilian PhD Thesis on South America river flow datasets, forecasts and post-processing assessment was defended under examination board of scientists of INCTMC2 water security subcomponent. For short-term water resilience maps, Siqueira et al (2021, doi:10.1016/j.jhydrol.2021.126520) use the Reliability Index maps depicting regionally the deviation from flatness, and the Ensemble Model Output Statistics (EMOS) and the Ensemble Copula Coupling "traces" (ECC-T) (Figures 18, 19)

Figure 18. RI maps of ensemble streamflow forecasts for a lead time of seven days. Results are shown for the raw ensemble (left), EMOS univariate postprocessing (center) and EMOS-ECC-T multivariate postprocessing (right). Source: Siqueira et al (2021).



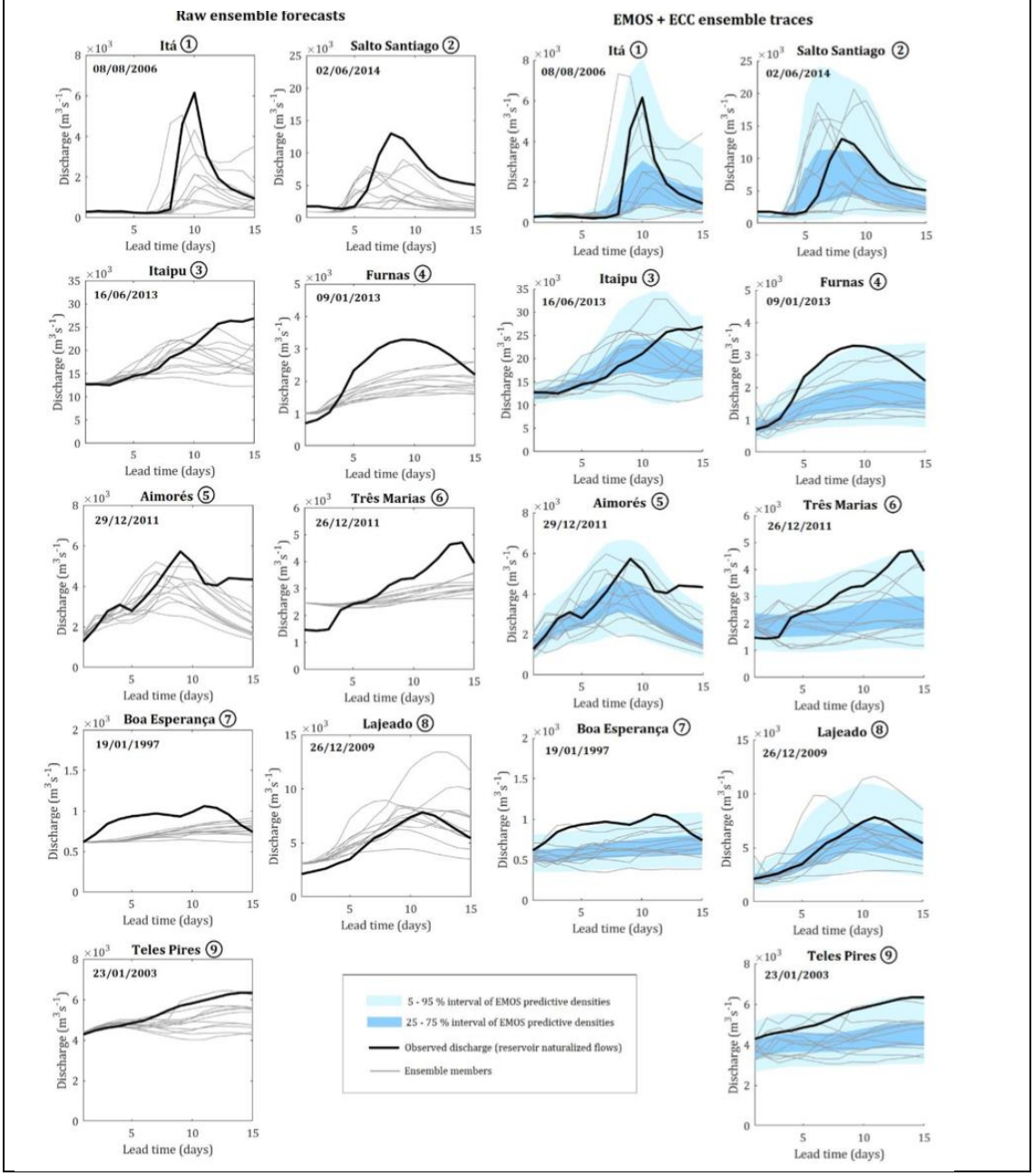


Figure 19. Examples of streamflow forecasts issued for selected locations and selected dates in SA (reservoirs of the Brazilian SIN). Forecasts are presented for the raw ensemble (left) and EMOS predictive distributions together with postprocessed ensemble traces derived using the ECC-T (right). Observed discharges and ensemble members are shown in black (thick) and gray (thin) lines, whereas the centered 50 % and 90 % EMOS prediction intervals are presented in dark and light blue colors, respectively. Source: Siqueira et al (2021).

5.3.4 Datasets on unprecedented droughts-and-floods

One of them is the participation of INCTMC2-Water Security subcomponent's scientists in a global comparative study published in the scientific journal *Nature* (Kreibich et al (2022) The challenge of unprecedented floods and droughts in risk management, *Nature*, https://doi.org/10.1038/s41586-022-04917-5).

On the one hand, the paper has shown that gearing risk management measures to the worst-case event experienced to date is not enough to reduce impacts from unprecedented events. This paper depicts the despite the impact of such natural hazards can be reduced through appropriate risk management if the causes of the increasing damage are known, however, this has so far been hampered by a lack of empirical data. So, a large-scale international collaborative effort by researchers from the International Association of Hydrological Sciences () has now led to important lessons from past events. A unique data set of two successive extreme flood or drought events in the same area was compiled and studied. Regions with large differences in population structure, socio-economic, climatic and hydrological conditions on all continents were studied. The analyses confirmed the assumption that appropriate risk management generally helps to reduce damage.

However, on the other hand, is particularly difficult to reduce the impact of extreme events whose magnitude has not been seen in the past in the affected area because of two factors. First, infrastructures such as dams and reservoirs have an upper design limit up to which they are effective, but once a threshold is exceeded, they become ineffective. Second, risk management is usually introduced or adjusted reactively after major floods and droughts, while proactive, anticipatory strategies are rare. The reason for this behaviour is partly due to a cognitive bias related to the rarity and previous uniqueness of these extreme events, as well as to the nature of human risk perception: events that one has already experienced oneself are more likely to be expected again in the future. Thus, this INCTMC2-contributed paper states worldwide approach, that applying these success factors can counteract the current trend of increasing damage from extreme events under climate change conditions.

-Digital Water for Resilience

The INCTMC2 Water Security has developed new insights to combine a new, three dimensional approach to water security from “real water”(X), “virtual water” (Y) and “digital water” (Z), through operational questions to follow in the sixth year with the 'Earth Observation for water management' Community of Practice (https://iwa-network.org/projects/earth-observation-for-water-management-community-of-practice/), namely :

1. How INV+O&M costs of online digital water monitoring (measured in $/bytes/Liter) are reshaping: (1) pre-COVID expected Return of Investment (ROI*), and (2) post-COVID unexpected "digital water gap" (DWGap) between projects in developED and projects in developING countries,

2. How can we visualize and interpret DWGap when comparing INV+O&M costs between projects in developed countries and in developing ones?

3. What type of new acceptable risk-aversion can we accept with decreasing ROI* on digital water monitoring in developing countries where COVID has impacted the hardest?

4. How could this new post-COVID DWGap help stakeholders (investors, users and utilities) accept decreasing ROI* on digital water monitoring for new projects in challenging sites, like Manaus City in Amazon Basin, Mumbai in India, or Lagos in Nigeria etc?

5. With increasing inequalities to afford secure sanitation especially in COVID times (i.e. in Africa, LATAM, MESA and Asia), it is expected that the DWGap and the ROI* would change, but up to what safe limits?

6. How Digital Twins (DT) for Nature-based Solutions (NbS) contribute to better assess those safe limits for both ROI* and DWGap?

Thus, the INCTMC2-WS' scientists have also focused this 3D approach (real, virtual and digital water cycle) on "big bets", i.e. Agriculture and Food, Climate Change, Environment, Natural Resources & Blue Economy, Environmental and Social Framework, Urban, Disaster Risk Management, Resilience & Land, Social Sustainability and Inclusion, and WaterWater Global Practice (GP), WIA (Water in Agriculture), Water Resources Management (WRM), Global Solutions Groups (GSGs), especially related with the "State of Climate in Latin America and Caribbean" (https://public.wmo.int/en/media/press-release/wmo-issues-report-state-of-climate-latin-america-and-caribbean).

5.3.5. Adaptation Measures of Water Security in Northeast Brazil

Under the supervision of Prof Suzana G Montenegro and Prof A Ribeiro, a new study analysed adapting measures, both structural and non-structural, in the Rio Capibaribe and Rio Ipojuca basinsto coping with climate change (*PhD student: Luiz Gustavo Costa Ferreira Nunes)* The objective of the research aims to propose an adaptation plan to face climate change, listing mitigating measures to the different uses of water, considering the non-stationarity of hydrological and meteorological variables. Analyzing, through modeling, the vulnerability of the existing water infrastructure to future scenarios, in addition to simulating various mitigating measures, both structural and non-structural. Briefly, the methodology is divided into: (a) analysis and considerations about current flow and precipitation trends (diagnosis) and future scenarios (prognosis); (b) applying a rain-flow model (MODHAC) and then (c) allocating water; where, the vulnerability of the existing water infrastructure and the implementation of various adaptive measures in an isolated and combined manner will be considered; finally, based on these results, (d) an adaptation plan will be proposed listing the priority and most effective measures for tackling climate change.The data used were extracted from CMIP5, model HadGEM2-ES. This data set of climatic variables comprises the period from 1850-2100. However, this study must evaluate two distinct periods of 30 years: a base period (1981-2010) and a medium-long term future period (2051-2080), for the RCP8.5 scenario. The calibration and validation of MODHAC for the Capibaribe River and Ipojuca River Basin is described in Ribeiro Neto et al. (2014). The allocation model that will be used will be AcquaNET. The initial results showed that the best performance of the RCP8.5 model for the study basins was r1, with NSE = 0.22, NMRSE = 9.98% and PB = -13.31%; considered excellent by NMRSE (less than 10%) and satisfactory by BP (between –25 and + 25%). Figure 1a illustrates the observed precipitation and the historical base period of RCP8.5 in the contribution basin of the Poço Fundo reservoir. The trend analysis was performed using the Mann-Kendall test and found changes in the trend for the future period in the sub-basins: Goitá (Capibaribe), Tapacurá (Capibaribe), Várzea do Una (Capibaribe) and Foz (Ipojuca). In all cases, the change occurred between the years 2055 and 2056. No trend changes were found in the observed period. Figure 1b illustrates the intersection of the two statistical curves, U (tn) and U * (tn), corresponding to the location of the approximate point of trend change for the Tapacurá sub-basin.

-Climate change and trends of the rainfall of the city of Recife-PE

Subject of major discussions, recent climate changes show the impact and magnitude of anthropic actions in the natural environment. The magnitude of the impacts caused by the changes reflects not only the major disasters caused by extreme events, but also the economic and social spheres, as these changes trigger an imbalance in ecosystems, as well as in climate configuration and hydrological regimes. Therefore, this study aims to analyze the transformations of rainfall over time by detecting trends in time series of hydrological data. The trends and fluctuations of the climatological variables, referring to the precipitation series obtained from 4 rainfall seasons located in Recife-PE, were analyzed by the Mann-Kendall test. According to the Mann-Kendall sequential test, there was a period of significant increase in rainfall that may have its occurrence related to extreme events in the region. Thus the results express a non-significant reduction in rainfall patterns in Recife.

-Science Webinars For Open Science

In several Brazilian postgraduate programs usually offer courses with syllabi related to water security and climate change. In the third year of the INCTMC2, with a partnership among UFPE, UFCG and USP postgraduate programs, using common schedule and syllabi, but independent internal codes, and with cofinancing of CAPES, CNPq and FAPESP, some of courses have addressed interdisciplinary and international topics on water security, global changes and regional impacts. http://climacom.mudancasclimaticas.net.br/3owebinario/. Also from 'Papo coNexus', the webinar on ''Water overexploitation and closure of hydrographic basins: causes and consequences'', by Molle Fraçois, IRD/G-EAU, https://youtu.be/mGRbYxE4vQ0, has taken great attention to INCTMC2 Water Security's recommendations for the Sixth Year.

-Open Science Repository, Popularization Outreach and Citizen Literacy on Interdisciplinary Water Security Under Global Changes

During the Fifth Year of the INCTMC2, the Water Security Subcomponent has strongly promoted open science outreach and a wide popularization of international and interdisciplinary webinars through CEPED/SP website (www.ceped.eesc.usp.br). With INCTMC2's researchers and international guests through partnered initiatives, INCTMC2-water security scientists have followed the recommendations from the School of Advanced Studies on Water & Security under Change, with an open repository of syllabi, knowledge and thinking evolution available to support water literacy, social empowerment and policy making towards a low carbon, more sustainable and resilient society

5.4 Human health and climate change

5.4.1 According to the World Health Organization (2010, 2011) the policies for surveillance/control actions for neglected diseases must be aligned with agendas committed to the assessment of climate and environmental changes.

Year 1: Projections were produced of the distribution of 04 vectors of American Cutaneous Leishmaniasis - ACL (*Lutzomyia flaviscutellata, Lutzomyia whitmani, Lutzomyia intermedia* and *Lutzomyia neivai*) in climate change scenarios.

Year 2: Projections for other vector species *Lutzomyia wellcomei, Lutzomyia complexa, Lutzomyia umbratilis, Lutzomyia migonei, Lutzomyia longipalpis* and *Lutzomyia cruzi*, the last two as vectors of American Visceral Leishmaniasis - AVL.

Year 3: The results were analyzed on the climate suitability scenarios for vectors studied individually, as well as their associations with the distribution of the respective ACL and AVL.

Year 4: With the update of new IPCC scenarios, the modeling for the vectors is being updated once the database is ready. The vector distribution projections associated with socioeconomic variables and the incidence of leishmaniasis will serve as a basis for calculating vulnerability indices for Brazilian Municipalities. Such results, aggregated and analyzed by municipality, constitute important products to support the National Control Program for the Control of Leishmaniasis and the Secretariats, State and Municipal Health Departments in Brazil, aiming at better planning of surveillance and control actions.

Year 5: Municipal vulnerability in the state of Rio de Janeiro/ Brazil, for transmission of American Visceral Leishmaniasis, human and canine Visceral Leishmaniasis, records of the vectors *Lutzomyia* (*Lutzomyia*) *longipalpis* and municipal classification.

The analysis of Lutzomyia (Nyssomyia) whitmani spatial distribution in association with vegetation cover and the six Spatial Circuits of ACL, showed a higher density of the vector in Dense Ombrophilous Forests, Seasonal Decidual Forests, Seasonal Semideciduous Forests, Savanna and Steppe.

The systematic review of climatic conditions that might affect the Covid-19 distribution is under construction. Also, the modelling process to predict the Covid-19 distribution under climatic conditions effects in Brazilian territory is in process of production.

5.4.2 Municipal vulnerability in the state of Rio de Janeiro/ Brazil, for transmission of American Visceral Leishmaniasis.

The State of Rio de Janeiro (RJ) has a small number of human cases of AVL; but it should not be neglected due to the high number of infected dogs, mortality, the vector adaptation, urbanization, and expansion of the disease. Therefore, preventive measures in silent areas are crucial to avoid its spread. This study aimed to identify vulnerable municipalities in RJ and guide future entomological surveys, by mapping the spatial distribution of the disease (human and canine) and its local vector, *L.* (*L.*) *longipalpis*.

The occurrence of *L.* (*L.*) *longipalpis*, human and canine cases of AVL were obtained at the National Information System on Notifiable Diseases, from the Health Department of the State of RJ, from the National Reference Services on Leishmaniasis and from the literature. The data were integrated into a Geographic Information System/QGIS and classified according to the above mentioned criteria, established by the Brazilian Ministry of Health. In the period of 2011-2022, human AVL occurred in 09 and canine VL in 41 of the 92 municipalities in RJ. In the last three years (2019-2021), 27 municipalities had records of canine VL (Figure 20). Five municipalities had records of human AVL; all classified as sporadic transmission, where Barra Mansa, Rio de Janeiro and Volta Redonda are municipalities with records of canine VL and the presence of the vector *L.* (*L.*) *longipalpis*.

In the state, 62 (67%) vulnerable municipalities were identified, 09 (8%) of which were receptive, and only one municipality was classified as silent and not vulnerable (Aperibé) (Figure 21). Rio de Janeiro has only 17 (18%) municipalities with entomological survey and records of the vector (Figure 22). The transmission of AVL currently occurs in 32% of the RJ and classified as sporadic. Approximately 82% of all the state, and among the vulnerable municipalities, 85% municipalities do not have information on sandflies, which shows a clear need for entomological studies.

It is known that notifications about human and canine cases of VL are still precarious, a fact that needs to be reviewed, since they are essential data for surveillance and control actions to be implemented efficiently in the state and in the municipalities. After the detection of the vector in vulnerable municipalities, the recommended control actions are: health education actions, environmental management, and canine investigation, aiming at the early detection of AVL cases. This type of study has as its main perspective to provide support for surveillance campaigns and prevention of AVL transmission, whose model could be applied to different regions of Brazil.

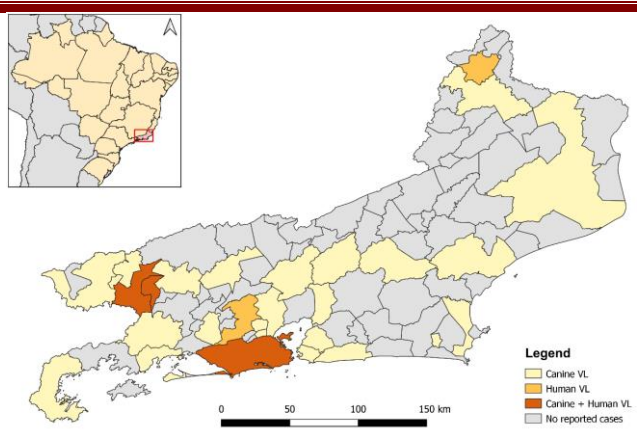


Figure 20: Occurrence of human and canine Visceral Leishmaniasis of the State of Rio de Janeiro.

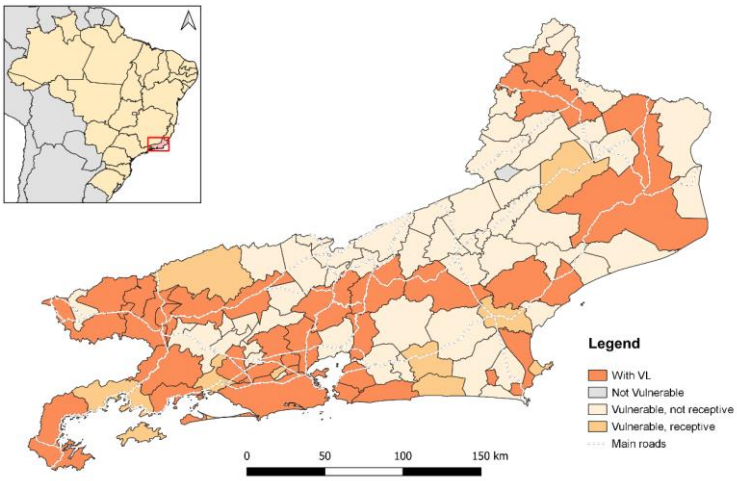


Figure 21: Classification of municipalities of the State of Rio de Janeiro according to the transmission of American Visceral Leishmaniasis.

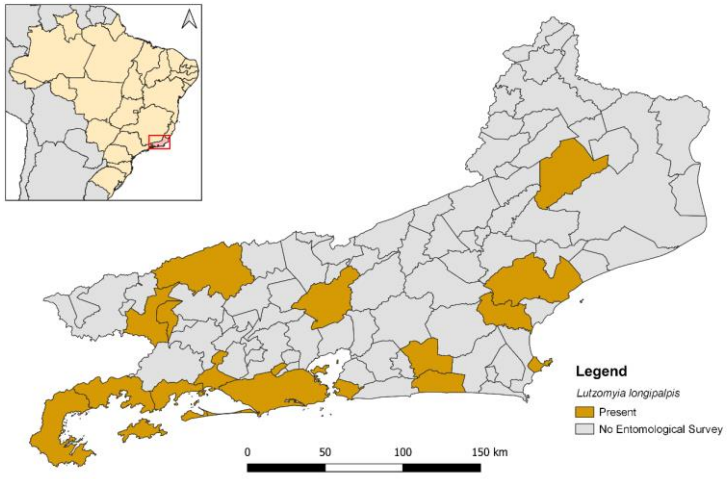


Figure 22: Entomological survey and records of the vector *Lutzomyia* (*L.*) *longipalpis* on the State of Rio de Janeiro.

5.4.3 Vulnerability of Brazilian population to climate change: A case study of American Cutaneous Leishmaniasis (ACL) in association with the spatial distribution of *Lutzomyia* (*Nyssomyia*) *whitmani* (Diptera: Psychodidae: Phlebotominae), with emphasis on the State of Rio de Janeiro, in comparison with other states in the context of the Southeast Region.

Given the complexity and challenge of controlling ACL in Brazil, the indication of future risk scenarios for epidemic outbreaks can optimize costs and facilitate the planning of well-targeted actions with a focus on monitoring and surveillance of environmental impacts. The present proposal is organized in two main objectives having as target the State of Rio de Janeiro in the context of the Southeast Region.

The first objective is to generate future projections of the geographic distribution of *L. whitmani*, the most important vector of ACL in Brazil, through ecological niche modeling;

The second is to assess the vulnerability of the Brazilian population to the occurrence of ACL in climate change scenarios. With this, we intend to update the known distribution and generate maps of potential areas of occurrence of *L. whitmani* of greater relevance for the transmission of ACL in Brazilian territory.

Future projections indicate a greater area of expansion of the climatic suitability of *L. whitmani* for the North region of Brazil, and reinforces the expansion trend towards the South. Although climate change scenarios show that the Amazon region will gradually become drier, the results indicate that *L. whitmani* will remain present in the region and should expand its area of climatic suitability. The models were able to identify that the continuous process of environmental degradation favors the establishment of *L. whitmani* and the occurrence of ACL.

In this view and associated with the new epidemiological patterns resulting from drastic environmental changes, the epidemiological scenario for ACL points to a continuous increase in human cases.

5.4.4 SARS-Cov2: Assessment of the relationship between climate and Covid-19 in Brazil: a systematic review.

For this topic, the present study aims to model the spatial distribution of communicable diseases in different scenarios of global warming and to understand how this will impact the probability of emergence of new cases. Although the etiological, clinical and epidemiological knowledge are evolving, some studies suggest that the incidence of SARS-CoV-2 might be influenced by environmental characteristics, such as regional climatic differences.

In addition to weather conditions, air pollution had been studied as a co-factor for Covid-19 lethality since most of the pre-existing conditions that increase the risk of death from SARS-CoV-2 can also be affected by the long-term exposure to air pollution. Here, we investigate the regional climatic characteristics in the distribution of cases of Covid-19 in Brazil and the possible effects of air pollution on the lethality of SARS-CoV-2 in Brazil. This is an ecological study that seeks to estimate the probability of favorable climatic conditions for the occurrence of cases of COVID-19 and American cutaneous leishmaniasis using georeferenced cases for the period of 2020-2021; and secondly, the Covid-19 lethality rates in 2020/2021 for each municipality in Brazil will be related to the mean concentrations of fine particulate matter (PM2.5) extracted from the period 2003-2020. For the construction of models for predicting future warming scenarios for diseases, a species distribution model will be used (proposed to predict species distributions based on environmental covariates for each grid in a grid). The environmental variables will be extracted from the database generated from the IPCC regionalized climate model Eta-HadGEM2 ES RCP 8.5, for the IPCC 1.5ºC, 2.0ºC and 4.0ºC global warming scenarios for the years 2020 to 2100. These projections are used to assess impacts as a consequence of climate change using impact methodologies and models, where the input variables are present and future climate scenarios derived from the Eta-HadGEM2 ES models.

As preliminary results, the analysis of suitability and contribution of bioclimatic variable to the modeling of high cumulative incidence of Covid-19 indicated that the variables

annual mean temperature, temperature seasonality, annual temperature range, annual precipitation and precipitation seasonality indicated a greater contribution to the general model in relation to the other variables used. Of the five selected variables, the annual temperature range was the variable with the best relative contribution to the seven models selected for the modeling and the average annual temperature was the variable that made the smallest contribution to the modeling (Figure 23). The areas highlighted in red on the map presented points of high climatic suitability (i.e., greater probability that climatic factors are contributing to the high health indicators investigated), mainly in the North and South regions and in some points in the Central West region.

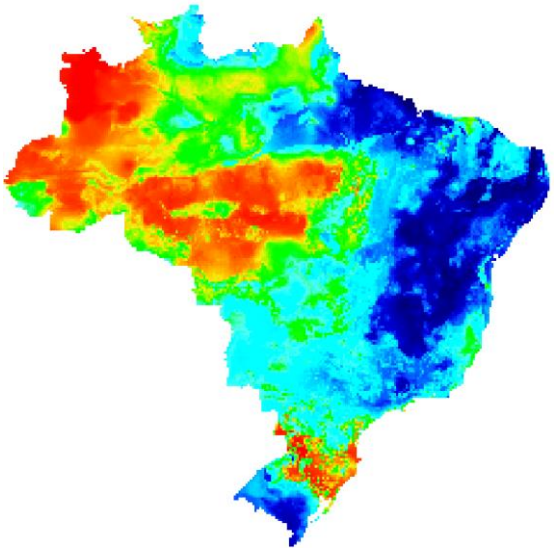


Figure 23. Prediction of suitable environmental conditions for the high cumulative incidence of COVID-19 in the years 2020 and 2021, Brazil.

5.4.5 Analyzing the Sars-Cov 2 epidemic from a socio-climate perspective

Acute viral infections of the respiratory tract (vARIs) are responsible for a high burden of acute diseases in all age groups and their association with local weather patterns in various parts of the world has long been demonstrated (Chadha et al., 2020; Li et al., 2019; Moura, Perdigão, & Siqueira, 2009; Shek & Lee, 2003; Stewart, 2016). The most common viral types are Influenza, an important cause of morbidity and mortality in humans and responsible for seasonal, pandemic and zoonotic outbreaks (e.g. H2N2, H3N2, H1N1, H5N1, H5N9). However, other non-influenza respiratory viruses have recently emerged or were detected such as the coronaviruses of severe acute respiratory syndrome (SARS-CoV and SARS-CoV-2) and of the Middle East respiratory syndrome (MERS-CoV), adenovirus type 14 (Ad14), human rhinovirus C (RV-C) and human bocavirus species (Dunn & Miller, 2014).

In general, a fundamental role of temperature is observed in the seasonality of these viruses, including the frequent migration of influenza viruses from warmer to colder geographical regions. (Li et al., 2019; Sundell, Andersson, Brittain-Long, Lindh, & Westin, 2016). In fact, almost all vARIs share the same seasonality in temperate regions, where cases are more prevalent in winter, while there is greater temporal diversity in the tropics (Li et al., 2019; Stewart, 2016). However, the timing of vARI epidemics varies between and within countries (Bloom-Feshbach et al., 2013).

Regarding coronaviruses, a study found that SARS-Cov probably behaved in a seasonal manner in China, appearing initially between late autumn and early spring, times when temperature, relative humidity and wind speed were the main meteorological factors affecting its transmission (Yuan et al., 2006). Sun et al. (2020) report that in the past 17 years two generalized SARS epidemics have occurred in China caused by the coronavirus, and that some

general patterns related to the epidemic are noticeable such as: the two epidemics appeared in the winter season, when a favorable condition for the survival of the virus is observed , and both occurred in times of severe drought, rare conditions in the locations where the epidemic broke out.

Considering this context, it is possible that the seasonality of the new coronavirus (SARS-COv-2) may also rest in climatic aspects, given that its seasonality in the world and in Brazil is still practically unknown, but it can share similarities with other vARIS. Obviously, human behavior, globalization and control measures (ie wearing masks, social isolation, lockdown, among others) are non-climatic factors that, in fact, seem to have the greatest impact on the epidemiology of SARS-VOC-2, but the climatic factors should be better analyzed in the Brazilian context to help understand the epidemic in the country. This understanding can benefit both from vulnerability assessments that allow identifying the territories most susceptible to localized outbreaks, and from the climate approach in epidemiological models that provide a holistic view of the behavior of the new pathogen.

Therefore, this research is justified since Covid 19 generated great social, concern. Due to the extension of the Brazilian territory, the intention is to use the state of Minas Gerais as a proxy for the possible socioeconomic and climatic relations that can be observed in other regions of the country with regard to the coronavirus epidemic. The state has 853 municipalities with very different human, economic, and climatic conditions, ranging from places such as the Jequitinhonha Valley and North region (semi-arid), with a hot, dry climate and greater human poverty, to the Triângulo Mineiro and Alto Paranaíba, with better living conditions and subtropical climate. The objective of the work is i) to survey social and health system vulnerabilities in the municipalities of Minas Gerais and ii) to study climatic patterns that may be related to the SARS-COV-2 epidemic in the state during the first year of registered cases (March 2020 - February 2021). To this end, meteorological, social, economic, demographic, epidemiological and health data were produced/collected (Tables 4, 5).

Meteorological data were being processed in partnership with Professor Marcelo de Paula Correa, Director of the Natural Resources Institute of the Federal University of Itajubá/MG (Unifei). Epidemiological, health, social and economic data were being collected on governmental websites. Data were analyzed using STATA version 16.0 software. In this, the accumulated incidence of COVID19 cases was calculated in each of the 14 macro-regions of the state of Minas Gerais, corresponding to the period between 03/01/2020 and 04/08/2021. Fourteen health and social-economic/housing variables were used in the study.

The results showed that the macro-regions of Minas Gerais presented a diversity of housing and demographic conditions. Vale do Aço is the macro-region with the highest percentage of people in vulnerability due to sanitation conditions, followed by the East macro-region. The macro North had the highest percentage of households with a high density of more than two people per bedroom. The percentage of women was similar among the twelve macro-regions.

The cumulative incidence of COVID-19 in the analyzed period was higher, respectively, in the macro-regions Triângulo do Norte and Vale do Aço, while the lowest cumulative incidence was identified in Jequitinhonha. The average incidence in the period was higher in the Centro macro-region, followed by Vale do Aço.

The East macro-region had the highest minimum, maximum and average temperatures. The lowest minimum temperature was identified in the South macro-region, while the lowest maximum temperature was in the Central South macro-region. A statistically significant and very weak correlation was identified between the daily incidence of COVID-19 and the minimum temperature in the Central South, East, Northwest, West, South, North Triangle and Vale do Aço macro-regions. With average temperatures, the correlations were statistically

significant and very weak in the Center, East, South East, Northeast, Northwest, Southeast, South and Southern Triangle. With maximum temperatures, a statistically significant and very weak correlation was identified in the Center, East, South East, Northeast, Southeast and Northern Triangle macro-regions (Tables 6, 7).

Table 4- Multiple linear regression model considering the cumulative incidence of COVID-19 as an outcome and sociodemographic and health variables as independent.

Variáveis	**Erro padrão**	**Coeficiente**	**Valor de p**	**IC95%**
Percentual em vulnerabilidade por condições de saneamento	0,442	0,352	0,572	-5,272; 5,977
Percentual de domicílios com alta densidade	0,729	-0,478	0,631	-9,749; 8,793
Estimativa populacional de zero a quatro anos	0,050	0,017	0,790	-0,624; 0,650
Percentual de mulheres	555.7976	232,569	0,748	-6829,508; 7294,648
População residente	0,002	-0,001	0,709	-0,032; 0,0304
Densidade populacional	0,054	-0,029	0,688	-0,732;0,665
População residente com 65 ou mais	0,007	0,008	0,477	-0,088;0,104
Auxílio emergencial	0,001	-0,0006	0,784	-0,023;0,021
Famílias beneficiadas pelo Bolsa Família	0,009	0,005	0,651	-0,114;0,125
IFDM emprego e Renda	44.6340	11.360	0,841	-555,768;578,489
Proporção da população atendida pela ESF	0,493	-0,189	0,767	-6,463;6,084
Gasto per capita com atividades de saúde	0,015	0,006	0,755	-0,186;0,198
Constante	208,3161	-99,804	0,716	-2746,711; 2547,102

Table 5- Correlation between temperature variables and daily incidence of COVID-19 in the macro-regions of Minas Gerais between 03/01/2020 and 04/08/2021.

Macrorregiões	**Temperatura mínima**		**Temperatura média**		**Temperatura máxima**	
	r	**Valor de p†**	**r**	**Valor de p†**	**R**	**Valor de p†**
Centro	-0,002	0,968	0,099	0,048	0,126	0,011
Centro Sul	0,122	0,014	0,076	0,129	0,065	0,195
Jequitinhonha	0,025	0,620	0,087	0,082	0,092	0,067
Leste	0,103	0,040	0,114	0,022	0,100	0,045
Leste do Sul	0,076	0,128	0,126	0,011	0,115	0,022
Nordeste	0,073	0,144	0,134	0,007	0,144	0,004
Noroeste	0,101	0,043	0,101	0,043	0,044	0,379
Norte	0,050	0,318	0,043	0,318	0,076	0,131
Oeste	0,103	0,040	0,068	0,172	0,019	0,703
Sudeste	0,075	0,136	0,106	0,033	0,113	0,024
Sul	0,178	<0,001	0,140	0,005	0,029	0,560
Triângulo do Norte	0,105	0,035	0,047	0,351	0,115	0,021
Triângulo do Sul	0,047	0,346	0,102	0,040	0,026	0,595
Vale do aço	0,099	0,048	0,079	0,115	0,083	0,098

† Teste de correlação de Pearson.

Table 6- Correlation between temperature variables and daily incidence of COVID-19 in the macro-regions of Minas Gerais between 03/01/2020 and 04/08/2021.

Macrorregiões	**Temperatura mínima**		**Temperatura média**		**Temperatura máxima**	
	r	**Valor de p†**	**r**	**Valor de p†**	**R**	**Valor de p†**
Centro	-0,002	0,968	0,099	0,048	0,126	0,011
Centro Sul	0,122	0,014	0,076	0,129	0,065	0,195
Jequitinhonha	0,025	0,620	0,087	0,082	0,092	0,067
Leste	0,103	0,040	0,114	0,022	0,100	0,045
Leste do Sul	0,076	0,128	0,126	0,011	0,115	0,022
Nordeste	0,073	0,144	0,134	0,007	0,144	0,004
Noroeste	0,101	0,043	0,101	0,043	0,044	0,379
Norte	0,050	0,318	0,043	0,318	0,076	0,131
Oeste	0,103	0,040	0,068	0,172	0,019	0,703
Sudeste	0,075	0,136	0,106	0,033	0,113	0,024
Sul	0,178	<0,001	0,140	0,005	0,029	0,560
Triângulo do Norte	0,105	0,035	0,047	0,351	0,115	0,021
Triângulo do Sul	0,047	0,346	0,102	0,040	0,026	0,595
Vale do aço	0,099	0,048	0,079	0,115	0,083	0,098

Table 7- Correlation between variables of humidity, precipitation and O3 concentration and daily incidence of COVID-19 in the macro-regions of Minas Gerais between 03/01/2020 and 04/08/2021.

Macrorregiões	**Umidade**		**Precipitação**		**Concentração de O3**	
	r	**Valor de p†**	**r**	**Valor de p†**	**R**	**Valor de p†**
Centro	-0,127	0,011	-0,035	0,485	-0,015	0,752
Centro Sul	0,029	0,556	0,059	0,241	-0,029	0,564
Jequitinhonha	-0,054	0,278	0,024	0,631	0,029	0,558
Leste	0,014	0,775	0,010	0,841	0,092	0,066
Leste do Sul	-0,100	0,046	-0,016	0,765	0,065	0,194
Nordeste	-0,060	0,228	-0,034	0,496	0,048	0,336
Noroeste	0,044	0,379	0,001	0,982	-0,008	0,868
Norte	0,076	0,131	-0,019	0,702	0,060	0,227
Oeste	0,019	0,703	0,083	0,095	0,002	0,997
Sudeste	0,113	0,024	-0,005	0,900	0,017	0,722
Sul	0,029	0,560	-0,003	0,994	-0,004	0,924
Triângulo do Norte	-0,143	0,004	-0,004	0,935	0,117	0,019
Triângulo do Sul	-0,058	0,249	0,018	0,714	0,130	0,009
Vale do aço	0,051	0,308	0,005	0,915	-0,015	0,755

Data analysis and preliminary results were carried out between June 2021 and June 2022.

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5.5 Energy security

To assess the extent to which Brazilian economic development and the increase in energy use is compatible with the objectives of a sustainable and less carbon-intensive economy, further assessing the relationship between future climate and energy availability.

5.5.1 Activities carried out during the fifth year

a) Scientific and Administrative Activities developed in the 5th year (July 2021 to Jule 2022), together with information from meetings and working groups where the INCT may have been presented.

Integrated Assessment Modelling tools improvements and advances (COPPE)

The energy security component's team at COPPE ended its participation in the Project in the end of February 2021, when the last CNPq scholarships allocated to the COPPE/UFRJ team were paid. As a consequence, no further activities were developed by the COPPE team to the project after February 2021.

Burning biomass aerosols impact on incoming solar energy (INPE, UNIFESP)

Problem statement

Atmospheric aerosols are the most important factor for solar radiation extinction in cloudless conditions, followed by water vapor. Amazon and central Brazil burning season spanning from August to October causes large scale impact on the atmospheric transmittance due to high loads of burning biomass aerosols emitted to the atmosphere. During this period of the year, in Central Amazon, values of AOD at 500 nm between 0.75 and 1.0 are frequently found, while in the Southern Amazon values well above 1.0 are common. AOD up to 5.0 have been reported in years with more intense biomass burning activity. The higher aerosol optical depth affects solar irradiance reflection and scattering, reducing the amount of shortwave radiative energy reaching

the surface, also increasing the diffuse fraction. These aerosol plumes are transported for long distances, impacting regions of interest for solar power exploitation. (Figure 24).

Brazil has a vast potential solar energy resource and has experienced a boost in photovoltaic deployment in recent years due to government incentives and technological advances. In particular, concentrating solar power (CSP) technologies have shown a noteworthy potential for Brazil in scenarios of climate change mitigation, especially as a complementary heat supply for industrial processes or hybrid power generation. It should be noted, however, that some potential areas for CSP development, like the Central-West and the Southeast regions, are often affected by biomass burning haze during the dry season.

Solar irradiance data are available only in a few locations in Brazil and are sparsely and heterogeneously distributed. Measurements of the direct component of irradiation are even more scarce, which makes it difficult to assess the potential of this technology. Numerical models came as an useful tool to improve the spatial monitoring of solar irradiance. The BRASIL-SR model is one of this model and has been used by LABREN/INPE in partnership with the Federal University of São Paulo for the assessment of the solar energy potential of the entire country.

BRASIL-SR model

BRASIL-SR is a satellite-based model that estimates the downward surface solar irradiance developed by INPE. The core of the BRASIL-SR is a physically-based radiative transfer model that is executed for two atmospheric conditions: cloudless and overcast with a very high cloud optical depth. Then, the solar irradiance components at the surface for any cloud cover conditions are obtained by the interpolation between both solutions using the effective cloud cover index obtained from visible satellite imagery. For clear sky assessments, the model BRASIL-SR requires the following regional input data for each grid cell: longitude, latitude, altitude, surface temperature, relative humidity, total precipitable water vapor (PWV), total ozone in the column (O3), AOD in 550 nm and Angström's exponent (AE), biome classification, and the Moderate Resolution Imaging Spectroradiometer (MODIS) bi-directional reflectance distribution functions (BRDF) kernel parameters. Additionally, local data from observations (e.g., from the Aerosol Robotic Network-AERONET) of PWV, O3, AOD, and AE can be entered as input for a particular grid cell, overriding regional data.

Methods

During this period a new version of the BRASIL-SR clear-sky model was developed by the LABSOLAR/INPE, with partnership with the Federal University of São Paulo (UNIFESP), to improve the representation of aerosol radiative attenuation and reduce the uncertainties of the surface solar irradiance estimates in cloudless hazy conditions and clean conditions. The main advances were:

- Better assimilation of burning aerosols
- Improved aerosol spectral attenuation
- New surface albedo representation due to inclusion of Bidirectional Reflectance Distribution Functions (BRDF)
- Improved simulation of water vapor and ozone spectral attenuation processes.
- New approach for using delta-Eddington optical depth scaling in simulations

The numerical experiments compared AOD inputs from local observations (AERONET) and regional gridded datasets (MERRA-2 reanalysis) for four sites in Central Brazil and Amazon: ARM_Manacapuru, Manaus_EMBRAPA, Brasilia_SONDA and Palmas_SONDA. ARM_Manacapuru, Manaus_EMBRAPA and Brasilia_SONDA have co-located AERONET stations, with the same name, that provide level 2.0 AOD , PWV, and O3 column content data. Additionally, spectral irradiance data were available from multifilter rotating shadowband

radiometers (MFRSR), operating at Manaus_EMBRAPA and ARM_Manacapuru. These two sites were part of the GoAmazon experiment under the classification of time point zero (T0e) and three (T3), respectively. In addition to the comparison with observational data, BRASIL-SR results were compared with two broadband clear sky models, McClear and REST2. All comparisons were made for the dry seasons of 2014 and 2015 on a minute basis using clear-sky periods only. Cloudy samples were removed using appropriate algorithms.

Figure 24: Study area and ground stations used for validation (ARM_Manacapuru, Manaus_EMBRAPA, Brasilia_SONDA and Palmas_SONDA)

Results

Results for DNI without delta-Eddington scaling presented the best skill in all sites and for both experiments. Relative bias for DNI ranged from −2.3% to −0.5% when using in-situ AOD data, while it ranges from 0.1 to 2.1% for the regional AOD data. The overall skill of BRASIL-SR for the estimation of both GHI and DNI was improved during this work (Figures 25, 26)

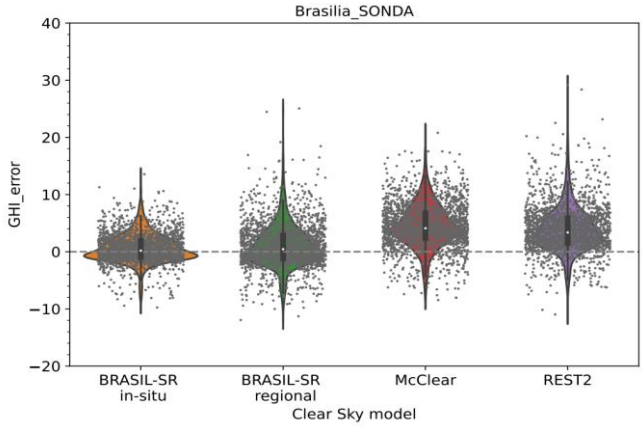


Figure 25: Combined violin and strip plots of the deviations of the BRASIL-SR GHI outputs in in-situ and regional experiments, McClear and REST2 for Brasilia_SONDA

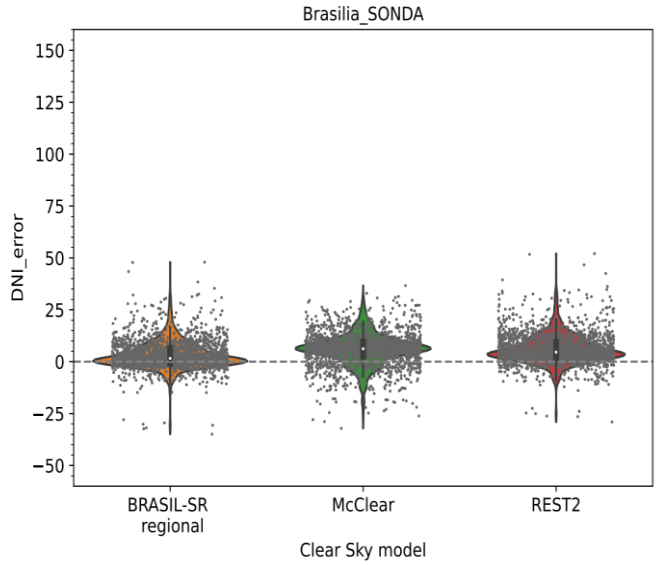


Figure 26: Combined violin and strip plots of the deviations of the BRASIL-SR DNI outputs in regional experiments, McClear and REST2 for Brasilia_SONDA

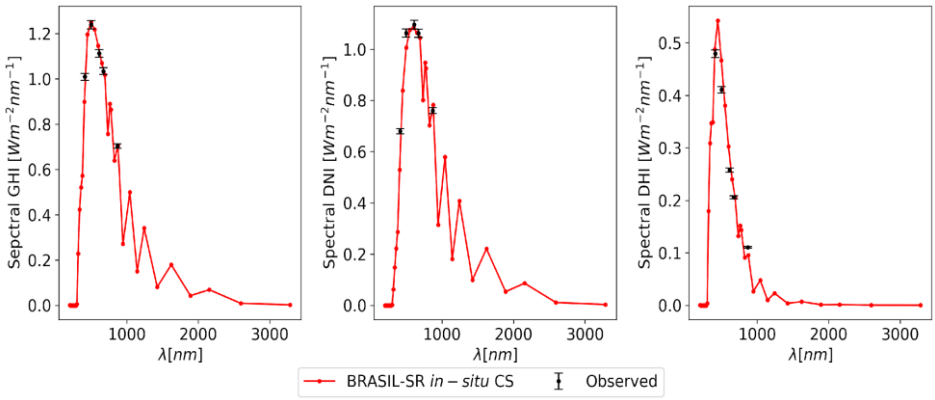


Figure 27: Spectral GHI, DNI and DHI at ARM_Manacapuru on 19 September 2015, 18:30 UTC.

Results indicate a good skill of BRASIL-SR for the estimation of both GHI and DNI. For the period of study, the model skill showed a comparable or superior skill than the obtained with broadband models McClear and REST2 at the measurements sites, except for Palmas_SONDA where McClear presented the best skill.

The RMSD deviations of the GHI provided by BRASIL-SR using local AOD data (in situ experiment) was below 2.9% for all ground sites and below 5.7% for regional experiment. The bias for GHI were below 1.3% for the in-situ experiment, and below 2.1% for the regional experiment. Our results also confirmed former research outputs that delta-Eddington scaling in the two-stream approximation led to an overestimation of the DNI. For the in-situ experiment, the DNI bias without scaling varied from −2.3 to −0.5% while RMSD ranged from 2.3 to 4.7%. For the regional experiment, bias were slightly positive, ranging from 0.1 to 2.1% while RMSD ranged from 5.9 to 9.6%, except for Palmas_SONDA that presented some quality issues in DNI ground data (Figure 27).

In summary, this study confirmed that aerosol emitted to the atmosphere by biomass burning events can intensely attenuate incident solar irradiance to the surface. The new improved version of the model BRASIL-SR provides GHI and DNI outputs with low uncertainties for cloudless conditions for all aerosol loads. Future studies should cover more extensive timeframes and geographical areas, allowing a more comprehensive and detailed performance

benchmark for this model. There is work in progress to improve cloud representation in BRASIL-SR. The major goal is to develop a reliable spectral model providing GHI, DNI for any atmospheric condition concerning cloud or aerosol optical thickness in a tropical region. The fine spatial resolution of the GOES imagery and its cloud and aerosol products can help to overcome the ground data scarcity. In addition, a parameterization for circumsolar irradiation should be included in future versions of BRASIL-SR.

5.5.2 Climate projections downscaling for solar and wind assessment in Brazil

Renewable energies are in the core of current energy transition, contributing to reduce GEE emissions but may be exposed to climate change impact. Future wind and solar resource availability and variability is being assessed through CMIP6 datasets. Earth system models provide valuable information on climate response to global environmental changes, but results should be assessed carefully due to high uncertainties inherent in these models. In this work a statistical downscaling procedure is used to adjust models to observations and to produce more reliable projections, especially for extreme events. An uncertainty analysis, using large-ensemble models is developed for defining confidence intervals and to rank the best performing models to build a smart multi-model ensemble. For this purpose, the activities below summarize the achievements during the last year by LABREN/INPE in partnership with the Federal University of São Paulo:

- Development of a validation algorithm for observed solar radiation data from INMET and the SONDA network;
- Comparison of reanalysis data (CFSR, MERRA-2 and ERA5) to observed data to identify the best datasets for representing wind and solar resource;
- Bias correction of selected reanalyses to obtain refined databases for 100m-wind and solar irradiation;
- Development of codes for faster downloads of CMIP6 datasets;
- Definition of three target areas over Brazil to support comparisons between the models (Semi-Arid, Central and Southern Brazil).
- Performance evaluation of the CMIP6 models through the analysis of the spatial correlation between the historical long-term averages from models and observations for each target area.
- Performance evaluation of CMIP6 models ability to simulate the seasonal cycle, through the calculation of monthly averages within each target area.

After the first steps (development of data quality check routines), the next stage was to determine which reanalyses dataset (MERRA-2, CFSR and ERA5) would be chosen to correct the climate models. This was made based on a trade-off analysis off the quantile map fit and the correlation analysis. The more temporally correlated the observed and reanalysis data are the higher the odds that the quantile mapping transfer functions will improve the reanalysis performance. Figure 28 compares the daily series of the three sets of reanalysis with Brazilian Solar Atlas data for the 17 years of daily data.

As a result from literature review, 20 climate models were selected among those available in CMIP6 to proceed in this analysis as described below:
25km spatial resolution - CESM1-CAM5-SE-HR, CMCC-CM2-VHR4 and ECMWF-IFS-HR;
50km spatial resolution - ECMWF-IFS-LR, ECMWF-IFS-MR and MPI-ESM1-2-XR;
100km spatial resolution - CESM2, EC-Earth3, EC-Earth3-Veg, EC-Earth3-Veg, INM-CM4-8, INM-CM5-0, MPI-ESM1-2-HR and MRI-ESM2-0;
250km spatial resolution - ACCESS-ESM1-5, FGOALS-g3, IPSL-CM6A-LR, IPSL-CM6A-LR-INCA, KACE-1-0-G and MIROC6.

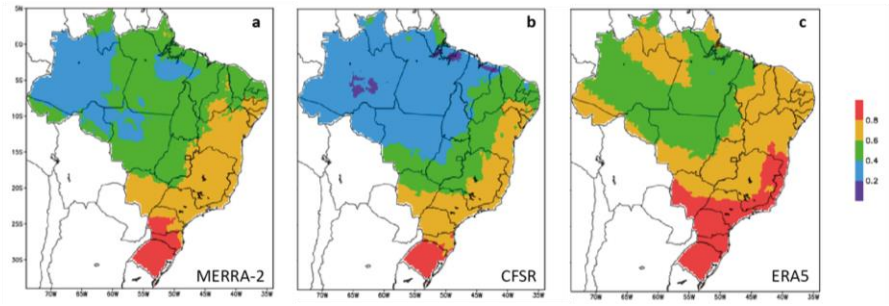


Figure 28: Temporal correlation coefficient (Pearson) between daily total irradiation data from the Brazilian Solar Atlas and reanalysis: a) MERRA-2; b) CFSR and c) ERA5.

Three areas of interest were defined for the initial analysis of the models. These regions were proposed due different characteristics in terms of the climatology of solar irradiation, but with an important complementarity between solar-wind-hidro resources - a box in the Semi-Arid region, a box inside Central Brazil and a last one, considering the southern region. The map in Figure 29 shows the mean global irradiance of the bias corrected ERA5 and the areas of interest.

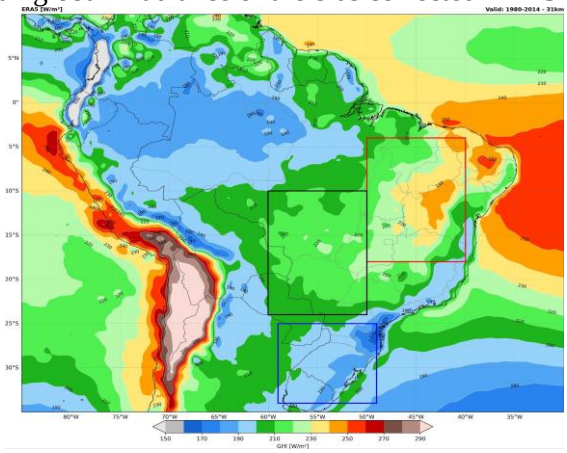


Figure 29: Global solar irradiance mean estimated by ERA5 with the three areasof interest.

Among the 20 CMIP6 climate models chosen for an initial evaluation, the spatial resolutions are distributed as follows. Some computational scripts were developed to download this data:

- 25km spatial resolution - CESM1-CAM5-SE-HR, CMCC-CM2-VHR4 e ECMWF-IFS-HR;
- 50km spatial resolution - ECMWF-IFS-LR, ECMWF-IFS-MR e MPI-ESM1-2-XR;
- 100km spatial resolution - CESM2, EC-Earth3, EC-Earth3-Veg, EC-Earth3-Veg, INM-CM4-8, INM-CM5-0, MPI-ESM1-2-HR e MRI-ESM2-0;
- 250km spatial resolution - ACCESS-ESM1-5, FGOALS-g3, IPSL-CM6A-LR, IPSL-CM6A-LR-INCA, KACE-1-0-G e MIROC6.

5.5.3 Preliminary evaluation of future solar resource

For a preliminary assessment, the results of the ECMWF-IFS-L climate model - which presented one of the best spatial correlations in the three areas of interest - are presented in the optimistic and pessimistic SSP scenarios. The scenarios were divided into time-slices, which comprise the periods 2015-2040, 2041-2070 and 2071-2100. Figure 30 presents the map for each of these periods in the most optimistic scenario, SSP245. A gradual increase in the solar potential is observed as the simulations advance in time, being more significant in the period 2071-2100, where positive variations between 1 and 5% are observed in the Brazilian territory, predominantly between MG and BA and in the western end of the territory.

Similarly, Figure 31 presents the SSP585 scenario, with potentially large impacts from climate change. The maps of the SSP585 scenarios show a significant increase in global solar radiation in several areas of Brazil and in all periods, eventually exceeding 3%. It is observed, in both scenarios, that the north of the Northeast and the south of Brazil did not present high gains in solar potential.

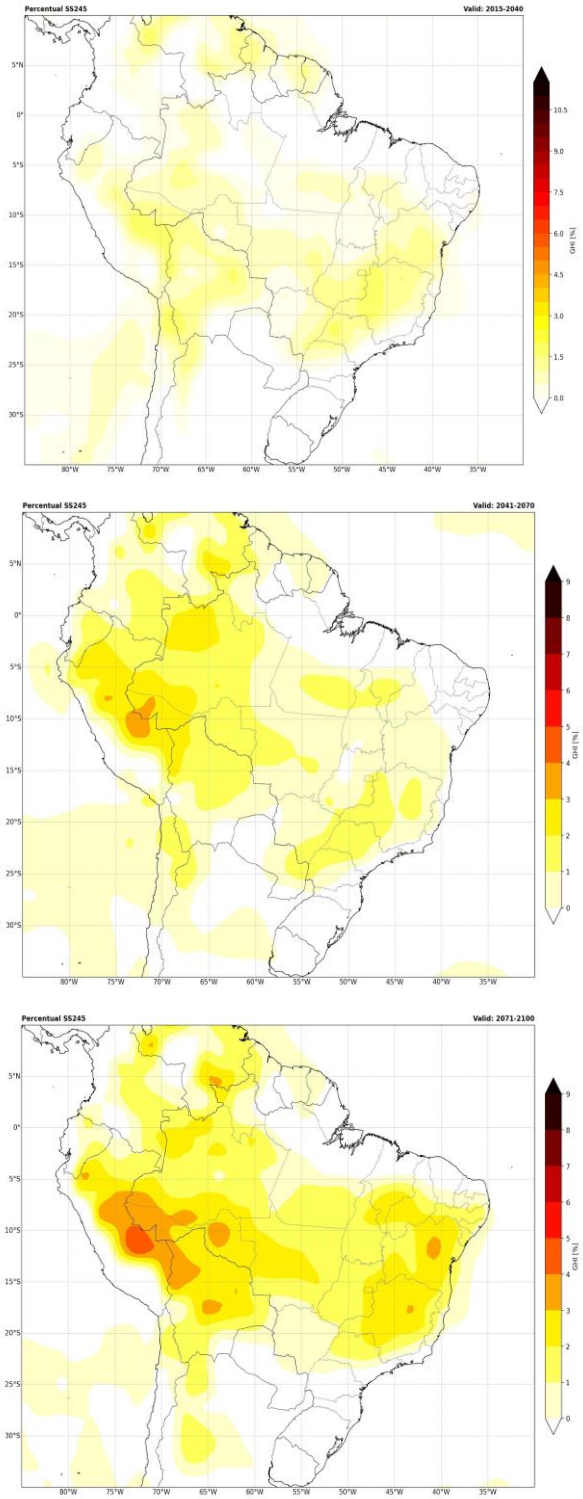


Figure 30: Global irradiation difference maps for SSP245 scenario in three different time slices.

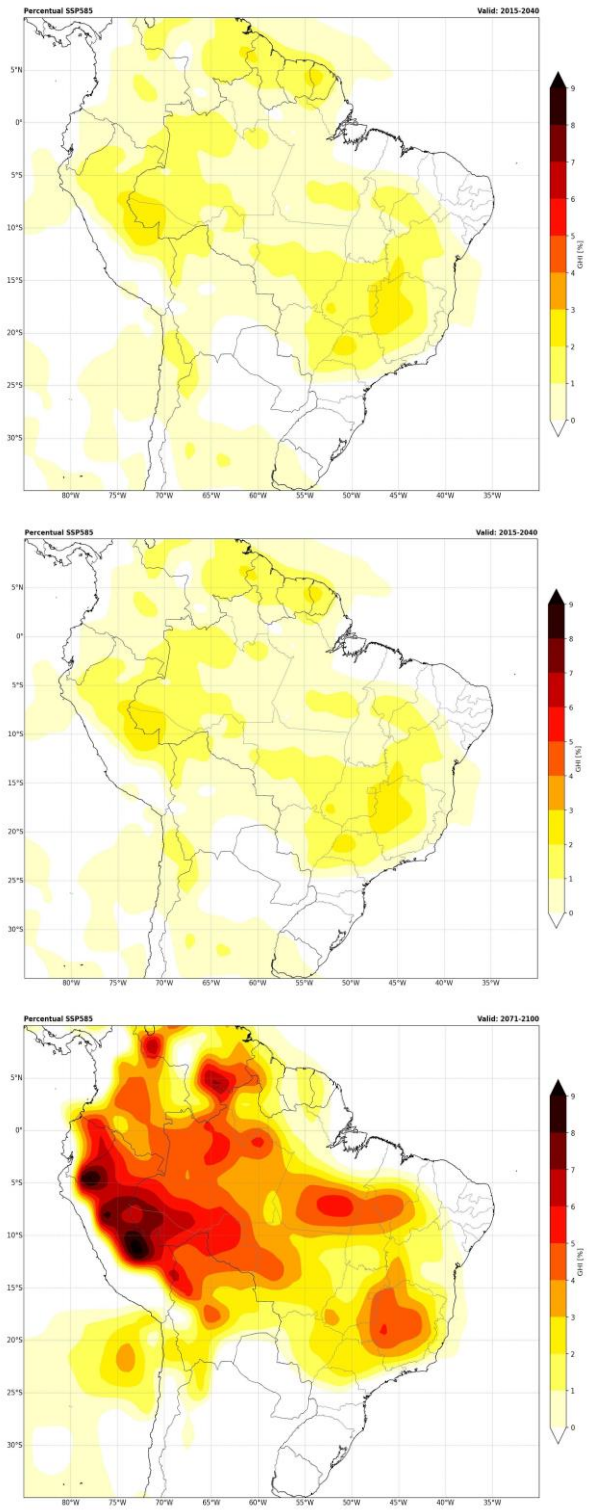


Figure 31: Global irradiation difference maps for SSP585 scenario in three Diferente time slices.

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

5.6.1 Introduction

In the fifth year of the project, despite the difficulties of conducting some steps of the sub-project that involve fieldwork, due to the Covid 19 pandemic, the efforts were to prioritize the proposed activities.

As previously highlighted in the years 1-4 report, the objective of the subcomponent "Natural Disasters, urban areas, infrastructure, and urban development" of the INCT-MC2 project - FAPESP is to analyze the vulnerability of Brazilian municipalities in relation to natural disasters associated with climate change, in order to propose a methodology for adaptation strategies to promote urban development and sustainability. Therefore, it is hoped to contribute to improving scientific knowledge on extreme events, disaster risk management, and vulnerability of cities as strategies for mitigation and adaptation to climate change.

The present report integrates and summarizes the research/contributions conducted during year 5 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 6 is presented, in order to achieve the general objective of the sub-component.

This section presents the main advances developed during the fifth year of activities, including interaction with another sub-project of the INCT-MC.

5.6.2– Collection of data to subsidize adaptation measures of the local level

– Economic losses related to disasters occurred from December 2021 to April 2022

During the last summer season, between December 2021 and April 2022, 817 occurrences of disaster (emergency situations or state of public calamity) related to Local Convective Storm caused by heavy rains and windstorm were reported to the Civil Defense (COBRADE 13214, 13215), in 626 municipalities in the states of Bahia (BA), Espírito Santo (ES), Minas Gerais (MG) and Rio de Janeiro (RJ). The spatial distribution of these municipalities is shown in Figure 32.

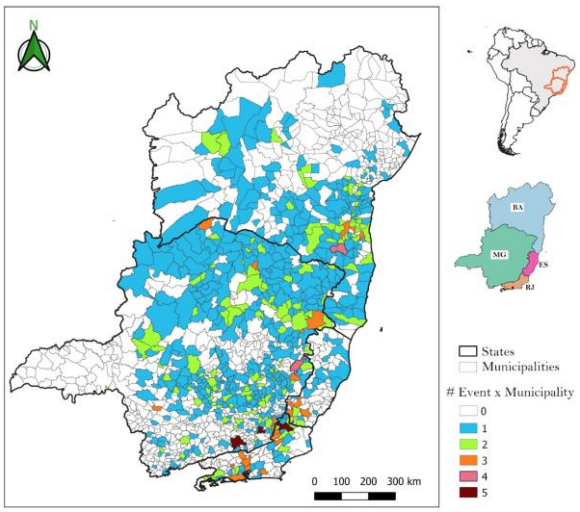


Figure 32 – States and its municipalities with occurrences of disasters related to Local Convective Storm caused by heavy rains and windstorms between December 2021 and April 2022.

According to the Report of Damages by the Integrated Disaster Information System, S2iD (BRASIL, 2022), the disasters analyzed resulted in total losses of approximately

R$12,832,571,014.77. Three municipalities in Minas Gerais accounted for 68% of these losses (Bom Despacho 32%; Monte Azul 25.3%; and Itabirito 11.1%). Two cities in Rio de Janeiro state accounted for 68% of the reported deaths (Petrópolis, 61% and Angra dos Reis, 7%). Three municipalities accounted for more than 50% of injuries (Petrópolis, RJ, 35%; Itabirito, MG, 10%; and Itabuna, BA, 7%). Table 8 presents a summary of the impacts, which include human and material damages and economic losses for the public and private sectors.

Table 8 – Summary of the impact of disasters caused by Local Convective Storm events, between December 2021 to April 2022, in the states of BA, ES, MG and RJ.

Variables	BA	ES	MG	RJ	Total
Events	215	37	498	67	817
Dead	18	1	20	97	136
Injured	411	1	208	391	1.011
Sick	2.698	10	2.129	830	5.667
Relocated	43.117	300	18.275	3.373	65.065
Evacuated	136.486	2.236	122.107	43.917	304.746
Other affected	938.684	55.486	1.489.635	1.776.578	4.260.383
Destroyed houses	4.151	11	1.348	454	5.964
Damaged houses	34.650	470	29.497	23.228	87.845
Destroyed hospitals	8	0	6	0	14
Damaged hospitals	133	3	204	119	459
Destroyed schools	64	0	1	0	65
Damayed schools	212	4	148	92	456
Destroyed service buildings	10	0	1	0	11
Damaged service buildings	25	0	64	11	100
Destroyed community use buildings	10	3	14	0	27
Damaged community use buildings	3.833	3	293	7	4.136
Destroyed Public Infrastructure	2.196	87	1.512	4	3.799
Damaged Public Infrastructure	96.672	235	10.416	431	107.754
Agriculture (R$)	R$ 723.653.013,73	R$ 4.851.808,55	R$ 4.476.522.109,72	R$ 24.571.880,00	R$ 5.229.598.812,00
Livestock (R$)	R$ 87.913.232,85	R$ 561.200,00	R$ 1.263.653.300,88	R$ 14.882.018,00	R$ 1.367.009.751,73
Industry (R$)	R$ 17.464.523,65	R$ 0,00	R$ 80.961.538,55	R$ 5.600.000,00	R$ 104.026.062,20
Electricity (R$)	R$ 1.520.350,00	R$ 0,00	R$ 14.592.000,00	R$ 6.575.000,00	R$ 22.687.350,00
Potable water (R$)	R$ 12.324.131,69	R$ 65.075,55	R$ 64.545.896,83	R$ 4.186.485,39	R$ 81.121.589,46
Urban and garbage cleaning system (R$)	R$ 32.420.445,69	R$ 145.560,00	R$ 73.150.481,94	R$ 20.342.737,22	R$ 126.059.224,85
Pest and vector control (R$)	R$ 2.366.700,00	R$ 0,00	R$ 10.347.417,96	R$ 703.434,80	R$ 13.417.552,76
Transport (R$)	R$ 30.193.404,63	R$ 1.425.000,00	R$ 3.268.273.696,75	R$ 19.583.718,36	R$ 3.319.475.819,74
Business(R$)	R$ 132.044.419,48	R$ 386.000,00	R$ 856.036.207,04	R$ 580.998.000,00	R$ 1.569.464.626,52
Teaching (R$)	R$ 6.469.335,46	R$ 517.500,00	R$ 50.246.964,68	R$ 5.828.384,04	R$ 63.062.184,18
Services (R$)	R$ 12.419.317,65	R$ 51.456,09	R$ 559.498.589,05	R$ 41.241.854,00	R$ 613.211.216,79
Public health, medical and emergency care (R$)	R$ 7.745.803,35	R$ 510.000,00	R$ 133.298.946,84	R$ 5.308.534,25	R$ 146.863.284,44
Telecommunications (R$)	R$ 244.000,00	R$ 0,00	R$ 2.982.765,00	R$ 1.731.000,00	R$ 4.957.765,00
Rainwater and sanitary sewage (R$)	R$ 36.226.495,94	R$ 464.780,35	R$ 80.533.623,74	R$ 15.026.368,13	R$ 132.251.268,16
Total	**R$ 1.114.325.230,03**	**R$ 9.292.470,98**	**R$ 10.961.234.088,59**	**R$ 747.719.225,17**	**R$ 12.832.571.014,77**

Source: S2iD (Brasil, 2022)

Table 9 shows the first 20 municipalities in the study area most affected in terms of deaths, injuries, damaged and destroyed homes and total losses.

Table 9 – Top 20 municipalities in the study area affected by Convective Storm between December 2021 and April 2022

	ST	Municipality	Dead	ST	Municipalitie	Injured	ST	Municipality	Damaged houses	ST	Municipality	Destroyed houses	ST	Municipality	Total losses
1	RJ	Petrópolis	83	RJ	Petrópolis	352	BA	Itabuna	18882	RJ	Petrópolis	400	MG	Bom Despacho	$ 4.111.741.011
2	RJ	Angra dos Reis	10	MG	Itabirito	100	RJ	Mesquita	13370	BA	Ibicaraí	300	MG	Monte Azul	$ 3.247.212.312
3	BA	Itabuna	6	BA	Itabuna	74	MG	Itabirito	6000	BA	Itabuna	284	MG	Itabirito	$ 1.421.000.000
4	BA	Amargosa	3	BA	Itapitanga	62	MG	Cataguases	4300	MG	Dores de Guanhães	280	RJ	Nova Iguaçu	$ 521.460.665
5	BA	Itamaraju	3	BA	Medeiros Neto	50	MG	Governador Valadares	4100	BA	Valença	200	BA	Dom Basílio	$ 452.765.247
6	MG	Betim	2	BA	Santa Inês	38	RJ	Itaperuna	4100	BA	Ibipeba	185	MG	Buritis	$ 225.630.000
7	MG	Caratinga	2	BA	Floresta Azul	30	MG	Congonhas	3000	BA	Prado	169	RJ	Petrópolis	$ 169.545.880
8	MG	Dores de Guanhães	2	MG	João Pinheiro	30	RJ	Santo Antônio de Pádua	2000	BA	Nova Itarana	150	MG	Formoso	$ 152.984.420
9	MG	Jeceaba	2	BA	Ilhéus	25	BA	Gandu	1689	BA	Santa Inês	141	MG	Rio Acima	$ 116.187.868
10	MG	Mesquita	2	RJ	Itaperuna	23	BA	Itapetinga	1610	BA	Itororó	113	MG	Matias Cardoso	$ 86.107.594
11	MG	Perdigão	2	BA	Teolândia	20	BA	Itajuípe	1425	BA	Wenceslau Guimarães	90	MG	Rio Pardo de Minas	$ 79.018.000
12	RJ	Italva	2	BA	Ubaitaba	20	RJ	Nova Iguaçu	1404	BA	Itambé	80	BA	Dário Meira	$ 70.885.000
13	BA	Aurelino Leal	1	MG	Esmeraldas	20	BA	Uruçuca	1219	BA	Wanderley	75	MG	Itaúna	$ 69.961.200
14	BA	Barra	1	BA	Prado	15	BA	Itamaraju	1207	MG	Congonhas	70	MG	Rio Piracicaba	$ 67.534.350
15	BA	Itapetinga	1	BA	Wenceslau Guimarães	15	MG	Muriaé	1100	BA	Laje	64	MG	Janaúba	$ 62.989.890
16	BA	Macarani	1	MG	Sabará	15	BA	Itapé	1010	BA	Porto Seguro	62	MG	Campo Azul	$ 61.267.700
17	BA	Prado	1	BA	Vereda	12	BA	Itororó	910	BA	Milagres	60	BA	Valença	$ 58.400.000
18	BA	Ubaitaba	1	BA	Aurelino Leal	10	BA	Prado	839	BA	Poções	58	MG	Indaiabira	$ 54.392.576
19	MG	Araújos	1	BA	Iramaia	10	RJ	Petrópolis	758	BA	Vereda	58	BA	Juazeiro	$ 54.111.975
20	MG	Campo Azul	1	BA	Porto Seguro	8	BA	Ibicaraí	700	BA	Amargosa	55	MG	Espinosa	$ 51.135.190

Source: S2iD (Brasil, 2022)

Although the state of ES had no significant impacts compared to other states, it was observed that 30% of the municipalities in this state reported occurrences by Local Convective Storm. among which the municipalities of Bom Jesus do Norte stand out in the top 20 by frequency of occurrences (Table 10), with four registered events and Muniz Freire also with three. This last municipality also stands out for having a significant number of people affected (1560) in relation to its population density (27.15 inhab/km²). It is interesting to observe that Itapetinga

and Bom Jesus do Norte, with high HDI, did not register affected people and are not in the Top 20 in the context of other variables analyzed.

Table 10 – Top 20 municipalities in the study area by storm frequency, with their corresponding cumulative number of affected people, inhab/km² and HDI.

MUNCOD	ST	MUNICIPALITY	#EVENTS	OTHER AFFECTED	DEMOGRAPHIC DENSITY	HDI
3136702	MG	Juiz de Fora	5	59.777	359,59	0,541
3302205	RJ	Itaperuna	5	9.460	86,71	0,654
3115300	MG	Cataguases	4	8.749	141,85	0,613
3118403	MG	Conselheiro Pena	4	2.300	14,99	0,761
2916401	BA	Itapetinga	4	0	41,95	0,73
3201100	ES	Bom Jesus do Norte	4	0	106,37	0,732
3303906	RJ	Petrópolis	3	330.000	371,85	0,656
2914802	BA	Itabuna	3	45.870	473,5	0,693
3303005	RJ	Miracema	3	25.382	88,15	0,665
3151909	MG	Pocrane	3	12.731	13	0,779
3166956	MG	Serranópolis de Minas	3	10.344	8,02	0,677
3302502	RJ	Magé	3	10.000	585,13	0,538
3112802	MG	Capitólio	3	8.000	15,68	0,639
3302106	RJ	Itaocara	3	8.000	53,09	0,629
3301801	RJ	Engenheiro Paulo de Frontin	3	6.279	99,57	0,655
3304706	RJ	Santo Antônio de Pádua	3	6.000	67,27	0,7
2908002	BA	Coaraci	3	5.842	74,17	0,709
3304557	RJ	Rio de Janeiro	3	2.976	5265,82	0,605
2912301	BA	Ibicuí	3	2.168	13,41	0,591
3203700	ES	Muniz Freire	3	1.560	27,08	0,617

HUMAN DEVELOPMENT INDEX (HDI)	VERY HIGH	HIGH	MEDIUM	LOW	VERY LOW
	0.8 - 1	0.7 - 0.799	0.6 - 0.699	0.5 - 0.599	0 - 0.499

Source: S2iD (Brasil, 2022); HDI (PNUD, 2022)

5.6.3 Analysis of extreme precipitation and streamflow

– Hydrological Droughts

We investigate hydrological drought patterns affecting priority basins for hydropower generation, distributed in all regions of the country (see details in Cuartas et al., 2022). For this, the time series of the Standardized Precipitation Index (SPI), the Standardized Precipitation Evapotranspiration Index (SPEI), and the Standardized StreamFlow Index (SSFI) were used. The SPI was calculated from the Climate Hazards Group Infrared Precipitation with Stations (CHIRPS), the SPEI dataset was obtained from the Global Drought Monitor available on (https://spei.csic.es/map/maps.html#months=7#month=4#year=2021) and the SSFI was calculated from discharge data, obtained from the National Water and Sanitation Agency (ANA) and from National Electrical System Operator (ONS).

In general, the frequency analysis by decades showed that the last decade (2010–2021) recorded the highest recurrence of severe droughts (indices values ≤ −1.3) since 1981 (Figure 33) for all of the time scales (12, 24, 36, and 48 months). SPEI and SSFI detected higher frequencies of severe drought events than SPI.

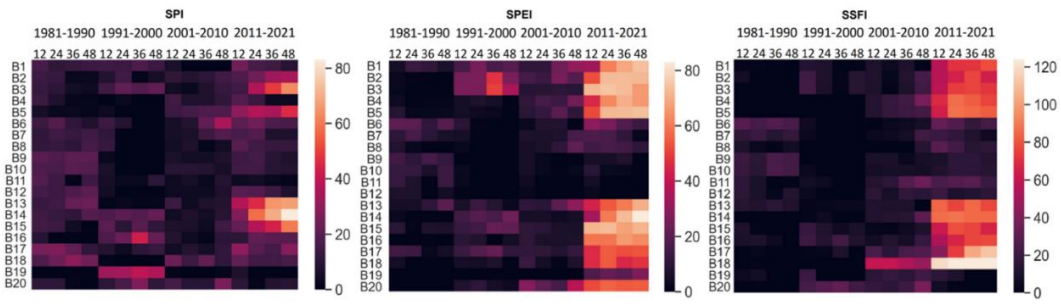


Figure 33 – Frequency of severe droughts (indices values ≤ −1.3) by decades in the studied basins.

Particularly in the last decade (2010–2021), droughts also occurred concomitantly in several regions of the country, with noticeable impacts in different socio-economic sectors, which are currently still being experienced. In most of the basins, the Mann–Kendall trend test showed a downward trend in the SPI, SPEI, and SSFI time series from 1981 to 2021 (Table 11), indicating an increased frequency of drought events (see Cuartas et al., 2022). This situation highlights that the basins can be considered with critical situations regarding water availability and, therefore, the urgent need to establish a preparation plan to mitigate the effects of drought in these regions.

Table 11 – Tau statistic values from Mann-Kendall (MK) test.

Indices	SPI-12		SPI-24		SPI-36		SPEI-12		SPEI-24		SPEI-36		SSFI-12		SSFI-24		SSFI-36	
Basins	MK	Sen's	MK	Sen's	MK	Sen's	MK	Sen's	MK	Sen's	MK	Sen's	MK	Sen's	MK	Sen's	MK	Sen's
B1	0.00	0.0000	0.04	0.0005	0.07	0.0009	-0.21	-0.0023	-0.25	-0.0028	-0.28	-0.0030	-0.35	-0.0040	-0.38	-0.0046	-0.39	-0.0052
B2	-0.13	-0.0014	-0.14	-0.0015	-0.17	-0.0021	-0.30	-0.0030	-0.39	-0.0040	-0.41	-0.0039	-0.32	-0.0037	-0.34	-0.0044	-0.34	-0.0049
B3	-0.17	-0.0020	-0.22	-0.0024	-0.24	-0.0031	-0.36	-0.0035	-0.42	-0.0050	-0.43	-0.0050	-0.33	-0.0038	-0.36	-0.0042	-0.35	-0.0048
B4	-0.12	-0.0013	-0.12	-0.0012	-0.08	-0.0009	-0.24	-0.0028	-0.30	-0.0046	-0.30	-0.0055	-0.43	-0.0051	-0.45	-0.0061	-0.45	-0.0072
B5	-0.19	-0.0020	-0.23	-0.0024	-0.24	-0.0027	-0.26	-0.0030	-0.29	-0.0039	-0.29	-0.0045	-0.41	-0.0047	-0.43	-0.0056	-0.43	-0.0066
B6	-0.12	-0.0014	-0.13	-0.0018	-0.11	-0.0016	-0.02	-0.0003	-0.09	-0.0013	-0.05	-0.0008	-0.13	-0.0016	-0.19	-0.0025	-0.20	-0.0027
B7	0.00	0.0000	0.04	0.0005	0.11	0.0015	-0.03	-0.0004	-0.04	-0.0006	-0.01	-0.0001	-0.04	-0.0005	-0.05	-0.0007	-0.02	-0.0002
B8	-0.04	-0.0005	0.01	0.0001	0.07	0.0008	-0.23	-0.0019	-0.22	-0.0020	-0.23	-0.0018	-0.18	-0.0018	-0.16	-0.0016	-0.13	-0.0014
B9	0.02	0.0003	0.04	0.0005	0.07	0.0010	0.03	0.0003	0.03	0.0004	0.06	0.0007	-0.03	-0.0004	-0.04	-0.0005	-0.02	-0.0003
B10	-0.05	-0.0005	-0.05	-0.0005	-0.04	-0.0005	0.05	0.0006	0.05	0.0006	0.07	0.0008	-0.03	-0.0004	-0.03	-0.0004	-0.02	-0.0003
B11	0.12	0.0015	0.18	0.0022	0.24	0.0038	0.08	0.0010	0.10	0.0011	0.15	0.0017	-0.09	-0.0012	-0.16	-0.0022	-0.16	-0.0024
B12	0.05	0.0006	0.08	0.0010	0.13	0.0020	0.07	0.0008	0.12	0.0013	0.14	0.0016	-0.01	-0.0002	-0.06	-0.0007	-0.04	-0.0005
B13	-0.14	-0.0017	-0.19	-0.0026	-0.24	-0.0031	-0.16	-0.0020	-0.23	-0.0031	-0.23	-0.0035	-0.32	-0.0047	-0.34	-0.0057	-0.34	-0.0061
B14	-0.14	-0.0016	-0.21	-0.0028	-0.26	-0.0042	-0.25	-0.0020	-0.39	-0.0027	-0.47	-0.0030	-0.48	-0.0065	-0.51	-0.0079	-0.54	-0.0085
B15	-0.19	-0.0022	-0.27	-0.0030	-0.29	-0.0042	-0.37	-0.0040	-0.43	-0.0053	-0.45	-0.0063	-0.40	-0.0051	-0.48	-0.0066	-0.50	-0.0076
B16	-0.03	-0.0003	-0.03	-0.0003	-0.08	-0.0010	-0.51	-0.0043	-0.65	-0.0054	-0.70	-0.0061	-0.29	-0.0037	-0.40	-0.0053	-0.48	-0.0073
B17	-0.02	-0.0002	-0.04	-0.0004	-0.07	-0.0008	-0.23	-0.0029	-0.21	-0.0026	-0.24	-0.0035	-0.25	-0.0029	-0.35	-0.0044	-0.38	-0.0058
B18	-0.06	-0.0007	-0.05	-0.0007	-0.07	-0.0009	-0.35	-0.0040	-0.43	-0.0048	-0.50	-0.0052	-0.34	-0.0053	-0.32	-0.0055	-0.32	-0.0060
B19	0.02	0.0003	0.07	0.0009	0.11	0.0015	-0.45	-0.0033	-0.54	-0.0038	-0.61	-0.0042	-0.16	-0.0021	-0.18	-0.0022	-0.18	-0.0022
B20	0.03	0.0004	0.04	0.0006	0.12	0.0023	-0.48	-0.0042	-0.51	-0.0046	-0.50	-0.0049	0.01	0.0001	0.08	0.0008	0.12	0.0015

The results suggest that droughts are more intense and frequent due to the compound effect of decreased precipitation and increased temperature, probably linked to the global warming scenario. According to the IPCC, the decreased precipitation and increased surface temperature result in increased evapotranspiration and decreased soil moisture, leading to negative feedback processes that exacerbate drought events.

Although Brazil has increased its hydropower capacity after the 2001 energy crisis, from 75,570 MW in January 2006 to 108,739 MW in November 2021, the intense and severe drought events in the past decade have substantially impacted the hydroelectricity generation in all of the Brazilian regions, except for the northern region.

In a second performed study (submitted to Water under Nº water-1756905), trends in streamflow, rainfall and potential evapotranspiration (PET) time series, from 1970 to 2017, were assessed for five relevant hydrological basins in Southeastern Brazil. The concept of elasticity was also used to assess the streamflow sensitivity to changes in climate variables for the annual dataset. Elasticity is a lumped representation of the hydrological effects of a multitude of processes affecting the response of streamflow to variations in climate variables (Zhang, Viglione & Blöschl, 2022). Elasticity estimators provide a measure of the streamflow resilience to changes in meteorological variables, such as rainfall and potential evapotranspiration, being particularly useful as initial estimates of climate change (Chiew et al., 2014; Kim; Hong & Lee, 2013). Elasticity can also be understood as the percent change of streamflow resulting from a 1% change in precipitation or other climate variables.

Significant negative trends in streamflow and rainfall, as well as significant increasing trends in PET were detected. Elasticity revealed that 1% decrease in rainfall resulted in 1.21% - 2.19% decrease in streamflow, while 1% increase in PET induced different reductions in streamflow,

ranging from 2.45% to 9.67% (Figure 34). Both PET and rainfall computed to calculate the elasticity showed positive results for some basins.

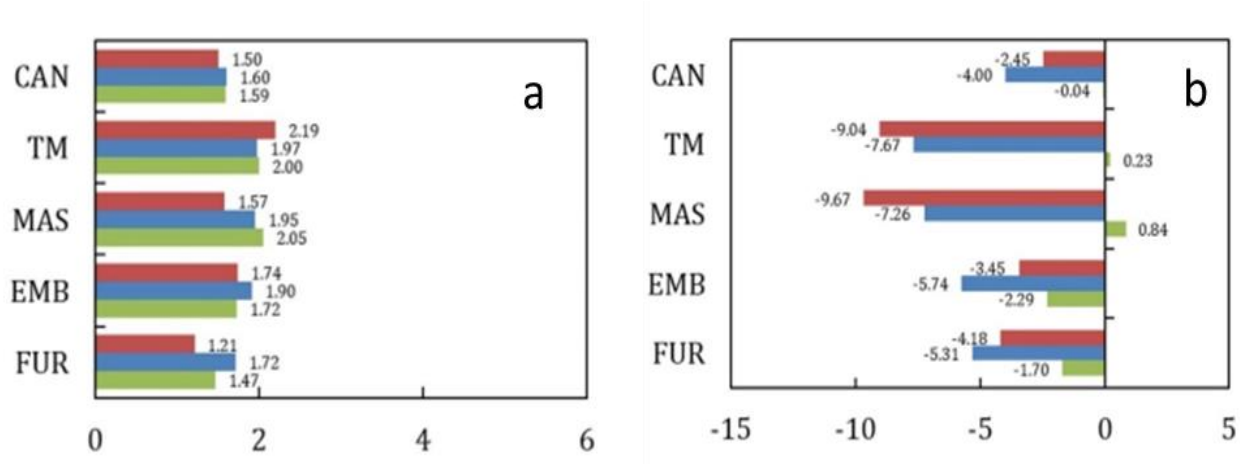


Figure 34 – Rainfall and potential evapotranspiration elasticity of the streamflow calculated using the non-parametric method (red bars), simple linear regression (blue bars) and multiple linear regression (green bars). FUR: Furnas, EMB: Emborcação, MAS: Mascarenhas, TM: Três Marias and CAN: Cantareira.

The Três Marias and Mascarenhas basins yielded the highest elasticity values, as well as the lowest runoff and aridity indexes, which corroborates the concept of more sensitive streamflow in less rainy basins. The Cantareira System did not yield high elasticity values, although its rainfall and potential evapotranspiration anomalies were significant over the years (the largest in this study), which led the streamflow production to reach critical levels, corroborating the severe water crisis in the years 2014 to 2016. Considering the economic importance of SEB to the Gross Domestic Product of the country and for the water supply of the Metropolitan Region of São Paulo City, the Cantareira System is here highlighted, due to its greatest streamflow changes.

The results showed that PET has a considerably larger influence on streamflow anomalies than rainfall. PET is well fitted by a quadratic in temperature with increases in PET following closely increases in temperature. The PET influence is associated with secular changes in the Southern Hemisphere circulation due to climate change. So it would seem that the PET contribution to SEB streamflow could also be a secular change due to climate change. Although droughts are not new in Brazil, the drought events in Southeastern Brazil are singular, not only for the immediate effects, but also for the associated long-term impacts. These new climate conditions have forced decision-makers to rethink public policies and management plans.

– Drought events and extreme heat

In the context of the intensification of drought impacts due to extreme heat, we also evaluated the occurrence of compound drought-heat events in Central South America (see details in Marengo et al., 2021). For this compound analysis, daily maximum temperature and precipitation data from Climate Prediction Center (CPC) of NOAA, were used to estimate the heatwave (Warm Spell Duration Index - WSDI) and SPI. Drought-heat compound events were identified in September-November 2020 over Central South America, mainly over the Pantanal wetland. In these regions, the SPI (Figure 35) shows exceptional drought conditions in areas where the WSDI reached the 95th or 99th percentile for a window of 7 days or more (Figure 35b,c). Figure 35 shows the regions where the WDSI and SPI conditions required to define a compound drought-heat are displayed.

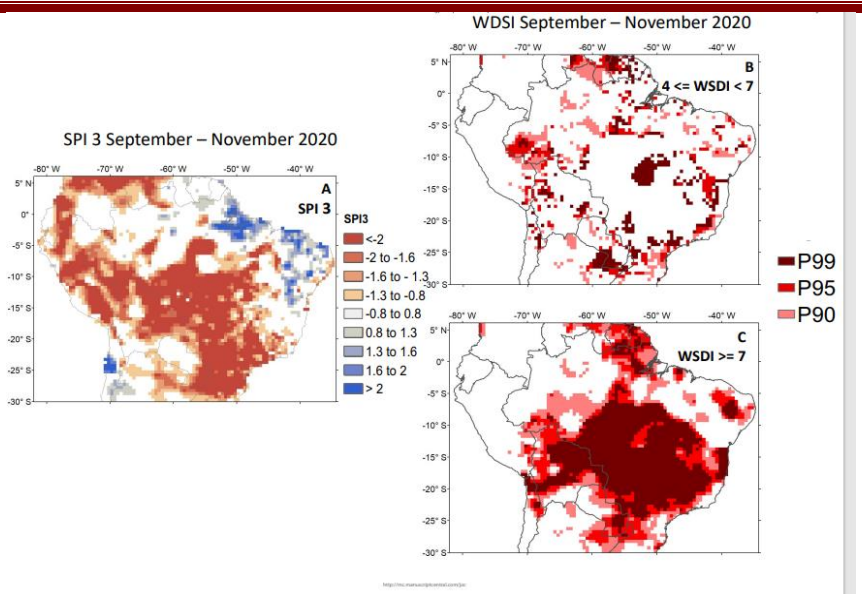


Figure 35 – SPI3 through November 2020 capturing drought in the study area (red colors) and Warm Spell Duration Index (WDSI) for the 90 -99 th percentiles for B) 4 -7 days, and C) for > 7 days, from September to November 2020. Source: Marengo et al., 2021.

For September-October 2020, Figure 36 shows regions where the WDSI and the conditions for exceptional drought SPI 3 < -2.0. The area affected by the drought-heat compound was identified over central-western Brazil, northern and eastern Bolivia, northern Argentina, and Paraguay, which cover the Pantanal wetland. This compound event was associated with specific hazards, such as high fire risk (Marengo et al., 2021).

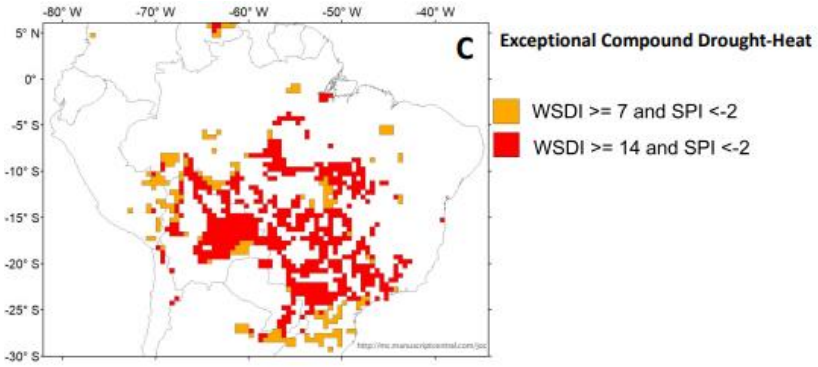


Figure 36 – Spatial map showing the exceptional event of the compound drought-heat events from September to November 2020. (Exceptional event: WDSI > 7 days and SPI3 < -2). Source: Marengo et al., 2021.

5.6.4 Assessment of historical disaster databases related to the Itajaí and Northeast Regions: DesInventar System and S2ID

In the INCT-MC2 progress report for the year 4 of the project (2021), the results of the assessment of the economic costs of flash floods in the Itajaí River Municipalities were presented. Hydrological events, and especially flash floods, were responsible for the greater material, economic and social losses in the region, between 2010 and 2016. In the last year, an assessment of socioeconomic and environmental impacts of the flash floods in those municipalities was conducted.

– Analysis of hydrological, flash floods and other disasters in terms of human and environmental damage, from 2010 to 2016, in Itajaí basin municipalities.

The study area was selected based on the results of Aguilar-Muñoz (2014), who identified 24 municipalities potentially exposed to flash floods in the Itajaí river basin. This basin covers an area of around 15.000km² (Figure 37), is part of the South Atlantic hydrographic region, whose rivers are born east of Serra Geral and have their mouths in the Atlantic Ocean. The largest channel is the Itajaí Açú River, formed by the confluence of the Itajaí do Oeste and Itajaí do Sul rivers. On its way from the municipality of Rio do Sul to its mouth, in the city of Itajaí, it encounters the rivers Itajaí do Norte (also known as Hercílio), Benedito, Luís Alves and Itajaí Mirim. The last section of the channel, from the meeting of the Itajaí Açú and Itajaí Mirim rivers to the mouth is called Itajaí.

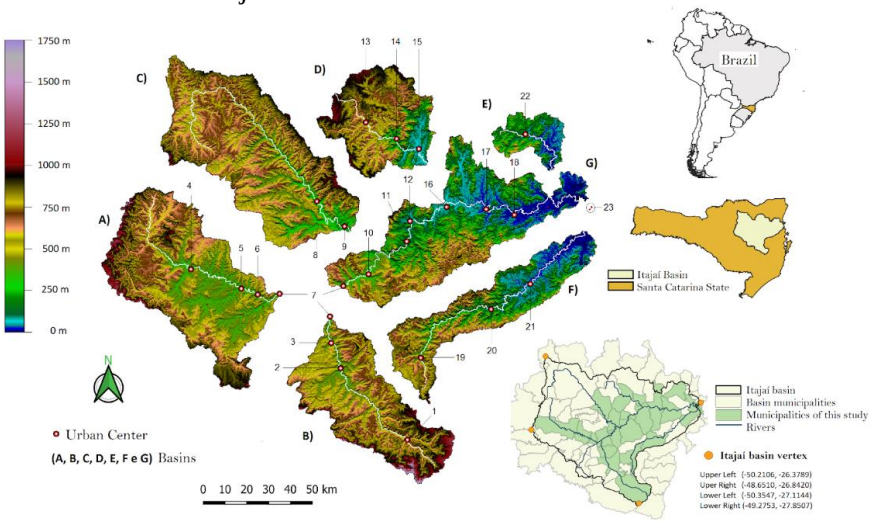


Figure 37 – Study area. The numbers in the elevation model indicate the approximate location of the urban centers of the 23 municipalities: 1. Alfredo Wagner; 2. Ituporanga; 3. Aurora; 4. Taió; 5. Rio do Oeste; 6. Laurentino; 7. Rio do Sul; 8. José Boiteux; 9. Ibirama; 10. Lontras; 11. Apiuna; 12. Ascurra; 13. Doutor Pedrinho; 14. Benedito Novo; 15. Timbó; 16. Indaial; 17. Blumenau; 18. Gaspar; 19. Vidal Ramos; 20. Botuvera; 21. Brusque; 22. Luís Alves; 23. Itajaí/Navegantes. The letters indicate the sub-basins of the Itajaí basin: A) Itajaí do Sul; B) Itajaí do Oeste; C) Itajaí do Norte; D) Benedito; E) Luís Alves; F) Itajaí Mirim; e G) Itajaí-Açú. Source: Adapted from Aguilar-Muñoz (2014).

Concerning to **Human Damages**, floods in Brazil caused the highest number of deaths compared to other events (58% - see Table 12) in the analyzed period. The same trend (37%) can be observed in the analyzed municipalities of the Itajaí basin (Figure 38). On the other hand, the percentage of people affected by flash floods was much lower (14%) for the country, but still high for the municipalities in this study (24%).

Table 12 – Comparison between the impacts of disasters in Brazil from the EMDAT and S2iD databases, period 2010-2016: total events and detail for hydrological events.

		EM-DAT	S2iD
Records	Total	61	19.735
	Hydrological	29	4.826
	Flash Floods	3	2.815
Deaths	Total	2.493	1.908
	Hydrological	1.563	1.291
	Flash Floods	60	1.098
Affected people	Total	34.840.264	78.968.669
	Hydrological	2.811.311	20.855.567
	Flash Floods	50.600	11.113.694
Losses	Total	$ 10.420.613.860	$ 30.372.581.977
	Hydrological	$ 3.299.022.390	$ 9.725.403.070
	Flash Floods	$ 106.218.370	$ 5.928.325.059

Source: S2iD data from UFSC-CEPED 2021

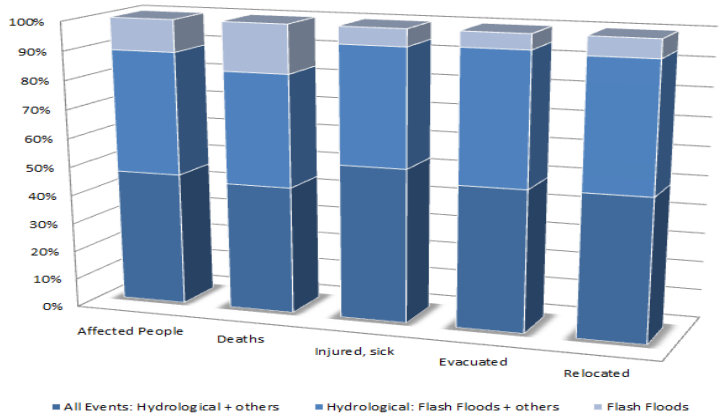


Figure 38 – Proportion of human damage by type of events in the municipalities of the study area.

The year 2011 was the worst of the analyzed period, with the highest proportion of human damage (categories analyzed: affected, dead, injured, evacuated and relocated) in all municipalities in the study area, caused by flash floods. In Figure 39, the number of people affected (82,598 inhabitants) and evacuees (11,302 people) stands out in relation to the other categories.

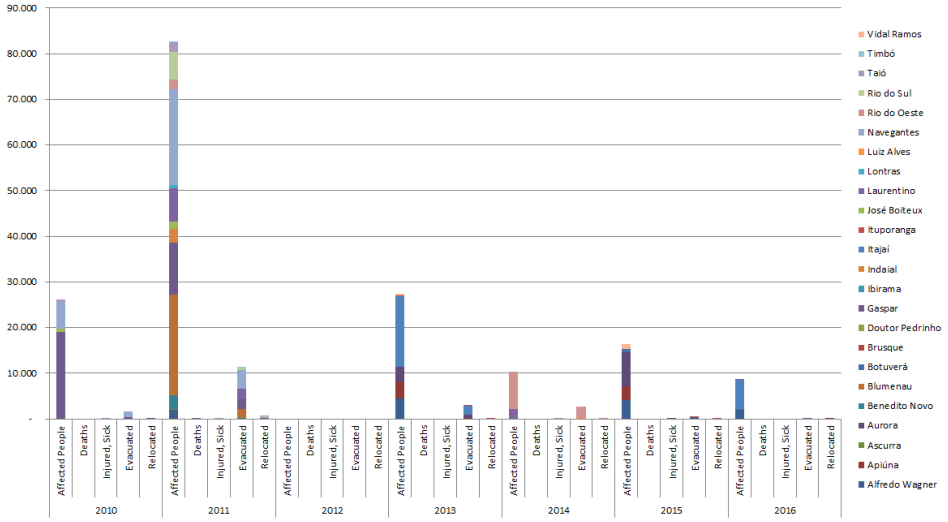


Figure 39 – Annual cumulative human damage by municipality.

Figure 40 shows that the municipality with the most people affected by disasters in the period was Blumenau (total hydrological events: 355,036). The second most affected in the period was Itajaí (total of events: 48,860; hydrological: 48,255), followed by Gaspar (total of events: 45,806; hydrological: 30,462).

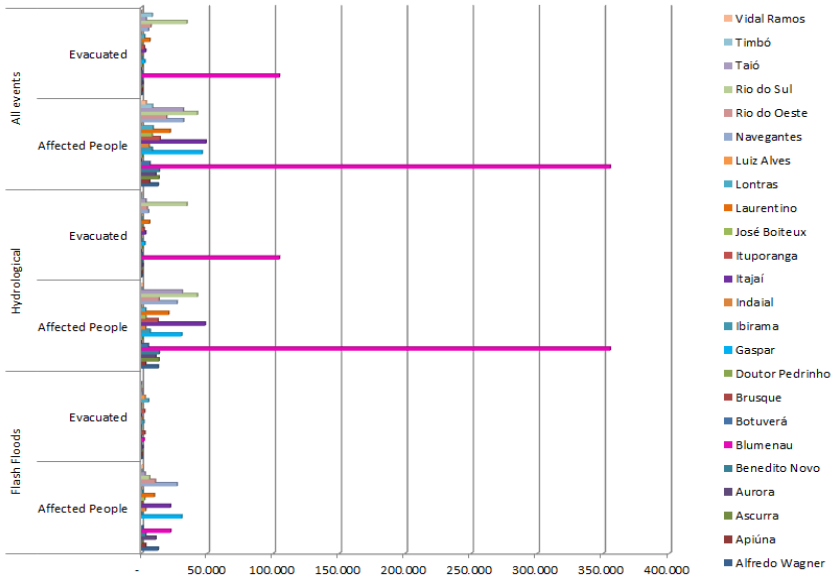


Figure 40 – Total number of people affected and evacuated by municipality and by event type.

It can be seen in Figure 41 that the municipality with the most people affected by flash floods was Gaspar, with 30,462 people affected, followed by Navegantes (26,811: 20,891 in 2011 and 5,920 in 2010) and Blumenau (22,036 this only for 2011 event). Almost all of those affected in Itajaí were due to hydrological events, 21,931 of which were due to flash floods.

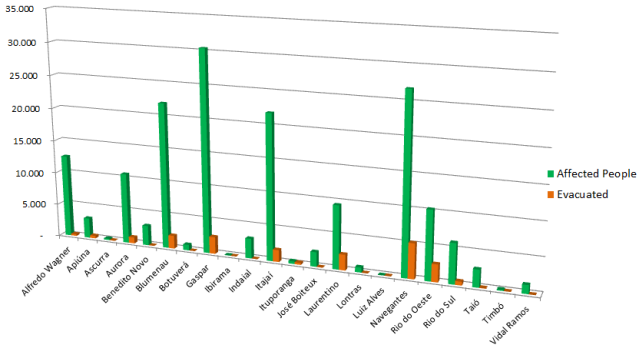


Figure 41 –Total affected and evacuated by flash floods and by municipality.

From disaggregated information on the affected population, it is possible to identify patterns of behavior that can serve to develop prevention and adaptation campaigns, as observed by Terti et al. (2017). “studies on aggregated flood disaster death data provide a first indication of vulnerability factors—namely age, gender and activity—which are important for analyzing the causes of flood fatalities” (Jonkman and Kelman, 2005). Nevertheless, from S2iD data is not possible to know details about gender, age or mental or physical health conditions of affected, dead, injured, evacuated or homeless people; this type of information is useful for, for example, inferring the degree of vulnerability and/or exposure of these people: adult men tend to be more frequently exposed to risky situations, for example, crossing flooded streets (Knocke, 2007).

-Environmental impacts

Concerning to Environmental Impacts, environmental sector damages have been severely simplified from AVADAN to FIDES; in AVADAN there were two categories of impact, (i) damage intensity (values from one to four) and (ii) estimated value. The data refer to natural resources in subcategories (i) water (sanitary sewage, industrial effluents, chemical residues, others), (ii) soil (erosion, landslide, contamination and others), (iii) air (toxic gasses, suspended particles, radioactivity and others) and (iv) flora and fauna (deforestation, burning, predatory hunting, others). In FIDES, only the presence or absence of the type of damage is recorded (water, air, soil and water resources) and it is only possible to select the percentage of the population affected by the municipality (0% to 5%, 5% to 10%, 10% to 20% and above 20%) and the percentage of fires in parks, environmental preservation areas (APA) and permanent preservation areas (APP) (up to 40% or above 40%).

Additionally, analyzes were performed considering each data period: AVADAN 2010 and 2011; FIDES 2012 to 2016.

AVADANS. Of the 31 registered occurrences (Table 6), 60% correspond to flash floods in Gaspar, especially in 2010. Although the main event is flash floods, in the formats it is stated that the damage was also related to other events, for example, landslides, soil erosion and deep fluvial and pluvial erosion. This is because several events usually occur in sequence.

Table 12 – Environmental damages reported at AVADAN.

Environmental Damage AVADAN	Records			Values		
	2010	2011	Total	2010	2011	Total
All events	5	26	31	4.482,48	4.827,75	9.310,234
Hydrological	5	23	28	4.482,48	4.598,39	9.080,88
Flash floods	5	18	23	4.482,48	3.215,01	7.697,50

FIDES. In the FIDES period, "water contamination" was the most reported variable, showing the highest percentages of the affected population (Figure 11). Vidal Ramos municipality stands out where the 2013 and 2015 flash floods affected more than 20% of the population, highlighting that "Due to the heavy rains, there was an increase in the volume of water courses, causing barriers, landslides, and all the organic matter coming from the crops, went to streams and rivers, peaks of turbidity levels above 400 ppm occurred, causing great difficulty in the treatment of water distributed in the city" (SC-F-4219200-12200-20150918).
According to the Vidal Ramos Municipality' FIDES report, soil damage is usually a consequence of landslides and garbage transported by water. As an example, he highlights the 2016 flood in Apiúna: "In the downtown district, due to the very large volume of water, we had some homes with a lot of garbage deposited inside or on the land. Also, in the locality of the left bank, we had houses invaded by the waters, bringing a lot of dirt and contaminating the soil in these places." (SC-F-4201257-12200-20161231).

The proportion of environmental effects caused by flash floods reported in FIDES is small and is limited to soil and water, as seen in Figure 42.

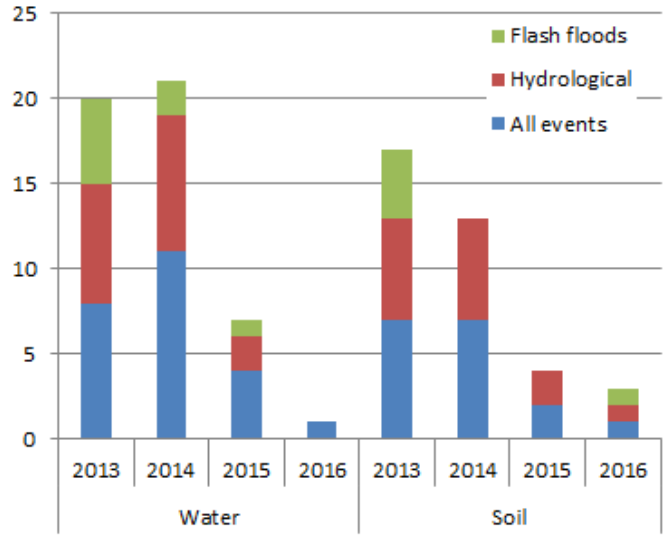


Figure 42 – Environmental damage recorded in FIDES, by year and type of event

From the information recorded in the FIDES forms, it is not possible to make in-depth estimates of the environmental cost of disasters, although this sector is increasingly present in international guidelines on risk management. In the most recent Global Assessment Report (GAR), for example, it is mentioned that there are "pitfalls in economic and governance systems [...]The first pitfall is the tendency to exclude key values, such as the value of human life and biodiversity […]" (UNDRR, 2022, p. 5).

-Assessment of socioeconomic drought impacts in the semi-arid region from 2002 to 2020.

In this project step, drought-related disaster data concerning the municipalities located in the states of Ceará and Pernambuco from 2002 to 2020 will be organized and used to assess the socioeconomic impacts of droughts.

Historically, the northeast region is marked by droughts that can be understood as a climatic extreme caused by the precipitation deficit, which results in low water availability for different human activities. The effects of drought build up over a long period and continue for several years after the event ends. Therefore, drought can cause serious impact on the agricultural, environmental, social and health sectors (Van Loon, 2015).

Various methods and indicators have been developed to identify drought events. Among the indicators, the Standardized Precipitation Index (SPI) developed by Mckee et al. (1993) is one of the most commonly used for drought monitoring.

The present study (in progress) aims to qualitatively and quantitatively evaluate drought events in the state of Ceará, identifying the beginning and end, duration, intensity and severity as well as investigating social and environmental data in order to find patterns of associated impacts. For the analysis of droughts, data on rainfall, streamflow and storage level in reservoirs will be used. Aiming to investigate the correlation of the associated impacts, data on waterborne diseases, sanitation, agriculture and tourism will be analyzed as shown in Figure 43. Among the expected results are identifying drought events and the association of possible impacts on sanitation, social and health. The results will be disseminated in technical-scientific events.

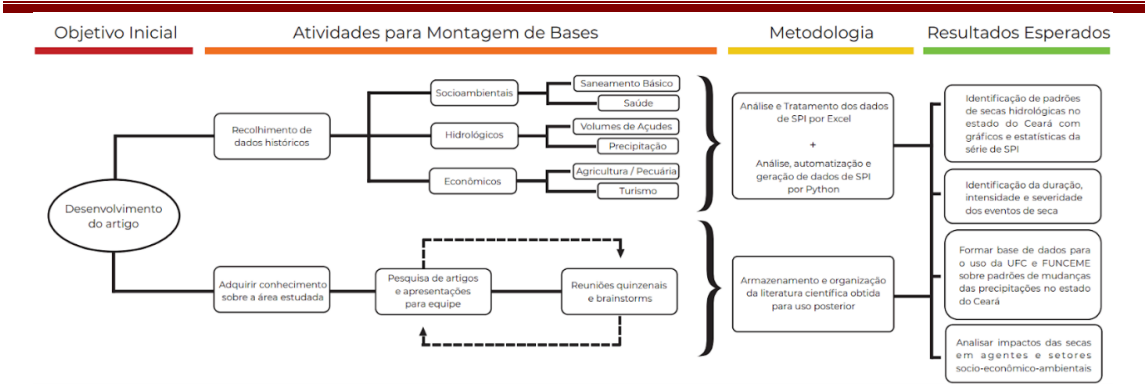


Figure 43. Flow chart of steps to be carried out in this study as well as the expected results.

– "Drought Risk" in municipalities previously defined as priorities due to the recurrence of drought events

Drought risk is composed of variables representing vulnerability, adaptive capacity, and drought hazard conditions. In this project phase, the drought risk was formulated and focused on smallholder agriculture. For this, information from the Brazilian Agricultural Census of 2017 was used. The socioeconomic variables representing vulnerability (V) and adaptive capacity (AC) were organized on a municipal scale and included the income of the rural establishment, the proportion of establishments that are part of cooperatives and associations, and the financial dependence on their agricultural production. The drought hazard (H), in turn, is composed of precipitation data, the vegetation health index, and soil moisture. Then, the risk (R) is given by $R = [(V+AC) \times X) + (H \times (1-X)]$, where X represents the weight of each component.

Figure 44 shows the drought risk considering the planting occurred in January, March, July, and August 2021. In general, the highest number of municipalities with moderate, high, and very high risk occurred from June to October of 2021. Figure 44b shows the drought risk for February, which is the critical period for planting in January; it is observed that 17 municipalities are classified with moderate risk. Figure 44c shows the end of the cycle that started in January 2021, pointing out 13 municipalities with moderate risk and 87 with low risk. Figures 44c, f, i, and l, show the end of the cycle of the generic culture (up to 90 days) for the study area. The municipalities categorized with moderate to very high risks are those with greater chances of a possible impact on family farming.

It is noteworthy that the municipalities whose planting was carried out in July ended the cycle with 7 municipalities classified as very high risk, 50 as high risk, and 14 as moderate risk (Figure 44l). The municipalities whose planting was carried out in July ended the cycle with 7 municipalities classified as very high risk, 50 as high risk, and 14 as moderate risk (Figure 13-l). As for the municipalities with possible planting in August, the cycle ended with 44 municipalities with very high risk, 13 high, and 13 moderate. Finally, it is worth mentioning that the methodology is still under construction and development and that this is a provisional result. In addition, it is important to highlight that drought risk mapping is essential to support drought impact mitigation actions and drought preparedness plans. From the drought risk mapping, it is possible to prioritize actions for the municipalities most affected by the drought.

Figure 44 - Case study: Drought risk considering planting in January, March, July, and August 2021.

– Disaster vulnerability analysis of small towns in Brazil

Considering that most of the global urban population lives in cities with less than one million inhabitants and that in Brazil it is estimated that more than 45% of the population lives in cities with up to 100,000 people, many of them prone to disaster risks, a study was conducted to assess the vulnerability and capacities of small Brazilian municipalities to reduce risks, especially those related to landslides and floods (Ribeiro et al., 2021). To this end, 234 municipalities located in the South and Southeast regions of the country (113 and 121 cities, respectively) were classified into two population classes, that is, municipalities with 20,000 to 50,000 inhabitants (Class A4) and those with 50,000 to 100,000 inhabitants (Class A4). A5). Such municipalities are characterized by high levels of municipal human development and the availability of municipal master plans. Statistical analysis of a set of 30 quantitative indicators and 40 qualitative indicators revealed that the vulnerability of populations and municipal capacities are mainly related to economic sectors, public policies and the size of cities, that is, vulnerability and coping capacity were associated the economic activities carried out in the municipalities, which were mainly characterized by: cities dependent on the agricultural sector; dependent on external resources; those characterized as labor reserves; and industrial cities.

Considering cities separately by population size, Figure 45 shows that Class A municipalities have greater vulnerability associated with populations with lower educational and income levels, whose municipalities have economies based mainly on the agricultural sector and that lack basic health services and transport. In Class A5, the greatest vulnerability is related to locations with precarious infrastructure, the result of rapid population growth rates that have not been accompanied by urban development.

Therefore, municipal master plans and high levels of municipal human development do not guarantee better urban infrastructure or specific risk management legislation. Although legal tools recommending disaster risk management policies have been proposed, such tools are insufficient to reduce vulnerabilities and increase capacities in small Brazilian cities.

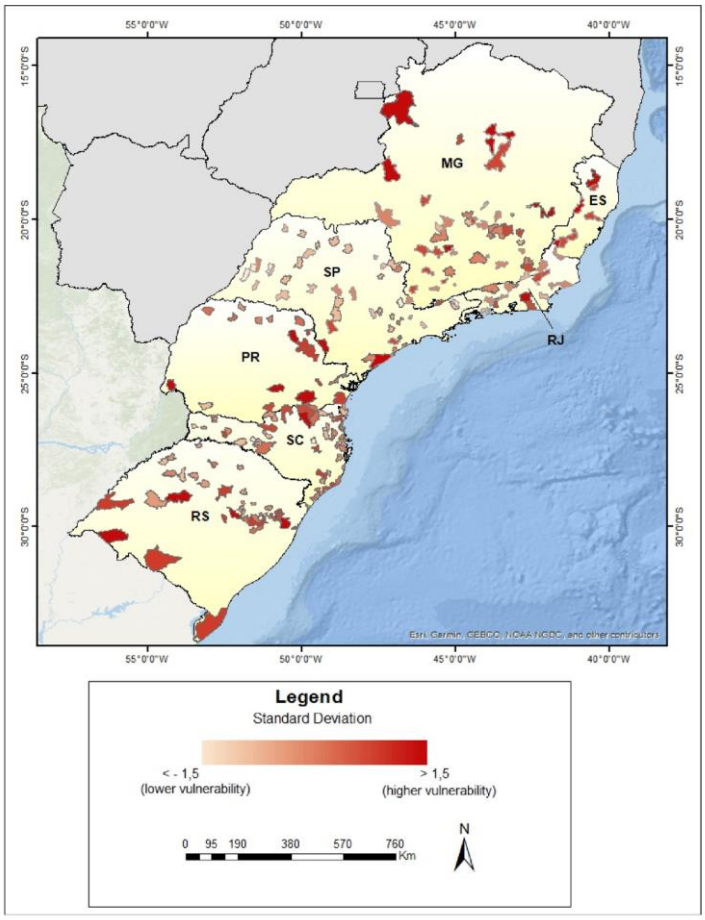


Figure 45 - Distribution of overall municipalities related to all municipalities analyzed. Source: Ribeiro et al. (2021).

– Risk communication

Considering the better conditions on the ongoing evolution of COVID-19 pandemic, we are organizing a live focus group with the public servants from the Blumenau municipal government city, which will be realized in the second semester of 2022. Focus groups consist in a research technique that collects data through group interaction on a topic determined by the researcher (Morgan, 1996). A moderator guides the participants' interaction to respond to open questions about topics of interest, allowing the group to explore them from as many angles as they want (Longhurst, 2003). This technique enables collating opinions of many people compared to individual interviews. The main advantage of focus groups compared to individual interviews is the creation of a potential synergy between the participants, resulting in a

productive debate. For this purpose, an active role is demanded of the researcher to conduct a discussion for data collection purposes.

The focus groups participants from Blumenau will be invited to discuss the following topics (i) the main sources of information about climate change; (ii) the comprehension about news and reports from the gray literature; (iii) the difficulties to apply the knowledge in the daily routine at the

As a complementary activity, we developed a risk perception assessment of the public servants of the Blumenau city hall mainly from the departments of protection and civil defense, urban planning and environment. These professionals were chosen for the present study due to their fundamental role in disaster risk management, especially regarding the potential to formulate structural and non-structural measures to reduce the disaster impacts. It is relevant furthermore to investigate whether municipal technicians perceive climate changes in their daily lives and in their work practice.

The consultation to the participants will be carried out through an online form, containing 8 questions about profile and 9 specific questions about the perception of climate risk. The questions address aspects related to climate change, its occurrence, impacts, access to information, challenges for the management and the role of public management. The use of questionnaires for climate perception is common for socioenvironmental studies (Soriano et al, 2017; Cesco & Ceolin 2017; Siegrist & Gutscher 2006).

The questions on the form will be mandatory due to the cross analysis between the questions, mainly the participants' profile and their perceptions of risk will be sought. The participants will be invited to answer the form once again after one year.

The process to the Brazilian National Committee for Ethics in Research (Conep) was submitted in December 2021 (Process 57581821.6.0000.0008). We received the first report in May 2022 demanding some adjustments to the project. An updated version was immediately submitted, and we are waiting for a final report.

– A tool for Assessment of Cities Vulnerability and Development of Adaptation Strategies - Climate Vulnerability Indicators

Looking for assessment of socioeconomic and environmental impacts of extreme events in pilot municipalities: present and future, during Year 5 efforts were put in order to continue the analysis of future changes of the aforementioned extremes using CMIP6 simulations. To provide risk assessment for stakeholders to elaborate public policies of mitigation and adaptation in urban areas, we are developing a vulnerability tool, which will be concluded in the following months. It will be presented and discussed in a virtual meeting to the members of Blumenau Secretariat, which are supporting the research, as well as to other local stakeholders indicated by them. After that, we will propose together with Blumenau stakeholders the establishment of adaptation strategies to support the local development, considering climate change risk.

The tool named SisVuClima - Cities is based on Climate Vulnerability indicators, which are being built for the city of Blumenau, Santa Catarina, as a case study. SisVuClima is an index developed by FioCruz, which was tested for some regions of Brazil and allows comparison between cities regarding its potential impacts to climate change. However, following the scope of INCT-2, we advanced and an adaptation to apply it in Blumenau at an intra-municipal level was made. After its development, the index was inserted into an online software platform, that will allow the city manager (who is responsible for it), to update it when new environmental and socioeconomic information becomes available. This tool should be used for

planning strategies and actions that mitigate the impacts of extreme rainfall-related disasters, improving the city's resilience to climate risk and strengthening the development.

The Conceptual Framework of SisVuClima is presented below (Figure 46) and it was proposed to identify different vulnerability categories at local level. The vulnerability index uses a framework based on Sensitivity and Adaptive Capacity.

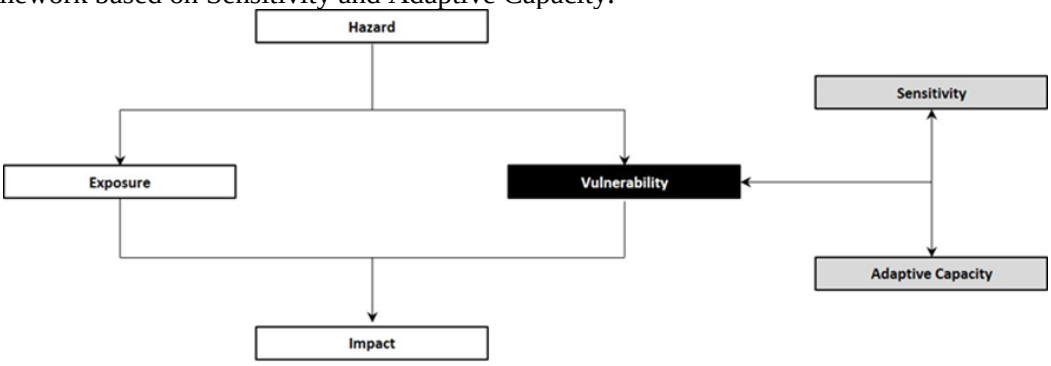


Figure 46 – Conceptual framework to assess vulnerability to climate change and also how the vulnerability is related to exposure, hazard and impacts.

The Index adapted to Blumenau is focused to evaluate vulnerability for each district. The Each index, sub index and indicators, for district level, that are being applied to operationalize the assessment of urban vulnerability to climate in the city of Blumenau are presented in Table 13. The indicators were defined considering the framework developed for identifying Brazilian medium cities' vulnerability to extreme rainfall-related disasters and the availability of official data provided by Blumenau.

Table 13 – Description of index, subindex, and indicators by scale of analysis neighborhood, to operationalize the assessment of urban vulnerability to climate in the city of Blumenau.

Index	**Subindex**	**Indicator**
Sensitivity	Natural Environment	Green area, including squares, parks, and forests
	Housing Conditions	Households in subnormal agglomerates Households in flooded areas
	Sanitation	Piped domestic sewage, connected to the general sewage network Households with availability of garbage collection service Households supplied by a general piped network
	Urban Mobility	Escape Routes

	Basic health and education services	Health equipment in disaster-prone areas Educational equipment in disaster-prone areas
Adaptative Capacity	Climate-Sensitive Morbidities	Incidence and proportion of diseases related to major disasters in the municipality
	Vulnerable Groups	Child population (children up to 5 years of age in the total population)
	Poverty	Income below the poverty line (earning less than ½ minimum wage) Literacy (illiterate people over 25 years of age) Private rented homes, without public lighting and on an unpaved street

All indices were be calculated through SisVuClima Cities, a software created to calculate, update and permit visualization of the indexes, as presented in Figure 47.

As shown in the framework presented in Figure 47, in order to advance in the analysis of the impacts of climate change, it is still necessary to cross this result (vulnerability) with the climatic dimension associated with each hazard. That is, for the next year we will evaluate the impacts at local level using the information developed in the Year 4 (that shows the increase of rainfall extreme events related to landslides and flash floods based on CMIP6 results) with the vulnerability index described previously. The purpose of this next step is to highlight the different climate risks that affect Blumenau at local level, finding hotspots, and provide accurate assessments of adaptation actions to disaster risk reduction and increasing resilience.

5.6.5 Analysis of extreme events, future projections under climate change and consequences for urban areas

Climate model precipitation is the foremost input for hydrological models in climate change risk assessment. However, some aspects of precipitation (e.g., frequency, seasonality, and extremes) are usually not well represented by climate models, especially at the regional scale

and in the tropics. It is important to evaluate the marginal, temporal, and spatial aspects of CMIP5 and CMIP6 precipitation to be used as input for downscaling studies and risk assessments. This is done for Southern Brazil which is one of the study areas of this project (Pereima et al. 2021). This region is in the transition between tropical and subtropical climates with diverse rainfall generation mechanisms and complex topography. We compare the multi-model-ensemble mean (MME) and a constrained ensemble (CE) of CMIP5 and CMIP6 against a high-resolution precipitation data grid. The constrained ensemble is obtained using a weighting approach that minimizes the difference between the simulated and observed cumulative distribution functions. We find that CMIP6 outperforms CMIP5 for most metrics, especially in the simulation of the seasonal cycle and the spatial distribution of precipitation. Simulated precipitation is more seasonal and more spatially dependent than the observations, with a dry bias characterized by lower precipitation amounts and higher consecutive dry days. Our analysis suggests that the models are not able to reproduce the transition between tropical and subtropical climates in this region as well as the passage of frontal systems. Our recommendations are that future studies using CMIP6 should focus on those regional mechanisms of precipitation variability. Nevertheless, further analysis of the CMIP6 outputs shows that atmospheric blocking will intensify over Southeast South America leading to more frequent, intense and prolonged droughts, land and marine heatwaves in this region (Costa and Rodrigues 2021).

Another important aspect is to identify the co-occurrence of floods and soil moisture. A coincidence in the timing of floods and their drivers can be used as a proxy for the causality of flood generation (Changas et al. 2022). The relationship between the seasonality of floods, maximum annual rainfall, and maximum annual soil moisture data of 886 basins in Brazil for 1980–2015 sheds light on process controls of flood generation. Floods tend to occur at the same time of year as soil moisture peaks and lag behind rainfall peaks by 3 weeks (Fig. 48). In Amazonia, central and northern Brazil, flood timing is more correlated with the timing of soil moisture peaks than with that of rainfall, which is interpreted as resulting from high subsurface water storage capacities. In southern and southeastern Brazil, on the other hand, flood timing is highly correlated with both soil moisture and rainfall because of low subsurface water storage capacities. These findings can support flood forecasting and climate impact studies.

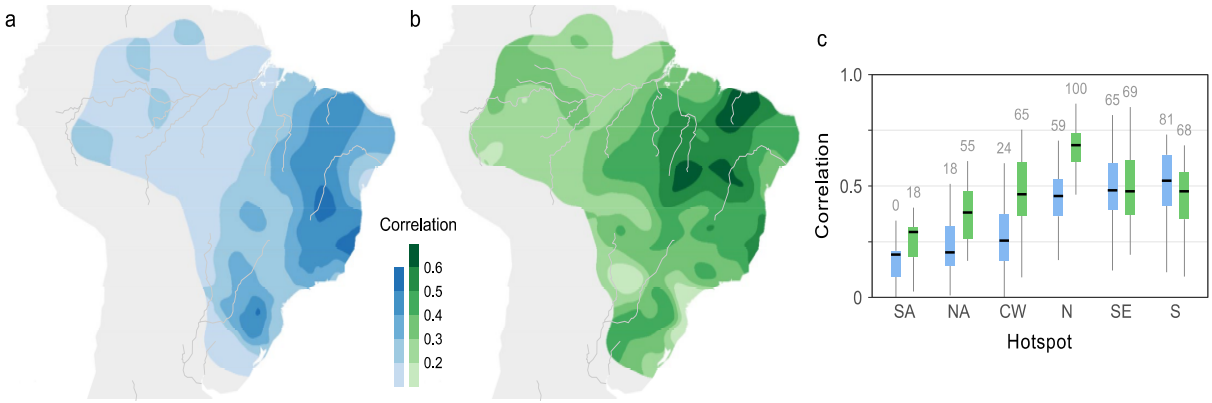


Figure 48: Circular correlation between the interannual variability of the timing of (a) floods and maximum annual rainfall, (b) floods and maximum annual soil moisture. Both (a) and (b) are obtained with interpolation using block kriging. (c) Spatial variability of the correlations with maximum rainfall (blue boxes) and maximum soil moisture (green boxes) over each hotspot. The numbers above the boxplots indicate the percentage of basins with significant correlations ($\alpha = 0.05$). The hotspots are Southern Amazonia (SA, n = 11), Northern Amazonia (NA, n = 11), Central-West (CW, n = 34), North (N, n = 22), Southeast (SE, n = 65), and South (S, n = 37). Extracted from Chagas et al. (2022).

Finally, much of the climate information, such as the outputs from CMIP5 and CMIP6, is presented in a form that cannot be used by the stakeholder and end-users. There is a widely accepted gap between the production and use of climate information. It is also widely accepted that at least part of the reason for this situation lies in the challenge of bridging between what may be characterized as ‘‘top-down’’ approaches to climate information on the global scale, and local decision contexts, which necessarily take a ‘‘bottom-up’’ perspective, in which climate change is just one factor among many to consider. After reflecting on how the climate information for adaptation can be more widely available, a set of recommendations was defined (Rodrigues & Shepherd 2022). One is the need to grapple with the complexity of local situations, which can be addressed by expressing climate knowledge in a conditional form. A second is the importance of simplicity when dealing with deep uncertainty, which can be addressed through the use of physical climate storylines using Bayesian networks. A third is the need to empower local communities to make sense of their own situation, which can be addressed by developing ‘‘intermediate technologies’’ that build trust and transparency.

5.7 Economy and impacts in key sectors

5.7.1 Highlights of Year 5

The most important results achieved by the group during the fifth year of the project are related to continuing applications of different tools and databases developed in the first years of the project by various modeling initiatives related to some of the ongoing projects. Different interregional input-output systems for various regional settings in Brazil have been used to calibrate CGE models. Such databases were used, for instance, to calibrate (i) a model for the Brazilian watersheds, and (ii) a model for São Paulo Metropolitan Region. In both instances, researchers have concluded the model integration with hydrological models developed in collaboration with the subcomponent “Water Security”. In the first case, a study on “Climate Change, Water Resources and Economic Impacts: An Analysis of Brazilian Hydrographic Regions” has been concluded (Rocha, 2022 -- Ph.D.dissertation). In the second case, the Ph.D. dissertation “Mudanças Climáticas, Secas e Impactos Econômicos: Uma Análise para a Região Metropolitana de São Paulo” (Sass, 2021), coadvised by Eduardo Mario Mendiondo (“Water Security” leader), was defended.

The regionalization method had been tested and implemented in different countries, such as Angola, Chile, Colombia, Greece, Iraq, Paraguay, Mexico, Morocco, and Ukraine. In this fifth year, the applications developed for Colombia will be published as part of an edited volume by Springer on “The Colombian Economy and its Regional Structural Challenges”. The project with the Banco de la República is partially linked to our INCT and proposes to replicate some of the INCT-MC features in the Colombian case. Given the project’s focus, we adapted one of its transversal themes (“economy and impacts on key sectors”) to Colombia. During fourth and fifth years, we addressed issues related to structural features of the Colombian regional system using the tools box developed in this project.

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 two areas that received more attention in years 1-4: (i) dealing with uncertainty in agriculture productivity models and the implications for economy-

wide impacts; and (ii) exploring the effects of climate on demographic variables, mainly fertility rates and, now, health.

We have also added two other key areas, since years 3-4, 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 the Civil Engineering Department at UNAM (Mexico), led by Prof. Mario Ordaz, to devise alternative methodological approaches to integrate risk assessment models and CGE models. Using modeling of earthquakes in Chile, this partnership has advanced in bringing additional insights and understanding of the economic consequences of unscheduled events. We hope to learn from this modeling experience to inform groups from the INCT better and elsewhere dealing with the economic impacts of sea-level rise. A first joint paper has entitled "Risk caused by the propagation of earthquake losses through the economy" has been published in *Nature Communications* (https://www.nature.com/articles/s41467-022-30504-3).

During the fourth and fifth years of INCT MC 2, the activities related to Work Package #2 have been focused on two main themes: (i) development of land-use models for assessing the potential for cattle raising intensification in Brazil; and (ii) development of econometric models to assess adaptation to climate shocks through rural labor market reallocations.

(i) Development of land-use models for assessing the potential for cattle raising intensification in Brazil

After focusing on agricultural land use efficiency in the Brazilian Legal Amazon during the third year of the project, the activities on land use modeling were devoted to cattle raising in the fourth and fifth years. In particular, research efforts focused on degraded pasture recovery in Brazil. Degraded pasture is a significant liability in Brazilian agriculture, but restoration and recovery efforts could turn this area into a new frontier for agricultural yield expansion and forest restoration. Recovery of degraded lands is a key strategy for achieving food security goals, and the Brazilian agricultural sector could play a leading role in this initiative. The country is an agricultural powerhouse, but it has also accumulated around 100 Mha of degraded pasturelands. Implementing restoration and recovery actions would result in significant environmental and economic gains.

In order to investigate this issue, José Féres teamed up with Rafael Feltran-Barbieri from the World Resources Institute to measure the potential economic and environmental gains associated with degraded pasture recovery in Brazil. Simulations showed that the recovery of 12 million ha of degraded pastures could generate an additional production of 17.7 million bovines while reducing the need for new agricultural land. More efficient allocation of degraded and native pastures for meat production and forest restoration could provide land enough to comply with its Forest Code requirements fully. These findings suggest that degraded pasture recovery and restoration is a win-win strategy that could boost livestock husbandry and avoid deforestation in Brazil.

Another important message from the paper is that, since only 1% of Brazilian municipalities contains 25% of degraded pastures, focusing pasture recovery efforts on this small group of municipalities could generate considerable benefits.

Rural credit can have a significant impact in reducing cattle raising inefficiency. This is an important bottleneck for economic and productive gains. On average, livestock farms invest 7–30 times less than necessary to recover pastures. On the other hand, rural credit finances only US$ 1 of every US$ 4 invested in livestock. Therefore, it is important to redirect working capital for investment.

The ABC Program, especially the subprogramme 'Recovery of Degraded Pastures', must be broadly expanded. One first step can be redirecting resources from rural savings and constitutional funds with controlling interest and currently available funds to promote pasture recovery without being linked to specific programs.

The paper was published in the journal *Royal Society Open Science* (https://doi.org/10.1098/rsos.201854).

(ii) Climate change adaptation through rural labor market adjustments

The paper on labor supply responses to weather shocks, which was published during the fourth year of the project, motivated an internal webinar to promote channels of integration between the two work packages of the component. The webinar/internal meeting took place on August 21, 2021, hosted by NEREUS, at USP, with the discussion led by José Féres.

The fifth year of the research project was also devoted to finding ways of integrating the land use findings with the computable general equilibrium model. In particular, results from the papers published in Land Use Policy (see third-year report) and in Royal Society Open Science (see above) serve as inputs to the CGE model in order to address the following questions:

(i) Which are the general impacts on the economy associated with an improvement in land use and agricultural efficiency?

José Féres and Marcelo Ferreira from the Federal University of Goiás showed plenty of room for agricultural land intensification: farmers could reduce agricultural land use by 87.4 % and produce the same output quantity while holding other input quantities constant. This means that, in this region, it is possible to achieve expressive reductions in land use without decreasing agricultural production. This finding also indicates that agricultural production could increase without resulting in further deforestation pressures.

During the fifth year of the project, the authors teamed up with researchers from FEA-USP to incorporate these findings as a shock to the CGE model. Work is still ongoing and we expect to evaluate the impact of improvements in land-use efficiency on macroeconomic aggregates (sectoral and overall GDP, agricultural employment, etc.)

(i) Which are the general impacts on the economy associated with cattle raising intensification?

José Féres and Rafael Feltran-Barbieri showed the potential economic and environmental gains associated with cattle raising. The research will be extended by incorporating the main results into the CGE model developed by FEA- USP. We expect to evaluate the impact of improvements in cattle stock rates on macroeconomic aggregates (sectoral and overall GDP, agricultural employment, etc.). In addition to that, we also expect to undertake a cost-benefit analysis associated with redirecting rural credit funds to pasture recovery. A Master student is working on a proposal to develop this topic.

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)

Throughout the five years, we have also succeeded in receiving additional funding from Instituto Escolhas for master and Ph.D. students: (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). Since January 2020, there is a member of the group with a Capes doctoral scholarship (88887.493251/2020-00): "Modelagem Integrada de Sistemas Econômicos e Hidrológicos com Base nas Unidades de Planejamento Hidrográfico do Brasil", Ademir Antônio Moreira Rocha (Eduardo A. Haddad).

Finally, we succeeded in other initiatives for additional fund raising, 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, and the ongoing project with the MCTIC "MODELAGEM E CONSTRUÇÃO DE BASE DE DADOS DE SOLUÇÕES E INDICADORES DE PLANEJAMENTO URBANO SUSTENTÁVEL/OICS DO PROJETO GEF".

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

This includes the following activities:

- BESM3.0 - (Global Atmos BAM1.2 sigma coupled to Global Ocean MOM6 via FMS coupler from NOAA/GFDL) version has been completed, incorporating the latest developments on ocean modeling of GFDL, with the global ocean model MOM6; which incorporates both vertical Z and isopycnal coordinates, in addition to an improved marine sea ice model SIS2 and biogeochemistry model COBALT.
- BESM 3.0 - During this period, BESM 3.0 has been tested both for a 100 years long free run and 30 years (1981-2010) of november 1st initialized one year seasonal predictions.
- BESM 3.0 - HighRes. A high resolution version of BESM3.0 has been compiled and test run, increasing the model resolution from its T062L42 (i.e. 200 Km horizontal grid and 42 levels in the vertical) to and intermediate horizontal resolution of T126L42 (i.e. 100 Km horizontal grid resolution and 42 levels in the vertical) and the T666L64 (i.e. 20 Km horizontal grid resolution and 64 levels in the vertical); under evaluation and tests.
- BESM3.1 - The newest version of the atmospheric component model of BESM has been upgraded into BESM3.1. It substitutes the previous version of the atmospheric model BAM1.2_sigma vertical coordinate of BESM3.0 by BAM2.0_hybrid sigma-pressure vertical coordinate system into BESM3.1; under evaluation and tests.

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

Model development includes:

-Improvements to the land-surface NOAH scheme to represent Brazilian Biomes

A version of the Eta regional model coupled to the Noah-MP surface model was developed (Niu et al., 2011). In this original version, the 'tile' approximation was implemented to represent the surface heterogeneities and the inclusion of 4 more layers of soil, reaching a depth of 12 meters of soil column, which is suitable for vegetation with deeper root zones, such as tropical forests. In this version, the ability to temporally update the land cover and use maps throughout the integration was introduced, which is the appropriate way to assess the impacts of land use on a climate time scale. The model proved capable of running at very high resolution (1km) and for long integrations to generate climate change scenarios throughout the 21st century.
Vegetation map is updated. The land surface scheme can now distinguish two types of tropical forest, the Amazon forest and the Mata Atlantica, through parameters such as root depth, albedo etc. The scheme can also distinguish the Caatinga type from the savannah type, which is a major biome in Northeast Brazil (Figure 49).

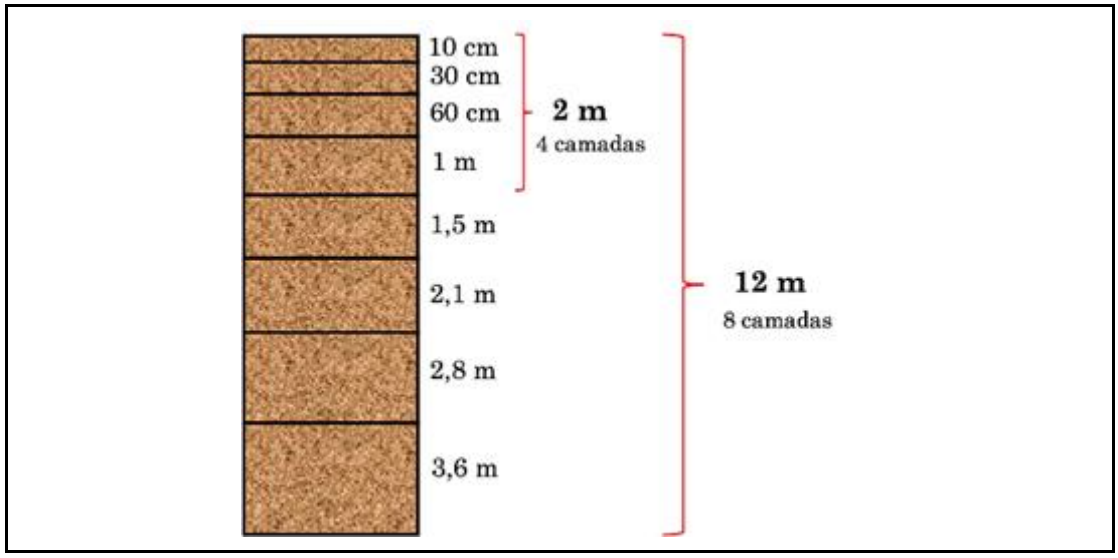


Figure 49– Additional soil layers, from 4 to 8, and depth increase, from 2 to 12 meters, implemented in the Eta-NOAH-MP version.

-New RRTMG radiation scheme and inclusion of convective clouds

Convective clouds play an important role in the local energy balance, interacting directly with solar radiation and terrestrial radiation. However, radiation parameterization schemes of atmospheric models generally consider clouds produced from microphysics schemes or some other moisture saturation criterion in the model grid. Deep convective parameterization schemes tend to generate convective cloud precipitation without the radiation scheme realizing its water load. This could be a source of excess solar radiation reaching the Earth's surface. The new radiation scheme introduced in the Eta model is the Rapid Radiation Transfer Model (RRTM). The scheme is tested in cloudy sky and an additional development is the inclusion of the deep convective cloud in the RRTM scheme. This produced a further reduction in the positive bias of incident shortwave radiative flux at the surface, improvement in cloud cover, in the diurnal cycle of net radiation at the surface and in temperature at 2 meters. However, total precipitation was reduced. Further adjustments in precipitation is required. In a 10-yearlong simulation, the model with the new modifications is able to reproduce the seasonal variability of radiation fluxes during the summer and winter seasons compared to reanalysis data. Figure 50 shows that the new RRTM scheme in the Eta model improved the mean radiative fluxes and the mean 2-m temperature.

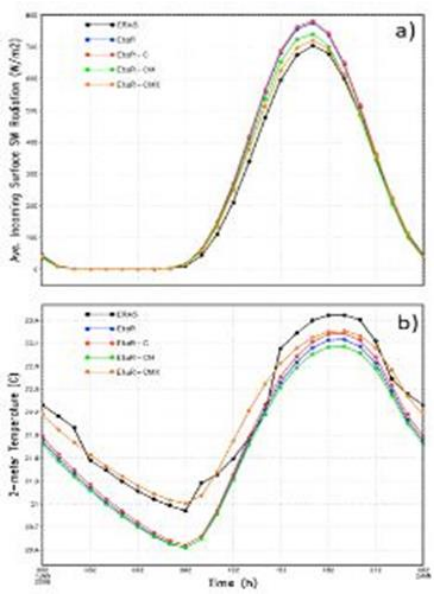


Figure 50. Mean diurnal cycle of solar radiation incident on the surface (da) and temperature at 2m (b), for different numerical experiments and ERA5 reanalysis.

-Development of a new parameterization of atmospheric eletrical discharge and production of the chemical component NOx from deep convection activity.

The inclusion of electrical discharges in the Eta model is performed as a function of variables diagnosed in cloud microphysics and cumulus convection. The parameterization diagnoses the total discharge, which affects the process of collision and coalescence of cloud droplets and acts on the chemistry of the atmosphere through the production, destruction and transport of nitric oxide (NO), nitrogen dioxide (NO2), nitric acid (HNO3), nitrogen trioxide (NO3) and dinitrogen pentoxide (N2O5). NOx act indirectly as a greenhouse gas. The lightning simulations showed a small underestimation in relation to the observed data. The inclusion of the effects of electrical discharges in the production of rain resulted in the intensification of electrical activity in a process of positive feedback. The effects of discharges on rain production also caused an increase in the proportion of ice mixing in clouds at upper levels, a decrease in cloud water at lower levels of the troposphere, a decrease in specific humidity at lower levels of the troposphere, and a decrease of vertical movement. The proposed scheme increased the frequency of heavy rains during the summer of 2017 and improved the performance of the rain forecast in the model. The electrical discharge scheme generated satisfactory vertical profiles of NO and NO2 when compared with the reanalysis data.

5.9 Communication, dissemination of knowledge and education for sustainability.

5.9.1 Situation in Year 5

The Communication, knowledge diffusion, and education for sustainability cross-cutting theme, from June 2021 to June 2022, invested in three work fronts: communication and arts, research in the area of social studies of science and technology, and education.

In the field where communication and the arts intersect, the team worked intensively on producing journalistic material to publicize the work carried out by the different components of INCT Climate Change Phase 2 and other researchers working in the field of climate change through publications in the ClimaCom magazine. The work was developed with a TT scholarship received by student Gláucia Pérez. In addition to the journalistic articles, two ClimaCom dossiers were released: “Facing denialism” (RODRIGUES; PALLONE;

DALMASO; DIAS, 2021), which proposed to reflect on denialism and its effects on society; and "This place, which is not mine? (FONSECA; ASUMPCAO; AMORIM, 2022), which deals with the problems of migration and destruction of refuges in the Anthropocene. The articles, essays, and artistic productions published in ClimaCom are intended to discuss, analyze, and propose new possibilities of action and thought in the face of denialism and forced or necessity migrations.

This matter is politically important in terms of climate change communication because, on the one hand, the planet is already experiencing a climate refugee crisis in several regions; on the other hand, research and artistic creations show that, among those who fight denialism and those who adhere to denialism, sometimes there is an element in common: "they tend to share the defense of universal truths, unquestionable and exclusivist certainties, monocultures of thought" " (RODRIGUES; PALLONE; DALMASO; DIAS, 2021) – which makes the communicative process difficult. For communication processes to deal with complex issues such as denialism and migration in the face of changes in the Earth's climate, new forms of interaction and new encounters are necessary: "the encounter should always be of the unpredictable order, always capable of provoking changes without anything marking it a priori" (FONSECA; ASSUMPÇÃO; AMORIM, 2022).

Assuming that communicating implies the creation of encounters between heterogeneous ways of thinking and life, or *odd kinship* (DIAS, 2021, 2022), that guarantees expression and dialogue between differences, has been a keynote of research developed by the Rede de Divulgação Científica e Mudanças Climáticas, which is part of this cross-cutting theme. This year, we highlight the studies that: problematize the relationship between the body and the city in times marked by fear (SANTOS, G. P.; MATHIAS, F. M. F.; QUEIROZ FILHO, 2021); that pay attention to the connections between the concepts of image, space, and education, and which propose combats to anthropocentric perspectives, reducing and imprisoning senses and experiences (GIRARDI; OLIVEIRA JR.; NUNES, 2022); that focus on how scientific practices articulate ecology, nature, enormous sets of data, complex theoretical frameworks and vast repositories of computer codes to ensure that the future is not one of devastation (MONTEIRO, 2022); that seeks to think about how scientists, writers, philosophers, indigenous peoples, and artists, in different ways, gain intimacy with beings, such as trees, making them effective partners in the production of thought and revealing fundamental multi-species learning for dealing with the Anthropocene (DIAS, 2021).

5.9.2 Social studies of science and technology

In the area of social studies of science and technology, in addition to articles and articles on the subject published in ClimaCom and other journals, the activities of the transversal theme gained new impetus with two activities: research on the variables, conditions, and contexts of collaboration interdisciplinary within the INCT-MC2, developed by Professor Julia S. Guivant, from the Federal University of Santa Catarina and a visiting researcher at LabJor/Unicamp with a grant from Fapesp; and the project "Socio-climatic imaginaries and meta-cognitions: their roles in interdisciplinary research and scientific communication in a case study of the National Institute of Science and Technology for Climate Change (INCT-MC)," coordinated by Renzo Taddei and Julia Guivant, submitted to CNPq call 26/2021, and approved in July 2022. Such research efforts are dedicated to understanding how deeply rooted disciplinary habits in research communities, including the social sciences, affect inter- and multidisciplinary cooperation in the face of climate change's complex and multi-scalar nature (TADDEI AND HAINES, 2019; GUIVANT, 2010). The research contributes to the effort to understand the contexts and conditions of collaboration between researchers from the natural sciences and the social sciences (ESCADA et al. 2021; TADDEI 2021), with particular attention to the issue of metacognition (KEESTRA, 2017).

In the field of educational activities, in addition to articles on the subject published in ClimaCom and other academic journals, researchers of the transversal theme started a partnership with the Escolas Pelo Clima movement and Cemaden Educação. The activity is based on the understanding that, in addition to exploring and proposing innovative ways of perceiving the environmental issue and engaging with other forms of life and the environment mentioned in the first item, it is of fundamental importance that such discussions and enactments of climate science are incorporated into the daily life of educational practices in the country. A series of meetings were held in planning the #aprenderparaprevenir program, an annual activity of Cemaden Educação and which, in 2022, will have the issue of climate change as its theme. So far, the cross-cutting theme has participated in a webinar with teachers and schools that integrate the Escolas Pelo Clima movement. A partnership is also being built on the cross-cutting theme with the Maré de Ciência project, based at Unifesp, and aimed at activities related to climate change in an event linked to Unesco on oceanic culture, to take place in October 2022. One of the results of this partnership is the participation of the transversal theme in two editions of the Forum of Young Ambassadors of the Ocean, in the second half of 2021 and the first of 2022, in sessions related to climate change.

5.9.3 Activities carried out in year 5 (June 2021 to June 2022)

- 20 journalistic articles published or in the process of being published in ClimaCom magazine concerning the activities of INCT-MC2 researchers or related research on climate change. This activity was developed by FAPESP TT3 grantee Gláucia Pérez, under the guidance of Susana Dias, aiming at the production of news for the magazine through the coverage of events (online), readings of articles, and interviews with researchers of the sub-components and transversal themes of the INCT, as well as interviews with other researchers. The following materials were produced (Figures 51, 52):

1) The coexistence between humans and algorithms in monitoring extreme weather phenomena. 10/08/2021. Mention to researcher Bruno Stramandinoli Moreno, a postdoctoral student at Unesp.

2) False information contributes to climate denialism and accelerates climate change. 10/13/2021. Mention to researchers Pablo Rubén Mariconda, professor of philosophy of science at USP, and Alyne Costa, professor of philosophy at UFRJ.

3) Thermal stress in the Amazon rainforest region is already a reality and tends to increase with climate change and deforestation. 10/16/2021. Mention to the researchers Beatriz Oliveira, from Fiocruz/Piauí; Marcus Bottino from INPE; Paulo Nobre from INPE and INCT – MC2; Carlos Nobre from the Institute of Advanced Studies at USP

4) INCT Climate Change researchers defend the connection between scientists and society to combat denialism and fake news. 10/19/2021. Mention to the researchers Regina Alvalá from Cemaden; Adelaide Nardocci from the School of Public Health at USP; Elizabeth Rangel from Fundação Oswaldo Cruz/Fiocruz and member of INCT – MC2; Eduardo Mário Mendiondo from USP São Carlos and from INCT – MC2

5) Cuts in investment in S&T are worrisome. 11/19/2021. Mention to researchers: Alfredo Lopes, philosopher, writer, and author of the blog Brasil Amazônia Agora; Emmanuel Tourinho, dean of the University of Pará; Camila Ribas from INPA; Sanderson de Oliveira, professor at the University of Amazonas; Adalberto Luis Val, member of the Brazilian Academy of Sciences.

6) The voices of indigenous peoples at COP26. 12/09/2021. Mention to researchers Alik Wunder from Unicamp and INCT-MC2; Joana Cabral de Oliveira from the Department of Anthropology at Unicamp.

7) Putting climate change within the elections is one of Brazil's priorities after COP26. Mention to researchers Paulo Artaxo from INCT – MC2; Ana Toni from Instituto Clima e Sociedade; Eduardo Trani, undersecretary for the environment of the State of São Paulo; Jacques Markovitch, professor at FEA at USP.

8) Indigenous lands, conservation units, climate, and the future are intertwined. Mention to researchers Mercedes Bustamante from UnB and INCT – MC2; Carlos Joly, professor of biology at Unicamp;

9) The challenge of reducing the vulnerability of cities in periods of rain. 01/25/2022. Mention to the researchers Mario Mendiondo from USP São Carlos and INCT – MC2; Adelaide Nardocci from the USP School of Public Health;

10) It is necessary to revitalize the power of trees for thought. 02/16/2022. Mention to researcher Susana Oliveira Dias, from LabJor/Unicamp and INCT – MC2;

11) Audiovisual productions and literature as means to understand the issue of climate refugees. 02/17/2022. Mention to researcher Antônio Carlos Amorim, from Unicamp and INCT – MC2;

12) The cancellation of financial resources for monitoring threatens the Brazilian cerrado. 02/17/2022. Mention to researchers Claudio Alencar from INPE; Tasso Azevedo of the Climate Observatory; Paulo Artaxo from USP and INCT – MC2; Ane Alencar from IPAM; Mercedes Bustamante from UnB and INCT – MC2;

13) A reinterpretation between a video game, climate change, and migrations to connect people to climate imaginaries. 04/26/2022. Mention to researchers: Santiago Arcila Rodríguez, philosopher and visual artist from Colombia; Antônio Carlos Amorim from Unicamp and INCT – MC2;

14) Social inclusion to mitigate the impacts of climate change. 05/04/2022. Mention to researchers: José Marengo from Cemaden and INCT-MC2; Renzo Taddei from Unifesp and INCT-MC2; and Jean Ometto from INPE.

15) Feminist Literature and Science Fiction in End of Worlds Times. 05/30/2022. Mention to researcher Jade Arbo, a doctoral student at UFPel.

16) Ecofeminism: a proposal for an ecology of care in the face of the Anthropocene. 05/30/2022. Mention to researcher Alyne Costa, professor at PUC-RJ.

17) Deforestation and burning fossil fuels are wiping out a habitable world on planet Earth. 06/09/2022. Mention to researcher Roberto Schaffer from UFRJ and INCT-MC2.

18) Tuned, lost, disconnected, and incredulous: research maps perceptions of climate change among Brazilians (in completion). 06/27/2022. Mention to the researcher Marina Thomás from the National Institute of Public Communication of Science and Technology (INCT – CPCT).

19) Other meetings (are) possible (in completion). Mention to researcher Fabíola Fonseca, Post-Doctoral Student in Education at Unicamp.

20) The importance of interdisciplinary groups in producing knowledge of climate services (in completion). Mention to researcher Marko Monteiro, from Unicamp and INCT-MC2.

Two of the materials mentioned above (numbers 4 and 9), in particular, were produced in direct collaboration with the Water Safety component of the INCT-MC2.

- Two ClimaCom Magazine dossiers were published, totaling 95 original contributions in the

form of articles, essays, reviews, signed column texts, news, interviews, reports, and artistic and cultural productions. This number includes 17 of the 20 journalistic articles mentioned in the previous item.

1) "In the face of denialism," November 2021, with 53 items (7 articles, 20 essays, 6 journalistic texts, links to 2 digital books, 18 artistic productions) - http://climacom.mudancasclimaticnas.net.br/apresentacao-editorial-diante-dos-negacionismos/

2) "This place, which is not mine?", May 2022, with 42 items (4 articles, 10 essays, 6 journalistic texts, 22 artistic productions) - http://climacom.mudancasclimaticas.net.br/

5.9.4 New projects linked to the INCT MC2

- The project "New sensitivities in the face of socio-environmental catastrophes: the creation of materials for the scientific dissemination of climate change," coordinated by Susana Dias, was approved in the BAS scientific initiation scholarship program at Unicamp. As a result, four fellows - Larissa Bellini, Karolyne Souza, Rayane Barbosa, and Paulinha Luiz Pinto, the last two being indigenous students Kaingang and Tikuna - worked at ClimaCom magazine between June 2021 and July 2022.

- The research project "Socio-climatic imaginaries and meta-cognitions: their roles in interdisciplinary research and scientific communication in a case study of the National Institute of Science and Technology for Climate Change (INCT-MC2)" coordinated by Renzo Taddei and Julia S. Guivant and submitted to CNPq call 26/2021, was approved. The research seeks to document and analyze the conceptual assumptions that guide researchers in their research practices on climate change and how these influence interdisciplinary relationships and collaboration between social scientists and researchers in the Earth system sciences. The execution of the project will take place from the second half of 2022.

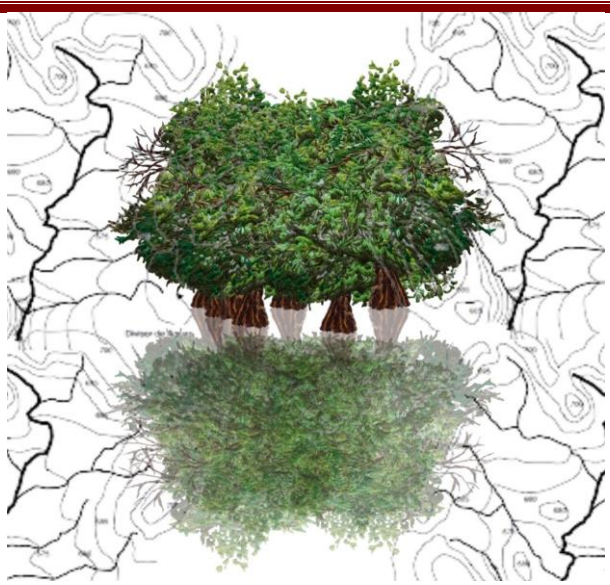
- The research project "Perceive-make-forest: alliances between arts, sciences and communications in the face of the Anthropocene," coordinated by Susana Oliveira Dias, was presented to the so-called LinCAr – Innovative approaches to research in Language, Communication and Arts 2022 from FAPESP. The result is not yet available.

- The project "Pedagogies of the image," under the coordination of Professor Gabriel Cid Garcia, was approved on two work fronts at UFRJ. It was awarded two (2) scholarships for undergraduate students of the Institutional Scholarship Program for Artistic and Cultural Initiation - PIBIAC/PR-1/UFRJ, public notice of 2021; and developed as an outreach project at the UFRJ School of Education, registered at the UFRJ Extension Dean's Office.

- The Radio Paideias podcast, Faculty of Education at UFRJ, is also carried out under the coordination of Professor Gabriel Cid Garcia. This is an extension project currently underway at the UFRJ Faculty of Education, registered with the UFRJ Extension Dean. A series of episodes dealing with the relationship between climate change, communication, education, and art is being prepared and should involve researchers from all components of the INCT-MC2.

- A new work plan for elaborating new journalistic articles was presented, through a request for a TT3 scholarship from Fapesp, to the student Milena Bachir. The request, which refers to the use of scholarship months already available within the scope of the INCT-MC2, is still pending.

- Articles, books, chapters, abstracts, expanded abstracts, and presentations of work at events were produced based on research carried out individually or in groups. The data is listed below.



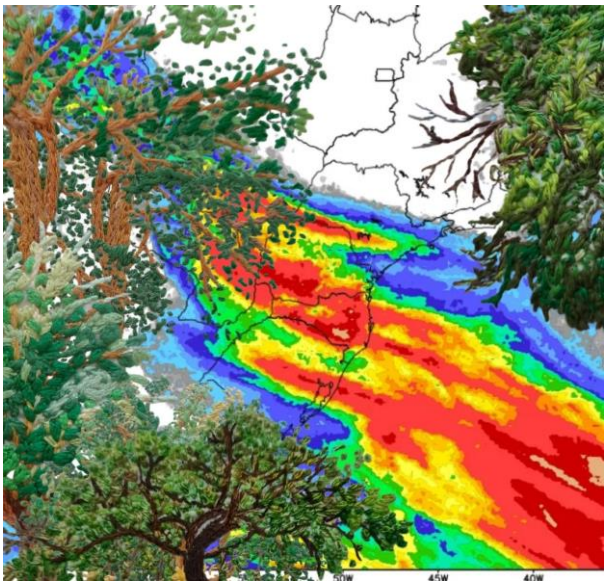


Fig 51 and 52 - Embroidery by Isilda Oliveira and digital collages by Paulinha Pinto and Susana Dias, 2022. This series of images highlights the importance of plant life for the Earth's climate and the need to reinvent the alliances between science and arts, digital and artisanal, to think about adaptation and mitigation measures of climate change. The activity is part of a research line that seeks alternative ways of framing climate change, aiming to build forms of engagement with different audiences not obtained by the usual forms of mass communication.

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

5.10.1 Highlights

A component of the INCT Climate change aims to quantify the sources and sinks of greenhouse gases and study the processes that control the fluxes of greenhouse gases (GHG) in the Amazon - GEE-AMAZONIA. Develop algorithmic methods of data analysis based on statistical models and Artificial Intelligence coupled to an Information and Service System - modeled in the cloud - that can be integrated with automated methods of data collection. Brazil has signed international commitments to reduce greenhouse gas emissions, especially in the Amazon

region, but it does not have the tools for these reductions to be monitored and for public policies to be developed based on science. The largest GHG emissions in Brazil are associated with the deforestation of the Amazon rainforest and the agricultural sector. About 44% of our emissions correspond to land use changes in the Amazon, with emissions from the agricultural sector corresponding to about 25% of emissions. CO2 (carbon dioxide) and CH4 (methane) emissions dominate Brazilian emissions.

Despite the huge amount of environmental data from the Amazon region, access to this data is very difficult, as it is spread across hundreds of different institutions and repositories. There are dozens of satellites measuring atmospheric and land use properties covering the Amazon region, as well as ground measurements in several towers of the LBA project (Large-Scale Experiment on the Biosphere and Atmosphere of the Amazon) and in the ATTO tower (Amazon Tall Tower Observatory), a 325-meter tower in operation in the central Amazon. There is a strong need for these environmental data to be easily accessible, and by lay users in the different techniques in which these data were collected. The visualization of these data also presents great scientific challenges, due to a large amount of multidimensional information, spatially and temporally. There are no platforms designed for easy access to this huge dataset.

The proposal involves the work of a large number of institutions and researchers. Among them, are USP, INPE, MapBiomas, IPAM, CEMADEN, IMAZON, UNIFESP, INPA, and other research groups that work comprehensively in Amazonian research. International partnerships are also essential, and we collaborate on this proposal with the Max Planck Institute (which operates the ATTO tower, together with INPA), NASA, KNMI, ESA, and US DoE NGEE-Tropics, among others. About 31 researchers are running this project, namely Paulo Artaxo (IF-USP), Tasso Azevedo and Julia Zanin Shimbo (MapBiomas), Carlos Souza Junior (Imazon), Ane A. C. Alencar, Paulo Moutinho (IPAM), Luiz E. O. Aragão, Alberto W. Setzer, William Rosa, Fabiano Morelli, Celso van Randow, Luiz Augusto T. Machado, Jean Ometto (INPE), Liana O. Anderson (CEMADEN), Carlos Souza Jr. (IMAZON), Fernando G. Morais, Fábio de Oliveira Jorge, Marco A. Menezes Franco, Rafael V. dos Santos, Micael A. Cechini, Bruno Backes Meller, Itiara Mayra Albuquerque, Simara O. Morais (IFUSP), Luciana V. Rizzo (UNIFESP), in addition to the contracted Post Docs. The WS2 component is being performed by José Reinaldo Silva, Pedro Luiz Pizzigatti, Glauco Caurin, Sergio Frascino Muller de Almeida, Marcos Sales Guerra Tsuzuki, Thiago de Castro Martins (USP), Luciana V. Rizzo (UNIFESP), Alan J. P. Calheiros (INPE)), in addition to several students.

Land use and changes in land use are the biggest sources of greenhouse gas emissions in Brazil. Most of the processes that control these emissions and sinks are in the Amazon. The project aims to quantify these GHG sources and sinks in the Amazon, as well as the drivers that control the carbon balance, with a focus on CO2 and CH4. Temperature, solar radiation, cloud cover, water vapor, large-scale meteorology and human impacts are the main factors responsible for the changes in GHG fluxes in the Amazon. It is essential that we understand the nonlinear and complex relationship between these variables. Changes in land use, especially deforestation, are responsible for the largest GHG emissions in Brazil. In 2020, around 11,088 km² of primary forests were deforested according to INPE's PRODES system.

We intend to integrate several existing tools and develop new knowledge about the processes that control the GHG balance in Amazon. This includes the integration of new remote sensing data systems and technologies such as: measurements from NASA and European Union satellites such as OCO-2 (Orbiting Carbon Observatory-2), GOSAT (Greenhouse Gases Observing SAtellite), and constellation of Sentinel satellites from ESA (European Space Agency), TROPOMI (TROPOspheric Monitoring Instrument) among others. We will operate at various locations in the Amazon a network of NASA solar photometers, called the Aerosol Robotics Network - AERONET, which measures aerosol particles, black carbon and water vapor. The LBA experiment (Large Scale Biosphere and Atmosphere Experiment of the Amazon) and the ATTO tower (Amazon Tall Tower Observatory) manage 7 forest towers in the

Amazon that measure GHG concentrations and fluxes at the forest level, in addition to flux towers in other Amazonian countries. We will integrate these analyzes with INPE products for deforestation, biomass burning and forest degradation, such as the PRODES systems (Monitoring the Deforestation of the Brazilian Amazon Forest by Satellite), DETER (Deforestation Detection System in Real Time), Queimadas Project, TREES among others, as well as the land use change and cover data generated by MapBiomas, which will provide data on secondary forests and their dynamics of gains and losses over the years. This integration will allow the proper calculation of net GHG emissions and/or removals in the Amazon. A new quantitative methodology of the role of forest degradation in GHG emissions will also be developed. Using the MapBiomas platform, we will incorporate data on GHG emissions and removals from the forest and land use changes in the Amazon at high resolution (up to 30 meters), allowing for comprehensive territorial analysis based on data from activities such as deforestation and land tenure. and land use patterns.

These data will be synthesized and integrated into an evolutionary platform based on Services Science, which in addition to managing and making queries available to all researchers in the area worldwide, also provides algorithms and data analysis packages based on various statistical methods, decision system Bayesian, in "knowledge graphs", and techniques that allow direct access by researchers to the results of models and GHG balance measurements.

A multidisciplinary data processing and analysis system will be developed, based on Data Science, Artificial Intelligence and Service Science, facilitating the complex and multidimensional visualization of the generated data and its sharing. Management will be based on the analysis of service systems and managed by the project team. Finally, the group will explore automation techniques for data collection in the Amazon rainforest and remote sensing, using robotic devices.

Brazil is committed in the Paris Agreement to reduce its GHG emissions by 37% in 2025 and 43% in 2030, compared to 2005 emissions, and to achieve zero illegal deforestation by 2025, in addition to restoring 12 million hectares of forests. Brazil is also committed to the implementation of the Sustainable Development Goals (SDGs), and it is necessary to develop the science and technology necessary to fulfill these commitments. Science-based solutions are essential to support effective, long-term policies that can reduce GHG emissions in Brazil. Reducing deforestation of tropical forests is one of the cheapest and fastest methods of reducing greenhouse gas emissions.

It is essential that we use remote sensing technologies to know and monitor GHG concentrations in the Amazon, validating satellite measurements over this region, and comparing with measurements obtained in situ. Sensors such as GOSAT, OCO-2 and TROPOMI are already well established and provide validated data to the scientific community, but not yet for the Amazon region. (Table 14)

And in order to contribute to the validation of measurements of atmospheric GHG concentration over the Amazon, measurements from 4 different sensors distributed in 5 data sets were used. For CO2: OCO-2, GOSAT, AIRS and a set that mixes OCO-2 and GOSAT; and CH4: the TROPOMI sensor, whose information can be found in Table below. The validation of these satellite measurements was carried out with concentration measurements obtained in situ at the Observatório da Torre Alta da Amazônia (ATTO) which is located in central Amazonia and has an atmosphere little affected by human action, making it possible to know, for example, the emissions of CO2 and CH4 from the forest itself.

Table 14. Satellites in Amazonia

	Lançamento	Alt. Orbital	Resoluçã o	HPE	Swath

GOSAT	jan/2009	675 km	10.5 km	17h	790 km
OCO-2	Jul/2014	705 km	1.29 x 2.25 km	17h30	10 km
OCO-3	maio/2019	408 km	4 km	Na passagem da ISS	13 km
TROPOMI	out/2017	834 km	5.5 x 7.0 km	17h30	2600 km
AIRS	maio/2002	834 km	13.5 km	17h30	1650 km

The MapBiomas network is a collaborative platform formed by NGOs, universities, and technology startups, which reveals the transformations of Brazilian territory through science, making knowledge about land use accessible to seek conservation and fight climate change. It has produced an annual mapping of land cover and use since 1985, validates and reports each deforestation event detected in Brazil since January 2019, and has monitored surface water and fire marks monthly since 1985 (MapBiomas, 2022). Figure 53 presents the land use map focused on the Amazon biome, and shows historical series of changes in forest and pasture areas, among other classes. In particular, there is a decrease in the forest area and an increase in the arable area.

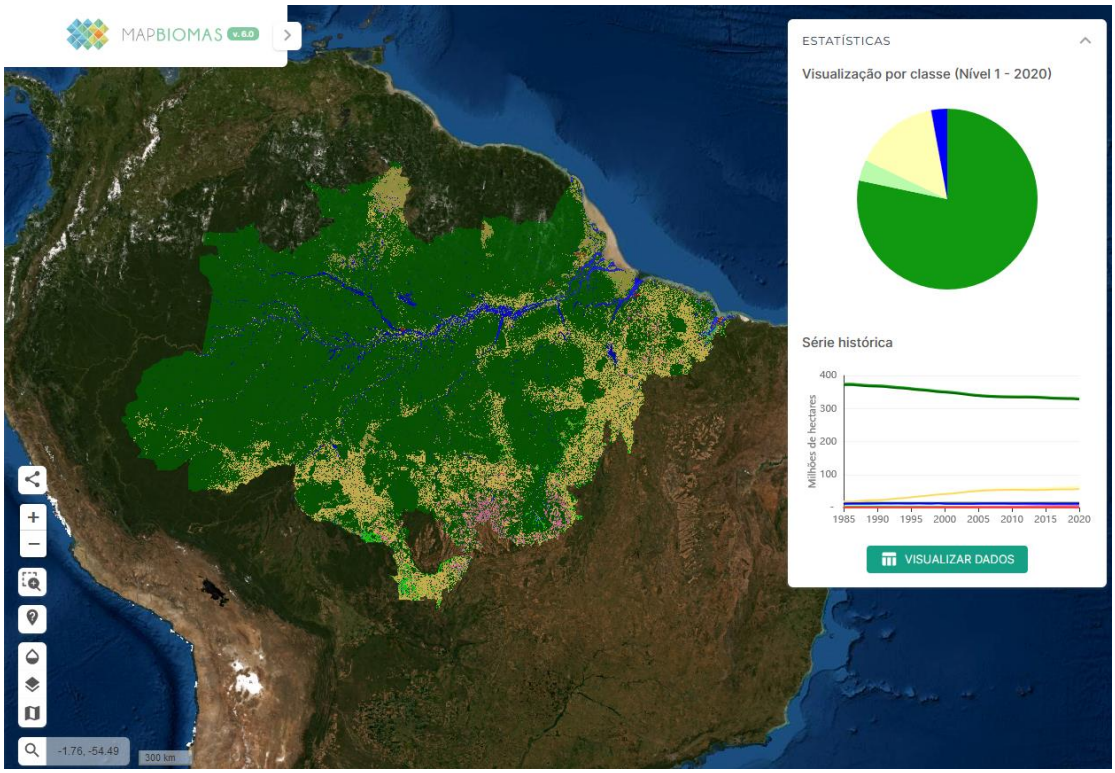


Figure 53: Type and land use in the Brazilian legal Amazon, together with statistics and time series of the transformation of areas between 1985 and 2020. The figure was extracted from the MapBiomas platform.

Table 15 presents the fraction of natural forest, agricultural and non-forest formation in the region of the municipality of six Amazonian sites in which there are NASA stations for monitoring air quality, called AERONET (Aerosol Robotic Network), namely: Manaus, ATTO, Cuiabá, Rio Branco, Ji-Paraná and Alta Floresta. All these data were obtained directly from the MapBiomas platform. For the ATTO site, we considered the region of the municipality of São Sebastião do Uatumã since the site is located in this municipal region. In addition, Table 2 also presents the amount of forest loss and agricultural coverage gain between 1985 and 2020. Alta Floresta is the site with the smallest fraction of forest and the largest fraction of agricultural land

in 2020. In particular, this region of the municipality is the one that suffered the most from deforestation over the years.

Table 15: Fraction of forest, agricultural and non-forest natural formation in the six Amazonian sites in 2020 and the fractional percentage of forest and agricultural land loss.

Site	% Forest (2020)	% $Loss_{Forest}$ (1985 - 2020)	% Agricultural (2020)	% $Gain_{Agricultural}$ (1985 - 2020)	% Non-forested natural formation (2020)
Alta Floresta	46.59	38.92	51.73	38.45	0.23
Ji-Paraná	64.73	13.54	33.34	13.51	0.63
Rio Branco	67.62	21.62	30.62	21.10	1.08
Cuiabá	61.43	14.83	30.03	12.83	5.80
Manaus	80.44	0.35	3.14	0.21	0.48
ATTO	92.91	0.66	1.18	0.68	1.83

In comparison, in 1985, the fraction of forest in the region was about 85%, with 13% of agricultural land. This big change was induced by the gold rush in the 1980s and, more recently, by the advancement of different crops, such as sugarcane and soybeans. Following the same pattern, Ji-Paraná, Rio Branco, and Cuiabá also showed a strong reduction in forest concentration, of 13.54, 21.62, and 14.83%, respectively, and an increase in the fraction of agricultural area in the same value of the loss. The relationship is directly observed in Table 1. In particular, in 2020 these urban areas have very similar fractions of forest and agricultural areas, although Cuiabá has a relatively large amount of non-forested natural formation, which could influence biosphere-atmosphere interactions. In contrast, sites in central Amazonia have the highest fraction of vegetation cover and the lowest forest loss converted to agricultural areas. In 2020, Manaus had 80.44% forest cover, with a loss of 0.35% of land to agricultural land in the last 35 years. São Sebastião do Uatumã, the region where the ATTO Site is located is also one of the most preserved in the entire Amazon rainforest.

In 2020, ATTO had about 93% of forest cover and only 1.18% of the fraction dedicated to agriculture. The conversion of forest area for agriculture was shallow, at 0.66%. The results show that the atmospheric dynamics around the ATTO are predominantly dominated by forest emissions, as mentioned elsewhere. In relation to Manaus, the region is also dominated by forest emissions. However, urban and thermoelectric emissions contribute significantly to the atmospheric aerosol balance, which can lead to the formation of new organic aerosol particles.

In particular, this project has developed a special collection of MapBiomas, MapBiomas Ar, which is planned to be an extension and also a new data collection of the MapBiomas project. In this aspect of the work, the team has integrated information on pollutants (for example, greenhouse gases - GHG- and aerosols) and meteorological variables into the platform in order to investigate the relationships between land use transformations, for example, discussed in Table 15, and GHG variability in the Amazon biome. It will be possible to look not only at specific sites, as described above, but also at the forest as a whole, since all data are extracted from platforms based on remote sensing.

All construction of the data repository specifically for MapBiomas Ar is developed on Google's infrastructure, via Google Earth Engine. The Google Earth Engine platform was recently incorporated and used by the group as a very efficient tool to visualize, analyze and process large amounts of environmental data, such as greenhouse gases, precipitation, temperature, and land use/type in the Amazon region. The GHG data repository is fully based on publicly available geospatial datasets, spanning different time periods and resolutions from temporal and spatial satellites. The cloud-based platform allows the user to easily access remote sensing data already stored on Google's servers as different data collections and perform fast complex calculations using high-performance computing systems installed around the world.

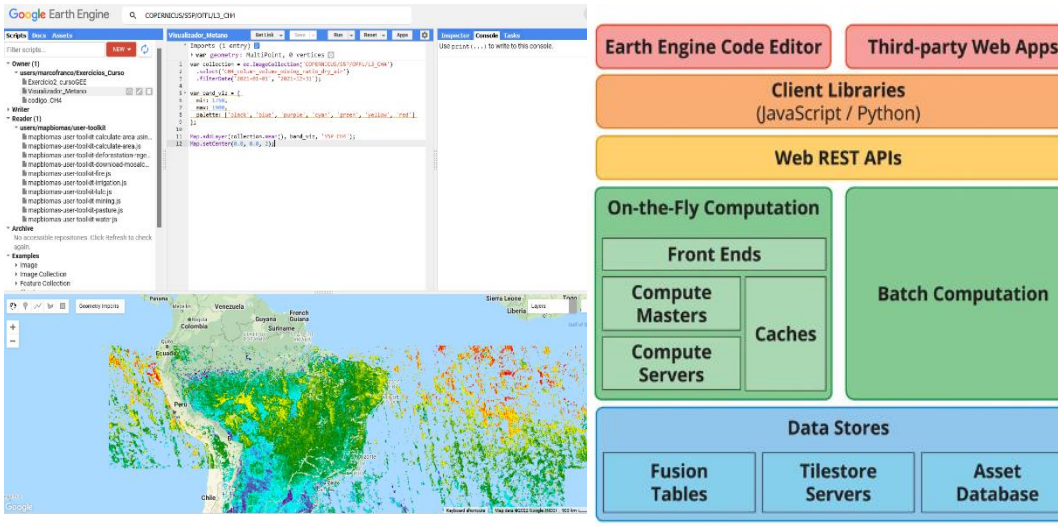


Figure 54: Left, Google Earth Engine user-friendly interface, showing scripts (left), code editor (middle) and console (right). The map at the bottom of the panel shows the CH4 concentration in some regions of South America obtained from the Copernicus data collection. On the right, a simplified diagram showing the GHG system architecture, based on user interfaces, JavaScript/Python platform libraries and environments, REST web APIs, compute grid, and storage servers.

Figure 54 on the left shows the user-friendly interface, where different collections of environmental data can be accessed and visualized using JavaScript-based algorithms and functions. In particular, it shows as an example the concentration of CH4 in some regions of South America, where the Amazon rainforest is located. It is worth mentioning that there are other APIs developed for Python and REST that can also be used if you prefer. The main advantage of using GHG for this particular research is that the entire process is cloud-based, the scientists can directly collaborate with each other in real time, and there is no need to store the data locally. In addition, the datasets already available allow us to immediately start forecasting regions of interest that are crucial for the availability of the carbon balance in the Amazon. Figure 1 on the right shows a simplified diagram of the GEE computing architecture. It is based on the direct integration of users and the entire Google infrastructure set, based on different web functionalities, high-performance computing grids and server storages.

To date, the group has completed what was called Phase 1, which aimed to compile data on monthly averages of CO, CO2, CH4, precipitation, minimum, average and maximum temperatures and aerosol optical properties. All Phase 1 datasets were obtained aiming at the highest level of data quality, but which may compromise, for example, its spatial resolution. In addition, data were compiled between the beginning of their measurements, which varies for each instrument/satellite, until the end date of 2021-12-31.
This data is initially stored on a local server, at the Physics Institute of the University of São Paulo, and later processed and inserted into the Google Earth Engine platform. This process is

not trivial and involves external processing based on Python and sending the data to Google Earth Engine by experts from the MapBiomas team. All available data is stored in the form of an Asset, which is the structure that MapBiomas uses to store and make data available on the Google platform.

There are currently 4 image collections on the Google Earth Engine (GEE) cloud platform ready to be ingested on the MapBiomasAr platform. These are concentrations of carbon dioxide and monoxide, methane and precipitation. For the next few weeks, aerosol data will be processed to include in the collection. Figure 2 shows an example of GHG visualization of precipitation data. This information, when available on the MapBiomasAr platform, will make it possible to study time series and compare detailed biome data with gas concentration sweeps and meteorological variables

5.10.2 Activities related to the Cerrado ecosystems

As indicated in the previous report, we focused our investigation on the impacts of fire in Brazilian biomes, in particular interest in the Cerrado, and the development of a model to evaluate fire behavior.
We investigated the determinants of the impact of fire in the Brazilian biomes using a dataset of burned areas between 2001 and 2019 to simulate its future impact under alternative policy and climate scenarios. We began by deriving a fire impact index using a principal component (PC) analysis comprising the variables: 1. fire intensity, 2. fire recurrence, 3. burned area size, 4. mean time interval between successive fires, and 5. predominance of fires in the dry season. We considered as High Impact Fires (HIF) those areas whose values of the first PC were above the 90th percentile. HIF occurred in the Amazon, Cerrado, and Pantanal, but not in the Atlantic Forest, Pampa, and Caatinga biomes. As the main drivers of HIF, our spatial autoregressive models (SAR) (Amazônia R 2 = 0.66, Pantanal R 2 = 0.86 and Cerrado R 2 = 0.79) indicated the climate (Amazon, 25%, Pantanal, 53%, and Cerrado, 56%) together with land-use change (Amazon, 75%, Pantanal, 25%, and Cerrado, 38%). Most HIF occurred in native vegetation remnants (NVR) (55% in the Amazon, 86% in the Pantanal and 94% in the Cerrado), especially in places close to areas deforested over the last two decades. Only in Pantanal fuel loads (dry biomass) play a major role in HIF (22% of explanation). In the Cerrado, it only accounted for 4% of the observed variability and in the Amazon, it was not a significant factor. Over the analyzed period, HIF imposed a loss of 23%, on average, on the NDVI response of the native vegetation in the Amazon, 19% in the Cerrado and 16% in the Pantanal, thus indicating physiological stress. Simulations of future climate and land-use change pointed to a dramatic increase in HIF by 2050. Under the RCP4.5 and strong environmental governance scenario, HIF in the Cerrado would expand from the current 3% of the biome to 15%, from 7 to 8% in the Pantanal and from 0.7 to 1.2% in the Amazon. In addition, the impact of fire would intensify in 95% of the Cerrado, 97% of the Amazon and 74% of the Pantanal.

In the case of the Brazilian Cerrado, estimates of risk of fire are fundamental to prevent and fight wildfires. To this end, we developed a monthly fire spread probability model for the Brazilian Cerrado biome based on the historical relation between fuel loads and burned areas. To so, we firstly stratified the biome into 16 climatic regions, given the climate influence on fuel loads. We used historical burned areas and fuel loads from remote sensed data between 2015 and 2018 to build a non-stationary model that estimates fuel loads dynamics across the biome. Climate seasonality is the main factor driving fuel loads dynamics. The correlation between fuel loads and the best predictor (monthly mean precipitation) ranges from 0.27 to 0.88 (mean r = 0.61 and deviation of 0.18) across the Cerrado. The average amplitude of fuel loads is 32% between dry and rainy seasons. Our Bayesian fire risk model uses the burned area as a prior probability and fuel loads to estimate the posterior probability of fire spread. Our results show that the probability of fire spread highly correlates with historical burning events (r = 0.87). The recovery of fuel loads post-fire takes, on average, 2.43 years; however, our results point to a downward pathway of the biome's vegetation biomass due to frequent

recurrent fires. The models we developed provide a useful tool for improving the representation of spatial patterns and seasonality of fires in order to support management practices.

Finally, we continue to publish outreach papers and opinion articles to raise public awareness about the environmental challenges in Brazil. One of them is related to our work for the Brazilian Inventory of GHG emissions for the Land use sector and was published in a special issue of the journal *Ciência e Cultura*.

During the 2021-2022 period, we participated in a series of webinars to present the results of the AR6 IPCC reports contributing to capacity building and outreach on topics related to climate change impacts, mitigation, and adaptation.

6 Integration among components of the project in Year 5 and prospects for Year 6

As previously described in the subcomponents and cross-cutting themes, there is convincing evidence that our climate is changing, and that emissions of greenhouse gases from human activities are partly responsible for these changes and decisions in different sectors of society. The economy will need to take into account and manage the risks associated with climate change. It is also known that climate change is a source of uncertainty for decision makers, due to the limitations of our scientific knowledge about the dynamics of the Earth system and how the climate will respond to anthropogenic forces at different scales. At the same time, there are trends and evidence of global environmental changes exceeding the limits of the planet, with increased risk for society to advances in the science of climate change models and allow us to be sure to present and future modifications. Recent extremes in Brazil such as droughts and water crises in Pantanal and Southeastern and Northeast Brazil, as well as intense rainfall that have triggered landslides and flash floods in Petropolis, Angra, Maceio and Recife in 2022 shows how vulnerable are some sectors of the population, and also the biodiversity as in the Pantanal and Amazonia.

So far, our findings reveal that the number of disasters that occur significantly drives public support for environmental spending and that different types of disaster have heterogeneous impacts with wildfires and severe winter weather events being the most impactful. These results shed light on the impact of environmental events on public opinion on the environment, helping both researchers and policymakers make sense of dynamic public opinions.

So the challenge of the INCT MC2 is to provide an integration of all six components and three cross-cutting themes through dialogue and workshops, for a better understanding of the impacts and benefits arising from current climate variability, and help to think of ways to reduce the uncertainty surrounding the consequences of future climate change scenarios.

The new observations and projections of climate models and future scenarios of climate change should be placed in the context of these established thresholds and integrated assessment of adaptation options and pathways. Results of the IPCC AR6 WG1 report show that natural disasters like this in globalised cities pose risks for societies and the global economy in general and that climate change will fundamentally reshape life on Earth in the coming decades, even if humans can tameplanet-warming greenhouse gas emissions. Species extinction, more widespread disease, unlivable heat, ecosystem collapse, cities menaced by risingseas -- these and other devastating climate impacts are accelerating.

Among the components of Energy (Enio), Hydrology/Disasters (Adriana) and Water Security (Suzana and Mario) a proposal was submitted to the so-called FACEPE-FAPESP: https://fapesp.br/15355/chamada-publica-fapesp-facepe- 092022-support-for-research-in-the-

environment (is under review at FAPESP and FACEPE). It was a period of preparatory meetings to understand and integrate the expertise within a scope of utility for the climate-water-energy-ecosystems nexus. We are still awaiting an opinion from FACEPE and FAPESP.

Among the components of Economics (USP/FEA, Eduardo Haddad), Agriculture (EMBRAPA, Silvio Crestana + ESALQ/Patricia Marques) and Water Safety (USP/Mario Mendiondo) we participated in a doctoral qualification panel in the form of a "webinar open to the public ": https://youtu.be/19fhbAkRAFw . A derivative work of this qualification is the manuscript submitted under open discussion for review at NHESS: https://egusphere.copernicus.org/preprints/2022/egusphere-2022-498/

Among the sub-components of disasters (CEMADEN/Regina Alvala), health (FIOCRUZ/Elizabeth Rangel), health (FSP/USP, Adelaide Nardocci, guest) and water security (EESC/USP, Mario Mendiondo) the 3rd webinar "Uma Gota of Science, A Dose of Resilience" (https://www.youtube.com/watch?v=GVX-ITZzKyk), which was the kick off of a new book to be co-edited by the participants of the webinar to be released in 2023

This task of coordination can help decision makers to recognize and assess the risks arising from a change in climate, making the best use of available information on climate change, its impacts and appropriate adaptive responses as a project of true integration. In the initial proposal we planned various workshops (total of six), which will lead to the preparation of documents and reports that to guide the upcoming workshops. Due to budget constraints we decided to have 5 workshops starting on 2019 until 2023. We had one workshop in 2019, but due to the pandemics we decided to have our meetings virtually, and so far we have one in 2020 and another in 2021.

Lastly, TV Cultura will show the documentary Rios Voadores, a partnership between Grifa Filmes, ZED e Arte France. This documentary was awarded the Deauville Green Awards, Silbersalz Festival e Festival Du Film Scientifique 2022 (França).

Although risk management has contributed to reduce vulnerability to climate-driven extremes, unprecedented floods and droughts have increased societal impacts because of lack of interdisciplinary actions at local scales. This is one conclusion in a new paper published in Nature (https://www.nature.com/articles/s41586-022-04917-5) using a global dataset from paired-flood-and-droughts events with contributions from INCTMC2's scientists. On the one hand, this Nature's paper brings a viable framework on how drought-and-flood impacts are shaped by risk factors (hazard, vulnerability and exposure), but strongly modified by the types of management. The approach to resilience (i.e. mitigation, adaptation or even transformation pathways) also matters and shapes the way lessons are learnt, or not. Cases with poor dialogue or interdisciplinary exchange among stakeholders tend to produce poor resilient solutions. On the other hand, the general framework of this Nature paper proposes feasible metrics to boost interdisciplinary dialogue among different localities. It thus would incentive future papers from local experiences with floods and droughts using science-for-policy, like the INCTMC2 is promoting..."

7 Plans for Year 6 of the project

Plans for the sixth year include further approximation with researchers from the subcomponents 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 4th National Communication (4CN) to UNFCCC. Under the leadership of the energy component, together with the food security to write a conceptual paper on integration of various components of the INCT MC2 facing problems linked to climate change, energy and food security and national security. The disasters component will work

with the economy component working on the impacts of flashfloods in the city of Sao Paulo and mobility, using data from Uber form the last 3 years.

7.1 Food security

For next year (Year 6), a database will be structured in the manner presented at the beginning of the report where all the information obtained over the last four years will be made available, as well as the finalization of the evaluations of the economic impacts with the respective livestock cost spreadsheets.

7.2 Water security

After COVID-19 pandemic impacts endured between 2020 and 2022, with social distancing, travelling restrictions and temporary closing of research labs did impose a new adaptation effort to INCTMC2 water security tasks. Notwithstanding, either objectives or goals are maintained and rescheduled. Hence, for the sixth year, INCTMC2 water security scientists promote actions for :

- rescheduling hibrid (remote+presencial) workshops with key partners in Brazil (SBPC, CEMADEN, INPE, ANA), especially revisiting and updating database of river catchments of flood risk prone areas; this activity has started in the period 2016/2017, but temporary paused because of changing workforce and other INCTMC2 priorities during COVID pandemic;
- consolidating final activities on water security indices in key basins for ANA/PNSH, with main focus on uncertainty analysis in prospective water infrastructure systems, linked to the new sanitation framework (Federal Act # 14.026) and Payment for Ecosystem Services (Federal Act # 14.119);
- enhancing new science-and-policy cross-partnership among Brazilian state agencies, i.e. APAC in Pernambuco, FUNCEME in Ceará, and statewide climate-and-resilience science groups, i.e. University of Sao Paulo's INCLINE (Center for Interdisciplinary Climate Investigation) and CEPED/SP (Center for Education and Research in Disasters),
- outreaching stronger communication activities on "water security and climate change", in partnership with INCTMC2's scientists from UFPE, UFC, UFPB, UFCG, USP and UFRGS, through the Brazilian Water Resources Association Education Technical Commission (ABRHidro/Ensino) linked to the UNESCO Chair on Water Security(USP),
- coauthoring new original papers with more INCTMC2's affiliated institutions,
- leading webinars with other INCTMC2's subcomponents, addressing the integration of SDG's, DRRs and COP/IPCC's recommendations,
- managing integrated activities with the Center of Applied Maths for Industry (CeMEAI) and the Center for Artificial Intelligence (C4AI) to optimize startups and spinoffs using database and modelling climate change scenarios;
- merging new insights of INCTMC2 water securrity with worldwide initiatives like the Global Climate Research Program (WMO/UNESCO/ISC) the UNEP World Water Quality Alliance, and Future Earth,
- promoting new Regional Centers of Global Water Security e-Courses in Brazil, in partnership with other UN Water Learning Centers, to boost interdisciplinary training using INCTMC2's experiences and lessons learnt,
- recommending "examples of circular governance on water security under climate change", with an open repository to be updated until the sixth year of the INCTMC2 (https://drive.google.com/file/d/1YXRuVqFsF0iS6IvU2FjyA8H2D4sZrHUP/view?usp=sharing).

7.3 Health and climate change

For the health component, we will study the spatial distribution of *Lutzomyia longipalpis* in the Southeast Region of Brazil in three time frames (historical, current and future) considering climate change scenarios. The results may fill gaps on the current picture of the geographic distribution of the species, vector of the etiological agent that transmits visceral leishmaniasis, as well as its adaptation to new environments. Through the development of ecological niche models; probability maps of occurrence in different scenarios; study of the correlation between the increase in deforestation, rates of human cases of visceral leishmaniasis and the presence of the sand fly vector, observing possible areas of expansion of American Visceral Leishmaniasis.

These projects had been expected the production of information that can indicate and show trends in the probability of occurrence of communicable diseases in future climatic conditions. With the current increase of global warming, the results produced here can collaborate with public authorities in the development of strategic planning to mitigate the effects of global warming.
Other activities include meetings between the technical team, data collection and analysis, scientific publications on research results ("Analyzing the Sars-Cov 2 epidemic from a socio-climate perspective" and "Analysis of the spatial and temporal variability of the mortality rate in Brazil associated with variations in atmospheric electromagnetism").

Other activities include:
- Production map of the spatial distribution of the LVA vector, *L.* (*L.*) *longipalpis*, in the states of the Southeast Region. To produce an ecological niche model of visceral leishmaniasis in the states of the Southeast Region, focusing on the historical and current temporal. To design ecological niche models of the visceral leishmaniasis vector in two climate change scenarios.
- Based on future projections in different climate change scenarios, it should be expected to prepare thematic maps of the spatial distribution of *L.* (*N.*) *whitmani*, discuss probable areas of expansion or contraction of *L.* (*N.*) *whitmani* in the states of the Southeast Region of Brazil, and evaluate the vulnerability of the Brazilian population to occurrence of ACL outbreaks in climate change scenarios.
- Elaboration of the systematic review with the theme "Relationship between climate and Covid 19 transmission" (in progress).
- Modelling the effects of climatic conditions on Covid-19 (in progress).
- Production of information that can indicate and show trends in the probability of occurrence of COVID-19 in future climatic conditions. With the current increase of global warming, the results produced here can collaborate with public authorities in the development of strategic planning to mitigate the effects of global warming.
- Participation in technical meetings for discussion and dissemination of results.

7.4 Energy Security

For the COPPE/AM team, improvements in the current models, especially regarding their capacity to encompass and represent the water-food-energy nexus are expected. Further, it is planned a study of different possible pathways of the energy system taking into account the impacts of COVID, using a scenario methodology in the IAM tools. For the INPE team, the evaluation of CMIP6 climate change impacts on energy resources will continue, including a spatial and seasonal analysis of the models performance to develop a smart ensemble output. These outputs will produce distinct scenarios for solar and wind power resources over Brazilian territory. Continuing a previous activity published with the support of this INCT, on the influences of extensive aquatic systems for local environmental conditions, the Federal University of Itajuba should start a campaign in the Furnas reservoir, with the support of a another CNPq project. Initially, there will be six days of field campaign, where data will be collected continuously with the instruments hosted in the stabilization system on board of a catamaran anchored in the middle of the reservoir. Similarly, the Federal University of São Paulo will be developing a solarimetric data collection system on a floating platform in the

Sobradinho hydroelectric reservoir, also with the support of another CNPq project. In both cases, although such activities do not have direct support of this INCT, they will be contributing to the integrated understanding of the water-energy-food NEXO by providing important data that can support studies in the context of the efficient use of natural and renewable energy resources with low environmental impact.

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

The next steps to be developed during the year 6 of the subcomponent are detailed below.

– Effectiveness analysis of the current urban legal instruments concerning the risk management of floods-associated disasters. Assessment of possible gaps in municipal urban planning instruments that make risk management difficult or preventable. For this, a case study will be carried out for the municipality of Pouso Alegre, Minas Gerais, which has a known history of disasters associated with flooding.
– Develop a vulnerability index to support monitoring the impact of urban drought in Brazil, considering two stages. In step 1, an indicator of vulnerability to urban drought will be proposed, based on socioeconomic and environmental data, for the whole of Brazil; step 2 will include the composition of an index for monitoring the impact of urban drought based on climatological variables and the step 1 indicator.
– Evaluate the occurrence of extreme drought in the Matopiba region based on drought indices from 1981 to 2020; characterize the dynamics of land uses and land cover in the area; and trends analysis of precipitation, temperature, and drought indices considering different land-use transitions over the Matopiba.
– Evaluate, with Blumenau stakeholders, the results obtained from SisVuClima implemented for the city of Blumenau, as well as (i) the places most susceptible to landslide risk and flooding associated with precipitation in the city; (ii) projections of future precipitation that may affect the city using the CMIP5 and CMIP6 models. These evaluations will be used to plan, together with Blumenau Stakeholders, the adaptation strategies which should contribute to mitigate impacts from climate-related disasters in the city, and amplify its resilience to climate risks.
– From the preliminary results about disaster occurred in BA, ES, MG, and RJ during the last summer season, some questions arise that guide the next steps to continue the assessment of impacts, that is (i) What is the historical behavior of the occurrences of disasters caused by convective storms, in terms of the spatial distribution and the intensity of the impacts? (ii) Is there a correlation between the magnitude of these storms and global phenomena, like El Niño?. In addition, efforts are being invested to propose alternatives for the composition of a population fragility index in the face of this phenomenon, which considers the combination of physical and social variables presented in this preliminary assessment, as well as others that may contribute to the discussions.
– In order to complement the analysis of risk in Itajai basin, studies of economic loss perceptions and assessment of vulnerability will be developed.
– Understand compound extreme events on land and in the ocean and determine their combined impacts on coastal urban communities, including on tourism, fisheries, aquaculture and human health.

7.6 Economy and impacts in key sectors

Plans for the sixth year include continuing and further approximation with researchers from the subcomponents “Natural Disasters” and “Water Security” to develop joint projects further. Moreover, as pointed in the previour report, the Fapesp granted scholarship abroad for Paula Pereira Pereda to develop the project “Assessing the Climate and Weather Effects in Brazil using Panel Data” at Yale University, which has provided additional incentives to integration with other areas of the INCT, mainly related to health and agriculture. Finally, an array of recent FIPE projects with Uber has granted us access to the Uber Movement database stimulating the

integration with the subcomponent "Natural Disasters". The protocol between NEREUS and Uber to have access to the data had been signed but the initiative was halted during the pandemic. In our last annual meeting, we decided, together with colleagues from CEMADEM, to resume this project. In addition to researchers at USP, researchers at CEMADEN already have access to the data to write a collaborative paper on the effects of climate on urban mobility and the associated economic costs. We also plan to continuing devoting time to integrating the land use findings with the computable general equilibrium model, as mentioned above.

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

- Due to the lack of adequate supercomputer power at INPE during the period, the CMIP6 SSP's scenarios planned for year 5 of the project are postponed for the year 6. 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.

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.
The RESM - Eta Model had received most of the support from CAPES project funds from ANA - National Water Agency. This project ended in December 2021. A FAPESP posdoctoral fellowship to Isabel Pilotto ended in June 2021.
Further meetings between the components of INCT-MC2 toward joint articles production should be promoted.

7.9 Communication, dissemination of knowledge and education for sustainability

- The project "Socio-climatic imaginaries and meta-cognitions: their roles in interdisciplinary research and scientific communication in a case study of the National Institute of Science and Technology for Climate Change (INCT-MC)" approved in the call 26/2021 of the CNPq, will be developed. We await the result of the submission of the project "Perceive-make-forest: alliances between arts, sciences and communications in the face of the Anthropocene," coordinated by Susana Oliveira Dias, presented to the so-called LinCAr – Innovative approaches to research in Language, Communication and/or Arts 2022, from Fapesp.

- We request the approval of a third TT3 grant from Fapesp so that a grantee can make news based on the papers produced by researchers from the various sub-components of the INCT, conducting interviews with the authors and other researchers for ClimaCom journals and the INCT website. The materials can be produced in different formats, from news to interviews, reports, to podcasts, videos, among others. In parallel with the production, collaborative readings and analyses will be carried out on the problems involving communication and climate change problems. The idea is that the issues to be worked out arise from the relationship between the researchers of this INCT, the production of materials, and the proposed bibliographies. Through these relationships, we aim to explore and broaden the understanding of the effectiveness of climate change communication in dialogue with the philosophy of science, environmental philosophy, and the social studies of science and technology.

- Two new ClimaCom dossiers will be launched with articles, essays, journalistic materials, and artistic productions with the themes: "Plant Policies" and another to be defined. The participation of researchers from the various components of the INCT in the journal will be encouraged with the production of texts, interviews, participation in news, etc.
- We will produce a series of online seminars with members of the transversal theme, INCT scientists, guest artists, and representatives of indigenous peoples. The idea is to address topics such as "Climate and life," "Disasters," "Futures," "Possible modes of existence," "Art and nature," and "Anthropocene" from an interdisciplinary perspective and create new relationships and common problematic fields.
- We will produce the book "Abecedary of climate change" with articles published by INCT researchers, guest researchers, and artists.
- We will continue to develop the partnership with the Escolas Pelo Clima movement, Cemadem Educação, and the Maré de Ciência project, creating activities with schools on the theme of climate change.
- We will diagram the pdfs of ClimaCom magazines produced during INCT Climatic Changes Phase 2.
- Tatiana Plens Oliveira, under the guidance of Wenceslao Machado de Oliveira Júnior and Susana Oliveira Dias, will defend her doctoral thesis - Living-soil-Body: between cultivation lines - which thinks about the relationships between the body, the land/Land and the Anthropocene.

In general, and conducted by the coordination of the project, Years 6 and 7 will be dedicated to integration of the results of the project. All this proposed world focus on then need of transdisciplinarity. According to the National Confederation of Municipalities 2022, in Brazil since 2019 more than 200 people have died every year as consequence of those disasters. In 2022 only, by the end of June almost 500 people died due to such disasters. Most of them were due to floods, flash floods and landslides triggered heavy precipitation. While weather forecasts issued by the state and federal meteorological agencies for those events of heavy precipitation, rainfall amount was sub estimated in terms of intensity as well its spatial distribution across the cities. While a weather forecast if not a disaster risk forecast, it is expected that with the forecasts of disaster risk alerts this number would go down. However, the recent events of intense rainfall and disasters where it While rainfall extremes have become more intense and frequent in several regions of the planet, vulnerability of exposure of populations and towns are also increasing, making the risk of disaster higher (IPCC 2021, 2022). These two last components of the risk equation cannot be predicted by meteorological centers since they depend on several non-environmental factors such as communication, governance, cultural attitudes towards messages from the scientific communities. Thus, transdisciplinary research in climate change adaptation must be considered to reduce the impacts of climate change in the present and future climates, since it can help overcome some adaptation barriers, including knowledge gaps, uneven local adaptive capacity, and power imbalances affecting decisions, that at the end could affect lives. Adaptation is needed since the very beginning, to strengthen the link to extremes of climate variability and climate change, and transdisciplinarity is needed to scaling up our capacity to adapt to climate change impacts in support of disaster risk reduction and management. We then focus on the Brazilian context to propose adjustments to transdisciplinary research training and practice to make it more inclusive and effective in supporting climate change adaptation.

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

We will continue the implementation of the MapBiomas Ar, with the integration for all of South America of greenhouse gas monitoring as well as land use change in the Google Earth Engine platform. We will also continue to measure aerosol and trace gases continuously at the ATTO tower. We will perform a large aircraft experiment in

Amazonia, the CAFÉ-Brasil experiment, scheduled for December 2022 and January 2023. The Cerrado component will continue the important work of the Brazilian emission inventory, as well as research related to fire emissions.

8 Events organized by the INCT MC2 and its components with interaction among sub components of the project in Year 5

1. Reunião com o Vice coordenador do projeto INCT MC2 Tercio Ambrizzi, 20-22 2021, USP Sao Paulo.
2. Reunião com o Vice coordenador do projeto INCT MC2 Tercio Ambrizzi and with Marcos Buckeridge líder of the INCT-Bioetanol, 29 Novemner-2 December , USP SP.
3. Reunião com Dra Marta Barata do IOC/FIORUZ, Dr Regina Alvala from CEMADENM and Dr. Elizabeth Rangel from FIOCRUZ-MG
4. Meeting of leaders of the component of the INCT MC2 on June 9-10 2022 at USP SP.
5. Meeting with Subcomponentes do projeto do INCT MC2 – INCT Climatic Changes
Date: 03/08/2021; Participants: Mário Mediondo, Margarete Afonso, Simone Costa
Link: https://meet.google.com/ruw-efrm-oqb?pli=1&authuser=0
6. Interdisciplinary meeting on collaboration on the Book CEPED; Date: 10/02/2022.Participants: Eduardo Mario Mendiondo, Marina Batalini de Macedo, Regina Alvava, Elizabeth Rangel, Maria Clara Fava
7. Monthly meetings to assess and forecast the impacts of extremes of hydro-geo-climatic origin on strategic activities for Brazil, organized by CEMADEN, Date: 08/04/2022, 14h30 (last meeting); Link: https://conferenciaweb.rnp.br/webconf/reuniao-impactos-cemaden; Participants: Elizabeth Ferreira Rangel, Margarete Martins dos Santos Afonso
8. Monthly meeting to assess and forecast the impacts of extremes of hydro-geo-climatic origin on strategic activities for Brazil***;*** Date: 11/5/2022**,** às 14h30***;*** Link**:** https://conferenciaweb.rnp.br/webconf/reuniao-impactos-cemaden; Participants: Elizabeth Ferreira Rangel, Margarete Martins dos Santos Afonso
9. Meetings between the technical team of the health component. December 2021. Meeting subject: data analysis
10. Meetings between the technical team of the health component. May 2022. Meeting subject: preliminary results of the analysis
11. Meetings between the technical team of the health component. June 2022. Meeting subject: final results of data analysis
12. NEREUS at FEAUSP hosts a weekly seminar, on Mondays, during the academic year. In 2021-2022, the events started online and moved in presence in March 2022 due to the improvement of the pandemic scenario. 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)
13. Workshop in 2022 focusing on "The Economy of Mantiqueira", involving different components of the INCT. The first part of the workshop took place in Itajubá (UNIFEI), where the focus was on discussions with local policymakers, and the second part took place in Gonçalves, MG, where the discussion was more technical. (https://unifei.edu.br/evento/seminario-internacional-a-economia-da-mantiqueira/)
14. The INCTMC2 water security subcomponent, with the Center for Education & Research on Disasters (CEPED/USP, www.eesc.usp.br) & LabJor/Unicamp (http://www.labjor.unicamp.br/) boosted the "open science campaign" #OneDropOfScience #OneDoseOfResilience with webinar on "Climate, Health & Resilience" (https://www.youtube.com/watch?v=GVX-ITZzKyk), with INCTMC2's subcomponents of Disaster Risk Reduction (Dr R. Alvala, CEMADEN), Health Security (Dr E. Rangel/FIOCRUZ) and FAPESP-Belmont Forum (Prof A. Nardocci, FSP/USP). Also, INCTMC2 supported the SBPC 74h Annual Meeting Seminar "Interdisciplinary on Climate Change Research" https://youtu.be/Uqag28p7YYU.

15. Also, parallel Actions on science popularization were performed under FUNCEME's Papo CoNexus Talks (@papoconexus) with free webinars of Dr. Christian Leduc, IRD (https://youtu.be/6Xbya6GTMEU), Dr. Karen Ryberg, Dakota Water Science Center (https://www.youtube.com/watch?v=V0RnDfvp1mI), Prof Patrick Reed, Cornell University (https://youtu.be/6Xbya6GTMEU), Dr Molle Fraçois, IRD/G-EAU (https://youtu.be/mGRbYxE4vQ0). Moreover, INCTMC2 also accepted indepedent webinars(https://www.youtube.com/watch?v=_PeCKfCPOec) and with UNESCO-PechaKucha #AguaTodavia podcast (https://www.pechakucha.com/presentations/the-route-of-water-eng).
16. On the other hand, INCTMC2 Water Security Subcomponent participated in the IAHS Panta Rhei Decade Meeting and the IAHS' 100th Anniversary Interdisciplinary Meeting in Montpellier, France (May/June, 2022) and in the 5th Int Symposium of Healthy Rivers & Sust. Wat. Resou. Mgmt under UNESCO-IHP-IX

9 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)

1. CID GARCIA, Gabriel. Coordinator of the workshop 'Podcast production, scientific dissemination, and humanities' at the IX National Symposium on Science, Technology, and Society – ESOCITE.BR 2021, online.
2. CID GARCIA, Gabriel. Participation in the session' Conversation with authors', regarding the launch of the book 'Science in focus, vol. 3 – Cinema, culture and thought', at the IX National Symposium on Science, Technology and Society – ESOCITE.BR 2021, online.
3. DIAS, Susana. "Communicating how to perceive the forest: the generation of rare kinships between arts, sciences and philosophies", presented in the framework of the VIII International Congress of Public Communication of Science and Technology (COPUCI), held on days 2, 3 and 4 March 2022 in the city of Bariloche-Argentina.
4. DIAS, Susana. The forest camera. Lecture given on 03/14/22 in the series of meetings "Conversas sobre a camera obscura", promoted by Casa de Eva, in Campinas-SP
5. DIAS, Susana. As a debater at the table "Encontros mais que humano" of the event "Encontros nos Labirinto", organized by the Labirinto group from Labjor-Unicamp, on 10/21/2021.
6. DIAS, Susana. A TREE is already a RHIZOME. Presentation of work on Thought Fold 23 of the 10th. Online edition of Raias Poéticas, on August 6, 2021. Available at: https://www.youtube.com/watch?v=DSTosxWhv0k&abchannel=RevistaInComunidade
7. DIAS, Susana; BELLINI, Larissa; BARBOSA, Rayane; PINTO, Paulinha Luiz. MULTI-SPECIE COMMUNICATION: THINKING WITH THE ATMOSPHERE, PLANTS AND ANIMALS. Paper presented at the IV Congress of Support Projects for the Permanence of Undergraduate Students at Unicamp - PAPE-G, held from 12/14/2021 to 12/15/2021 in Campinas.
8. DIAS, Susana; SOUZA, Karolyne; BELLINI, Larissa. "Gaia-graphy of images: thinking with an artemosphere between flows and breaths". Paper presented at the VI International Colloquium Education through images and their geographies, promoted by OLHO - Laboratory of Audiovisual Studies, from November 08, 2021 to November 10, 2021, on an online platform.
9. DIAS, Susana; SOUZA, Karolyne; BELLINI, Larissa. Telling stories between arts and sciences as a nest: scientific dissemination in the face of the perceptive deafness that marks the Anthropocene. Paper presented at EDICC VIII, a meeting promoted by the Master's Program in Scientific and Cultural Dissemination of the Laboratory of Advanced Studies in Journalism (Labjor) of the State University of Campinas (Unicamp), from October 19 to 21, 2021.
10. MATTOS, Thamires Ribeiro de; AMORIM, A. C. R. . Anthropo-scene: Cultural Sudies and Post-Foundational Theories of Curriculum in The Handmaid's Tale. 2002 AAACS Conference. (Work/Congress Presentation).
11. TADDEI, R. Advancement of climate change: consequences and perspectives. II National Week of Environmental Sciences (SENACAMB), 11/11/2021. Available at

https://www.youtube.com/watch?v=xLfMtwwJnw&t=16s
12. TADDEI, R. Disaster Science. Rede Clima 15 years. 04/12/2022. Available at https://www.youtube.com/watch?v=EBJK331lpko
13. TADDEI, R. Social dimensions of climate change in Brazil: perceptions and perspectives. Debate series "Science, risk and disasters". São José dos Campos, Cemaden, 03/24/2022.
14. TADDEI, R. II Forum of Young Ocean Ambassadors, mediator of the COP26 session: changes and our lives. Maré Science Project/Unesco, Santos, 11/10/2021. https://www.youtube.com/watch?v=nSshDcK3570&t=3601s
15. TADDEI, R. III Forum of Young Ocean Ambassadors, facilitator of the session The UN conference on climate change (COP27). Maré Science Project/Unesco, Santos, 06/15/2022. Available at https://www.youtube.com/watch?v=0I2NCEpzKHE
16. TADDEI, R. Interventions of another nature: resources for thinking about (and outside) the Anthropocene. Course History, Environment and Knowledge in the Anthropocene. Osvaldo Cruz House, Osvaldo Cruz Foundation, 05/30/2022. Available at https://www.youtube.com/watch?v=AzlpNFz0MdA&t=3160s
17. TADDEI, R. Thinking about climate change in the context of the Anthropocene. Opening lecture of the IV Academic Week of Research, Innovation and Extension of the State University of the Tocantina Region of Maranhão (UEMASUL), on February 22, 2022. Available at https://www.youtube.com/watch?v=8LsO4kn9ox8
18. CID GARCIA, G. Monthly virtual conversations of the Pedagogias da Imagem extension project - cineclube of the Faculty of Education at UFRJ, with lectures and debates with invited researchers, motivated by a film: December 16, 2021 - Film: A cloud rosa, by Iuli Gerbase, 2019 Lecture title: The cloud, the body, the same: pandemic-form and ways of educating in the present. Guest: André Bocchetti - Faculty of Education/UFRJ
19. TADDEI, R. VIII Meeting of Anthropology of Science and Technology, Federal University of São Carlos, 2021. Member of the scientific council.
20. ROVERE, E. L. L.; MELLO-SILVA, C. C.; BARATA, M. M. L. . 1ª Conferência Latino-Americana de Saúde e Educação Ambiental: das mudanças climáticas à qualidade de vida nas cidades. 2021.
21. Marengo, et al : The INCT for Climate Change Phase 2-Water resources and security component. B-EPICC Kick-Off Workshop on August 23 and 24, 2022, in São José dos Campos (São Paulo)
74ª Reunião Annual SBPC. Painel: ESTRATÉGIAS PARA ENFRENTAR O NOVO NORMAL DOS EVENTOS CLIMÁTICOS EXTREMOS NO BRASIL29/7/2022 – Brasília (virtual) https://www.youtube.com/watch?v=fEYoP2oFq_8
22. 74ª Reunião Anual da SBPC, mesa-redonda intitulada "Interdisciplinaridade na pesquisa sobre mudança climática", no dia 28 de julho de 2022, às 14 horas, pelo canal da ESOCITE.BR, link: https://youtu.be/Uqag28p7YYU
23. 74ª Reunião Annual SBPC. Reunião de Coordenadores de INCTs, L29/7/2022 – Brasília (virtual), 26 de julho de 2022
24. Café Filosófico. Palestra Clima & Natureza, 4 de agosto de 2022, Campinas
25. Seminário "O Impacto da Ciência na Sociedade e no Avanço do Conhecimento: os novos desafios da pesquisa orientada a missão". 21 de março de 2022 – das 10h às 14h, FAPESP, SP.
26. INCT-Mudanças Climáticas Fase 2, Maio 2022, Brasília (onl\ine)
27. INCT e Sustentabilidade do Planeta: Terra, Mar e Ar: Pesquisa e Desenvolvimento em Mudanças Globais: O INCT para Mudanças Climáticas Fase II, Junho 22 2022, Webinar ABC/CNPq, Rio de Janeiro (virtual)
28. Extremos da variabilidade do clima e mudanças climáticas e Segurança Alimentar no Brasil e na América do Sul, Webinar Entendendo as Mudanças Climáticas Agricultura -

segurança alimentar - recursos hídricos, FUNDAG, Campinas 27 Julho 2022 (virtual)

29. Impact based Early Warning System at a Urban Scale: The Brazilian Experience in DRR, WMO Urban Workshop, Geneva 13-15 June 2022

30. CSSP Brazil Annual Science Hybrid Workshop: Heavy rainfall associated with natural disasters in South-eastern Brazil in November-December 2021: Meteorological context, CEMADEN/MCTI, 28th-30th June 2022

31. Pensando o Clima na Cidade de São Paulo – Assimetrias, Conflitos e Soluções. Organização: Prefeitura da Cidade de São Paulo. Titulo: Mudanças Climáticas e Eventos Extremos na Cidade de São Paulo. Período: Set/2021.

32. Simpósio em Clima, Água, Energia e Alimentos. Organização: SIMCLEA. Titulo: IPCC AR6, Mudanças Climáticas e Eventos Extremos. Período: Out/2021.

33. XXIV Simpósio Brasileiro de Recursos Hídricos. Organização: ABRHidro. Titulo: Aquecimento Global, Eventos Extremos, Mudanças Climáticas e o AR6 IPCC. Período: Nov/2021

34. Webinars da Academia Cearense de Matemática (ACM). Organização: ACM. Titulo: Variabilidade Climática e suas Mudanças: Passado, Presente e Futuro. Período: Fev/2022.

35. Webinar – Panorama e Perspectivas das Mudanças Climáticas. Organização: Consórcio PCJ. Titulo: IPCC AR6, Mudanças Climáticas e Eventos Extremos. Período: Maio/2022.

36. Mudanças Climáticas e Seus Impactos. Organização: UNIPAMPA. Titulo: Variabilidade Climática e seus Extremos: Alguma relação com o aquecimento global?. Período: Maio/2022.

37. Participar juntamente com o diretor do centro de audiência presencial com o Exmo. Sr. Ministro de Estado da Ciência, Tecnologia e Inovações; e também participação na primeira reunião do Comitê Gestor de Cooperação (CSC em inglês), criado em 18/5/22 pelo Memorando de Entendimento entre o MCTI, o Centro Nacional de Monitoramento e Alertas de Desastres Naturais - CEMADEN, o Departamento de Comércio dos EUA-DoC e a Administração Oceânica e Atmosférica Nacional - NOAA , em Washington -DC, Estados Unidos da América. 11-16 Julho 2022

38. Reunião UKCSSP MCTI– Brasília –DF, 27=20 March 2022

39. Drought in Pantanal, 2º Seminário Estadual- IMASUL- Campo Grande /MS

40. USP-CENA Piracicaba, SP. Participação membro comissão julgadora concurso, 4-11 May 2022

41. Participation Forum Clima e Saúde – Hospital Albert Einstein -SP, May 18 2022

42. Participation representante do CEMADEN no Grupo Operacional de Monitoramento e Previsão de Secas do SISSA (Sistema de Informações sobre Secas para o Sul da América do Sul), em Buenos Aires, Argentina, 29 iunho-1 Julho 2022

43. Aquecimento Global, Eventos Extremos, Mudanças Climáticas e o AR6 IPCC, T. Ambrizzi, XXIV Simposio Brasileiro de Recursos Hidricos, Belop Horizonte, Novembro 202

44. IPCC AR6, Mudanças Climáticas e Eventos Extremos, T. Ambrizzi, Simposio em Clima, Agua, Energia e alimentos, 13-15 outubro 2021

45. Mudanças Climáticas e Eventos Extremos na Cidade de São Paulo, T. Ambrizzi, Seminario Pensando o Clima na Cidade de São Paulo, 24 setembro 2021

46. Variabilidade Climática e suas Mudanças: Passado, Presente e Futuro, T. Ambrizzi, Academia Ceaerense de Matematica, Fevereiro 2022.

47. IPCC AR6, Mudanças Climáticas e Eventos Extremos, T. Ambrizzi, Seminario Consorcio PCJ, Maio 2022.

48. Variabilidade climática e seus extremos: alguma relação com o aquecimento global?, T. Ambrizzi, Unipampa. Maio 2022

49. Margarete Martins dos Santos Afonso, Bruno Moreira, Simone Costa, Monica Magalhães, Elizabeth Rangel. Impactos das Mudanças Climáticas e do Desmatamento na Expansão das Leishmanioses no Brasil. 1ª Conferência Latino-Americana de Saúde e Educação ambiental: das mudanças climáticas à qualidade de vida nas cidades (1ª edição). November 16-19 2021.

50. Margarete Martins dos Santos Afonso, Bruno Moreira de Carvalho, Artur Augusto

Velho Mendes Júnior, Cristina Maria Giordano Dias, Lucas Keidel, Sandro Antônio Pereira, Patrícia Meneguete, Elizabeth Ferreira Rangel. Municipal vulnerability in the state of Rio de Janeiro/ Brazil, for transmission of American Visceral Leishmaniasis. WorldLeish7 - Leishmaniasis World Congress. Cartagena, Colombia, August 1-6, 2022.

51. Simone Miranda da Costa; Monica de Avelar Figueiredo Mafra Magalhães; Renata de Saldanha da Gama Gracie Carrijo; Elizabeth Ferreira Rangel. Geographic distribution of *Lutzomyia whitmani* associated with vegetation, and impacts on the expansion of American Cutaneous Leishmaniasis in Brazil. WorldLeish7 -Leishmaniasis World Congress. Cartagena, Colombia, August 1-6, 2022.
52. Elizabeth Ferreira Rangel, Margarete Martins dos Santos Afonso, Simone Miranda da Costa, Marco Aurelio Pereira Horta, Jéssica Milena Moura Neves, Bruno Moreira de Carvalho. Impacts of climate change on the occurrence of Leishmaniasis and COVID-19 in Brazil. Euro-Global Climate Change Conference. September 20-21 2022, Paris, France.
53. Modelagem Acoplada Oceano-Atmosfera-Biosfera e as Mudanças Climáticas, Paulo Nobre, Ph.D., Disciplina Mudanças Climáticas e Biodiversidade - UFPE, 14 de julho de 2021
54. Workshop Linking Human and Earth System Models for Global Change Analysis, Paulo Nobre, Ph.D., Aspen Global Change Institute, 19-21 July 2021
55. Webinar: NORDESTE PRÓSPERO! Ação De Desenvolvimento Socioeconômico Sustentável Do Semiárido Frente Às Mudanças Climáticas. Paulo Nobre, Ph.D., F. Francis Lacerda, Dra.. Brasília, DF, Instituto SAGRES, 2 July 2021
56. Webinar: O surgimento de manchas de óleo em Fernando de Noronha - um diagnóstico; Paulo Nobre, Ph.D., ComTecPolÓleo, Marinha do Brasil, 26 August 2021.
57. Webinar: e-NORDESTE PRÓSPERO! potencial energético regional como eixo de desenvolvimento nacional. Paulo Nobre, Ph.D., Confederação Nacional de Municípios-CNM, Brasília, DF, 31 October 2021
58. Webinar: Impacto do Clima nas Fontes Renováveis de Energia, Paulo Nobre, Ph.D., Associação Brasileira de Energias Alternativas e Meio Ambiente – ABEAMA, 7 October 2021
59. Webinar: Decarbonization & Climate Change: A Path To A Safe(r) Future!, Paulo Nobre, Ph.D., 1st Seminar on Upstream Decarbonization - SPE Brazil Section, 20 October 2021
60. Webinar: Adaptação à ocorrência de eventos meteorológicos extremos num mundo mais aquecido! Paulo Nobre, Ph.D., EPGMET, 2 December 2021
61. Webinar EMBRAPA "Tendências na Agricultura Irrigada Brasileira: Ambiente, Clima, Energia e Equipamento" . Chou Sin Chan . 15/07/2021
62. Workshop ANA: Na Oficina de Trabalho do Programa Nacional de Recursos Hídricos. "Modelos climáticos e bases de dados". Chou Sin Chan. 24/08/2021
63. Webinar: UERJ: "Técnicas de análise das Mudanças Climáticas Globais", em Aula de Teoria e Métodos da Climatologia" Chou Sin Chan. 3/11/2021
64. Round table by ABRHidro. "Mudanças Climáticas: O que sabemos e o que esperar?" Chou Sin Chan. 22/11/2021
65. Webinar Central Bank: "Modelos numéricos de previsão de tempo e clima e de projeções de mudanças climáticas" 4/10.2021
66. Webinar/workshop CAPES-ANA PRO RECURSOS HÍDRICOS: "Incorporação de previsões climáticas e hidrológicas nos horizontes sazonal e subsazonal visando orientar a gestão da alocação de água na bacia do rio São Francisco". Chou Sin Chan. 14/10.2021
67. Webinar/workshopCAPES-ANA Mudanças Climáticas e Recursos Hídricos: "“Inclusão de Esquema de Descarga Elétrica e Produção de NOx no Modelo Eta". Chou Sin Chan. 10/11/2021
68. Workshop on Environmental Geospacial Data and Health - II CIDACS. “.Forecast models for studies of climatic extremes” Chou Sin Chan..04/05/2022. (Hybrid)
69. Workshop: II Fórum Laboratório SisBaHiA.”Modelagem em escala local das mudanças climáticas”. Chou Sin Chan. 12/04/2022.
70. Workshop Sensoriamento Remoto e Agronegócio.”Modelagem atmosférica: previsão de tempo e clima”.Chou Sin Chan. 27/04/2022.
71. Webinar Aula Magna of the Post Graduate Programa of Water Resources UFPel - “Projeções de Mudanças Climáticas e alguns exemplos de impactos sobre os recursos hídricos”.

Chou Sin Chan. 22/04/2022.
72. Congresso Brasileiro de Energia Solar, 2022, Florianópolis. Avaliação da irradiação solar com modelo Brasil-SR em condições de céu claro – impacto de aerossóis na amazônia e cerrado. MARTINS, FERNANDO RAMOS; MADELEINE S. G. CASAGRANDE, NILTON E. ROSÁRIO, GONÇALVES, ANDRÉ RODRIGUES ; COSTA, RODRIGO SANTOS ; LIMA, FRANCISCO J. L. ; PES, MARCELO P. ; PEREIRA, E. B.
73. SILVA, J. G. ; VIANA, J. F. S. ; GUSMAO, A. C. V. E. L. ; Montenegro, S. M. G. de . VARIÁVEIS METEOROLÓGICAS NA ESTIMATIVA DA EVAPOTRANSPIRAÇÃO DE REFERÊNCIA NA BACIA DO RIO PIRAPAMA-PE.. In: IX Workshop de Mudanças Climáticas e Recursos Hídricos do Estado de Pernambuco e do VI Workshop Internacional de Mudanças Climáticas e Biodiversidade (IX WMCRHPE/VI WIMB), 2019, Recife. IX Workshop de Mudanças Climáticas e Recursos Hídricos do Estado de Pernambuco e do VI Workshop Internacional de Mudanças Climáticas e Biodiversidade (IX WMCRHPE/VI WIMB), 2019.
74. GUSMAO, A. C. V. E. L.; RODRIGUES, D. F. B.; ARAÚJO, DIEGO C. DOS S VIANA, J. F. S.; MONTENEGRO, S. M. G. L. ESTUDO DA VARIABILIDADE DE ÍNDICES DE VEGETAÇÃO UTILIZANDO ANÁLISE DE AGRUPAMENTOS. In: IX Workshop de Mudanças Climáticas e Recursos Hídricos do Estado de Pernambuco e do VI Workshop Internacional de Mudanças Climáticas e Biodiversidade (IX WMCRHPE/VI WIMB), 2019, Recife. IX Workshop de Mudanças Climáticas e Recursos Hídricos do Estado de Pernambuco e do VI Workshop Internacional de Mudanças Climáticas e Biodiversidade (IX WMCRHPE/VI WIMB), 2019.
75. ALVES, P. B. R. ; DJORDJEVIC, S. ; JAVADI, A. ; Rufino, Iana A. A. . Challenges for SuDS implementation in developing countries context: does governance arrangements make it harder?. In: VIII OXBRIDGE CONFERENCE ON BRAZILIAN STUDIES, 2019, Cambridge.
76. BENTES, L. V. ; CARVALHO, R. M. C. M. O. ; RIBEIRO NETO, A. Preparação governamental para o enfrentamento às mudanças climáticas: uma análise institucional. In: IX Workshop de Mudanças Climáticas e Recursos Hídricos do Estado de Pernambuco, 2019, Recife. Anais do IX Workshop de Mudanças Climáticas e Recursos Hídricos do Estado de Pernambuco, 2019.
77. SOUZA, F A A ET AL, Why Should Brazilian Researchers Join Socio-Hydrological Research Opportunities?", In: XXIII Braz Symp. Water Res., Foz de Iguacu Nov., 2019 (full text), ABRHidro
78. 100th Anniversary of IAHS, Montpellier, France between 29 May and 6 June, 2022. Accelerating Inclusive Learning of Hydrology Under Change and COVID Times With Actions Towards a Panta Rhei Open Science for Future Earth (https://meetingorganizer.copernicus.org/IAHS2022/IAHS2022-748.html)
79. 100th Anniversary of IAHS, Montpellier, France between 29 May and 6 June, 2022. Index-based Insurance to Mitigate Drought Financial Losses for Water Supply Sector (https://meetingorganizer.copernicus.org/IAHS2022/IAHS2022-645.html)
80. 100th Anniversary of IAHS, Montpellier, France between 29 May and 6 June, 2022. Artificial intelligence for agricultural drought monitoring based on soil moisture and crop yield under change (https://meetingorganizer.copernicus.org/IAHS2022/IAHS2022-407.html)
81. 100th Anniversary of IAHS, Montpellier, France between 29 May and 6 June, 2022. Modelling urban floods in megacities: a comparative bibliometric review of traditional physically based and artificial intelligence models (https://meetingorganizer.copernicus.org/IAHS2022/IAHS2022-687.html)

10 List of publications

The papers published within the Year 5 of the INCT-MC2 included in the publication list reflects the activities of the subgroups that have funding other than FAPESP, as well as a continuous interdisciplinary work over the recent years.

1. CASAGRANDE, M. S. G. ; MARTINS, F. R. ; ROSARIO, N. E.; LIMA, F. J. L.; GONÇALVES, A. R.; COSTA, R. S. ; ZARZUR, M. ; PES, M. P. ; PEREIRA, E. B. . Numerical Assessment of Downward Incoming Solar Irradiance in Smoke Influenced Regions - A Case Study In Brazilian Amazon and Cerrado. Remote Sensing, v. 13, p. 4527, 2021.
2. DIAS, Susana. Uma árvore já é um rizoma: Antropoceno, clima e vida multiespécie. Revista Incomunidade, out. De 2021. Disponível em: https://www.incomunidade.com/uma-arvore-ja-e-um-rizoma-antropoceno-clima-e-vida-multiespecie-susana-oliveira-dias/.
3. ESCADA, P.; COELHO, C.A.S.; TADDEI, R; DESSAI, S.; CAVALCANTI, I.F.A. ; DONATO, R.; KAYANO, M.; MARTINS, E.S.P.R. ; MIGUEL, J.C.H. ; MONTEIRO, M.; MOSCATI, M.C.L. Climate services in Brazil: Past, present and future perspectives. Climate Services, v. 24, p. 100276, 2021. https://doi.org/10.1016/j.cliser.2021.100276
4. FONSECA, F.; AMORIM, A. C. R. Residências artísticas e currículo-experimentação: como podem nos ajudar a adiar o fim do mundo?. SÉRIE-ESTUDOS, v. 26, p. 11-31, 2021.
5. GUZZO, M. S. L. (2022). Práticas artísticas diante do Antropoceno: uma experiência de refúgio. Liinc Em Revista, 18(1), e5908. https://doi.org/10.18617/liinc.v18i1.5908
6. MIGUEL, J. C. H.; TADDEI, R. Electrical energy infrastructure and social worlds: an anthropological perspective on the circulation of meteorological artifacts. Energy Research & Social Science, v. 90, p. 102641, 2022.
7. SANTOS, G. P.; MATHIAS, F. M. F.; QUEIROZ FILHO, A.C. Entre Janelas: Páginas de um Diário Corpográfico Sensível da Cidade-Medo. CADERNOS DO PROARQ (UFRJ), v. 36, p. 53-73, 2021.
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INTERVIEWS CLIPPING

Períod: 01/06/2021 a 30/07/22

TÍTLE	DATA	NEWSPAPER	LINK
Agroeconomia - US$ 100,8 bilhões na berlinda	2 de junho de 2021	Revista Isto É Dinheiro Rural	https://www.dinheirorural.com.br/us-1008-bilhoes-na-berlinda/
Novo aplicativo permite medir emissões de gases para ter fazenda mais sustentável	27 de junho de 2021	Globo Rural	https://revistagloborural.globo.com/Um-So-Planeta/noticia/2021/06/novo-aplicativo-permite-medir-emissoes-de-gases-para-ter-fazenda-mais-sustentavel.html
Agronegócio e a sustentabilidade	15 de junho	Canal Agro+	https://www.youtube.com/watch?v=JsMzexV_3Fs
Produção Agrícola Sustentável	22 de junho	Canal Agro+	https://www.youtube.com/watch?v=MgeYx2cdHFk
Conceitos de sustentabilidade Ambiental	8 de junho	Canal Agro+	https://www.youtube.com/watch?v=rHBepm7cUds
Mercado de Carbono	25 de maio	Canal Agro+	https://www.youtube.com/watch?v=bZae6238w7k
Incêndios florestais	08 de agosto	Canal Agro+	https://youtu.be/vy02bLRyacc
Carne baixo carbono	27 de julho	Canal Agro +	https://www.youtube.com/watch?v=oU5zqQnosB8
Carne Carbono Neutro	20 de julho	Canal Agro+	https://youtu.be/Pn55d_XpylY
Mudança de dieta com carne	13 de julho	Canal Agro+	https://youtu.be/Ir4C5SNgJ8U

Some links with news that talk about the Report Science Panel on Amazonia (SPA), for which the INCT-MC2 was contributor"

https://www.wwf.org.br//?80708/painel-cientifico-para-a-amazonia-lanca-relatorio-de-avaliacao-da-amazonia-2021
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http://www.bbc.com/storyworks/unlocking-science/the-locals-leading-more-sustainable-science-in-the-amazon
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https://www.eurasiareview.com/15112021-amazon-approaches-catastrophic-potential-tipping-point/
https://www.theguardian.com/environment/gallery/2021/nov/13/cop26-goes-into-overtime-in-pictures
Rios Voadores documentary, TV Cultura: https://estreianatv.com.br/rios-voadores-estreia-na-tv-cultura-neste-domingo/
Mudancas climáticas, Interview Studios Flow- São Paulo, March 3 2022,

Reports

1. MARCHEZINI, VICTOR; SAITO, SILVIA MIDORI ; LONDE, LUCIANA DE RESENDE ; GAMBARDELLA, A. D. ; VIANA, A. S. ; PAULA, A. L. ; PORTELA, C. I. ; PAULETTI, C. ; LOOSE, E. B. ; DAMACENA, F. D. L. ; SANTOS, F. A. ; OLIVEIRA, F. L. S. ; FORINI, H. A. ; PASSOS, I. C. ; MARENGO, J. A. ; BONELLI,

M. G. ; BARRETO, P. B. ; BRAGA, R. ; NASCIMENTO, T. M. ; GODOY, M. . Diagnóstico de capacidades e necessidades municipais em proteção e defesa civil. 1. ed. Brasília: Secretaria Nacional de Proteção e Defesa Civil, 2021. v. 1. 84p .

2. MARCHEZINI, VICTOR; SAITO, SILVIA MIDORI ; LONDE, LUCIANA DE RESENDE ; GAMBARDELLA, A. D. ; VIANA, A. S. ; PAULA, A. L. ; PORTELA, C. I. ; PAULETTI, C. ; LOOSE, E. B. ; DAMACENA, F. D. L. ; SANTOS, F. A. ; OLIVEIRA, F. L. S. ; FORINI, H. A. ; PASSOS, I. C. ; MARENGO, J. A. ; BONELLI, M. G. ; BARRETO, P. B. ; BRAGA, R. ; NASCIMENTO, T. M. ; GODOY, M. . Diagnóstico de capacidades e necessidades municipais em proteção e defesa civil: região sul. 1. ed. Brasília: Secretaria Nacional de Proteção e Defesa Civil, 2021. v. 1. 61p .
3. MARCHEZINI, VICTOR; SAITO, SILVIA MIDORI ; LONDE, LUCIANA DE RESENDE ; GAMBARDELLA, A. D. ; VIANA, A. S. ; PAULA, A. L. ; PORTELA, C. I. ; PAULETTI, C. ; LOOSE, E. B. ; DAMACENA, F. D. L. ; SANTOS, F. A. ; OLIVEIRA, F. L. S. ; FORINI, H. A. ; PASSOS, I. C. ; MARENGO, J. A. ; BONELLI, M. G. ; BARRETO, P. B. ; BRAGA, R. ; NASCIMENTO, T. M. ; GODOY, M. . Diagnóstico de capacidades e necessidades municipais em proteção e defesa civil: região sudeste. 1. ed. Brasília: Secretaria Nacional de Proteção e Defesa Civil, 2021. v. 1. 59p .
4. MARCHEZINI, VICTOR; SAITO, SILVIA MIDORI ; LONDE, LUCIANA DE RESENDE ; GAMBARDELLA, A. D. ; VIANA, A. S. ; PAULA, A. L. ; PORTELA, C. I. ; PAULETTI, C. ; LOOSE, E. B. ; DAMACENA, F. D. L. ; SANTOS, F. A. ; OLIVEIRA, F. L. S. ; FORINI, H. A. ; PASSOS, I. C. ; MARENGO, J. A. ; BONELLI, M. G. ; BARRETO, P. B. ; BRAGA, R. ; NASCIMENTO, T. M. . Diagnóstico de capacidades e necessidades municipais em proteção e defesa civil: região centro-oeste. 1. ed. Brasília: Secretaria Nacional de Proteção e Defesa Civil, 2021. v. 1. 59p .
5. MARCHEZINI, VICTOR; SAITO, SILVIA MIDORI ; LONDE, LUCIANA DE RESENDE ; GAMBARDELLA, A. D. ; VIANA, A. S. ; PAULA, A. L. ; PORTELA, C. I. ; PAULETTI, C. ; LOOSE, E. B. ; DAMACENA, F. D. L. ; SANTOS, F. A. ; OLIVEIRA, F. L. S. ; FORINI, H. A. ; PASSOS, I. C. ; MARENGO, J. A. ; BONELLI, M. G. ; BARRETO, P. B. ; BRAGA, R. ; NASCIMENTO, T. M. . Diagnóstico de capacidades e necessidades municipais em proteção e defesa civil: região nordeste. 1. ed. Brasília: Secretaria Nacional de Proteção e Defesa Civil, 2021. v. 1. 62p .
6. MARCHEZINI, VICTOR; SAITO, SILVIA MIDORI ; LONDE, LUCIANA DE RESENDE ; GAMBARDELLA, A. D. ; VIANA, A. S. ; PAULA, A. L. ; PORTELA, C. I. ; PAULETTI, C. ; LOOSE, E. B. ; DAMACENA, F. D. L. ; SANTOS, F. A. ; OLIVEIRA, F. L. S. ; FORINI, H. A. ; PASSOS, I. C. ; MARENGO, J. A. ; BARRETO, P. B. ; BRAGA, R. ; NASCIMENTO, T. M. . Diagnóstico de capacidades e necessidades municipais em proteção e defesa civil: região norte. 1. ed. Brasília: Secretaria Nacional de Proteção e Defesa Civil, 2021. v. 1. 62p .

Summary of scientific production 2021-2022 (Year 5)

Activity	quantity
Events organized by the INCT MC2 and its components with interaction among subcomponents of the project in Year 5	16
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)	81
List of publications	153
Books and book chapters	19

Other activities and web sites of reports, art exhibitions and courses/seminars online and videos :	
Art workshops/Videos/Artistic productions	10
Interviews, News and online magazines	86
Reports	6

13. Fellowships (bolsas) granted by FAPESP and other funding agencies in Year 4 (including students)

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*. The project continued in the fifth year.

FAPESP 19/00057-98
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/

FAPESP 21/12397-9
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/

Fapesp TT (process 20/07175-4)
Title – INCT's press release Climatic changes – 2nd phase
Scholarship holder - Glaucia Perez
Advisors – Antonio Carlos Amorim and Susana Oliveira Dias (Unicamp)
Type of scholarship: TT3 Scholarship / Duration – 1 year / Dedication - 40 hours / Monthly value – R$ 1,136.40

BAS-Unicamp Scientific initiation
Title - New sensitivities in the face of socio-environmental catastrophes: creation of materials for the scientific dissemination of climate change
Scholarship holder - Larissa Bellini
Mentors – Susana Dias
Type of scholarship: BAS Unicamp Scholarship / Duration - 1 year / Dedication - 40 hours / Monthly amount R$ 678.00

Title - New sensitivities in the face of socio-environmental catastrophes: creation of materials

for the scientific dissemination of climate change
Scholarship holder - Karolyne Souza
Mentors – Susana Dias
Type of scholarship: BAS Unicamp Scholarship / Duration - 1 year / Dedication - 40 hours / Monthly fee R$ 678.00

CNPq Scientific Initiation (process 102449/2021-0)
Title - Environmental Preservation and Migrant Peoples: how artists and journalists influence social vision, based on research data and image characteristics.
Scholarship holder - Pedro Battistella Sentinaro.
Advisor - Antonio Carlos Rodrigues de Amorim.

Type of scholarship - 2022. Scientific Initiation. (Undergraduate in Physics) - State University of Campinas, National Council for Scientific and Technological Development.

CNPq Post-Doctoral (process 88887.658690/2021-00)
Title - Climate change and ideas for postponing the end of the world.
Scholarship holder - Fabiola Simões Rodrigues da Fonseca.
Advisor - Antonio Carlos Rodrigues de Amorim.
Type of scholarship - Start: 2021. State University of Campinas, Coordination for the Improvement of Higher Education Personnel.

CNPq PhD (process 142075/2018-3)
Title - Living Soil-Body: Between Cultivation Lines
Scholarship holder - Tatiana Plens Oliveira
Advisors - Wenceslao Machado de Oliveira Júnior and Susana Oliveira Dias
Scholarship type - 2019-2022. State University of Campinas, Coordination for the Improvement of Higher Education Personnel.

Fapesp visiting researcher grant (process 21/09683-0)
Title - Climate Change, Interdisciplinary and Scientific Communication
Scholarship – Julia Silvia Guivant
Advisors – Antonio Carlos Rodrigues Amorim
Effective period - March 01, 2022 - August 31, 2022

MASTER – CAPES
PROCESS NUMBER: 88887.477406/2020-00
TITLE: Incerteza e Não Estacionariedade na Análise de Frequência de Precipitação Máxima Anual na Bacia do Itajaí
NAME: Gabriel Anzolin
PERIOD: 01/03/2020-28/02/2022
INSTITUTION: Universidade Federal de Santa Catarina

Margarete Martins Afonso dos Santos, PhD. Research collaborator
Sub-component Health
Project: Surveillance and Control of American Visceral Leishmaniasis in the State of Rio de Janeiro: spatial distribution and analysis of municipal vulnerability.

Simone Miranda da Costa, PhD. Research collaborator
Sub-component Health
Project: The importance of "Sentinel Areas" associated with climate change in the context of epidemiological surveillance of American Cutaneous Leishmaniasis in Brazil.

Vanessa Rendeiro Vieira, PhD, CNPq scholarship holder
Sub-component Health

Attached

Spatial Distribution of American Visceral Leishmaniasis in Association with Environmental, Climatic Impacts, Deforestation and its Expansion in the States of the Southeast Region, in Brazil

Jéssica Milena Moura Neves, PhD student
Sub-component Health
Modelling the effects of climatic conditions on Covid-19 and American Visceral Leishmaniasis distribution for future climatic scenarios in Brazil.

Francisco Agustinho Neto, Doctoral Student developing Antarctic Ice modeling studies with BESM. Advisor: Paulo Nobre.

Pedro Regoto, Doctoral Student developing global climate modeling abrupt climate change. Advisor: Paulo Nobre

Nicole Laureantti, Doctoral Student developing regional coupled climate modeling studies over South America and the South Atlantic.
Advisors: Sin Chan Chou, Paulo Nobre

Diego de Andrade Campos, Doctoral Student. Inclusion of the Radiative Effect of Convective Clouds Deep in Eta Model Simulations. Advisor: Sin Chan Chou. Graduated in August 2021.

Marcely Sondermann, Doctoral Student. Eta Model evaluation in rapid cyclogenesis.

Eliseu Oliveira Afonso, Doctoral Student. Regional climate around the Sobradinho Lake from numerical simulations with FLake model coupled to the Eta model

FAPESP / CNPq / CAPES scholarships already implemented (indicate the process number, project title, name of the fellow and scholarship period)

Degree	Researcher Project Title	Funded researcher	Component
Post-doc	Impacto dos aerossóis no potencial de energia solar Brasileiro	Madeleine Sánches Gácita Casagrande	Energy security

List of scholarships from this project or by other sources;

Process code	INCT Project Title	Researcher Project Title	Funded researcher	Scholarship period
2020/15754-4 FAPESP	88887.136402/2017-00 - 2020/15754-4 - INCT para Mudanças Climáticas (INCT-MC)	MÉTODOS DE REFINAMENTO ESTATÍSTICO DE PROJEÇÕES CLIMÁTICAS PARA QUANTIFICAÇÃO DOS POTENCIAIS SOLAR E EÓLICO NO BRASIL	Francisco José Lopes de Lima	From 01/02/2021 To 31/01/2023
2019/05361-8 FAPESP	88887.136402/2017-00 - 465501/2014-1 - INCT para Mudanças Climáticas (INCT-MC)	Impacto dos aerossóis no potencial de energia solar Brasileiro	Madeleine Sánches Gácita Casagrande	From 01/08/2019 To 31/07/2021

FAPESP IC
Bittar - Completed, New Method of Valuation of Watershed Ecosystem Services Using Flow Duration Curves as Water Supply/Demand Under Climate Change, 2020-2022, Funding: FAPESP

CAPES PD
Ana Claudia Villar e Luna. Period: 2017/2022. Federal University of Pernambuco. Funding agency: CAPES/Foundation for the Support of Science and Technology of the State of Pernambuco. In progress.

14. Changes in Personnel

Food Security
Researcher José Ruy Porto de Carvalho from EMBRAPA-Informatica passed away in the year 2019 leaving a rich contribution to the INCT MC2.

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

Inclusion of a researcher in the CEMADEN team: Carolina Galhardo, Carolina Gomes Vergetti Amim, Daniela Ferreira Ribeiro, Lidiane Cristina Costa. Exclusion of a researcher: in the CEMADEN team: Vanesa Canavesi. Insertion of the following researchers in the FIOCRUZ team: Denise Silva e Souza

Water Security

There were not changes of initiatl groups of scientists from CEMADEN, INPE, USP, UFPE, UFCG, UFRGS, UFPB, UFC, FUNCEME and EMBRAPA, affiliated to INCTMC2 water security subcomponent. The only inclusions were from new researchers:

Dr Dulce Buchala Bicca Rodrigues, CV: http://lattes.cnpq.br/4956730907128122
Dr Jamil Alexandre Ayach Anache, CV: http://lattes.cnpq.br/8735169530525485
Dr Paulo Tarso Sanches de Oliveira, CV: http://lattes.cnpq.br/5149856612324019
Dr Pedro Chaffe, CV: http://lattes.cnpq.br/8610492605179316

Communications

Professor Antonio Carlos Amorim, due to other commitments, left the coordination of the cross-cutting theme, remaining in the group as a researcher, and professor Renzo Taddei from UNIFESP assumed the coordination together with Susana Dias.

15 Financial report: Use of the RT and BC (summary)

Using the BC, Susana Oliveira Dias participated in the VIII International Congreso de Comunicación Pública de la Ciencia y Tecnologia in Bariloche, Argentina, at the Universidad Nacional de Río Negro (UNRN), on March 2, 3 and 4, 2022. She presented the work "Communicating with the understanding of the forest: the generation of rare kinships between arts, sciences, and philosophies," with research results within the scope of the cross-cutting theme. She participated in several seminars, workshops and presentation panels in which highly relevant aspects of thinking about communication in crisis contexts were highlighted. During the event, she met with Sandra Murriello, a researcher in the cross-cutting theme group, to think about future projects and the participation of new members from Argentina. As a result of the meeting, researchers Gabriela Alora (URFN), Adriana Menegaz and Daniela Garcia, both from Universidad Nacional Arturo Jauretche (UNAJ), and Valéria Coitaimich, from Universidad Nacional de Córdoba (UNC), joined this Cross-Cutting Theme. Some future work axes were considered, such as the power of thinking about climate change communication in partnerships with forests; the need to expand experiments between climate sciences and the arts in the face of the Anthropocene; the urgency to expand the participation of indigenous peoples in discussions, narratives, and practices aimed at adapting and mitigating climate change. Also, as a result of the meeting, the idea arose of submitting a project for a public notice that would consider communication from the perspective of the forest. A project with this objective was sent by Susana to Fapesp, for the Chamada LinCAr – Innovative approaches to research in Language, Communications and/or Arts – 2022, and the result is scheduled for October 2022.

The water security component used resources from the BC for daily allowances for: (a) participating and presenting co-authored science paper in the 100th IAHS Assembly, Montpellier, France, May - June 2022. The Scientific Assembly was the opportunity to celebrate the 100-year anniversary of the association, to look forward to the end of the Panta Rhei decade which will close in 2023, to envisage progress on the 23 UPHs - Unsolved Problems in Hydrology, and to screen developments of Open Science and support to Agenda 2030 in water-related fields.F. Science Meetings Organized by the INCTMC2 Water Security

Use of the RT:

	Valor cada Componente	**Valor Gasto**	**Descrição**	**SALDO**
COORDENAÇÃO				
DESASTRE NATURAIS	-	-	-	-
ECONOMIA	-	-	-	
SEGURANÇA	-	-	-	-

ALIMENTAR				
ENERGIA				
COMUNICAÇÃO				
ECOSSISTEMA				
HIDROLOGIA				
SAÚDE				
MODELAGEM				

Use of the BC: Year 2020-2021

PI	**BC individual para Pis**	**Valor Gasto**	**Descrição**	**Saldo**
JOSÉ ANTÔNIO MARENGO ORSINI				
REGINA CÉLIA ALVALÁ				
EDUARDO AMARAL HADADD				
EDUARDO D. ASSAD				
ENIO B. PEREIRA				
ANTONIO C RODRIGUES AMORIM				
EDUARDO MENDIONDO				
PAULO NOBRE				

Use of the BC: Year 2021 (Partial)

PI	**BC individual para Pis**	**Valor Gasto**	**Descrição**	**Saldo**
JOSÉ ANTÔNIO MARENGO ORSINI	-	-		-

16. 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

UK-CSSP Climate Service Science Project
Newton Fund UK
CEMADEN, INPE, INPA, UKMO

Pantanal Research Network MCTI (Rede de Pesquisas do Pantanal do MCTI)

Approved Projects – Complementary

DIAS, Susana. New sensitivities in the face of socio-environmental catastrophes: creation of publicity materials. SAE-BAS-Unicamp. Granted R$ 50,400.00

TADDEI, Renzo; GUIVANT, Julia. Socio-climatic imaginaries and meta-cognitions: their roles in interdisciplinary research and scientific communication in a case study of the National Institute of Science and Technology for Climate Change (INCT-MC). CNPq process 402504/2022-4, granted R$ 41.964,00.

Project: Spatial Distribution of American Visceral Leishmaniasis in Association with Environmental, Climatic Impacts, Deforestation and its Expansion in the States of the Southeast Region, in Brazil - Public Call MCTI/CNPQ/CAPES/FAPS Nº 16/2014 - PROGRAMA INCT.

Spatial Distribution of Leishmaniasis in Association with Environmental, Climatic Impacts, Deforestation and its Expansion in the States of the Southeast Region, in Brazil - FAPERJ, Programa Cientista do Nosso Estado – 2020.

Impacts of Climate Change and Deforestation on the Expansion of Leishmaniasis in Brazil – Public Call CNPq Nº 11/2020 - Bolsas de Produtividade em Pesquisa SÊNIOR - PQ-Sr 2020.

Because no new FAPESP scholarship was issued during the 2021/2022, the INCTMC2 water security participants agreed to allocate two (2) new CNPq-granted technical support scholarships under supervision of CEMADEN/MCTI (Sao Jose dos Campos-SP) and of APAC/UFPE (Recife-PE). The criteria for those allocation are in accordance with objectives, goals and actities prioritizited timely by INCTMC2 members. The procedures of setup, timetable and candidate selection of these two scholarships will be under responsibility of both CEMADEN and APAC.

Annexes

Transdisciplinary work among INCT MC2 components

Desafios e oportunidades na gestão de riscos de secas e de inundações

jornal.usp.br/artigos/desafios-e-oportunidades-na-gestao-de-riscos-de-secas-e-de-inundacoes/

19 de agosto de 2022

Eduardo Mario Mendiondo – Foto: IEA-USP

Um recente estudo publicado na revista *Nature* mostra os desafios para nossa sociedade sobre a gestão de riscos de secas e de inundações sem precedentes. O estudo é liderado pela dra. Heidi Kreibich, do GFZ/Potsdam, Alemanha, coautorado por pesquisadores de vários países e da Escola de Engenharia de São Carlos da USP (EESC/USP). Os coautores da EESC/USP participam dos Núcleos de Apoio à Pesquisa (NAPs) INCLINE e CEPED/USP, e participam da Subcomponente de Segurança Hídrica do Instituto Nacional de Ciência e Tecnologia para Mudanças Climáticas Fase 2, INCTMC2-FAPESP coordenado pelo CEMADEN/MCTI, e se articulam junto a um laboratório-ateliê: o WADILab (Water-Adaptive Design & Innovation Lab), criado na EESC/USP em 2017 após experiência junto ao CEMADEN/MCTI.

Este artigo da *Nature* mostra, primeiro, que estudos comparativos e interdisciplinares reforçam a tese que a redução de risco de desastres passa pela integração de todas as dimensões de risco. Assim, o artigo aponta que a quantificação completa dos riscos, com múltiplas ameaças, dos níveis de exposição e dos graus de vulnerabilidade, apresenta interações peculiares e até paradoxos em diferentes partes do planeta. A solvência financeira de setores usuários, como hidrelétricas, companhias de saneamento, perímetros de irrigação, mineradoras, navegação etc., depende de como se gerenciam esses riscos a extremos hidrológicos. Isso passa por uma comunhão entre medidas estruturais e não estruturais, e por aceitar a gestão da oferta e a gestão da demanda de água. O que leva a uma "reflexão-ação-reflexão socio-hidrológica" promovida pela Década 2013-2012 Panta Rhei Everything Flows (Society & Hydrology Under Change) da International Association of Hydrological Sciences.

Exemplos recentes: o caso de São Paulo

Por exemplo, a construção de reservatórios para conter efeitos de secas é fundamental para segurança hídrica. Porém, seu sucesso está condicionado a ter campanhas de popularização da ciência e de incorporação de competências na educação (primária, média e superior) que incentivem o uso racional, o reaproveitamento e o reúso de água. Sem essa conscientização cultural e de melhores hábitos, a simples existência de mais reservatórios pode até induzir ao expressivo consumo de água. Assim, aumentariam os riscos de déficits hídricos futuros e trariam as chamadas "secas socio-hidrológicas", criando um círculo vicioso, com a necessidade de mais reservatórios. Este enorme potencial de reúso de água foi mostrado em outro estudo recente para a Região Metropolitana de São Paulo (RMSP), liderado por Felipe A. A. de Souza, doutorando do

1/2

Presentations of the INCT MC2 at meetings and conferences (presential and virtual)

INCT MC2
INCT para Mudanças Climáticas - Fase 2

Reunião de Lideres de Componentes e Membros do Comité Cientifico do INCT-MC Fase 2

Junho 9 e 10 2022

FEA USP

São Paulo, SP

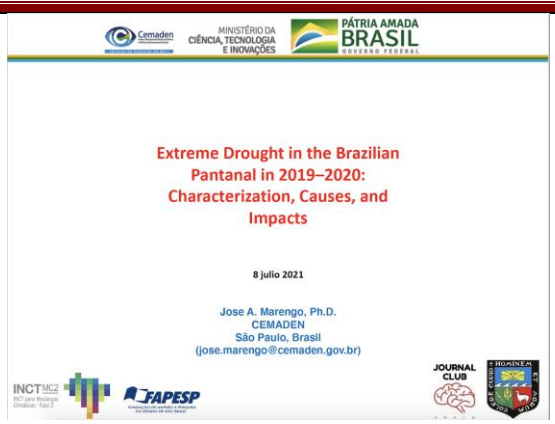

State of the Climate in Latin American and the Caribbean (LAC) 2020
Jose A. Marengo
CEMADEN (National Center for Monitoring and Early Warning of Natural Disasters
Sao Paulo, Brazil
jose.marengo@cemaden.gov.br
Overarching question:
"What are the status and trends of the state of climate indicators in LAC, associated impacts and key needs for adapting to climate variability and change?"
Congreso Científico por el Bicentenario de la Independencia del Perú
Coloquio virtual
Pre Congreso CCBIPERÚ
Cambio Climático em la Amazonia y sus impactos en el clima regional
19 - 23 de julio 2021
Jose A. Marengo, Ph.D.
CEMADEN
São Paulo, Brasil
(jose.marengo@cemaden.gov.br)


Vulnerabilidade socioambiental no contexto das mudanças climáticas
Jose A. Marengo
CEMADEN-MCTI
(Centro Nacional de Monitoramento e Alertas de Desastres Naturais)
jose.marengo@cemaden.gov.br
30 Novembro 2021

SIXTH ASSESSMENT REPORT
Working Group I – The Physical Science Basis
ipcc
10 Agosto 2021
Alguns Resultados do Relatório do WG1 do IPCC AR6
Jose A. Marengo, Climatologista, CEMADEN MCTI
#ClimateReport #IPCC
ACADEMIA BRASILEIRA DE CIÊNCIAS


COMUNICAÇÃO NACIONAL DO BRASIL À CONVENÇÃO-QUADRO DAS NAÇÕES UNIDAS SOBRE
MUDANÇA DO CLIMA
AVALIAÇÃO À VULNERABILIDADE E MEDIDAS DE ADAPTAÇÃO
setembro de 2021


INCT MC2
INCT para Mudanças Climáticas - Fase 2
Cemaden
UFSC
INCT – MUDANÇAS CLIMÁTICAS
INCT - FASE II
DESASTRES NATURAIS, ÁREAS URBANAS, INFRAESTRUTURA FÍSICA, DESENVOLVIMENTO URBANO
Regina Alvalá (Cemaden/MCTI); Regina Rodrigues (UFSC); Martha Barata (Fiocruz)
São Paulo, 09-10 de junho de 2022
CENTRO CLIMA



Extreme Drought in the Brazilian Pantanal in 2019–2020: Characterization, Causes, and Impacts

8 julio 2021

Jose A. Marengo, Ph.D.
CEMADEN
São Paulo, Brasil
(jose.marengo@cemaden.gov.br)

JOURNAL CLUB

BeeCut

Série 2
Frente à frente com o capital humano da Ciência Climática brasileira

ENTREVISTA 5: CIENTISTA JOSÉ ANTONIO MARENGO ORSINI

O climatologista e meteorologista peruano José Marengo, radicado no Brasil há mais de 20 anos, é coordenador-geral de Pesquisa e Desenvolvimento, do Centro Nacional de Monitoramento e Alertas de Desastres Naturais (Cemaden), unidade de pesquisa do Ministério da Ciência, Tecnologia, Inovações e Comunicações (MCTIC). Ele é considerado um dos pesquisadores mais influentes do mundo, segundo lista do *Highly Cited Researchers, de 2019*. O cientista é graduado em Física e Meteorologia pela *Universidad Nacional Agraria* (1981), possui Mestrado em *Ingeniería de Recursos de Agua y Tierra*, pela *Universidad Nacional Agraria* (1987) em Lima, Peru e Doutorado em Meteorologia, pela *University of Wisconsin*– Madison (1991), em EUA. Marengo fez pós doutorado na NASA-GISS e *Columbia University* em Nova York e na *Florida State University* (EUA) em modelagem climática. Em sua trajetória profissional, exerceu o cargo de coordenador científico da previsão climática do Instituto Nacional de Pesquisas Espaciais CPTEC-INPE. Integra o corpo de cientistas no Painel Intergovernamental de Mudanças Climáticas (IPCC) e é membro Titular da Academia Brasileira de Ciências, da Academia de Ciências do Estado de São Paulo e da Academia Mundial de Ciências.

DATA DA ENTREVISTA: 16/08/2021

Politica Ambiental, Crise Climática e Construção social do futuro

Indicadores cientifico- tecnológicos do sistema climático terrestre: O Relatório do IPCC AR6 para o Brasil

3 Setembro 2021

Jose A. Marengo, Ph.D.
CEMADEN
São Paulo, Brasil
(jose.marengo@cemaden.gov.br)

Convite

O FunBEA preocupado em atuar na crise climática a partir da sua popularização para o engajamento das comunidades e movimentos inicia com a coordenação da professora Eda Tassara uma parceria inédita com o Instituto de Estudos Avançados da Universidade de São Paulo (IEA-USP) e um dos principais movimentos populares do país - Fórum Popular da Natureza.

Para celebrar esta parceria será realizada a mesa de diálogos:
Política Ambiental, Crise Climática e a Construção Social do Futuro.

A força deste momento, traz importantes especialistas para dialogar sobre a urgência de geração de conhecimento e intervenções no território na direção de projetos voltados para a construção de um futuro comprometido com o bem-comum diante da necessidade imediata para o enfrentamento da crise climática.

Essa iniciativa fortalece coletivos, organizações sociais, educadores e educadoras ambientais, movimentos, por meio do conhecimento compartilhado por importantes instituições, capazes de fomentar a criação de condições para uma construção intencional de ambiências planetárias futuras tendo como objetivo o **Fazer da Terra/terra uma morada**.

Gilmar Mauro (MST)
líder nacional do Movimento dos Trabalhadores Rurais Sem Terra (MST)

Eda Tessara
COORDENAÇÃO
Professora Emérita e Titular do Departamento de Psicologia Social e do Trabalho do Instituto de Psicologia da Universidade de São Paulo. Graduada em Física, Mestra, Doutora e Livre Docente em Psicologia pela Universidade de São Paulo.

José Antônio Marengo
Cientista, integra o Painel Intergovernamental de Mudanças Climáticas (IPCC) e coordenador geral de Pesquisa e Desenvolvimento, do Centro Nacional de Monitoramento e Alerta de Desastres Naturais (CEMADEM).

03 set 14h às 16h online

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https://bit.ly/abczoom42*
*Link exclusivo para Acadêmicos e jornalistas
PAULO ARTAXO (USP)
Professor de física da Universidade de São Paulo (USP). Membro do IPCC, da Academia Brasileira de Ciências (ABC) e da Academia Mundial de Ciências (TWAS). É vice-presidente da Academia de Ciências do Estado de São Paulo (Aciesp) e da Sociedade Brasileira para o Progresso da Ciência (SBPC).
JOSÉ MARENGO (CEMADEN)
Pesquisador sênior do Cemaden, participante dos Relatórios do IPCC desde o 2º Relatório de Avaliação, review editor do Capítulo 3 do Grupo de Trabalho I (WGI) do IPCC AR6. É membro da ABC, da TWAS e da Aciesp.
LINCOLN ALVES (INPE)
Pesquisador do Instituto Nacional de Pesquisas Espaciais (Inpe). Autor líder do Grupo de Trabalho I (WGI) do 6º Relatório de Avaliação (AR6) do IPCC. Participa de diversos projetos nacionais e internacionais.
THELMA KRUG (IPCC)
Pesquisadora titular aposentada do Inpe, onde foi coordenadora da área de Observação da Terra. Foi diretora do Departamento de Políticas para Combate ao Desmatamento do Ministério do Meio Ambiente (MMA). É vice-presidente do


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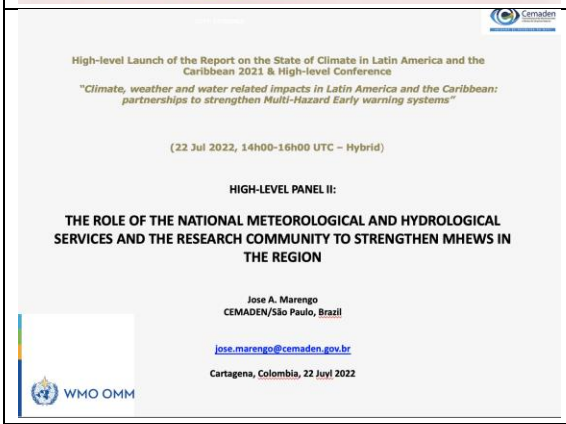
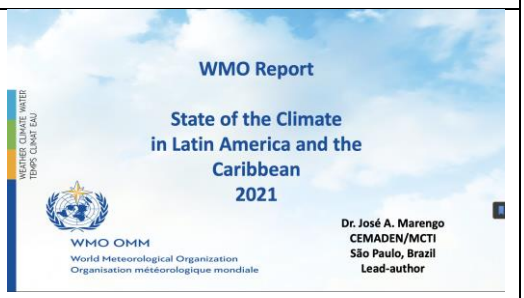
ACORDO AMBIENTAL SÃO PAULO
O novo relatório do IPCC sobre a ciência do clima:
lesafios e oportunidades para combater a mudança do clim
30 de SETEMBRO de 2021
16h00 às 17h30
youtube.com/cetesboficia
facebook.com/CetesbSP
José Marengo
Patrícia Iglecias
Josilene T. V. Ferrer
Paulo Artaxo
Thelma Krug
Lincoln Alves


High-level Launch of the Report on the State of Climate in Latin America and the Caribbean 2021 & High-level Conference
"Climate, weather and water related impacts in Latin America and the Caribbean: partnerships to strengthen Multi-Hazard Early warning systems"
(22 Jul 2022, 14h00-16h00 UTC – Hybrid)
HIGH-LEVEL PANEL II:
THE ROLE OF THE NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES AND THE RESEARCH COMMUNITY TO STRENGTHEN MHEWS IN THE REGION
Jose A. Marengo
CEMADEN/São Paulo, Brazil
jose.marengo@cemaden.gov.br
Cartagena, Colombia, 22 Juyl 2022
WMO OMM


WMO Report
State of the Climate in Latin America and the Caribbean 2021
WEATHER CLIMATE WATER
TEMPS CLIMAT EAU
WMO OMM
World Meteorological Organization
Organisation météorologique mondiale
Dr. José A. Marengo
CEMADEN/MCTI
São Paulo, Brazil
Lead-author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27 E 28 DE JULHO
ENTENDENDO AS MUDANÇAS CLIMÁTICAS
AGRICULTURA - SEGURANÇA ALIMENTAR - RECURSOS HÍDRICOS
Extremos da variabilidade do clima e mudanças climáticas e Segurança Alimentar no Brasil e na América do Sul
Jose A. Marengo
CEMADEN
jose.marengo@cemaden.gov.br
July 27-28 2022
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INTERDISCIPLINARIDADE NA PESQUISA SOBRE MUDANÇA CLIMÁTICA
Canal da ESOCITE.BR 28 de julho - 14h
Palestrantes:
Coordenadora:
Leila Ferreira (UNICAMP)
Mario E. Mendiondo (EESC-USP)
Myanna Lahsen (Linkoping University, Suécia)
Julia Silvia Guivant (UFSC)


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PÁTRIA AMADA BRASIL
GOVERNO FEDERAL
Mesa 1
Diagnósticos e apontamentos sobre os incêndios no Pantanal: dimensões climáticas e ambientais
Atualizações, balanços e perspectivas
Comissão Externa Queimadas em Biomas Brasileiros
2 Setembro de 2021
Jose A. Marengo
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INCT MC2
FAPESP
CÂMARA DOS DEPUTADOS
COMISSÃO EXTERNA - QUEIMADAS EM BIOMAS BRASILEIROS


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Série de Debates "Ciência, Riscos e Desastres"
Mudanças climáticas, intensificação de desastres e formas de enfrentamento
Andréa Ventura
Professora da UFBA e coordenadora do Grupo de Pesquisa em Governança para Sustentabilidade e Gestão de Baixo Carbono
José Marengo
Coordenador Geral de Pesquisa e Desenvolvimento do Centro Nacional de Monitoramento e Alertas de Desastres Naturais
14 de outubro, às 10h
(horário de Brasília)
Transmissão pelo canal da Série de Debates
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PRIMERA EXPOAMBIENTAL UNI-2021
El Cambio Climático en Sudamérica y el Perú: adaptación, retos y desafios
23 de Agosto 2021
Jose A. Marengo, Ph.D.
CEMADEN
São Paulo, Brasil
(jose.marengo@cemaden.gov.br)
INCT MC2
FAPESP
ipcc


PENSANDO O CLIMA NA CIDADE DE SÃO PAULO
ASSIMETRIAS, CONFLITOS E SOLUÇÕES
CIDADE DE SÃO PAULO
Mudanças Climáticas e Eventos Extremos na Cidade de São Paulo
Tércio Ambrizzi
Departamento de Ciências Atmosféricas
IAG/USP
INCT MC2
24 de setembro de 2021
USP
FAPESP


XXIV SIMPÓSIO BRASILEIRO DE RECURSOS HÍDRICOS
ABRHidro
Associação Brasileira de Recursos Hídricos
Aquecimento Global, Eventos Extremos, Mudanças Climáticas e o AR6 IPCC
Tércio Ambrizzi
Departamento de Ciências Atmosféricas
IAG/USP
BH, novembro 2021
INCT MC2
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SIM
13 A 15 DE OUTUBRO DE 2021
SIMPÓSIO EM CLIMA, ÁGUA, ENERGIA E ALIMENTOS
IPCC AR6, Mudanças Climáticas e Eventos Extremos
Tércio Ambrizzi
Departamento de Ciências Atmosféricas
IAG/USP
Mesa redonda
A Crise Hídrica no Brasil: Panorama Atual e Perspectivas Futuras
13 de outubro de 2021
INCT MC2
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CONSÓRCIO PCJ
essencial
PARA CUIDAR DA NOSSA ÁGUA
IPCC AR6, Mudanças Climáticas e Eventos Extremos
Tércio Ambrizzi
Instituto de Energia e Ambiente - USP
Webinar: Panorama e Perspectivas das Mudanças Climáticas
Maio 2022
INCT MC2
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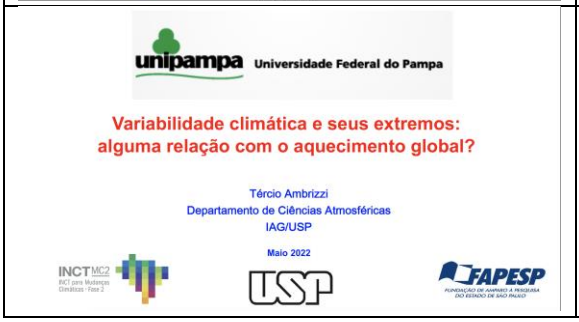
unipampa Universidade Federal do Pampa
Variabilidade climática e seus extremos: alguma relação com o aquecimento global?
Tércio Ambrizzi
Departamento de Ciências Atmosféricas
IAG/USP
Maio 2022
INCT MC2
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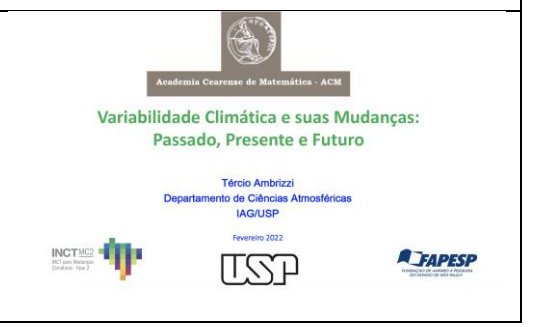
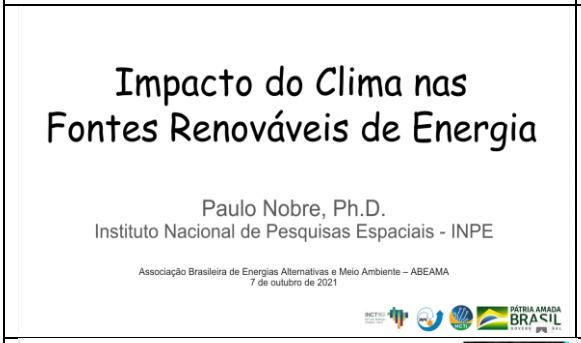
FAPESP

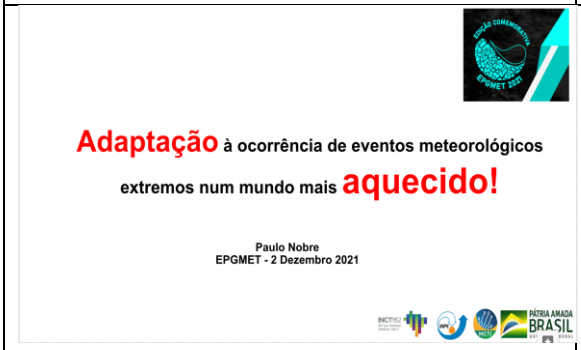

Academia Cearense de Matemática - ACM
Variabilidade Climática e suas Mudanças: Passado, Presente e Futuro
Tércio Ambrizzi
Departamento de Ciências Atmosféricas
IAG/USP
Fevereiro 2022
INCT MC2
USP
FAPESP


NORDESTE PRÓSPERO!
AÇÃO DE DESENVOLVIMENTO SOCIOECONÔMICO SUSTENTÁVEL DO SEMIÁRIDO FRENTE ÀS MUDANÇAS CLIMÁTICAS.
PAULO NOBRE
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS – INPE
paulo.nobre@inpe.br
FRANCINETE FRANCIS LACERDA
INSTITUTO AGRONÔMICO DE PERNAMBUCO – IPA
francis.lacerda@ipa.br
Instituto SAGRES, 2 de julho de 2021


WEBINÁRIO
O surgimento de fragmentos de óleo em Fernando de Noronha - um diagnóstico
26 de Agosto às 14h30
Participações:
REALIZAÇÃO

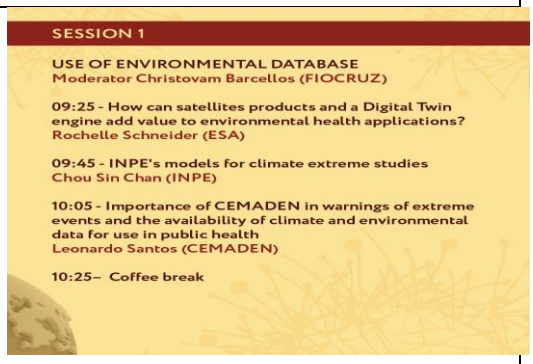

Impacto do Clima nas Fontes Renováveis de Energia
Paulo Nobre, Ph.D.
Instituto Nacional de Pesquisas Espaciais - INPE
Associação Brasileira de Energias Alternativas e Meio Ambiente – ABEAMA
7 de outubro de 2021


Decarbonization & Climate Change:
A Path To A Safe(r) Future!
Paulo Nobre, Ph.D.
National Institute for Space Research - INPE
1st Seminar on Upstream Decarbonization - SPE Brazil Section
20th October 2021

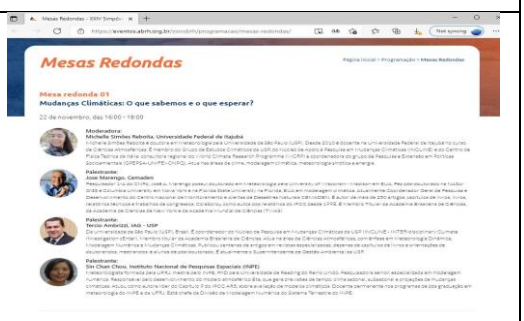

Adaptação à ocorrência de eventos meteorológicos extremos num mundo mais aquecido!
Paulo Nobre
EPGMET - 2 Dezembro 2021


WORKSHOP
Sensoriamento Remoto & Agronegócio
INFORMAÇÕES
Local: Auditório Roger Horiat - LIT, INPE, São José dos Campos-SP
Formato: Evento presencial com gravação de palestras
Data: 26/04 a 28/04
Carga horária: 2 dias de palestras (8h30-17h30) + 1 dia de visita
Número de participantes: até 30 pessoas


II WORKSHOP
Environmental Geospatial Data and Health
MAY 4TH
8:30 TO 12:00
INSCRIPTION:
bit.ly/WorkshopEGDH
TRANSMISSION: Zoom Meetings and youtube.com/cidacs.fiocruz
Ministério da Saúde
FIOCRUZ
Fundação Oswaldo Cruz
cidacs
Centro de Integração de Dados e Conhecimentos para Saúde

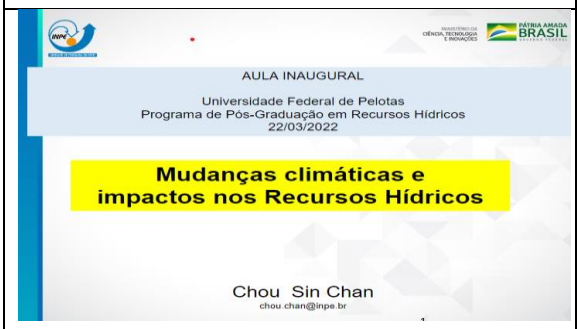

SESSION 1
USE OF ENVIRONMENTAL DATABASE
Moderator Christovam Barcellos (FIOCRUZ)
09:25 - How can satellites products and a Digital Twin engine add value to environmental health applications?
Rochelle Schneider (ESA)
09:45 - INPE's models for climate extreme studies
Chou Sin Chan (INPE)
10:05 - Importance of CEMADEN in warnings of extreme events and the availability of climate and environmental data for use in public health
Leonardo Santos (CEMADEN)
10:25– Coffee break

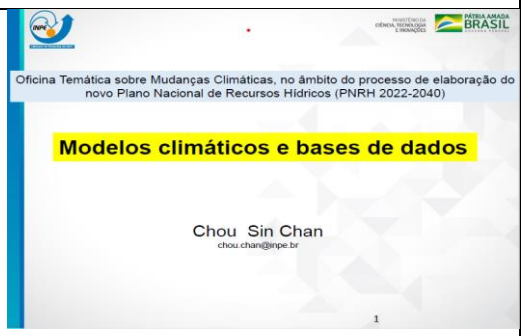

II Fórum Laboratório SisBaHiA
USO DE MODELAGEM AMBIENTAL COMO FERRAMENTA DE SUPORTE A ANÁLISE DE MUDANÇAS CLIMÁTICAS E EVENTOS EXTREMOS
12 de abril • Terça-feira
de 14:00 às 15:30
Palestrantes
Paulo Cesar Colonna Rosman
Sin Chan Chou
Monica Frickmann Young Buckmann
Lidiane dos Santos Lima
Moderadora
Verônica Andrade


Mesas Redondas
Mesa redonda 01
Mudanças Climáticas: O que sabemos e o que esperar?

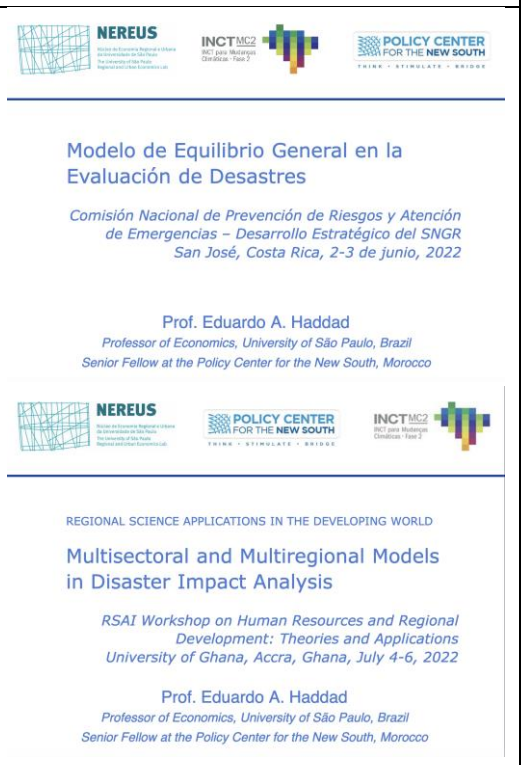

Sin Chan Chou
Instituto Nacional de Pesquisas Espaciais
Ângela Livino
Empresa de Pesquisa Energética
Edson Sano
Embrapa Cerrados
Carlos Sanches
NetaFim
Marcus Schmidt
Senninger Brasil
Lineu Rodrigues
Embrapa/ MODERADOR
inovagri
INOVAGRI
QUINTA FEIRA | JULHO 15 | 19h BRT
youtube.com/inovagri
WEBINAR #18-2021
Tendências na Agricultura Irrigada Brasileira: Ambiente, Clima, Energia e Equipamentos


Técnicas de análise das Mudanças Climáticas Globais
Chou Sin Chan
Teoria e Métodos da Climatologia
Pós-graduação em Geografia – UERJ
03/11/2021


AULA INAUGURAL
Universidade Federal de Pelotas
Programa de Pós-Graduação em Recursos Hídricos
22/03/2022
Mudanças climáticas e impactos nos Recursos Hídricos
Chou Sin Chan
chou.chan@inpe.br


Oficina Temática sobre Mudanças Climáticas, no âmbito do processo de elaboração do novo Plano Nacional de Recursos Hídricos (PNRH 2022-2040)
Modelos climáticos e bases de dados
Chou Sin Chan
chou.chan@inpe.br


ANAIS
IX CONGRESSO BRASILEIRO DE ENERGIA SOLAR • 2022
FLORIANÓPOLIS • 23 A 27 DE MAIO
Associação Brasileira de Energia Solar
Florianópolis – SC, Brasil
2022
ISBN: 978-65-993338-1-1


NEREUS
INCT MC2
POLICY CENTER FOR THE NEW SOUTH
Modelo de Equilibrio General en la Evaluación de Desastres
Comisión Nacional de Prevención de Riesgos y Atención de Emergencias – Desarrollo Estratégico del SNGR
San José, Costa Rica, 2-3 de junio, 2022
Prof. Eduardo A. Haddad
Professor of Economics, University of São Paulo, Brazil
Senior Fellow at the Policy Center for the New South, Morocco
REGIONAL SCIENCE APPLICATIONS IN THE DEVELOPING WORLD
Multisectoral and Multiregional Models in Disaster Impact Analysis
RSAI Workshop on Human Resources and Regional Development: Theories and Applications
University of Ghana, Accra, Ghana, July 4-6, 2022
Prof. Eduardo A. Haddad
Professor of Economics, University of São Paulo, Brazil
Senior Fellow at the Policy Center for the New South, Morocco


NEREUS
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POLICY CENTER FOR THE NEW SOUTH
THINK · STIMULATE · BRIDGE
Modelo de Equilibrio General en la Evaluación de Desastres
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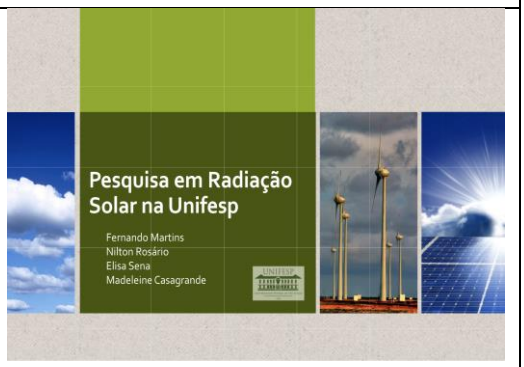
Professor of Economics, University of São Paulo, Brazil
Senior Fellow at the Policy Center for the New South, Morocco


NEREUS
POLICY CENTER FOR THE NEW SOUTH
THINK · STIMULATE · BRIDGE
A Economia da Mantiqueira
09-10 de março de 2022
Prof. Dr. Eduardo A. Haddad
Professor Titular do Departamento de Economia da FEA-USP
SEMINÁRIO INTERNACIONAL
A ECONOMIA DA MANTIQUEIRA


Estimativa da radiação solar com base em imagens de satélite
Fernando Martins
Universidade Federal de São Paulo
Lab. de Estudos e Modelagem de Recursos Renováveis de Energia (LabREN/INPE)
UNIFESP
LABREN

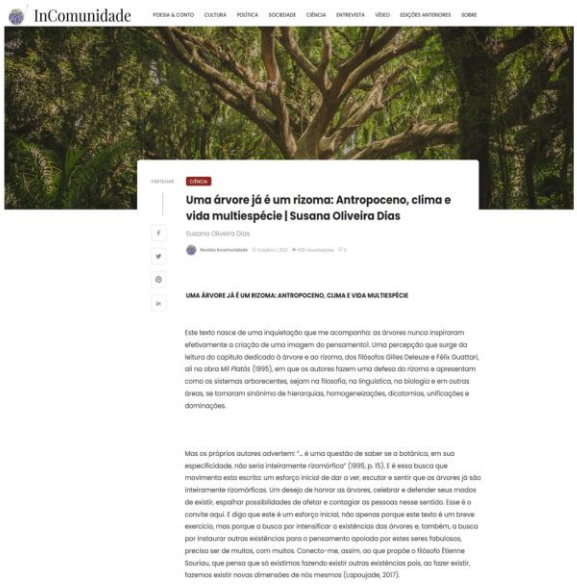

Pesquisa em Radiação Solar na Unifesp
Fernando Martins
Nilton Rosário
Elisa Sena
Madeleine Casagrande


LABREN
LABORATÓRIO DE MODELAGEM E ESTUDOS DE RECURSOS RENOVÁVEIS DE ENERGIA
60 ANOS INPE
PRODUZINDO CIÊNCIA E TECNOLOGIA NO BRASIL
IX CONGRESSO BRASILEIRO DE ENERGIA SOLAR • 2022
FLORIANÓPOLIS • 23 A 27 DE MAIO
Mesa Redonda: Previsão do Recurso Solar
Rodrigo S. Costa
Divisão de Impactos, Adaptação e Vulnerabilidades
Coordenação-Geral de Ciências da Terra
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÕES
PÁTRIA AMADA BRASIL
GOVERNO FEDERAL


AVALIAÇÃO DA IRRADIAÇÃO SOLAR COM MODELO BRASIL-SR EM CONDIÇÕES DE CÉU CLARO - IMPACTO DE AEROSSÓIS NA AMAZÔNIA E CERRADO
FERNANDO R. MARTINS, MADELEINE S. G. CASAGRANDE, NILTON E. ROSÁRIO, ANDRÉ R. GONÇALVES, RODRIGO S. COSTA, FRANCISCO J. L. LIMA, MARCELO P. PES, ENIO B. PEREIRA
IX CONGRESSO BRASILEIRO DE ENERGIA SOLAR • 2022
FLORIANÓPOLIS • 23 A 27 DE MAIO


Sustainable Development in Latin America & Caribbean Summit
Free virtual summit | September 6, 13, 20, 2022
Spanish and Portuguese translations available
Alice Rangel de Paiva Abreu
Federal University of Rio de Janeiro
Daniel Vargas
Getulio Vargas Foundation
Alison Bentley
International Maize and Wheat Improvement Center
Claudia Martinez
Food and Land Use Coalition
Jose Marengo
Center for Monitoring & Alerts of Natural Disasters
SPRINGER NATURE

Reports, interviews, pod casts, and press communications where results of the INCT MC2 were mentioned


InComunidade

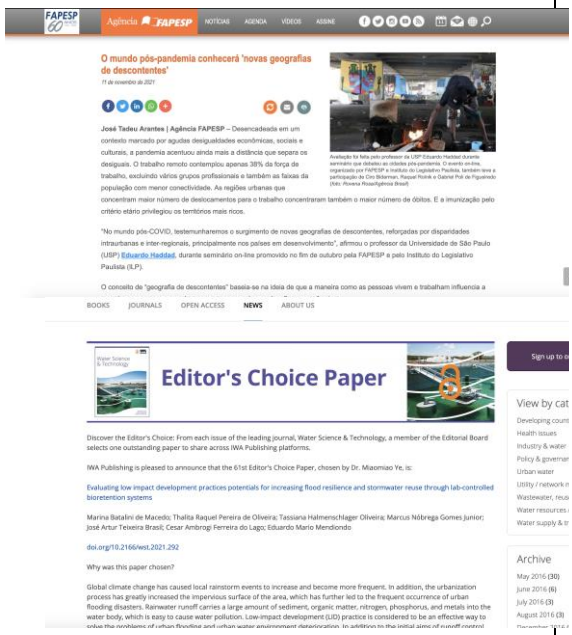
Uma árvore já é um rizoma: Antropoceno, clima e vida multiespécie | Susana Oliveira Dias

Susana Oliveira Dias

UMA ÁRVORE JÁ É UM RIZOMA: ANTROPOCENO, CLIMA E VIDA MULTIESPÉCIE

Este texto nasce de uma inquietação que me acompanha: as árvores nunca inspiraram efetivamente a criação de uma imagem do pensamento. Uma percepção que surge da leitura do capítulo dedicado à árvore e ao rizoma, dos filósofos Gilles Deleuze e Félix Guattari, ali na obra *Mil Platôs* (1995), em que os autores fazem uma defesa do rizoma e apresentam como os sistemas arborescentes, sejam na filosofia, na linguística, na biologia e em outras áreas, se tornaram sinônimo de hierarquias, homogeneizações, dicotomias, unificações e dominações.

Mas os próprios autores advertem: "... é uma questão de saber se a botânica, em sua especificidade, não seria inteiramente rizomórfica" (1995, p. 15). E é essa busca que movimenta esta escrita: um esforço inicial de dar o ver, escutar e sentir que as árvores já são inteiramente rizomórficas. Um desejo de honrar as árvores, celebrar e defender seus modos de existir, espalhar possibilidades de afetar e contagiar as pessoas nesse sentido. Esse é o convite aqui. E digo que este é um esforço inicial, não apenas porque esta texto é um breve exercício, mas porque a busca por intensificar a existências das árvores e, também, a busca por instaurar outros existências para o pensamento apoiada por estes seres fabulosos, precisa ser de muitos, com muitos. Conecto-me, assim, ao que propõe o filósofo Étienne Souriau, que pensa que só existimos fazendo existir outras existências pois, ao fazer existir, fazemos existir novas dimensões de nós mesmos (Lapoujade, 2017).


Agência FAPESP

O mundo pós-pandemia conhecerá 'novas geografias de descontentes'

José Tadeu Arantes | Agência FAPESP – Desencadeada em um contexto marcado por agudas desigualdades econômicas, sociais e culturais, a pandemia acentuou ainda mais a distância que separa os desiguais. O trabalho remoto contemplou apenas 38% da força de trabalho, excluindo vários grupos profissionais e também as faixas da população com menor conectividade. As regiões urbanas que concentram maior número de deslocamentos para o trabalho concentraram também o maior número de óbitos. E a imunização pelo critério etário privilegiou os territórios mais ricos.

"No mundo pós-COVID, testemunharemos o surgimento de novas geografias de descontentes, reforçadas por disparidades intraurbanas e inter-regionais, principalmente nos países em desenvolvimento", afirmou o professor da Universidade de São Paulo (USP) Eduardo Haddad, durante seminário on-line promovido no fim de outubro pela FAPESP e pelo Instituto do Legislativo Paulista (ILP).

O conceito de "geografia de descontentes" baseia-se na ideia de que a maneira como as pessoas vivem e trabalham influencia a

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Editor's Choice Paper

Discover the Editor's Choice: From each issue of the leading journal, Water Science & Technology, a member of the Editorial Board selects one outstanding paper to share across IWA Publishing platforms.

IWA Publishing is pleased to announce that the 61st Editor's Choice Paper, chosen by Dr. Miaomiao Ye, is:

Evaluating low impact development practices potentials for increasing flood resilience and stormwater reuse through lab-controlled bioretention systems

Marina Batalini de Macedo; Thalita Raquel Pereira de Oliveira; Tassiana Halmenschlager Oliveira; Marcus Nóbrega Gomes Junior; José Artur Teixeira Brasil; Cesar Ambrogi Ferreira do Lago; Eduardo Mario Mendiondo

doi.org/10.2166/wst.2021.292

Why was this paper chosen?

Global climate change has caused local rainstorm events to increase and become more frequent. In addition, the urbanization process has greatly increased the impervious surface of the area, which has further led to the frequent occurrence of urban flooding disasters. Rainwater runoff carries a large amount of sediment, organic matter, nitrogen, phosphorus, and metals into the water body, which is easy to cause water pollution. Low-impact development (LID) practice is considered to be an effective way to

Archive

May 2016 (30)
June 2016 (6)
July 2016 (3)
August 2016 (3)


SÉRIE DE SEMINÁRIOS

SBPC

PROJETO PARA UM BRASIL NOVO

12 seminários
de 9 de março a 29 de junho de 2022
sempre às quartas-feiras, às 16h

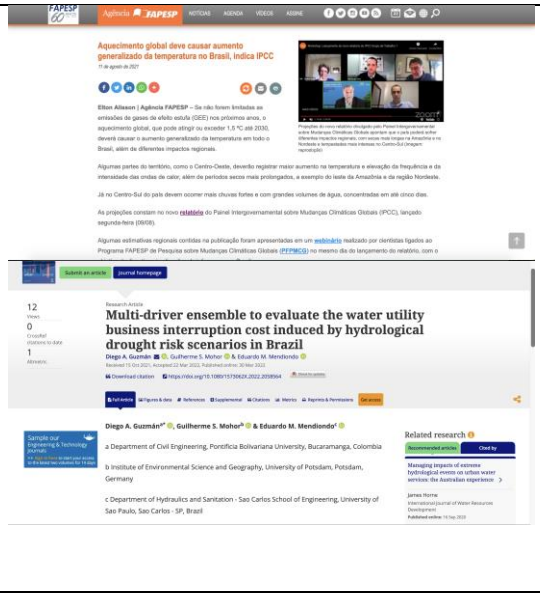
08 DE JUNHO, 16H

MUDANÇAS CLIMÁTICAS

COORDENAÇÃO
Paulo Artaxo (SBPC/USP)

PARTICIPANTES
Carlos Nobre (INPE)
Moacyr Araújo (UFPE)
Suzana Kahn Ribeiro (COPPE/UFRJ)
Thelma Krug (IPCC)

Participe!
youtube.com/canalsbpc


Agência FAPESP

Aquecimento global deve causar aumento generalizado da temperatura no Brasil, indica IPCC

Elton Alisson | Agência FAPESP – Se não forem limitadas as emissões de gases de efeito estufa (GEE) nos próximos anos, o aquecimento global, que pode atingir ou exceder 1,5 °C até 2030, deverá causar o aumento generalizado da temperatura em todo o Brasil, além de diferentes impactos regionais.

Algumas partes do território, como o Centro-Oeste, deverão registrar maior aumento na temperatura e elevação da frequência e da intensidade das ondas de calor, além de períodos secos mais prolongados, a exemplo do leste da Amazônia e da região Nordeste.

Já no Centro-Sul do país devem ocorrer mais chuvas fortes e com grandes volumes de água, concentradas em até cinco dias.

As projeções constam no novo relatório do Painel Intergovernamental sobre Mudanças Climáticas Globais (IPCC), lançado segunda-feira (09/08).

Algumas estimativas regionais contidas na publicação foram apresentadas em um webinário realizado por cientistas ligados ao Programa FAPESP de Pesquisa sobre Mudanças Climáticas Globais (PFPMCG) no mesmo dia do lançamento do relatório, com o

Multi-driver ensemble to evaluate the water utility business interruption cost induced by hydrological drought risk scenarios in Brazil

Diego A. Guzmán | Guilherme S. Mohor | & Eduardo M. Mendiondo

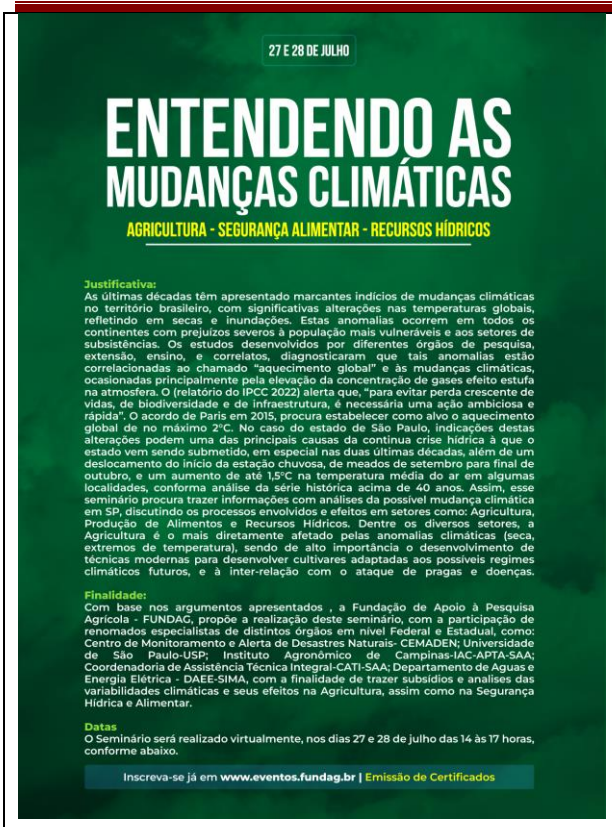
Diego A. Guzmán[a*], Guilherme S. Mohor[b] & Eduardo M. Mendiondo[c]

a Department of Civil Engineering, Pontificia Bolivariana University, Bucaramanga, Colombia

b Institute of Environmental Science and Geography, University of Potsdam, Potsdam, Germany

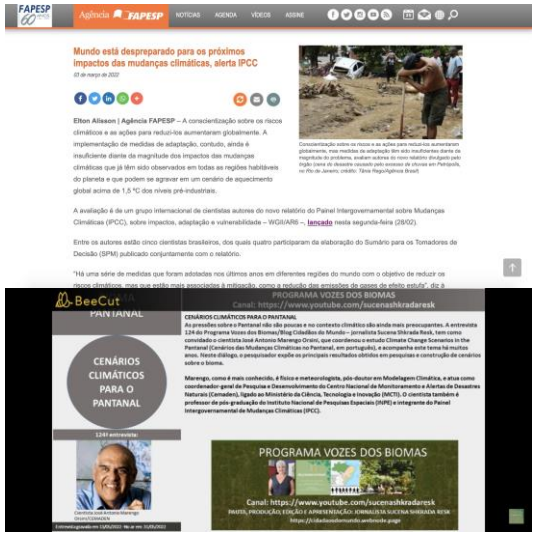
c Department of Hydraulics and Sanitation - Sao Carlos School of Engineering, University of Sao Paulo, Sao Carlos - SP, Brazil

Related research


27 E 28 DE JULHO
ENTENDENDO AS MUDANÇAS CLIMÁTICAS
AGRICULTURA - SEGURANÇA ALIMENTAR - RECURSOS HÍDRICOS
Justificativa:
As últimas décadas têm apresentado marcantes indícios de mudanças climáticas no território brasileiro, com significativas alterações nas temperaturas globais, refletindo em secas e inundações. Estas anomalias ocorrem em todos os continentes com prejuízos severos à população mais vulneráveis e aos setores de subsistências. Os estudos desenvolvidos por diferentes órgãos de pesquisa, extensão, ensino, e correlatos, diagnosticaram que tais anomalias estão correlacionadas ao chamado "aquecimento global" e às mudanças climáticas, ocasionadas principalmente pela elevação da concentração de gases efeito estufa na atmosfera. O (relatório do IPCC 2022) alerta que, "para evitar perda crescente de vidas, de biodiversidade e de infraestrutura, é necessária uma ação ambiciosa e rápida". O acordo de Paris em 2015, procura estabelecer como alvo o aquecimento global de no máximo 2°C. No caso do estado de São Paulo, indicações destas alterações podem uma das principais causas da continua crise hídrica à que o estado vem sendo submetido, em especial nas duas últimas décadas, além de um deslocamento do início da estação chuvosa, de meados de setembro para final de outubro, e um aumento de até 1,5°C na temperatura média do ar em algumas localidades, conforma análise da série histórica acima de 40 anos. Assim, esse seminário procura trazer informações com análises da possível mudança climática em SP, discutindo os processos envolvidos e efeitos em setores como: Agricultura, Produção de Alimentos e Recursos Hídricos. Dentre os diversos setores, a Agricultura é o mais diretamente afetado pelas anomalias climáticas (seca, extremos de temperatura), sendo de alto importância o desenvolvimento de técnicas modernas para desenvolver cultivares adaptadas aos possíveis regimes climáticos futuros, e à inter-relação com o ataque de pragas e doenças.
Finalidade:
Com base nos argumentos apresentados , a Fundação de Apoio à Pesquisa Agrícola - FUNDAG, propõe a realização deste seminário, com a participação de renomados especialistas de distintos órgãos em nível Federal e Estadual, como: Centro de Monitoramento e Alerta de Desastres Naturais- CEMADEN; Universidade de São Paulo-USP; Instituto Agronômico de Campinas-IAC-APTA-SAA; Coordenadoria de Assistência Técnica Integral-CATI-SAA; Departamento de Aguas e Energia Elétrica - DAEE-SIMA, com a finalidade de trazer subsídios e analises das variabilidades climáticas e seus efeitos na Agricultura, assim como na Segurança Hídrica e Alimentar.
Datas
O Seminário será realizado virtualmente, nos dias 27 e 28 de julho das 14 às 17 horas, conforme abaixo.
Inscreva-se já em www.eventos.fundag.br | Emissão de Certificados


Desmatamento e mudança climática colocam em risco nova fronteira agrícola brasileira
Elton Alisson | Agência FAPESP – O desmatamento para a expansão do agronegócio, juntamente com as mudanças climáticas, induziu o agravamento das condições de seca severa na última década na zona de transição entre o leste da Amazônia e o Cerrado.
Essa combinação de tendências pode colocar em risco a estabilidade dos biomas e, consequentemente, a produção de alimentos na região onde está situado o Matopiba – área considerada a nova fronteira agrícola brasileira, compreendida por porções dos Estados do Maranhão, Tocantins, Piauí e Bahia, e responsável por quase 12% da produção brasileira de soja.
O alerta foi feito por um grupo de cientistas ligados a instituições de pesquisa no Brasil e no exterior em artigo publicado na revista Scientific Reports.
O estudo, conduzido por pesquisadores do Centro Nacional de Monitoramento e Alertas de Desastres Naturais (Cemaden), teve apoio da FAPESP por meio de um Projeto Temático e do Instituto Nacional de Ciência e Tecnologia para Mudanças Climáticas (INCT-MC) – um dos INCTs financiados pela FAPESP em parceria com o Conselho Nacional de Desenvolvimento Científico e

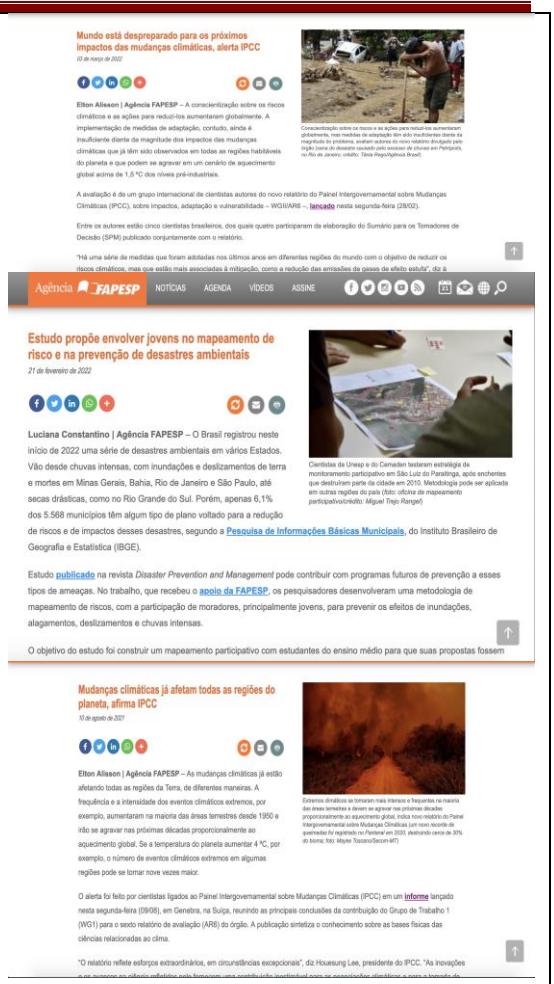

MEIO AMBIENTE
Desastre em Petrópolis: população vulnerável acentua impacto da crise climática
Reportagem visitou a região nos dias seguintes à maior chuva a cair no município em 90 anos. Com aumento de eventos climáticos extremos, população precisa ser protegida.


Agência FAPESP
Mundo está despreparado para os próximos impactos das mudanças climáticas, alerta IPCC
Elton Alisson | Agência FAPESP – A conscientização sobre os riscos climáticos e as ações para reduzi-los aumentaram globalmente. A implementação de medidas de adaptação, contudo, ainda é insuficiente diante da magnitude dos impactos das mudanças climáticas que já têm sido observados em todas as regiões habitáveis do planeta e que podem se agravar em um cenário de aquecimento global acima de 1,5 °C dos níveis pré-industriais.
A avaliação é de um grupo internacional de cientistas autores do novo relatório do Painel Intergovernamental sobre Mudanças Climáticas (IPCC), sobre impactos, adaptação e vulnerabilidade – WGII/AR6 –, lançado nesta segunda-feira (28/02).
Entre os autores estão cinco cientistas brasileiros, dos quais quatro participaram da elaboração do Sumário para os Tomadores de Decisão (SPM) publicado conjuntamente com o relatório.
"Há uma série de medidas que foram adotadas nos últimos anos em diferentes regiões do mundo com o objetivo de reduzir os riscos climáticos, mas que estão mais associadas à mitigação, como a redução das emissões de gases de efeito estufa", diz a

BeeCut
CENÁRIOS CLIMÁTICOS PARA O PANTANAL
PROGRAMA VOZES DOS BIOMAS
Canal: https://www.youtube.com/sucenashkradaresk


mudanças no clima ameaçam a economia brasileira e a segurança alimentar global
Acompanhe o que a ciência tem revelado sobre a Amazônia com a colunista Dra. Janaina Guidolini, idealizadora da Accessible Science.


BRASIL 200 ANOS
ACOMPANHE O ESPECIAL SOBRE O BICENTENÁRIO DA INDEPENDÊNCIA
Pesquisa FAPESP
As causas pouco lembradas das inundações
Assoreamento de rios, ocupação de áreas de risco e precariedade das estruturas de atendimento a emergências ampliam o impacto das chuvas de verão, cada vez mais intensas



Mundo está despreparado para os próximos impactos das mudanças climáticas, alerta IPCC

10 de março de 2022

Elton Alisson | Agência FAPESP – A conscientização sobre os riscos climáticos e as ações para reduzi-los aumentaram globalmente. A implementação de medidas de adaptação, contudo, ainda é insuficiente diante da magnitude dos impactos das mudanças climáticas que já têm sido observados em todas as regiões habitáveis do planeta e que podem se agravar em um cenário de aquecimento global acima de 1,5 °C dos níveis pré-industriais.

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Agência FAPESP NOTÍCIAS AGENDA VÍDEOS ASSINE

Estudo propõe envolver jovens no mapeamento de risco e na prevenção de desastres ambientais

21 de fevereiro de 2022

Luciana Constantino | Agência FAPESP – O Brasil registrou neste início de 2022 uma série de desastres ambientais em vários Estados. Vão desde chuvas intensas, com inundações e deslizamentos de terra e mortes em Minas Gerais, Bahia, Rio de Janeiro e São Paulo, até secas drásticas, como no Rio Grande do Sul. Porém, apenas 6,1% dos 5.568 municípios têm algum tipo de plano voltado para a redução de riscos e de impactos desses desastres, segundo a Pesquisa de Informações Básicas Municipais, do Instituto Brasileiro de Geografia e Estatística (IBGE).

Estudo publicado na revista *Disaster Prevention and Management* pode contribuir com programas futuros de prevenção a esses tipos de ameaças. No trabalho, que recebeu o apoio da FAPESP, os pesquisadores desenvolveram uma metodologia de mapeamento de riscos, com a participação de moradores, principalmente jovens, para prevenir os efeitos de inundações, alagamentos, deslizamentos e chuvas intensas.

O objetivo do estudo foi construir um mapeamento participativo com estudantes do ensino médio para que suas propostas fossem

Cientistas da Unesp e do Cemaden testaram estratégia de monitoramento participativo em São Luiz do Paraitinga, após enchentes que destruíram parte da cidade em 2010. Metodologia pode ser aplicada em outras regiões do país (*foto: oficina de mapeamento participativo/crédito: Miguel Trejo Rangel*)

Mudanças climáticas já afetam todas as regiões do planeta, afirma IPCC

10 de agosto de 2021

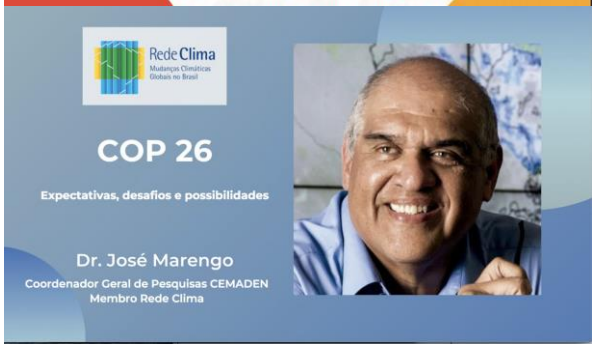
Elton Alisson | Agência FAPESP – As mudanças climáticas já estão afetando todas as regiões da Terra, de diferentes maneiras. A frequência e a intensidade dos eventos climáticos extremos, por exemplo, aumentaram na maioria das áreas terrestres desde 1950 e irão se agravar nas próximas décadas proporcionalmente ao aquecimento global. Se a temperatura do planeta aumentar 4 °C, por exemplo, o número de eventos climáticos extremos em algumas regiões pode se tornar nove vezes maior.

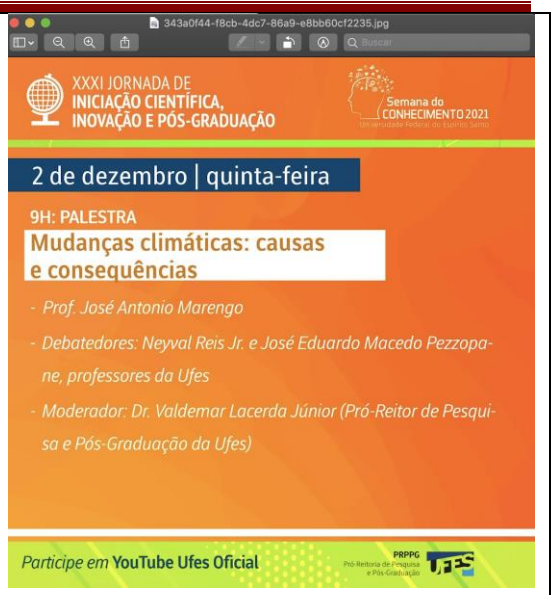
O alerta foi feito por cientistas ligados ao Painel Intergovernamental sobre Mudanças Climáticas (IPCC) em um informe lançado nesta segunda-feira (09/08), em Genebra, na Suíça, reunindo as principais conclusões da contribuição do Grupo de Trabalho 1 (WG1) para o sexto relatório de avaliação (AR6) do órgão. A publicação sintetiza o conhecimento sobre as bases físicas das ciências relacionadas ao clima.

"O relatório reflete esforços extraordinários, em circunstâncias excepcionais", diz Houesung Lee, presidente do IPCC. "As inovações

Extremos climáticos se tornaram mais intensos e frequentes na maioria das áreas terrestres e devem se agravar nas próximas décadas proporcionalmente ao aquecimento global, indica novo relatório do Painel Intergovernamental sobre Mudanças Climáticas (*um novo recorde de queimadas foi registrado no Pantanal em 2020, destruindo cerca de 30% do bioma; foto: Mayke Toscano/Secom-MT*)


III WORKSHOP DO GENAT
II SIMPÓSIO PARA REDUÇÃO DO RISCO DE DESASTRES NA REGIÃO NORDESTE
I ENCONTRO INTERNACIONAL DE GEOMORFOLOGIA E GESTÃO DO RISCO DE DESASTRES
30 de Novembro a 03 de Dezembro
30/11 - 20:30 hrs - Conferência de abertura
Vulnerabilidade socioambiental no contexto das mudanças climáticas
José Antônio Marengo Orsini
Pesquisador Titular e Coordenador Geral de Pesquisa e Desenvolvimento do Centro Nacional de Monitoramento e Alertas de Desastres Naturais e Membro do Painel Intergovernamental sobre Mudança do Clima (IPCC)
NEUD
GENAT
https://iiiworkshop.wixsite.com/genat

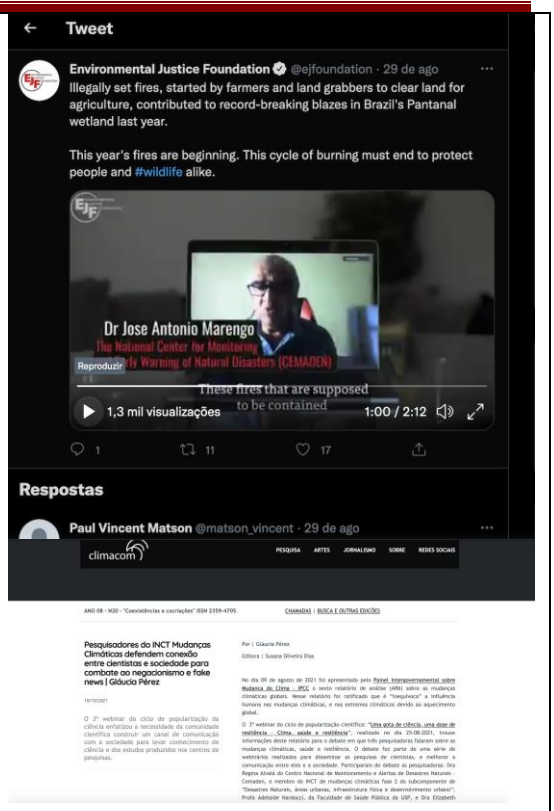

Rede Clima
Mudanças Climáticas Globais no Brasil
COP 26
Expectativas, desafios e possibilidades
Dr. José Marengo
Coordenador Geral de Pesquisas CEMADEN
Membro Rede Clima


XXXI JORNADA DE INICIAÇÃO CIENTÍFICA, INOVAÇÃO E PÓS-GRADUAÇÃO
Semana do CONHECIMENTO 2021
2 de dezembro | quinta-feira
9H: PALESTRA
Mudanças climáticas: causas e consequências
- Prof. José Antonio Marengo
- Debatedores: Neyval Reis Jr. e José Eduardo Macedo Pezzopane, professores da Ufes
- Moderador: Dr. Valdemar Lacerda Júnior (Pró-Reitor de Pesquisa e Pós-Graduação da Ufes)
Participe em YouTube Ufes Oficial
PRPPG


NEXO POLÍTICAS PÚBLICAS
PERGUNTAS QUE A CIÊNCIA JÁ RESPONDEU
12 pontos sobre incêndios nos ecossistemas brasileiros
Vânia R. Pivello, Ima Vieira, Alexander V. Christianini, Danilo Bandini Ribeiro, Luciana da Silva Menezes, Christian Niel Berlinck, Felipe P. L. Melo, José Antonio Marengo, Carlos Gustavo Tornquist, Walfrido Moraes Tomas e Gerhard Ernst Overbeck
10 Nov 2021 (11 Nov 2021 às 13h51)


Pesquisa
Cidades contra a crise climática


MONGABAY
NOTÍCIAS AMBIENTAIS PARA INFORMAR E TRANSFORMAR
FLORESTAS TROPICAIS CONSERVAÇÃO MEIO AMBIENTE DESMATAMENTO POVOS INDÍGENAS INFRAESTRUTURA
Secas recorrentes afetam a capacidade de recuperação da Floresta Amazônica, alerta estudo
por Elizabeth Oliveira em 25 Novembro 2021 |


Tweet
Environmental Justice Foundation @ejfoundation · 29 de ago
Illegally set fires, started by farmers and land grabbers to clear land for agriculture, contributed to record-breaking blazes in Brazil's Pantanal wetland last year.
This year's fires are beginning. This cycle of burning must end to protect people and #wildlife alike.
Dr Jose Antonio Marengo
Reproduzir
These fires that are supposed to be contained
1,3 mil visualizações
1:00 / 2:12
Respostas
Paul Vincent Matson @matson_vincent · 29 de ago
climacom

Pesquisadores do INCT Mudanças Climáticas defendem conexão entre cientistas e sociedade para combate ao negacionismo e fake news | Gláucia Pérez


Especial

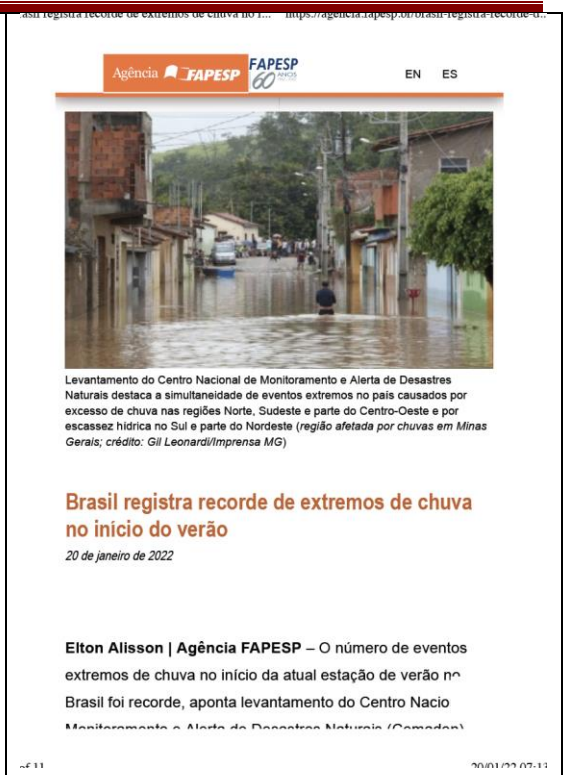
Ambiente 'Brasil é muito vulnerável', avalia José Marengo

Extremos climáticos ameaçam agronegócio

Daniela Chiaretti
De São Paulo

"Inundações, secas, incêndios florestais. Estamos vendo no presente uma amostra do que era projetado para o futuro"

"Não se a Amazônia deve ser protegido. O Cerrado, a Caatinga, a Mata Atlântica, são todos importantes"


Agência FAPESP FAPESP 60 EN ES

Levantamento do Centro Nacional de Monitoramento e Alerta de Desastres Naturais destaca a simultaneidade de eventos extremos no país causados por excesso de chuva nas regiões Norte, Sudeste e parte do Centro-Oeste e por escassez hídrica no Sul e parte do Nordeste (*região afetada por chuvas em Minas Gerais; crédito: Gil Leonardi/Imprensa MG*)

Brasil registra recorde de extremos de chuva no início do verão

20 de janeiro de 2022

Elton Alisson | Agência FAPESP – O número de eventos extremos de chuva no início da atual estação de verão no Brasil foi recorde, aponta levantamento do Centro Nacio

CERTIFICADO

11º CONGRESSO BRASILEIRO DE EPIDEMIOLOGIA

Certificamos que o trabalho

VIGILÂNCIA EM SAÚDE, ARTICULAÇÃO INTERSINSTITUCIONAL E FLUXO DE INFORMAÇÃO EM DESASTRES

dos autores: RHAVENA BARBOSA DOS SANTOS; JÚLIA ALVES MENEZES; CARINA MARGONARI DE SOUZA; ULISSES EUGÊNIO CAVALCANTI CONFALONIERI; CARLOS MACHADO DE FREITAS, foi aprovado na modalidade Poster Eletrônico, no 11º Congresso Brasileiro de Epidemiologia ocorrido de 22 a 26 de novembro de 2021.

26 de novembro de 2021

Para validar, acesse http://www.abrasco.eventos.org.br/validacao/?cod=1231918

Ligia Regina Franco Sansigolo Kerr
Presidente do 11º Congresso Brasileiro de Epidemiologia

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REFLEXÕES SOBRE UTILIZAÇÃO DOS SISTEMAS DE INFORMAÇÃO DE SAÚDE EM DESASTRES

dos autores: RHAVENA BARBOSA DOS SANTOS; JÚLIA ALVES MENEZES; CARINA MARGONARI DE SOUZA; ULISSES EUGENIO CAVALCANTI CONFALONIERI; CARLOS MACHADO DE FREITAS, foi aprovado na modalidade Poster Eletrônico, no 11º Congresso Brasileiro de Epidemiologia ocorrido de 22 a 26 de novembro de 2021.

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11º CONGRESSO BRASILEIRO DE EPIDEMIOLOGIA

Certificamos que

RHAVENA BARBOSA DOS SANTOS

participou do "11º Congresso Brasileiro de Epidemiologia", realizado de 22 a 26 de novembro de 2021.

26 de novembro de 2021

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Rosana Teresa Onocko Campos
Presidente da Associação Brasileira de Saúde Coletiva

Some papers and other publications derived from the project

Climate Services 24 (2021) 100276

Contents lists available at ScienceDirect

Climate Services

journal homepage: www.elsevier.com/locate/cliser

Original research article

Climate services in Brazil: Past, present, and future perspectives

Paulo Escada [a,*], Caio A.S. Coelho [a], Renzo Taddei [b], Suraje Dessai [c], Iracema F.A. Cavalcanti [a], Roberto Donato [d], Mary T. Kayano [a], Eduardo S.P.R. Martins [e,f], Jean C.H. Miguel [b], Marko Monteiro [d], Marley C.L. Moscati [a]

[a] National Institute for Space Research (INPE) – São José dos Campos, São Paulo, Brazil
[b] Federal University of São Paulo (UNIFESP), Brazil
[c] School of Earth and Environment and ESRC Centre for Climate Change Economics and Policy, University of Leeds, Leeds, UK
[d] University of Campinas (UNICAMP), Brazil
[e] Ceará State Meteorology and Water Resources Foundation (FUNCEME), Brazil
[f] Federal University of Ceará (UFC), Brazil

ARTICLE INFO

Keywords:
Climate services
Co-production
Social sciences
Climate science
Brazil

ABSTRACT

From the devastating effects of the 1877–1879 Great Drought in the Northeast region to the creation of the Center for Weather Forecast and Climate Studies (CPTEC) at the National Institute for Space Research (INPE) in the early 1990's, Brazil went from a total absence of meteorological expertise to becoming a member of a select group of nations with the infrastructure and technical expertise to build and run a global general circulation model. This article reviews the most critical moments in the development of climate services in Brazil, addressing the evolution of its infrastructure for observation, monitoring, modeling, and prediction, the still incipient efforts in systematically understanding users' perspectives and needs, and the work required to incorporate the usable science and co-production paradigms into the main centers of production of climate information. Advances and challenges are analyzed, and actions for strengthening the climate services framework are proposed.

Practical implications

Climate services are considered to be fundamental for planning the activities of several Brazilian economic sectors (e.g., water management, energy and agricultural production, and health protection). This paper documents, from a historical perspective, the activities that boosted the development of climate services in Brazil, including climate studies, monitoring, and prediction initiatives, as well as initial efforts for systematically understanding users' perspectives and needs, and the work needed for incorporating the usable science and co-production paradigms into the climate information production process. To further develop these services in Brazil, the following recommendations are put forward:

Investment in synergistic forms of cooperation that contribute to the popularization of climate services in strategic settings – such as university undergraduate courses, agricultural extension organizations, academic conferences, etc. – contributing to capacity building in key sectors of the Brazilian technical and economic landscape.

Creation of a forum and an associated research network integrated with representatives of private users, third sector organizations, public

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Residências artísticas e currículo-experimentação: como podem nos ajudar a adiar o fim do mundo?[1]

Artistic residencies and curriculum-experimentation: how can they help us to postpone the end of the world?

Residencias artísticas y currículo-experimentación: ¿cómo pueden ayudarnos a retrasar el fin del mundo?

Fabíola Fonseca[2]
Antônio Carlos Rodrigues de Amorim[3]

DOI: http://dx.doi.org/10.20435/serie-estudos.v26i58.1592

Resumo: Diante de um cenário urgente posto pelas mudanças climáticas, questionamos e pensamos, junto de Ailton Krenak e pesquisadores da filosofia da diferença, em como um currículo *outro* pode nos ajudar a adiar o fim do mundo. Trazemos para essa conversa as experimentações que temos feito com as residências artísticas nos laboratórios de pesquisa como possibilidade de traçar linhas de fuga, que inspiram compor currículos. Assim, experimentar é o que nos abre para as potências das coisas e o que tem nos ajudado a encontrar aberturas para outras biologias possíveis e outras formas de nos relacionarmos com espécies humanas e não humanas, seres vivos e não vivos.

Palavras-chave: currículo; residência artística; mudanças climáticas.

Abstract: Faced with an urgent landscape imposed by climate change, we question and think, with Ailton Krenak and researchers from philosophy of difference, on how *another* curriculum can help us to postpone the end of the world. We bring to this conversation the experimentations that we

[1] Este trabalho foi financiado pela Fundação Cearense de Apoio ao Desenvolvimento Científico e Tecnológico (FUNCAP-CE) e pelo Instituto Nacional de Ciência e Tecnologia para Mudanças Climáticas (INCT-MC) Fase 2, com financiamento do CNPq Processo 465501/2014-1, FAPESP Processo 2014/50848-9 e da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) Processo 16/2014.

[2] Universidade Federal do Ceará (UFC), Fortaleza, Ceará, Brasil. Pós-doutoranda UFC.
[3] Universidade Estadual de Campinas (Unicamp), Campinas, São Paulo, Brasil. Pesquisador 1B do CNPq.

RELATO

Práticas artísticas diante do Antropoceno: uma experiência de refúgio

Artistic practices in the face of the Anthropocene: an experience of refuge

Marina Souza Lobo Guzzo *

RESUMO: A crise climática é uma situação que evidencia a emergência ambiental do planeta relacionada aos eventos extremos do clima e da forma de resposta da natureza à ação da destruição humana. É sobretudo uma questão política pois envolve formas de produzir, viver e morrer. Diante da crise, ou dessa crise específica: o que pode o artista? Como a arte se relaciona com essas questões? Que imagens são possíveis diante de uma catástrofe? Que articulações podemos inventar como artistas ou trabalhadores culturais? Quais alianças são necessárias para evitar a 6ª. extinção em massa, que está acontecendo agora? Este texto visa apresentar uma experiência, uma tentativa de refúgio e criação. Uma plataforma que criou uma micro-comunidade de artistas que se uniram temporariamente para trabalhar em torno da questão da crise climática. A proposta reuniu ações artísticas e educacionais que confundem as fronteiras entre arte e ativismo climático, para imaginar outros mundos possíveis diante da catástrofe que vive hoje no Brasil. O projeto visou reunir pessoas dispostas a fazer um intercâmbio de práticas, formar e informar artistas e interessados em relação ao tema, mas também manter viva a criação durante o tempo de confinamento causado pela pandemia de Covid-19. Pretendeu também promover um espaço de pensamento e imaginação em torno das possíveis ações para o enfrentamento da crise. O projeto foi pensado principalmente para acontecer à distância, criando uma plataforma de encontros mensais entre coletivos do Brasil e de outros países para pensar em "tarefas" de proximidade entre arte, vida e arte, arte e cuidado planetário. Cada "tarefa" foi proposta por diferentes participantes do projeto / coletivos e a cada mês todos os artistas desenvolvem uma ação com base nesta provocação. As propostas e tarefas realizadas pelos participantes foram divulgadas em uma plataforma online, criada especialmente para o projeto. A partir dessa experiência, o texto pretende apontar alguns caminhos possíveis para pensar a arte e seu papel nesse momento crucial da história do planeta.

Palavras-chave: Arte; Crise Climática; Práticas de Vida; Utopias.

ABSTRACT: The climate crisis is a situation that highlights the environmental emergency of the planet related to extreme weather events and the way nature responds to the action of human destruction. It is above all a political issue as it involves ways of producing, living and dying. Faced with the crisis, or this specific crisis: what can the artist do? How does art relate to these issues? What images are possible in the face of a catastrophe? What articulations can we invent as artists or cultural workers? What alliances are needed to avoid the 6th. mass extinction, what is happening now? This text aims to present an experience, an attempt at refuge and creation. A platform that created a micro-community of artists who came together temporarily to work around the issue of the climate crisis. The proposal brought together artistic and educational actions that blur the boundaries between art and climate activism, to imagine other possible worlds in the face of the catastrophe that Brazil is experiencing today. The project aimed to bring together people willing to exchange practices, train and inform artists and interested parties in relation to the theme, but also keep creation alive during the time of confinement caused by the Covid-19 pandemic. It also intended to promote a space for thought and imagination around possible actions to face the crisis. The project was designed mainly to take place at a distance, creating a platform for monthly meetings between groups from Brazil and other countries to think about "tasks" of proximity between

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Perspective

Electrical energy infrastructure and social worlds: An anthropological perspective on the circulation of meteorological artifacts

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ABSTRACT

The article provides an anthropological analysis of the different social worlds that make up electrical energy infrastructures. Using the lens of the anthropology of infrastructures, we reflect on the role of meteorological information artifacts in the constitution of the infrastructure of the electrical energy system in Brazil. Based on fieldwork, we show how meteorological artifacts play a performative role as *boundary objects* in the sociomaterial dynamics of the hydropower infrastructure. The article describes how social worlds are entangled with the circulation of weather and climate knowledge in the electrical energy infrastructures, which is increasingly important in the current context of climate change.

1. Introduction

The Brazilian National Interconnected System (SIN) is a system that physically interconnects the entire infrastructure of electrical energy production and transmission in Brazil. Extraordinarily, when compared to the global energy matrices, the SIN is composed of 66.6% hydraulic energy, generated by 144 hydroelectric plants [1]. The SIN is an infrastructure of continental dimensions, whose operation is based on the availability of water from the rivers where the plants are installed. This makes meteorological information of special importance for the management of the system.

The question that arises is how tensions and divergences between actors (specifically electricity technicians, energy traders, and climate scientists) are negotiated and managed so that the SIN infrastructures can meet the objectives of different social worlds. Through data generated by ethnographic fieldwork on three interrelated social worlds - the National Electrical System Operator, energy trading in the electrical energy markets, and the operation of climate services, such as climate forecasting provision - we will describe, in this article, how meteorological artifacts are used for the production of coordination and in the effort to coherently execute the SIN infrastructure.

The information and analysis that we present in this article are the result of four-years of experience working with meteorologists and electrical energy sector professionals in the scope of the international project "CLIMAX - Climate Services Through Knowledge Co-Production: A Euro-South American Initiative for Strengthening Societal Adaptation Response to Extreme Events," an interdisciplinary research effort done in cooperation between European and South American researchers to develop climate services in South America. Among the objectives proposed by the different working groups that make up the project, the team dedicated to social studies sought to map and analyze the process that goes from the generation of climate information to the moment when the energy sector stakeholders use meteorological products to make decisions.

The research results presented in this article contribute to understanding how the electrical energy sector is constituted in a context that relies heavily on atmospheric-hydrological cycles. The fact that the worldwide transition toward renewable energy increases the dependency of generation on atmospheric and hydrological processes, not only for rain but also sunlight and wind, suggests that the analysis of the Brazilian electrical energy infrastructure, and the role that meteorological objects play in it, is relevant to the international debate.

2. Electrical energy infrastructures: 'convergence' across different 'social worlds'

Social scientists have been increasingly interested in qualitative research dedicated to infrastructure and its social complexity [2]. Star

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Introdução

A partir do entendimento do espaço como instância do encontro de trajetórias, aberto, processual e desarticulado, segundo as proposições da geógrafa Doreen Massey (2008) e apoiados pelos balizamentos tanto conceituais quanto metodológicos do antropólogo Massimo Canevacci (2004) a respeito da polifonia da comunicação urbana, investimos num percurso que busca compreender os estudos da cidade por meio de sua multiplicidade e diversas técnicas interpretativas. Olhamos para um espaço urbano que pode ser narrado pelo modo como seus agentes participam como atores e, ao mesmo tempo, espectadores de um emaranhado de vivências e mediações, agora se presentificando em outros modos, enquadramentos e ritmos.

Das múltiplas faces que o contexto da pandemia apresenta e permite investigar, escolhemos tratar a relação do medo e suas derivações, como expõe o sociólogo Bauman, ao dizer que o medo é "mais assustador quando difuso, disperso (...) quando a ameaça que devemos temer pode ser vislumbrada em toda parte, mas em lugar algum se pode vê-la" (BAUMAN, 2006, p. 8).

Dessa forma, o cenário[1] estabelecido para entender a cidade-medo configura-se por essa situação de isolamento das pessoas em casa, não mais livres para andar pelas ruas ou praticar suas atividades diárias. Afastadas de uma experiência citadina proveniente do convívio, do contato e dos seus itinerários para uma nova disposição voltada ao isolamento e distanciamento social, elas dispõem, como principal fonte de notícias, do consumo diário veiculado pela mídia em massa.

Por isso interessa investigar quais novas relações podem ser estabelecidas entre as pessoas e a cidade-medo, bem como as marcas que circunscrevem ao isolamento social esses corpos, diariamente consumidos pelas informações e desinformações, adotando como proposta metodológica a criação de um diário a partir das experiências corpográficas mediadas entre janelas. O binômio cidade-medo cria-se a partir da construção do próprio cenário urbano tratado no contexto deste artigo, ao pensarmos no emprego do hífen como superfície, adotando o conceito de Paul Virilio: "Toda superfície é uma interface entre dois meios onde ocorre uma atividade constante sob forma de troca entre as duas substâncias postas em contato" (VIRILIO, 1993, p. 12). Tal conceito servirá de proposição para ir à janela e marcar a transição para a experiência da cidade em quarentena.

Nesse sentido, as experiências entre janelas nas cidades de Santa Cecília (SP), Bento Ferreira (ES) e Hélio Ferraz (ES) serviram para a criação dos diários corpográficos organizados por registros em nuvens de palavras, desenho, poesias e fotografias. Cada diário é marcado pelas diferentes maneiras sensíveis de pensar o espaço urbano, intensificando as sensações que cada "ex-posição" (LARROSA, 2014, p. 22) pode ocasionar.

Portanto, reside nessa imobilidade a abertura ao agucamento do olhar para a cena urbana enquadrada através de janelas, e nesses escritos de quarenta do diário corpográfico, a proposição de um método potente para fomento de uma análise e composição dessa cidade-medo estabelecida, investigando outras maneiras de relacionamento com a cidade a partir das diversas vozes que narram a experiência do lugar.

1 As atividades empíricas executadas durante a produção deste artigo ocorreram entre os meses de maio e junho de 2020, concomitantemente ao período mais rígido de isolamento social decretado por alguns Estados. Além disso, o intenso consumo das mídias sociais e dos veículos de comunicação em massa por causa da quarentena abriu novas possibilidades de exploração dos espaços de vida urbanos. Nesse sentido, é desse cenário pandêmico e informativo que surge a necessidade de criação dos diários corpográficos sensíveis como meio de registrar as sensações e sensibilidades atravessadas por esse corpo em estado de isolamento que habita entre janelas, emoções aqui durante a atual pandemia de Covid-19.

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Dez notas sobre as ruínas do Antropoceno:

uma busca por um solo comum entre diversos campos do saber

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Citizens' viewpoints on stormwater Beneficial Management Practices (BMPs) in Brazil

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ABSTRACT
Floods are among the most dangerous and destructive hazards in the world. Stormwater Beneficial Management Practices (BMPs) are a set of strategies that can assist in reducing urban floods and their damages by capturing surface runoff and promoting infiltration. Engagement of citizens in the selection of stormwater BMPs may facilitate the decision-making processes and increase the chance of adopting and maintaining them. Due to existence of catastrophic floods in Brazil, implementing BMPs is essential in the urban areas. The objective of this study is to understand the viewpoints of citizens about a set of stormwater BMPs in Brazil. Moreover, we aim to comprehend whether diverging viewpoints about the BMPs can be associated with existence of different layers in the society. For this purpose, online surveys were used to access wide and diverse groups of citizens from different ages, levels of education and income, as well as geographical location. The questions and descriptions of BMPs were prepared in an accessible language, and then disseminated through various platforms. The responses of more than 1000 participants were analyzed using descriptive and statistical methods. Our results show that the participants found the retention and detention basins, as well as permeable pavement as the most efficient BMPs. Moreover, considering the small-scale practices, although lot related BMPs are considered less efficient, citizens are willing to use green roof, bioretention, and rain barrels in their properties. In addition, most of the respondents support public investments on stormwater BMPs. Our analyses show that participants' age and level of education statistically influenced their choice of BMPs and willingness to pay for their maintenance and construction. These results can help Brazilian policy makers to prepare flood management plans by including stormwater BMPs that would be more accepted by the population. In addition, proposing practices that are aligned with citizens' perceptions creates a sense of responsibility, and is in accordance with the Brazilian New Framework of Sanitation that includes public participation in policy making.

1. Introduction

Frequent and intense extreme rainfall events over impervious surfaces have caused formation of severe floods in various cities across the globe, increasing human and material losses (Bisckl et al., 2019). In Brazil, floods have caused high socioeconomic destructions and human losses. Specifically, 34.9% of disastrous events between 2000 and 2015 in Brazil are related to floods (de Freitas et al., 2020). More recently, in the state of minas Gerais, for example, floods caused losses of approximately 230 million dollars in January 2020, making around 90 thousand people have to temporarily leave their houses (Constantino, 2020). This shows the country's vulnerability to flash floods has been increasing. Therefore, with the increasing population in the cities, it is critical to implement strategies to mitigate the effects of urban flooding.

Stormwater Beneficial Management Practices (BMPs) under two categories of structural and non-structural strategies are commonly used worldwide to reduce urban flooding (Kolles et al., 2019). Non-structural strategies use watershed characteristics to reduce floods. Some examples include protecting the riparian buffer, stormwater disconnection, and improving flood warning systems (Fava et al., 2020; Meyer et al., 2012;

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Multi-driver ensemble to evaluate the water utility business interruption cost induced by hydrological drought risk scenarios in Brazil

Diego A. Guzmán, Guilherme S. Mohor & Eduardo M. Mendiondo

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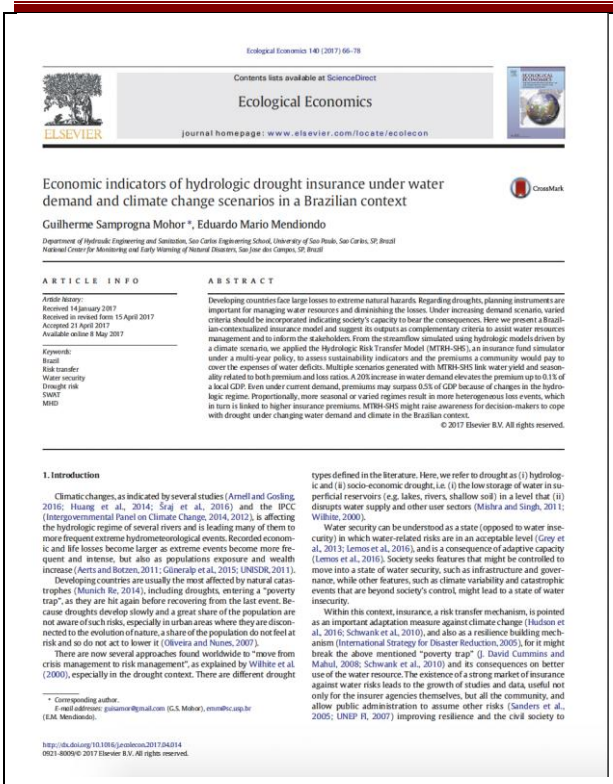

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Economic indicators of hydrologic drought insurance under water demand and climate change scenarios in a Brazilian context

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ABSTRACT

Developing countries face large losses to extreme natural hazards. Regarding droughts, planning instruments are important for managing water resources and diminishing the losses. Under increasing demand scenario, varied criteria should be incorporated indicating society's capacity to bear the consequences. Here we present a Brazilian-contextualized insurance model and suggest its outputs as complementary criteria to assist water resources management and to inform the stakeholders. From the streamflow simulated using hydrologic models driven by a climate scenario, we applied the Hydrologic Risk Transfer Model (MTRH-SHS), an insurance fund simulator under a multi-year policy, to assess sustainability indicators and the premiums a community would pay to cover the expenses of water deficits. Multiple scenarios generated with MTRH-SHS link water yield and seasonality related to both premium and loss ratios. A 20% increase in water demand elevates the premium up to 0.1% of a local GDP. Even under current demand, premiums may surpass 0.5% of GDP because of changes in the hydrologic regime. Proportionally, more seasonal or varied regimes result in more heterogeneous loss events, which in turn is linked to higher insurance premiums. MTRH-SHS might raise awareness for decision-makers to cope with drought under changing water demand and climate in the Brazilian context.

1. Introduction

Climatic changes, as indicated by several studies (Arnell and Gosling, 2016; Huang et al., 2014; Šraj et al., 2016) and the IPCC (Intergovernmental Panel on Climate Change, 2014, 2012), is affecting the hydrologic regime of several rivers and is leading many of them to more frequent extreme hydrometeorological events. Recorded economic and life losses become larger as extreme events become more frequent and intense, but also as populations exposure and wealth increase (Aerts and Botzen, 2011; Güneralp et al., 2015; UNISDR, 2011).

Developing countries are usually the most affected by natural catastrophes (Munich Re, 2014), including droughts, entering a "poverty trap", as they are hit again before recovering from the last event. Because droughts develop slowly and a great share of the population are not aware of such risks, especially in urban areas where they are disconnected to the evolution of nature, a share of the population do not feel at risk and so do not act to lower it (Oliveira and Nunes, 2007).

There are now several approaches found worldwide to "move from crisis management to risk management", as explained by Wilhite et al. (2000), especially in the drought context. There are different drought types defined in the literature. Here, we refer to drought as (i) hydrologic and (ii) socio-economic drought, i.e. (i) the low storage of water in superficial reservoirs (e.g. lakes, rivers, shallow soil) in a level that (ii) disrupts water supply and other user sectors (Mishra and Singh, 2011; Wilhite, 2000).

Water security can be understood as a state (opposed to water insecurity) in which water-related risks are in an acceptable level (Grey et al., 2013; Lemos et al., 2016), and is a consequence of adaptive capacity (Lemos et al., 2016). Society seeks features that might be controlled to move into a state of water security, such as infrastructure and governance, while other features, such as climate variability and catastrophic events that are beyond society's control, might lead to a state of water insecurity.

Within this context, insurance, a risk transfer mechanism, is pointed as an important adaptation measure against climate change (Hudson et al., 2016; Schwank et al., 2010), and also as a resilience building mechanism (International Strategy for Disaster Reduction, 2005), for it might break the above mentioned "poverty trap" (J. David Cummins and Mahul, 2008; Schwank et al., 2010) and its consequences on better use of the water resource. The existence of a strong market of insurance against water risks leads to the growth of studies and data, useful not only for the insurer agencies themselves, but all the community, and allow public administration to assume other risks (Sanders et al., 2005; UNEP FI, 2007) improving resilience and the civil society to

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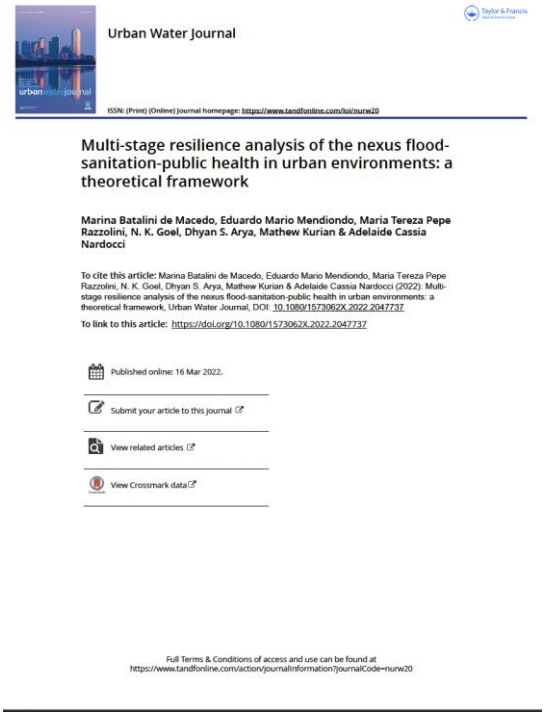

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Multi-stage resilience analysis of the nexus flood-sanitation-public health in urban environments: a theoretical framework

Marina Batalini de Macedo, Eduardo Mario Mendiondo, Maria Tereza Pepe Razzolini, N. K. Goel, Dhyan S. Arya, Mathew Kurian & Adelaide Cassia Nardocci

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Multi-driver ensemble to evaluate the water utility business interruption cost induced by hydrological drought risk scenarios in Brazil

Diego A. Guzmán, Guilherme S. Mohor & Eduardo M. Mendiondo

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Multi-Year Index-Based Insurance for Adapting Water Utility Companies to Hydrological Drought: Case Study of a Water Supply System of the Sao Paulo Metropolitan Region, Brazil

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check for updates

Abstract: The sustainability of water utility companies is threatened by non-stationary drivers, such as climate and anthropogenic changes. To cope with potential economic losses, instruments such as insurance are useful for planning scenarios and mitigating impacts, but data limitations and risk uncertainties affect premium estimation and, consequently, business sustainability. This research estimated the possible economic impacts of business interruption to the Sao Paulo Water Utility Company derived from hydrological drought and how this could be mitigated with an insurance scheme. Multi-year insurance (MYI) was proposed through a set of "change" drivers: the climate driver, through forcing the water evaluation and planning system (WEAP) hydrological tool; the anthropogenic driver, through water demand projections; and the economic driver, associated with recent water price policies adopted by the utility company during water scarcity periods. In our study case, the evaluated indices showed that MYI contracts that cover only longer droughts, regardless of the magnitude, offer better financial performance than contracts that cover all events (in terms of drought duration). Moreover, through MYI contracts, we demonstrate solvency for the insurance fund in the long term and an annual average actuarially fair premium close to the total expected revenue reduction.

Keywords: multi-year insurance; climate change; hydrological drought; water security and economy

1. Introduction

The link between climate change and the economic impact of natural disasters is a fact that can hardly be contradicted [1]. According to a report published by the World Meteorological Organization [2], from 1971 to 1980 and 2001 to 2010, the number of reported disasters and amount of economic losses by decade increased by factors of 4.7 and 5.5, respectively, despite policy and adaptation actions against climate change that were adopted [3]. The report specified that approximately 11% of natural disasters reported from 1971 to 2012 were related to severe drought and extreme temperature. Moreover, these events accounted for 34% of all deaths and approximately USD 286.88 billion in economic losses [2].

A drought is generally established from a serious rainfall deficiency that propagates to the next components of the hydrological cycle [4]. If this water deficiency extends over a long period of time, it can lead to a low availability of surface and groundwater, constituting a hydrological drought [5,6].

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Droughts in São Paulo: challenges and lessons for a water-adaptive society

Felipe Augusto Arguello Souza, Guilherme Samprogna Mohor, Diego Alejandro Guzmán Arias, Ana Carolina Sarmento Buarque, Denise Taffarello & Eduardo Mario Mendiondo

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Evidence of Amazon rainforest dieback in CMIP6 models

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Abstract. Amazon forest dieback is seen as a potential tipping point under climate change. These concerns are partly based-on an early coupled climate-carbon cycle simulation, that produced unusually strong drying and warming in Amazonia. In contrast, the 5th generation Earth System Models (CMIP5) produced few examples of Amazon dieback under climate change. Here we examine results from seven 6th generation models (CMIP6) which include vegetation dynamics, and in some cases interactive forest fires. Although these models typically project increases in area-mean forest carbon across Amazonia under CO_2-induced climate change, five of the seven models also produce abrupt reductions in vegetation carbon which indicate localised dieback events. The Northern South America region (NSA), which contains most of the rainforest, is especially vulnerable in the models. These dieback events, some of which are mediated by fire, are preceded by an increase in the amplitude of the seasonal cycle in near surface temperature, which is consistent with more extreme dry seasons. Based-on the ensemble mean of the detected dieback events we estimate that 7+/-5 % of the NSA region will experience abrupt downward shifts in vegetation carbon per °C of global warming above 1.5°C.

1 Introduction

A 'tipping point' commonly refers to small changes to input levels causing a system to abruptly transition to some alternative (often less desirable) stable state (Lenton et al., 2008). Future tipping points pose a risk to both natural ecosystems and, by extension, human activities, as they produce abrupt system wide changes that are often difficult or even impossible to reverse (Lenton et al., 2013). The Amazon rainforest is one example in the climate system that is at risk of experiencing a tipping event, with the possibility of abrupt forest dieback in response to rising global temperatures (Cox et al., 2004). Amazon dieback has the potential to accelerate global warming through reducing the Amazon's ability to act as a carbon sink, and releasing carbon dioxide that would lead to additional global warming (Cox et al., 2000). Tipping points may play an important role in the future of our changing climate (Jørgensen et al., 2014; Lenton et al., 2013), with previous analysis of CMIP5 models suggesting that multiple regional abrupt transitions could occur for global warming levels less than 2 degree Celsius (Drijfhout et al., 2015).

There are several factors which could contribute to a decline in vegetation in the Amazon, including a lengthened dry season, increased fire frequency, and reduced precipitation (Malhi et al., 2009). The number of extreme hot and dry days in the Amazon is predicted to increase with global warming (Vogel et al., 2020) and the length and intensity of the dry season expected to intensify (Malhi et al., 2009). Further drying in the Amazon is anticipated from the slowdown of the Atlantic Meridional Overturning circulation due to ice melt causing an influx of fresh water into the North Atlantic (Lenton et al., 2019). Moisture

Avaliação da irradiação solar utilizando modelo BRASIL-SR em condições de céu claro – estudo do impacto de aerossóis na Amazônia brasileira e no Cerrado

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Resumo. *As plumas de aerossol geradas durante a estação de queima de biomassa no Brasil sofrem transporte de longo alcance, resultando em grandes profundidades ópticas de aerossol em um domínio extenso do território brasileiro. Como consequência, a irradiância solar da superfície descendente, e em particular o componente direta, pode ser significativamente reduzida. Estimativas da irradiância solar incidente na superfície considerando a contribuição radiativa dos aerossóis de queima de biomassa são necessárias para apoiar o setor de energia solar do Brasil. Este trabalho apresenta resultados obtidos com a 2ª geração do modelo de transferência radiativa BRASIL-SR, desenvolvida para melhorar a representação do aerossol e reduzir as incertezas nas estimativas de irradiância solar de superfície em condições de céu sem nuvens. Dois experimentos numéricos permitiram avaliar a habilidade do modelo usando dados AOD observacionais ou regionais de reanálise do MERRA-2 em uma região frequentemente afetada por queimadas. Quatro locais de medição de solo forneceram dados para a alimentar o modelo e validar valores de GHI e DNI por ele fornecidas. As estimativas para a componente GHI foram obtidas utilizando o escalonamento ô-Eddington, mas para a DNI o escalonamento não foi adotado. É evidenciado um aumento no erro relativo das estimativas de GHI e DNI à medida que AOD aumenta. Os desvios de MBD variaram de -2,3 a -0,5%, RMSD entre 2,3 e 4,7% e OVER entre 0 e 5,3% ao usar dados de AOD observados in-situ. De maneira geral, nossas resultados indicam uma boa habilidade do BRASIL-SR para estimar GHI e DNI quando comparados com dados apresentados pelas estimativas produzidas pelos modelos McClear e Rest2. Estudo de caso com estimativa da irradiância espectral também é apresentada neste artigo..*

Palavras-chave: *Avaliação de recursos solares; Irradiância normal direta; Aproximação Delta-Eddington; Queima de biomassa*

1. INTRODUÇÃO

O Brasil possui um vasto recurso de energia solar (Lima *et al.*, 2019; Pereira *et al.*, 2017) e tem experimentado um aumento na implantação fotovoltaica nos últimos anos devido a incentivos governamentais e avanços tecnológicos (Santos e Cunha, 2019). Diversos estudos têm mostrado que a energia solar pode ser alternativa para aumentar a segurança energética, contrabalançando a vulnerabilidade imposta pela alta dependência da hidrelétrica (Luz *et al.*, 2018; Campos *et al.*, 2021). Em particular, as tecnologias de concentração de energia solar (CSP) têm mostrado um potencial notável para o Brasil em cenários de mitigação das mudanças climáticas (Martins *et al.*, 2012; Fichter *et al.*, 2017), especialmente como fonte de calor complementar para processos industriais ou geração de energia híbrida (Sona *et al.*, 2015; Milani *et al.*, 2017). Deve-se notar que algumas áreas potenciais para o desenvolvimento de CSP, como as regiões Centro-Oeste e Sudeste, são frequentemente afetadas pelas emissões de aerossóis em eventos de queimadas, principalmente durante a estação seca (Rosário *et al.*, 2013; Martins *et al., 2018*).

Os aerossóis atmosféricos são o fator mais importante para a extinção da radiação solar em condições sem nuvens, seguido pelo vapor d'água. Em particular, a irradiância normal direta (DNI) é 2 a 4 vezes mais sensível à presença de aerossol do que a irradiância horizontal global (GHI) (Gueymard, 2012). O impacto dos aerossóis de poeira no DNI foi avaliado para vários locais áridos e semiáridos (Ruiz-Arias *et al.*, 2019; Boraey *et al.*, 2017). No entanto, faltam avaliações semelhantes levando em consideração os aerossóis de queima de biomassa. Embora menor em magnitude do que o impacto dos aerossóis de poeira devido à profundidade óptica comparativamente moderados, o impacto dos aerossóis de queima de biomassa no DNI é significante em regiões onde a atividade de queima é sazonalmente intensa. As grandes cargas de aerossóis normalmente injetadas na atmosfera durante a estação seca no Brasil podem resultar em profundidade

Journal Pre-proof

Increased chlorophyll-a concentration in Barra Bonita reservoir during extreme drought periods

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Article

Trends and Climate Elasticity of Streamflow in South-Eastern Brazil Basins

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Abstract: Trends in streamflow, rainfall and potential evapotranspiration (PET) time series, from 1970 to 2017, were assessed for five important hydrological basins in Southeastern Brazil. The concept of elasticity was also used to assess the streamflow sensitivity to changes in climate variables, for annual data and 5-, 10- and 20-year moving averages. Significant negative trends in streamflow and rainfall and significant increasing trend in PET were detected. For annual analysis, elasticity revealed that 1% decrease in rainfall resulted in 1.21–2.19% decrease in streamflow, while 1% increase in PET induced different reductions percentages in streamflow, ranging from 2.45% to 9.67%. When both PET and rainfall were computed to calculate the elasticity, results were positive for some basins. Elasticity analysis considering 20-year moving averages revealed that impacts on the streamflow were cumulative: 1% decrease in rainfall resulted in 1.83–4.75% decrease in streamflow, while 1% increase in PET induced 3.47–28.3% decrease in streamflow. This different temporal response may be associated with the hydrological memory of the basins. Streamflow appears to be more sensitive in less rainy basins. This study provides useful information to support strategic government decisions, especially when the security of water resources and drought mitigation are considered in face of climate change.

Keywords: runoff; precipitation; potential evapotranspiration; Pettitt test; sensitivity

1. Introduction

A number of studies have reported streamflow reduction in several important basins throughout the world [1–5], putting enormous social, environmental and economic pressure on the world's population and leading to great insecurity when it comes to water, energy and food supply [6,7]. This phenomenon can be associated with the increase on frequency and intensity of extreme climatic events, such as heat waves and droughts [8], as well anthropogenic interferences in the climate via greenhouse gases emission and land use and cover modifications [9–11]. Both interferences together affect streamflow discharge and water resources management. In relation to climate variations, streamflow

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RESEARCH ARTICLE

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Uncertainties in projections of climate extremes indices in South America via Bayesian inference

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Abstract
Historical simulations and projections of climate extremes indices of precipitation and temperature were analysed over South America until the end of the 21st century through 31 general circulation models (GCMs) under four Representative Concentration Pathways. Simulations were compared with reanalysis data, and a Bayesian inference method was used to assess the uncertainties involved in the multi-model climate projections. Regarding the precipitation extremes indices, the GCMs' simulations reasonably approached the reanalysis data, but with heterogeneous biases, both in sign and in the location of the highest values. The temperature extremes indices presented the smallest biases when compared to precipitation. Projections show a gradual growth of precipitation extremes events as the analysed radiative forcing scenario increases, both in magnitude and extent, over a large part of South America. Projections also indicate a decrease in cold days and nights and an increase in warm days and nights, more pronounced in the equatorial region. Bayesian inference method smoothed changes in precipitation extremes events, both in magnitude and extent, compared to the simple GCMs' ensemble mean. There was no considerable variation in the temperature indices when applying the Bayesian inference. Finally, the probability density functions resulted in a predominance of multimodal and wide curves for the precipitation indices, showing great uncertainties in the GCMs' results, differently from those for the temperature indices, where the GCMs presented good agreement represented through unimodal and narrow curves.

KEYWORDS
Bayesian inference, climate extremes events, CMIP5, general circulation models

1 | INTRODUCTION

Changes in climate observed in recent decades, and widely described in the various reports of the Intergovernmental Panel on Climate Change (IPCC), are more intense and faster than those that would be observed by some known natural factor, particularly for weather and climate extremes (IPCC, 2013, 2018, 2021). Nowadays, it is known that the anthropic influence on these changes is undoubted, and one of the main factors is the high concentrations of greenhouse gases (GHG) accumulated in the climate system, which is unprecedented in the recent history of the planet (IPCC, 2021). This has already caused global warming to reach 1°C in 2017 (IPCC, 2018).

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Article

Recent Hydrological Droughts in Brazil and Their Impact on Hydropower Generation

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Abstract: Brazil has endured the worst droughts in recorded history over the last decade, resulting in severe socioeconomic and environmental impacts. The country is heavily reliant on water resources, with 77.7% of water consumed for agriculture (irrigation and livestock), 9.7% for the industry, and 11.4% for human supply. Hydropower plants generate about 64% of all electricity consumed. The aim of this study was to improve the current state of knowledge regarding hydrological drought patterns in Brazil, hydrometeorological factors, and their effects on the country's hydroelectric power plants. The results show that since the drought occurred in 2014/2015 over the Southeast region of Brazil, several basins were sharply impacted and remain in a critical condition until now. Following that event, other regions have experienced droughts, with critical rainfall deficit and high temperatures, causing a pronounced impact on water availability in many of the studied basins. Most of the hydropower plants end the 2020–2021 rainy season by operating at a fraction of their total capacity, and thus the country's hydropower generation was under critical regime.

Keywords: hydrological drought; drought monitoring; hydrometeorological extreme; hydropower generation

1. Introduction

Heat waves, heavy rain, drought and associated wildfires, and coastal flooding are examples of extreme weather events that pose risks to human health, livelihood, assets, and ecosystems. The 21st century begins with a considerable record of natural disasters associated with hydrometeorological and climatic extremes. These occurrences resulted in significant economic and environmental losses worldwide. Over 4.4 billion people were injured, homeless, displaced or in need of emergency assistance from 1998 to 2017. Floods, storms, droughts, heat waves, and other extreme weather events caused 91% of all disasters, according to the UNISDR and CRED report [1]. However, droughts can seriously harm a country's economic performance, causing widespread problems in various sectors. According to GAR [2], climate change increases the frequency, severity, and duration of droughts globally, requiring efforts to effectively respond to the significant risks posed by droughts. Future climate change scenarios are expected to cause considerably more

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Assessing the role of compound drought and heatwave events on unprecedented 2020 wildfires in the Pantanal

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Abstract

The year 2020 had the most catastrophic fire season over the last two decades in the Pantanal, which led to outstanding environmental impacts. Indeed, much of the Pantanal has been affected by severe dry conditions since 2019, with evidence of the 2020's drought being the most extreme and widespread ever recorded in the last 70 years. Although it is unquestionable that this mega-drought contributed significantly to the increase of fire risk, so far, the 2020's fire season has been analyzed at the unwarrantable level of a single climate event, not considering the co-occurrence of extreme and persistent temperatures with soil dryness conditions. Here, we show that similarly to other areas of the globe, the influence of land-atmosphere feedbacks contributed decisively to the simultaneous occurrence of dry and hot spells (HPs), exacerbating fire risk. The ideal synoptic conditions for strong atmospheric heating and large evaporation rates were present, in particular during the HPs, when the maximum temperature was, on average, 6 °C above the normal. The short span of the period during those compound drought-heatwave (CDHW) events accounted for 55% of the burned area of 2020. The vulnerability in the northern forested areas was higher than in the other areas, revealing a synergistic effect between fuel availability and weather-hydrological conditions. Accordingly, where fuel is not a limiting factor, fire activity tends to be more modelled by CDHW events. Our work advances beyond an isolated event-level basis towards a compound and cascading natural hazards approach, simultaneously estimating the contribution of drought and heatwaves to fuelling extreme fire outbreaks in the Pantanal such as those in 2020. Thus, these findings are relevant within a broader context, as the driving mechanisms apply across other ecosystems, implying higher flammability conditions and further efforts for monitoring and predicting such extreme events.

Keywords: Pantanal, Brazil, compound events, droughts, heatwaves, climate extremes, wildfires

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Essays and Perspectives

Understanding Brazil's catastrophic fires: Causes, consequences and policy needed to prevent future tragedies

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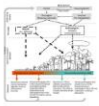
HIGHLIGHTS

- Fire incidence in Brazil increased in 2019–2020, with unprecedented magnitude in the Pantanal.
- Fire effects vary according to the evolutionary history of the affected ecosystem.
- A drier climate and land use changes increase the risk of wildfires throughout Brazil.
- Poor governance further exacerbates the risk and damage of wildfires.
- Fire policies must be improved by collaboration among different sectors of the society.

GRAPHICAL ABSTRACT



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ABSTRACT

Brazil has experienced unprecedented wildfires in the last decade. Images of immense burnt areas or dead animals that failed to escape the 2020 wildfires have shocked the world. To prevent or minimize further similar disasters we must understand the factors that have led to these catastrophic events. The causes and consequences of wildfires entail complex interactions between the biophysical and sociocultural spheres, and suitable management decisions require a sound scientific base. We present the recent panorama of increasing fire outbreaks in the Brazilian biomes, and discuss the causes that have contributed to such fires, their impacts on the environment and overall consequences for human well-being, based on reviewing the extensive specialist literature, on authors' expert knowledge and information provided by environmental managers, researchers and politicians during a workshop organized to debate the

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REVIEW ARTICLE

Drought in Northeast Brazil: A review of agricultural and policy adaptation options for food security

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Abstract
The semiarid lands of Northeast Brazil represent one of the most densely populated regions of the country. Rainfall variability together with land degradation and large-scale poverty in rural areas makes this region vulnerable to droughts. Most of the agriculture in this region is rainfed and deficient rainfall leads to severe drought impacts. In this review, we examine different short- and long-term strategies directed to cope with possible impacts of droughts proposed by the government, farmers, civil society, and the private sector. These are approaches to adaptation to drought in the Northeast of Brazil, and among them, we have agricultural management and soil conservation and better management of water resources. Other actions include seasonal climate forecasts and funds transfer and credits to affected small-scale farmers. Although some of these actions are for the short term and may help to survive the drought situation, they may be only postdisaster mitigation options that do not improve adaptive capacity. They favor maladaptation and create dependency of farmers to government actions. Some experiences such as AdaptaSertão show potential benefits for small-scale farmers. We identify key challenges for moving toward a more holistic risk management approach and highlight the need to integrate actions and tools for adaptation, combining technology-based solutions with in-depth knowledge of local and regional social, economic, and cultural aspects, among them seasonal climate forecasts and drought impacts studies, among some other proactive predisaster ways, rather than reactive postdisaster actions. Adaptation strategies must increase long-term resilience of food production in the Brazilian Northeast, going beyond an individual drought event.

KEYWORDS
adaptation, climate change, drought, food security, Northeast Brazil

AN EARLY WARNING FOR SOIL MOISTURE APPLIED TO AGRICULTURE IN BRAZIL, USING RADAR DATA AND NORMALIZED DIFFERENCE VEGETATION INDEX

SISTEMA DE ALERTA DE CONDIÇÕES DE UMIDADE DO SOLO APLICADO PARA AGRICULTURA NO BRASIL, UTILIZANDO DADOS DE RADAR E NDVI

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Abstract: Soil moisture has an important impact on agriculture by alerting decision makers to flooding and drought. Considering that direct measurements of soil moisture on a large scale are relatively rare, soil moisture can be calculated based on water balance models.

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The new historical flood of 2021 in the Amazon River compared to major floods of the 21st century: Atmospheric features in the context of the intensification of floods

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ABSTRACT

In June 2021 a new extreme flood was reported in the Amazon Basin, the largest hydrological system on Earth. During this event water level was above 29 m (the emergency threshold) for 91 days at Manaus station (Brazil), surpassing even the previous historical flood of 2012. Since the late 1990s, 9 extreme floods occurred, while only 9 events were reported from 1903 to 1990. Here we report that the 2021 flood is associated with an intensification of the atmospheric upward motion in the northern Amazonia (5°S-5°N), which is related to an intensification of the Walker circulations. This atmospheric feature is associated with an enhanced of deep convective clouds and intense rainfall over the northern Amazonia that produce positive anomalies of terrestrial water storage over northern Amazonia in the 2021 austral summer. The intensification of Walker circulation is associated with La Niña conditions that characterize the major floods observed in Amazonia during the 21st century (2009, 2012 and 2021). However, during the 2021 an intensification of the continental Hadley circulation is also observed. This feature produces simultaneous dry conditions over southern and southeastern Amazonia, where negative rainfall anomalies, low frequency of deep convective clouds and negative anomalies of terrestrial water storage are observed.

1. Introduction

The Amazon River has the highest average discharge in the world with approximately 200,000 m^3/s (Mendé et al., 1991, Callède et al., 2004; Latrubesse 2005). Four of the ten largest rivers in the world, considering their discharge, occur in the Amazon Basin (Solimões-Amazonas, Madeira, Negro and Japurá) (Latrubesse 2015). Due to the absent of a road network in the past, most cities, rural settlements and indigenous villages in the Central Amazon region have been established along the large flood-pulsing rivers. The associated flood-plains have been settled and used for centuries by indigenous and traditional populations performing activities for subsistence and commerce such as agriculture, livestock production, fishery and forestry which are intrinsically related to the annual hydrological cycle (Junk et al., 2000). During the last three decades the hydrological regime in the largest watershed on Earth was characterized by a higher frequency of extreme floods and droughts (Fig. 1) (Marengo and Espinoza., 2016; Marengo et al., 2018). This intensification has severe impacts on the urban and rural riverine population and associated socioeconomic sectors. Flooding also alters sediment transport – an important process for downstream ecosystems, fisheries and farms – and carbon storage in plants, soils and wetlands (Abril, 2014; Armijos et al., 2020). Therefore, extreme floods can cause extensive agricultural and infrastructure damage.

At the Port of Manaus (Central Amazonia), where daily water level measurements exist since September 1902, when the water level reaches the threshold of 29.0 m (threshold value determined by the Brazilian Geological Survey - CPRM), emergency situation is declared due to the severe impacts on public health, loss of infrastructure, properties and impacts on several socioeconomic sectors (Maciel et al., 2020). At this hydrological station major flood events (water level >29 m) occurred during the first seven decades of the instrumental record with a return period of about 20 years but reduced to about four years in the recent decades (Barichivich et al., 2018).

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Increased climate pressure on the agricultural frontier in the Eastern Amazonia–Cerrado transition zone

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Several large-scale drivers of both anthropogenic and natural environmental changes are interacting nonlinearly in the transition zone between eastern Amazonia and the adjacent Cerrado, considered to be another Brazilian agricultural frontier. Land-use change for agrobusiness expansion together with climate change in the transition zone between eastern Amazonia and the adjacent Cerrado may have induced a worsening of severe drought conditions over the last decade. Here we show that the largest warming and drying trends over tropical South America during the last four decades are observed to be precisely in the eastern Amazonia–Cerrado transition region, where they induce delayed wet-season and worsen severe drought conditions over the last decade. Our results evidence an increase in temperature, vapor pressure deficit, subsidence, dry-day frequency, and a decrease in precipitation, humidity, and evaporation, plus a delay in the onset of the wet season, inducing a higher risk of fire during the dry-to-wet transition season. These findings provide observational evidence of the increasing climatic pressure in this area, which is sensitive for global food security, and the need to reconcile agricultural expansion and protection of natural tropical biomes.

Land-use change for agrobusiness expansion together with underlying climate change may induce higher frequency of extreme climate events[1–4], increasing the exposure and vulnerability of tropical forests and Cerrado[5–9]. The transition zone between the Eastern Amazon and the Cerrado (EAC) biomes comprises the largest area of contact between forest and savanna in the tropics, with the Cerrado recognized as the world's most biodiverse savanna[10]. The hypothesis of "savannization" of Amazonia suggests that such a new equilibrium state becomes more likely as the climate gets warmer and drier, deforestation advances and fires become more frequent[11]. The expected result of this interplay of processes is a contraction of the humid and dense forests giving way to a Cerrado-like biome. Modeling studies show that the Amazon may have "tipping points"[12] linked to their exceeding of deforestation and temperature thresholds[13]. Satellite-based observations have recently revealed that the area of degradation and natural disturbance its surpassing that impacted by deforestation in the Amazon region[3,4]. Acting synergistically with processes already in play in the Amazon, the deterioration described here may increase climate change pressure in the region, especially putting at risk productive areas responsible for supporting global food security[5,6].

In the EAC, the MATOPIBA region (which includes the states of Maranhão, Tocantins, Piauí and Bahia—Extended Data Fig. 1) became an important agricultural frontier during the past 20 years[5]. The Cerrado is the dominant biome in the MATOPIBA (91% of the area), which also has patches of Amazon Forest and the Caatinga vegetation (shrubland vegetation typical of northeastern Brazil). The Cerrado biome is the second largest biome in Brazil, only 0.85% of its area is legally protected, and it is the biome with the most important area in terms of grain production in Brazil[14].

The current economic scenario continues to conspire against the Amazon by placing a higher premium on agricultural commodities such as soybeans, meat, and tropical timber than on standing forests[15]. The agricultural development in the MATOPIBA region in the EAC is an example of this. To prioritize deforestation-free agricultural expansion here, it is critical to increase pasture productivity coupled with incentives for direct agricultural

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comment

Advancing transdisciplinary adaptation research practice

Transdisciplinary research is increasingly seen as critical for advancing climate change adaptation. Operationalizing transdisciplinary research in the global South, however, confronts ingrained cultural and systemic barriers to participatory research.

Silvia Serrao-Neumann, Fabiano de Araújo Moreira, Michele Dalla Fontana, Roger Rodrigues Torres, David Montenegro Lapola, Lucí Hidalgo Nunes, Jose Antonio Marengo and Gabriela Marques Di Giulio

As we face an unprecedented planetary crisis[1], we must urgently scale up our capacity to adapt to climate change impacts (Fig. 1). Any attempt to address the climate emergency requires well-coordinated collaboration between the scientific, policy and social domains[2]. Planning for climate change adaptation, however, often requires information and knowledge granularity that are not always available for the specific local context[3]. Decision-making processes addressing weather and climate-related disasters need to account for complex urban and rural contexts[4]. This presents challenges because there is a time lag between policy needs and the urgency of the corresponding response and the generation of robust climate change information and knowledge[5]. Transdisciplinary research, a type of research guided by overarching conceptual frameworks that transcend disciplinary siloes[6] through mutual and joint learning processes[7], has been identified as a potential avenue to bridge the temporal and knowledge gaps hindering adaptation because it enables the integration of knowledge from different disciplines and social actors[8].

The impacts of climate change are not evenly distributed, with less-resourced communities and governments in both the global North and South already bearing the brunt of recent extreme weather events[9,10] and reaching adaptation limits[11,12]. Transdisciplinary research can aid by improving the understanding of the local context on the basis of local communities' knowledge and experiences and supporting collaborative solutions to manage adaptation constraints at the local scale. It can also strengthen the local adaptive capacity by creating opportunities for less and well-resourced as well as smaller and larger inter- and intra-jurisdictions to share tacit and local knowledge, expertise and data to better inform and design adaptation decisions[13].

However, decisions occur within political settings, which have recently led the climate agenda, and the scientific agenda more specifically, to lose traction in various countries, including those in the global South[12]. Additionally, climate change is abstract for the general public: it is often seen as a global and long-term issue rather than a local and immediate priority, and its inherent uncertainties cause mistrust[13]. Because transdisciplinary research aspires to strengthen the science–policy–society interface[14], it may also contribute to the restoration of society's trust in science and inform decisions hampered by climate science uncertainty[13,15].

While a number of general barriers to transdisciplinary research processes have been identified in the literature[16], the discussion of and reflection upon other ingrained cultural and systemic barriers is less prominent[17,18]. These include colonization legacies that still shape social relationships in many countries, especially in the global South[19,20]. For example, while transdisciplinary research has been seen as a process that promotes the inclusion of different perspectives and sources of knowledge and as important for achieving transformative pathways for climate adaptation[1], the dominant scientific, technological and innovation discourses in some countries follow a deeply rooted hierarchical and technocratic process.

Like other colonized countries, Brazil has inherited a political culture in which authoritarian government positions in combination with political clientelism have led to a resistance to public engagement in policy-making. This extends to the scientific community and underpins its reluctance to reduce its autonomy through collaborating with or responding to the needs of societal groups that lie outside of the academic community[21]. Recently, changes in the national political scene further challenged the place of science

Fig. 1 | **Inundation of the waterfront on a sunny day in Santos, São Paulo.** The port city of Santos was one of the first Brazilian cities to develope a local climate change adaptation plan. Santos is also a leader in the resilient cities project, which aims to share data and expertise to better understand the impacts of climate change at the local level. Credit: Santos Civil Defence.

in Brazilian society, which led to a confrontation between Brazilian researchers and the anti-science movement[21]. It also reinforced debates around the country's deeply entrenched colonial tradition, which, for a long period of time, was contrary to freedom of thought and restricted higher education opportunities to small parts of the elite whilst supporting simplistic and dualistic debates around research funding and outputs[22]. As the Brazilian scientific community struggles to engage with the wider society, it unintentionally reproduces pervese hierarchical colonial practices and further disempowers already disadvantaged social groups, which is especially concerning given that climate change impacts also exacerbate social inequalities.

This context reinforces the need for the research community to rethink their academic traditions and perhaps embrace transdisciplinary research more widely in the quest to help solve urgent societal problems. We stress that real solutions

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RESEARCH ARTICLE

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The heat wave of October 2020 in central South America

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Abstract

During September–November 2020, the meteorological services of Brazil, Argentina, Peru, Paraguay, and Bolivia reported record-high maximum temperatures in several warm spells during this season. Positive and significant trends in heat wave frequency, intensity, and duration have been recorded since the 1980s, particularly in large cities. In this study, a heat wave is defined as a period in which both daily maximum and minimum air temperatures exceed the corresponding climatological 90th percentile for three or more consecutive days during September–November 2020. In this period, an intense heat wave during the first half of October and two heat waves events in November resulted in record-breaking daily maximum temperatures in several locations in central South America. Places experienced temperature of about 10°C above normal, and some locations reported maximum temperatures above 40°C for several days in a row. Because its intensity and geographical extension, affecting central South America from southern Peruvian Amazon to southeastern Brazil, the heat wave of September 23–October 15 was selected as a case study. This intense heat wave was due a persistent atmospheric blocking located starting in late September and lasting until middle October 2020, a continuous presence of a warm air mass for several consecutive days contributed to pronounced positive temperature anomalies, possibly reinforced by extremely low soil moisture. This makes it easier for these high-pressure systems to generate extreme heat waves because more of the sun's energy is going into heating the atmosphere rather than evaporating non-existent water in the soil. This heat wave aggravated the drought over the Pantanal and other regions in October 2020, increasing fires and impacts on natural and human systems, representing a severe drought-heat compound event. This vicious cycle of drought and extreme heat is of the kind expected under a warming climate.

KEYWORDS
compound event, drought, heat wave, maximum temperature

Article

The challenge of unprecedented floods and droughts in risk management

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Check for updates

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Risk management has reduced vulnerability to floods and droughts globally[1,2], yet their impacts are still increasing[3]. An improved understanding of the causes of changing impacts is therefore needed, but has been hampered by a lack of empirical data[4,5]. On the basis of a global dataset of 45 pairs of events that occurred within the same area, we show that risk management generally reduces the impacts of floods and droughts but faces difficulties in reducing the impacts of unprecedented events of a magnitude not previously experienced. If the second event was much more hazardous than the first, its impact was almost always higher. This is because management was not designed to deal with such extreme events: for example, they exceeded the design levels of levees and reservoirs. In two success stories, the impact of the second, more hazardous, event was lower, as a result of improved risk management governance and high investment in integrated management. The observed difficulty of managing unprecedented events is alarming, given that more extreme hydrological events are projected owing to climate change[3].

Observed decreasing trends in the vulnerability to floods and droughts, owing to effective risk management, are encouraging[1]. Globally, human and economic vulnerability dropped by approximately 6.5- and 5-fold, respectively, between the periods 1980–1989 and 2007–2016 (ref. [2]). However, the impacts of floods and droughts are still severe and increasing in many parts of the world[3]. Climate change will probably lead to a further increase in their impacts owing to projected increases in the frequency and severity of floods and droughts[3]. The economic damage of floods is projected to double globally[3] and that of droughts to triple in Europe[3], for a mean temperature increase of 2 °C.

The purpose of risk management is to reduce the impact of events through modification of the hazard, exposure and/or vulnerability: according to United Nations (UN) terminology[6], disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience against, and reduction of, disaster losses. Hazard is a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation; exposure is the situation of people, infrastructure,

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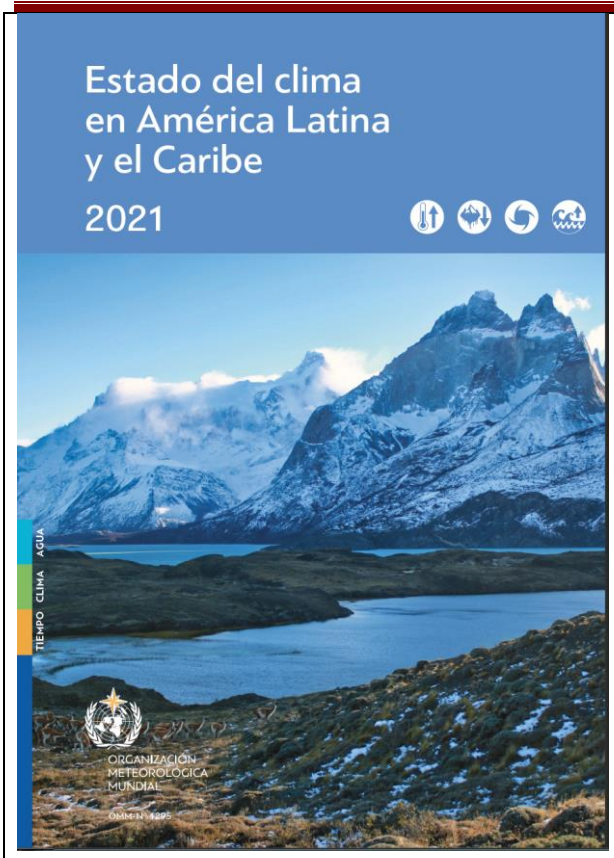

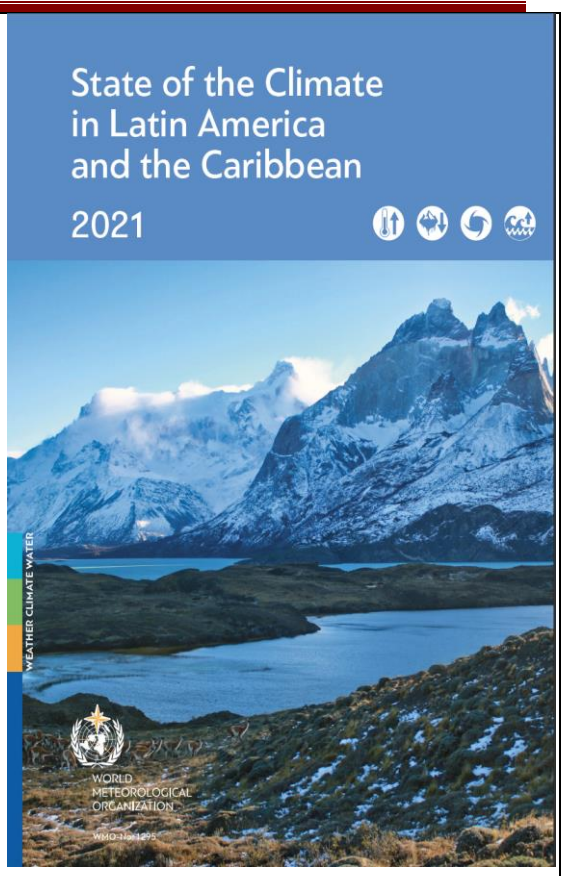

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Disaster vulnerability analysis of small towns in Brazil

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ABSTRACT

Most of the global urban population lives in cities with less than one million people, whereas in Brazil, more than 45% of the population is estimated to live in cities with up to 100,000 people. As in both the global and Brazilian contexts, many of these people live in disaster-prone areas, there has been an increasing demand for research on small cities to subsidize actions contributing to disaster risk reduction. Thus, this study evaluates the vulnerability and capacities of small Brazilian municipalities to reduce risks, especially those related to landslides and floods. To this end, 234 municipalities located in the southern and southeast regions of the country were classified into two population classes, that is, cities from 20,000 to 50,000 people and those from 50,000 to 100,000 people. These municipalities are characterized by high levels of municipal human development and availability of municipal master plans. Statistical analysis of a set of quantitative and qualitative indicators revealed that the vulnerability of populations and municipal capacities is mainly related to the economic sectors, public policies, and city size. Municipal master plans and high levels of municipal human development guarantee neither hence urban infrastructure nor specific risk management legislations. Although there are legal tools recommending disaster risk management policies, such tools are insufficient to reduce vulnerabilities and increase capacities in small Brazilian cities.

1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) studies indicate toward an increased magnitude and frequency of extreme climatic events. These events can potentiate the risk of disasters arising from floods, flash floods, landslides, windstorms, and droughts. These risks, along with the vulnerabilities of populations, have caused significant social, economic, and environmental damage worldwide [1]. Urban areas are considered the most vulnerable to potential disasters, as more than half of the global population resides in areas that face accelerated urbanization and increased disaster risk related problems [2].

In general, studies addressing urban areas, vulnerability, and disaster risk reduction have primarily focused on megacities and large cities. These studies are justified once megacities and large cities accommodate large populations and are associated with relevant economic activities [3–11]. However, considering that most of the world's population lives in cities with less than 1 million inhabitants, studies that focus on disaster risk reduction in small towns are essential in the present context. Currently, few scientific studies have addressed this subject, highlighting i) the limited response and recovery capacities of these cities, ii) the ineffectiveness of

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https://www.revistaemergencia.com.br/ocorrencias/cemaden-analisa-as-solucoes-para-evitar-tragedias-como-a-de-petropolis/

Cemaden analisa as soluções para evitar tragédias como a de Petrópolis

Por Paula Barcellos/Jornalista da Revista Emergência

Após 11 anos, a região serrana do RJ volta a ser foco dos noticiários. Há pouco mais de uma semana, a cidade de Petrópolis sofreu forte chuva que causou um grande número de ocorrências. Até 25 de fevereiro, foram 218 mortes e 34 pessoas continuam desaparecidas. Alagamentos e deslizamentos de terra mergulharam a cidade no caos e transformaram a tragédia na maior da história do município. Segundo a prefeitura, a maior catástrofe anterior causada por temporais foi em 1988, com 171 mortes.

Em entrevista exclusiva para a revista **Emergência**, o Cemaden (Centro Nacional de Monitoramento e Alertas de Desastres Naturais) lembra que as chuvas são recorrentes em todo país, mas a fragilidade da população torna o cenário crítico. "Eventos hidroclimáticos extremos são recorrentes em todo o Brasil. Na região Sudeste do Brasil esses eventos são frequentes durante o verão, sendo mais intensos em cidades localizadas em áreas serranas. Portanto, as chuvas que deflagram os deslizamentos e enxurradas têm ocorrido não somente na região serrana do Rio de Janeiro, mas também em municípios dos estados de São

Meio Ambiente

Desastre em Petrópolis: população vulnerável acentua impacto da crise climática

Reportagem visitou a região nos dias seguintes à maior chuva a cair no município em 90 anos. Com aumento de eventos climáticos extremos, população precisa ser protegida. Deslizamento de terra cortou ao meio a comunidade do Morro da Oficina, que concentra grande parte das vítimas.
Por Lucas Ninno
Publicado 25 de fev. de 2022 14:57 BRT, ~~Atualizado~~ 7 de mar. de 2022 16:02 BRT

De Petrópolis, Rio de Janeiro | Aos 19 anos, Emerson Machado precisava trabalhar e teve uma ideia: aproveitar a estrutura de três andares do sobrado em que morava com a mãe, aos pés do Morro da Oficina, em Petrópolis, para abrir o próprio negócio. Ágil, bom de papo e carismático, Emerson transformou o andar térreo em um bar e o terceiro piso em salão de festas. De portas abertas para a comunidade que transitava pela Servidão Frei Leão, principal ladeira do morro, o lugar virou um sucesso.

Ao longo de 20 anos, o comerciante fluminense teceu uma rede que lhe conectou com boa parte da vizinhança em uma dinâmica social típica das periferias do estado do Rio de Janeiro, onde a geografia dos morros é um desafio tanto para as edificações quanto para a vida em sociedade. Parentes e vizinhos se ajudam no dia a dia enquanto vigas e estacas seguram as casas no solo íngreme.

Mas, no final da tarde do último 15 de fevereiro, durante uma chuva torrencial, o chão em que Emerson ergueu a vida cedeu. "Eu estava dentro do bar. Tinha uma casa de três andares ao lado, colada com a minha", contou ele em entrevista à reportagem. "Quando ouvi um estalo, essa casa estava caindo. Mas, em vez de cair em cima do bar, ela caiu para a lateral. Eu corri e puxei minha mãe."

O estrondo ouvido por Emerson era o golpe final da massa de lama, pedras, troncos de árvores e escombros de mais de 50 casas arrastadas por um deslizamento que começou no topo da montanha. A camada fina de solo, apoiada sobre rocha lisa com inclinações de 40º, se liquefez com a ação da água e escorregou morro abaixo, levando junto pedras enormes.

"A pedra rolou e veio igual uma avalanche. Ela se desprendeu, caiu em cima da primeira casa e foi derrubando tudo", conta o comerciante enquanto anda apressado pelas vielas, levando a reportagem até o que sobrou de sua casa. No caminho sujo de barro e com pontos onde a água ainda minava, grupos de moradores trocavam informações sobre mortos e desaparecidos:

"Jacó morreu, Paulo morreu", dizia um homem a seu amigo. "O Célio também? Meu Deus…", lamentava outro morador.

Mais a frente, três homens conversavam. ~~"O Pit não acharam~~ não. E o Luís Paulo?", perguntou um. ~~"O Luís Paulo acharam~~ lá embaixo, na rua."

O comerciante Emerson Machado, 39, caminha no quintal de um vizinho para chegar até sua casa, parcialmente destruída por um deslizamento durante a chuva torrencial que atingiu a comunidade em que nasceu, no Morro da Oficina, em Petrópolis.

Foto de Lucas ~~Ninpo~~

Mudanças no clima ameaçam a economia brasileira e a segurança alimentar global

Acompanhe o que a ciência tem revelado sobre a Amazônia com a colunista Dra. Janaína Guidolini, idealizadora da Accessible Science.

Dias mais quentes e chuvas escassas trazem riscos à produção agrícola na Amazônia Oriental e no Cerrado adjacente.

Este conteúdo foi produzido pela colunista Dra. Janaína Guidolini, idealizadora da Accessible Science.

Em um futuro próximo, a Amazônia pode virar Savana (No Brasil, Cerrado). O "novo bioma" seria mais pobre em biodiversidade e teria menor reserva de carbono. Cientistas alertam para essa possibilidade à medida que o clima fica mais quente e seco. Aliado às mudanças do clima, há um cenário alarmante de mudanças no uso da terra que inclui: desmatamento e queimadas frequentes.

Considerando a Amazônia, maior floresta tropical do mundo, e o Cerrado, savana com a maior biodiversidade do planeta, a perda seria brutal, não é mesmo?

Enquanto as leis e órgãos ambientais são fragilizados, as florestas tropicais e o Cerrado, estão mais expostos e vulneráveis às mudanças do clima.

A maior área de contato entre floresta e savana nos trópicos encontra-se entre os biomas Amazônia Oriental e Cerrado (AOC). Na AOC, o regime de chuvas, o clima seco, as altas temperaturas e as queimadas causam impactos na biodiversidade local e na vida dos povos tradicionais. Além disso, podem prejudicar a produção de alimentos e a estabilidade do bioma.

A região do MATOPIBA – poderosa fronteira agrícola que contempla os estados do Maranhão, Tocantins, Piauí e Bahia – está incluída na AOC e expandiu sobre áreas de vegetação de nativa. Ironicamente, a vegetação nativa é a reguladora do microclima local. Ou seja, sem floresta a área da lavoura fica mais seca e prejudica o crescimento das plantas como a soja e o milho, por exemplo.

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RESEARCH ARTICLE

International Journal of Climatology | RMetS

A systematic analysis of climate model precipitation in southern Brazil

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Abstract

Climate model precipitation is the foremost input for hydrological models in climate change risk assessment. However, some aspects of precipitation (e.g., frequency, seasonality, and extremes) are usually not well represented by climate models, especially at the regional scale and in the tropics. In this study, we use a set of well-established metrics to evaluate the marginal, temporal, and spatial aspects of CMIP5 and CMIP6 precipitation in Southern Brazil. This region is in the transition between tropical and subtropical climates with diverse rainfall generation mechanisms and complex topography. We compare the multi-model-ensemble mean (MME) and a constrained ensemble (CE) of CMIP5 and CMIP6 against a high-resolution precipitation data grid. The constrained ensemble is obtained using a weighting approach that minimizes the difference between the simulated and observed cumulative distribution functions. We find that CMIP6 outperforms CMIP5 for most metrics, especially in the simulation of the seasonal cycle and the spatial distribution of precipitation. Simulated precipitation is more seasonal and more spatially dependent than the observations, with a dry bias characterized by lower precipitation amounts and higher consecutive dry days. Our analysis suggests that the models are not able to reproduce the transition between tropical and subtropical climates in this region as well as the passage of frontal systems. Future studies using CMIP6 should focus on those regional mechanisms of precipitation variability.

KEYWORDS
Brazil, CMIP5, CMIP6, rainfall, spatial variability, temporal dependency

1 | INTRODUCTION

Precipitation is the main component in hydrological modelling and climate change impact assessments. Its prediction and projection are used in infrastructure design, agricultural risk assessments, and food and water security planning (Rosenzweig *et al.*, 2002; Lobell *et al.*, 2008; Nissen and Ulbrich, 2017; Eekhout *et al.*, 2018) However, precipitation is not easy to predict, being sensitive to orography and natural climate variability (Clark *et al.*, 2016). Moreover, rainfall regimes are expected to change worldwide due to global warming, increasing the contrast between dry and wet seasons and areas, as well as an increase in risk for climate extremes (Collins *et al.*, 2013). While global climate models are the main tools to simulate precipitation regime changes due to emissions of greenhouse gases (Jun *et al.*, 2008), there are still limitations in model formulation, parametrizations,

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Perspective

Small is beautiful: climate-change science as if people mattered

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Abstract

There is a widely accepted gap between the production and use of climate information. It is also widely accepted that at least part of the reason for this situation lies in the challenge of bridging between what may be characterized as 'top–down' approaches to climate information on the global scale, and local decision contexts, which necessarily take a 'bottom-up' perspective, in which climate change is just one factor among many to consider. We here reflect on the insights provided in a different context—that of economics—by E.F. Schumacher in his celebrated book *Small is Beautiful* (1973), to see what light they might shed on this challenge, with a focus on climate-change science for adaptation. Schumacher asked how economics might look if it was structured "as if people mattered". We ask the same question of climate-change science, and find many parallels. One is the need to grapple with the complexity of local situations, which can be addressed by expressing climate knowledge in a conditional form. A second is the importance of simplicity when dealing with deep uncertainty, which can be addressed through the use of physical climate storylines. A third is the need to empower local communities to make sense of their own situation, which can be addressed by developing 'intermediate technologies' that build trust and transparency. Much of climate-change science is necessarily big science. We argue that in order to make climate information useable for adaptation, it is also necessary to discover the beauty of smallness.

Introduction

As climate change increasingly permeates public discourse, the relevance of climate-change science continues to grow across many different sectors of society. There has long been a call for useable (or actionable) climate information, beginning already 50 years ago (1), and formalized in the launch of the World Meteorological Organization's Global Framework for Climate Services a decade ago (2). Yet despite this awareness and global effort, it is widely accepted that there is a significant gap between the production and use of climate information (3, 4). In the case of climate services—defined by NRC (5) as "The timely production and delivery of useful climate data, information, and knowledge to decision makers"—Findlater et al. (6) argue that the gap results in part from the focus on better data rather than on better decision-making. Even if user-informed, such a 'top–down' approach adopts disciplinary-based measures of scientific quality, and is inevitably driven by the climate scientists themselves. It thus violates the core principles of co-production, which has a rich legacy in sustainability studies (7). Findlater et al.'s critique aligns with Coen's (1) conclusion that in order to be useable, climate-change science has to break with the traditional research/assessment/policy paradigm, and "[bring] into existence a community of users".

While a 'top–down' approach is necessary for a global coordinated action of government policies to stay under the Paris agreement target of 1.5°C (mitigation), the local nature of adaptation action requires the sort of 'bottom-up' approach that Coen 1) describes, while the global target is more aspirational, represented broadly by the Sustainable Development Goals (SDGs; Fig. 1), which concern vulnerability. (The Intergovernmental Panel on Climate Change (IPCC) defines 'Adaptation' as "the process of the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities", and 'Mitigation' as "human intervention to reduce the sources or enhance the sinks of greenhouse gases" (8). Climate information for adaptation aims to reduce climate vulnerability.) To adopt such a 'bottom-up' approach is, however, a radical proposition from a traditional climate science perspective. For example, Guldi (9) argues for democratizing the collection and production of climate information, which goes against the oft-heard mantra of producing 'authoritative' climate information (e.g. (10)). In the broader context of sustainability, Wuelser et al. (11) argue for the need to find ways of building common ground and constructing useable knowledge from single case studies, whilst Szabo et al. (12) point out the need for spatially disaggregated data in translating the SDGs into practical actions to reduce vulnerability in tropical delta regions. Both requirements go against the natural tendency of climate scientists to aggregate data in the search for general explanations (13), and necessarily embed climate-change science within a social context. Ultimately, the bottom-up imperative argues for looking at climate-change science from a *human* perspective. Coen (1) captures this spirit when she suggests that in order to be useable, climate-change sci-

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AGU ADVANCING EARTH AND SPACE SCIENCE

Geophysical Research Letters

RESEARCH LETTER
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Process Controls on Flood Seasonality in Brazil

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Key Points:
- Flood peaks tend to occur at the same time of year as annual soil moisture peaks and lag behind annual rainfall peaks by 3 weeks
- Flood seasonality is linked mainly with soil moisture peaks in Amazonia and central Brazil, where soil storage capacity is high
- Flood timing is highly correlated with rainfall and soil moisture peaks in the south and southeast, where soil storage capacity is low

Supporting Information:
Supporting Information may be found in the online version of this article.

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Abstract A coincidence in the timing of floods and their drivers can be used as a proxy for the causality of flood generation. Here, we investigate the relationship between the seasonality of floods, maximum annual rainfall, and maximum annual soil moisture data of 886 basins in Brazil for 1980–2015 to shed light on process controls of flood generation. Floods tend to occur at the same time of year as soil moisture peaks and lag behind rainfall peaks by 3 weeks. In Amazonia, central and northern Brazil, flood timing is more correlated with the timing of soil moisture peaks than with that of rainfall peaks, which is interpreted as resulting from high subsurface water storage capacities. In southern and southeastern Brazil, on the other hand, flood timing is highly correlated with both soil moisture and rainfall because of low subsurface water storage capacities. These findings can support flood forecasting and climate impact studies.

Plain Language Summary In warm regions, floods are usually generated by a combination of intense rainfall and wet soils. In this paper, we analyze the average timing within the year of floods, extreme rainfall, and soil moisture to elucidate how floods come about in the main Brazilian rivers. We find that in some regions, such as Amazonia and central Brazil, floods tend to occur when soils are wet. In other regions, such as southern Brazil, floods tend to occur when rainfall is most extreme. We believe that these differences are related to differences in the soil water storage capacity. The understanding of the regional importance of each of these components helps increase the efficiency of flood prevention measures and climate change adaptation.

1. Introduction

River floods are usually generated by the interplay of event precipitation, antecedent soil wetness, and snowmelt (Merz & Blöschl, 2003; Rosbjerg et al., 2013; Tarasova et al., 2019). One way of exploring the relative importance of these drivers is by analyzing flood seasonality, defined as the day of the year that floods occur. A coincidence in the timing of floods and their drivers can be used as a proxy for the causality of flood generation (Parajka et al., 2010; Sivapalan et al., 2005; Tramblay et al., 2021).

The relative importance of the drivers of flood seasonality depends on climate, landscape properties, and has a large regional variability (Berghuijs et al., 2016, 2019; Parajka et al., 2010; Tramblay et al., 2021; Wasko et al., 2020). In northeastern Europe, for example, floods are aligned with the onset of the warm season that leads to snowmelt (Blöschl et al., 2017; Kemter et al., 2020). In much of Western Europe, floods are associated with soil moisture peaks in the winter because, even though rainfall peaks in the summer or autumn, it gets stored in the soil which slowly becomes wet over several months (Berghuijs et al., 2019; Blöschl et al., 2017). On the other hand, in central Europe's mountain ranges, flood timing frequently coincides with annual rainfall peaks (Berghuijs et al., 2019; Kemter et al., 2020). A similar pattern is found in the USA, where floods are linked with snowmelt in the coldest regions in the north, soil moisture peaks in the central-east, and extreme rainfall in the mountain ranges in the west (Berghuijs et al., 2016; Brunner et al., 2020; Stein et al., 2020).

In South America, more specifically Brazil, few studies have analyzed flood seasonality (Bartiko et al., 2019; Cassalho et al., 2019; Do et al., 2020). So far, no study has explored the process controls of flood seasonality by considering the interplay of rainfall and soil moisture. Even though soil moisture is crucial in determining if rain infiltrates or runs off (Bonell, 2004; Elsenbeer, 2001), floods in Brazil have usually been explained in terms of extreme rainfall and meteorological phenomena such as the South American monsoon, mesoscale convective systems, and the El-Niño-Southern Oscillation (Cavalcanti, 2012; Fleischmann et al., 2020; Lima et al., 2017; Marengo & Espinoza, 2016; Schöngart & Junk, 2007; Sena et al., 2012; Towner et al., 2021).

Geophysical Research Letters

RESEARCH LETTER
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Future Summer Marine Heatwaves in the Western South Atlantic

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Key Points:
- The frequency, intensity, and duration of marine heatwaves will significantly increase for the next decades in the western South Atlantic
- The greatest trends in the marine heatwave characteristics occur during the period of 2021–2050 and not by the end of the 21st century
- The future trends are driven not only by the long-term warming, but also by the intensification of atmospheric blocking over the region

Supporting Information:
Supporting information may be found in the online version of this article.

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Writing – review & editing: Natasha V. Costa, Regina R. Rodrigues

Abstract Marine heatwaves (MHWs) are periods of abnormally high ocean temperatures and their impacts threaten physical, biological, and human systems. Here, we show through different scenarios of the Coupled Model Intercomparison Project Phase 6 (CMIP6) that significant positive trends in frequency, duration, and cumulative intensity are identified for the western South Atlantic, leading to an almost permanent state of MHW by the end of the 21st century considering a constant baseline. We also find that the main mechanism that causes MHWs in this region, atmospheric blocking, is likely to intensify in the future. Thus, the increase in occurrence of MHWs is not just due to the direct effect of long-term warming. Moreover, the largest trends occur during 2021–2050, and not during 2071–2100. This has important implications for marine ecosystems and the ocean ability of absorbing heat and CO_2, underlying the urgency for a global reduction in greenhouse gas emissions.

Plain Language Summary Marine heatwaves (MHWs) are periods when the surface ocean temperatures reach a threshold well above the normal. They are similar to their counterparts on land and have significant impacts on marine ecosystems. Since most of the atmosphere's excess heat trapped by greenhouse gas emissions goes into the oceans, there is robust evidence that they have already intensified in the last decades and scientists predict that those trends will continue. This study quantifies future increases in the occurrence, duration, and intensity of MHWs in the western South Atlantic using model simulations considering one path broadly following the historical patterns of emissions and another path taking a fossil-fueled development. In both cases, the largest increases will occur much earlier than previously thought, that is, during the period of 2021–2050, rather than in 2071–2100. Moreover, the results show that the changes are not only a direct effect of long-term warming but also due to an intensification of the mechanism that generates the MHWs in this region. The mechanism involves long-lasting high-pressure systems that inhibit the formation of clouds leading to more solar radiation going into the ocean and calm winds decreasing evaporative cooling. Combined, these factors cause droughts and MHWs.

1. Introduction

Marine heatwaves (MHWs) are defined as extended periods in which sea surface temperatures (SST) exceed a climatological threshold (Hobday et al., 2016). They have received much attention lately due to their harmful impacts on marine ecosystems, ranging from habitat shifts and changes in populations' genetics to high mortality of several marine species (Coleman et al., 2020; Smale et al., 2019). Recent studies have identified an increase in their frequency, duration, intensity, and spatial extension over most of global oceans and linked these trends to long-term warming (Pröllocher et al., 2018; Laufkötter et al., 2020; Oliver et al., 2019). However, most of them have been conducted at a global level (Oliver et al., 2018; Plecha & Soares, 2020; Scannell et al., 2016).

There are few studies on MHWs in the South Atlantic Ocean, but none analyzes their future projections (Manta et al., 2018; Rodrigues et al., 2019). Rodrigues et al. (2019) have shown that up to 60% of the MHWs in the western South Atlantic are caused by atmospheric blocking during austral summer for the period of 1985–2016. The atmospheric blocking is linked to an anomalous persistent anticyclonic circulation that suppresses the South Atlantic Convergence Zone (SACZ)—the main source of rainfall for eastern South America in austral summer—causing persistent droughts. Once the anticyclone is established over eastern South America, the MHWs are generated by local changes in the heat fluxes between the ocean and the atmosphere. The anticyclonic circulation suppresses convection. The associated decrease in cloud cover

Zoom Out

International Journal of *Environmental Research and Public Health*

MDPI

Article

Analyzing Spatial Patterns of Health Vulnerability to Drought in the Brazilian Semiarid Region

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Abstract: Health determinants might play an important role in shaping the impacts related to long-term disasters such as droughts. Understanding their distribution in populated dry regions may help to map vulnerabilities and set coping strategies for current and future threats to human health. The aim of the study was to identify the most vulnerable municipalities of the Brazilian semiarid region when it comes to the relationship between drought, health, and their determinants using a multidimensional index. From a place-based framework, epidemiological, socio-economic, rural, and health infrastructure data were obtained for 1135 municipalities in the Brazilian semiarid region. An exploratory factor analysis was used to reduce 32 variables to four independent factors and compute a Health Vulnerability Index. The health vulnerability was modulated by social determinants, rural characteristics, and access to water in this semiarid region. There was a clear distinction between municipalities with the highest human welfare and economic development and those municipalities with the worst living conditions and health status. Spatial patterns showed a cluster of the most vulnerable municipalities in the western, eastern, and northeastern portions of the semiarid region. The spatial visualization of the associated vulnerabilities supports decision making on health promotion policies that should focus on reducing social inequality. In addition, policymakers are presented with a simple tool to identify populations or areas with the worst socioeconomic and health conditions, which can facilitate the targeting of actions and resources on a more equitable basis. Further, the results contribute to the understanding of social determinants that may be related to medium- and long-term health outcomes in the region.

Keywords: vulnerability; drought; health; social determinants; rural population; Brazil

1. Introduction

The importance of socio-economic status and other underlying living conditions of the population has been considered relevant to public health policies and the reduction of health inequalities worldwide, especially after the Commission on Social Determinants of Health established by the World Health Organization in 2005 [1–4]. This approach recognizes the interaction between social, economic, cultural, ethnic, psychological, environmental, and behavioral factors that influence the occurrence of health problems and their risk factors in the population, creating health inequities among different strata. Recently,

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Impact of climate change on eucalyptus plantations in southern Brazil

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Josiléia Acordi Zanatta
Marcos Fernando Gluck Rocheral
Vanessa Silva Pugliero
Marilia Ribeiro Zanetti
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2022

(WRI, 2020). Despite the obvious reduction in the rate, cumulative emissions continued to increase over this period. It is therefore critical to identify and adopt viable options of mitigating GHG emissions, limiting global warming and reducing the much needed cost of adaptive measures.

The pattern of emissions in Brazil differs than that observed globally. via Nationally Determined Contributions or NDCs (BRAZIL, 2020b). These options promote practices and measures such as reforestation, elimination of illegal deforestation, restoration of degraded pastures and expansion of the area under integrated and no-till (NT) systems.

Indeed, NT is one of the most studied agricultural systems, and its benefits related to agronomic and environmental aspects such as erosion

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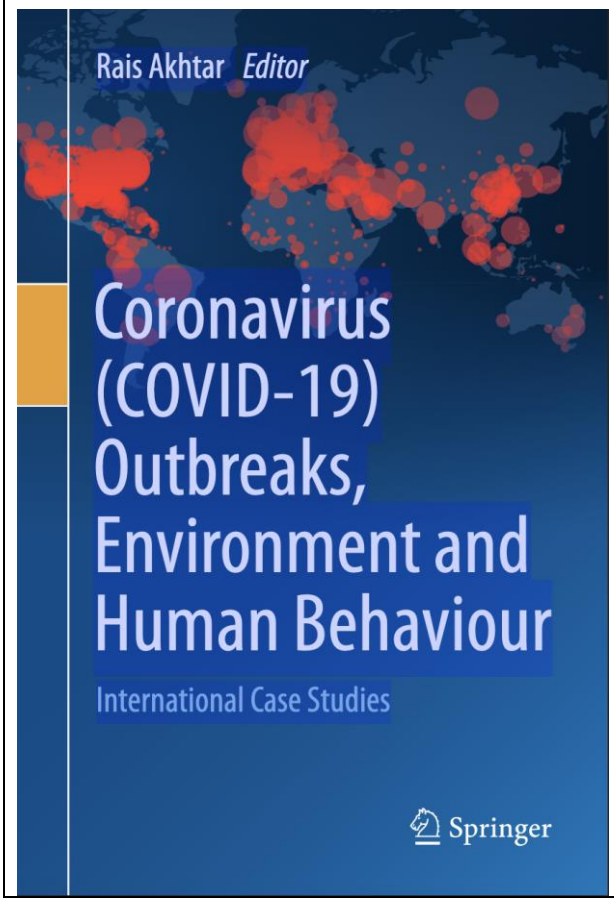

Early Stages of the Coronavirus Disease (COVID-19) Pandemic in Brazil: National and Regional Contexts

Rhavena Barbosa dos Santos, Júlia Alves Menezes, and Ulisses Confalonieri

Abstract The first case of COVID-19 in Brazil occurred in February 2020, affecting mainly the country's large urban centers. The initial strategy to suppress the transmission of the virus was based on social isolation and the suspension of economic activities to flatten the incidence curve and allow health services to prepare for the expected increase in hospital admissions. However, there was no coordinated strategy between the federal government, states and municipalities to adopt effective control measures and to carry out epidemiological surveillance of the disease and/or contact tracing, favouring the rapid increase in the number of new COVID-19 cases. The spread of the disease occurred in a non-homogeneous manner throughout the territory, reaching small and medium-sized cities in the country and overloading local health services, which in many places reached their maximum capacity. There is still no clear trend toward stabilization of the epidemic curve, since the data available to estimate the behaviour of infection in the country are lagged by the low testing rate.

Keywords COVID-19 · Brazil · Health surveillance · Pandemic · Regional hubs · São paulo · Rio de janeiro · Amazon

Introduction

In December 2019, cases of pneumonia of unknown etiology began to be reported in Wuhan, China, which was later characterized as a new coronavirus (SARS-Cov-2 or COVID-19). It is estimated that in this region alone, around 75,000 people were infected with COVID-19 by the end of January, including patients who did not travel to Wuhan, which indicated the possibility of person-to-person transmission (Wu et al. 2020). By mid-February, about 30 countries had already reported cases of the new coronavirus, with varying severity of infection and symptoms, as well as deaths, forcing the World Health Organization to declare the COVID-19 epidemic

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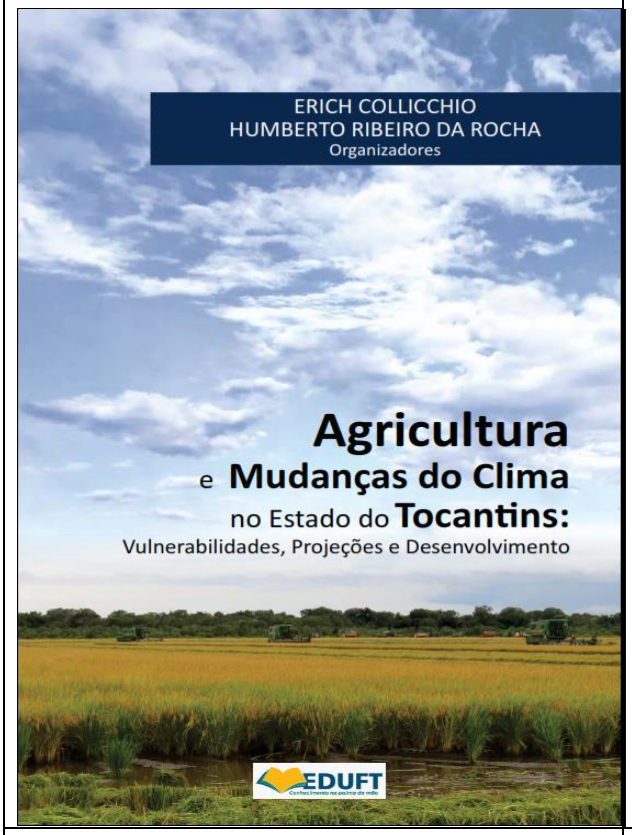

CAPÍTULO 3

Mudança do Clima no Brasil

Eduardo Delgado Assad[1]; Susian Christian Martins[2]

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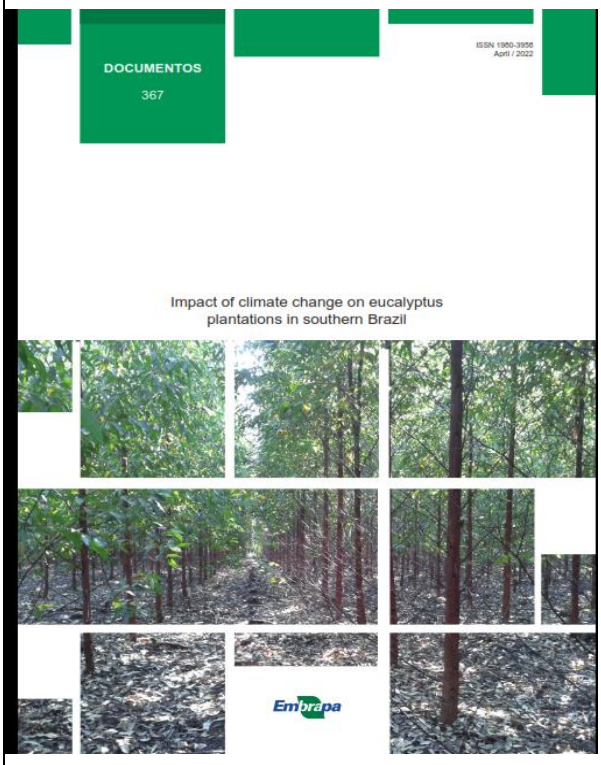
1 - Introdução

O Brasil participa do Painel Intergovernamental sobre Mudanças do Clima - IPCC, desde 1988, ou seja, desde a sua primeira versão. Várias discussões têm sido feitas desde então sobre o assunto, tanto no nível científico como político. Logo no início a Universidade de São Paulo - USP, promoveu um encontro já em 1988, para discutir o assunto, que naquela época não estava muito claro, para diversos cientistas brasileiros. Defendiam-se então duas teses, uma de que a terra estava aquecendo, fortemente apoiada por grupos americanos e europeus, e outra de que estava esfriando, neste caso apoiada por grupos japoneses. Algumas instituições brasileiras começaram então a estudar mais profundamente o assunto, e dois grupos foram fortes protagonistas nesta ação, a saber, o Instituto Nacional de Pesquisas Espaciais - INPE e o Instituto de Astronomia, Geofísica e Ciências Atmosféricas, IAG-USP.

No ano de 1990 a Assembleia Geral das Nações Unidas estabeleceu o Comitê Intergovernamental de Negociação para a Convenção Quadro sobre Mudança do Clima - CIN/UNFCCC com o objetivo de preparar a redação de um instrumento jurídico multilateral específico para esse tema. Reuniões de negociação ocorreram entre 1991 e 1992 tendo sido finalizadas em 9 de maio de 1992 com a adoção da Convenção Quadro das Nações Unidas sobre Mudança do Clima – UNFCCC, na Sede das Nações Unidas na cidade de Nova York. Este instrumento foi finalmente firmado na cidade do Rio de Janeiro em junho de 1992 durante a Cúpula da Terra.

Após a Cúpula da Terra, a Presidência da República, por meio do Decreto nº 1160 de 21 de junho de 1994, constitui a Comissão Interministerial de Desenvolvimento Sustentável – CIDES.

A CIDES estabeleceu as bases sobre as quais a política ambiental brasileira passou a ser conduzida após a reunião da Cúpula da Terra em 1992. Coube ao Ministério das Relações Exteriores - MRE, a coordenação e definição das posições brasileiras no âmbito das negociações internacionais, ao Ministério da Ciência, Tecnologia e Inovação – MCTI, a coordenação nacional dos compromissos resultantes da Convenção Quadro das Nações Unidas sobre Mudança do Clima e



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DOCUMENTOS 367

Impact of climate change on eucalyptus plantations in southern Brazil

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Joslleia Acordi Zanatta
Marcos Fernando Gluck Rachwal
Vanessa Silva Pugliero
Marilia Ribeiro Zanetti
Eduardo de Morais Pavão
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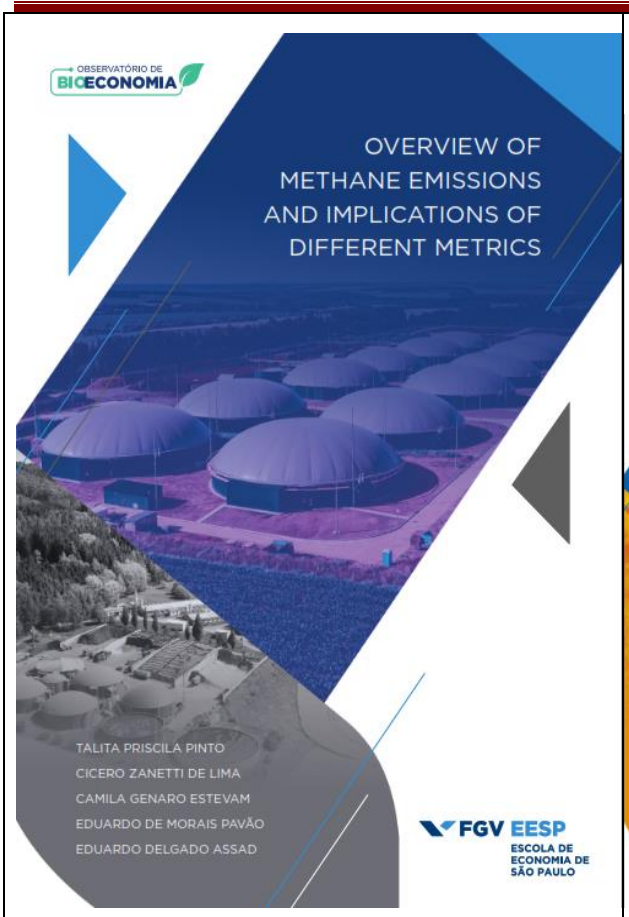

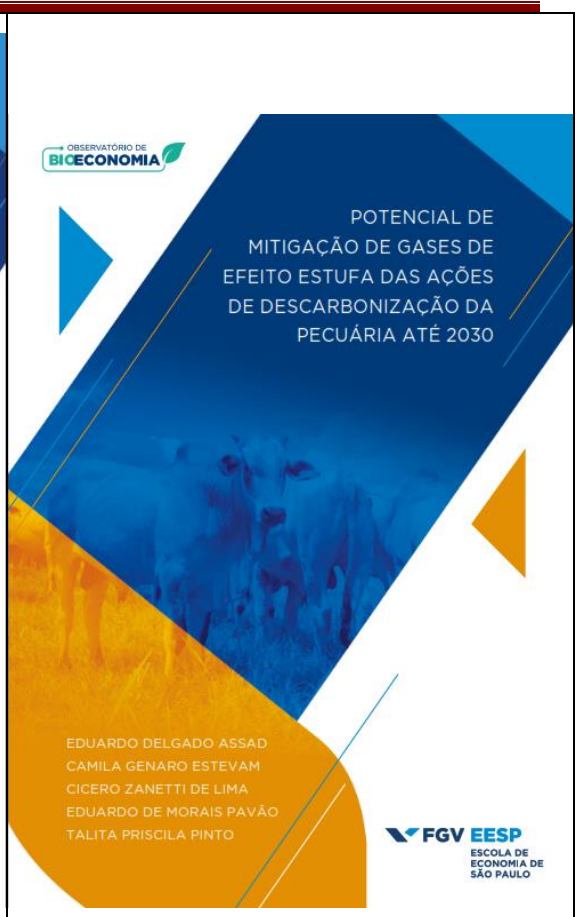

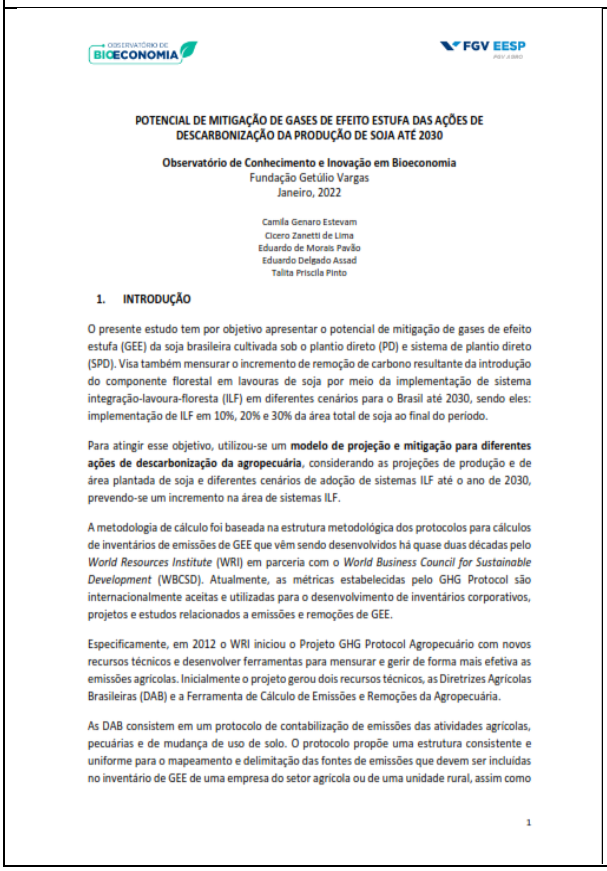

OBSERVATÓRIO DE BIOECONOMIA — FGV EESP

POTENCIAL DE MITIGAÇÃO DE GASES DE EFEITO ESTUFA DAS AÇÕES DE DESCARBONIZAÇÃO DA PRODUÇÃO DE SOJA ATÉ 2030

Observatório de Conhecimento e Inovação em Bioeconomia
Fundação Getúlio Vargas
Janeiro, 2022

Camila Genaro Estevam
Cicero Zanetti de Lima
Eduardo de Morais Pavão
Eduardo Delgado Assad
Talita Priscila Pinto

1. INTRODUÇÃO

O presente estudo tem por objetivo apresentar o potencial de mitigação de gases de efeito estufa (GEE) da soja brasileira cultivada sob o plantio direto (PD) e sistema de plantio direto (SPD). Visa também mensurar o incremento de remoção de carbono resultante da introdução do componente florestal em lavouras de soja por meio da implementação de sistema integração-lavoura-floresta (ILF) em diferentes cenários para o Brasil até 2030, sendo eles: implementação de ILF em 10%, 20% e 30% da área total de soja ao final do período.

Para atingir esse objetivo, utilizou-se um **modelo de projeção e mitigação para diferentes ações de descarbonização da agropecuária**, considerando as projeções de produção e de área plantada de soja e diferentes cenários de adoção de sistemas ILF até o ano de 2030, prevendo-se um incremento na área de sistemas ILF.

A metodologia de cálculo foi baseada na estrutura metodológica dos protocolos para cálculos de inventários de emissões de GEE que vêm sendo desenvolvidos há quase duas décadas pelo *World Resources Institute* (WRI) em parceria com o *World Business Council for Sustainable Development* (WBCSD). Atualmente, as métricas estabelecidas pelo GHG Protocol são internacionalmente aceitas e utilizadas para o desenvolvimento de inventários corporativos, projetos e estudos relacionados a emissões e remoções de GEE.

Especificamente, em 2012 o WRI iniciou o Projeto GHG Protocol Agropecuário com novos recursos técnicos e desenvolver ferramentas para mensurar e gerir de forma mais efetiva as emissões agrícolas. Inicialmente o projeto gerou dois recursos técnicos, as Diretrizes Agrícolas Brasileiras (DAB) e a Ferramenta de Cálculo de Emissões e Remoções da Agropecuária.

As DAB consistem em um protocolo de contabilização de emissões das atividades agrícolas, pecuárias e de mudança de uso de solo. O protocolo propõe uma estrutura consistente e uniforme para o mapeamento e delimitação das fontes de emissões que devem ser incluídas no inventário de GEE de uma empresa do setor agrícola ou de uma unidade rural, assim como

1

remote sensing — MDPI

Article

Numerical Assessment of Downward Incoming Solar Irradiance in Smoke Influenced Regions—A Case Study in Brazilian Amazon and Cerrado

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Abstract: Smoke aerosol plumes generated during the biomass burning season in Brazil suffer long-range transport, resulting in large aerosol optical depths over an extensive domain. As a consequence, downward surface solar irradiance, and in particular the direct component, can be significantly reduced. Accurate solar energy assessments considering the radiative contribution of biomass burning aerosols are required to support Brazil's solar power sector. This work presents the 2nd generation of the radiative transfer model BRASIL-SR, developed to improve the aerosol representation and reduce the uncertainties in surface solar irradiance estimates in cloudless hazy conditions and clean conditions. Two numerical experiments allowed to assess the model's skill using observational or regional MERRA-2 reanalysis AOD data in a region frequently affected by smoke. Four ground measurement sites provided data for the model output validation. Results for DNI obtained using δ-Eddington scaling and without scaling are compared, with the latter presenting the best skill in all sites and for both experiments. An increase in the relative error of DNI results obtained with δ-Eddington optical depth scaling as AOD increases is evidenced. For DNI, MBD deviations ranged from −2.3 to −0.5%, RMSD between 2.3 and 4.7% and OVER between 0 and 5.3% when using *in-situ* AOD data. Overall, our results indicate a good skill of BRASIL-SR for the estimation of both GHI and DNI.

Keywords: solar resource mapping; direct normal irradiance; δ-Eddington approximation; biomass burning

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1. Introduction

Brazil has a vast solar energy resource [1–3] and has experienced a boost in photovoltaic deployment in recent years due to government incentives and technological advances [4,5]. Several studies have shown that solar energy, as part of the diversification of the renewable energy mix, could be decisive to increase energy security, counter-balancing the vulnerability imposed by the high dependency on the hydro-power [6–9]. In particular, concentrating solar power (CSP) technologies have shown a noteworthy potential for Brazil in scenarios of climate change mitigation ([10–13]), especially as a complementary heat supply for industrial processes or hybrid power generation [14,15]. It should be noted, however, that some potential areas for CSP development, like the Central-West and the Southeast regions, are often affected by biomass burning haze during the dry season as a result of long-range transport [16–19].

IX Congresso Brasileiro de Energia Solar – Florianópolis, 23 a 27 de maio de 2022

Avaliação da irradiação solar utilizando modelo BRASIL-SR em condições de céu claro – estudo do impacto de aerossóis na Amazônia brasileira e no Cerrado

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Resumo. *As plumas de aerossol geradas durante a estação de queima de biomassa no Brasil sofrem transporte de longo alcance, resultando em grandes profundidades ópticas de aerossol em um domínio extenso do território brasileiro. Como consequência, a irradiância solar da superfície descendente, e em particular o componente direto, pode ser significativamente reduzida. Estimativas da irradiância solar incidente na superfície considerando a contribuição radiativa dos aerossóis de queima de biomassa são necessárias para apoiar o setor de energia solar do Brasil. Este trabalho apresenta resultados obtidos com a 2ª geração do modelo de transferência radiativa BRASIL-SR, desenvolvida para melhorar a representação do aerossol e reduzir as incertezas nas estimativas de irradiância solar de superfície em condições de céu sem nuvens. Dois experimentos numéricos permitiram avaliar a habilidade do modelo usando dados AOD observacionais ou regionais de reanálise do MERRA-2 em uma região frequentemente afetada por queimadas. Quatro locais de medição de solo forneceram dados para a alimentar o modelo e validar valores de GHI e DNI por ele fornecidas. As estimativas para a componente GHI foram obtidas utilizando o escalonamento ô-Eddington, mas para a DNI o escalonamento não foi adotado. É evidenciado um aumento no erro relativo das estimativas de GHI e DNI à medida que AOD aumenta. Os desvios de MBD variaram de -2,3 a -0,5%, RMSD entre 2,3 e 4,7% e OVER entre 0 e 5,3% ao usar dados de AOD observados in-situ. De maneira geral, nossos resultados indicam uma boa habilidade do BRASIL-SR para estimar GHI e DNI quando comparados com desvios apresentados pelas estimativas produzidas pelos modelos McClear e Rest2 Estudo de caso com estimativa da irradiância espectral também é apresentada neste artigo..*

Palavras-chave: *Avaliação de recursos solares; Irradiância normal direta; Aproximação Delta-Eddington; Queima de biomassa*

1. INTRODUÇÃO

O Brasil possui um vasto recurso de energia solar (Lima *et al.*, 2019, Pereira *et al.*, 2017) e tem experimentado um aumento na implantação fotovoltaica nos últimos anos devido a incentivos governamentais e avanços tecnológicos (Santos e Cunha, 2019). Diversos estudos têm mostrado que a energia solar pode ser alternativa para aumentar a segurança energética, contrabalançando a vulnerabilidade imposta pela alta dependência da hidrelétrica (Luz *et al.*, 2018, Campos *et al.*, 2021). Em particular, as tecnologias de concentração de energia solar (CSP) têm mostrado um potencial notável para o Brasil em cenários de mitigação das mudanças climáticas (Martins *et al.*, 2012; Fichter *et al.*, 2017), especialmente como fonte de calor complementar para processos industriais ou geração de energia híbrida (Soria *et al.*, 2015; Milani *et al.*, 2017). Deve-se notar que algumas áreas potenciais para o desenvolvimento de CSP, como as regiões Centro-Oeste e Sudeste, são frequentemente afetadas pelas emissões de aerossóis em eventos de queimadas, principalmente durante a estação seca (Rosário *et al.*, 2013; Martins *et al.*, *2018*).
Os aerossóis atmosféricos são o fator mais importante para a extinção da radiação solar em condições sem nuvens, seguido pelo vapor d'água. Em particular, a irradiância normal direta (DNI) é 2 a 4 vezes mais sensível à presença de aerossol do que a irradiância horizontal global (GHI) (Gueymard, 2012). O impacto dos aerossóis de poeira no DNI foi avaliado para vários locais áridos e semiáridos (Ruiz-Arias *et al.*, 2019; Boraiy *et al.*, 2017). No entanto, faltam avaliações semelhantes levando em consideração os aerossóis de queima de biomassa. Embora menor em magnitude do que o impacto dos aerossóis de poeira devido à profundidade ótica comparativamente moderados, o impacto dos aerossóis de queima de biomassa no DNI é significante em regiões onde a atividade de queima é sazonalmente intensa. As grandes cargas de

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Does Decentralized and Voluntary Commitment Reduce Deforestation? The Effects of Programa Municípios Verdes

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Accepted: 12 February 2022 / Published online: 15 March 2022

Abstract
One-third of total CO_2 emissions from deforestation in the 2000s took place in the Amazon region, in Brazil. This paper examines the effectiveness of a locally-led policy—the Green Municipalities Programme—in curbing illegal deforestation in the Pará state, part of the legal Amazon. We combine a regression discontinuity (RD) design and a 10-year high-resolution spatial dataset (1,781,122 pixels covering 162,242 km^2) to evaluate the programme's impact. Evidence suggests that municipalities reduced deforestation only 4 years after joining the programme at about 0.01 km^2 within the optional bandwidth (10 km). The effect comes mainly from municipalities traditionally with lower deforestation rates. This effect represents avoidance of 0.02 $MtCO_2$/year released to the atmosphere, or USD 1.7 million per year of avoided damage. Since Brazil has committed through its NDC to eliminate deforestation in the Amazon by 2030, decentralized programmes focusing on indirect benefits appear to be effective only in the long run, serving as a "bonus" to support regions with relatively higher levels of forest cover.

Keywords Regression discontinuity design · Policy evaluation · Deforestation · High-resolution spatial panel

1 Introduction

One-third of total CO_2 emissions from deforestation between 2005 and 2018 took place in the Amazon region (SEEG 2019), which comprises 49% of Brazil's territory. This corresponds to approximately 646 $MtCO_2$ released due to an average deforestation rate of 8772 km^2/year (SEEG 2019; INPE 2019). The conservation of the Amazon forest could provide benefits to global biodiversity (Barlow et al. 2007), water cycling (Nobre et al. 2016), aboveground carbon storage and climate regulation (Baccini et al. 2017) and up to USD 5 trillion of economic benefits (Pindyck 2019). Therefore, the protection of the rainforest has become a central concern in many federal and state level initiatives over the past years.

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Risk caused by the propagation of earthquake losses through the economy

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The economy of a country is exposed to disruptions caused by natural and man-made disasters. Here we present a set of probabilistic risk indicators, the Average Annual Loss (AAL) and the Loss Exceedance Curve (LEC), regarding to production, employment, Gross Domestic Product (GDP), Gross Regional Product (GRP), export volume, inflation, tariff revenue, among others, due to earthquakes. All indicators are computed using a systematic probabilistic approach, which integrates the seismic risk assessment with spatial computable general equilibrium models, both robust and well-known frameworks used worldwide in their respective fields. Our approach considers the induced damage and frequency of occurrence of a vast collection of events that collectively describe the entire seismic hazard of a country, giving us a better and more complete understanding of the full consequence of earthquakes. We illustrate this approach with an example developed for Chile.

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ANALYSIS

The Brazilian intergovernmental fiscal transfer for conservation: A successful but self-limiting incentive program

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Keywords:
Ecological ICMS
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ABSTRACT

Brazil's ecological intergovernmental fiscal transfer (ICMS-E) is a conservation incentive for protected areas (PAs). It redistributes tax revenues to reward municipalities for hosting PAs. To quantify its impact on the creation of state and municipal PAs, we used panel regressions on a longitudinal municipality dataset that combined information on PA creation and ICMS-E implementation for the 1467 municipalities in 6 Brazilian states in the Atlantic Forest region that never changed borders, from 1987 to 2016. We found that the percent of the municipal area covered with state or municipal PAs increased as a consequence of ICMS-E implementation. However, the magnitude of this effect declined as the ICMS-E revenue is shared more widely due to the expansion of PAs that reduced the gain from new PAs. We also found that ICMS-E policy primarily spurred the creation of PAs with less restrictive rules – similar to IUCN category V reserves – mainly by municipalities. For more restrictive PAs with higher local costs for municipalities, ICMS-E promoted state-proposed PAs but not municipal PAs. Our results suggest that states used ICMS-E to incentivize local implementation of their conservation preferences, including strict conservation, while municipal governments responded mostly with low-cost actions to increase their revenues.

1. Introduction

Intergovernmental fiscal transfers are public-finance instruments that can be used to support the provision of public goods by assisting in the internalization of spatial externalities (Ring, 2008). Brazil has innovated by using an intergovernmental fiscal transfer mechanism to emphasize environmental externalities in what is now called the Ecological Fiscal Transfer (EFT). EFT offer financial support for ecosystem-service production from locations that benefit from those services to where they are generated, similar to the motivation for payments for ecosystem services (PES) (Parley and Costanza, 2010; Ring, 2008). Higher levels of government transfer money to local administrations in order to compensate for the costs of, for instance, increasing biodiversity conservation (Loureiro, 2002) or more generally improving environmental quality (Gong et al., 2020) or reducing losses of ecosystem services. EFT has been described as a promising mechanism for environmental conservation (Parley and Costanza, 2010) and even has been suggested as the basis for a global mechanism to finance biodiversity conservation (Droste et al., 2019).

Ecological Fiscal Transfers are increasingly being adopted around the globe. Brazil first conceived and adopted an EFT for biodiversity conservation and was followed by Portugal (Santos et al., 2012); France has implemented similar program albeit on different spatial scales (Schröter-Schlaack et al., 2014); India has innovated by basing the revenue redistribution on forest cover and applying the rule to the whole country (Busch and Mukherjee, 2018) and China has identified ecological zones in which EFT was applied to avoid environmental degradation (Gong et al., 2020). EFT mechanisms were also proposed for other European countries such as German and Poland (Schröter-Schlaack et al., 2014) but not yet implemented.
The impacts of EFT, including different program designs, are now beginning to be evaluated. EFT for biodiversity conservation has shown positive effects on the increase of PA share at the state level in Brazil (Droste et al., 2017) and the ratio of municipal and national PAs in Portugal (Droste et al., 2018). India's EFT was expected to function as an incentive mechanism for state governments to raise investments on forestry; however, results were disappointing so far and forestry budgets as a share of total state budgets decreased by 16% after the

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ORIGINAL PAPER

COVID-19 crisis monitor: assessing the effectiveness of exit strategies in the State of São Paulo, Brazil

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Abstract
As COVID-19-related health indicators improve after restrictive measures were set in place in different parts of the world, governments are expected to guide how to ease interventions while minimizing the risk of resurgent outbreaks. Whereas epidemiologists track the progress of the disease using daily indicators to understand the pandemic better, economic activity indicators are usually available at a lower frequency and with considerable time lags. We propose and implement a timely trade-based regional economic activity indicator (EAI) that uses high-frequency traffic data to monitor daily sectoral economic activity in different sectors for the Brazilian State of São Paulo, a highly impacted region, overcoming the challenge of real-time assessment of the economy amid the COVID-19 outbreak. We then use this novel set of information combined with hospitalization rates to provide a first assessment of the São Paulo Plan, the COVID-19 exit strategy designed to gradually lifting interventions introduced to control the outbreak in the State. Available data show that, in its first 60 days, the phased strategy pursued in São Paulo has been effective in gradually reactivating economic activity while maintaining the adequate responsiveness of the healthcare system.

JEL Classification C55 · C67 · R11 · R40

1 Introduction

The COVID-19 pandemic has brought unforeseen and unpredictable effects in terms of both health and economics. With unprecedented research efforts that generated several articles tackling clinical presentation, preventive and treatment measures, and possible correlated and permanent effects of the disease, as well as various other articles exploring its economic effects (from micro to macroeconomic elements),

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Atmospheric Chemistry and Physics Discussions

Occurrence and growth of sub-50 nm aerosol particles in the Amazonian boundary layer

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Abstract. New particle formation (NPF), referring to the nucleation of molecular clusters and their subsequent growth into the cloud condensation nuclei (CCN) size range, is a globally significant and climate-relevant source of atmospheric aerosols. Classical NPF exhibiting continuous growth from a few nanometers to the Aitken mode around 60-70 nm is widely observed in the planetary boundary layer (PBL) around the world, but not in central Amazonia. Here, classical NPF events are rarely observed in the PBL, but instead, NPF begins in the upper troposphere (UT), followed by downdraft injection of sub-50 nm ($CN_{<50}$) particles into the PBL and their subsequent growth. Central aspects of our understanding of these processes in the Amazon have remained enigmatic, however. Based on more than six years of aerosol and meteorological data from the Amazon Tall Tower Observatory (ATTO, Feb 2014 to Sep 2020), we analyzed the diurnal and seasonal patterns as well as meteorological conditions during 254 of such Amazonian growth events on 217 event days, which show a sudden occurrence of particles between 10 and 50 nm in the PBL, followed by their growth to CCN sizes. The occurrence of events was significantly higher during the wet season, with 88 % of all events from January to June, than during the dry season, with 12 % from July to December, probably due to differences in the condensation sink (CS), atmospheric aerosol load, and meteorological conditions. Across all events, a median growth rate (GR) of 5.2 nm h^{-1} and a median CS of 0.0011 s^{-1} were observed. The growth events were more frequent during the daytime (74 %) and showed higher GR (5.9 nm h^{-1}) compared to nighttime events (4.0 nm h^{-1}), emphasizing the role of photochemistry and PBL evolution in particle growth. About 70 % of the events showed a negative

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Atmospheric Chemistry and Physics

The friagem event in the central Amazon and its influence on micrometeorological variables and atmospheric chemistry

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Abstract. In the period between 9 and 11 July 2014, a friagem event reached the Amazon region. On 11 July, the southwest flow related to the friagem converged with the easterly winds in the central Amazon. The interaction between these two distinct air masses formed a convection band, which intensified over the Manaus region and the Amazon Tall Tower Observatory (ATTO) site. The satellite images show the evolution of convective activity on 11 July, which led to 21 mm of precipitation at the ATTO site. Moreover, the arrival of the friagem caused a sudden drop in temperature and a predominance of southerly winds, which could be seen in Porto Velho between 7 and 8 July and in Manaus and the ATTO site from 9 to 11 July. The results of ERA-Interim reanalysis and Brazilian developments on the Regional Atmospheric Modeling System (BRAMS) simulations show that this friagem event coming from the southwest, carries a mass of air with higher O_3 and NO_2 mixing ratios and lower CO mixing ratio compared to the air masses present in the central Amazon. At Lake Balbina, the friagem intensifies the local circulations, such as the breeze phenomena. In the Manaus region and at the ATTO site, the main effects of the friagem event are a decrease in the incoming solar radiation (due to intense cloud formation), a large temperature drop and a distinct change in surface O_3 and CO_2 mixing ratios. As the cold air of the friagem was just in the lower 500 m the most probable cause of this change is that a cold pool above the forest prevented vertical mixing causing accumulation of CO_2 from respiration and very low O_3 mixing ratio due to photochemistry reduction and limited mixing within the boundary layer.

1 Introduction

The Amazon region suffers from the incursion of cold waves from the high latitudes of the Southern Hemisphere (SH), with a relatively common occurrence mainly in the less rainy season, between June and September. These events are de-

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Global Sustainability

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Ten new insights in climate science 2021: a horizon scan

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Review Article

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POLICY DIRECTION

Journal of Applied Ecology

Time to integrate global climate change and biodiversity science-policy agendas

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Abstract

1. There is an increasing recognition that, although the climate change and biodiversity crises are fundamentally connected, they have been primarily addressed independently and a more integrated global approach is essential to tackle these two global challenges.
2. Nature-based Solutions (NbS) are hailed as a pathway for promoting synergies between the climate change and biodiversity agendas. There are, however, uncertainties and difficulties associated with the implementation of NbS, while the evidence regarding their benefits for biodiversity remains limited.
3. We identify five key research areas where incomplete or poor information hinders the development of integrated biodiversity and climate solutions. These relate to refining our understanding of how climate change mitigation and adaptation approaches benefit biodiversity conservation; enhancing our ability to track and predict ecosystems on the move and/or facing collapse; improving our capacity to predict the impacts of climate change on the effectiveness of NbS; developing solutions that match the temporal, spatial and functional scale of the challenges; and developing a comprehensive and practical framework for assessing, and mitigating against, the risks posed by the implementation of NbS.
4. *Policy implications.* The Conference of the Parties (COP) for the United Nations Framework Convention on Climate Change (COP26) and the Convention on Biological Diversity (COP15) present a clear policy window for developing coherent policy frameworks that align targets across the nexus of biodiversity and climate change. This window should (a) address the substantial and chronic underfunding of global biodiversity conservation, (b) remove financial incentives that negatively impact biodiversity and/or climate change, (c) develop higher levels of integration between the biodiversity and climate change agendas, (d) agree on a monitoring framework that enables the standardised quantification and comparison of biodiversity gains associated with NbS across ecosystems and over time and (e) rethink environmental legislation to better support biodiversity conservation in times of rapid climatic change.

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Atmospheric Chemistry and Physics

Aerosols from anthropogenic and biogenic sources and their interactions – modeling aerosol formation, optical properties, and impacts over the central Amazon basin

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Abstract. The Green Ocean Amazon experiment – GoAmazon 2014–2015 – explored the interactions between natural biogenic forest emissions from central Amazonia and urban air pollution from Manaus. Previous GoAmazon 2014–2015 studies showed that nitrogen oxide ($NO_x = NO + NO_2$) and sulfur oxide (SO_x) emissions from Manaus strongly interact with biogenic volatile organic compounds (BVOCs), affecting secondary organic aerosol (SOA) formation. In previous studies, ground-based and aircraft measurements provided evidence of SOA formation and strong changes in aerosol composition and properties. Aerosol optical properties also evolve, and their impacts on the Amazonian ecosystem can be significant. As particles age, some processes, such as SOA production, black carbon (BC) deposition, particle growth and the BC lensing effect change the aerosol optical properties, affecting the solar radiation flux at the surface. This study analyzes data and models SOA formation using the Weather Research and Forecasting with Chemistry (WRF-Chem) model to assess the spatial variability in aerosol optical properties as the Manaus plumes interact with the natural atmosphere. The following aerosol optical properties are investigated: single scattering albedo (SSA), asymmetry parameter (g_{ae}), absorption Ångström exponent (AAE) and scattering Ångström exponent (SAE). These simulations were validated using ground-based measurements at three experimental sites, namely the Amazon Tall Tower Observatory – ATTO (T0a), downtown Manaus (T1), Tiwa Hotel (T2) and Manacapuru (T3), as well as the U.S. Department

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Biogeosciences

Bioaerosols in the Amazon rain forest: temporal variations and vertical profiles of Eukarya, Bacteria, and Archaea

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Abstract. The Amazon rain forest plays a major role in global hydrological cycling, and biogenic aerosols are likely to influence the formation of clouds and precipitation. Information about the sources and altitude profiles of primary biological aerosol particles, however, is sparse. We used fluorescence in situ hybridization (FISH), a molecular biological staining technique largely unexplored in aerosol research, to investigate the sources and spatiotemporal distribution of Amazonian bioaerosols on the domain level. We found wet season bioaerosol number concentrations in the range of 1–5 × 10^5 m^{-3} accounting for > 70 % of the coarse mode aerosol. Eukaryotic and bacterial particles predominated, with fractions of ∼ 56 % and ∼ 26 % of the intact airborne cells. Archaea occurred at very low concentrations. Vertical profiles exhibit a steep decrease in bioaerosol numbers from the understory to 325 m height on the Amazon Tall Tower Observatory (ATTO), with a stronger decrease in Eukarya compared to Bacteria. Considering earlier investigations, our results can be regarded as representative for near-pristine Amazonian wet season conditions. The observed concentrations and profiles provide new insights into the sources and dispersion of different types of Amazonian bioaerosols as a solid basis for model studies on biosphere–atmosphere interactions such as bioprecipitation cycling.

1 Introduction

The study of atmospheric bioaerosols represents a challenging field in aerosol research because of their diverse particle properties, including size, morphology, mixing state, hygroscopic behavior, and metabolic activity. Bioaerosols are ubiquitous in the atmosphere worldwide and comprise prokaryotic (Bacteria and Archaea) and eukaryotic (e.g., fungi and algae) cells, various reproductive entities (e.g., spores and pollen), and fragments of biological material (Andreae and Crutzen, 1997; Jaenicke, 2005; Després et al., 2012). The scientific and socioeconomic attention that bioaerosols have received can be explained by their manifold and fundamental roles in atmospheric chemistry and physics, biogeography, public health, ecology, and agriculture (e.g., Pöschl et al., 2010; Morris et al., 2014; Fröhlich-Nowoisky et al., 2016;

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Atmospheric Chemistry and Physics

Identifying source regions of air masses sampled at the tropical high-altitude site of Chacaltaya using WRF-FLEXPART and cluster analysis

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Abstract. Observations of aerosol and trace gases in the remote troposphere are vital to quantify background concentrations and identify long-term trends in atmospheric composition on large spatial scales. Measurements made at high altitude are often used to study free-tropospheric air; however such high-altitude sites can be influenced by boundary layer air masses. Thus, accurate information on air mass origin and transport pathways to high-altitude sites is required. Here we present a new method, based on the source–receptor relationship (SRR) obtained from backwards WRF-FLEXPART simulations and a k-means clustering approach, to identify source regions of air masses arriving at measurement sites. Our method is tailored to areas of complex terrain and to stations influenced by both local and long-range sources. We have applied this method to the Chacaltaya (CHC) GAW station (5240 m a.s.l.; 16.35° S, 68.13° W) for the 6-month duration of the "Southern Hemisphere high-altitude experiment on particle nucleation and growth" (SALTENA) to identify where sampled air masses originate and to quantify the influence of the surface and the free troposphere. A key aspect of our method is that it is probabilistic, and for each observation time, more than one air mass (cluster) can influence the station, and the percentage influence of each air mass can be quantified. This is in contrast to binary methods, which label each observation time as influenced by either boundary layer or free-troposphere air masses. Air sampled at CHC is a mix of different provenance. We find that on average 9 % of the air, at any given observation time, has been in contact with the surface within 4 d prior to arriving at CHC. Furthermore, 24 % of the air has been located within the first 1.5 km above ground level (surface included). Consequently, 76 % of the air sampled at CHC originates from the free troposphere. However, pure free-tropospheric influences are rare, and often samples are concurrently influenced by both boundary layer and free-tropospheric air masses. A clear diurnal cycle is present, with very few air masses that have been in contact with the surface being detected at night. The 6-month analysis also shows that the most dominant air mass (cluster) originates in the Amazon and is responsible for 29 % of the sampled air. Furthermore, short-range clusters (ori-

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Determinants of Fire Impact in the Brazilian Biomes

Ubirajara Oliveira[1], Britaldo Soares-Filho[1], Mercedes Bustamante[2], Letícia Gomes[2], Jean P. Ometto[3] and Raoni Rajão[1,4]*

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More and more, wildfires are raging in large parts of the world due to a warmer climate, more frequent and severe droughts, and continued land-use changes. In Brazil, the weakening of public environmental policies has further aggravated wildfires with widespread impacts across the country. Here, we investigated the determinants of the impact of fire in the Brazilian biomes using a dataset of burned areas between 2001 and 2019 to simulate its future impact under alternative policy and climate scenarios. We began by deriving a fire impact index using a principal component (PC) analysis comprising the variables: 1. fire intensity, 2. fire recurrence, 3. burned area size, 4. mean time interval between successive fires, and 5. predominance of fires in the dry season. We considered as High Impact Fires (HIF) those areas whose values of the first PC were above the 90th percentile. HIF occurred in the Amazon, Cerrado, and Pantanal, but not in the Atlantic Forest, Pampa, and Caatinga biomes. As the main drivers of HIF, our spatial autoregressive models (SAR) (Amazônia R^2 = 0.66, Pantanal R^2 = 0.86 and Cerrado R^2 = 0.79) indicated the climate (Amazon, 25%, Pantanal, 53%, and Cerrado, 56%) together with land-use change (Amazon, 75%, Pantanal, 25%, and Cerrado, 38%). Most HIF occurred in native vegetation remnants (NVR) (55% in the Amazon, 86% in the Pantanal and 94% in the Cerrado), especially in places close to areas deforested over the last two decades. Only in Pantanal fuel loads (dry biomass) play a major role in HIF (22% of explanation). In the Cerrado, it only accounted for 4% of the observed variability and in the Amazon, it was not a significant factor. Over the analyzed period, HIF imposed a loss of 23%, on average, on the NDVI response of the native vegetation in the Amazon, 19% in the Cerrado and 16% in the Pantanal, thus indicating physiological stress. Simulations of future climate and land-use change pointed to a dramatic increase in HIF by 2050. Under the RCP4.5 and strong environmental governance scenario, HIF in the Cerrado would expand from the current 3% of the biome to 15%, from 7 to 8% in the Pantanal and from 0.7 to 1.2% in the Amazon. In addition, the impact of fire would intensify in 95% of the Cerrado, 97% of the Amazon and 74% of the Pantanal. Effective public and private policies will be vital to mitigate the growing threat of HIF. In this sense, our spatially explicit models can help direct prevention and firefighting programs.

Keywords: modeling, deforestation, land use change, protected areas, native vegetation

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Article type : Research Review

Amazonian Biogenic Volatile Organic Compounds under Global Change

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Modeling fuel loads dynamics and fire spread probability in the Brazilian Cerrado

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ABSTRACT

Fire events substantially influence biodiversity, carbon cycling, hence climate, human health, and the economy on a global scale. To cope with increasingly widespread fires, we need accurate estimates of the chances of fire occurrence across heterogeneous landscapes. Estimates of risk of fire are fundamental to prevent and fight wildfires. To this end, we developed a monthly fire spread probability model for the Brazilian Cerrado biome based on the historical relation between fuel loads and burned areas. To so, we firstly stratified the biome into 16 climatic regions, given the climate influence on fuel loads. We used historical burned areas and fuel loads from remote sensed data between 2015 and 2018 to build a non-stationary model that estimates fuel loads dynamics across the biome. Climate seasonality is the main factor driving fuel loads dynamics. The correlation between fuel loads and the best predictor (monthly mean precipitation) ranges from 0.27 to 0.88 (mean r = 0.61 and deviation of 0.18) across the Cerrado. The average amplitude of fuel loads is 32% between dry and rainy seasons. Our Bayesian fire risk model uses the burned area as a prior probability and fuel loads to estimate the posterior probability of fire spread. Our results show that the probability of fire spread highly correlates with historical burning events (r = 0.67). The recovery of fuel loads post-fire takes, on average, 2.43 years; however, our results point to a downward pathway of the biome's vegetation biomass due to frequent recurrent fires. The models we developed provide a useful tool for improving the representation of spatial patterns and seasonality of fires in order to support management practices.

1. Introduction

Fire is a recurrent event in the savannas of the world (Bond, 2015). The open structure of the savanna vegetation, the dominance of grasses, and the remarkable seasonality of the climate, with a long dry period, favor the occurrence of extensive and recurrent fires (Hutley, 2018). Natural fires occur mainly due to lightning in the rainy season and do not usually pose significant threats (Hardesty et al., 2005). However, anthropogenic fires occurring in the dry season are becoming more frequent and extensive (Balch et al., 2018; Fidelis et al., 2018). Fire activity in the Cerrado in 2019 (35,547 hot pixels) increased by 44% from that of 2017 (32,962 hot pixels) during the same period—January to September (INPE, 2019). Fires reduce soil and vegetation carbon stocks (Collins et al., 2019), thereby emitting Greenhouse Gases (GHG) (Marasenі et al., 2016), and cause biodiversity losses (Enright et al., 2015). Also, fires impose high economic costs for preventing or fighting them with field brigades and airplanes (Thomas et al., 2017), or due to monetary losses and respiratory ailments (Mendonça et al., 2004; Oliveira et al., 2019).

The Brazilian Cerrado is a fire-prone biome (Pettinari et al., 2014), whose local flammability varies according to the dominant vegetation type (Hoffmann et al., 2012). Grassland and savanna vegetation comprises 65% of the biome and is much more flammable than forests (32%) (Hoffmann et al., 2012; Isaac et al., 2016). Grasses hold large amounts of fuel (or fuel loads) that become highly flammable during the dry period (Bowman et al., 2009; Cardoso et al., 2018) when its high exposure to sunlight results in warmer and drier microclimate (Hoffmann et al., 2012). Grassland and savanna vegetation are more resilient to fire than forest vegetation due to adaptive characteristics, such as thicker bark acting as a thermal barrier and proportionally larger root biomass as a source of carbohydrate for regrowth (Hoffmann et al., 2003). However, frequent anthropogenic fires hinder vegetation biomass recovery

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Mapping the stock and spatial distribution of aboveground woody biomass in the native vegetation of the Brazilian Cerrado biome

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ABSTRACT

The Brazilian Cerrado biome consists of a highly heterogeneous tropical savanna, and is one of the world's biodiversity hotspots. High rates of deforestation, however, place it as the second-largest source of carbon emissions in Brazil. Due to its heterogeneity, biomass and carbon stocks in the Cerrado vegetation are highly variable, and mapping and monitoring these stocks are not a trivial effort. To address this challenge, we built an aboveground woody biomass (AGWB) model for the Cerrado biome using 30-m resolution optical satellite imagery (Landsat-8 and Landsat-8), 25-m resolution SAR imagery (ALOS and ALOS-2), and a set of plot-based and LiDAR-derived AGWB estimates (n = 1050) from a wide network of researchers in Brazil. We implemented both a Classification and Regression Tree (CART) and a Random Forest (RF) algorithm to model AGWB over the native vegetation in the year 2019 (as classified by MapBiomas) in the Cerrado. The RF algorithm resulted in a slightly better result (R^2 = 53%; rel. RMSE = 57%) than the CART model (R^2 = 49%; rel. RMSE = 63%), but our map shows an underestimation of very high AGWB (negative bias over 200 t ha^{-1}) and a slight overestimation of low AGWB (positive bias), especially in the RF model (bias of 1.19 t ha^{-1} against 0.06 t ha^{-1} for the CART model). We believe we have contributed to knowledge on the woody biomass stocks in the biome, especially in the predominant savanna woodlands, which is where the highest current rates of conversion take place in the Cerrado.

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BAMS
Article

The SALTENA Experiment

Comprehensive Observations of Aerosol Sources, Formation, and Processes in the South American Andes

Federico Bianchi, Victoria A. Sinclair, Diego Aliaga, Qiaozhi Zha, Wiebke Scholz, Cheng Wu, Liine Heikkinen, Rob Modini, Eva Partoll, Fernando Velarde, Isabel Moreno, Yvette Gramlich, Wei Huang, Alkuin Maximilian Koenig, Markus Leiminger, Joonas Enroth, Otso Peräkylä, Angela Marinoni, Chen Xuemeng, Luis Blacutt, Ricardo Forno, Rene Gutierrez, Patrick Ginot, Gaëlle Uzu, Maria Cristina Facchini, Stefania Gilardoni, Martin Gysel-Beer, Runlong Cai, Tuukka Petäjä, Matteo Rinaldi, Harald Saathoff, Karine Sellegri, Douglas Worsnop, Paulo Artaxo, Armin Hansel, Markku Kulmala, Alfred Wiedensohler, Paolo Laj, Radovan Krejci, Samara Carbone, Marcos Andrade, and Claudia Mohr

ABSTRACT: This paper presents an introduction to the Southern Hemisphere High Altitude Experiment on Particle Nucleation and Growth (SALTENA). This field campaign took place between December 2017 and June 2018 (wet to dry season) at Chacaltaya (CHC), a GAW (Global Atmosphere Watch) station located at 5,240 m MSL in the Bolivian Andes. Concurrent measurements were conducted at two additional sites in El Alto (4,000 m MSL) and La Paz (3,600 m MSL). The overall goal of the campaign was to identify the sources, understand the formation mechanisms and transport, and characterize the properties of aerosol at these stations. State-of-the-art instruments were brought to the station complementing the ongoing permanent GAW measurements, to allow a comprehensive description of the chemical species of anthropogenic and biogenic origin impacting the station and contributing to new particle formation. In this overview we first provide an assessment of the complex meteorology, airmass origin, and boundary layer–free troposphere interactions during the campaign using a 6-month high-resolution Weather Research and Forecasting (WRF) simulation coupled with Flexible Particle dispersion model (FLEXPART). We then show some of the research highlights from the campaign, including (i) chemical transformation processes of anthropogenic pollution while the air masses are transported to the CHC station from the metropolitan area of La Paz–El Alto, (ii) volcanic emissions as an important source of atmospheric sulfur compounds in the region, (iii) the characterization of the compounds involved in new particle formation, and (iv) the identification of long-range-transported compounds from the Pacific or the Amazon basin. We conclude the article with a presentation of future research foci. The SALTENA dataset highlights the importance of comprehensive observations in strategic high-altitude locations, especially the undersampled Southern Hemisphere.

KEYWORDS: Aerosol nucleation; Aerosols/particulates; Atmospheric composition; Biosphere/atmosphere interactions; Gas-to-particle conversion; Measurements

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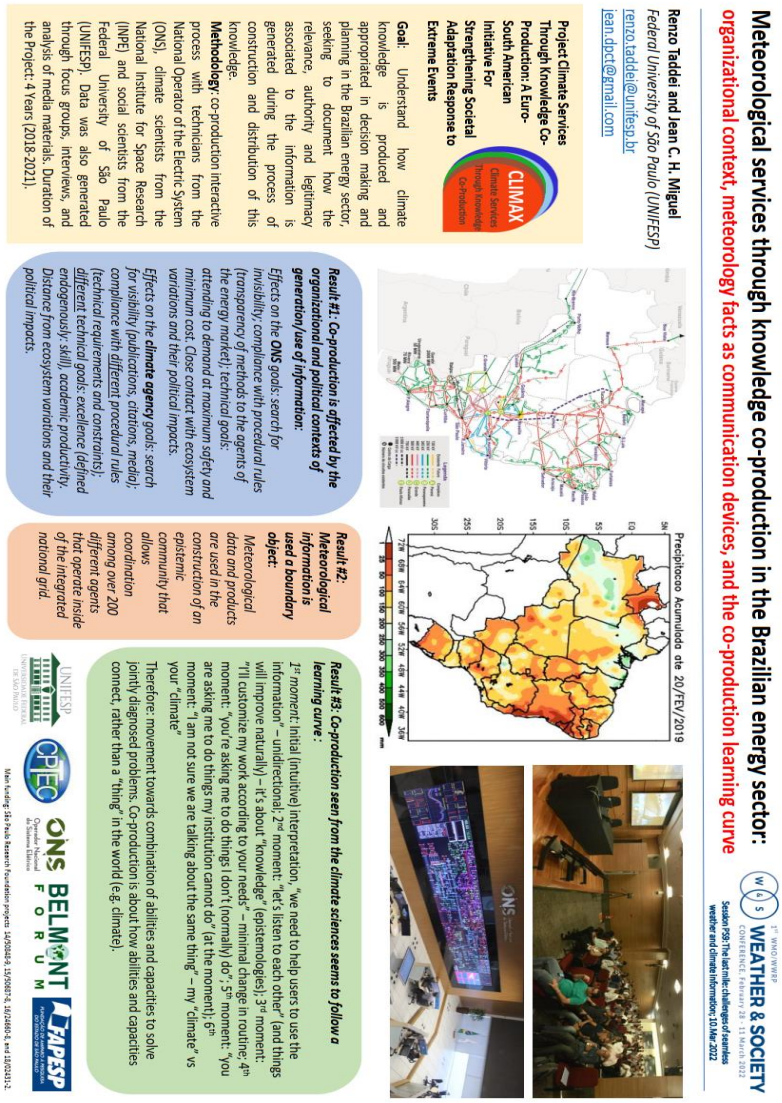
In final form 17 July 2021

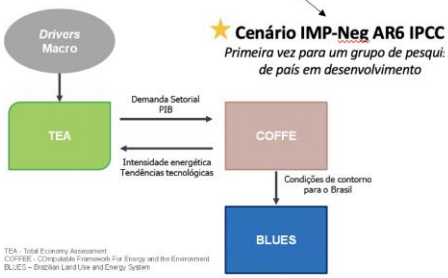
Pesquisa FAPESP – Interviews Agencia FAPESP



Principais Resultados

Energia - *modelagem de avaliação integrada*

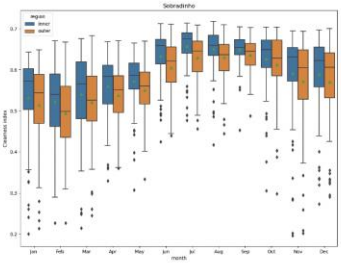
- Melhorias na representação de sistemas e processos
  - Nacional (modelo BLUES):
    - Nexo água-energia-uso do solo
      - Representação do uso do solo
    - Transporte
      - Aéreo e aquaviário
    - Biocombustíveis e biomateriais
  - Global (modelo COFFEE):
    - Navegação
    - Oferta de óleo e gás



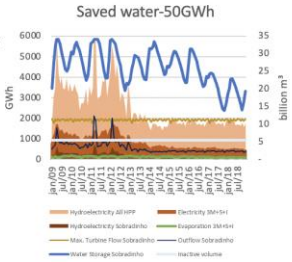
O Nexo água-energia-alimento

Geração híbrida de energia hidro-solar aumenta a segurança hídrica e energética no semi-árido brasileiro – Estudo de caso para Sobradinho

- Várias composições de geração fotovoltaica flutuante no reservatório de Sobradinho
- Revelou melhor gerenciamento no uso múltiplo da água
- E possibilita evitar racionamento em períodos de secas prolongadas



Índice de claridade (K_t) interno e externo ao lago



- A brisa-lacustre propicia menor cobertura de nuvens sobre grandes áreas alagadas, como no caso do reservatório de Sobradinho.
- Em conseqüência, maior rendimento de geração fotovoltaica flutuante
- Novo nixo de exploração de energia para hibridização com a geração hidrelétrica

MUNICIPAL VULNERABILITY IN THE STATE OF RIO DE JANEIRO/ BRAZIL, FOR TRANSMISSION OF AMERICAN VISCERAL LEISHMANIASIS

ID 100288

Margarete M S Afonso[1], Bruno M Carvalho[2], Artur A V Mendes Júnior[3], Cristina M G Dias[4], Lucas Keidel[4], Patrícia S Meneguete[4], Sandro A Pereira[3], Elizabeth F Rangel[1]

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INTRODUCTION

The Brazilian Program for the Surveillance and Control of American Visceral Leishmaniasis (AVL) classifies municipalities with specific control actions recommended for each category. Municipalities without reported human or canine cases in the last three years are considered silent and can be further classified as vulnerable if: 1) share borders with municipalities with transmission, 2) have intense human migration, and/or 3) are part of the same road network. Vulnerable municipalities can be classified as receptive (with records of the vectors *Lutzomyia* (*Lutzomyia*) *longipalpis*/ *Lutzomyia* (*L.*) *cruzi* or non-receptive (without records of the vector) (Figure 1). The State of Rio de Janeiro (RJ) has a small number of human cases of AVL; but it should not be neglected due to the high number of infected dogs, mortality, the vector adaptation, urbanization, and expansion of the disease. Therefore, preventive measures in silent areas are crucial to avoid its spread. This study aimed to identify vulnerable municipalities in RJ and guide future entomological surveys, by mapping the spatial distribution of the disease (human and canine) and its local vector, *Lu.* (*L.*) *longipalpis*.

METHOD

The occurrence of *Lu.* (*L.*) *longipalpis*, human and canine cases of AVL were obtained at the National Information System on Notifiable Diseases, from the Health Department of the State of RJ, from the National Reference Services on Leishmaniasis and from the literature. The data were integrated into a Geographic Information System/QGIS and classified according to the abovementioned criteria, established by the Brazilian Ministry of Health.

RESULTS

In the period of 2011-2022, human AVL occurred in 09 and canine VL in 41 of the 92 municipalities in RJ. In the last three years (2019-2021), 27 municipalities had records of canine VL. Five municipalities had records of human AVL (Figure 2); all classified as sporadic transmission, where Barra Mansa, Rio de Janeiro and Volta Redonda are municipalities with records of canine VL and the presence of the vector *Lu.* (*L.*) *longipalpis*. In the state, 62 (67%) vulnerable municipalities were identified, 09 (8%) of which were receptive, and only one municipality was classified as silent and not vulnerable (Aperibé) (Figure 3). Rio de Janeiro has only 17 (18%) municipalities with entomological survey and records of the vector (Figure 4). The transmission of AVL currently occurs in 32% of the RJ and classified as sporadic. Approximately 82% of all the state, and among the vulnerable municipalities, 85% municipalities do not have information on sandflies, which shows a clear need for entomological studies.

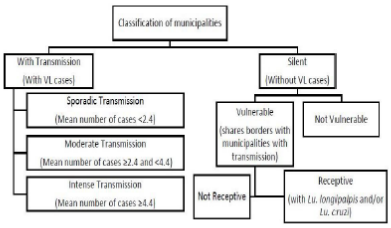

Figure 1. Classification of municipalities according by the Brazilian Program for the Surveillance and Control of American Visceral Leishmaniasis.

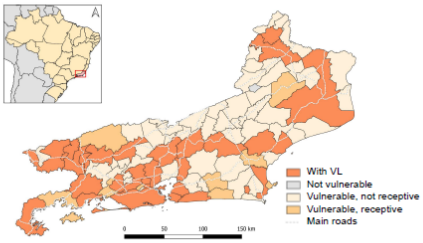

Figure 3. Classification of municipalities of the State of Rio de Janeiro according to the transmission of American Visceral Leishmaniasis.

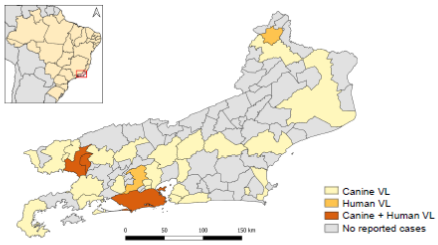

Figure 2. Occurrence of human and canine American Visceral Leishmaniasis in the State of Rio de Janeiro.

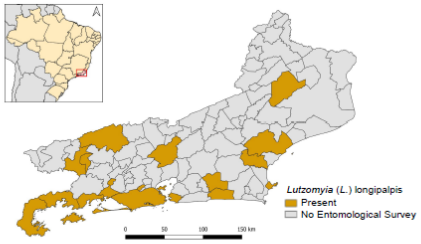

Figure 4. Municipalities with entomological survey and records of the vector *Lutzomyia* (*L.*) *longipalpis* in the State of Rio de Janeiro.

CONCLUSIONS

It is known that notifications about human and canine cases of VL are still precarious, a fact that needs to be reviewed, since they are essential data for surveillance and control actions to be implemented efficiently in the state and in the municipalities. After the detection of the vector in vulnerable municipalities, the recommended control actions are, health education actions, environmental management, and canine investigation, aiming at the early detection of AVL cases. This type of study has as its main perspective to provide support for surveillance campaigns and prevention of AVL transmission, whose model can be applied to different regions of Brazil.

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GEOGRAPHIC DISTRIBUTION OF *Lutzomyia whitmani* ASSOCIATED WITH VEGETATION, AND IMPACTS ON THE EXPANSION OF AMERICAN CUTANEOUS LEISHMANIASIS IN BRAZIL

ID100558

WORLD LEISH7

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[1]Laboratório Interdisciplinar de Vigilância Entomológica em Diptera e Hemiptera, Instituto Oswaldo Cruz, FIOCRUZ; Rio de Janeiro, Brazil; [2]Laboratório de Informação em Saúde, Instituto de Comunicação e Informação Científica e Tecnológica em Saúde, FIOCRUZ, Rio de Janeiro, Brazil.
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In Brazil, due to new and complex epidemiologic scenarios, the focal and dynamic transmissions of American Cutaneous Leishmaniasis (ACL) occur in different patterns, depending on location depending on the variables related to the parasites, vectors, ecosystems and the social processes of production and use of the soil. An important example of this phenomenon is the widespread distribution and various behavior patterns of *Lutzomyia whitmani*, a vector that transmits three species of Leishmania: *Leishmania* (*V.*) *braziliensis*, *Leismania* (*V.*) *shawi* and *Leishmania* (*V.*) *guyanensis*. This study aims to correlate different types of Brazilian vegetation with the spatial distribution of *Lutzomyia whitmani* in representative areas of the Spatial Circuits of Production of American Cutaneous Leishmaniasis in Brazilian municipalities, contributing to a better understanding of the epidemiology of this parasite in Brazil.

To evaluate the ACL surveillance and monitoring model in Brazil, the Ministry of Health adopted the Spatial Circuit of the disease until 2013 (Fig. 1), currently it has been adopting the composite indicator index of cutaneous leishmaniasis (ICLT). For this study, a Geographic Information System (GIS) was used to integrate the geographic distribution layers of *L. whitmani* with the vegetation cover and the ACL Spatial Circuits in Brazilian municipalities. To calculate the correlations between the vegetation and the presence of the vector, the SPSS was used, through the t test, the significance of the proportions of the averages of the areas of vegetation related to the presence and absence of the vector was evaluated.

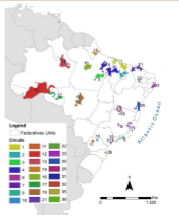

Figure 1. Geographic distribution of the 36 Spatial Circuits of ACL production

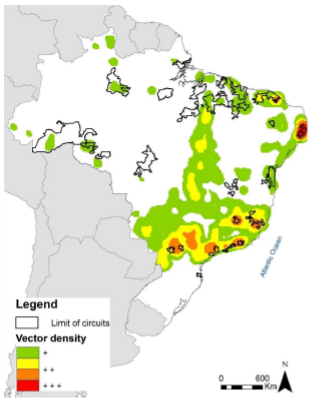

Figure 2. *Lutzomyia whitmani* density, in association with Spatial Circuits of ACL Production in Brazil, according to the Kernel technique.

Of the 5,570 Brazilian municipalities analyzed here, information on *L. whitmani* was found for 862 in association with the spatial circuits of ACL production (Fig 2).The vector occurred in nearly all types of vegetation, with a widespread distribution in: Dense Ombrophilous Forests, Open Ombrophilous Forests (or transition forests), Seasonal Decidual Forests (or deciduous woods), Seasonal Semidecidual Forests (semideciduous woods) and Steppe. The vector was not found in Oligotrophic Woody Vegetation of the Marshes and of Sand Accumulation (Fig. 3).

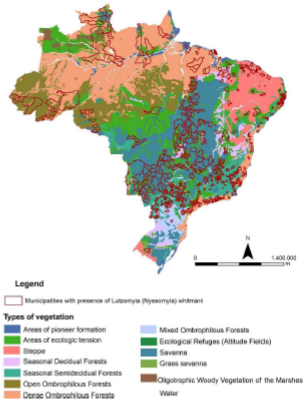

Figure 3. Spatial distribution of *Lutzomyia whitmani* associated to vegetation types (https://mapas.ibge.gov.br/tematicos/vegetacao).

The use of geotechnologies reinforces the importance of the spatialization of *L. whitmani* in the transmission of ACL, in areas of important spatial circuits, in association with different types of vegetation. The combination of these aspects associated with deforestation causes an important environmental impact that favors the establishment of outbreaks in endemic areas of ACL. Considering that environmental changes can impact the eco-epidemiology of ACL, the results obtained should be evaluated in surveillance actions, contributing to the production of health in areas at risk for ACL associated with *L. whitmani*, designed to the municipalities according to the epidemiological situation of the disease.

FAPERJ Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro
CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico
IOC Instituto Oswaldo Cruz
Ministério da Saúde
FIOCRUZ
Fundação Oswaldo Cruz

CNPq - Suplementação de Contrato - [465501/2014-1]

Subject: CNPq – Suplementação de Contrato – [465501/2014-1]
From: Cnpq<atendimento@cnpq.br>
Date: 25/03/22 07:02
To: jose.marengo@cemaden.gov.br,jose.marengo@pq.cnpq.br,marengojose2@gmail.com
CC: cgnac@cnpq.br

Nome: Jose Antonio Marengo Orsini
Processo: 465501/2014-1
Ref: Suplementação
Edital/Chamada: CHAMADA PÚBLICA MCTI/CNPQ/CAPES/FAPS Nº 16/2014 – PROGRAMA INCT
Projeto: INCT para Mudanças Climáticas (INCT-MC)
Instituição: Centro Nacional de Monitoramento e Alertas de Desastres Naturais/CEMADEN-SP

Prezado(a) Senhor(a),

Comunicamos que a Diretoria Executiva do CNPq autorizou a suplementação de recursos para o desenvolvimento do seu projeto, conforme discriminado abaixo:

Custeio: R$ 798.142,00

Bolsas concedidas:

Modalidade/Nível: Apoio Técnico a Pesquisa – Nível Médio
Quantidade: 1
Duração: 4 meses

Modalidade/Nível: DTI-A
Quantidade: 10
Duração: 24 meses

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Quantidade: 8
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Modalidade/Nível: Iniciação Científica Júnior – ICJ
Quantidade: 17
Duração: 24 meses

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http://efomento.cnpq.br/efomento/termo?token=vST25708P855679181460101819579 7

e enviá-lo eletronicamente com a MÁXIMA BREVIDADE, clicando no botão "Enviar ao CNPq".

Atenciosamente,

Evaldo Ferreira Vilela
Presidente

CONSELHO NACIONAL DE DESENVOLVIMENTO CIENTÍFICO E TECNOLÓGICO
Diretoria de Cooperação Institucional
Coordenação-Geral de Cooperação Nacional
Coordenação de Apoio a Parcerias Institucionais

OFÍCIO nº 22967/2021/COAPI/CGNAC/DCOI

Brasília, na data da assinatura eletrônica.

Aos
Institutos Nacionais de Ciência e Tecnologia - INCT
Chamada INCT – MCTI/CNPq/CAPES/FAPs nº 16/2014

Assunto: Avaliação dos INCT da Chamada nº 16/2014 e recursos suplementares para os projetos.

Processo SEI nº: 01300.007504/2021-71 *(Em caso de resposta, favor utilizar este número de referência).*

Prezado(a) Coordenador(a),

Inicialmente, queremos agradecer o empenho e a colaboração no envio do relatório parcial e demais informações que irão subsidiar à avaliação do Programa INCT, em andamento pelo CNPq.

Aproveitamos para registrar que, em parceria com a Academia Brasileira de Ciências – ABC, será realizado um Seminário, no início de 2022, para discutir a importância estratégica do Programa INCT para o desenvolvimento do País, além da realização de uma série de webinários para divulgação dos avanços alcançados pelos INCTs vigentes, previstos para o primeiro semestre de 2022.

Por último, destacamos que o CNPq dará continuidade aos esforços realizados junto ao Fundo Nacional de Desenvolvimento Científico e Tecnológico, cujo Conselho Diretor aprovou a destinação de recursos para apoio aos INCTs, de modo a garantir a liberação dos aportes em 2022. Dessa forma, o plano de aplicação encaminhado por seu INCT permanece válido, e deverá ser atendido com os recursos do FNDCT constantes da PLOA 2022, a ser aprovada nos próximos dias.

INCT Climate Change Phase 2
(INCT MC Phase 2)
Ref: FAPESP 2014/50848-9
CNPq 465501/2014-1
CAPES 16/2014

Principal Researcher and Coordinator:
Jose Antonio Marengo Orsini
CEMADEN

Partial report 2020-21

1. Overview

The INCT for Climate Change Phase 2 (INCT MC Phase 2) 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 and 4 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.

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

0. Observed framework of extremes of climate variability and change and Integration among cimponents;
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:

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

So far the INCT MC Phase 2 scientific agenda has been developed as planned, providing scientific excellence in various areas of global environmental change and its implications for sustainable development. The emphasis on the impacts of global climate change on agriculture, health,

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Diretoria de Cooperação Institucional
Coordenação-Geral de Cooperação Nacional
Coordenação de Apoio a Parcerias Institucionais

OFÍCIO nº 22967/2021/COAPI/CGNAC/DCOI

Brasília, na data da assinatura eletrônica.

Aos
Institutos Nacionais de Ciência e Tecnologia - INCT
Chamada INCT – MCTI/CNPq/CAPES/FAPs nº 16/2014

Assunto: Avaliação dos INCT da Chamada nº 16/2014 e recursos suplementares para os projetos.

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Ofício 22967 (1245720) SEI 01300.007504/2021-71 / pg. 1

Pauta apresentada ao CNPq
Memória da Reunião com o Ministro de CTI em 11 Julho 2021

i) Prorrogação do Prazo Atual;
O CNPq considera ser necessária a prorrogação dos prazos dos processo em andamento. Considerando que a maioria dos INCTs têm prazo até o final de 2022, a Agência ainda terá tempo para estudar o novo prazo, pois este também estará atrelado ao item iii da nossa Pauta!

Perguntado sobre a possibilidade do ato de prorrogação ser GERAL e depender apenas da aderência e não da solicitação especifica dos INCTs o Presidente acenou com a possibilidade de estudar internamente mecanismos que permitam esta ação

ii) Bolsas CNPq (e CAPES);
Foram apresentados gargalos com as bolsas (CNPq) e grandes dificuldades com as Bolsas CAPES.
Com relação `as bolsas CNPq que estão praticamente exauridas em vários INCTs, a solução também estará atrelada ao nosso item iii.
Com relação `a CAPES solicitamos ao Presidente que o CNPq, na qualidade de responsável diretor pelos INCTs intermediasse/agendasse uma reunião com a Presidência da CAPES para discutirmos o assunto e apresentar sugestões.
O Presidente Evaldo destacou que o relacionamento com a CAPES é excelente e que proporá a reunião para a segunda quinzena deste mês, pois na próxima semana estará em ferias.
Em resumo, o assunto foi bem discutido e o CNPq está atento as demanda/dificuldades dos INCTs neste assunto.

iii) Recomposição dos 30%;
De acordo com o Presidente Evaldo: este assunto é prioridade 1! A única pendencia é a dependência dos recursos provenientes do FNDCT (comentário: o FNDCT esta como prioridade máxima na ABC, SBPC e CNI. Vários membros do CD-FNDCT estavam na reunião e sabiam de todos os esforços que estão sendo feitos nesta direção. A ABC, inclusive, tem um GT focado no tema.)
Na reunião o Presidente Evaldo destacou também que entende os 30% como cerca 3 milhões por INCT que foram retirados do orçamente previsto (isto considerando os que tiveram aprovados valores próximos aos 10 milhões. Valores aprovados menores implicarão em "desconto proporcional"!
Na contabilidade dos 30%, o CNPq não considerou as FAPs, mas sim, tudo como responsabilidade do CNPq. Entretanto, isto não impede que aditivos sejam realizados pelas FAPs.
Foi claramente colocado por Evaldo e Zaíra que cada INCT devera, no momento da recomposição, decidir pelas rubricas que deseja alocar os recursos. Esta decisão não será do CNPq, mas sim de cada INCT.
O Presidente Evaldo também mencionou os aditivos que já foram feitos a alguns INCTs com relação `a COVID-19 e Desastre do óleo.

iv) Avaliação dos INCTs;
O Presidente Evaldo anunciou que está em andamento o processo para a realização da avaliação dos INCTs. A ação, segundo o Presidente, está sendo planejada em parceria com a ABC e deverá ocorrer, provavelmente em Novembro. Fizemos alguns breves comentários e sugestões sobre a avaliação... Esperamos ter noticias mais elaboradas brevemente e assim que tivermos partilharemos com os demais colegas Coordenadoras(es).

v) Novo Edital.
O Presidente Evaldo anunciou **que teremos sim um novo edital INCT**. Entretanto o lançamento depende do orçamento 2022 e do andamento da prorrogação dos INCTs atuais. O formato do edital ainda está em estudo no CNPq...

Comentários Finais
O Presidente Evaldo mais uma vez destacou a importância de manter contato com os Coordenadores de INCTs e que considera que o Grupo de Coordenadores que estiveram nas duas reuniões: Agosto de 2020 e Julho de 2021, muito representativo do conjunto (destaco que temos colegas de todas as regiões do pais e atuando em estados desde o Amazonas até o Rio Grande do Sul!) e atuando em áreas do conhecimento complementares..
A memoria aqui apresentada representa um breve extrato do que foi discutido em quase duas horas de reunião (1h e 46 min).

Coordenadores de INCT, representando todo o **Grupo**.

1. Adalberto Luís Val, INCT para Adaptações da Biota Aquática da Amazônia - ADAPTA-II.

2. Belita Koiller, INCT Informação Quântica.

3. Elibio Leopoldo Rech Filho, INCT Biologia Sintética

4. Jailson Bittencourt de Andrade, INCT de Energia e Ambiente.

5. Jefferson Cárdia Simões, Instituto Nacional de Ciência e Tecnologia da Criosfera.

6. João Batista Calixto, INCT INOVAMED- Inovação em Medicamentos e Identificação de Novos Alvos Terapêuticos.

7. Mauro Martins Teixeira, INCT em Dengue e Interação Microorganismo-hospedeiro.

8. Vanderlan da Silva Bolzani, INCTBioNat - Biodiversidade e Produtos Naturais.

9. Roberto Kant, INCT de Estudos Comparados em Administração Institucional de Conflitos, da UFF.

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PESQUISA ARTES JORNALISMO SOBRE REDES SOCIAIS

ANO 09 - N22 - "Esse lugar, que não é meu?" ISSN 2359-4705 CHAMADAS | BUSCA E OUTRAS EDIÇÕES

O desafio da redução da vulnerabilidade das cidades em períodos de chuvas | Gláucia Pérez

25/01/2022

Os eventos extremos se tornarão mais frequentes no futuro e os impactos serão maiores devido ao crescimento constante e desordenado das cidades e populações. Porém, grupos de pesquisas que estudam a vulnerabilidade das cidades às enchentes podem aumentar a resiliência dos centros urbanos.

Por | Gláucia Pérez

Editora | Susana Oliveira Dias

As enchentes que ocorreram em dezembro de 2021 na Bahia e em Minas Gerais, que alagaram cidades, destruíram pontes e interditaram estradas e deixaram inúmeras pessoas desabrigadas, sem falar das mortes provocadas, demonstraram como são necessárias alternativas e métodos adequados para diminuírem os riscos das enchentes em áreas urbanas. Para os especialistas brasileiros que avaliam a vulnerabilidade, exposição, risco e resiliência das megacidades de países em desenvolvimento, pode haver relação dessas enchentes com as mudanças climáticas.

Isso porque "as magnitudes de precipitações observadas, e as condições hidrometeorológicas que desencadearam essas chuvas extremas, surpreenderam os especialistas mais experimentais em observação e previsão meteorológica", afirma o pesquisador Mario Mendiondo, coordenador do subcomponente "Hidrologia e segurança hídrica" do INCT Mudanças Climáticas Fase 2. Com o aumento das temperaturas a nível global, eventos extremos como os que temos assistido poderão se tornar mais frequentes e os impactos ainda maiores, considerando ainda o crescimento constante e

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PESQUISA ARTES JORNALISMO SOBRE REDES SOCIAIS

ANO 08 - N20 - "Coexistências e cocriações" ISSN 2359-4705 CHAMADAS | BUSCA E OUTRAS EDIÇÕES

Pesquisa aponta as dificuldades atuais e futuras da segurança hídrica no Brasil | Gláucia Pérez

20/08/2021

O Brasil por sua dimensão continental possui um grande potencial hídrico com características diversas, a depender da região. O estudo considerou a situação atual da segurança hídrica no país para que não falte a gerações futuras. Levantou ainda os desafios e quais as possibilidades para sanar os problemas.

Por | Gláucia Pérez

Editora | Susana Oliveira Dias

De acordo com o artigo "Segurança hídrica no Brasil: situação atual, principais desafios e perspectivas futuras" da Revista DAE de setembro de 2020, a segurança hídrica tem como objetivo garantir e fornecer água de qualidade e com quantidade satisfatória para a população atual e futura, e preservar o ecossistema. Assunto esse bem discutido nas últimas décadas em movimentos sociais, por ambientalistas, em temas econômicos, sociais e políticos. O texto da pesquisa nos diz: "Esse tema está ganhando cada vez mais espaço entre os líderes mundiais e nas discussões ambientais, econômicas e sociais".

O estudo considerou que a dimensão continental do Brasil faz com que cada região tenha problemas e fatores relevantes que devem ser levantados especificamente para se realizar pesquisa sobre a segurança hídrica. Ressalta também a importância dos seguintes temas para o estudo: a disponibilidade hídrica, o uso da água, a captação e tratamento de esgoto, e a gestão hídrica. Indicou ainda como desafio o uso do solo e as mudanças climáticas, e por fim colocou as perspectivas futuras levantadas ao logo do

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PESQUISA ARTES JORNALISMO SOBRE REDES SOCIAIS

ANO 08 - N20 - "Coexistências e cocriações" ISSN 2359-4705 CHAMADAS | BUSCA E OUTRAS EDIÇÕES

Pesquisadores do INCT Mudanças Climáticas defendem conexão entre cientistas e sociedade para combate ao negacionismo e fake news | Gláucia Pérez

19/10/2021

O 3º webinar do ciclo de popularização da ciência enfatizou a necessidade da comunidade científica construir um canal de comunicação com a sociedade para levar conhecimento de ciência e dos estudos produzidos nos centros de pesquisas.

Por | Gláucia Pérez

Editora | Susana Oliveira Dias

No dia 09 de agosto de 2021 foi apresentado pelo Painel Intergovernamental sobre Mudança do Clima - IPCC o sexto relatório de análise (AR6) sobre as mudanças climáticas globais. Nesse relatório foi ratificado que é "inequívoca" a influência humana nas mudanças climáticas, e nos extremos climáticos devido ao aquecimento global.

O 3º webinar do ciclo de popularização científica: "Uma gota de ciência, uma dose de resiliência - Clima, saúde e resiliência", realizado no dia 25-08-2021, trouxe informações deste relatório para o debate em que três pesquisadoras falaram sobre as mudanças climáticas, saúde e resiliência. O debate fez parte de uma série de webinários realizados para disseminar as pesquisas de cientistas, e melhorar a comunicação entre eles e a sociedade. Participaram do debate as pesquisadoras: Dra Regina Alvalá do Centro Nacional de Monitoramento e Alertas de Desastres Naturais - Cemaden, e membro do INCT de mudanças climáticas fase 2 do subcomponente de "Desastres Naturais, áreas urbanas, infraestrutura física e desenvolvimento urbano";

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Atenciosamente,

Evaldo Ferreira Vilela
Presidente

AGENDA REUNIÃO INCT FASE II
09 E 10 DE JULHO DE 2022

Data: 09-10 de Junho de 2022
Horário: 09h – 17h00
Local: FEA-USP

Justificativa: Reunir os participantes lideres de componente e do Comitê Gestor do INCT MC Fase 2 "

Agenda preliminar:

9 Junho

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 Saúde
- Apresentação Energia
- Apresentação Comunicação
- Apresentação Segurança Alimentar

12h30 – 14h00 Almoço

14h00 - 16h30 Discussões

- Discussões inter-componentes e intra-componentes
- Estratégia para elaborar Relatório do Ano 5 do projeto
- Uso dos recursos financeiros até o momento (FAPESP, CNPq, CAPES) -Josi

De: **Jailson de Andrade** <jailsondeandrade@gmail.com>
Date: sex., 4 de fev. de 2022 às 16:37
Subject: Mensagem INCTs Ao Ilustríssimo Ministro da Ciência, Tecnologia e Inovações
To: <gm@mcti.gov.br>, Gabinete do Ministro <ministro@mcti.gov.br>
Cc: <presidente@cnpq.br>

Ao Ilustríssimo Ministro da Ciência, Tecnologia e Inovações

Astronauta Marcos Pontes

Cumprimentamos V. Excelência pela liberação do FNDCT e a possibilidade de receber os recursos provenientes do fundo em duodécimos em 2022 e gostaríamos de destacar o Programa dos Institutos Nacionais de Ciência e Tecnologia, INCTs, iniciado em 2008 e financiado pelo FNDCT, em parceria com as fundações de amparo à pesquisa dos estados. Os INCTs congregam a excelência científica brasileira em áreas estratégicas, configurando redes inter-regionais de colaboração com abrangência nacional e desempenho acadêmico, científico e tecnológico compatível com os melhores programas internacionais.

A segunda fase foi iniciada em 2014 e formalizada em 2016, com liberação de recursos em dezembro de 2016. Atualmente, são 102 INCTs com presença em todas as regiões do País, com atuação em áreas altamente estratégicas, tais como Saúde, Ecologia e Meio Ambiente, Ciências Exatas e Naturais, Ciências Humanas e Sociais, Ciências Agrárias, Engenharia e Tecnologia da Informação, Energia e Nanotecnologia.

Em setembro de 2021, quando o CNPq, acertadamente, iniciou uma nova etapa de Avaliação do Programa INCT e através do **Processo SEI nº**: 01300.007504/2021-7, sinalizou com a recomposição orçamentária relativa à recomposição dos 30% dos recursos, indevidamente cortados, o CNPq solicitou que:

…tendo em vista a possibilidade de o CNPq receber recursos orçamentários complementares, solicitamos o envio de um Plano de Trabalho e um Plano de Aplicação para esses recursos - estimados em cerca de 30% do valor do projeto original - detalhando a destinação nas rubricas de capital, custeio e bolsas…

Porém, o projeto de lei (PLN 16/2021) que previa a liberação de R$ 690 milhões em créditos suplementares para o Ministério da Ciência, Tecnologia e Inovação (MCTI), dos quais 95% (R$ 655,4 milhões) foram suprimidos, impediu a concretização do aporte de recursos aos INCTs e a vários outros Projetos relevantes do MCTI e, consequentemente, do CNPq.

Neste momento, em que os recursos do FNDCT estão sendo liberados em forma de duodécimos, solicitamos ao Senhor Ministro atenção especial ao Programa INCT, uma vez que, além da falta de recursos de custeio e de capital, também já exauriram o valor aportado para os projetos pelo CNPq/CAPES para as Bolsas em todas as modalidades das atividades de Pesquisa e de Inovação!

Senhor Ministro, neste momento em que os investimentos para C,T,I são vitais para o país continuar sua liderança na América Latina e destacado mundialmente, contamos com a sua sensibilidade para priorizar o CNPq e o Programa INCT, pois isto significa fortalecer o FUTURO do BRASIL!!!

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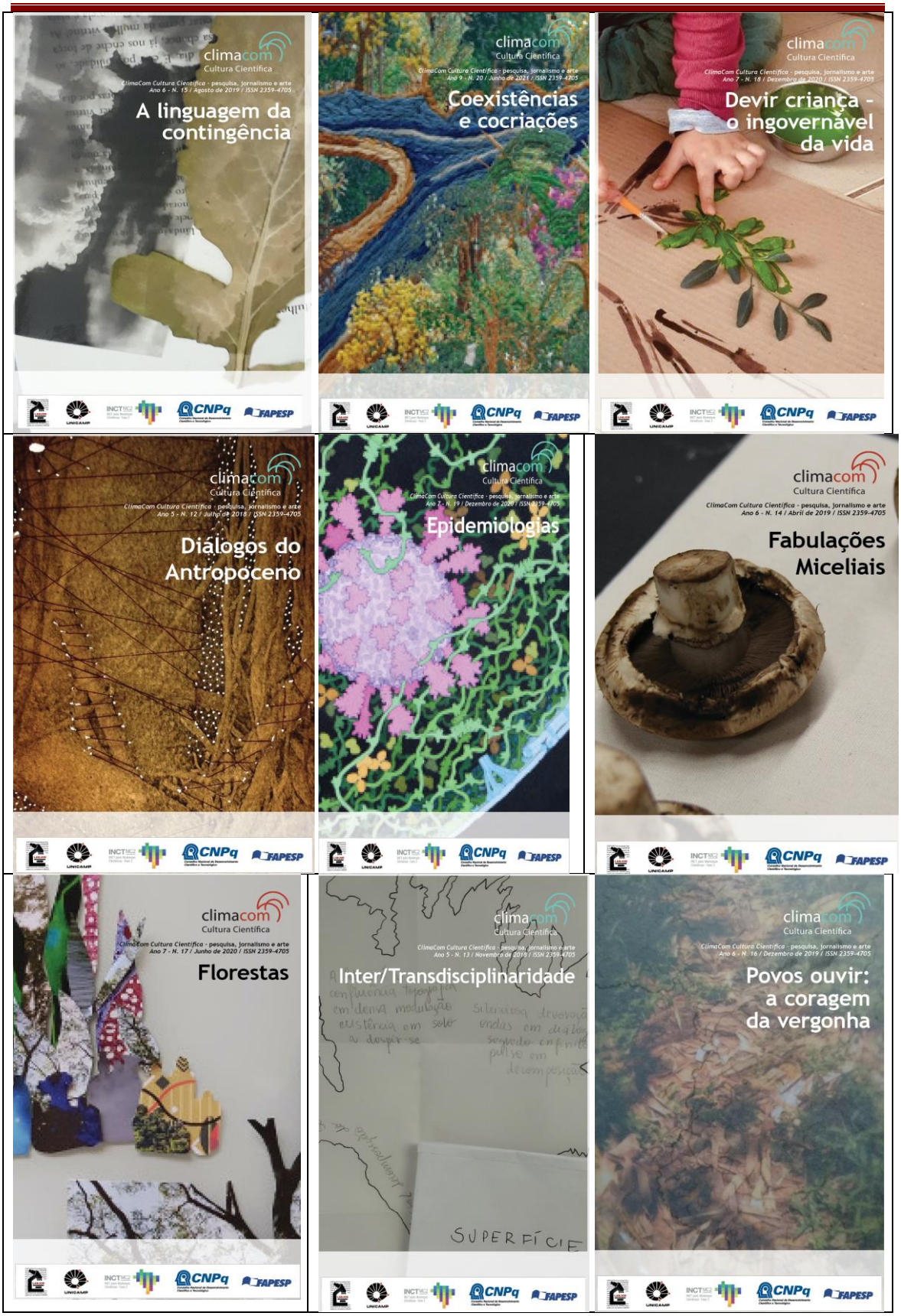
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