INCT Climate Change Phase 2
(INCT MC Phase 2)

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Year 4 Report

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CEMADEN

SUMMARY

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 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 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, 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 and 4 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.

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.

Perhaps one of the most important contributions of the INCT MC Phase 2 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 is convened by the United Nations Sustainable Development Solutions Network (SDSN), and will issue 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 will 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. This July the SPA will release their initial findings as well as a draft version of their full report for public consultation. The SDSN and the World Bank will co-host a high-level dialogue to present these initial findings and foster conversations between scientists and policymakers to advance sustainable development pathways in the Amazon.

2. Objectives and aims

The objectives of the INCT MC Phase 2 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 A-CNPq classification, CEMADEN, Sao Paulo
Vice-Coordinator: Tercio Ambrizzi, Researcher, Level 1 A-CNPq classification, IAG USP,

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-Steering Committee

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Jose Antonio Marengo Orsini	Project's coordinator. Climate modelling, impacts and vulnerability assessments	CEMADEN	jose.marengo@cemaden.gov.br
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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 3 .

4. 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.

4.1 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 MC Phase 2 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.

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

The Pantanal region in South America is one of the world's largest wetlands. Since 2019, the Pantanal has suffered a prolonged drought that has spelled disaster for the region, and subsequent fires have engulfed hundreds of thousands of hectares. The lack of rainfall during the summers of 2019 and 2020 was caused by reduced transport of warm and humid summer air from Amazonia into the Pantanal. Instead, a predominance of warmer and drier air masses from subtropical latitudes contributed to a scarcity of summer rainfall at the peak of the monsoon season. This led to prolonged extreme drought conditions across the region. This drought had severe impacts on the hydrology of the Pantanal. Hydrometric levels fell all along the Paraguay River. In 2020, river levels reached extremely low values, and in some sections of this river, transportation had to be restricted. Very low river levels affected the mobility of people and shipping of soybeans and minerals to the Atlantic Ocean by the Hidrovia-Parana-Paraguai (Parana-Paraguay Waterway). This study is directed to better understand the hydroclimatic aspects of the current drought in the Brazilian Pantanal and their impacts on natural and human systems. As a consequence of the drought, fires spread and affected natural biodiversity as well as the agribusiness and cattle ranching sectors. While fires had serious socioecological and economic consequences, we do not intend to investigate the effect of the downstream low-level waters on the Pantanal ecosystems or the drought in the risk of fire.

The hydrological cycle in the Northern Pantanal is highly related to precipitation. More extended periods without rain tend to decrease the river depth. This consequently affects the floodplain as a total. Figure 4.1.1 shows the mean water levels of the Paraguay River at Ladário and annual rainfall at this river basin. Variability of the mean levels is similar to that of the maximum and minimum levels. It shows the lowest levels in 1910, 1915, 1938, 1967–72, and 2018– 2020, with a jump to upper levels from 1974 to 96. This is consistent with rainfall variability, particularly in 2019 to 2020, as shown by various rainfall data sets (Figure 4.1 C) and SPI-12 (Figure 4.1D). Rainfall data from GPCC and CHIRPS show reductions consistent with lower river levels at the Ladário stage during 2019–20 and in previous events as 1910, 1936, and 1962–73. In this later, the rainfall reduction was less intense than in reduction in water levels. These reductions in 1962–73 and the jump in the river series after 1974 can be better explained by the SPI-12 (Figure 4D), with a period with negative SPI values during the anomalously low levels observed during that decade. Over the periods between 1962–1965 and 1967–1972, the drought duration was 36 and 62 months, and severity, −43.96 and −53.68, respectively.

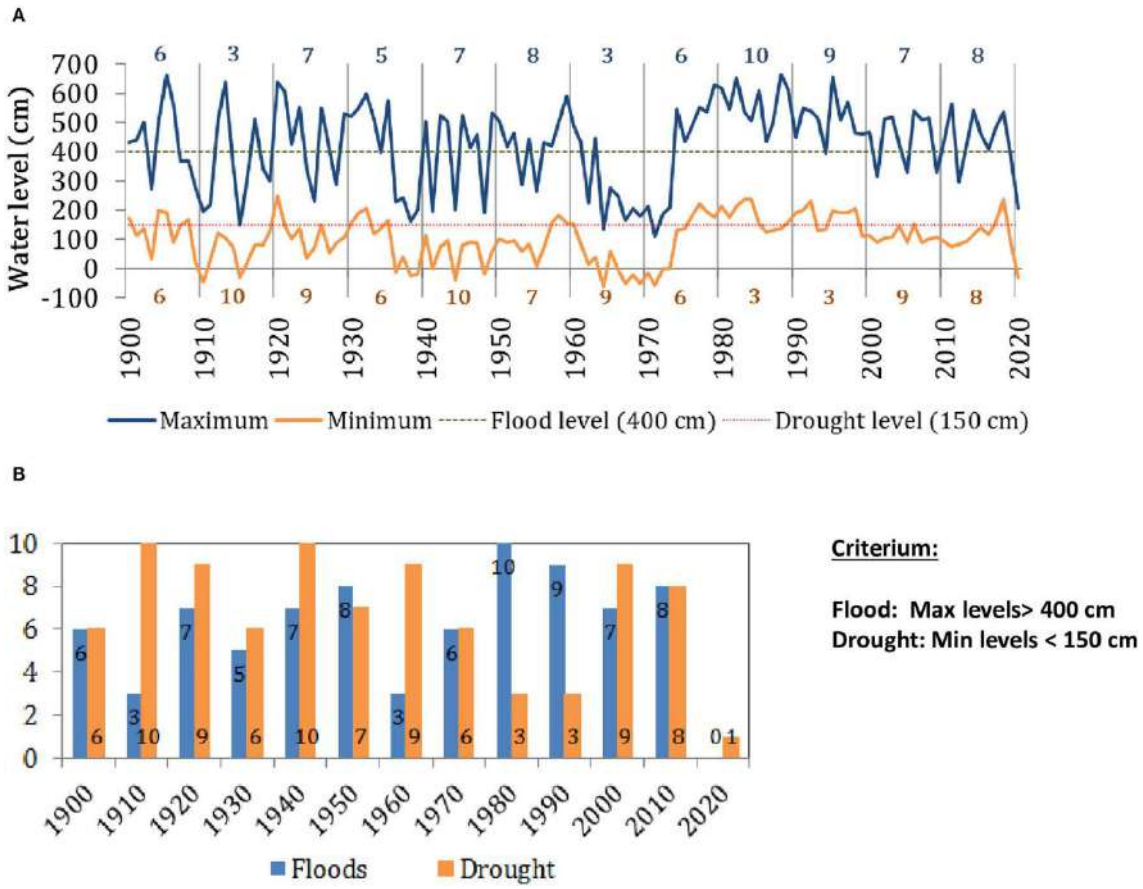

Figure 4.1.1. Maximum and minimum levels of the Paraguay River at Ladário, from 1900 to 2020. Numbers indicate the number of droughts and flood episodes at the decadal level. Floods are defined according to the Brazilian Navy when maximum levels are equal or higher than 400 cm, and drought episodes are defined when minimum river levels are equal to or below 150 cm. (A) Frequency of floods and droughts for Ladario stage. (B) Decadal frequency of floods and droughts from Paraguay River levels at Ladario.

Records from the Paraguay River at the Porto Murtinho gauge station, located in the section downstream of the Lad rio station, within Brazilian territory, show the largest flood ever recorded in this section was in June 1982 when the level reached 952 cm, with the emergency level being 700 cm (CPRM, 2020). In that year, according to data from the National Civil Defense, the damage was recorded in the municipalities of Ladário, Porto Murtinho and Corumbá in Mato Grosso do Sul and in 16 other municipalities in Mato Grosso, including Cuiabá, Varzea Grande, Rondonopolis and C ceres. It is also worth mentioning the historical importance of the 1974 flood. After a prolonged period of low water levels throughout the 1960s and early 1970s, herds were moved to lower areas of the basins. When the flood occurred in 1974, rural properties and herds were submerged, causing great social, economic, and environmental damage. As a consequence of the floods, between 1973 and 1975, the price of meat increased in the domestic market. We need to better understand current drought and flood dynamics in the Pantanal. To accomplish this, an adequate hydrometeorological monitoring network in the entire Pantanal basin is crucial. To improve our knowledge of the hydrological processes in the region it is still necessary to install additional ground-based stations. There is a need to study the feedback between aerosols from the Pantanal's biomass smoke and rainfall during the wet season.

All these facts suggest the need for a science network with collaborative capability to generate creative ideas and solutions to address the big challenges faced by the Pantanal wetland. With better knowledge of the causes and trends in droughts or floods, it would be possible to propose

strategies to reduce the impacts on natural and human systems in the region. Conservation of natural resources and ecosystems services provided by the Pantanal wetland must consider actions in favor of water security. The resilience of the biome will be greatly improved by reducing the risk of fires and the over exploitation of its natural resources. Increasing agriculture, cattle ranching, fishing and tourism must proceed in a sustainable way so the Pantanal can be preserved. If current climate and land-management trends persist, the Pantanal as we know it will cease to exist. This could be worsened if anti-environment politics are adopted. Lastly, the many effects of climate change are felt most strongly in vulnerable ecosystems and poorest communities of the world. To avoid devasting impacts, the world needs urgent action in the next decades, with radical shifts by 2050 following the Paris Agreement.

4.1.2 **The heat wave of October 2020 in central South America**

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 heating of about 10 ^{o}C above normal, and some locations reported maximum temperatures above 40 ^{o}C several days in a row. Because its intensity and geographical extension, hitting 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 nonexistent 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. That is sort of the vicious cycle of drought and extreme heat in a warming climate.

Figure 4.1.2 summarizes some record maximum temperatures detected in some stations in central South American countries. These records show warmest days during September 23-October 15 period, and are compared to the 1981-2010 LTM. The qualifications of those records e.g. (warmest in history, etc.) come from the meteorological services and consider the historical record since the opening of the station, that may vary among stations. Maximum temperatures at some stations showed record-breaking values, where some days had temperatures up to 10^{o}C above the 1981-2010 LTM. Particularly in Paraguay and northern Argentina, the warming was more intense on from September 30 to October 1and 2. On October 1, the maximum temperature in Asuncion reached 42.3 ^{o}C, a new historical record. The previous record had been 42.0 °C on January 2, 1934. In the city of São Paulo, maximum temperatures reached 37.5 ^{o}C on 2nd October (climatology of 28.8 ^{o}C), and in three occasions temperatures surpassed 37.4ºC. In the interior of the state of Sao Paulo new historical records were established: the city of Lins had a maximum temperature of 43.5 ^{o}C on October 5 (climatology of 31.4 ^{o}C), and Jales had a maximum of 41.9 °C on October 5, surpassing the record high of 41.7 °C recorded on September 30 (climatology of 33°C). In Votuporanga maximum temperatures reached 42.1 ^{o}C on October 3 (climatology of 31.4 ^{o}C), and by October 7 there had been twelve consecutive days with temperatures above 40 °C. According to the

INMET, five maximum temperature measurements recorded in October 2020 are among the twelve highest in history.

The media reported that because of the October 2020 warm spell, with temperatures above 41 ºC, up to a million chickens died in the city of Bastos, in São Paulo State, about 530 km west from the capital. The loss of the birds likely reduced monthly egg production by 6%, with a direct impact on the egg market. Consumer prices climbed significantly. Local producers said: *"In 54 years, we never had a situation like that. We have had heat waves before, but none so strong and for so many days,"* (www.poultryworld.net/Eggs/Articles/2020/10/Heat-wave-kills-over-1-million-layers-in-Brazil-653572E/, last accessed on February 13, 2020). In the city of Rio de Janeiro on October 2, temperatures reached 43.6 ºC. In Cuiabá, the capital city of Mato Grosso state, two historical heat records were broken on September 30. The maximum temperature reached 43.7 °C, becoming the highest on records since December 1910, when official measurements began. On October 1, 2020, the town of Foz do Iguacu in Brazil recorded a temperature of 40.4 ºC, the first time it has ever climbed above 40 ºC.

In Paraguay, various stations showed maximum temperatures records highest in history during September 30 -October 3 were detected Minga Guazú had three consecutive days (September 30-October 2) with record maximum temperatures. On October 2, 2020, a new all-time record high temperature was reached at Concepcion, of 43.0 ºC (the previous record had been 42.6 ºC in November 1985). New maximum temperature records were established in Paraguay on October 1: Asuncion 43.1ºC, Coronel Oviedo 40.4 ºC, San Estanislao 41.2 ºC, San Juan Bautista 41.6 ºC, Paraguari 42.2 ºC, Pilar 43.5 ºC, and General Bruguez 43.6 ºC.

In Bolivia, the heat wave produced record-breaking temperatures for October in four cities. The highest-ever temperature in San José de Chiquitos 43.4 ºC was on October 8, 2020, beating the previous record of 42.7 ºC set in Robore in September 2019. The warm conditions in October, combined with a moderate to severe drought in eastern Bolivia during the September-November quarter, stoked forest fires (Libonati et al 2020). The number of fires and the burned surface (1.4 million hectares) peaked in October in the Bolivian Pantanal. By September 30-October 1, 2020, the record high temperature in Argentina was beaten again in Corrientes with 43.5 ºC and the record was tied at Iguazu with 40.1 ºC.

Outside this period, according to the DHM-Paraguay three were warm spells in September 30-October 6. However, between 22-24 November in Bolivia, SENAMHI reported new record maximum temperatures in the Santa Cruz and Beni regions, and in Rurrenabaque maximum temperatures reached 41.3 ºC (climatology of 30.0 ºC), 40.2 ºC in San Joaquin (climatology of 32.0 ºC). In Requena (northern Amazon of Peru) maximum temperatures reached 40.7 ºC on November 22 (climatology of 31.7 ºC). In Ascensión de Guarayos maximum temperatures reached 40 ºC (climatology of 33.0 ºC) and in San José de Chiquitos con 42.6 ºC (climatology of 33.0 ºC) and in Roboré temperatures reached 41.9 ºC (climatology 32.0 ºC). In Brazil, INMET reported a record maximum temperature in Nova Maringa (state of Mato Grosso) reaching 44.8°C (Climatology of 30.0 ºC) on November 6. This is the highest maximum temperature registered in Brazil in 111 years by INMET since it was created in 1909. On November 25 Oberá in Argentina reached 39.6 ºC (climatology of 29.5 ºC).

Daily maximum temperatures during the heath wave of September 23-October 15 2020

BRAZIL			
Station	TMax	Date	LTM
1.São Paulo (highest in 77 years)	37.5 °C	10/2	24.8 °C
2.Lins (highest in history)	43.5 °C	10/2	31.4 °C
3.Curitiba (highest in 110 years)	35.5 °C	10/2	22.6 °C
4.Goiania	41.2 °C	10/7	31.0 °C
5.Campo Grande (highest in 100 years)	41.0 °C	10/5	30.6 °C
6.Aguas Claras	44.4 °C	10/1	34.0 °C
6.Aguas Claras (second highest in history)	44.6 °C	10/5	34.0 °C
7.Corumba	43.4 °C	09/30	32.3 °C
8.Nova Maringa	44.6 °C	10/7	34.0 °C
9.Paranaiba	44.7 °C	10/7	32.8 °C
10.Brasilia (highest in 110 years)	36.4 °C	10/2	27.5 °C
11.Cuiabá (highest since 1910)	44.0 °C	09/30	34.0 °C

PARAGUAY			
Station	TMax	Date	LTM
1.San Estanislao (highest in history)	41.2 °C	10/1	28.4 °C
2.Asunción	42.8 °C	10/1	26.9 °C
3.Paraguari (highest in history)	42.0 °C	09/30	26.6 °C
4.Pilar (highest in history)	43.5 °C	10/1	28.4 °C
5.Concepción (highest in history)	42.6 °C	10/2	33.4 °C
6.S. Juan Bautista Misiones (highest in history)	41.6 °C	10/1	28.2 °C
7.Luque (highest in history)	42.8 °C	10/1	29.6 °C
8.Gral Bruguez (highest in history)	43.6 °C	10/1	30.7 °C
9.Puerto Casado (highest in history)	42.4 °C	10/1	32.6 °C
10.Mariscal Estigarribia	44.0 °C	10/1	34.4 °C
11.Minga Guazú (highest in history)	42.4 °C	09/30	26.9 °C
12.Villarica (highest in history)	41.0 °C	10/1	29.0 °C

BOLIVIA			
Station	Tmax	Date	LTM
1.Ascensión de Guarayos	40.0 °C	10/1, 2	32.7 °C
2.Robore	41.6 °C	10/8	34.0 °C
3.San Ignacio de Velazco	40.6 °C	10/8	32.7 °C
4.San José de Chiquitos (highest ever)	43.4 °C	10/8	33.9 °C
5Cobija	38.3 °C	10/11	32.6 °C
6.San Joaquín	39.5 °C	10/11	33.5 °C
7.San Ramon	39.8 °C	10/11	33.7 °C
8.Riberalta	38.2 °C	10/8	32.6 °C

ARGENTINA			
Station	Tmax	Date	LTM
1.Formosa (highest in history)	43.3 °C	10/1	29.0 °C
2.Corrientes (highest in history)	43.5 °C	10/1	27.9 °C
3.Las Lomitas (highest in history)	43.6 °C	10/1	32.2 °C
4.Resistencia (highest in history)	43.6 °C	10/1	28.1 °C
5.Iguazú (highest in history)	40.1 °C	10/1	28.3 °C
6.Posadas (highest in history)	40.6 °C	10/1	28.3 °C
7.P. Roque S. Peña (highest in history)	43.5 °C	09/30	26.5 °C
8.Oberá (highest in history)	40.0 °C	10/1	27.8 °C

Figure 4.1.2. Daily maximum temperatures at stations across central South America from September 30 to October 15, 2020, case study. Information includes the maximum temperature data, date of occurrence and the long-term LTM, 1981-2010 climatology for comparison. Sources of daily data and the LTM are the meteorological services: Instituto Nacional de Meteorologia INMET (Brazil), Servicio Meteorologico Nacional SMN (Argentina), Servicio Nacional de Meteorologia e Hidrologia SENAMHI (Bolivia), and Direccion Nacional de Meteorologia-Departamento Nacional de Aeronautica Civil DMH-DINAC (Paraguay). Some additional information if these temperatures were historical records was also provided by the meteorological services. Maps to the right of the tables indicated the location of the stations (with red circles) in each country identified as numbers following the numbering in the tables.

The co-occurrence of a drought-heat compound event of September 23- October 15, 2020, was detected in several areas of central South America. The area affected by the drought-heat compound was identified over the southern Peruvian Amazon, northern and eastern Bolivia, northern Argentina, central-western Brazil, and Paraguay, covering the Pantanal wetland. This compound event was associated with specific hazards, such as high fire risk. During September 23-October 15, 2020.

The drought-heat compound event over the Pantanal wetland area aggravated the drought situation, increasing the risk of fires. This shows that natural and social systems and natural biodiversity are vulnerable to such extremes. It affected hydro-climatological functioning in the Pantanal and increased the risk and frequency of fire. It is not yet possible to have an exact number of animals killed by fire in Pantanal, but it is known that the loss of wildlife is quite significant, and whereas the long-term damages to the local fauna and ecosystems are yet unknown, the currently inefficient system of fines needs to change.

This work has begun to build a better understanding of the physical mechanisms connecting the occurrence of extremes across central South America in September-November 2020, with focus on the heat wave of September 23-October 15. Even though it was a case study, we can affirm that with better knowledge of the causes and trends in droughts, heat waves, or drought-heat compound events, it will be possible to propose strategies to reduce their impacts on human populations. The experience of impacts of past heat waves and drought-heat compound events show the need for urgent measures promoting adaptation and for conservation policies to cope with the impacts of more intense, frequent weather and climate extremes on health, water and food security, and risk of wildfires. In addition, climate change amplifies the risk of spatially compounded drought-heat situations. Therefore, we emphasize the need to understand the physical drivers and characteristics of such events. Better predictions and projections for their future occurrence will be useful to potentially mitigate their impacts on human and natural systems.

4.1.3 Impacts of teleconnection patterns on South America climate

In atmospheric science, the term "*teleconnection*" refers to the link between large-scale climate anomalies occurring in different regions of the globe, typically separated by thousands of kilometers (Liu and Alexander 2007; American Meteorological Society 2020). These teleconnections can be triggered, for instance, by oceanic heat sources which disturb the atmosphere, generating waves that travel and affect the climate in remote regions. Different teleconnection patterns have different spatial and temporal variabilities (from intramonthly to multidecadal) and understanding more about the mechanisms involved and how these patterns may affect different regions of the globe throughout the year is of utmost importance. Specifically for South America, deepening the state-of-the-art knowledge on different teleconnection patterns that may influence the region can serve as a powerful tool for improving climate and seasonal forecasting, which to this day still remains a challenge.

Reboita et al. (2021) reviewed and analyzed eight teleconnection patterns that affect the South America climate: (1) the El Niño–Southern Oscillation (ENSO), (2) the Pacific Decadal Oscillation (PDO), (3) the Atlantic Multidecadal Oscillation (AMO), (4) the Tropical Atlantic Dipole (TAD), (5) the South Atlantic Dipole (SAD), (6) the Southern Annular Mode (SAM), (7) the Madden–Julian Oscillation (MJO), and (8) the Indian Ocean Dipole (IOD). **Figure 4.1.3** indicates the main source regions for each of these patterns, and **Figure 4.1.4** illustrates their positive phase through different fields and metrics. The impacts of each of these patterns over South America was analyzed in Reboita et al (2021) through composite fields of precipitation and 850-hPa wind anomaly for each season of the year and considering their positive and negative phases; for patterns (2) to (8), only periods of ENSO neutral were considered, to filter out potential superposed effects of the ENSO phases. The following paragraph includes a description of the results obtained by Reboita et al. (2021) for the SAM teleconnection pattern;

for brevity, the analysis of the other seven patterns that affect South America are not included in this report, but instead a general overview of the results obtained by Reboita et al. (2021) is provided at the end of this section.

Figure 4.1.5 shows an example of the composite fields analyzed by Reboita et al. (2021), considering the negative and positive phases of SAM. For this pattern, the most intense anomalies occur during the austral autumn (March-April-May), while the weakest anomalies occur during the austral winter (June-July-August); in general, the positive SAM phase contributes to dry conditions over southeastern South America (SSA) and wet conditions between southeastern and northeastern Brazilian regions; conversely, the negative SAM phase contributes to wet conditions over SSA and dry conditions between southeastern and northeastern Brazilian regions (**Figure 4.1.5**). In addition, the SAM pattern effect over South America has some seasonal variability: in the austral summer (December-January-February) during the its positive phase (**Figure 4.1.5E**), not the whole of SSA is dry (for example, the Rio Grande do Sul state of Brazil is wet) and not the whole of the southeast region of Brazil is wet; in the transition seasons (austral autumn and spring), both SAM phases cause a well-configured dipole of precipitation anomalies between SSA and southeastern Brazil.

Overall, Reboita et al. (2021) found that the SSA region and the north sector of the North and Northeast regions of Brazil are the most affected areas by the eight teleconnection patterns; in general, there is a precipitation dipole pattern between these two regions during each teleconnection pattern. The teleconnection patterns also affect the South Atlantic Convergence Zone (SACZ) region, influencing the quality of the rainy season (monsoon period). For instance, during the austral spring (September-October-November), the positive phase of the AMO and the IOD contributes to reducing the precipitation in the SACZ region, while the negative phase of the PDO increases it. Finally, even though the work of Reboita et al. (2021) focused on isolated effects of each teleconnection pattern over South America, it is important to note that the patterns can also interact between each other and produce different anomaly patterns. Even though there a few studies in the literature (e.g., Cai et al. 2019; Wang 2019) that have analyzed some interactions between different teleconnection patterns and their results on the atmospheric conditions, this is still a topic that requires further investigation in the literature, particularly considering the region of South America.

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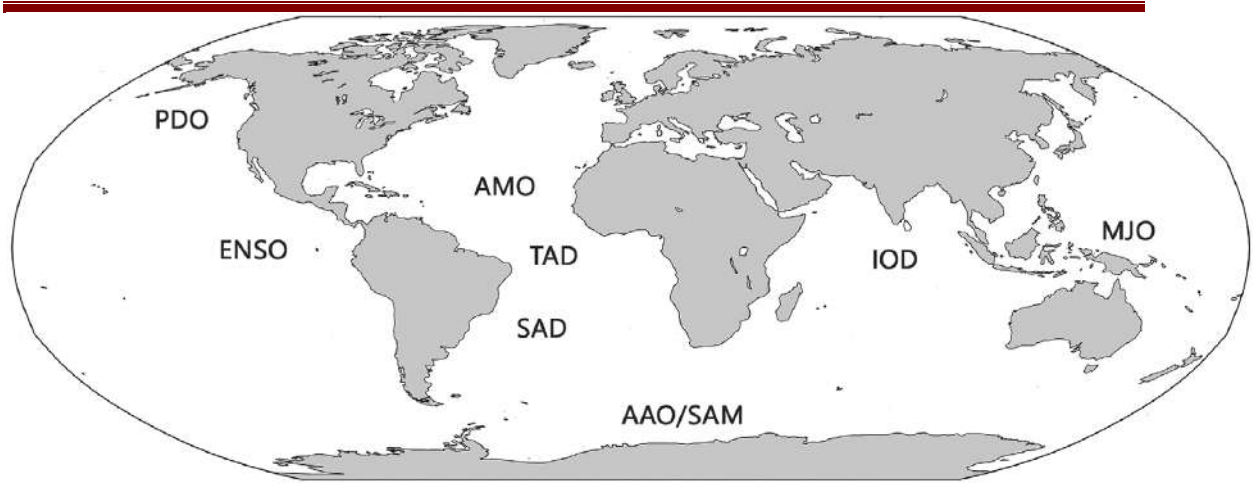


Figure 4.1.3: Main source regions of the teleconnection patterns analyzed in Reboita et al. (2021). Source: Reboita et al. (2021), their figure 1.

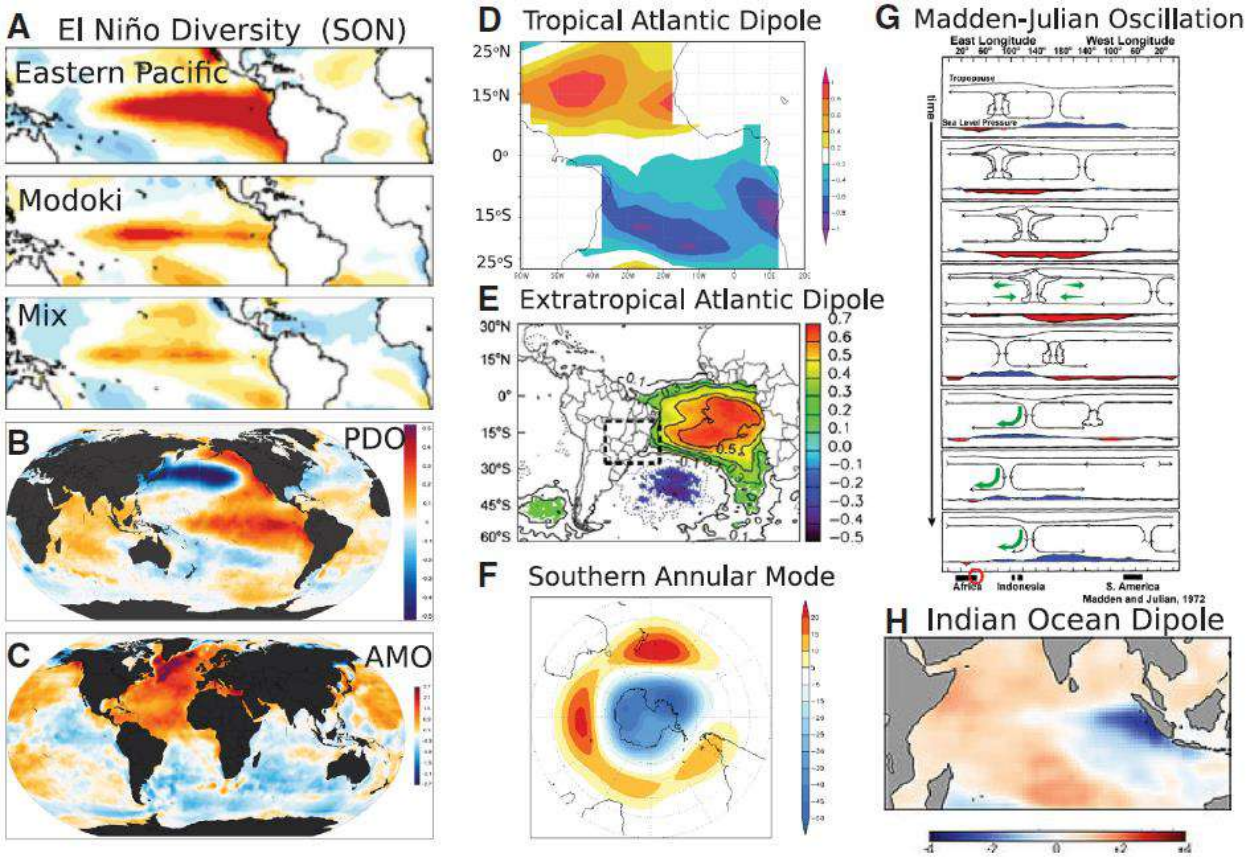


Figure 4.1.4: The positive phase of the teleconnection patterns shown in Figure 1. Source: Reboita et al. (2021), their figure 2.

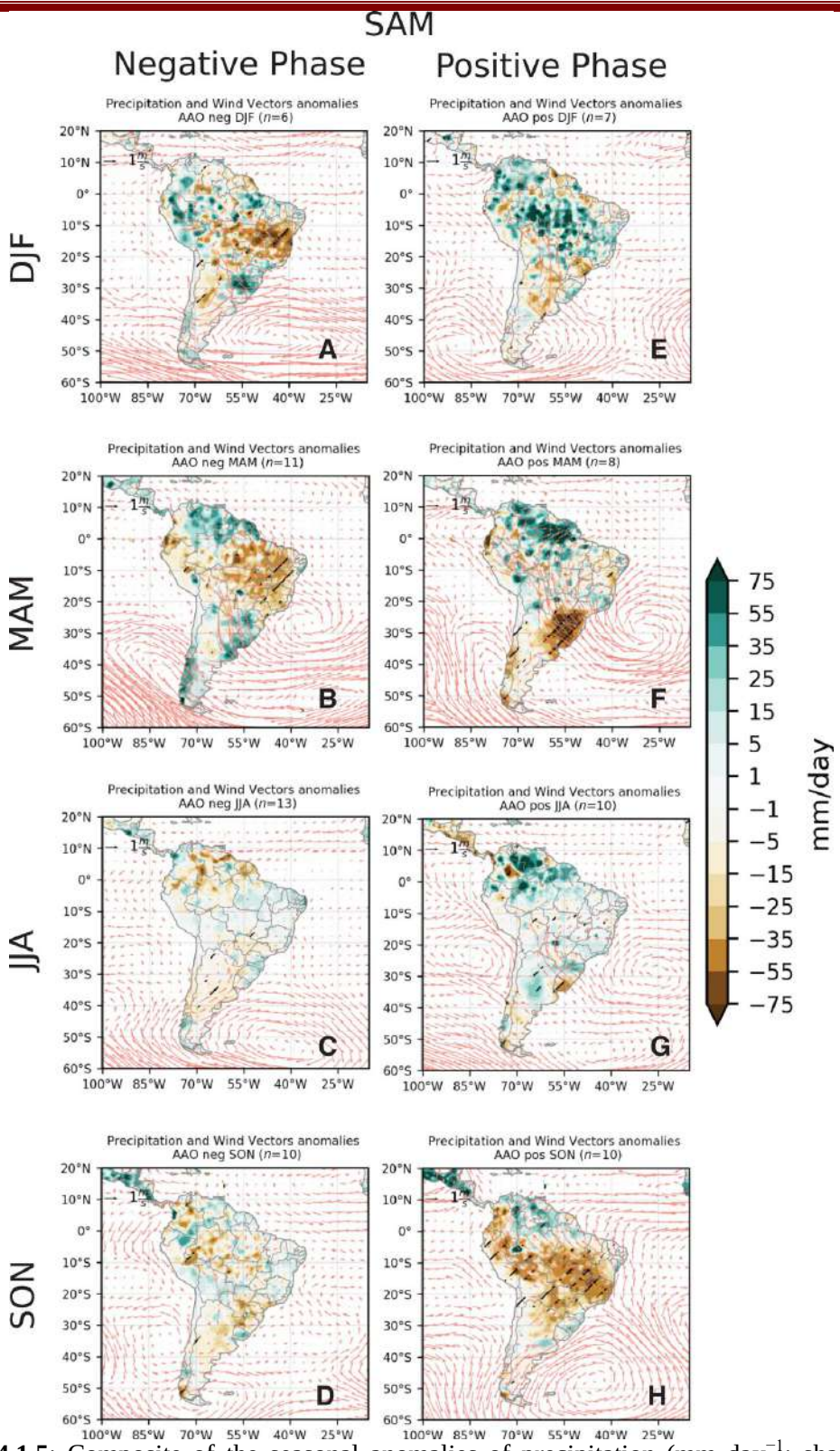


Figure 4.1.5: Composite of the seasonal anomalies of precipitation (mm day^{-1}; shaded) and wind at 850 hPa (m s^{-1}; vectors) in the negative (left column) and positive (right column) phases of the SAM during neutral ENSO events.

4.2 Food security

This subcomponent is divided into three activities

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

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

The crop yield assessment studies established in Report of year 3 were continued, according to the methodology described below. In order to organize the complete information and follow the necessary flow to establish the final results, the scheme of calculation and organization of the information is as follows. Almost all the information that is in this scheme is finished, what is missing is to complement the cost sheets and evaluate the economic impacts. The effort in the next period will be to organize a unique base that integrates all the data and can be accessed by all. (Figure 4.2.1)

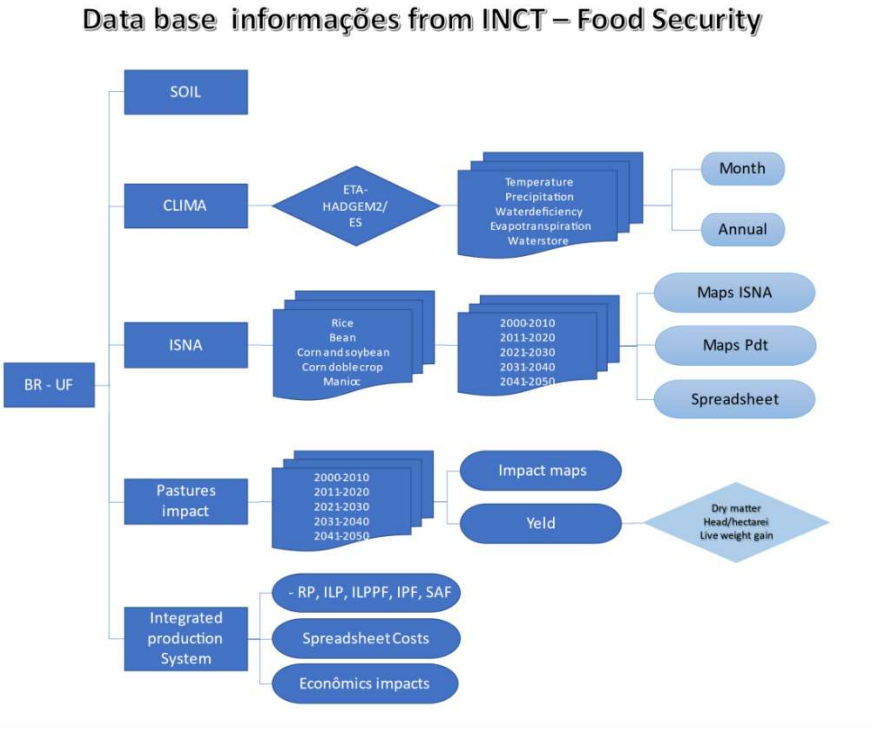


Figure 4.2.1. Date Baser for INCT NC Phase 2-Food security component

-Determination of the water balance for each simulation point

Considering Brazilian agricultural and livestock sector relevance, its activity and police planning must be done in order to maintain sustainable models over decades. In the case of pastureland areas, which occupy large areas, beyond economic aims, well maintained areas can act as a GEE sink and help the country to achieve its goals against climate change. Brazilian soil and climate conditions vary along its extension, thus, knowing this variation and modelling it through time and space is important to assess areas which can achieve higher or lower yield, as well as their risk, mainly related to climate factors. This knowledge concerns both government and private entities, as its negative impacts can deteriorate society development in economic, social, and environmental aspects. On the other hand, well developed strategies bring opportunities to choose better management for higher risk areas, and improve investing allocation to those with lower risk, for example.

Hydrologic simulation must be both temporal and spatial well scaled to improve decision making actions. So, a water model balance model (THORNTHWAITE e MATHER, 1955) was

applied over the entire country aiming to characterize the water bulk available for agricultural exploration from 1990 up to 2050. The data used as model entry were extracted from two distinct meteorological models, one focused in past time meteorological modelling (XAVIER et al., 2016), and the other one aiming to model future trends of climate factors, mainly temperature and precipitation water gains were accounted for by precipitation and losts by evapotranspiration, considering time variance over sequence and decadal intervals. Also, three scenarios of the root system were considered, with shallow (75 mm), average (100 mm) and deeper (125 mm) water bulk depth. Due to the high volume of data, all processing steps were conducted through a framework that automated the water balance calculation all over the 11,000+ virtual weather stations. Resulting products were exported as single station results, for each available water capacity value (representing the root system depth) and for each decade, as well as for the entire.

-Productivity assessment using CIMP6 models.

The scientific activities developed in the climatic scope aimed at estimating the projected productivity for rice, beans, corn and soybean crops through the CROP WATER STRESS INDEX and the IBGE data. And to analyze the resilience of different types of beef cattle breeders to the impacts of climate change in the Atlantic Forest, Cerrado and Amazon biomes. Single, integrated and diversified production systems will be compared as units of analysis in soy planting and beef cattle activities.

Two databases for climate were used to estimate the productivity for Brazil, are XAVIER (2015) and the global climate model from HadGEM3-GC31-MM CIMP6 provided by INPE CEPTEC. The resolution between the models is different being 11.299 points gridded in 0,25° and its importance is in the daily information about climate parameters as maxima temperature, minimum temperature and rainfall, and 3900 points for the model HadGEM3-GC31-MM. Up until the time of obtaining the results, INPE was evaluating what kind of correction would be made to the HadGEM3-GC31-MM model results.
Methodology for calculating present and future productivity with HadGEM3-GC31-MM model

Actual productivity (Yp) is estimated from relative water deficiency [1 - (Er / ETP)], weighted by a crop sensitivity factor to water deficit (ky), according to Doorenbos & Kassam (1979):

$Yr / Yp = 1 - ky [1- (Er / ETP * Kc)]$ (equation 1)

Where:

- Yr is the estimated productivity;
- Yp is the potential productivity;
- Er is the actual evapotranspiration of the culture;
- ETP is the potential evapotranspiration of the crop, estimated by the method of Thornthwaite (1948);
- Kc is the culture coefficient for each phenological phase;
- ky is the coefficient of productivity penalty for water deficit, variable with the phenological phase of the crop. In the case of soy, ky is equal to 1.

The ETP * ks ratio is called ETC (culture evapotranspiration).

Despite the great scientific advances in the use of the geoprocessing of satellite images, in estimating the area of agricultural crops, there is still no operational method and of low cost, for national estimates of the planted area of soybeans. Alternatively, in order to estimate the national harvest, in addition to the productivity estimate, the system incorporates a module to access a database, based on surveys carried out by the Brazilian Institute of Geography and Statistics (IBGE), on a municipal scale. The system points to the crops producing municipalities and associates to each of them their fraction relative to the total area of crop produced. At the

state scale, data on planted areas are used, derived from surveys carried out by the National Supply Company (CONAB), which are converted into municipal areas, multiplying the relative fraction of the municipality by the total area of the State. The following parameters of crops are used:

- Vegetative cycle length: subdivided into phenological phases, by identification of critical periods (stages), such as initial period, crop development, mid-season, and late season;
- Kc (crop coefficient): as method for definition of the plant water demand;
- Root system depth: The root system depth is particularly important to estimate the available water capacity (AWC). Considering the depth of the tobacco root system in the zone where nutrients are mostly available, in this Study, it was considered 30 cm as the standard depth of the roots and where was calculated / estimated the AWC.

The schematic summary of the methodology and the flow of data calculation is presented below.

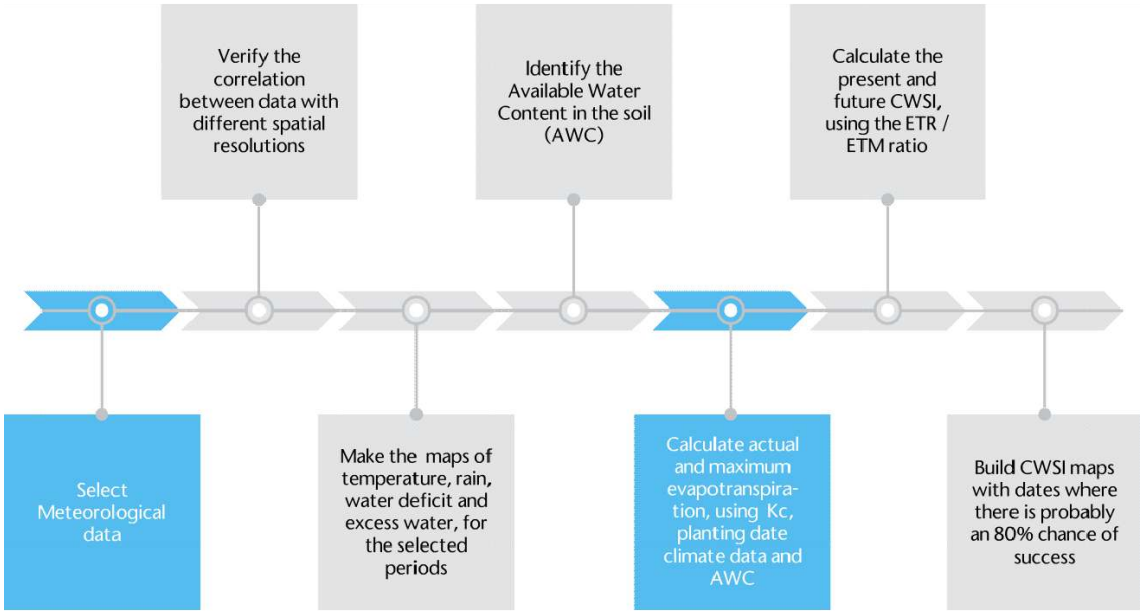


Figure 4.2.2. Methodology and data flow

For productivity analysis this time with the evaluation of the results with the HadGEM3-GC31-MM model, The results appear more pessimistic than that of the CIMIP5 HADgem2-ES model. The yield losses were greater than those obtained in the previous model. In this case, the model values and possible corrections are being verified.

In all cases, the impact on productivity is negative, which indicates a possible reduction in the supply of food if the current production practices are maintained. However, with the adoption of ABC agriculture practices, and the intensification of production, what has been observed is an increase in productivity, especially in soybean and corn. However, the effect of extreme events on production has appeared with greater intensity. A study made by the food security sub-component team, involving Embrapa and Unicamp/CEPAGRI, shows the impact on production losses that occurred in the last ten years in the state of Rio Grande do Sul. The losses are due to

extreme events related to droughts (intense summer dry spells), and were strongly enhanced in the 2019-2020 harvest.

Table 1 shows the results obtained with the CIMP6 model HadGEM3-GC31-MM.

Biome		2011/2020	2021/2030	DIFFERENCE	DIFFERENCE (%)	2031/2040	DIFFERENCE	DIFFERENCE (%)	2041/2050	DIFFERENCE	DIFFERENCE (%)
Amazon	Soy	3.078	2.456	623	20	2.504	574	19	2.562	516	17
	Maize	2.543	2.795	- 252	- 10	3.597	- 1.054	- 41	2.867	- 324	- 13
	Rice	1.917	1.907	10	1	1.825	92	5	1.766	151	8
	Bean	678	679	- 2	- 0	672	6	1	660	18	3
Savanna	Soy	3.244	2.399	845	26	2.277	967	30	2.486	758	23
	Maize	4.331	4.879	- 548	- 13	6.964	- 2.633	- 61	5.227	- 896	- 21
	Rice	2.105	1.867	238	11	2.083	21	1	1.897	207	10
	Bean	1.179	1.077	103	9	1.210	- 30	- 3	1.166	14	1
Atlantic Forest	Soy	3.349	3.524	- 175	- 5	3.523	- 174	- 5	3.702	- 353	- 11
	Maize	4.818	5.329	- 510	- 11	6.176	- 1.358	- 28	5.608	- 790	- 16
	Rice	3.542	3.433	109	3	3.708	- 166	- 5	3.513	29	1
	Bean	1.171	1.112	58	5	1.193	- 22	- 2	1.178	- 7	- 1
Pampa	Soy	2.458	2.845	- 387	- 16	2.819	- 361	- 15	2.998	- 540	- 22
	Maize	3.812	3.756	56	1	3.314	498	13	3.936	- 124	- 3
	Rice	7.337	7.337	-	-	7.337	-	-	7.337	-	-
	Bean	1.030	1.030	-	-	1.030	-	-	1.030	-	-
Caatinga	Soy	-	-	-	-	-	-	-	-	-	-
	Maize	660	722	- 62	- 9	925	- 265	- 40	716	- 56	- 8
	Rice	1.604	1.819	- 215	- 13	1.879	- 275	- 17	1.899	- 295	- 18
	Bean	321	344	- 23	- 7	374	- 53	- 16	374	- 53	- 16

Figure 4.2.2. shows the evolution of production in the state of Rio Grande do Sul at the municipal level. In the last year analyzed, 2019/2020 the results are still preliminary, since IBGE has not released the productivity data for this harvest. By these analyses, it is not a cyclical phenomenon, since losses were observed in the years 2010, 2011, 2012, 2013, 2014, 2016 and 2020. In the next activities these losses (estimated at 15 billion reais) will be quantified and the relationship with extreme events in the state will be verified. A similar situation happened in the state of Paraná and more recently, a strong impact on the losses of safrinha corn in the state of Mato Grosso (evaluated at 10 billion reais, according to CONAB).

Figure 4.2.3. Soybean productivity evolution in Rio Grande do Sul, between the crop years 2010 to 2020.

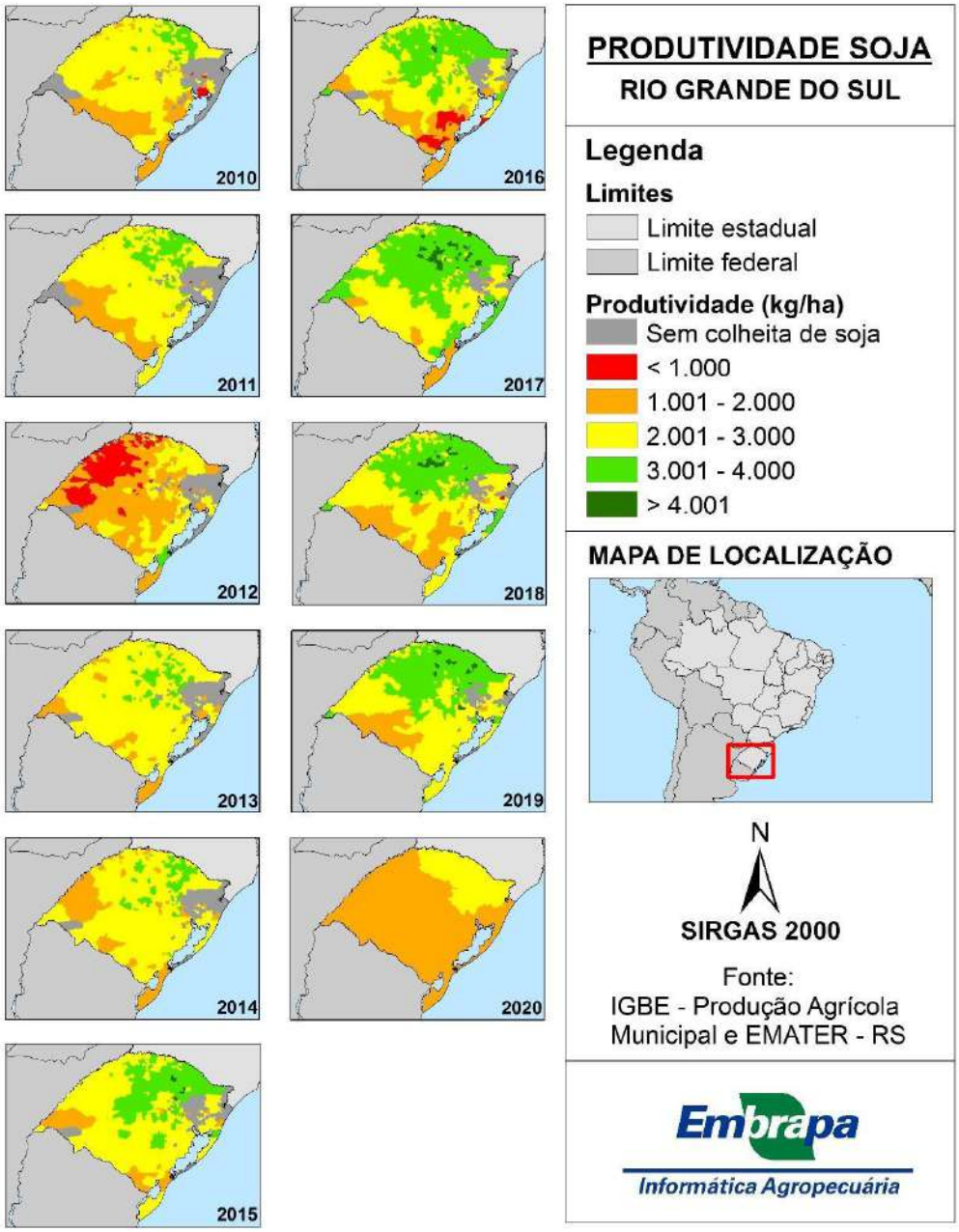


Figure 4.2.3. Soybean productivity evolution in Rio Grande do Sul, between the crop years 2010 to 2020.

These results indicate the vulnerability of agriculture to climate change. In productivity table 1, potential losses are calculated for the RCP 8.5 scenario with both the Hadgem2-ES model presented in the previous report and the HadGEM3-GC31-MM model.

4.2.2 Activity 2 - Climate, livestock and implications for food security

-Impact on forage production

To evaluate the impact on forage production in Brazil and consequently on the production potential of cattle ranching, a model developed by EMBRAPA-Pecuária Sudeste was used. The effect of climatic events on the dry matter accumulation rate of Panicum maximum, cv.

Tanzania, and Bachiaria Brizantha was quantified with agrometeorological parameters. The results are from years 2010 to 2040, using as input parameters the results of the HADgem2-ES model RCP8.5 scenario. In this case it was not possible to simulate with the HadGEM3-GC31-MM model. The analyses showed the climatic effect on forage accumulation rate, mainly with respect to thermal and hydric parameters together. The results are presented in figures 4.2.4, 4.2.5, 4.2.6 and 4.2.7. There was no significant impact on forage production in Brazil in the coming years. A more detailed study is desirable, to identify possible impacts along the annual cycle of pastures.

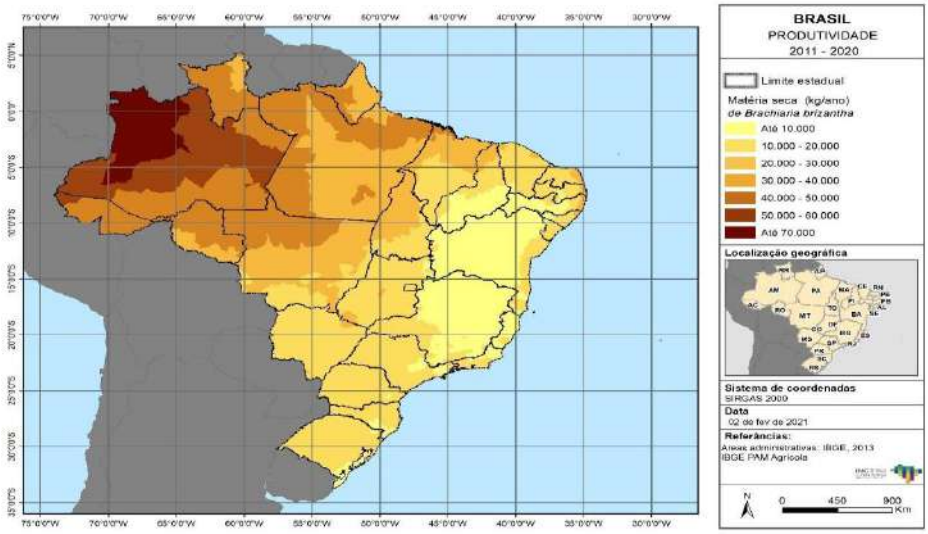


Figure 4.2.4 *Brachiaria* productivity from 2011 to 2020.

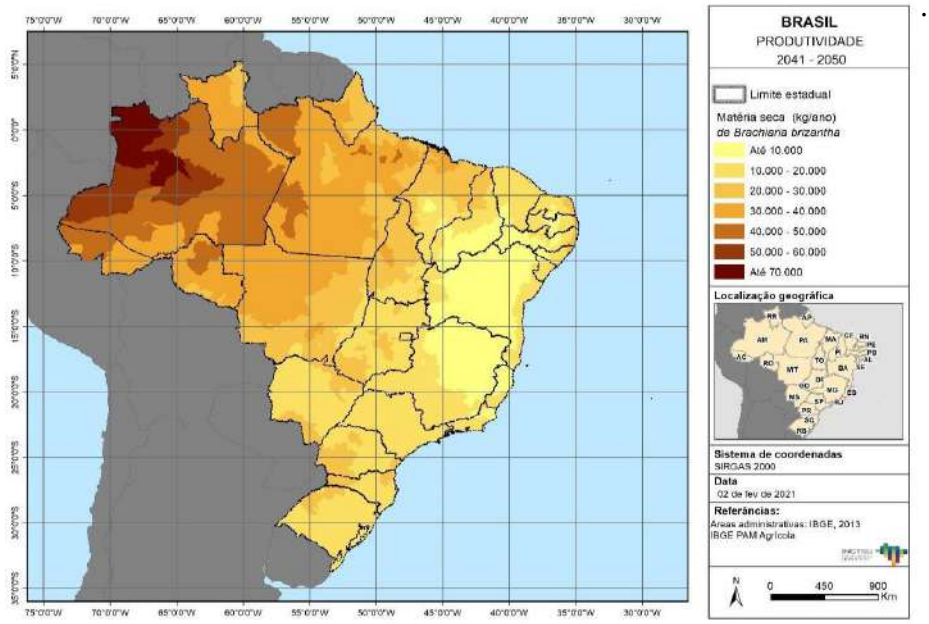


Figure 4.2.5 : *Brachiaria* productivity from 2041 to 2050

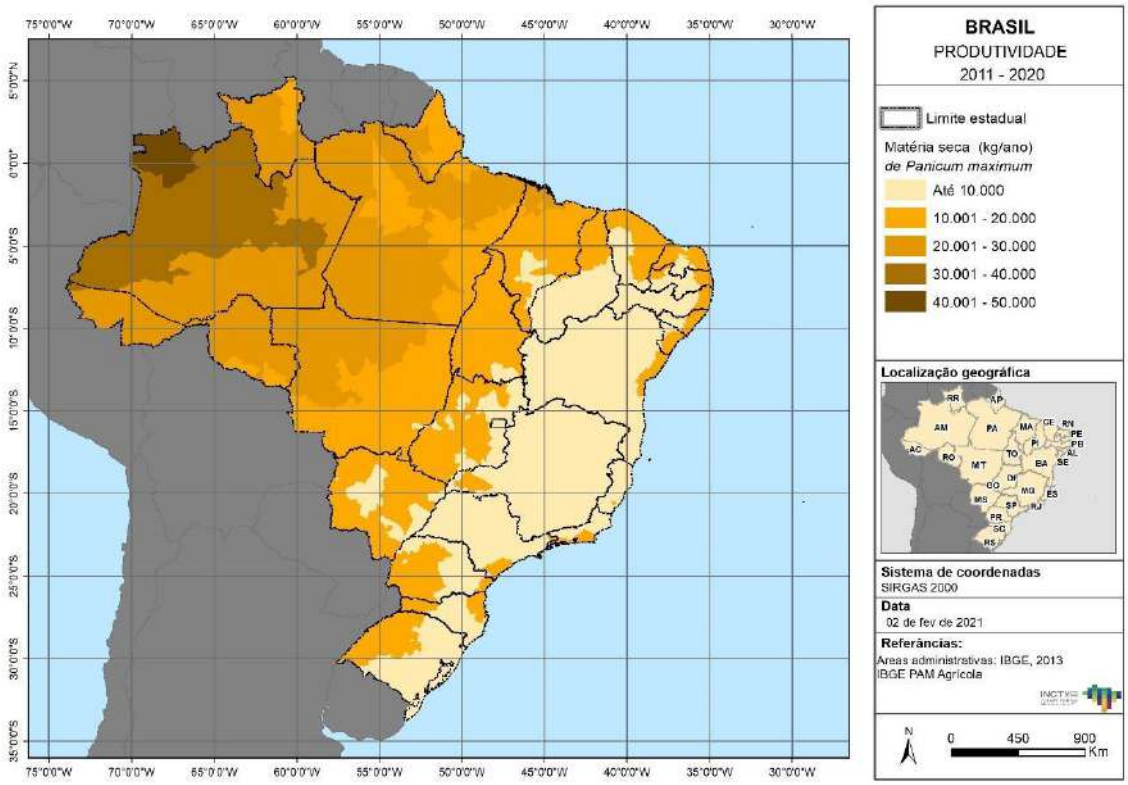


Figure 4.2.6: *Panicum* productivity from 2011 to 2020.

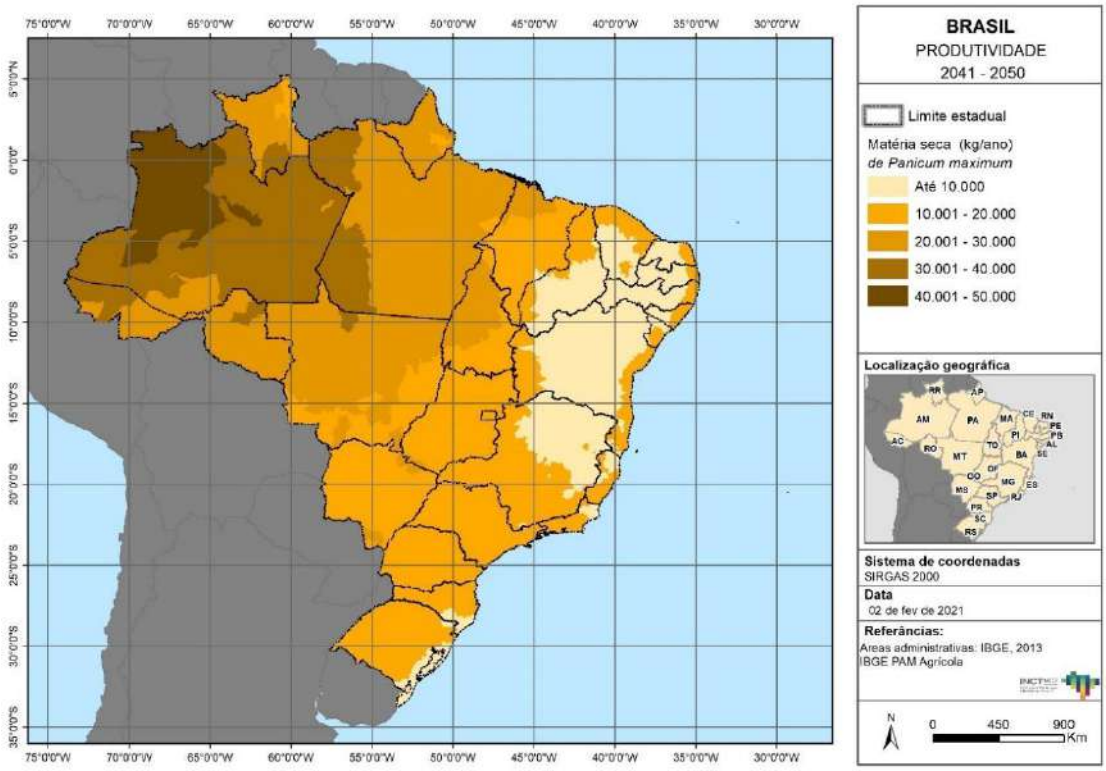


Figure 4.2.7: *Panicum* productivity from 2041 a 2050

-Identification of production systems

One of the activities of the food security subcomponent is to identify the main production systems in the Amazon, Cerrado and Atlantic Forest, and to evaluate the impacts generated from the adoption of these systems.

-Production systems in the Amazon

In the Amazon, based on the information gathered by the study, 29 arrangements of production systems were described in the following modalities:

- Well-managed pastures;
- Crop-livestock integration (CLI);
- Crop-livestock forest integration (CLFI);
- Agroforestry systems (SAF).
- Forest Livestock Integration (FLI)

Table 2 provides a summary description of these main systems.

System	Management
CLFI with Paricá and African Mahogany	1st - corn + fertilization; 2nd - ruziziensis brachiaria planted in the second. corn cover; 3rd - planting of paricá and African Mahogany and harvest of corn
CLFI with Eucalyptus	1° - Corn + fertilization; 2nd - brachiaria ruziziensis implanted in the second ad. corn cover; 3rd - eucalyptus planting and corn harvesting
CLFI with Teak	1° - Maize and Teak with a spacing of 3x3m with four lines of Teak interspersed with a spacing of 50 meters for the planting of annual crops and subsequent forage. 2nd - corn harvest and cowpea planting - 3rd bean harvest + forage planting with teak
CLFI	1st - Rice intercropped with brachiaria grass; 2nd - Rice harvest and harvest with sorghum; 3rd - Forestry component is implanted in blocks inserted in areas with grains or livestock.
CLFI	Area 20ha is divided into 4 treatments of 5ha, each one with a forest species. 1st year: Safrinha rice and planting in triple rows by 20m strips of forest species (Cuiabano pine, pau-balsa, teak and eucalyptus); 2nd year: soybeans and rice in the second harvest; 3rd year: early soybeans and forage brachiaria ruziziensis + cattle
CLFI	Corn and cowpea beans + teak + Piatã grass
CLFI	CLFI Corn and cowpea beans + African mahogany + Piatã grass
CLFI	LPF Brachiaria and Teak; 1st year - Soybean + Ruziziensis (2008); 2nd year - Caupi + Ruziziensis (2009); 3rd year - Corn + Brizantha + Ruziziensis (2010).
CLFI	CLFI Rice + Brachiaria (2011); Corn + Brachiaria (2012); Soybean + Brachiaria (2013); Teak 54 meters away. Planting direct system since 2008.
System	Management
CLI	CLI 1st crop year: rice; 2nd crop year: corn and brachiaria or mombaça intercrop; 3rd crop year: soybean; 4th crop year: corn in intercrop with brachiaria or mombaça. The cattle (safrinha oxen) are removed before the rainy season, which begins in the second half of December.
CLI	The CLI consisted of soybean and rice crops in the harvest and the consortia of corn, millet, sorghum grazing and sunflower with forage crops of the genus Brachiariaspp in the second harvest. Five-year crop rotation as follows: early soybean in the 1st year, early rice in the 2nd year, early soybean in the 3rd year, pasture (Brachiaria

	brizantha cv. Marandu and/or Piatã) in the 4th and 5th year
CLI	there are 5 CLI systems with different crop succession models - a) summer with soybean and rice in summer; b) sorghum + brachiaria, millet + brachiaria marandu or piatã, crotalaria + brachiaria ruziziensis, brachiaria piatã + estilosantes in winter. Managed under no-tillage system.
CLI	CLI Area divided into 3 modules of 20 ha where a rotational management was done between grain crops and forage crops. Module 1 - corn + piatã brachiaria; Module 2 - beans under ruziziensis brachiaria straw; Module 3 - sorghum under pasture with ruziziensis brachiaria.
CLI	CLI for pasture recuperation Rice, corn, soy and cowpea crops are cultivated for two or three harvests, with the tree component already installed in the first year. As of the third harvest it is possible to cultivate pasture.
CLI	Soybeans in the summer; Corn in the off-season and Barquiária grass + cattle in the off-season
CLI	Experimental fields. Embrapa Rondônia - 2008/2009 (Soybean/Pousage) - 2009/2010 (Fallow) - 2010/2011 (Soybean/Millet silage) - 2011/2012
CLI	Soy/Corn (2008 a 2009) - Cor/ Brizantha grass (2009 a 2010)
CLI	Rice / Corn (2008 to 2009) - Soybean / Corn / Brizantha Grass (2009 to 2011) - Corn and Brizantha Grass (2011 to 2012) - Brizantha Grass (2012 until now)
CLI	Soy + BrachiariaBrizantha
CLI	CLI Caupi, Corn and Tanzania grass
CLI	CLI for pasture recuperation Rice + Brachiaria brizantha; Soy + Brachiaria brizantha; Soy + Brachiaria Tanzania
CLI	Corn + Ruziziensis; Corn + Brizanta grass Brizanta
CLI	1st year - Corn+Estilosante (2008); 2nd year - Soy+Ruziziensis (2009); 3rd year - Corn + Brizantha (2010); 2011, 2012 and 2013 Brizanta and Ruziziensis.
CLI	Corn and xaraes

-Production systems in the cerrados

The same effort was made to identify the main production systems in the Brazilian cerrados. According to the works consulted, a predominance of certain forage, vegetal and arboreal components is observed for the CLI and CLFI systems in the Cerrado:

- CLI: i) Brachiaria as the main forage component followed by Panicums; ii) corn (predominant), millet, soybean, sorghum or beans for grain production as vegetable components
- CLFI: i) forage and vegetal components similar to the CLI system mentioned above; ii) eucalyptus as main tree component in CLFI and LFI

The integration systems existing for the Cerrado are diverse, but configured according to profiles, objectives and regional peculiarities (climate and soil characteristics, infrastructure, available technology, for example) of each farm. In the Cerrado, CLI has been expanding more rapidly, since grain producers who practice crop rotation with pasture have invested in the benefits of this system). In summary, there are three modalities of crop-livestock integration highlighted in the Cerrado region:

- Livestock farms that introduce grain production (rice, corn, sorghum, soybean) in pasture areas with the purpose of recovering pasture productivity;
- Grain farms that adopt forage grasses with the objective of improving soil coverage for the no-till farming system and use forage grasses to feed the cattle (ratoon cattle) during the off-season;

- Systematic adoption of crop-livestock rotation to intensify land use and benefit from the synergism of the two activities.

-Production systems of the Atlantic Forest

It is observed that the production systems for the Atlantic Forest present some particularities regarding the cultivation of certain species for different regions of the biome. This is because the Atlantic Forest presents a wide variety of climate, soil and vegetation due to its extension, in addition to characteristics of other biomes with which it borders. According to the works consulted, the plant and tree components within the CLI and CLFI systems are:

- CLI: i) Northeast region of the biome: corn for grain production; ii) Southeast region: soybean, corn and cotton for grain production; and iii) South region: soybean, corn, wheat and beans for grain production and brachiaria, ryegrass or black oat for pasture formation;
- CLFI: eucalyptus as tree component for all regions of this biome. Other tree components for the northeastern Atlantic Forest region are gliricídia and coconut.

The plant components are the same as in CLI. In the case of FPI, the production system used the natural landscape to introduce cattle production in the southern region of the biome. It is important to note that the forage component most used in the Atlantic Forest Biome was the genus Brachiaria. In the Southern region, there is a consolidation of annual summer crop rotation (soy and corn) with forage and winter cover crops in no-till systems.

The gliricídia used in the productive systems found in the northeastern Atlantic Forest region is also used in CLFI and FPI systems in the Coastal Tablelands region with the purpose of increasing sustainability Muniz, Sá, 2010). Another system cited as promising for this region is the consortium of soy, eucalyptus, and brachiaria.

In the Southeast region, according to the literature surveyed, native or exotic species have been used in CLFI systems to renew and recover pastures. The tree component contributes with nitrogen contribution and provides income generation through timber forest products (firewood, fences, poles, etc.) and non-timber (nuts, honey, and fruit). In addition, afforestation helps to mitigate climate extremes, favoring good conditions for animal ambience. Another advantage of CLFI in relation to IPF is that the agricultural component usually contributes to reduce the cost of implementing trees. The integrated forest-livestock systems in the southeast region of the biome are developed where the relief is rugged and the soil has low fertility.

-Production systems in the Caatinga

The predominant crops in Caatinga are corn, beans and cotton; other species such as manioc, castor and agave are also economically important. Small-scale crops are often produced in backyards or intercropped with plantations.

The Northeastern presents some peculiar characteristics, such as: i) land structure formed, basically, by unproductive latifundia and degraded minifundia; ii) great relevance of sheep and goat flocks, besides cattle. Historically, extensive cattle raising and cotton production are the two activities linked to land use in the northeastern semi-arid region. Extensive cattle ranching was traditionally developed by large landowners while cotton by large landowners while cotton production was responsible for generating income for smallholders. Beginning in the 1980s there were changes in land use and in the land tenure structure. The agricultural areas of the Caatinga are characterized by the subtraction of native vegetation, however, not all native plants are eliminated. In general, the works that deal with the CLFI theme in Brazilian biomes point to the natural landscape (Caatinga) as a fundamental component for the integration system in this biome.

In well managed pasture systems, Gliricídia is used as a legume in brachiaria intercropping. According to Embrapa, Gliricídia helps in the recovery of pastures or in the formation of new pastures. In the integration with coconut, despite the greater work in the harvest, it increases the yield of the coconut plantation and adds income with the sale of animals (Teixeira et al., 2015). Other benefits linked to the use of the gliricídia legume in silvipastoral or agrosilvipastoral systems, for direct grazing in a rotational regime, are: improvement of soil fertility and complementation of herd feeding during the dry season.

In the CLI, CLFI and IPF systems in the Caatinga, the forage, tree and plant components are

- CLI: corn and sorghum for grain production; brachiaria and pangola grass for pasture production;
- CLFI: eucalyptus and the natural landscape itself (raw caatinga) as tree components. The forage and vegetal components are the same as in CLI;
- IPF: same tree components mentioned for CLFI and buffel grass, as a grass for pasture formation. The use of buffel grass in the integration aims to increase the sustainability of the system.

In CLI, corn is used to recover pastures from crops in the northeastern Agreste region, in regions such as northern Bahia and southern Sergipe, where corn crops predominate. After the corn harvest, the grass is used to graze the animals until the next rainy season begins. At the end of grazing, the grass sprouts are desiccated to serve as straw for the next cycle of corn-grass cultivation in no-till. The eucalypt species planted in CLFI systems in the Northeast are destined for the timber sector. However, in some soils of the Tabuleiros Costeiros and sub-region of Agreste, eucalyptus has not shown good adaptation.

Another CLFI modality indicated for Caatinga, Zona da Mata and Agreste is the intercropping of corn with brachiaria grass and, after the emergence of the two crops, the planting of gliricídia by means of seedlings.

-Production systems in the Pampa

According to the sources consulted, it is noted that some works are between two biomes and have been identified in the tables below. It can be observed that the integrated production systems for the Pampa present the following arrangements for CLI, CLFI and IPF systems:

- CLI: corn, soybean, rice and wheat for grain production; black oats, ryegrass (predominant) white oats, fescue, fescue corn, pensacola, vesicular clover or Ball clover for forage formation;
- CLFI: pine, eucalyptus, black acacia, citrus and peach as tree component and sorghum as plant component;
- IPF: black acacia as tree component and gatton, aruana and pangola forage for cattle.

The Pampa Biome has adopted integration since the early years of the 20th century. A practice still carried out is the grazing of cattle on the rangeland of rice crops in lowland areas. In addition, experiments show that winter pastures in succession to irrigated rice crops during three years have increased productivity.
The main modalities of CLI for the southern region are the intercropping of oats and ryegrass as annual winter pastures, followed by succession of summer grain crops such as soy, rice, and corn. The benefits provided are income and improved soil quality.

In CLFI the eucalyptus component used for timber purposes in consortium with pastures is the main model for the South Region. It is noteworthy that these systems (CLI and CLFI) have great potential for expansion, and CLFI, compared to CLI, is more recent and less frequent in the South Region of Brazil.

Another interesting point regarding the production systems in this biome is the use of the landscape itself (native fields) as an integration component, but it is important that the management is adequate to avoid the degradation of natural resources.

-Production systems in the Pantanal

There is a lack of studies that address production systems for this biome, especially low carbon emission systems such as the integrated ones and their variations. A search to identify the existence of an Embrapa Technological Reference Unit (URT) was carried out through Embrapa Gado de Leite's CLFI database. The result of the search showed that there is no URT registered in this biome.

For integrated production systems, the information found refers to general data. Native vegetation is an essential element used in the system. The bibliography suggested by specialists pointed out that the dominant integration system is the IPF, with native vegetation as a tree component and exotic grass species for pasture formation, such as brachiaria, with the following variations:

i) Native tree species such as bocaiúva, canjiqueira, acuri, paratudo and aroeira, with managed grazing;
ii) In campo cerrado areas, the native herbaceous species are substituted by exotic forage plants while maintaining the tree species. Example: planting of balsam in a Brachiaria brizantha pasture implemented in an area previously occupied by cerradão; and
iii) substitution of macegas area for cultivated pastures maintaining native shrub and tree species.

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

The diffusion of agroforestry systems is among the priority actions of the plan to reduce carbon emissions in Brazil, but its economic impacts are still little known. We assessed the impacts of agroforestry diffusion on cattle herds and on the total value of agricultural production in Brazilian municipalities. The analyses are based on models for panel data with municipal information from the 2006 and 2017 agricultural censuses. The empirical strategy adopted controls for potential sources of bias associated with spatial dependence (spatial models), omission of unobservable factors that are constant in time (fixed effects estimators), and the potential endogeneity of the diffusion of agroforestry systems (instrumental variables estimators). The analyses also consider differentiated impacts for different integrated crops and by biome. The results highlight that the diffusion of agroforestry systems has positive and relevant impacts on the stocking rate (increase in the number of head of cattle/grazing area), besides stimulating the substitution of livestock for activities that add more value to production (reduction of the herd in the municipality). The most positive impacts on the use of pasture and the value of production occur in the Atlantic Forest biome and when the diffusion of agroforestry systems is associated with soybean cultivation.

4.3 Water security

4.3.1 Highlights

The noteworthy results achieved by the group during the fourth year of the project were the continuous promotion of INCTMC2 water security goals on (see Figure 1 and Table 2, with a Summary and Appendix enclosed):

- adapted communication with policy makers and society under COVID-19,
- new scientific advances on water security under changing conditions, and

- novel alliances for policy-relevant research with local impacts.

These achievements were developed through strategies of:
(1) promoting INCTMC2's water security institution coauthorship,
(2) organization webinars through UNESCO Chair on Urban Water,
(3) new of Belmont Forum project to promote synergism with INCTMC2,
(4)optimization of capacity building with other INCTMC2 subcomponents,
(5)submission of new grant proposals and publication in high-impact journals,
(6)identification, selection and retention of early-career scientists promoting INCTMC2's objectives and action plan,
(7) following and updating the INCTMC2 water security timeplan (see Table 1).

Figure 4.3.1. Summary of achievements of the INCTMC2 water security in the period 2019/2020.

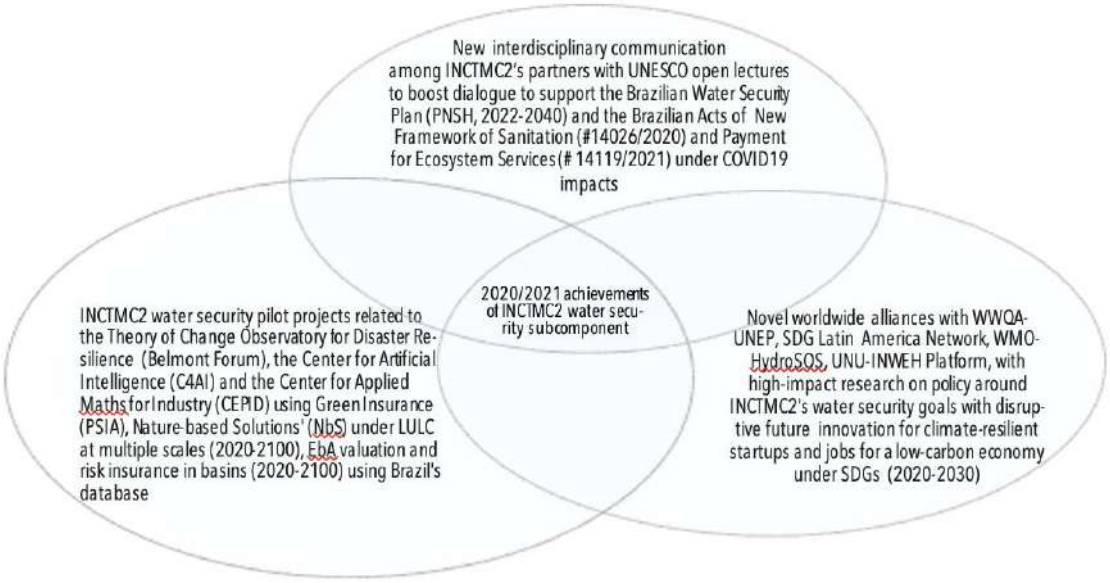


Table 1. INCTMC2-Water Security in the 2020/2021 period (adapted from Marengo, 2014)

	executed activities			planned activities		
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		??	??	??	✔	✔

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		??	??	??	✔	✔
[4.] Providing technical tools for policies with strategies of adaptation to future changes		??	??	??	✔	✔
[5.] New courses of water security in graduate programs, including interdisciplinary	??	??	??	s??	✔	✔
[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 network of experts to collaborate with the Brazilian Water Resources Plan (ANA), under the legal framework (i.e.. Law. 9.433/97, the Braz.	??	??	??	??	✔	✔

This part outlines a summary of activities developed by INCTMC2's water security affiliated institutions, i.e. UFPE, UFCG, USP, UFCG, UFRGS, CEMADEN, INPE, FUNCEME and EMBRAPA. Scientific and management activities are subdivided into sections of advances in water security at local scales, climate change and trends in selected urban scales, temporal stability of soil moisture in agricultural lands and other strategies at local scales of selected basins.

4.3.2 **Climate Change, Water Security and COVID-19**

During this fourth year, INCTMC2's water security researchers have driven also attention to the linkage of water and COVID-19 to contribute to SDG 13 (Climate Action). Thus, independent elicitation from experts and stakeholders is collecting views and experiences, as well as priority actions aligned with international communities. INCTMC2 researchers analyse how the Sars-CoV-2 pandemic started 2020 led to a significant change in water consumption behaviors, mainly because of the quarantine to avoid the spread of the virus. COVID-19 restriction measures affected both economic activities and citizens´ behaviors as they developed more intense hygiene habits to avoid contamination and switched to home office. Thus, these exceptional behaviors also affect the way that water is consumed and need to be fully understood to manage supply systems.

On the one hand, Marinho e Silva et al (2021) assess the impact of Sars-CoV-2 on water consumption in São Paulo State, Brazil. Therefore, their study aims to investigate changes in residential and commercial water consumption in 31 municipalities in the State of São Paulo during the Sars-CoV-2. By using the Holt-Winters Multiplicative method and compared to the data observed do they calibrate monthly records of new contaminations to establish a comparison between the number of infections and changes in water consumption. Their preliminary results show for residential consumption rate of +8.4 L person^{-1}day^{-1} only or the first semester of 2020.

On the other hand, this also recognizes multi-stakeholder partnerships as important vehicles for mobilizing and sharing knowledge, expertise technologies and financial resources, as SDG 17 (Partnerships for the Goals), is needed to counterpart COVID-19 impacts on water consumption. So, local outcomes of COVID-19 impacts could contribute to refine the expert elicitation about Brazilian water security status and short-term scenario (Gesualdo et al, 2021). In this coauthored work, INCTMC2 researchers from CEMADEN, UFPE, APAC, UFC, FUNCEME, UFCG and USP unveil water security in Brazil, with current challenges and future perspectives. As presented in Figure 4.3.2, water governance needs to integrate human needs with ecosystem functioning, considering climate uncertainties to move towards better water resources planning.

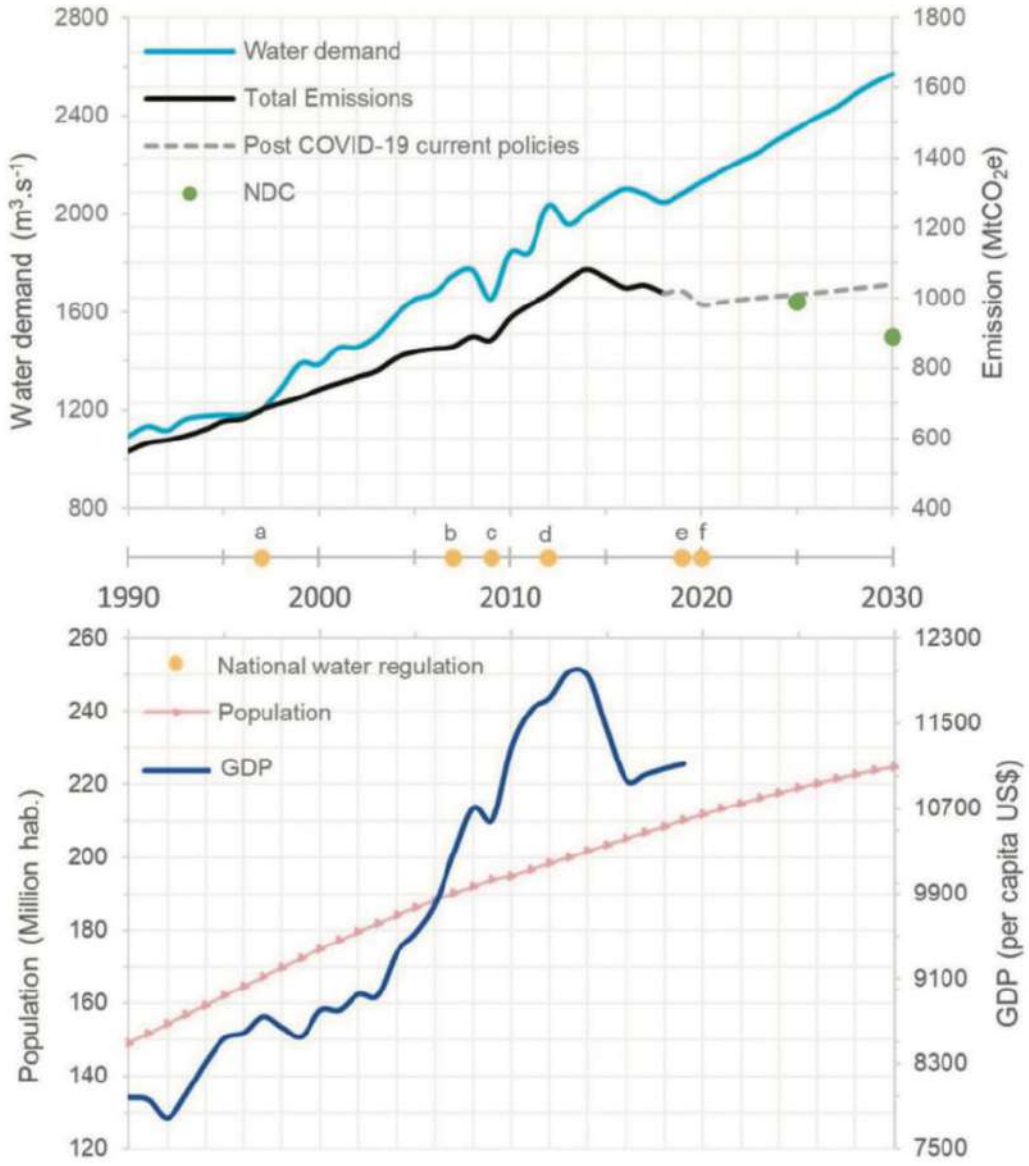


Figure 4.3.2. Correlation of data on water demand, CO2 emissions, population growth, gross domestic product (GDP), Nationally Determined Contributions (NDCs), and national water regulations from 1990 to 2030. National water regulations: (a) Act 9433/1997: National Water Resources Policy; (b) Act 11445/2007: National Guidelines for Basic Sanitation; (c) Act 12187/2009: National Policy on Climate Change; (d) Act 12608/2012: National Policy for Civil Protection and Defense; (e) Water Security National Plan; (f) Act 14026/2020: Update of the

Basic Sanitation Act. *Data are in constant 2010 US dollars (1USD = 1.76 Brazilian Real - BRL). Sources: CAT (2020), IBGE (2020), World Bank (2020) and Gesualdo et al (2021).

Furthermore, there is still a positive trend in CO2 emissions, indicating that Brazil will possibly fail to comply with the 2025/2030 Nationally Determined Contributions (NDCs) under the Paris Agreement goals. Thus, INCTMC2 expert elicitation could help the implementation during the decade of actions toward the 2030 Agenda on Sustainable Development. Especially, these opinions merged with COVID-19 impacts will probably influence novel contributions for the UN Conference on the Midterm Comprehensive Review of the Implementation of the Objectives of the International Decade for Action, "Water for Sustainable Development", 2018-2028 in 2023.

4.3.3 Understanding, modeling, and forecasting of extreme events

In this 2020/2021 period, CEMADEN-led research groups of INCTMC2-Water Security have advances for understanding, modeling and forecasting of extreme events. On the one side, several direct and indirect mechanisms associated with soil degradation / desertification, mainly in relation to the impacts on local population livelihoods, such as income, immigration / emigration rate and mortality, were addressed in the article by Vieira et al. (2020). Based on a social vulnerability index, a spatio-temporal analysis of population dynamics was carried out in response to the effects of degradation / desertification and long periods of drought. The results of this study demonstrated that social vulnerability is dictated mainly by social factors, but marginally by environmental factors. This conclusion has an impact on federal public policies aimed at reducing social inequality in the region.

On the other side, it is widely recognized that land use / cover change (LULC) is one of the main drivers of desertification, since environmental degradation is always triggered by the removal of natural vegetation cover. In the study by Vieira et al. (2021), a LULC change model was calibrated and validated using simulations of climate models, demographic data and land susceptibility maps for the historical period 2000-2010. Then, the susceptibility to desertification in the Northeast of Brazil was estimated through the integration of LULC trajectories with three different scenarios of climate change and projection of population growth for the period 2015-2025, 2025-2035 and 2035-2045, for the emission scenarios RCP4.5 and RCP8.5. The results indicated that, between 2010 and 2035–2045, areas of moderate susceptibility decreased by 10.34%, while areas of high susceptibility increased by 12.28% in the case of RCP4.5. For the RCP8.5 scenario, these numbers are -16.85% for moderate susceptibility and + 19.62% for high susceptibility. Among all the indicators included in the analysis, soil management was the main precursor to susceptibility to desertification, which indicates that mitigation and adaptation strategies for the region must follow sustainable land use policies.

4.3.4 Attribution and modeling of the effects of increasing the frequency of hydrological extremes due to climate change and land use and land cover, including human uses, on water availability, with an emphasis on water security issue

The conversion of primary forest (PF) to other types of land cover in the Amazon, such as pasture and agriculture, affects regional carbon and water balances, contributing significantly to the increase in carbon emissions and the reduction of evapotranspiration. However, the growth of the secondary forest (FS), resulting from the abandonment of areas of low productivity pastures, offers a potential alternative to counteract the effects of deforestation on the release of carbon into the atmosphere and reduction of evapotranspiration. In the study by von Randow et al (2020), we present four years of measurements of turbulent flow of an FS of approximately

20 years, located in Central Amazonia, and we compare these measurements with those of an FP in the same region, analyzing the daily variations and evapotranspiration, gross primary carbon productivity and water use efficiency. On average, evapotranspiration is 20% higher in FS (3.6 mm day − 1) than in FP (3.1 mm day − 1), while gross primary productivity is only 5% higher in SF (8.1 gC m − 2 day − 1) than in PF (7.8 gC m − 2 day − 1). Despite the robust evidence of increased evapotranspiration and gross primary productivity in FS, the range of estimated uncertainty in water use efficiency was large in reaching definitive conclusions about the differences in carbon gain from water loss between sites. However, the significantly higher evapotranspiration and the gross primary productivity of the FS can offset the water and C losses from deforestation and have important implications for regional budgets.

The increase water consumption is one of the most challenging problems facing human societies today and has encouraged further studies to examine water security and management. Seeking to discuss this important issue in the Brazilian context, we analyzed the impacts of urban expansion on water security in the Paraíba do Sul River basin (Paiva et al. 2020) located in the most populous region of Brazil. To quantify the increase in water demand, we combine urban expansion and projections of an increase in the regional population. In this context, our study contributes to discussions on water security by addressing the importance of integrating water resources and urban planning. Simulations indicate good performance in reproducing the real conditions of the water supply system. Our findings demonstrates that urban expansion in the region is mainly driven by the proximity of roads. Urban occupation is projected to increase by 170% by 2050, increasing the demand for water for domestic use by 38%. The results indicate the feasibility of including the landscape and socioeconomic constraints in order to obtain scenarios of potential domestic demand for water, using land use and coverage change modeling to assess urban expansion and population growth. For the study region, our results suggest that although urban expansion increases the demand for water, urban supply will not be compromised due to the large volume of water available in the basin. However, the indirect consequences of urban expansion, such as industrialization and the intensification of agriculture, can compromise the quality of this resource and require better management of water use in the region. Moreover, this study was part of a doctoral thesis, the final work of which is in the elaboration phase.

In the study by Giane Valles (2020), changes in land use and land cover in the hydrographic basins of the Piracicaba, Capivari and Jundiaí (PCJ) rivers, which covers the states of São Paulo and Minas Gerais, resulted in 7 thematic LULC maps between 1985 and 2015. The basin has a strategic importance in terms of water availability since it includes the Cantareira System, the main source of drinking water of the metropolitan area of São Paulo. The mapping was based on visual interpretation of images, and the thematic classes used were: Forest, Reforestation, Pasture, Agriculture, Urban area, and Water bodies. Through the mapping it is possible to observe that a large part of the study area consists of pasture, followed by agriculture and forest in third. The importance of this characterization will help to assess the potential impacts on water security in the basin. In the São Paulo portion of the basins, there is a predominance of sugar cane production, around which an agro-industrial complex of sugar and alcohol was formed. In the area of the basin located in the state of Minas Gerais, predominalty land uses include livestock (beef and dairy), potatoes, corn and beans cropping. LULC maps are being applied in the hydrological modeling of the PCJ basin, aiming to identify if the historical LULC have significantly changed the hydrological regime of the basin, and, later, to elaborate future water security scenarios based on projections of changes climate change and land use and coverage. Due to several problems in the execution of the study, there was not enough time to carry out future projections of LULC changes, however, this activity will be carried out later to continue the research for publication of articles.

4.3.5 Agricultural Impacts on Hydrobiogeochemical Cycling

INCTMC2 researchers also analysed the expansion of agriculture in the Brazilian Amazon. Although Figueiredo et al (2020, Fig. 4.3.3) have been focused of intensive study for the past 20 years for understanding, considerable gaps still remain in the ability to provide adequate recommendations for land use and land cover change (LULCC) and climate. For small properties, the use of fire to prepare land for cultivation remains controversial, while in large properties, forest conversion to pasture and/or crop production has had a meaningful and adverse effect on water quality. Riparian forest conservation can make a significant difference in reducing impacts of land-use change. Secondary vegetation can also play an important role in mitigating these impacts. New types of sustainable agricultural production systems, together with incentives such as payments for ecosystem service can also contribute. Continued monitoring of these changes, together with robust sustainable development plans, can help to preserve forest while still addressing the social and economic needs of Amazonian riverine inhabitants.

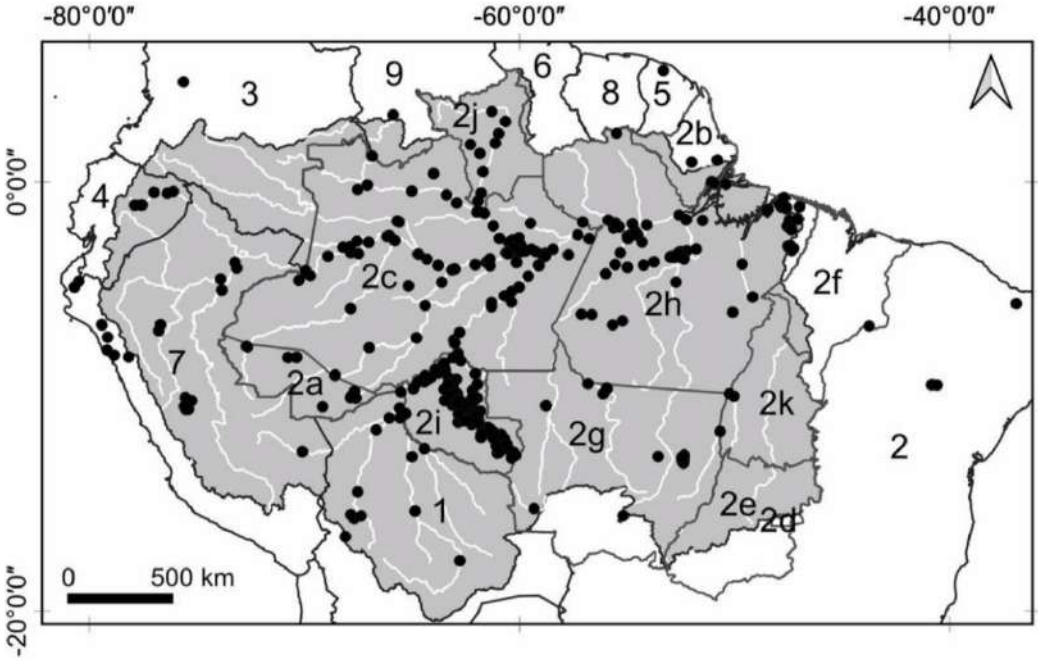


Figure 4.3.3. Approximate locations (black circles) of sampling areas of studies that assess hydrobiological aspects of streams and rivers in the Amazon river basin. Source: Figueiredo et al (2020)

4.3.6 Citizen-Adaptive Pathways and Nature-based Solutions

In this way, the Federal Act of payment for ecosystem services (# 14119, Art. 4, section X) postulates: "*to ensure accountability of information related to environmental services with society participation*". The more frequent weather/climate extremes and COVID-19 impacts, the higher citizens' perceptions on water security and potential solutions, either proactive or even reactive ones. In this way, INCTMC2 anticipatory ecohydrological methods using water-sensed data from citizens require alternative knowledge about empirical social values, beliefs and norms, implicit in both Socio-Hydrology (SH) and Nature-based Solutions for water systems (NbS-water). However, emerging SH and NbS linked to citizen science still struggle when under- represented groups barely participate. Therefore, INCTMC2 have presented a

coevolution method, through SH and NbS-water, which intertwines storylines of citizens' beliefs towards catchment sustainability under climate change scenarios. Likewise, INCTMC2-elicited experts rationale novel viable metrics with participatory ecohydrological insights from elucidating inequalities of citizen-water values. Thus, this bottom-up method of assisting both SH and NbS-water systematizes volunteers' responses into measurable variables of citizen-based metrics to outline adaptive pathways. Applications in urban catchments unveil citizens' changing perspectives, paradoxes, norms and preferences on water security, technology and green economy (see Figure 4.3.4). By equally admitting diverse ecohydrological insights, this bottom-up method unravels co-evolutionary ecosystems and barriers to a robust water governance. Hence, it facilitates top-down policies, SH's interfaces, affordable NbS-water and potential ecohydrological jobs.

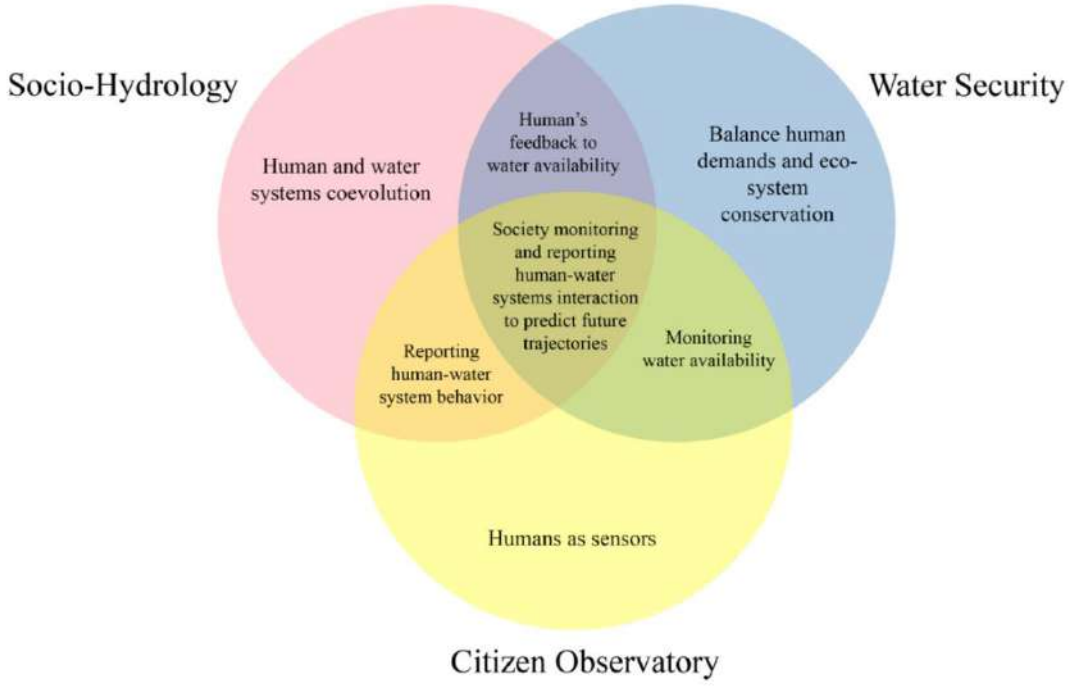


Figure 4.3.4. Relationships among Socio-Hydrology fundamentals (left circle), Water Security concerns (right circle) and Citizen Observatory's features (bottom circle). All circles and their intersections represent fundamental hypotheses of (a) sociohydrological tools intertwine citizens' storylines towards catchment sustainability, (b) citizen-based metrics systematize participatory pathways for ecohydrological insights, (c) adaptive pathways for a green economy benefit from under-represented insights, (d) bottom-up storylines place key interfaces in water resources' and sanitation's policies, and (e) affordable nature-based solutions and jobs emerge from diverse citizen's storylines. Source: Souza et al (2021).

4.3.7 Alternative Water Security Strategies at Mid-size Watersheds

Water security metrics are scale-dependent, highly non-stationary and policy-correlated with the Brazilian changing legal framework, progressively redefined by enactments # 9433 (year 1997), # 11445 (year 2007), #14026 (year 2020) and recently with #14119 (year 2021). Hence, INCTMC2 has explored how water security metrics rely on low impact development practices in the context of United Nations Sustainable Development Goals, through a new concept (Fig. 6), lessons learned and challenges for mid-size watersheds. To contribute to the increase of resilience in urban centers, LID practices have been used as a new approach of mitigation and adaptation within urban drainage systems, aiming at runoff retention, peak flow attenuation, pollutant removal and ecosystem services restoration (e.g., resources recycling, carbon

sequestration, thermal comfort and landscape integration).

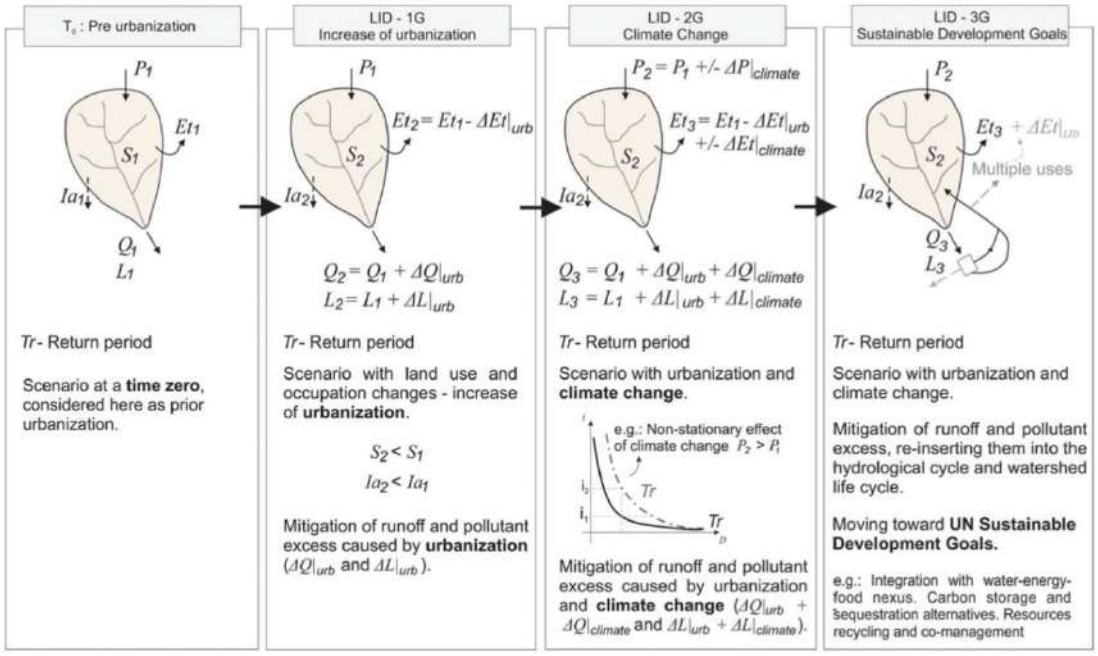


Figure 4.3.5: Concept and evolution of LID practices generations in terms of water balance varia- bles and mitigation purpose. In the figure, P1, Et1, Q1, L1, S1, Ia1 and Tr represent, respectively, rainfall, evapotranspiration, runoff, pollutant load, soil storage capacity, infiltration and return period to base scenario of preurbanization . Source: Macedo et al (2020).

4.3.8 **Science** Training of Panta Rhei Open Science for Future Earth

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. Brazilian and foreign students did assist to these courses the period 2019/2020. Some selected titles and codes given as courses in postgraduate levels:

- “Mudanças climáticas e suas interdisciplinaridades” (AGM5832),
- “Applied Solutions for Water Security" (SHS5934), and
- "New Sanitation Framework Under Changing Scenarios" (SHS5966; in partnership with Agência Nacional de Águas e Saneamento Básico).

The International Colloquium of Panta Rhei Open Science for Future Earth (PROSFE) on knowledge & thinking evolution (Panta Rhei from Greek philosopher Heraclitus, Greek Ήράκλειτος Herakleitos, c. 535 – 475 B.C.E.). It has addressed open and citizen science for a resilient, post-pandemic society. During the Colloquium, participants will share own examples and experiences, thereby attending the questions of: “What examples of science-in-action can we share for a more resilient society?”, “What are the challenges for the evolution towards a citizen science, either more inclusive and even more participative?”.

This I PROSFE Colloquium helped to integrate international initiatives at the local scales, mainly at the municipality scale, adopting actions from i.e., the United Nations Sustainable

Development Goals (UN SDGs), the IAHS Panta Rhei Water & Society Under Change, and the Red Latinoameriacana de ODSs. Moreover, ProAlertas-CEMADEN The PROSFE Colloquium acknowledges representatives from academia, social influencers, makers, doers and decision makers, with online presentations and offline contributions. The first PROSFE Colloquium is organized by the University of São Paulo, and because COVID-19 pandemics it is free-of-charge, with limited number of participants, accepting contributions in English, Portuguese and/or Spanish.

4.3.9 Partnership Projects and Cofunding Activities on Water Security

PEGASUS/CNPq - Integrated Research to Guarantee Water, Food and Energy Sustainability in the Caatinga Biome. Period of validity: 2017 to 2020. Integrated research for long-term monitoring, field experimentation and climate, hydrological, agricultural and biogeochemical modeling to develop sustainable technologies for increasing water, food and energy security and adaptation to climate changes in the Caatinga Biome. The proposal brings together several research groups dedicated to topics related to sustainability in the Caatinga Biome of the main research institutions in the Northeast of Brazil. The proposal also includes the main group of researchers from the National Observatory of Water and Carbon Dynamics in the Caatinga Biome (ONDACBC).

Universal Call - MCTI/CNPq Nº 28/2018 - Study of hydrological attributes to support the management of water resources in the state of Pernambuco, Brazil. Period of validity: Feb. 2019 to Feb. 2022. Scientific and technological advances regarding distributed hydrological processes, with the improvement of remote sensing techniques, which favors the provision of subsidies for
)
https://www.comciencia.br/especies-invasoras-representam-perigo-global-a-biodiversidade-e-a-saude-humana/
#6 Escuta Clima – Amazônia e Cerrado: a importância dos biomas para o clima (The Amazon and the Cerrado: the importance of biomes for the climate)
http://climacom.mudancasclimaticas.net.br/6-escuta-clima-amazonia-e-cerrado-a-importancia-dos-biomas-para-omanagement strategies, decision making and the establishment of public policies related to the conservation of water resources. In addition, the project innovates by providing farmers, through an application, the maps resulting from the studies, such as maps of precipitation, evapotranspiration and soil moisture in the evaluated basins. It will also contribute to the dissemination of knowledge and training of human resources.
CNPq/BRICS-STI-2 Call - Integrated water management model for BIS countries under climate change scenarios. Period of validity: Aug. 2018 to Aug. 2021. Qualitative and quantitative impacts on water resources under different climate change scenarios for selected basins in BIS countries (Brazil, India and South Africa) and to develop an Integrated Water Resource Management (IWRM) model as a political tool for decision-making. The project is developed in collaboration with two foreign institutions: the National Institute of Technology Warangal - NITW, India, and the Durban University of Technology - DUT, South Africa, as well as two national co-executing institutions: the Federal Rural University of Pernambuco - UFRPE and the Brazilian Agricultural Research Corporation - EMBRAPA.

SMART Control (FACEPE) - SMART Framework for Real-Time Monitoring and Control of Subsurface Process in Managed Aquifer Recharge Applications. Period of validity: 2019 to 2021. *Reduce risks in the application of sustainable groundwater management techniques by developing an innovative real-time monitoring and control system, in combination with risk assessment and management tools. The improvement of groundwater recharge, storing excess water underground in times of high availability, followed by recovery in times of high demand, represents a low-cost technology that increases the resilience of the water supply infrastructure for extreme hydroclimatic events. This technique, known as Managed Aquifer Recharge (MAR),*

represents a viable adaptation solution for the sustainable management of water resources, while reducing the impact of water scarcity.

DIGIRES (CNPq) - Digital-enabled green infrastructure for sustainable water resources management. Period of validity: 2019 to 2021.The main objective of the project is the development and use of ICT-based tools, together with citizen observations of science for the design and implementation of Managed Aquifer Recharge (MAR) as a nature-inspired component for sustainable management of water resources in the LAC region (Latin America and the Caribbean). The efficiency of the proposed solutions will be demonstrated through success stories, by demonstrating MAR's efficiency through ICT-based tools and implementing small-scale MAR schemes with active stakeholder participation and capacity building for sustainable urban development. In this project, the Managed Aquifer Recharge (MAR) is proposed to replace the traditional water infrastructure with greener and nature-inspired solutions, which allow a more equitable water supply.

Climate change impacts in hydrological extremes: droughts and floods (2016-2021). Funding by CAPES and ANA. Partner institutions: UFC (Coordinator), UFCG, UnB.

Water, food and energy security in the extended São Francisco river basin (2018-2021). Funding by CNPq. Partner institutions: UFC (Coordinator), UFCG, UnB, EMBRAPA.

Metropolis and the right to the city: INCT Metropolis Observatory (2016-2022). Funding by CNPq and FAPERJ. Partner institutions: UFRJ (Coordinator) and a wide institutional network under INCT Program.

Water governance: analysis and assessment in multiple scales and domains (2018-2021). Funding by CNPq. Partner institutions: UFCG (Coordinator), UFPB, IFPB, UPE.

New Generation of Nature-based Solutions for Water-Energy-Food Nexus Under Climate Change, FAPESP, 2018/04527-2, 2019-2020. Partner Institution: USP.

Social Memory for Water Security and Socio-Hydrology, FAPESP, 2018/03473-0, 2019-2020. INstitutions: USP and Univ of Chester (UK)

Center for Artificial Intelligence/Agriculture and Environmental Systems, Funding: FAPESP (2019-2029). Partner Institutions: USP (coordinator), IBM, Unicamp, Embrapa

Center of Applied Maths for Industry, Funding: FAPESP (2019-2023). Coordinator: ICMC/USP

Water-Health-Data Resilience Nexus, Funding: SPRINT UK/BR, Partners: USP and Univ of Warwick (UK) (2018-2020),

School of Adv Stud. Water & Society Change, Funding: CAPES, 2019-2020, Partner Institutions: USP, UFPE, UFCG, ANA

Observatório Sócio Hidrológico de Segurança Hídrica (SHOWS) para Redução de Riscos de Enchentes e Aumento da Resiliência Comunitária sob Cenários de Mudanças e de COVID-19, Funding: Pró-Reitoria de Pesquisa, USP, 2020-2022.

4.4 Impacts on Brazilian ecosystems in view of changes in land use and biodiversity.

4.4.1 Introduction

A large set of activities was performed during 2020 in several sites in Amazônia to fulfil the objectives of INCT Global Change. The activities in Amazonia focused on continuous measurements of trace gases and aerosols at the ATTO tower, as well as the continuous operation of the NASA/AERONET network of sun-photometers. We also worked on several projects looking at physico-chemical properties of aerosols in Amazonia.

Among the studies we have done in terms of aerosol impacts in the ecosystem, one of them is the climatic impacts of aerosol particles. Aerosol optical depth (AOD) measures the total amount of optically active aerosol in the whole atmospheric column. Figure 3.5.6 shows the time series of AOD at several AERONET sites in Amazonia from 2000 to 2021. The figure shows the strong seasonality of AOD, with very low values in the wet season (typically 0.1 at 500 nm) to very high values in the dry season. It is possible to observe the decrease in AOD with the decrease in deforestation after 2007 (figure 1).

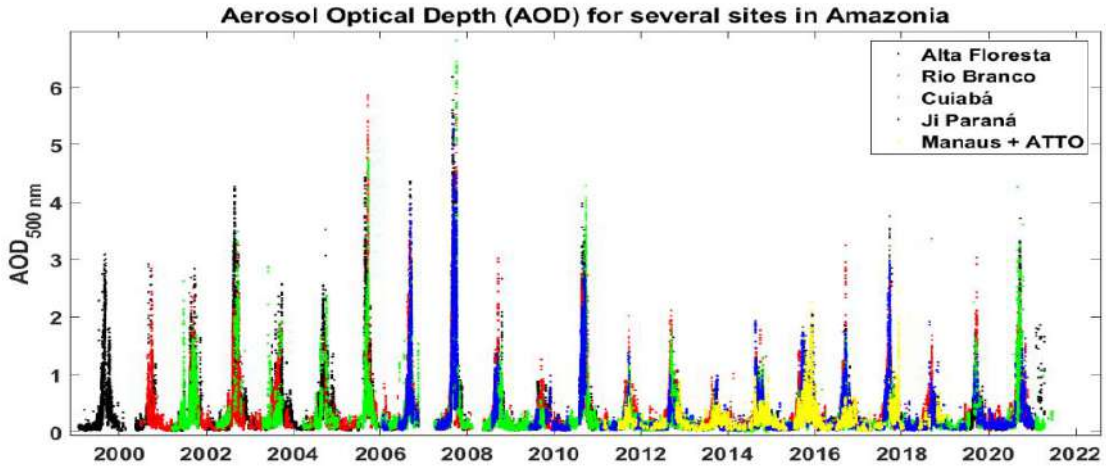


Figure 4.4.1a - Time series of aerosol optical depth (AOD) at the wavelength of 500 nm for several sites in Amazonia from 2000 to 2021 measured with AERONET sun photometers. Figure from Artaxo et al., 2021.

The newly discovered absorption component called Brown Carbon (BrC) cand be a significant fraction of the total aerosol absorption that is an important component of the Amazonian climatic system, since it affects the radiative forcing. Figure 1b shows a map with the fraction of absorption that is attributed to Black Carbon (BC) and also BrC. In Northern Amazonia, 25% of the aerosol absorption is associated to BrC that is the organic aerosol absorption component.

Figure 4.4.1b show - Map with the fraction of absorption that is attributed to Black Carbon (BC) and Brown Carbon (BrC).

We also derived changes in Amazonia in terms of biogenic trace gases such as isoprene. Figure 2 shows the time series of isoprene in Amazonia, over the time span of 2005 to 2014, showing a decrease in concentrations.

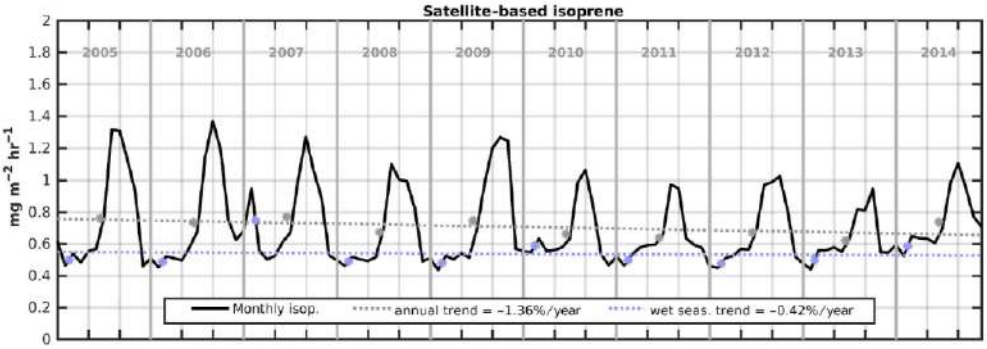


Figure 4.4.2 – Wet season satellite-based isoprene flux estimates from 2005 to 2014 in Amazonia, derived from OMI formaldehyde columns. A decreasing trend of -0.42% per year for isoprene fluxes was observed during the wet season. Figure from Yáñez-Serrano et al., 2020.

Over the ATTO tower, detailed chemical and physical properties of aerosol have continued. In particular, we analyzed mechanisms of 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. While 'classical' NPF within the planetary boundary layer (PBL) occurs worldwide, the Amazon rain forest represents a remarkable exception. Here, classical nucleation events are rarely observed in the PBL, but instead NPF takes place in the upper troposphere (UT), followed by downdraft injection of sub-50 nm (CN<50) particles into the PBL, which grow subsequently. Central aspects of our mechanistic understanding of these processes in the Amazon have remained enigmatic, however. Here, we analyze 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. Our study is based on more than six years (Feb 2014 to Sep 2020) of aerosol and meteorological data from the Amazon Tall Tower Observatory (ATTO). The event day occurrence was significantly higher during the wet season with 88% of all events from January to June, relative to the dry season with 12 %, from July to December, probably due to

differences in the condensation sink (CS), atmospheric aerosol load and meteorological conditions. Figure 3 illustrates a conceptual scheme on how new particle formation happens in high altitude in Amazonia (Franco et al., 2021).

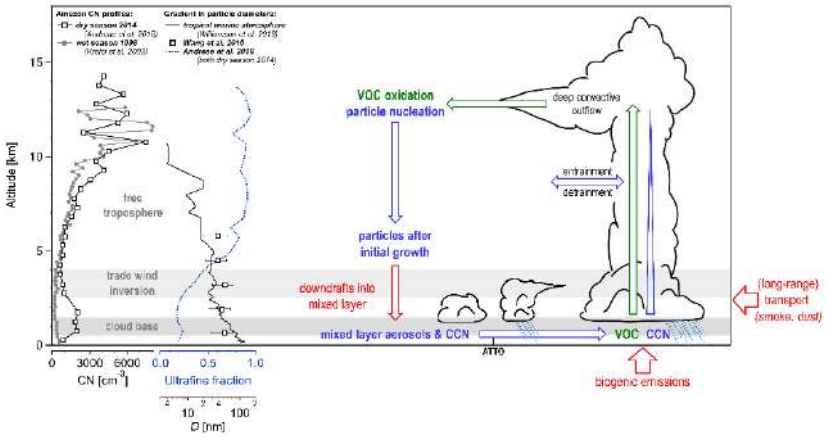


Figure 4.4.3 - Conceptual scheme of sources, redistribution, and removal of aerosol particles and cloud condensation nuclei (CCN) over the Amazon rain forest. The three main categories of aerosol sources in the Amazon are shown in red. Emphasized is the aerosol cycling in the course of deep convective clouds with upward transport of volatile organic compounds (VOC) and aerosol particles, new particle formation in the free troposphere, downward transport with initial particle growth, and eventually downward injection of ultrafine particles in the mixed layer. Figure from Franco et al., 2021.

Besides the aerosol studies, we also worked on modelling of reactive trace gases, through regional modelling of the chemistry of aerosols and trace gases. The WRF-Chem simulations are reported on the paper published by Nascimento et al., 2021.

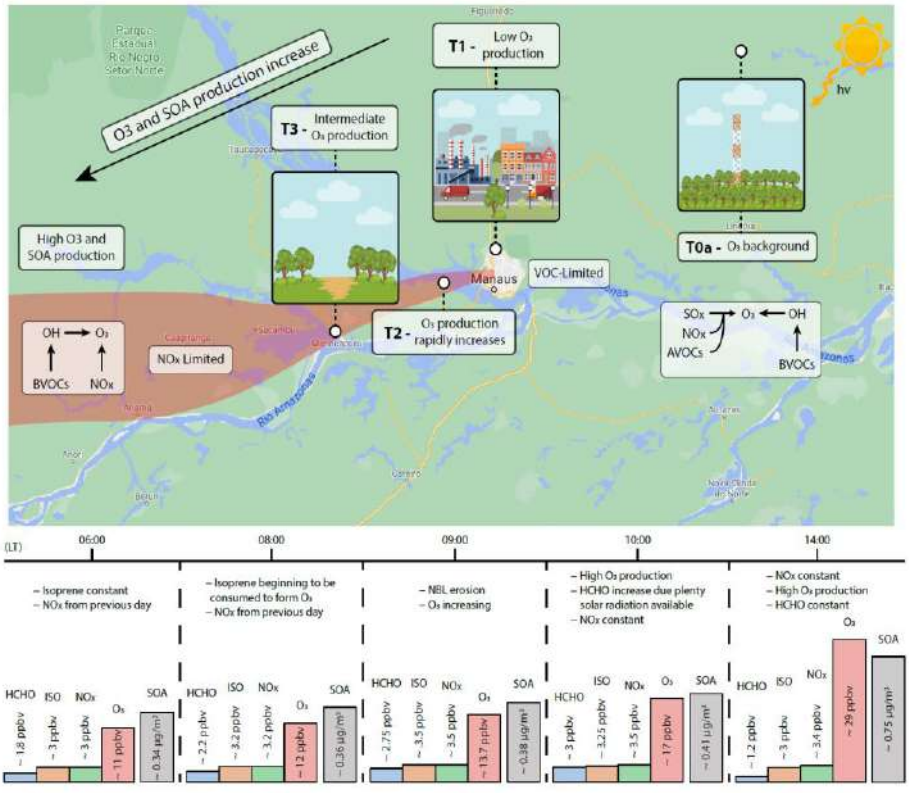


Figure 4.4.4 - Schematic illustration of the role Manaus NOx and Amazonian tropical forest VOC emissions play in O3 production. The chemical atmosphere in Manaus and the

surrounding regions 70-200 km downwind change the potential for O3 formation. Pollution from Manaus is critical in the greatly enhanced formation of O3 150-200 km downwind. The T1 site presents low O3 production due to the VOC limited regime. Downwind, at the T2 and T3 sites O3 production rapidly increases. Further south-west the downwind T3 area has even greater O3 production, showing the evidence of a more oxidizing atmosphere.

The results shows that the Manaus plume interacting with the natural biogenic emissions produces significant amounts of ozone far from Manaus, as showed in figure 5.

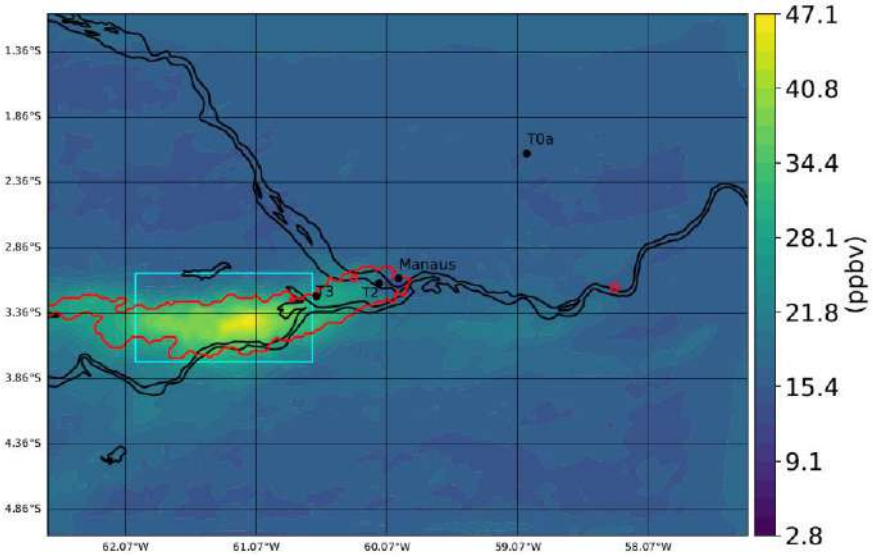


Figure 4.4.5 - Regional modeling simulations of O3 plume produced from the interaction of Manaus emissions with the natural biogenic component.

We also studied biomass burning emissions from Amazonia, and the aging processes in air masses after emissions. We have done that together with the analysis of aerosol optical properties (Ponczek et al., 2021). Figure 6 shows the map of the study region in Rio Branco, Acre.

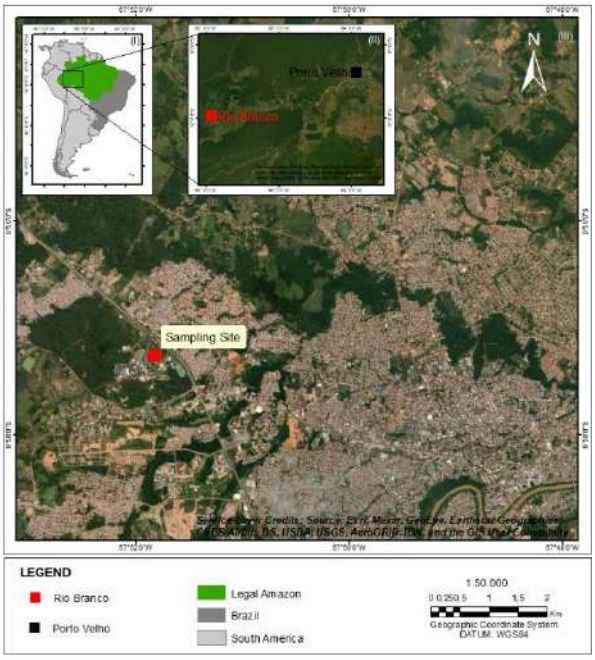


Figure 4.4.6 - The sampling site location in the city of Rio Branco, Acre, Brazil. (I) Latin America and the Brazilian legal Amazon contour in green, (II) Zoom showing Rio Branco and Porto Velho, the state capitals of Acre and Rondônia, respectively, and biggest cities in the region, (III) City of Rio Branco indicating the geographical location of the sampling site

In this study we focused on the links between aerosol composition and optical properties. Figure 7 shows the mass absorption coefficient 9MAE) as function of the wavelength as well as the contribution to aerosol absorption for each of the 5 organic aerosol components.

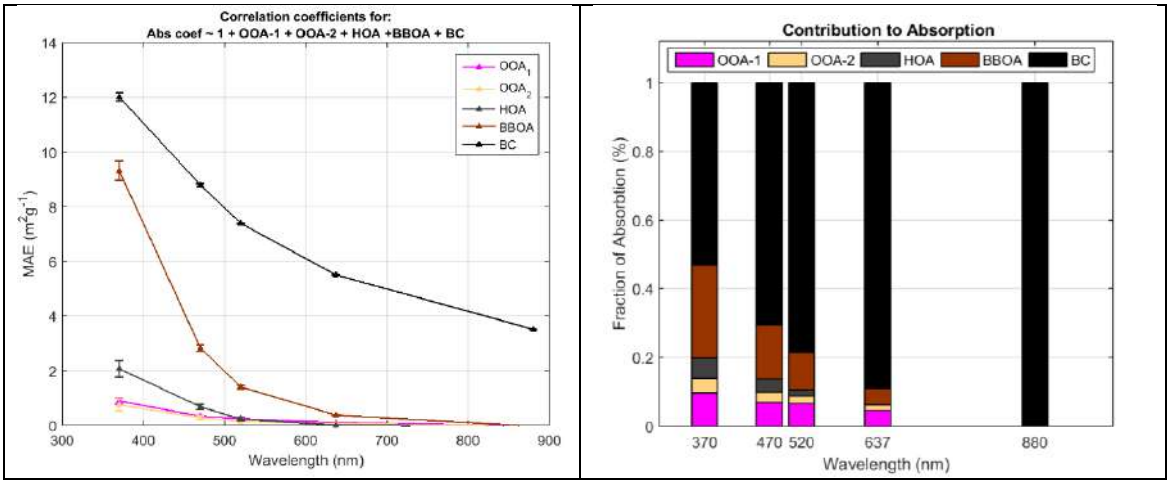


Figure 4.4.7: a) Mass absorption efficiencies (MAE) for each aerosol component (OA factors and BC), MAE is the coefficients from multivariate linear regression. The error bars represent the coefficients standard deviation b) Estimate of the contribution of OA and BC to the absorption coefficient at each wavelength.

4.4.2 Activities related to the Cerrado ecosystem.

During this period, we finalized the preparation of the 4th National Inventory of Greenhouse Gases coordinated by the Brazilian Ministry of Science, Technology, and Innovation and in partnership with the Rede Clima (Projeto BRA/16/G31 – Quarta Comunicação Nacional e Relatório de Atualização Bienal à Convenção do Clima (UNFCCC).

The Reference Report of the Sector Land Use, Land Use Change, and Forests of the Fourth National Inventory of Greenhouse Gas Emissions and Removals (1990 - 2016) was submitted to public consultation for comments in June 2020, and the final version was completed in December 2020 being available at https://sirene.mctic.gov.br/portal/opencms/publicacao/index.html.

Also, in collaboration with other institutions, we evaluated the land-use changes in the Brazilian Cerrado in the last 30 years. We improved the approaches for biomass estimates in this highly heterogenous biome using remote sensing methods.

We centered another line of investigation on the impacts of fire in the Brazilian Cerrado and the development of a model to evaluate fire behavior.

Finally, outreach papers and opinion articles were published to raise public awareness about the conservation challenges in Brazil.

4.5 Human health and climate change

4.5.1 Leishmaniasis

Brazil, with a tropical climate, is particularly vulnerable to the increase in the incidence of vector-borne diseases, in the context of global climate change. It is estimated that such events may particularly impact geographic distribution, population density, seasonality, prevalence of infection and parasite load of vectors. In Brazil, the ecoepidemiology of leishmaniasis is extremely complex, considering that different species of vectors, parasites and hosts participate in the transmission cycle, in restricted ecological niches. According to the World Health Organization (2010, 2011) the policies of 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, L. whitmani, L. intermedia* and *L. neivai*) in climate change scenarios.

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

Year 3: The results were analyzed of 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 also 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.

Analysis of the potential distribution of *L. longipalpis*, the most important vector of AVL in the American Continent and municipal vulnerability, receptive to the occurrence of human cases of AVL in the states of the entire Southeast Region, with a focus on the state of Rio de Janeiro. This proposal seeks to generate knowledge as a basis for a process innovation in the fight against AVL, precisely bringing the proposal of Surveillance in Vulnerable Areas to the occurrence of desiase, not only from the point of view of a control program, but as health-promoting tools. With an impact on the economic perspective, it works with the perspective of rationalizing resources spent by the Ministry of Health, working on actions in a preventive manner. The municipal vulnerability index (IV) will be based on principal component analysis (PCA), as proposed by Cutter (2003). This methodological approach reduces the number of variables selected through the formulation of components using the collinearities and correlations between each variable. After the execution of the PCA, the Kaiser criterion will be applied to determine the components that will be considered in the IV (Kaiser, 1958). The definition of the weights of the components will be based on the variance explained by each one in the PCA. The IV calculation will be done according to equation 1, where VarPCi is the variance explained by each component and ScorePCi is the weight of each component with an adjusted signal to agree with the vulnerability signal (Pinheiro et al 2015) components. Equation 1- Definition of the municipal vulnerability index. The calculations and statistical analyzes will be carried out in the R software, while the spatialization of indexes by municipality and production of final maps will be carried out in the ArcGIS software.

In Brazil, due to new and complex epidemiologic scenarios, the focal and dynamic transmission of American Cutaneous Leishmaniasis (ACL) occur in different patterns, depending on

location. An important example of this phenomenon is the widespread distribution and various behavior patterns of *Nyssomyia whitmani*, a vector of dermatropic leishmaniases: *Leishmania* (*Viannia*) *braziliensis*, *Leishmania* (*Viannia*) *shawi* and *Leishmania* (*Viannia*) *guyanensis*. This study aims to correlate different types of Brazilian vegetation with the spatial distribution of *N. whitmani* in the areas representing Spatial Circuits of Production for American Cutaneous Leishmaniasis (ACL).

In order to evaluate the ACL vigilance and monitoring model in Brazil, the Ministry of Health has analyzed the Spatial Circuit of the disease until 2013, currently adopting a classification of ACL transmission in municipalities that is based on the composite indicator of cutaneous leishmaniasis (ICCT). For this study, a Geographic Information System (GIS) was used to integrate the *N. whitmani*'s geographic distribution with vegetation cover and Spatial Circuits of ACL in Brazilian municipalities (Figure 4.5.1).

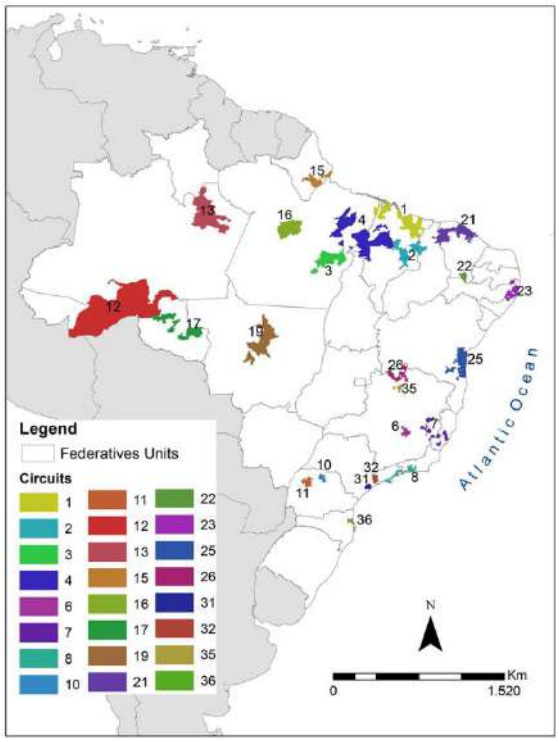


Figure 4.5.1. Geographic distribution of the 36 Spatial Circuits of American Cutaneous Leishmaniasis' production.

Out of the 5570 Brazilian municipalities here analyzed, information on *N. whitmani* was found for 862. 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 (Figure 4.5.2).

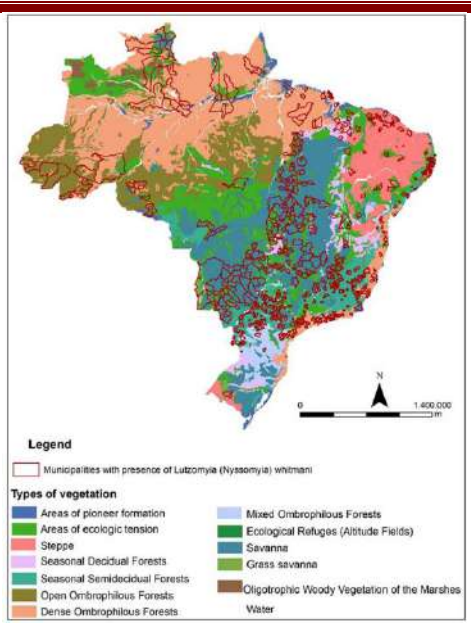


Figure 4.5.2. Spatial distribution of *Nyssomyia whitmani* associated to vegetation types (https://mapas.ibge.gov.br/tematicos/vegetacao).

According to the risk stratification defined by the Leishmaniasis Information System (SisLeish - PAHO/WHO/State/Municipality), considering the index for the triennium from 2017 to 2019, the State of Ceará has 141 municipalities with transmission of leishmaniasis (ACL and AVL) and according to data from the Health Department of Ceará (HDC), during the same period, 5,912 cases of AVL were observed throughout the state. According to HDC it is a chronic and systemic zoonosis that, if not treated correctly, can progress to death in more than 90% of cases. In the same period, 8,405 cases of ACL were confirmed in its clinical cutaneous form, most of them being men, 4,452 (52.65%), with an outstanding age group of 20 to 39 years old, 2,392 (28.46%).

The municipality of Barbalha, according to the stratification index, presented high transmission, with a high incidence of the insect vector, being captured mainly in sites close to the mountain slope. However, health professionals suggested that sandflies are adapting to urban areas. Therefore, the objective of the study is to generate quantitative and qualitative monitoring strategies to capture the vectors of leishmaniasis that frequent the indoor, outdoor and forest environments in the Municipality of Barbalha, in order to give information that will contribute to the understanding of the determinants of expansion of the disease, facilitating the identification of geographic areas that are more receptive to outbreaks and more vulnerable population groups (sentinel areas) in the Staate of Ceará.

To carry out the study, sandflies were captured monthly, in the period from March 2010 to February 2012. During three consecutive days per month, for a period of 24 uninterrupted months. Subsequently, entomological monitoring was performed in the same location from June 2016 to August 2017, following the same methodology (for three consecutive days per month), in a period of 15 uninterrupted months. In 2018, the captures started, but in 2019 they were canceled due to the Covid-19 pandemic.

Captures were carried out using CDC light traps model HP (Pugedo et al. 2005), installed indoors, peridomiciles and forest, from 6 PM to 6 AM. The sites selected for installation of traps were chosen based on the number of cases of ACL, as well as the number of sandflies captured in entomological surveys, carried out in this same location in a previous period. After the captures, the sandflies were placed in test tubes, previously labeled, containing 70% alcohol, then sent to the Medical Entomology Laboratory Zolide Mota Ribeiro, in the municipality of Juazeiro do Norte, CE. In the laboratory, the insects were processed according to the method by

Ryan et al. (1986), which consists of successive passages of the specimens in 10% potassium hydroxide (KOH) for two hours; 15 to 20 minutes in acetic acid; 20 minutes in type II water and then in lactophenol. The specimens were mounted between microscope slides for later taxonomic identification, according to the classification proposed by Young & Duncan (1984).

The abundance of sandflies species was calculated by the Standardized Index of Species Abundance (SISA), according to Roberts & Hsi (1979), following the equation:

$$\text{ISA} = \frac{(a + R_j)}{K} \qquad \text{SISA} = \frac{(c - ISA)}{(c - 1)}$$

Where:
a: number of capture points where the species was absent x *c*;
c: highest value obtained in the "ranking" of species, according to their frequencies at each capture point, considering all points + 1;
Rj: sum of positions for each species;
K: number of collection points.

The frequencies and regularity of the sandflies captured during a given time interval were calculated using Williams' averages (Haddow, 1954).

Preliminary results: During the years 2011 to 2012 and 2016 to 2017, 3,781 specimens were captured, 13 species of sandflies of the genus *Lutzomyia* França, 1924, listed, according to Young & Duncan (1994): *Lutzomyia (Lutzomyia) longipalpis, Lutzomyia (Nyssomyia) intermedia, Lutzomyia lenti, Lutzomyia evandroi, Lutzomyia migonei, Lutzomyia (Nyssomyia) whitmani, Lutzomyia walkeri, Lutzomyia quinquefer, Lutzomyia (Sciopemyia) sordellii, Lutzomyia sallesii, Lutzomyia cortelezzii, Lutzomyia goiana* and *Brumptomyia brumpti*. (Table 1).

The Brazilian control program of visceral leishmaniasis classifies municipalities by the number of human cases in the last three years, with specific control actions recommended for each category. Rio de Janeiro State has small numbers of human AVL; but it should not be neglected due to the high number of infected dogs, disease mortality and urbanization. Taking preventive measures in areas without AVL is crucial to avoid its spread. This study aims to identify vulnerable municipalities in RJ and guide future entomological surveys, by mapping the spatial distribution of the disease (human and canine) and of its vector, *Lutzomyia (Lutzomyia) longipalpis*.

Table 1. Total number of sandflies captured in the municipality of Barbalha, CE, in periods from 2011 – 2012 and 2016 – 2017.

		Captura dos flebotomíneos utilizando armadilhas do tipo CDC										
Espécies	ID				PD				M		
	♀	♂	Total	%	♀	♂	Total	%	♀	♂	Total
L. longipalpis	38	67	105		54	258	312		33	68	101
L. intermedia	21	4	25		19	42	61		104	64	168
L. whitmani	22	20	42		48	66	114		289	315	604
L. goiana	5	56	61		5	39	44		10	90	100
L. evandroi	2	7	9		2	4	6		6	13	19
L. migonei	15	22	37		13	155	168		165	279	444
L. lenti	8	4	12		14	5	19		13	19	32
L. quinquefer	3	1	4		0	0	0		0	0	0
L. walkeri	62	512	574		35	86	121		160	391	551
L. cortelezzi	0	0	0		0	0	0		0	0	0
L. sordellii	9	0	9		6	0	6		2	0	2
L. sallesi	8	9	17		4	6	10		2	1	3
B. brumpti	0	0	0		0	0	0		0	1	1

Occurrence of *L. longipalpis*, human and canine cases of visceral leishmanises were obtained from the National Information System of Notifiable Diseases, the Health Department of Rio de Janeiro State and based on the literature. The data were integrated in a Geographic Information System and analyzed to map the distribution of AVL and identify vulnerable municipalities (those with no previous records of human AVL but sharing a border or a main road with another municipality with human or canine VL in the last three years). Vulnerable municipalities were further classified as receptive (with records of *L. longipalpis*), non-receptive (without records of *L. longipalpis*) or pending entomological investigation.

With this data, human AVL occurred in 23 from 92 municipalities of RJ. In the last three years, only 7 municipalities had records od disese; all classified as sporadic transmission (Barra Mansa, Rio de Janeiro, Paraty, Volta Redonda, Angra dos Reis, Macaé and Teresópolis). 2 municipalities have records of canine VL since 2007, but without human cases (Mangaratiba and Maricá). 21 vulnerable municipalities were identified, with 4 being receptive, 3 non-receptive and 14 pending entomological investigation (Figura 4.5.3).

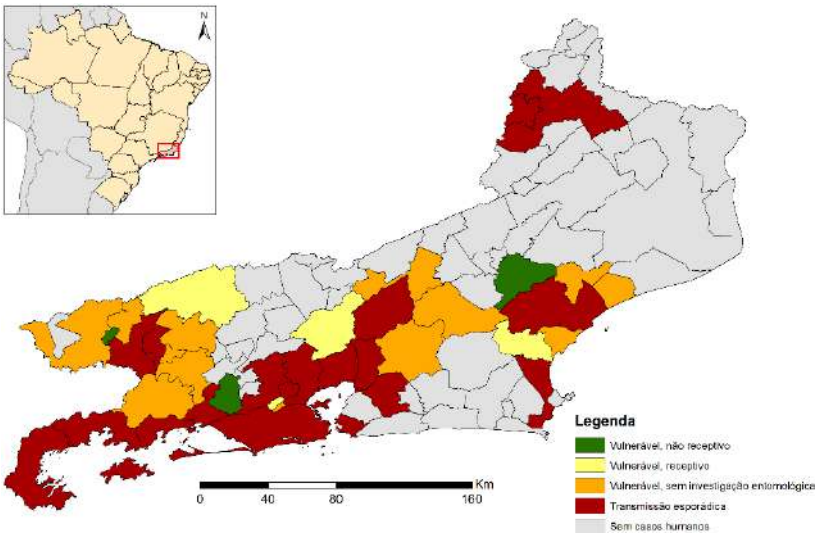
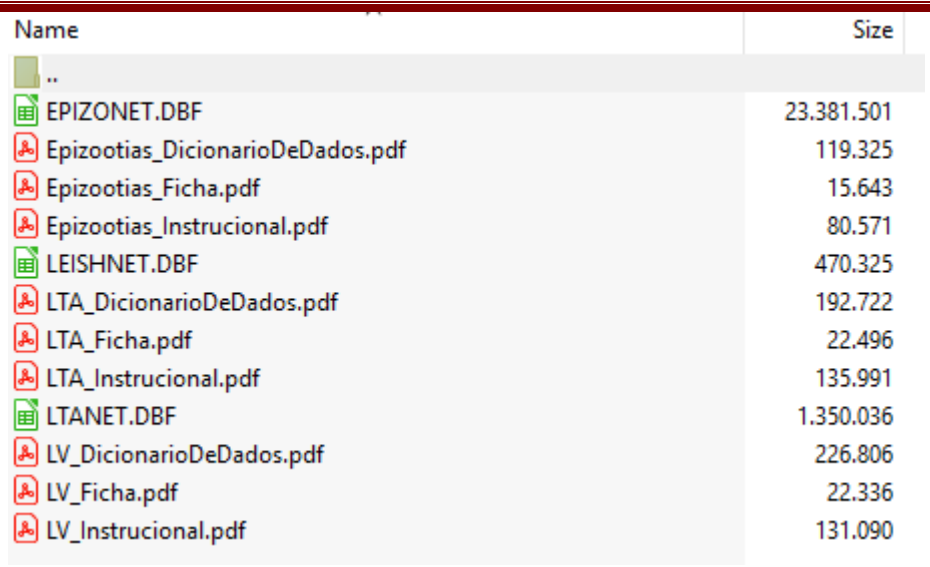


Figure 4.5.3: Classification of municipalities of the State of Rio de Janeiro according to the transmission of American Visceral Leishmaniasis. Green: vulnerable, non-receptive; yellow: vulnerable, receptive; orange: vulnerable, without entomological investigation; red: sporadic transmission; grey: no human cases.

The database in relation to human cases was updated, and information on canine cases for AVL was included, as well as information on human cases of ACL upon request by Division of Epidemiological and Environmental Data of the State of Rio de Janeiro. Data for the period from 01.2007 to 11.2020 were obtained. At this moment, the information is being georeferenced for further analysis (Figure 4.5.4).



Name	Size
..	
EPIZONET.DBF	23.381.501
Epizootias_DicionarioDeDados.pdf	119.325
Epizootias_Ficha.pdf	15.643
Epizootias_Instrucional.pdf	80.571
LEISHNET.DBF	470.325
LTA_DicionarioDeDados.pdf	192.722
LTA_Ficha.pdf	22.496
LTA_Instrucional.pdf	135.991
LTANET.DBF	1.350.036
LV_DicionarioDeDados.pdf	226.806
LV_Ficha.pdf	22.336
LV_Instrucional.pdf	131.090

Figure 4.5.4 Database: municipal vulnerability in the State of Rio de Janeiro, for Cutaneous and Visceral Leishmaniasis.

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

Coronavirus 2 syndrome (Covid-19) was identified in Wuhan, China, in December 2019 (Wu et al. 2020, Zhou et al. 2020), and quickly spread across continents, leading to World Health Organization to redefine the problem as a pandemic in March 2020 (WHO, 2020). Currently, with the diversity of vaccine options, the number of new cases and deaths remain on a trend and fall in relation to the pandemic. However Brazil is the country in South America to contribute the largest notification of cases and deaths (WHO, 2021).

It is known that climatic conditions can play a crucial role in driving epidemics caused by respiratory viruses. Although there is still no consensus on whether the circulation of SARS-CoV-2 is effectively associated with environmental factors and climatic parameters, it is a gap to be filled. For now it is impossible to predict if new epidemic waves of Covid-19 will occur seasonally or the disease will remain in transmission throughout the year, like other respiratory viruses (Rangel et al. 2021). Thus, the influence of climate, as well as the climate changes, are factors that must be taken into account, given the challenges of prevention control of Covid-19. Based on the great epidemiological and scientific relevance of the subject, many articles have been published, often with different opinions. Given this reality, our group chose to carry out a systematic review at first and a meta-analysis based on the data generated at a second moment, seeking to answer the following question: **“ Is there evidence to support the relationship between climate and transmission of Covid-19? “**

The objective of this study is to evaluate the possible relationship between climate and climate change with the dispersion of Covid-19 cases through a literature review based on previously published data.

Development / ongoing steps: This step consists of carrying out a systematic review to assess the relationship among climate, climate change and Covid-19. For this, the following keywords were defined: Covid-19 AND/OR Sars-Cov-2, AND/OR climate AND/OR temperature AND/OR precipitation AND/OR climate change, in the following databases, Scientific Electronic Library Online (Scielo), Regional Portal of the Virtual Health Library, Web of Science and National Library of Medicine (PubMed) (Figure 4.5.5). The period of the study included articles published between December 2019 and June 2021 (Table 2). For the next steps we will follow the steps: defining the inclusion and exclusion criteria of the studies that will be

analyzed, reading the eligible studies, analyzing the risk of bias, assessing the quality of the studies, extracting, and interpreting their data, as well as their analysis.

Table 2. Systematic Review: number of publications surveyed according to keyword searches in the Title or Abstract.

Key-words	Databases			
	BVS	PubMed	Scielo	Web os Science
Covid-19 and climate	130	10996	4	2319
Sars-CoV-2 and climate	348	4102	7	34
Covid-19 and temperature	163	28478	5	956
Sars-CoV-2 and temperature	1061	19409	7	90
Covid-19 and precipitation	141	2610	0	43
Sars-CoV-2 and precipitation	95	1398	0	8
Covid-19 and climate change	314	8843	1	2061
Sars-CoV-2 and climate change	121	2957	3	15

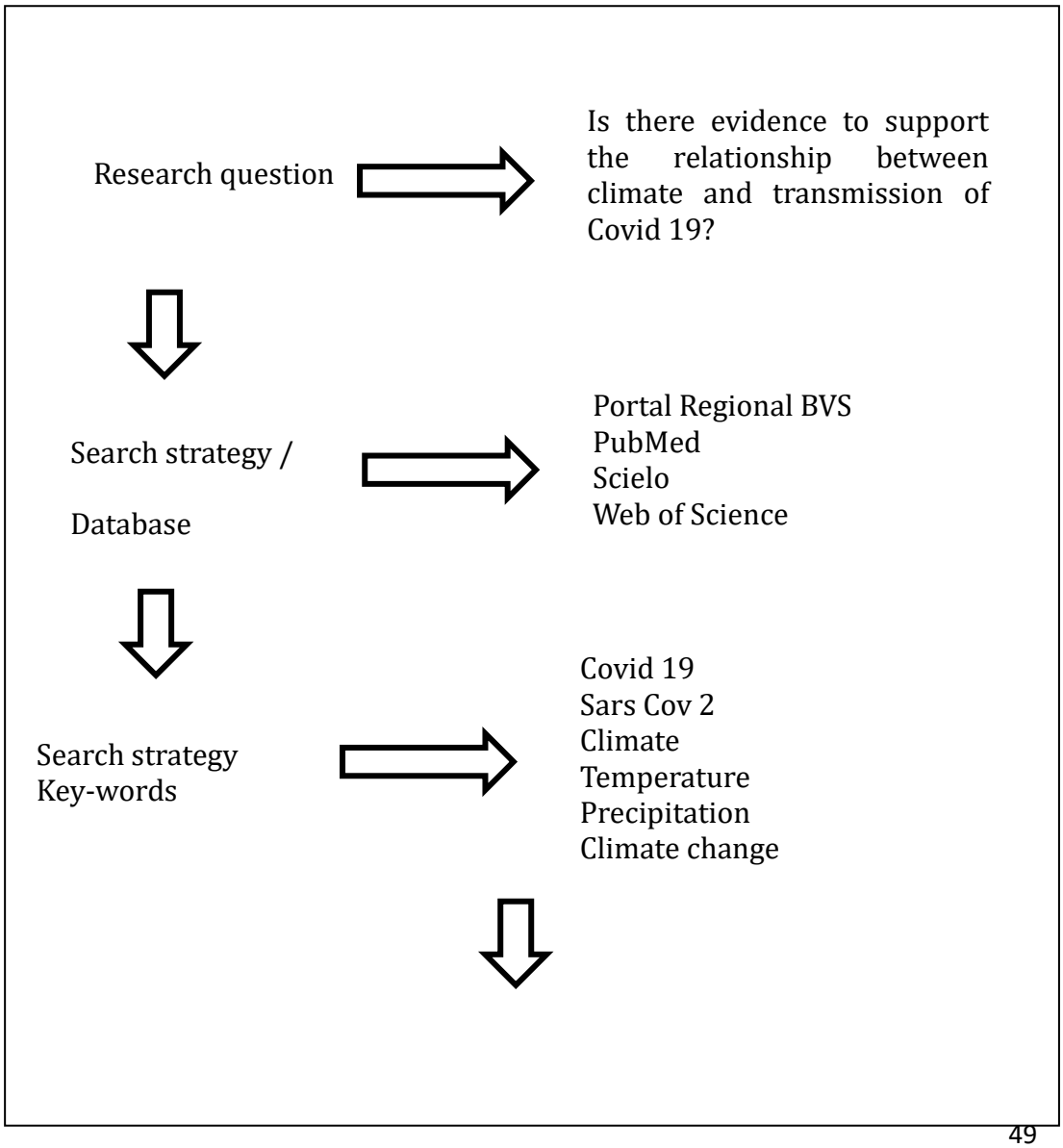


Figure 4.5.5. Systematic Review and Meta-analysis: steps already performed.

Future steps: The next step of the study consists of filtering the selected articles in the various bibliographic databases based on reading the title and abstract, removing duplicates, reading the text of the selected articles, setting up a table and analyzing the data from the selected manuscripts. At this time, it will be performed a review of the evidence on a formulated question (climate and Covid-19), select and critically appraise relevant primary research, and to extract and analyze data from the studies that are included in the review. We will map out the number of records identified, included and excluded, and the reasons for exclusions. Results will be presented as a flow-diagram that depicts the flow of information through the different phases of out systematic review.

For a second step, we will perform a meta-analysis, being a statistical analysis that combines the results of the multiple scientific studies. Meta-analysis can be performed when there are multiple scientific studies addressing the same question, with each individual study reporting measurements that are expected to have some degree of error. The results of meta-analyses are often presented in a forest plot, where each study is shown with its effect size with its respective risk ratio and the corresponding 95% confidence interval.

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4.5.3 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, promotion and environmental changes, specifically for the following reasons:

• Preliminary data indicate that climatic factors may play a role in modulating the transmission of SARS-Cov2;
• Its social importance, being the most severe pandemic in 100 years, with serious impacts on the health of communities and on the economy;
• The importance of evaluating the impact of the SARS-COV-2 surveillance and control of other diseases, related to the State and Municipal Health Departments, as well as population well-being;
• The expertise of the researchers involved will allow a broad approach to COVID-19 in Brazil, with the analysis of climatic, social, environmental and health system factors, bringing important proposals to the health decision-making agencies.

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 are being produced/collected (table 3).

Dimension	Data	Justification	Source	Timing
Meteorological	Daily observed data of temperature (average, minimum and maximum) and relative humidity from weather stations and UV radiation	The seasonality of coronaviruses seems to bear some relation to local climatic conditions.	INMET	March 2020-February 2021
Socioeconomics/ Demographics	Region of influence of cities	An estimate of the flow of people, goods, and services between cities serves as a proxy for the need for people to	IBGE	2018

Dimension	Data	Justification	Source	Timing
		move around the territory, including for health care.		
	Income: percentage of people receiving up to 1 minimum wage.	People with low incomes find it difficult to maintain social distance due to factors associated with housing and employment, and are therefore more exposed to the virus.	IBGE	2010
	Population density: number of inhabitants per km2	It works as a proxy for the agglomeration of people. The greater the number of people, the greater the possibility of spreading the virus	IBGE	2019
	Age: proportion of people in the municipality who are over 65.	The elderly have been considered a more vulnerable group to SARS-Cov 2 infection, and also have a higher mortality rate from the virus.	IBGE	2010
Health	System Access*: - Number of medium complexity hospitalizations sensitive to primary care per 100 inhabitants; - Number of medium complexity hospitalizations per 100 inhabitants; - Proportion of people who consulted a doctor in the last 12 months; - Proportion of people who referred hospitalization in the last 12 months	Greater access to the health service is an indication of the ability to address health outcomes, consequently, it may designate a place more prepared to withstand the impacts of Covid-19 on the population.	SIH/SUS e IBGE	March 2020-February March 2020-February 2021
	Human resources and equipment: - Number of physicians per inhabitants; - Number of nurses per inhabitant; - Number of adult and pediatric ICU beds per inhabitant	Human resources are needed to ensure the identification of positive cases and the minimum appropriate care of these cases.	DATASUS e IBGE	March 2020-February 2021

Dimension	Data	Justification	Source	Timing
Epidemiological	Number of daily Covid-19 cases	The fluctuation of daily Covid-19 cases aids in identifying the rate of virus transmission and the critical times for caring for positive cases.	Ministério da Saúde	March 2020-February 2021
	Pre-existing health conditions: -Proportion of patients diagnosed with cancer -Proportion of transplant patients	People with certain preexisting health conditions apparently have a higher risk of contracting the disease	DATASUS e IBGE	2020

Table 3. Meteorological data are being processed in partnership with Professor Marcelo de Paula Coerrea, Director of the Natural Resources Institute of the Federal University of Itajubá/MG (Unifei). Epidemiological, health, social and economic data are being collected on official websites. Data collection will be completed in June 2021.

4.6 Energy security

4.6.1 Integrated Assessment Modelling tools improvements and advances

The energy security component's team at COPPE continued to improve its Integrated Assessment Models (IAMs), to further explore scenarios and technologies. The Brazil Land-Use and Energy Systems model (BLUES model), the Total Economy Assessment model (TEA model) and the Computable Framework for Energy and the Environment model (COFFEE model) are constantly incorporating new features for better representing different dimensions of the economy, the environment, and the society. These advances allow the exploration of new scenarios and assumptions, unlocking the assessment of a whole new set of possible paths for the society in the near and long-term future.(Fig 4.6.1)

New improvements have been done in the link between COPPE IAM models. TEA, COFFEE and BLUES models exchange information in order to produce better and more consistent results regarding scenario trajectories and economic variables and to make the process less manual. The full process includes the definition of macroeconomic scenarios and assumptions following the scenario narrative of the case study that will be input for TEA model. Then TEA results are used to feed COFFEE model which defines BLUES model boundary condition which will be ultimately respecting global macroeconomic scenario primarily defined.

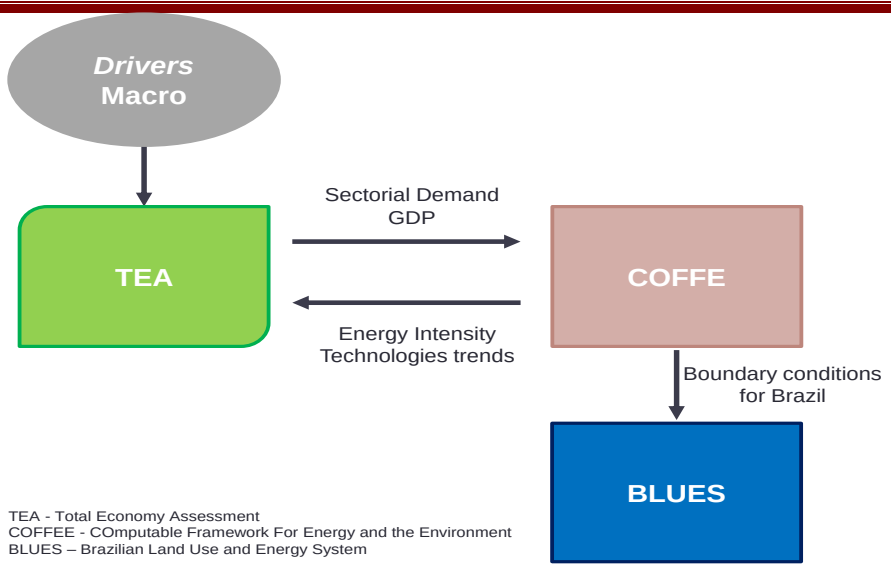

Figure 4.6.1 – Link between different IAM models developed by COPPE component.

The national IAM, BLUES, was significantly improved during the INCT project's 4th year. Much effort has been put for better representing the water-energy-land-use nexus in the model, as well as the synergies and trade-offs of local and global pollution mitigation strategies. Advances in the representation of sectoral-specific technologies were also achieved, such as biomaterials, shipping fuels and agricultural production. From these new modelling features, novel studies were originated exploring innovative ways for the sectors to contribute to the climate goals of Brazil.

There have been also improvements to the global models. Better representation of international shipping and of the quality of oil resources were included in the global IAMs. Further, studies of the impacts of global climate financial flows in national mitigation strategies and of long-term climate scenarios from the Covid-19 pandemic response were performed by using the global IAM tools developed at COPPE.

The 4th year of the INCT project was marked by a substantial role of the energy security team in the global IAM community. There was a major participation in the 13th IAMC Annual Meeting, the most important IAM conference in the World, which was held online in 2020 due to the Covid-19 pandemic. The team presented a total of 15 studies in the conference and Professor Roberto Schaeffer received the Extraordinary Contribution to the Field of IAM award 2020.

4.6.2 Hybrid power generation for increasing water and energy securities during droughts

Reservoirs can provide water security to water-stressed regions. However, for multi-purpose reservoirs, the prioritization for other functions such as hydropower generation may jeopardize water security. The inclusion of a second power source to the existing hydropower plant, turning it into a hybrid powerplant, can help to save water in the reservoirs, making it available for other purposes and providing a solution for developing integrated resources management and rising governance. Resource availabilities are driven by environmental characteristics of the site and the dynamic process of positive and negative feedbacks involving anthropogenic interventions and ecosystem regeneration.

The Sobradinho hydroelectric plant is an emblematic case and has been studied by INPE since 2018 under the NEXUS perspective of Water-Energy-Food. The 34 billion m^3 reservoir is located near Petrolina-Juazeiro, in the Brazilian semiarid region, and is fed by the flow of the

São Francisco River. In this semi-arid region, the water deficit is estimated at 1,000 mm and the dry periods last from 7 to 8 months. During the last severe drought (2010-2016), control of water for electricity generation in Sobradinho was no longer possible. The volume of water dropped to less than 2% of capacity in December 2015 and November 2017. As outlets were gradually reduced over the years, electricity generation dropped from 5,113 in 2007 to 1,162 GWh in 2017. In this context, combining hydroelectric and solar generation is an alternative to provide electricity and reduce water dependence on the energy sector in this region critical to water resources.

In one of the studies developed in this project by LABREN-INPE, we have simulated the use of solar power in the range of 50–1000 MW to partially replace the hydropower generation and manage the water allocation among three large-scale reservoirs in cascade aiming to reduce water shortage over a severe drought in the semi-arid region of Brazil. The simulations revealed the influence of PV systems on water and energy resources at Sobradinho and São Francisco River in 2009–2018. The research framework was defined in the severe drought to provide information for stakeholders to better prepare for future climate conditions at semi-arid areas since climate projections point to an intensification of dry periods.

The results show that solar photovoltaic added to a hydropower plant can preserve water and energy security during drought events. In Brazil, the São Francisco river provides water for human activities at the semi-arid part of the basin, while the reservoirs that the river feeds represent ~15% of the water storage capacity of the national electric grid. To meet the demand for water and energy supply, the operation was conducted regardless of ecological aspects. The study demonstrated that a large-scale PV could play a significant role in high-dependent water demand areas such as the Brazilian Northeastern region during severe drought events. Water security was improved at the 34 billion cubic meter reservoir of Sobradinho by adopting floating PV power plants in the range of 250 to 1000 MW. The water reserve achieved 0.7–2.3 years of the water demand in the most critical year while electricity dispatches increased by 17–63%, on average. Besides the local security in water and energy, the measure could produce collateral improvements in social, environmental, and economic aspects such as in river water quality, ecological conservation, jobs and income creation, and the optimization of the existing infrastructure of water and energy supply. However, on a regional scale, as Sobradinho is part of a five-hydropower plant system in cascade, the total electricity output was reduced by 4.4%. Such energy loss counterbalanced the solar power output by 50–60%. Despite this overall loss, a power generation increment was quantified in the critical years of the prolonged drought, which would have contributed to the renewable share of the grid. In fact, scenarios of PV > 500 MW surpassed the hydroelectricity provided by Sobradinho in the critical dry months. As the potential of solar and hydropower complementarity is expected to be enhanced under future climatic conditions, the research provides information to actors responsible for the water and energy supply systems to comprehend the interlinkages across sectors. The results subsidize the actors towards the joint operation and the proposal of appropriate public policies.(Fig. 4.6.2)

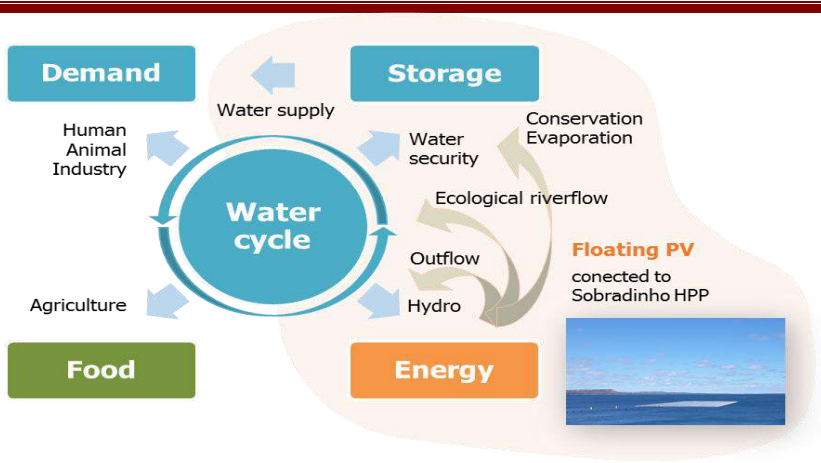

Figure 4.6.2 - Hybrid power generation for increasing water and energy securities during drought in the S. Francisco river basin.

4.6.3 Lake breeze and hydro-solar complementarity

Brazil has dozens of hydroelectric reservoirs with vast extension capable of influencing the local climate through the lake breeze mechanism. The change in heat flows on the surface caused by the flooding of large areas triggers the circulation of the lake breeze and affects the hydrological cycle, the energy balance, and the local cloudiness. In this way, the reservoirs can induce areas of less cloudiness over the lake, creating a spatial pattern of complementarity between solar and hydraulic generation.

The INPE team, in collaboration with UNIFESP and UNIFEI, is evaluating the effects of lake breezes on incident radiation in the area of influence of Brazilian hydroelectric power plants. In a first paper we evaluated the microclimatic effect of Serra da Mesa water reservoirs on local cloudiness and on the surface solar radiation using GOES-16 satellite images and surface measurements. We evaluated the frequency of cloudiness from the spatial and temporal perspectives, comparing cloud cover over the water surface and areas close to its margins. Results have shown an around 2% enhancement of solar irradiance over the flooded area compared to surrounding land. More details are found in Gonçalves et al, (2020).

This work was extended to include 10 more large Brazilian hydroelectric reservoirs. The period of analysis was also extended covering three years of GOES-16 satellite operation. The results indicated that the enhancement of cloudless skies is more intense in tropical climate, reaching is maximum for reservoirs in the Amazon biome like Balbina and Tucuruí. For these reservoirs the gains in energy production can achieve 10% for certain months. On the other hand, subtropical reservoirs like Itaipu, despite its large flooded area, causes small impact over cloudiness.

Floating photovoltaic plants (FPV) are emerging as a cost-effective solution to stabilize hydroelectric energy production and take advantage of improved PV performance over the water. The mapping of microclimate effects of water reservoirs over incoming surface solar irradiance for Brazilian reservoir is a necessary technical scientific task to allow a higher penetration of renewables in the GRI keeping adequate levels of energy security from the electricity supply side.(Fig 4.6.3)

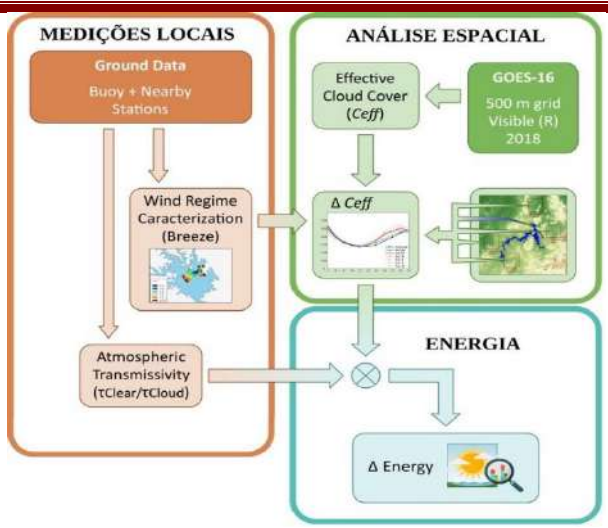

Figure 4.6.3. Flowchart of the three strategies used in this study to characterize the lake breeze

4.6.4 Climate Projections downscaling for solar and wind assessment in Brazil

A new impact assessment of climate change over energy resources was initiated during 2021 by INPE in collaboration with UNIFESP, taking advantage of the recent release of CMIP6 datasets. The task "Statistical downscaling of climate projections for wind and solar resources in Brazil" supported by FAPESP scholarship began with the update quality checks of a new observational database for wind and solar measurements from different networks like SONDA, airport data (METAR), INMET and INPE automated weather stations. These data will help to assess uncertainties associated with the estimates produced by climate models. This observational database is being merged to a physically consistent spatial model to allow pairwise grid comparisons. This grid is obtained from a combination of climate reanalysis datasets, consolidated on a monthly, daily, and hourly scales. This database will contain the frequency distribution of wind speed and solar irradiation variables, generated from data in original resolution (hourly) in spatial resolution compatible with the outputs of refined climate models. All reanalysis data was already downloaded and is under processing. Next steps of this work involve the evaluation and selection of appropriate CMIP6 experiments and models, define future scenarios and proceed the systematic error correction through quantile mapping (Fig. 4.6.4). Final results of impact assessment are expected for the next 12 months.

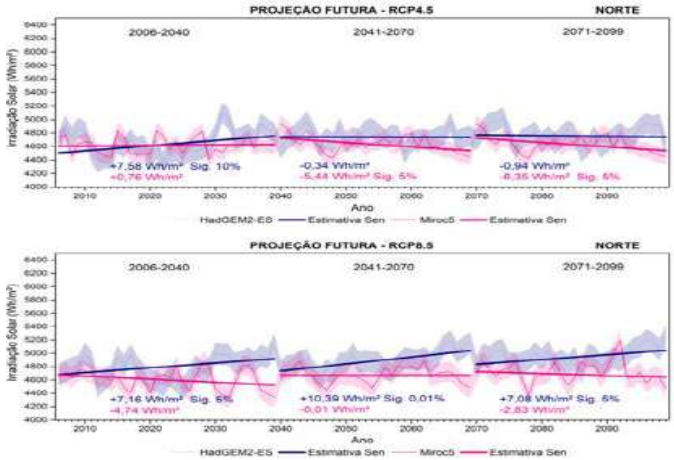

Figure 4.6.4. Future projections of solar irradiation for the Northern region of Brazil, RCP 45 (a) and RCP85 (b) simulated by the Eta-HADGEM2-ES (blue curve) and Eta-MIROC5 (red curve) models

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

4.7.3 Current situation

In the fourth year of the project, the efforts were to prioritize the following proposed activities: (i) detailed analysis of extreme precipitation and streamflow in pilot municipalities that lead to natural disasters in Southern Brazil, including the case study for Itajaí Açu River region. Other regions such Pantanal, Paraná River Basin were also studied; (ii) detailed analysis of future projections of precipitation in Southern Brazil, using models outputs from both Coupled Model Intercomparison Project Phases 5 and 6 (CMIP5 and CMIP6); (iii) detailed analysis of future projections of atmospheric blocking and severe droughts in Southeastern Brazil and marine heatwaves in the western South Atlantic, using CMIP6 models outputs; (iv) detailed analysis of future projections of extreme rainfall and hydro-geo-meteorological disaster risk considering different global warming scenarios, in order to assess the vulnerability and risk of Brazilian municipalities to natural disasters of hydrometeorological origin; (v) initiated the development of a tool to identify the major vulnerabilities of cities regarding natural disasters associated with climate change, considering Blumenau city, Santa Catarina as the case study; (vi) In the context of drought risk, the Drought Composite Index (DCI) was development, which measures the intensity and frequency of meteorological drought considering climatic variables, and, also, the Integrated Drought Index (IDI) and Standardized Streamflow Index (SSFI) were used to assess drought impacts on the agricultural sector and water resources from the period of 1998 - 2020 in the Southern region of Brazil.

4.6.2 Analysis of extreme events and consequences for urban areas

The research conducted during year 4 focuses on the uncertainty and non-stationary in the frequency of extreme precipitation in southern Brazil, including the study area of Itajaí Açu River. The results provided recommendations for infrastructure projects in urban areas, which is the main objective of this INCT component. The analysis indicated that the seasonality in the annual maximum series was significant for only 99 out of the 489 evaluated rainfall records (Figure 4.7.1b – rainfall records with large values of the R parameter). For these rainfall gauges with significant seasonality, the most common season for the occurrence of extreme rainfall is during summer (~71.7%), autumn (~16.2%), winter (~9.1%), and spring (3%) (Figure 4.7.1a).

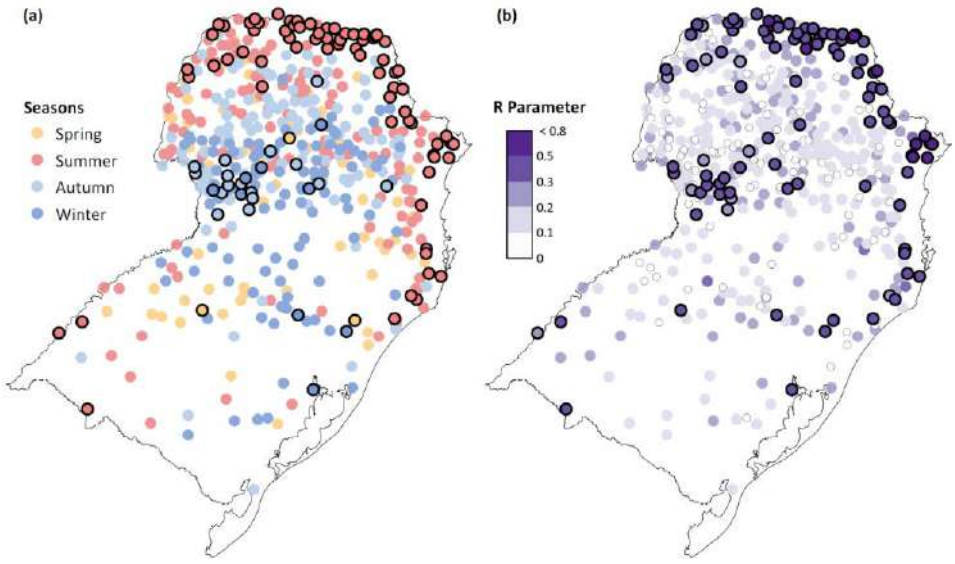

Figure 4.7.1– Seasonality in the annual maximum series: (a) most common date of occurrence of the annual maximum daily rainfall and (b) seasonality strength, represented by the R parameter. The R parameter can assume values between 0 (no seasonality, i.e., uniform distribution) and 1 (strong seasonality, i.e., unimodal distribution), evaluated with directional

statistics. Markers with thick borders indicate statistically significant seasonality at a 95% confidence level using the Rayleigh test.

Statistically significant trends were identified in the magnitude and frequency of extreme rainfall events in Southern Brazil at both annual and seasonal scales, with a well-defined spatial pattern for all hydrographic regions. Overall, at the annual scale we found positive trends in both magnitude and frequency of extreme rainfall events (Figure 4.7.2), which means that in SB the extreme rainfall events are becoming more severe and frequent. For instance, the median of the trends is 0.83 mm day-1 year-1 for magnitude and 1.2 % year-1 for frequency. Over 40 years (1976-2015), this indicates an increase of 32.3 mm day-1 in the magnitude and 48% in the frequency of extreme rainfall events. Similar results are found at the seasonal scale, i.e., a predominance of positive trends in the magnitude and frequency of extreme rainfall. The exceptions are extreme rainfall events that occur during autumn, predominantly of negative trends in some regions, i.e., South/Southeast Atlantic regions in the magnitude of the events, and in the Paraná River and Uruguay River regions in the frequency.

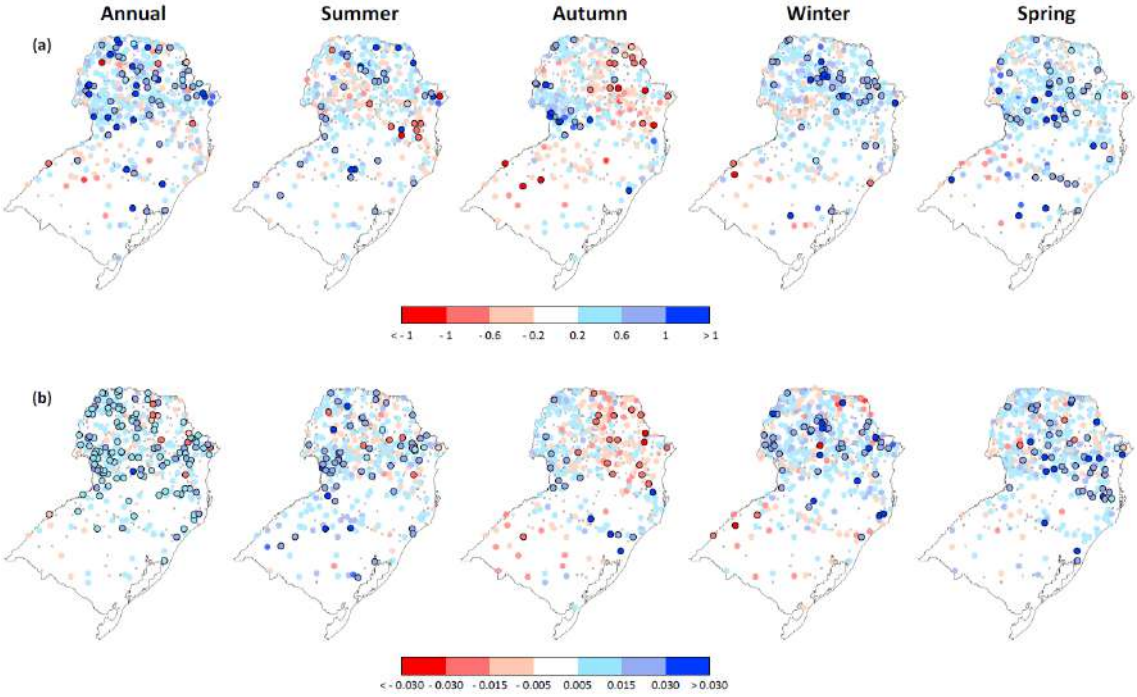

Figure 4.7.2 – Trends detected for the 1976 - 2015 period for (a) the magnitude of extreme rainfall events (mm day-1 year-1 or mm day-1 season-1), at annual and seasonal scales, and (b) the frequency of extreme rainfall events (probability of an event year-^{2} or probability of an event season-^{2}). Markers with thick borders indicate statistically significant trends at a 95% confidence level using the Mann-Kendall test (a) and Poisson regression (b).

In addition, a systematic analysis of future projections of precipitation in southern Brazil was conducted using CMIP5 and CMIP6 models. There is an improvement in most marginal metrics between multi-model ensemble (MME) and constrained ensemble (CE), and CMIP6 generally has a better performance than CMIP5. Apart from the annual precipitation in the CMIP6, most models show a dry bias in Southern Brazil (Figure 4.7.3). Correlations between the models and observed precipitation are generally weak. Apart from the CMIP6CE ensemble, models simulate smaller volumes of annual rainfall. Although variability is still lower in the models, CMIP6 is the closest to the observed temporal and spatial variability. There is still a persistent dry bias in extreme precipitation, and CMIP6 shows an improvement in these metrics compared to CMIP5. The lack of correct representation of high intensities implies that several other metrics are poorly simulated, since they are dependent on the simulation of high precipitation.

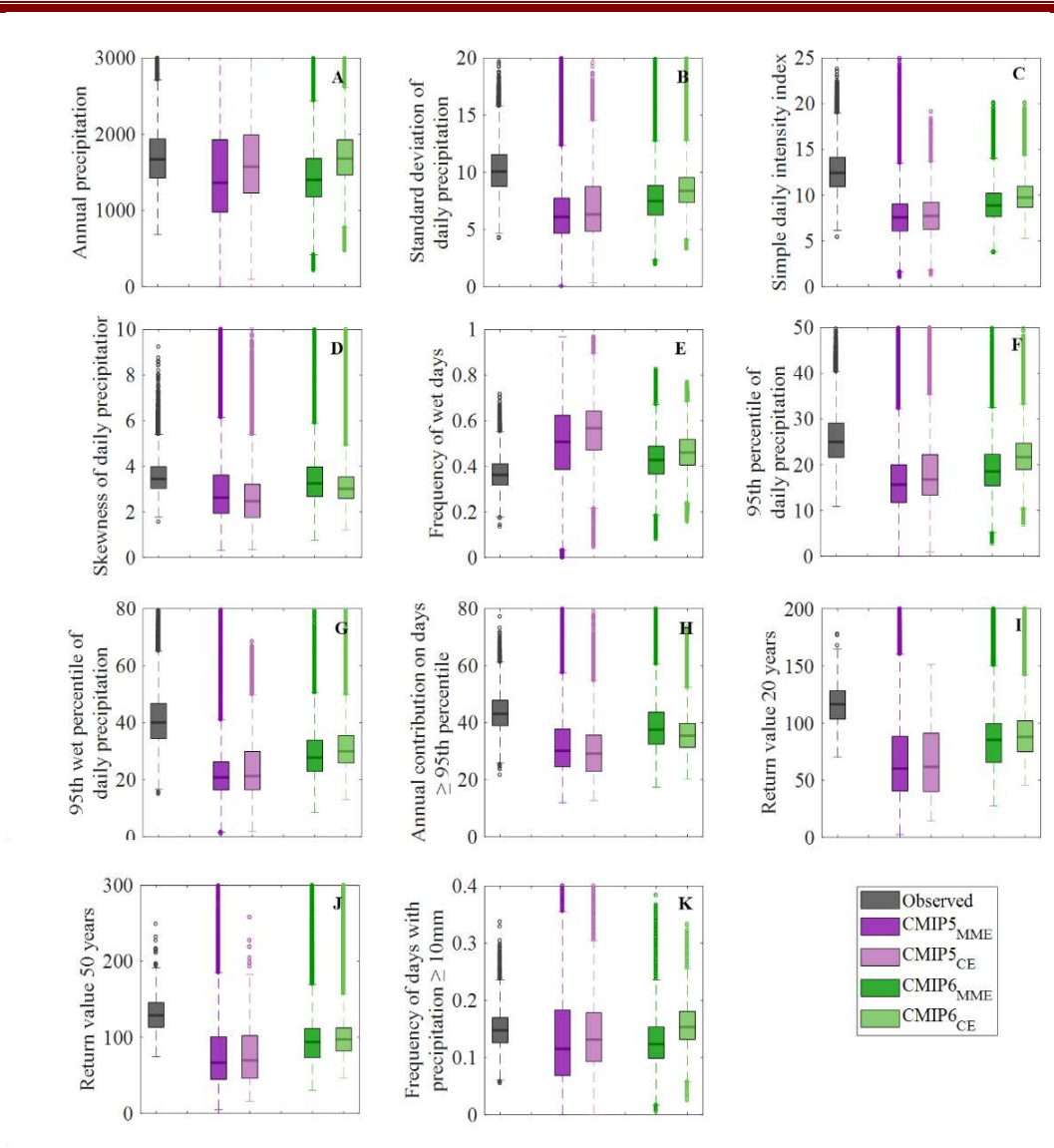

Figure 4.7.3 – Marginal characteristic performance metrics for the observation (gray box), CMIP5MME (dark purple box), CMIP5CE (light purple box), CMIP6MME (dark green box), and CMIP6CE (light green box): (A) annual precipitation, (B) standard deviation of daily precipitation, (C) simple intensity daily index (average precipitation on days with precipitation ≥ 1mm), (D) skewness of daily precipitation, (E) frequency of days with precipitation ≥ 1mm, (F) 95th percentile of daily precipitation, (G) 95th percentile of precipitation on days with precipitation ≥ 1mm, (H) percentage of annual contribution of days with precipitation ≥ the 95th percentile, (I) 20-year precipitation intensity, (J), 50-year precipitation intensity, (K) frequency of occurrence of days with precipitation ≥ 10mm.

The simulation of the seasonal cycle has improved between phases (Figure 4.7.4). CMIP5 exaggerates seasonality, simulating dry winters with sporadic extreme events and wet summers with frequent low-intensity precipitation. Southern Brazil has well-distributed precipitation throughout the year in most areas. CMIP6 smoothens the annual cycle, although lower monthly precipitation values are still found in the winter months. CMIP6 also simulates lower values of the seasonality index, narrowing the distance between simulation and observation.

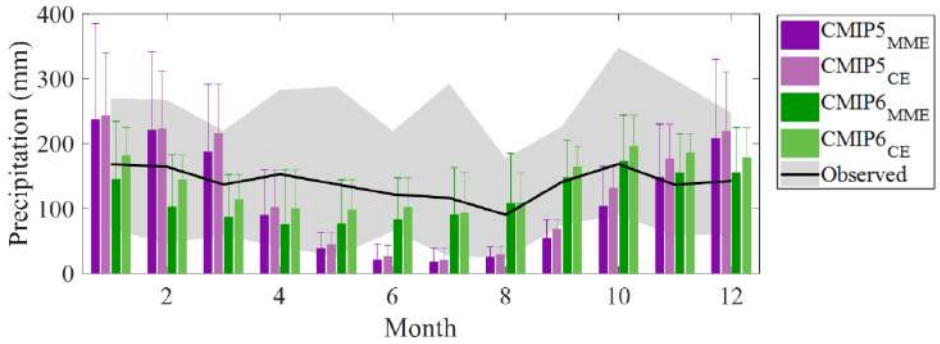

Figure 4.7.4 – Annual cycle of precipitation of CMIP5MME (dark purple bars), CMIP5CE (light purple bars), CMIP6MME (dark green bars), and CMIP6CE (light green bars). The black line is the averaged observed cycle, grey shading is all observed annual cycles.

The spatial distribution of annual rainfall is improved between CMIP phases – CMIP5 tends to cluster precipitation in the middle portion of Southern Brazil while CMIP6 precipitation is more evenly distributed, better mimicking the observed spatial pattern. The correlograms suggest that to find a definitive spatial dependency pattern, the area of study should be expanded (Figure 4.7.5). Overall, spatial dependency is better represented by CMIP6 and for this phase, the optimization process seems to not have a big impact on performance. For CMIP5, however, the constrained ensemble worsens performance compared to the multi-model ensemble. We find that for most metrics, CMIP6 shows a performance improvement compared to CMIP5. Similarly, constrained ensembles mostly outperform multi-model ensembles, as well as reduce uncertainty. However, even in the best-performing case of the CMIP6 constrained ensemble, rainfall simulation is still limited. Models still do not fully capture observed characteristics of precipitation such as high percentiles, seasonality, and spatial dependency. These results support the importance of a thorough performance assessment of modeled rainfall before any further impact study, especially in a highly complex area.

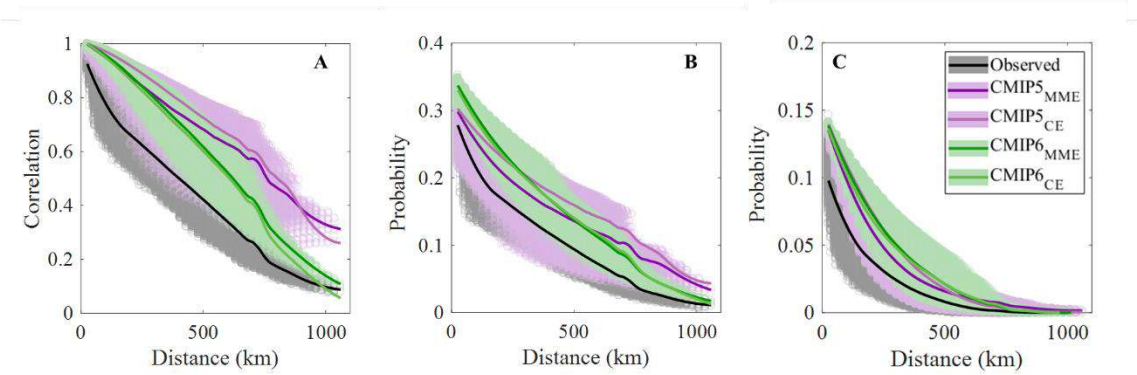

Figure 4.7.5 – Correlograms of spatial dependence. (A) Spearman correlation, (B) Mutual information of the occurrence of wet days (daily precipitation ≥ 1mm), and (C) Mutual information of exceedance of the 95th percentile of daily precipitation. Lines are smoothed curves ("loess" regression) and dots are pairwise results. Gray dots and the black line are observations, purple dots are CMIP5 pairwise correlations, dark purple line is the CMIP5MME and light purple line is the CMIP5CE. Green dots are pairwise correlations in the CMIP6, and the dark green line is CMIP6MME and the light green line is CMIP6CE.

In addition, research was also conducted focusing on future projections of compound extreme events in Brazil that have devastating socio economic consequences, in particular, for urban areas. Compound extreme events are the combination of events that occur simultaneously and lead to several serious impacts at the same time. In the southeast and south of Brazil the anomalously dry year of 2013/14 was a compound event that led not only to a severe drought in the south and southeast of Brazil, but also to land heatwaves and marine heatwaves in the South

Atlantic (Rodrigues et al., 2019). Outputs of the CMIP6 models were analyzed and the results show that atmospheric blocking that caused severe droughts like the 2013/14 are going to become more intense and frequent in the near future (2021-2050) and far future (2071-2100). Figure 4.7.6 shows, for instance, through different scenarios of CMIP6 (SSP2-4.5 and SSP5-8.5) that significant positive trends in frequency, duration and cumulative intensity of marine heatwaves are identified for the western South Atlantic, leading to an almost permanent state of heatwave by the end of the 21st century (Costa & Rodrigues, 2021). This is linked to an increase in atmospheric blocking and severe droughts over southeastern Brazil. Moreover, Sen Gupta et al. (2020) show that persistent high-pressure centers associated with droughts are a common cause of heat waves in the Southern Hemisphere.

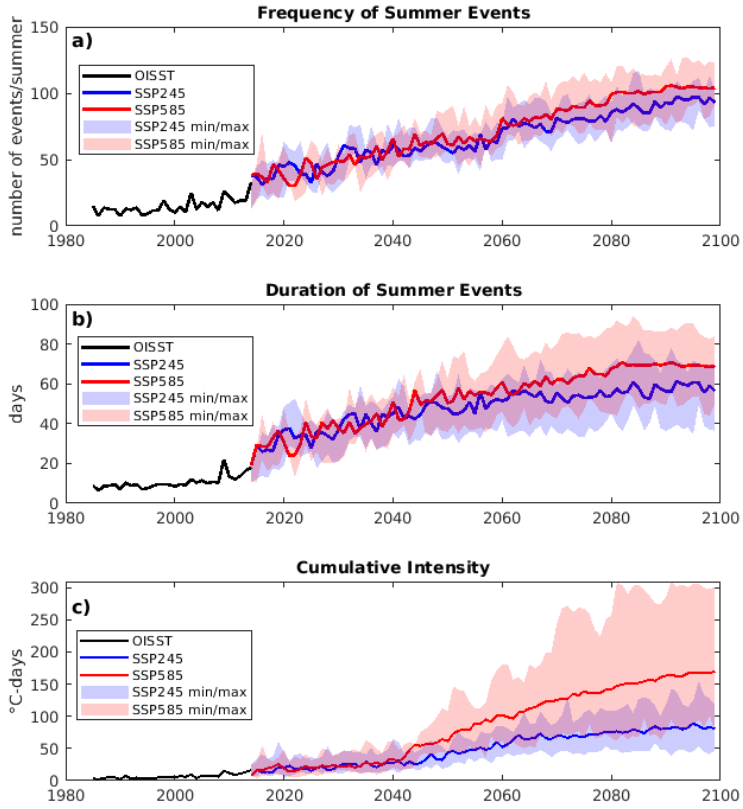

Figure 4.7.6 – Time series of austral summer mean marine heatwave (a) frequency (days per summer), (b) duration (days), (c) cumulative intensity (°C days). Black lines represent the metrics obtained from observations (OISST) for the period of 1985-2014, blue lines from CMIP6 SSP2-4.5 for the period of 2015-2100 and red lines from CMIP6 SSP5-8.5 for the period of 2015-2100. The blue and red shaded regions show the maximum range between individual model runs.

4.7.3 Municipalities risk indexes associated with climate change

The efforts conducted during the last year focused on identifying the case studies of municipalities, contacted local stakeholders, and initiated the assessment of their vulnerability to natural disasters associated with climate change.

– **Extreme rainfall and Hydro-geo-meteorological disaster risk considering different global warming scenarios: an analysis for Brazil and for Blumenau, SC.**

A study was conducted to address the evolution of past works focusing on the entire national territory in order to assess the vulnerability and risk of Brazilian municipalities to natural disasters of hydrometeorological origin, including the results presented in the 1st report of the INCT-MC Phase 2 project (Marengo et al. 2021 a). The approach included the demographic

characteristics of the population living at vulnerable areas, as well as the combination of empirical models of potential impact, which aggregated climate modeling data to project climate changes and potential impacts caused by extreme precipitation events. The effects of changes in extreme rainfall patterns related to the risk of flash floods and landslides were investigated considering three levels of global warming (1.5, 2.0 and 4.0 °C), which had not yet been addressed in studies on this scale. Projections from a robust set of CMIP6 models at different levels of warming showed a notable shift in extreme event trends. As a result, the increase in global warming levels culminates in an increased risk of landslides and flash floods in a large portion of the national territory. Comparisons between the historical reference period (1961-1990) and the future indicated that three regions of Brazil, composed of densely populated areas, are the most exposed to these types of disasters. The South and Southeast regions of Brazil stand out, including the metropolitan regions, characterized by high economic development and densely populated, whose disasters can intensify both in frequency and magnitude. The eastern portion of the Northeast region is also indicated as one of the regions affected by its high vulnerability and exposure in the current period, although future climate projections do not allow inferring that there will be an intensification of extreme rain events in scenarios below 4 °C. The main metropolitan regions and tourist centers, as well as the main infrastructure of Brazil are located in these regions. The study results reinforce the importance of environmental policies to protect human lives and minimize financial losses in the next decades, as well as reinforce the need for decision-making, monitoring and early warning systems to better manage potential disasters, as part of risk management and disaster reduction. Figures 4.7.7 and 4.7.8 summarizes the principal results from the study, associated with vulnerability-exposure index for landslides, while Figures 4.7.9 and 4.7.10 show the results related to the vulnerability-exposure index for sudden floods, flash floods, and floods.

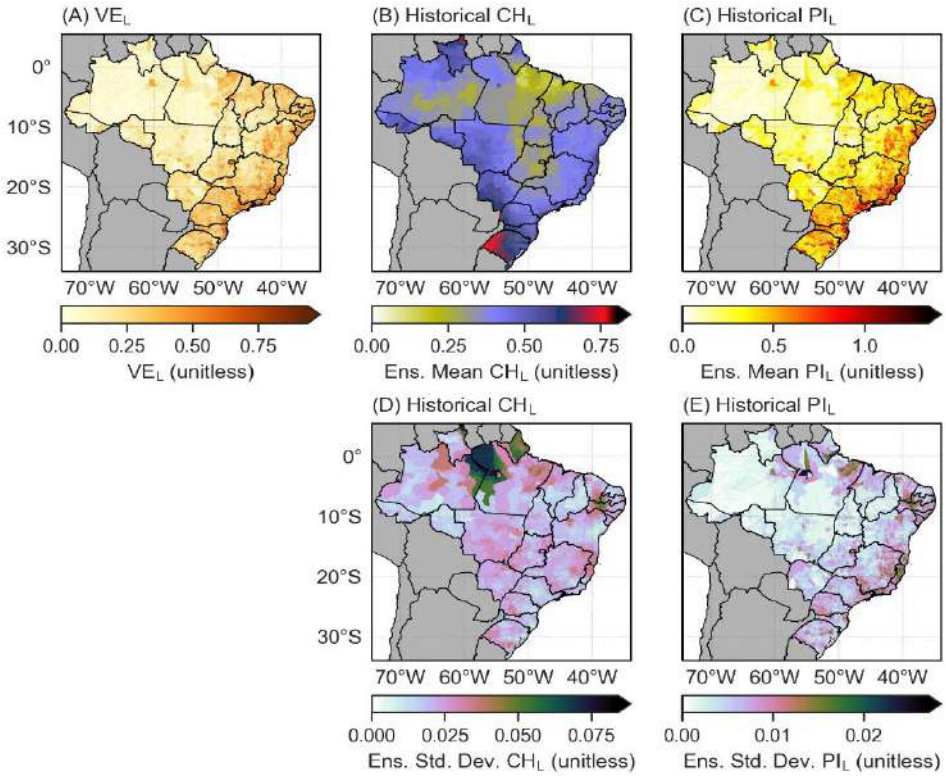

Figure 4.7.7 – Geographical distribution of (A) the vulnerability-exposure index for landslides (VEL), (B,D) the ensemble mean and standard deviation of the historical climatic hazards index

for landslides (CHL), respectively, as well as (C,E) the ensemble mean and standard deviation of the historical potential impact index for landslides(PIL).

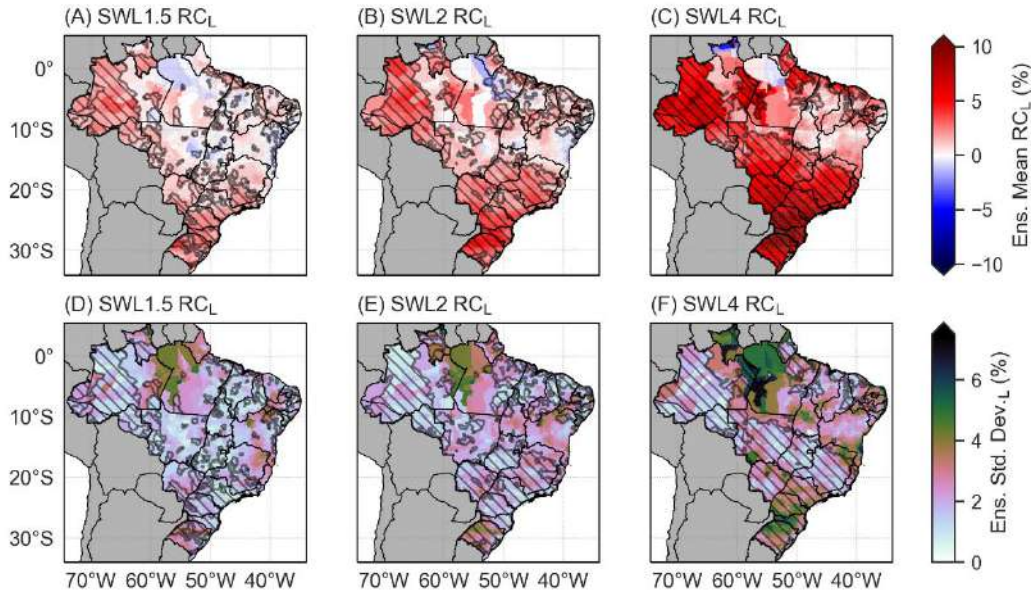

Figure 4.7.8 – Geographical distribution of the ensemble mean (top) and standard deviation (bottom) relative changes of the potential impact index for landslides (RCL) with respect to the historical period for various scenarios: (A,D) SWL1.5; (B,E) SWL2; and (C,F) SWL4. The hatch pattern represents areas where the ensemble sign agreement presents values above or below +66% or -66%, respectively.

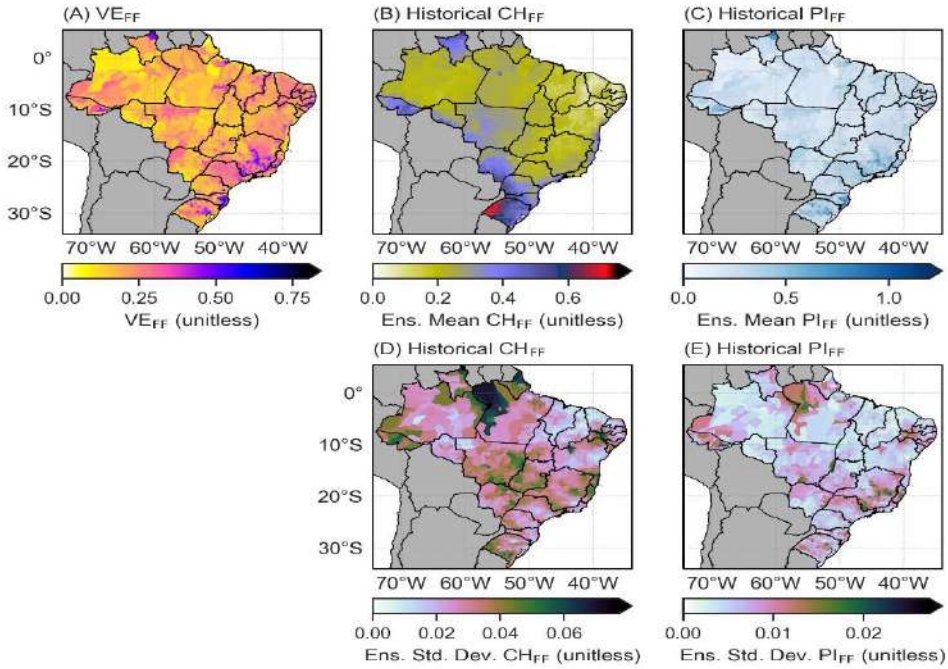

Figure 4.7.9 – Geographical distribution of (A) the vulnerability-exposure index for flash floods (VEFF), (B,D) the ensemble mean and standard deviation of the historical climatic

hazards index for sudden floods, flash floods, and floods (CHFF), respectively, as well as (C,E) the ensemble mean and standard deviation of the historical potential impact index for sudden floods, flash floods, and floods (PIFF).

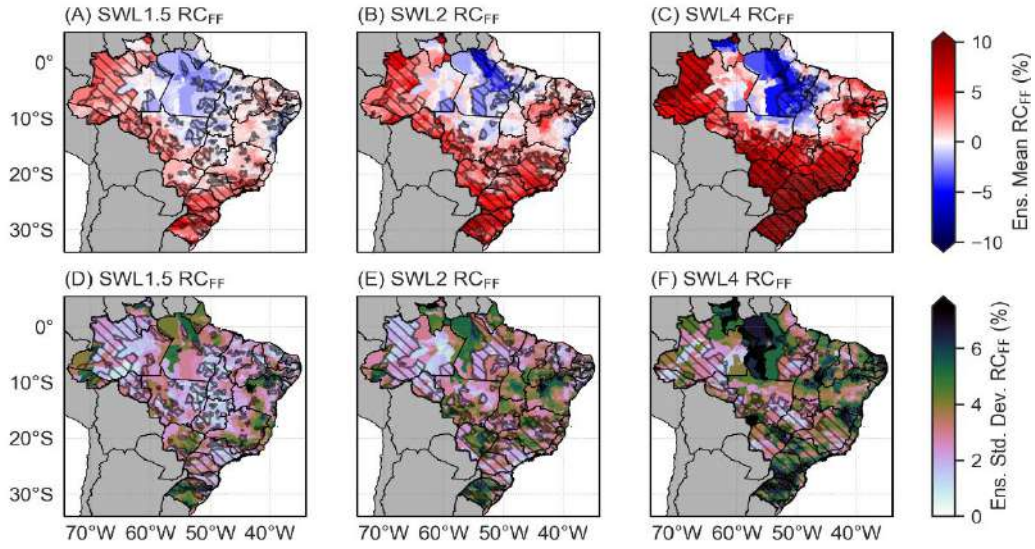

Figure 4.7.10 – Geographical distribution of the ensemble mean (top) and standard deviation (bottom) for relative changes of the potential impact index for flash floods (RCFF) with respect to the historical period under various scenarios: (A,D) SWL1.5; (B,E) SWL2; and (C,F) SWL4. The hatch pattern represents areas where the ensemble sign agreement presents values above or below +66% or -66%, respectively.

The results presented in the study above were obtained for all municipalities in Brazil, which allows extracting the calculated indices for specific municipalities. Thus, Table 1 summarizes the calculated indexes for the municipality of Blumenau, SC, since it was selected as the city for which will be constructed the landslide risk index which will incorporate the city exposition and vulnerability to the climate related disaster of landslide. The Blumenau landslide risk index generated will be presented and evaluated with local stakeholders, in order to prepare the adaptation strategy proposal for the city.

Table 1 – Results of Relative Change in the Potential Impact Index for Blumenau – SC and the level of agreement of the trend between the climate models used.

Hazard	**Statistical Metrics**	**Heating Scenarios**		
		1.5°C	**2.0°C**	**4.0°C**
Landslides	Relative Change (Increment)	+1.53%	+2.81%	+7.38%
	Level of Agreement	67%	100%	100%
Sudden floods, Flash floods, Floods	Relative Change (Increment)	+1.98%	+3.77%	+9.85%
	Level of Agreement	67%	100%	100%

The results presented in Table 1 suggest that there will be a significant increase in the Potential Impact Index, whether for landslides or sudden floods, floods and flash floods. It is important to emphasize that the percentage values of the increments refer to the relative comparison between the index calculated for future scenarios (defined by the warming levels) and the index calculated for the reference period (baseline, between 1961-1990). In addition, it should be noted that the values of these increments do not mean that future impacts will increase in the same proportion, given that - given the formulation of the index - the results are more related to the representation of the increase/decrease in the magnitude of the most extreme events, but not necessarily with the increase/decrease in the frequency with which they occur. In other words, the results are essential to subsidize the understanding that the intensity of events will increase, but the impacts can be much greater. First, because the concrete impacts depend on many variables and complex relationships between the various systems involved, but which are usually related to critical situations that can be reached in extreme cases, especially those without precedent. Secondly, because the frequency of extreme events is expected to also increase, what could further amplify the possibility of the boundary conditions being exceeded and, consequently, the related impacts.

-Critical Factor: Rainfall and Landslide events

The development of a tool to identify the major vulnerabilities of cities regarding natural disasters associated with climate change was initiated. It is being developed for the city of Blumenau, Santa Catarina, as previously defined during year 1 and year 2 of the project. Interaction with local partnerships were conducted during last year; thus, the research counts with the valuable collaboration of the local Secretariat of Civil Defense, the Secretariat of Urban Planning and the Municipal Health Department. They have been supporting the provision of important data for the analysis.

The tool shall 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 that is being developed for the city should be useful for the evaluation of their effectiveness for adaptation and sustainable development. The conceptual framework developed to assess the vulnerability of Brazilian municipalities with regard to natural disasters associated with climate change is written in a paper submitted by Menezes et al. (2021), which is in the review process.

-Critical factor: Hydrological Drought in the Northeast Semi-arid

In the previous project years, it was observed that the expected drought in the Semi-arid Northeast would impact the Padre Cícero Public Weir Reservoir, known as Castanhão (see report June 2019-June 2020), which is currently the largest freshwater reservoir in Ceará. Their waters are used for irrigated agriculture, fish farming, fishing (sports and subsistence) and supply the population of Fortaleza, the metropolitan region and the Pecém Port Complex. The proposal was to assess how much water scarcity in Castanhão should impact the city and define together with city stakeholder's adaptation strategies to mitigate the potential impact. For that, some state institutions, among them the Ceará Water and Sewage Company (Cagece), to know how the water supply in the chosen municipality is processed and we realized that currently this is made up of more than one reservoir (Castanhão and Gavião). When one of them does not have enough water for supply, the second reservoir meets this need; thus, the supply of Fortaleza and the metropolitan region is maintained. This adaptation strategy was just developed.

In this context, it was decided to direct the research to the municipalities that are around Castanhão and use the water from this reservoir for purposes other than human supply. It is

highlighted that due to the pandemic, contacts were suspended. On the other hand, during the research process, interaction with colleagues who were evaluating health vulnerability in the Brazilian semiarid region were made; thus, it was decided to work together with them to assess strategies to mitigate the health vulnerability of those municipalities that are also supplied by the Castanhão reservoir. We are aware that at this stage the Castanhão reservoir has benefited from the São Francisco River Integration Project (Pisf), which may reduce the danger of hydrological drought in it. The strategies that are being adopted to reduce the impact of the potential hydrological drought in the municipalities supplied by the Castanhão reservoir have been shown to be effective strategies for reducing their vulnerability and developing them. Over the next year, we will carefully observe its effective results.

4.7.4 Drought's risk monitoring and evaluation of their impacts in different regions/scales

In the context of drought risk monitoring, Bravo et al. (2021) developed a new drought composite index (DCI) to measure the intensity and frequency of the hazard component of meteorological drought. The DCI considers multiple indicators, such as precipitation, temperature, evapotranspiration, wind speed, relative humidity, and sunshine duration. The DCI was validated through an application to the Brazilian semiarid context. Concerning other drought indices, the results were compared with two ones to provide an initial validation, since they are not exclusively meteorological indices. The findings also indicate that the drought intensity is growing in this region in the last decades.

In the recent study conducted by Marengo et al. (2021b) "Drought in Northeast Brazil: a review of agricultural and policy adaptation options for food security", (Manuscript submitted for publication in Climate Resilience and Sustainability), a summary of strategies to cope with the possible impacts of droughts proposed by the government, farmers, civil society, and the private sector was presented. The study included approaches to adaptation to drought in the Northeast of Brazil, and among them, focusing on agricultural management, soil conservation, better management of water resources, funds transfer, and credits to affected small-scale farmers. In this study, key challenges for moving towards a more holistic risk management approach were identified.

Considering another relevant region in Brazil impacted by drought, Marengo et al. (2021c) evaluated the Pantanal region, one of the world's largest wetlands. This region, since 2019 has suffered a prolonged drought that has spelled disaster, and subsequent fires have engulfed hundreds of thousands of hectares. The lack of rainfall during the summers of 2019 and 2020 was caused by the reduced transport of warm and humid summer air from Amazonia into the Pantanal. Instead, a predominance of warmer and drier air masses from subtropical latitudes contributed to a scarcity of summer rainfall at the peak of the monsoon season. This led to prolonged extreme drought conditions across the region. This drought had severe impacts on the hydrology of the Pantanal. Hydrometric levels fell all along the Paraguay River. In 2020, river levels reached extremely low values, and in some sections of this river, transportation had to be restricted. Very low river levels affected the mobility of people and shipping of soybeans and minerals to the Atlantic Ocean by the Hidrovia -Paraná-Paraguai (Paraná-Paraguay Waterway). The study aimed to better understand the hydroclimatic aspects of the current drought in the Brazilian Pantanal and their impacts on natural and human systems. As a consequence of the drought, fires spread and affected natural biodiversity as well as the agribusiness and cattle ranching sectors.

Although drought events are less frequent in the South Region when compared to other regions of Brazil, when it occurs, they impact the water supply, agricultural production, and the generation of electricity. In this context, Fernandes et. al. (2021) presented an assessment of drought impacts on the agricultural sector and water resources from 1998 and 2020 in the Southern region of Brazil. For this, drought indices were calculated based on precipitation and

streamflow datasets, as well, satellite information. The most severe drought event occurred in the Paraná state in 2006; consequently, more than 80% of the agro-productive area were affected. Besides, an exceptional hydrological drought condition was identified in the affluent hydrographic basin (BHA) to the Segredo hydropower plant (UHE) by the Standard Streamflow Index (SSFI) and affluent streamflow below the 90th percentile during half of the year. In the 2019/2020 drought (Figure 4.7.11), the first quarter of 2020 was the most critical in terms of intensity and expansion, as indicated by the Integrated Drought Index, in which 100% of municipalities across the region were classified as drought conditions.

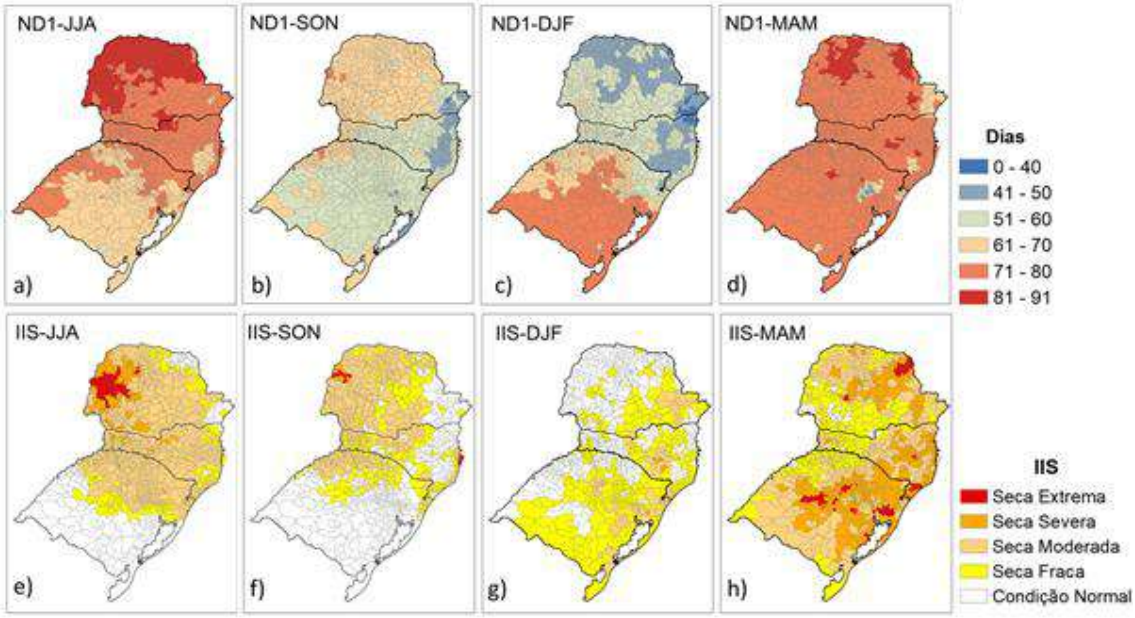

Figure 4.7.11: Number of days with precipitation below 1mm (ND1) (a-d) and Integrated Drought Index (IIS) (e-h) in the JJA, SON, DJF and MAM seasons of 2019/2020 at the municipality level for the Southern Region.

Water management in the Paraná River basin is quite complex, since it is associated with the hydropower generation, water supply and other water uses. Each hydropower plant (HPP) has specific legislation regarding the minimum and maximum outflows for a certain period of the year, in order to prevent flood events and also water scarcity. In the past, the number of legislations related to flood control in the Paraná River basin was higher than legislation associated with drought events. It is noteworthy that drought events in this basin are not frequent; however, when they occur, they cause serious impacts on electricity generation, navigation and public supply. For example, the case of the "blackout", which occurred in Brazil in 2001, stands out due to the low inflow to reservoirs and the consequent mismatch between the generation and demand for electricity. Management that favors hydroelectric power generation can trigger or mask drought events for some period of time. In recent years, it has been noted that the reservoirs in this region have low storage, as well as low inflow values. However, it appears that the outflow rates took a long time to be reduced, in order to adjust to the inflows and, in some reservoirs, it even increased, in order to favor water storage in certain regions. In this context, research is underway to analyze the worsening of the water crisis due to water resource management caused by the hydropower generation. For this, inflow data (blue lines, Figure 4.7.12), that actually reaches the reservoir, were compared with natural inflow data (green lines, Figure 4.7.12), which is the discharge that would eventually arrive, if the management of upstream reservoirs were neglected. It is possible to notice, through Figure 4.7.12, that the natural inflow follows the pattern of rainfall (not shown), with the wettest months at the end/beginning of the year (December to March) and drier months in the middle of the year (July to October). However, the management of water resources has modified this distribution pattern, making the values stable throughout the year. Preliminary results show that,

due to changes in water availability, drought events can be masked, due to the use of volumes stored in reservoirs as a way of supplying the water deficit; however, these volumes are capable of supplying water for a few months and may end up masking severe hydrological drought events.

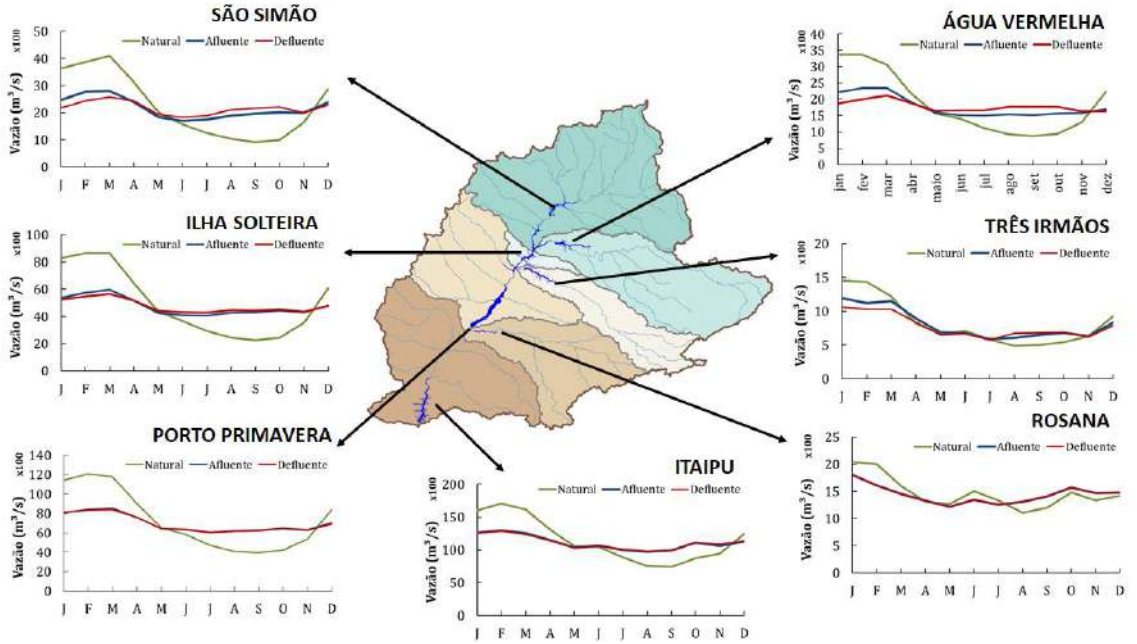

Figure 4.7.12. HPPs located in the Parana River basins and its inflows (blue lines), outflows (red lines) and natural discharge (green lines).

In the context of drought, a study focusing evaluation of dry spells and heat waves forecasts at the regional scale in Brazil was conducted (Cunninghan et al., 2021). Dry spells and heatwaves subseasonal forecasting, at regional scale in Brazil were analyzed. Subseasonal forecasting, dry spell and heatwaves are emerging topics with a high potential for subsidizing planning and preparedness to mitigate disaster impacts. The work indicates the potential for setting a forecast system to predict dry spells and heat waves in Brazil. The outline of a forecast system for a Climate Service is challenging and must be collaboratively among all interested parties.

4.7.5 Historical disaster databases related to the Itajaí and Northeast Regions: DesInventar System and S2ID

The databases on disaster losses are "a set of systematically collected records about disaster occurrence, damages, losses, and impacts, compliant with the Sendai Framework for Disaster Risk Reduction 2015-2030 monitoring minimum requirements." (UNDRR, 2016; P. 14). Thus, these data are fundamental inputs for disaster risk studies.

The Disaster Inventory System emerged in Latin America and the Caribbean, in the context of the International Decade for Natural Disaster Reduction, IDNDR (1990s), from the need for detailed data, emphasizing social variables, for studies on vulnerability (LA RED, 1992). DesInventar is a tool for creating National Disaster Inventories and a Disaster Information Management System, composed of databases, software, methodology, and a conceptual framework of reference. As a management system, DesInventar has a simple structure for compiling, systematic recording, organization, storage, documentation, and analysis of data on disaster losses, as well as for the maintenance and permanent updating of this data.

The Integrated Disaster Information System - S2iD was established in 2012 by the Brazilian government (BRASIL, 2012a); it is today the official national system for federal recognition of the emergency (EM) and state of public calamity (SPC) of the federated entities, as well as the

transfer of federal resources to cities and states affected by disasters (BRASIL, 2021). The system has an online platform where various products from the National Secretariat for Civil Defense and Protection - SEDEC are integrated, such as the historical series on EM and SPC, management reports of reported damages, and a digital file. In the digital archive, newspaper reports, ordinances, declarations, preliminary disaster notification (NOPRED), damage assessment forms (AVADAN), and disaster information forms (FIDE) are available in PDF format, replacing AVADAN since 2012. The documents provide data and information on damage and losses caused by disasters and types of threats according to the Brazilian Disaster Code - COBRADE (BRASIL, 2012b). The events are referred to the city and census sectors (spatial resolution); and, has coverage for the entire national territory from 1970 to the present.

The database on disaster losses related to the 24 municipalities located in the Itajai river basin (State of Santa Catarina) was composed for the period 2010 – 2016, based on 146 documents from the S2iD digital archive, of which 89 correspond to hydrological disasters, and 57 to flash floods. Beyond that, drought-related disasters data of 53 municipalities located in the portion of the State of Piauí with the greatest historical recurrence of drought events since the 1980s, according to Brito et al. (2018), from 2002 to 2012 were also included in this database within 152 individual forms. The DesInventar software, conceptual framework, and methodology was used, maintaining the five sectors affected categories grouping of the S2iD documents (AVADAN and FIDES): human damage (HD), material damage (MD), environmental damage (ED), economic loss (EL) and social losses (SL).

This study involved five stages of activities. **(i) Data Collection:** AVADAN and FIDES forms from the period 2010 - 2016 were selected for the municipalities located in the study area; **(ii) Data Homologation:** The correspondence between the fields (variables) available in the S2iD and DesInventar forms was evaluated; **(iii) Creation of BD**: Based on this approval, the extended form was created and the S2iD forms were registered on the DesInventar platform; **(iv) Preliminary Analysis of Database:** The first analysis was a descriptive statistics of the database; and (v) **Analysis of the Direct Cost and Economic Impact:** Finally, the monetary values were transformed into the Real value of the year 2019, using the World Bank Inflation Index; these updated amounts were then converted to the value of the US dollar using the official exchange rate of the Central Bank of Brazil for December of the same year. Damage (Environmental, Human, and Material) and Losses (Economic and Social) were analyzed based on these values.

4.7.6 Database of disasters related to drought to the Northeast region

In addition to the drought disasters database of 53 municipalities located in the state of Piauí from 2002 to 2016, which were firstly included in Desinventar, other data of the same state besides Ceará and Pernambuco (covering a total of 144 municipalities), from 2002 to 2020, are being included in the database through Excel spreadsheets, due to the period of update of that platform, according to S2iD data availability. Therefore, this database is supporting the analysis of socioeconomic impacts of drought events in these municipalities located in the semi-arid region included in the study area.

Preliminary results showed that about 2.5 million people were affected by drought from 2003 to 2020 in municipalities of the State of Piauí located in the study area. In this state, agriculture was the sector affected in 100% of the municipalities, followed by water supply, as exemplified in Table 2, while bean and corn were the main crops affected.

Table 2 - Main sectors affected by drought in the State of Piauí.

Year	Agriculture and Livestock	Water supply	Others (wildfire)

2003	100%	100%	-
2004	100%	94%	33%
2005	100%	33%	-
2006	100%	72%	-
2007	100%	82%	-
2008	100%	94%	6%
2009	100%	91%	-
2010	100%	92%	31%
2011	100%	100%	33%
2012	100%	88%	25%

* Percentage of municipalities in which the sectors were cited in relation to the total of municipalities.

The economic losses of the municipalities of Piauí State located in the study area are being estimated. In the period from 2003 to 2016, these losses were about BRL 1.4 billion (updated values for 2020). In this state, the municipalities that registered the greatest losses (both in agriculture and in total) were Pio IX, Jaicós, Fronteiras and Simões. It is noteworthy that between 2003 and 2009, the economic losses recorded in the database were predominantly relative to losses in agriculture, whereas from 2010, the values of losses associated with water supply (for example, due to the reduction in the water volume of reservoirs and, consequently, the need of water trucks for water supply) were also presented in AVADANs and FIDEs, increasing the value of economic losses. In addition, a comparison between economic losses and GDP (Gross Domestic Product) of each municipality (data from the Brazilian Institute of Geography and Statistics - IBGE) has also been carried out. These estimates have allowed the identification of the municipalities with the highest losses in Reais (BRL) and the municipalities that had the greatest losses in relation to their GDP, as exemplified in Figure 4.7.13.

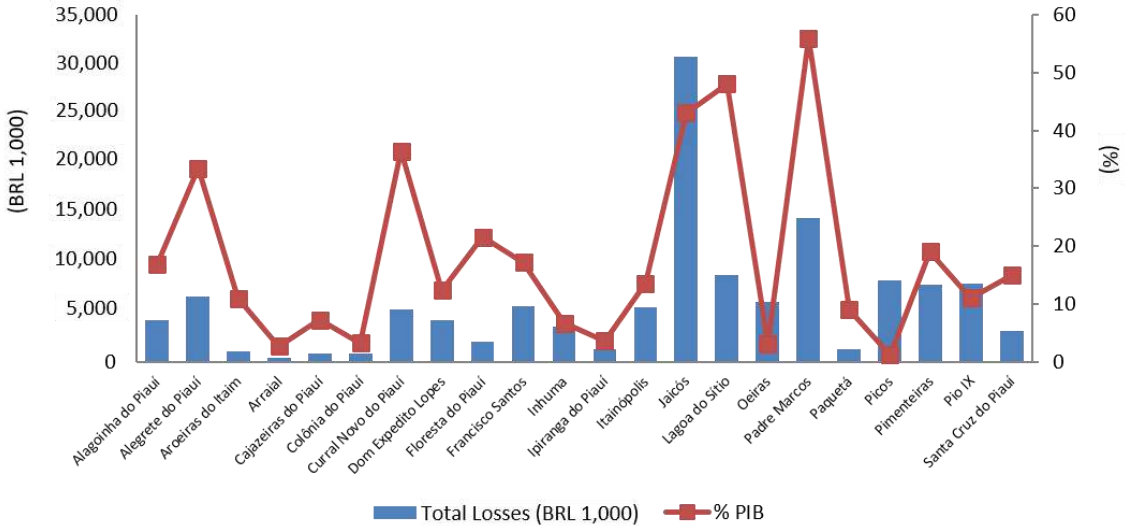

Figure 4.7.13 – Economic losses of municipalities of Piauí State in relation to GDP in 2010.

Furthermore, the specific economic losses of agriculture and livestock due to drought were compared to the gross value added of the agriculture and livestock sector to the GDP of the respective municipality, aiming to better identify the influence of these damages on GDP. Figure 4.7.14 shows this comparison for Pio IX, one of the municipalities in the state of Piauí that presented the greatest economic losses throughout the period analyzed. This graph indicates that, in general, there is a reduction in the gross value added of the agriculture and livestock to the GDP in years when losses in this sector due to drought are higher, indicating the importance of these activities for the municipality's economy.

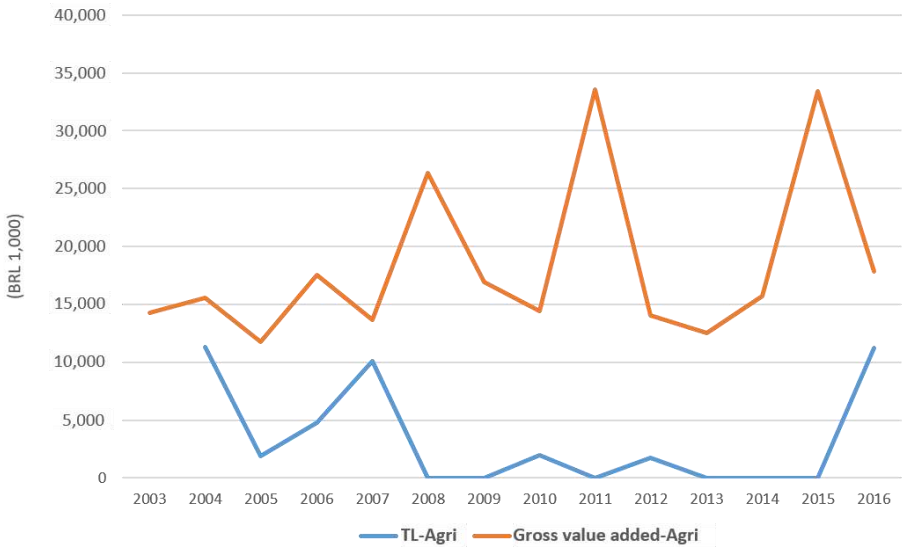

Figure 4.7.14 – Total losses of agriculture and livestock (TL-Agri) and the gross value added of this sector to the GDP of Pio IX throughout the historical series (no data = 0).

4.7.7 Economic Costs of Flash Floods in the Itajaí River Municipalities

In the INCT-MC-II progress report for the year 2019, preliminary results of the evaluation of the economic cost of the November 2008 disaster in Blumenau, caused by an extreme precipitation event, were presented. These results generated the hypothesis that other municipalities located in the basin, also affected by this event, would have had high economic costs; and, considering the conditions of threat and exposure to flash floods in this basin, that these impacts may be recurrent. To verify this hypothesis, and continuing the results presented in 2019, data on disaster losses caused by flash floods in 24 municipalities in the basin were selected from the S2ID database and processed in DesInventar.

Flash floods in Brazil, known as “Enxurradas”, fall into the category of natural threats that trigger, so to speak, “small” disasters. These events are associated with extensive disaster risk, that is, the likelihood of minor disasters occurring, but very often in small communities (UNDRR, 2016).

The analysis of historical data on flash floods losses in the Itajaí river basin, offers an interesting perspective of the real dimension of this threat and may offer subsidies to the knowledge of the vulnerability of local communities exposed to extensive risks, whose impact is often undervalued. These data are fundamental inputs for the development of economic studies, which aim to account for and value the costs of disasters; the economic approach is crucial for understanding some underlying causes of disasters, and therefore for identifying prevention and mitigation measures that can reduce losses. On the other hand, it offers evidence on the need to have specialized databases and quality protocols for the systematic, consolidated, continuous, and permanent survey, classification, organization, and recording of reliable data on small and frequent disasters in the country.

This study includes preliminary results related to the direct costs of hydrological disasters in the study area, with an emphasis on flash floods. Table 3 shows that the category of hydrological events represents 82% of the total losses due to disasters and only the flash floods were responsible for approximately a quarter of these losses. This flash floods-related cost (57 in total over the entire period) was only surpassed by the cost of some extreme flood events (2011, 2013, and 2015).

Table 3 – Total Losses related to **flash floods in the Itajaí river municipalities** highly exposed to flash floods for the period 2010-2016.

Sector	**Total value of losses (US$)**			**Losses by sector (%)**	
	All events	**Hidrológicos**	**Flash Floods**	**All events**	**Flash Floods**
Material Damage	155,268,903	140,599,892	35,241,190	90.55	22.70
Environmental Damage*	9,310,233	9,080,877	6,303,653	97.54	67.71
Economic Losses	228,743,731	168,170,571	36,688,228	73.52	16.04
Social Losses	67,431,154	62,526,295	19,005	92.73	0.03
Total value of losses	**449,978,414**	**370,221,472**	**108,637,392**	**82.28**	**24.14**
2019 Dollar Values					
* The record only includes information for the years 2010 and 2011 due to changes in the format of the forms					

Between 2010 - 2016, except in 2012, every year there were flash floods in the study area, in two periods per year, with peak losses in January and September (Figure 4.7.15). Although the frequency curve of occurrence follows the value of losses in almost the entire period, from the data it is observed that it would not be common to run flash floods in May, July, or November; however, in May 2010 there was a flash flood in Gaspar that generated losses of 9.9 million dollars.

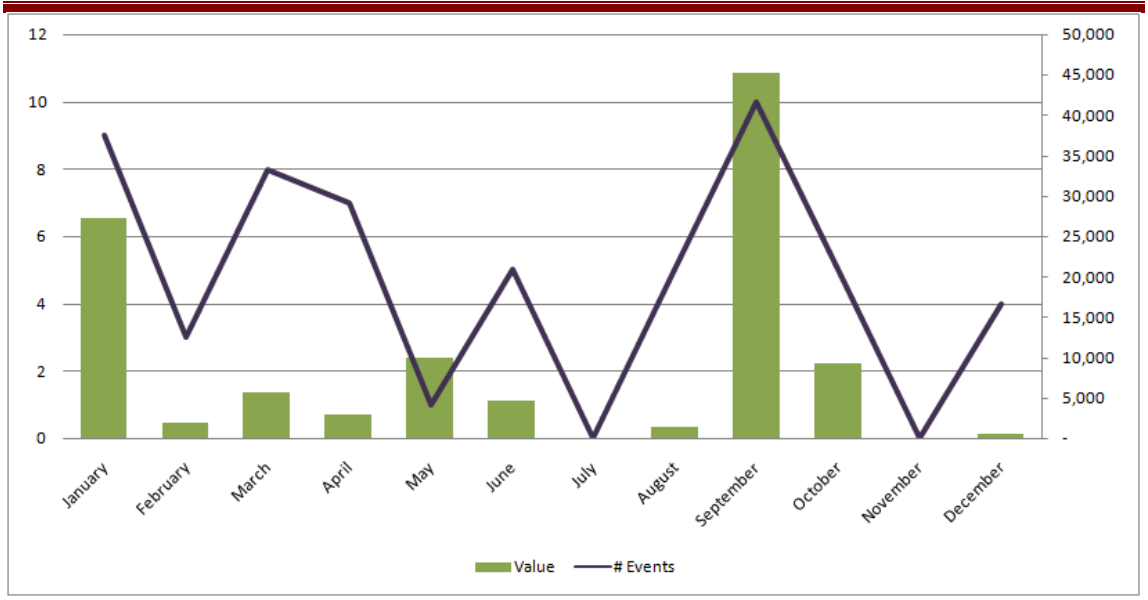

Figure 4.7.15 – Frequency and monthly value of flash floods for the period 2010 - 2016.

There is a record of at least one flash flood in the study period for 22 of the 24 municipalities analyzed. The municipality of Alfredo Wagner, where eight events were recorded (Figure 4.716), does not record the highest value of losses in this period. The municipality of Laurentino records five events and the highest value of total losses; when the value of losses from a single event (2011) is removed, they fall below the average for the period concerning all municipalities. From this observation, it may be possible to conclude that small events precede (and thus warn about) larger events, although less frequent. If this is correct, in the municipality of Alfredo Wagner an event could occur with losses higher than its average for the period.

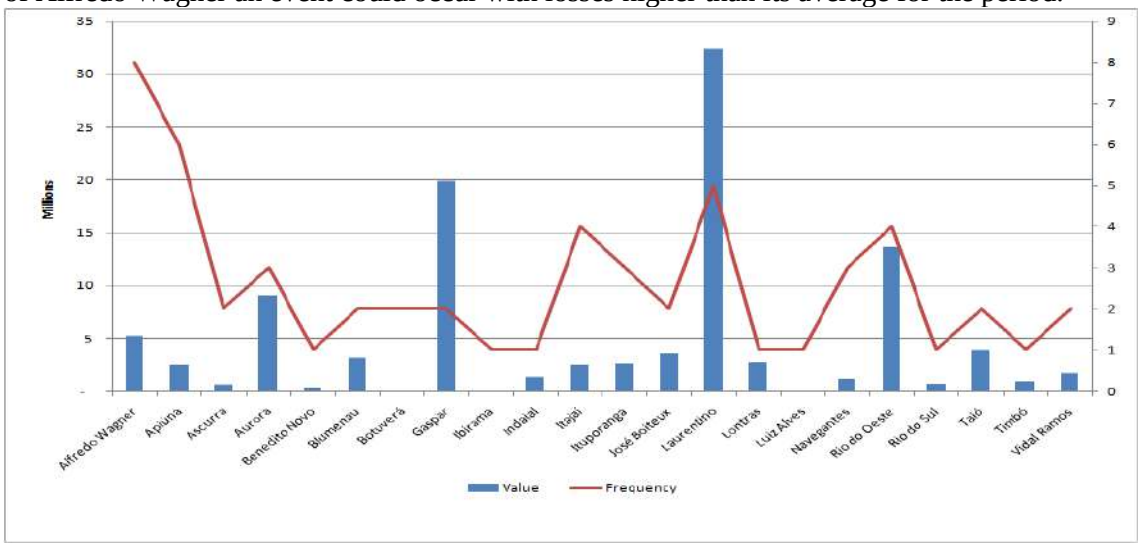

Figure 4.7 16 – Frequency and monthly value of flash floods period 2010 - 2016.

The data indicate that territorial planning processes should consider natural regions, such as river basins, in addition to administrative regions. The conditions of susceptibility and exposure to flash floods are common for all the municipalities analyzed, which are part of the same basin. The occurrence of flash floods in almost all municipalities in 2011 (Figure 4.7.17) highlights the possibility of a major event with damage to the entire basin, preceded by recurring events, but dispersed in time and space.

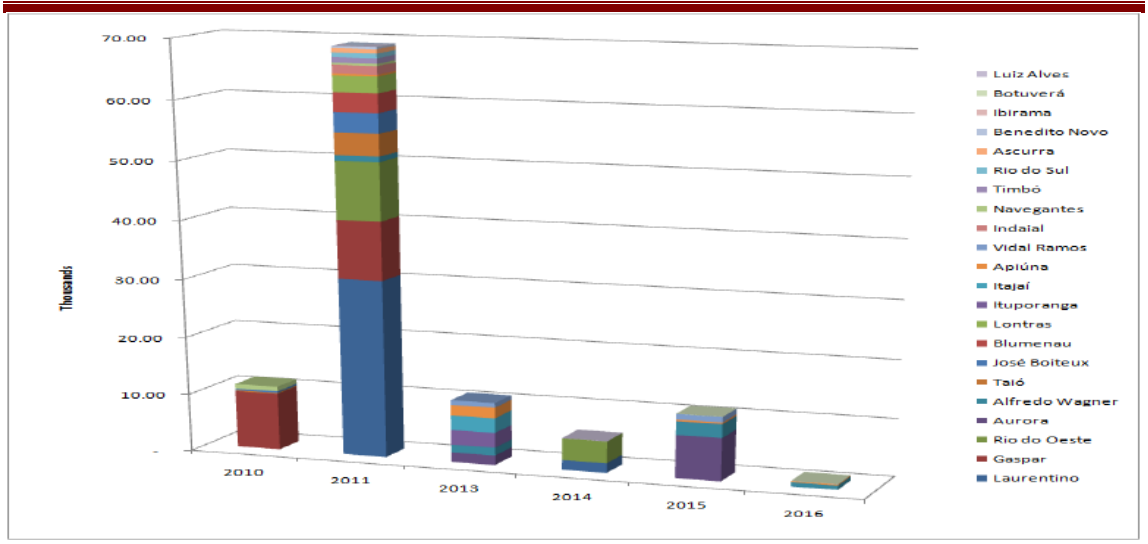

Figure 4.7.17 – Total value of losses by flash floods per year.

4.7.8 Proposition of strategies to promote the improvement of risk communication among the scientific community, public managers and the population

This phase of the project remains dependent on the ongoing evolution of COVID-19 pandemic, mainly on progress of the vaccine campaign. The initial plan considered the development of presential focus groups, a technique which demands interaction among the participants. Facing the current scenario of uncertainties related to the pandemic, the survey of qualitative data will be re-designing in order to assure social-distancing measures. Recent studies showed that the focus groups method could be adapted for an online model, including some advantages such as allowing the interaction of geographically-diverse participants and cost savings (Richard et al. 2021; Halliday et al. 2021). Notwithstanding the benefits of an online model, some limitations could affect the attendance of some stakeholders, e.g. lack of devices, internet limited access. The re-designing of the survey will consider these aspects to guarantee the participation of the scientific community, public managers and the population of the selected municipalities (Blumenau and a municipality of the Northeast region).

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4.8 Economy and impacts in key sectors

The most important results achieved by the group during the fourth year of the project are related to applications of different tools and databases developed in the first three 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 a model for Brazil's semiarid, a model for the Brazilian watersheds, and a model for Sã Paulo Metropolitan Region. In the first case, a study on the economic impacts of droughts has been concluded (Pimenta, 2020 -- Master thesis) with the participation of researchers from CEMADEN related to the sub-component "Natural Disasters, Urban Areas, Infrastructure, and Urban Development" of the INCT MC Phase 2; in the other two cases, researchers have concluded the model integration with hydrological models developed in collaboration with the subcomponent "Water Security". The regionalization method had been tested and implemented in different countries, such as Angola, Chile, Colombia, Greece, Paraguay, Mexico, and Morocco.

In this fourth year, the applications developed for Colombia will be 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 this fourth year, we addressed issues related to structural features of the Colombian regional system using the tools box developed in this project.

Finally, it should be mentioned that the modeling expertise and the tools developed in the context of the INCT were very successfully used to give prompt responses to policymakers in the context of the COVID-19 crisis control and monitor, especially providing elements to the State Government of São Paulo to develop its "São Paulo Plan", and officers from the MCTIC (Brazil), the Policy Center for the New South -- PCNS (Morocco), and the Banco de la República (Colombia). Many publications followed.

4.8.1 Integrated modeling

This has 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 1-3: (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, 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 of a country" has been submitted to Nature Communications (R/R).

During the fourth year 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.

4.8.2 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 year. 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 submitted to the journal Royal Society Open Science in November 2020. It was accepted for publication in May 2021, and it is available on the website: https://royalsocietypublishing.org/doi/full/10.1098/rsos.201854.

4.8.3 Climate change adaptation through rural labor market adjustments

The paper on labor supply responses to weather shocks, which was already in progress during the third year of the project, was concluded and published during the fourth year. The text "Weather Shocks and Labor Allocation: Evidence from Rural Brazil", by José Féres and Danyelle Branco, was published in the American Journal of Agricultural Economics. The authors show that agricultural workers adapt to weather-related shocks through labor market reallocations. In particular. more intense droughts are associated with a greater likelihood of holding more than one job, a lower share of agricultural employment, and more time spent performing a secondary job. The work may be found at https://onlinelibrary.wiley.com/doi/abs/10.1111/ajae.12171.

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)

Throughiut the four years, wWe 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).

Also, in the fourth year, we succeeded in receiving a grant under the CNPq call "CNPq/MCTI Nº 23/2020 – PESQUISA E DESENVOLVIMENTO EM SUSTENTABILIDADE URBANA E REGIONAL", with the project "MODELAGEM INTEGRADA E PROPOSIÇÃO DE INDICADORES PARA SUSTENTABILIDADE REGIONAL E URBANA NO BRASIL", led by Prof. Roberto Schaeffer (COPPE-

UFRJ) with the participation of members of this component as PIs. The Project is related to *Adapta-Brasil*.

Finally, in the context of Rede CLIMA and the INCT MC Phase 2, we received a grant from Finep involving collaboration/integration of researchers from FIOCRUZ, USP, UFMG, UFPR, UFJF and UFBA related to Economy and Health ("Saúde, Economia e Clima frente à COVID-19 no Brasil: Impactos Socioeconômicos e o Papel da Mitigação de Emissões de GEE na Recuperação Econômica").

Current initiatives for additional fund raising include negotiations with the World Resources Institute, to join the New Economy for the Amazon (NEA) project, and a collaboration with COPPE-UFRJ in a project for the State of Pernambuco. Initial negotiations with the MCTIC to develop a project on "MODELAGEM E CONSTRUÇÃO DE BASE DE DADOS DE SOLUÇÕES E INDICADORES DE PLANEJAMENTO URBANO SUSTENTÁVEL/OICS DO PROJETO GEF" are also underway

Following up on the INCT-MC meeting hosted at FEAUSP on November 30, 2018, we moved on to enhance interactions with the "Natural Disasters" subcomponent on issues related to urban mobility. After a meeting hosted by CEMADEN on February 26, 2019, we agreed to collaborate on a study using the Uber database and the study on drought in the Brazilian semiarid. While the latter has been developed during the third-fourth year, the former is expected to gain momentum next year.

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

4.9.1 BESM model

During this period, a new version of BESM version 3.0 has been developed. The new version incorporates 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. BESM3.0 also incorporates improvements on the ocean grid mesh, with improved grid spacing towards the poles.

This research paper depicts CMIP5 and CMIP6 models responses to Abrupt4x increases of atmospheric CO2 regarding seasonal response of polar amplification of air temperature responses, contrasting to those generated by BESM2.5. Figure 4.9.1 below illustrates one of the paper's main findings.

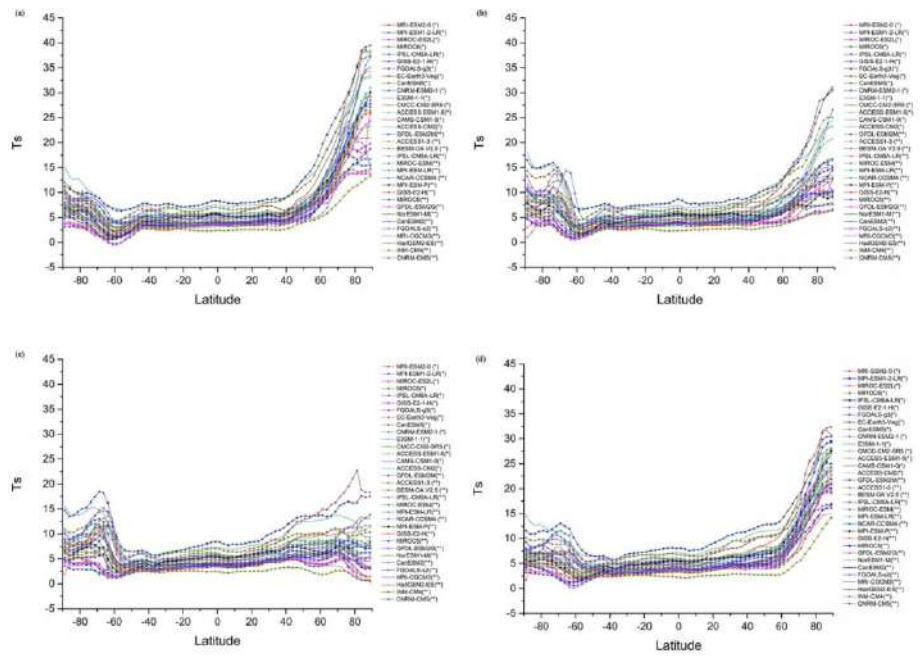

Figure 2. Seasonal zonal mean surface temperature differences (K) for the last 30 years of the Abrupt-4 × CO_2 numerical experiment minus the last 30 years of the piControl run for the CMIP5 and CMIP6 models for **(a)** winter (DJF), **(b)** spring (MAM), **(c)** summer (JJA) and **(d)** fall (SON).

Figure 4.9.1 - CMIP5 and CMIP6 models temperature responses to Abrupt4xCO2 scenario.

The Brazilian Earth System Model (BESM-OA2.5), while simulating the historical period proposed by the fifth phase of the Coupled Model Intercomparison Project (CMIP5), detects an increasing trend in the sea surface height (SSH) on the southern hemisphere oceans relative to that of the pre-industrial era. The increasing trend is accentuated in the CMIP5 RCP4.5 and RCP8.5 future scenarios with higher concentrations of greenhouse gases in the atmosphere. This study sheds light on the sources of such trends in these regions. The results suggest an association with the thermal expansion of the oceans in the upper 700 m due to a gradual warming inflicted by those future scenarios. BESM-OA2.5 presents a surface height increase of 0.11 m in the historical period of 1850–2005. Concerning future projections, BESM-OA2.5 projects SSH increases of 0.14 and 0.23 m (relative to the historical 2005 value) for RCP4.5 and RCP8.5, respectively, by the end of 2100. These increases are predominantly in a band of latitude within 35–60°S in the Atlantic and Indian oceans. The reproducibility of the trend signal detected in the BESM-OA2.5 simulations is confirmed by the results of three other CMIP5 models. (Fig. 4.9.2)

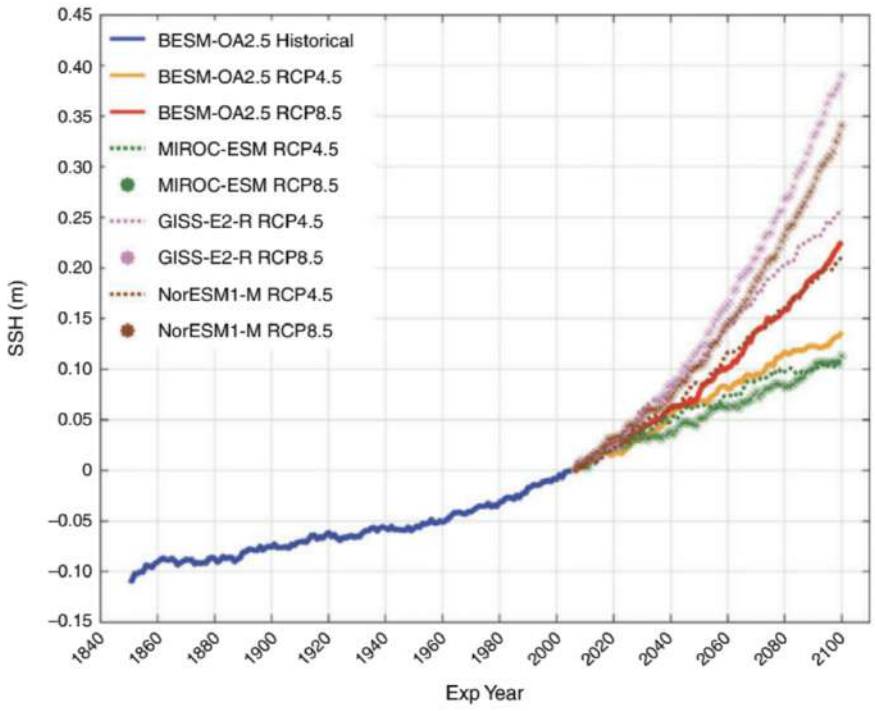

Fig. 1. Time series of the mean annual SSH (m) in the southern hemisphere oceans (10–60°S, 180°W–180°E) from the historical RCP4.5 and RCP8.5 runs, as simulated by BESM-OA2.5. Time series of the SSH variations from MIROC-ESM, GISS-E2-R, and Nor-ESM1-M for RCP4.5 and RCP8.5 are also shown. The values are relative to the last year of each model's historical experiment, being positive in the RCPs and negative in the historical curves.

Figure 4.9.2 - Southern Hemisphere sea surface height time series intercomparison of BESM2.5 to other CMIP5 models for radiative concentration pathways (RCP) 4.5 and 8.5.

This component reports the developments of the Spectral Diagram (DE) algorithm, which provides a new way of comparing time series in the frequency domain by bringing together amplitude, phase and spectral energy variations in a single graph. The versatility of the DE is demonstrated through a series of comparisons of the model's high resolution tides with tidal time series spread around the world. (Figure 4.9.3)

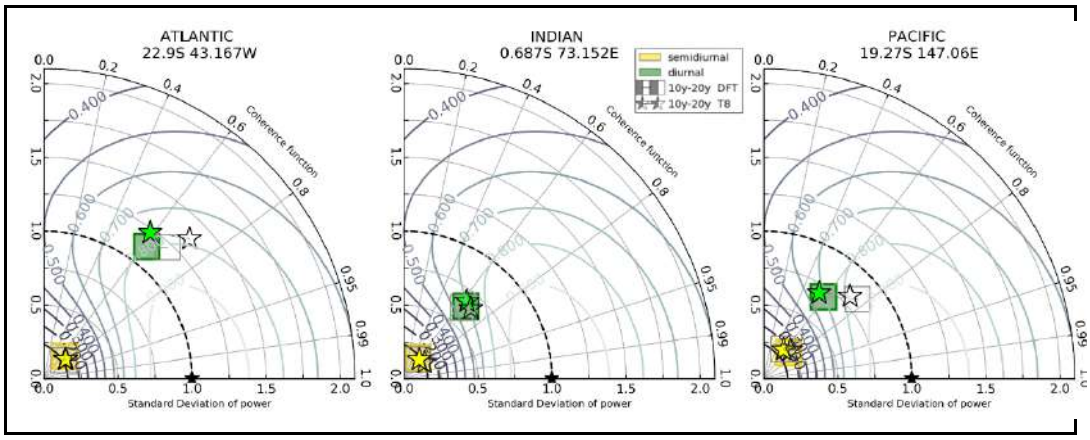

Figure 4.9.3 - Spectral diagrams for phase and amplitude of tides over the Atlantic, Indian and Pacific Oceans.

4.9.2 Development of the Regional Earth System Model –

4.9.2.1 Coupling with the Dynamic vegetation model: Eta-Inland.

The impacts on the Amazon, Cerrado and Atlantic Forest biomes were obtained using the decoupled version of INLAND forced with the Eta-HadGEM2-ES model. In the period 2055-2065, some tropical forest areas in the southern part of the Amazon Biome are replaced by Savannah in the RCP4.5 scenario and by natural pasture in the RCP8.5 scenario. At the end of the century (2085-2095) the grid points with vegetation of the Tropical Forest type are reduced and much of the area defined as the Amazon Biome is replaced by vegetation of the Deciduous Forest or Natural Pasture type. When comparing the changes in vegetation types with the temperature and precipitation projections in the RCP4.5 and RCP8.5 scenarios, it is noted that the pattern of change in the vegetation type is strongly determined by the pattern of change in these variables.

In the Cerrado Biome, the impacts are greater and even in the middle of the century, changes in the types of vegetation that cover practically the entire area of the Cerrado are already projected. Considering both emission scenarios, in almost the entire area, the initial vegetation types such as Savannah and Deciduous Forest are replaced by the Natural Pasture vegetation type. By the end of the century this same pattern of change has continued. Although land use is not considered in this study, a large part of the Cerrado Biome area is already degraded or used for agriculture. Therefore, the impacts caused by climate change in this Biome need to be known.

The projected impacts on the Atlantic Forest Biome are different, the northern regions of this biome have greater changes in vegetation types than the southern regions. The areas of the Atlantic Forest Biome of the States of Santa Catarina and Paraná and part of the State of São Paulo remain unchanged in both RCPs scenarios. However, in the areas of the Atlantic Forest Biome in the States of Espírito Santo and Bahia, changes in the type of vegetation are projected for Natural Pasture or some areas for Savannah.

This version of the Eta-INLAND model developed during postdoctoral research is capable of projecting changes in biomes. Although processes involving the impact of increased CO2 on

plants still need to be improved, the impacts are differentiated in each Biome, and thus, adaptation or mitigation measures can be designed based on the information presented in this study.

4.9.2.3 Influence of different scenarios of land use and land cover in Amazonia on the climate change projections over the La Plata River Basin – Coupled Eta - NOAH-MP (Isabel Pilotto)

The Amazonia has an important role in the moisture transport that influences precipitation over La Plata River Basin. Therefore, it is interesting to know the potential effects that the land use and land cover change in the Amazonia have on the water balance over La Plata River Basin. The study aims to adapt the regional projections of climate change including plausible scenarios of land use and land cover, developing knowledge on this topic.

The effect of Amazon deforestation on future climate (2011-2040) simulated by the Eta/Noah-MP nested to CanESM2 model RCP4.5 is predominantly local, indicating a reduction of up to 2 mm day-1 of precipitation in DJF, and a warming of approximately 3oC in JJA.

Figure 4.9.4 shows that the simulated climate for 2011-2040 considering climate changes due to increased CO2 and land use changes in the Amazon, produces an increase in moisture transport in the Amazon, Northeastern region of Brazil and southern of La Plata River. This result may be indicative of an increase in flood events in the rainy season. Also found a reduction in moisture transport in the Southeast region of Brazil and in the north of La Plata River Basin, suggesting an increase in drought events in the rainy season. Note that in the region of the La Plata River Basin, the effect of changes in land use on moisture transport is dominant (Figure 1b). The impact considering only land use changes was the oppositive in the Amazon (Figure 1b).

(a) (b)

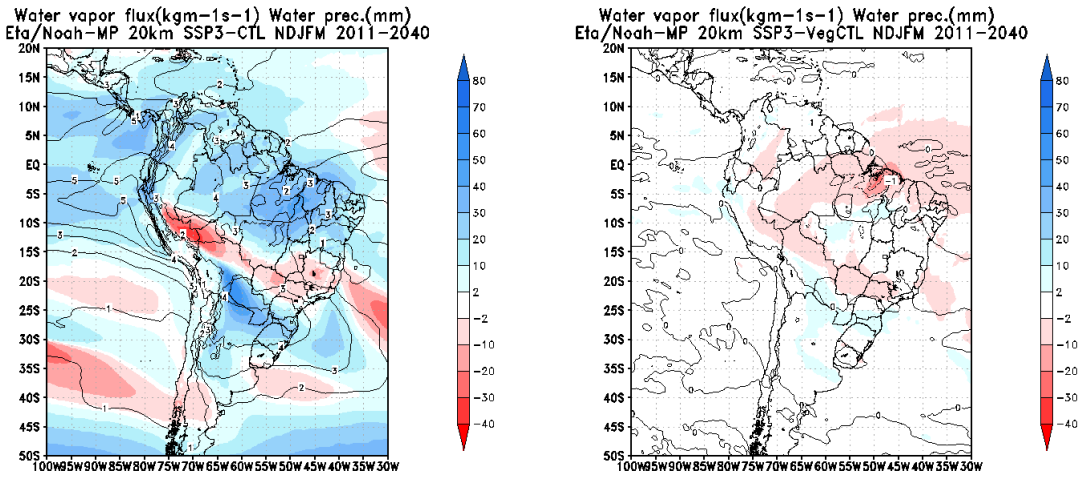

Figure 4.9.4 (a) Difference in vertically integrated moisture transport (kg $m^{-1}s^{-1}$, shading) between the future climate (2011-2040), and the climate present (1961-1990) for NDJFM. (b) Difference in vertically integrated moisture transport (kg $m^{-1}s^{-1}$, shading) of future climate (2011-2040) between the runs considering land use changes and without land use changes for NDJFM. The contour areas correspond to precipitable water (mm).

4.9.2 Assessment of CMIP6 Performance and Projected Temperature and Precipitation Changes Over South America

The performance of a large ensemble of Global Climate Models (GCMs) from the Coupled Model Intercomparison Project Phase 6 (CMIP6) was assessed over South America for a recent past reference period and examine their projections of twenty-first century precipitation and

temperature changes. The future changes are computed for two time slices (2040–2059 and 2080–2099) relative to the reference period (1995–2014) under four Shared Socioeconomic Pathways (SSPs, SSP1–2.6, SSP2–4.5, SSP3–7.0 and SSP5–8.5). The CMIP6 GCMs successfully capture the main climate characteristics across South America. However, they exhibit varying skill in the spatiotemporal distribution of precipitation and temperature at the subregional scale, particularly over high latitudes and altitudes. Future precipitation exhibits a decrease over the east of the northern Andes in tropical South America and the southern Andes in Chile and Amazonia, and an increase over southeastern South America and the northern Andes—a result generally consistent with earlier CMIP (3 and 5) projections. However, most of these changes remain within the range of variability of the reference period. In contrast, temperature increases are robust in terms of magnitude even under the SSP1–2.6. Future changes mostly progress monotonically from the weakest to the strongest forcing scenario, and from the mid-century to late-century projection period. There is an increase in the seasonality of the intra-annual precipitation distribution, as the wetter part of the year contributes relatively more to the annual total. Furthermore, an increasingly heavy-tailed precipitation distribution and a rightward shifted temperature distribution provide strong indications of a more intense hydrological cycle as greenhouse gas emissions increase. The relative distance of an individual GCM from the ensemble mean does not substantially vary across different scenarios. There was found no clear systematic linkage between model spread about the mean in the reference period and the magnitude of simulated sub-regional climate change in the future period. Overall, these results could be useful for regional climate change impact assessments across South America (Figures 4.9.5 and 4.9.6)

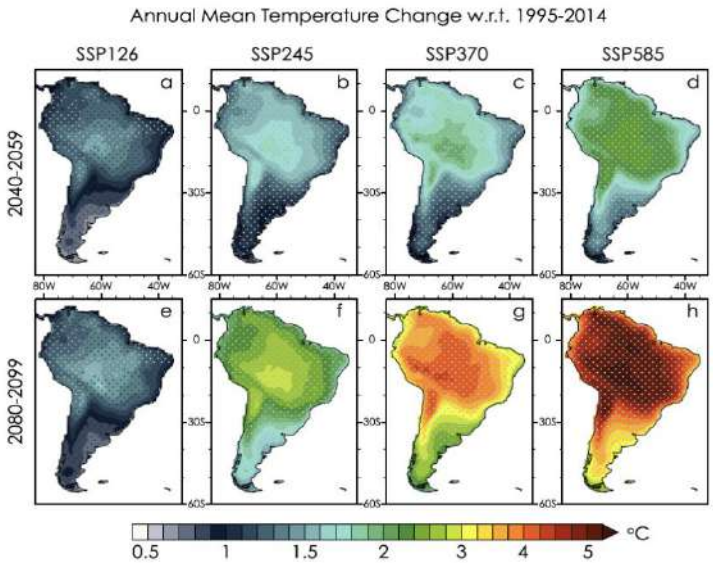

Figure. 4.9.5. Annual temperature change (C) in the mid-century (2040–2059; a–d) and late-century (2080–2099; e–h) futures with respect to the reference period (1995–2014) under all four future scenarios. terms of the sign of change. Black stippling represents the regions where projected changes are greater than baseline variability (1 Standard deviation; 1SD) while white dots represent the regions where projected changes are greater than twice the baseline variability (2 SD) (Almazroui et al. 2021)

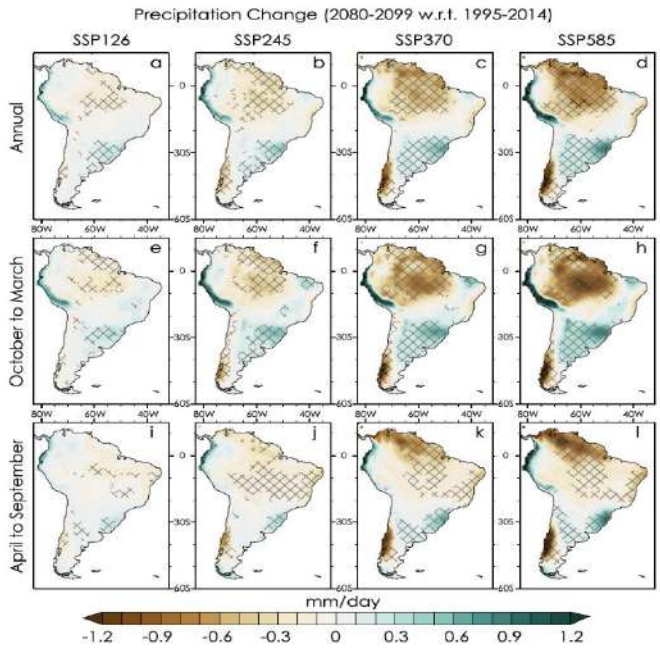

Figure. 4.9.6. Precipitation change in the mid-century future (2080–2099; mm/day) with respect to the reference period (1995–2014) under all four future scenarios a–d annual, e–h October–March, i–l April–September. Gray stippling represents the regions where projected changes are robust in terms of the sign of change, meaning that at least 66% of GCMs agree on the sign of precipitation change. Mid-century changes in the precipitation amplitude (m-p; mm/day) in all four future scenarios. All changes in amplitude are robust in terms of the sign of change (Almazroui et al. 2021)

4.10 Communication, dissemination of knowledge and education for sustainability.

4.10.1 Production of journalistic material

The Cross Cutting Theme Communication of the INCT (National Institute of Science and Technology) MC2, during the period from June 2020 to June 2021, heavily invested in the production of journalistic material to publicize the work carried out by the different components of the INCT for Climatic Change Phase 2, and this was facilitated by Gláucia Pérez, a student holder of a TT scholarship, and publications in the ClimaCom Journal. Unlike conventional and massive efforts on dissemination with focus on the informational dimension, opinion and slogans, when the subject is climate change, the group work focused on the practices of the scientists and the methodological dimension of their research, an effort strongly inspired by the studies of the philosophy of sciences by Isabelle Stengers and Bruno Latour. Such emphasis was more intense in the video-report (PÉREZ, DIAS, 2020a) carried out with the Water security subcomponent, considering the possibility, before the pandemic, of visiting the laboratory, contacting the advisees' team of the coordinator Mário Mendiondo, as well as accessing spaces, materials, procedures and ongoing experiments. With the pandemic, we had to focus exclusively on papers produced by the INCT researchers.

One of the pursuits of journalistic production was entering the publications and conducting interviews as someone who also accesses an architectural, practical, material, aesthetic and ethical dimension of the INCT research (PÉREZ, DIAS, 2020b, 2020c, 2020d, 2020e…). In terms of the research carried out by the Scientific Dissemination Network, which is part of this cross cutting theme, we highlight the studies that problematize our times, the ways that they have been called Anthropocene and Chuthulucene, for instance, assessing how these gestures of naming are part of our movements to domesticate reality and/or to translate possibilities of

destabilizing our conceptual schemes and making, in symbiosis, a new driving force in the human relations with the Earth (TADDEI, SCARSO, CASTANHEIRA, 2020; MATTOS, AMORIM, 2020). The assessment of perceptions related to climate change remains an important focus of the group. This year, in particular, the studies carried out with public managers on the effects of climate change in the coastal region of the state of São Paulo stand out, and they show that, despite being increasingly concerned about the hyper problem of climate change, there is a lack of an effective capacity of elaboration of public policies capable of mitigating the expected impacts (PERES, NEVES, TADDEI, 2020).

The group of researchers on this cross cutting theme continues to focus, when investigating climate change, on materials and spaces for scientific and cultural dissemination (films, literary and artistic works, among others) and, this year, we have emphasized in the group analyses: the relationships of power involved in cultural pedagogy, that is, in the ways in which they participate in the constitution of ourselves and others (MATTOS, AMORIM, 2020); the potencies of creating plural meanings for science, multiplying the possibilities of enjoyment by the public and generating an experience of coexistence with sciences that are not distant from life, from the fluctuations of chance, from the impermanence and the transformations (GARCIA, 2021); the need for thoughts that are aligned with non-humans and that are open to the perspectives of Amerindian peoples in order to generate new ecologies of emissions and disseminations that are capable of producing a shamanic-becoming of sciences and communicating systems, opening them up to the continuous movement of innovation and differentiation (DIAS, WIEDEMANN, 2021).

Several studies and creations of dissemination materials this year were carried out in partnership with people from the Kariri-Xocó and Tupi-Guarani ethnic groups (WUNDER et al, 2021; DIAS, VILELA, 2021; DIAS, FERREIRA, 2021) and these have strongly shown how the songs, the medicine, the narratives and the dreams of these peoples are lived in complicity with the universe of the plants, and also how the plants emerge as “beings who have taken care of everything that exists for thousands of years” (WUNDER et al, 2021). Based on perspectives such as the multispecies studies and the ecological epistemologies, part of the group has worked to turn trees, rivers, clouds, rains, bioluminescent beings, and so on, as effective research partners (DIAS, WIEDEMANN, 2021; DIAS, VILELA, 2021, WUNDER, 2021), while analyzing the consequences of these partnerships for communication on climate change. The three dossiers of the ClimaCom Journal that were published in this period, with the themes ““Devir criança” (Becoming child) (DIAS, RODRIGUES, 2020), “Epidemiologias” (Epidemiologies) (DIAS, RODRIGUES, 2020) and “Coexistências e cocriações” (Coexistences and co-creations) (DIAS, RODRIGUES, BELLINI, SOUZA , 2021), are also a kind of laboratory-atelier for these ideas, when researchers from the various components and cross cutting themes of this INCT, in addition to other guests, join with articles, essays, subscribed columns, news, reports, photo essays, workshops, and so on.

The multiTÃO research group, from Labjor-Unicamp, expanded the actions of the ClimaCom Journal with a new project - “Arvorecer de casa em casa” - which brought to the journal the relationship with the Tupi-Guarani village Awa Porungawa Dju and ten artists that work with different languages and materialities. The book “Experiências de arvorecer” (Treelike experiences) (DIAS, VILELA, 2021), funded by the Aldir Blanc Law, was the first production resulting from this encounter and it offers thought on what a forest book can be, establishing relationships between the practices and knowledge of the original peoples, from ecology and the arts, bringing into relation sciences, phytotherapy, cosmology and Amerindian art, embroidery, female clowning, puppet theater, creative writing, collages and drawings.

4.10.2 Results from interviews

The work by Gláucia Pérez, Fapesp TT3 scholarship holder, was done by interviewing researchers linked to all sub-components and cross-cuting themes of INCT aiming to produce

journalistic material (news, interviews, story, etc.) both to ClimaCom Journal and INCT sites. The following interviews were published:

1) O desafio de dar visibilidade às complexas relações entre humanos e rios (The challenge of giving visibility to the complex relationships between humans and rivers):
http://climacom.mudancasclimaticas.net.br/relacoes-humanos-rios/
Researcher: Mário Mendiondo and his team of advisees, from the INCT for Climate Change Phase 2, the Water security subcomponent

2) Reinvenção do agora e do porvir: novo livro dá a pensar nas mudanças climáticas para além do já dado (Reinventing the now and what is to come: new book makes thinking climate change beyond what has already been said)
http://climacom.mudancasclimaticas.net.br/conversasinfinitas/
Researcher: Susana Oliveira Dias, from the INCT for Climate Change Phase 2, Cross Cutting Theme Communication, dissemination of knowledge and education for sustainability

3) Etnógrafos podem ser colaboradores importantes em grupos multidisciplinares quando são participantes ativos nas pesquisas (Ethnographers can be important collaborators in multidisciplinary groups when they are active participants in research)
http://climacom.mudancasclimaticas.net.br/etnografos/
Researcher: Marko Monteiro, from the INCT for Climate Change Phase 2, Cross Cutting Theme Communication

4) A urgência de dar atenção à relação entre meio ambiente e doenças, o exemplo da Leishmaniose (The urgency to pay attention to the relationship between the environment and diseases, the example of Leishmaniasis)
http://climacom.mudancasclimaticas.net.br/leishmaniose/
Researchers: Everton Falcão de Oliveira, Instituto Integrado de Saúde, Universidade Federal de Mato Grosso do Sul/UFMS; Eunice Aparecida Bianchi Galati, Departamento de Epidemiologia, Faculdade de Saúde Pública, USP; Alessandra Gutierrez de Oliveira, Instituto de Biociências, Universidade Federal de Mato Grosso do Sul/UFMS; Elizabeth Ferreira Rangel, from the INCT for Climate Change Phase 2, Health subcomponent; Bruno Moreira de Carvalho, Laboratório Interdisciplinar de Vigilância Entomológica em Diptera e Hemiptera, Instituto Oswaldo Cruz, Fundação Oswaldo Cruz, Rio de Janeiro/RJ.

5) Sustentabilidade da Amazônia requer alianças entre cientistas e comunidades tradicionais (Amazon sustainability requires alliances among scientists and traditional communities)
http://climacom.mudancasclimaticas.net.br/sustentabilidade-da-amazonia/
Researcher: Carlos Nobre, senior researcher at the Instituto de Estudos Avançados/USP, and professor at the postgraduate program at INPE

6) Pesquisador relata perseguição à pesquisa relacionada com a Covid-19 pelo governo federal (Researcher reports persecution of Covid-19-related research by the federal government)
http://climacom.mudancasclimaticas.net.br/ataque-a-ciencia/
Researcher: Pedro Hallal, professor, scientist and former dean or the Universidade Federal de Pelotas/UFPel

7) Metodologia Nexus+ propõe abordagem integrada para tratar de vulnerabilidades relacionadas às mudanças climáticas (Nexus+ Methodology proposes an integrated approach to address vulnerabilities related to climate change)
http://climacom.mudancasclimaticas.net.br/metodologia-nexus/
Researchers: Sonia Maria Viggiani Coutinho, from the Instituto de Estudos Avançados/USP; Diogo V. Santos, Ministério da Ciência, Tecnologia, Inovações e Comunicações/MCTI; Marcel Bursztyn, Centro de Desenvolvimento Sustentável/UnB; José Antônio Marengo, Coordinator of the INCT for Climate Change Phase 2, Climate change, and researcher at Cemaden/MCTI;

Saulo Rodrigues-Filho, Centro de Desenvolvimento Sustentável/UnB; André F. P. Lucena, researcher at Universidade Federal do Rio de Janeiro/UFRJ; Daniel Andres Rodriguez, researcher at Universidade Federal do Rio de Janeiro/UFRJ; Stoécio Malta Ferreira Maia, researcher at Instituto Federal de Alagoas

8) Imagens poéticas nos aproximam de Gaia: diálogos entre ciências e filosofias (Poetic images bring us closer to Gaia: dialogues within sciences and philosophies)
http://climacom.mudancasclimaticas.net.br/imagens-poeticas/
Researchers: Ailton Krenak, professor, philosopher, indigenous leader and environmentalist; Antônio Nobre, retired researcher from the Instituto Nacional de Pesquisas Espaciais/INPE

9) Pesquisas com a Amazônia se esforçam para garantir dados e análises vitais para a sociedade (Amazon surveys strive to ensure society with vital data and analysis)
http://climacom.mudancasclimaticas.net.br/fapesp/
Researchers: Adalberto Luis Val, professor and researcher at the Instituto Nacional de Pesquisas da Amazônia (INPA), and coordinator of the Instituto Nacional de Ciência e Tecnologia Adaptações da Biota Aquática da Amazônia (INCT/Adapta); Carlos Nobre, senior researcher at the Instituto de Estudos Avançados/USP, professor of the graduate program of the INPE; Gilberto Câmara Neto, assistant director for the UN Earth Observation Group, and former diretor at INPE; Paulo Artaxo, from the INCT for Climate Change Phase 2, Impacts on Brazilian ecosystems in view of changes in land use and biodiversity subcomponent

10) Aumento da invasão às unidades de conservação, desmatamentos e queimadas estão destruindo biomas (Increased invasion of conservation units, deforestation and fires are destroying biomes)
http://climacom.mudancasclimaticas.net.br/destruicaobiomas/
Researchers: Margareth Copertino, associate professor at the Instituto de Oceanografia da Universidade Federal do Rio Grande/FURG; Maria Teresa Fernandez Piedade, head researcher at the Instituto Nacional de Pesquisas da Amazônia/INPA; Ima Célia Guimarães Vieira, head researcher at the Museu Paraense; Emilio Goeldi Mercedes Bustamante, from the INCT for Climate Change Phase 2, Impacts on Brazilian ecosystems in view of changes in land use and biodiversity subcomponent

11) Pesquisadores monitoram o vasto sistema de água doce subterrânea na região amazônica (Researchers monitor the vast underground freshwater system in the Amazon region)
http://climacom.mudancasclimaticas.net.br/aquiferofreatico/
Researchers: Alderlene Pimentel Brito, scholarship holder at Instituto Nacional de Pesquisas da Amazônia/INPA; Javier Tomasella, Centro Nacional de Monitoramento e Alertas de Desastres Naturais/CEMADEN; Ingo Daniel Wahnfried, Universidade Federal do Amazonas/UFA; Luiz Antônio Cândido, Instituto Nacional de Pesquisas da Amazônia/INPA; Maria Terezinha Monteiro, Instituto Nacional de Pesquisas da Amazônia/INPA; Sávio José Filgueiras Ferreira, Instituto Nacional de Pesquisas da Amazônia/INPA

12) Residências reúnem indígenas e não indígenas em criações conjuntas de arte digital (Residencies bring together indigenous and non-indigenous people in joint digital art creations)
http://climacom.mudancasclimaticas.net.br/aire/
Researcher: Susana Oliveira Dias, from the INCT for Climate Change Phase 2, Cross Cutting Theme Communication, dissemination of knowledge and education for sustainability

13) Estudo considera consequências da Covid-19 para o desenvolvimento sustentável (Study considers the consequences of Covid-19 for sustainable development)
http://climacom.mudancasclimaticas.net.br/ods/
Researchers: Alejandro López-Feldman, Centro de Investigación y Docencia Económicas (CIDE) y Tecnológico de Monterrey, Ciudad de México/MX; Carlos Chávez, Universidad de Talca, Facultad de Economía y Negocios y Centro Interdisciplinario para la Investigación

Acuícola (Incar), Talca, Chile; María Alejandra Vélez, Universidad de los Andes, Facultad de Economía, Bogotá, Colombia; Hernán Bejarano, Centro de Investigación y Docencia Económicas (CIDE), Ciudad de México/MX; Ariaster B. Chimeli, Universidad de São Paulo/USP; José Gustavo Féres, from the INCT for Climate Change Phase 2, Economy and impacts in key sectors subcomponent, Instituto de Pesquisa Econômica Aplicada (IPEA) and FGV; Juan Robalino, Universidad de Costa Rica, Escuela de Economía and Instituto de Investigaciones en Ciencias Económicas, San José, Costa Rica; Rodrigo Salcedo, Universidad del Pacífico, Departamento de Economía, Lima, Perú; César Viteri, Fundación Charles Darwin, Puerto Ayora, Ecuador

14) Projeto Ecolume no semiárido pernambucano visa integrar água, energia e alimento para a população (The Ecolume Project in Pernambuco's semiarid region aims to integrate water, energy and food for the population)
http://climacom.mudancasclimaticas.net.br/projeto-ecolume/
Researcher: Francinete Francis Lacerda, from the INCT for Climate Change Phase 2, Cross Cutting Theme Communication, dissemination of knowledge and education for sustainability

15) Desafios do Brasil para a conservação da floresta e mudanças no uso da Terra (Brazil's Challenges for Forest Conservation and Land Use Change)
http://climacom.mudancasclimaticas.net.br/ndc-fapesp/
Researchers: Ane Alencar, Instituto de Pesquisa Ambiental da Amazônia/IPAM; Ângelo Gurgel, economist and professor at FGV; Annelise Vendramini, professor and researcher at FGV in the field of Administration; Eduardo Assad, from the INCT for Climate Change Phase 2, Food security subcomponent; and researcher at Embrapa; Mercedes Bustamante, from the INCT for Climate Change Phase 2, Impacts on Brazilian ecosystems in view of changes in land use and biodiversity subcomponent, and professor at UnB; Paulo Artaxo, from the INCT for Climate Change Phase 2, Impacts on Brazilian ecosystems in view of changes in land use and biodiversity subcomponent

16) Uma ciência feita com e para sociedade (A science made with and for society)
http://climacom.mudancasclimaticas.net.br/ciencia-e-sociedade/
Researcher: Regina Rodrigues Rodrigues, from the INCT for Climate Change Phase 2, Natural disasters, impacts on physical infrastructure in urban areas and urban development subcomponent

17) Livro floresta compartilha diferentes conexões afirmativas com a Terra (Forest book shares different affirmative connections with Earth)
http://climacom.mudancasclimaticas.net.br/livro-floresta/
Researcher: Susana Oliveira Dias, from the INCT for Climate Change Phase 2, Cross Cutting Theme Communication, dissemination of knowledge and education for sustainability; Alik Wunder and Sara Ramos Faculdade de Educação at Unicamp.
We have prepared a new work plan and requested the renewal of FAPESP's TT3 scholarship for the student Gláucia Pérez (not yet approved, pending).

4.10.3 Publications in Clima.com Journal

Three dossiers of ClimaCom Journal were published with articles, essays, reviews, subscribed column texts, news, interviews, reports and artistic and cultural productions:

1) “Devir criança” (Becoming child) (Aug 2020);
2) “Epidemiologias” (Epidemiologies) (Dec 2020);
3) “Coexistências e cocriações” (Coexistences and co-creations) (May 2021).

4.10.4 **Results from scientific divulgation activities**

We have started, with the researcher Mário Mendiondo, the organization of the INCT Interdisciplinary Seminar Cycle, which will be held during the next year of the project.
We have written articles, abstracts, expanded abstracts and books, and we have presented papers in events based on research carried out individually or in groups.

Professors Simone Pallone and Susana Dias received a Fapesp Mídia Science scholarship approved for the student Camila Ramos, who has produced podcasts for the Escuta Clima section of the ClimaCom Journal and texts for the journalism section of the ClimaCom Journal and the Comciência Journal, involving every subcomponent and cross cutting themes of the INCT for Climate Change. This is a list of the material produced:

#3 – Escuta Clima: Vulnerabilidade: desigualdade social e estruturas urbanas (Vulnerability: social inequality and urban structures)
http://climacom.mudancasclimaticas.net.br/3-escuta-clima-vulnerabilidade-desigualdade-social-e-estruturas-urbanas/

Ativismo climático: uma possibilidade de futuro em meio ao caos (Climate activism: a possibility for the future in the midst of chaos)
https://www.comciencia.br/movimento-ativista-uma-possibilidade-de-futuro-em-meio-ao-caos-climatico/

O deslocamento invisível de milhões de pessoas pelas mudanças ambientais (The invisible displacement of millions of people by environmental changes)
https://www.comciencia.br/o-deslocamento-invisivel-de-milhoes-de-pessoas-pelas-mudancas-ambientais/

Quarentena reduz poluição atmosférica, mas impactos das mudanças climáticas são tímidos (Quarantine reduces air pollution, but climate change impacts are timid)
http://climacom.mudancasclimaticas.net.br/camila-ramos-quarentena-clima/
Coprodução e a natureza especulativa das modelagens computacionais nas pesquisas em mudanças climáticas (Co-production and the speculative nature of computer modeling in climate change research)
http://climacom.mudancasclimaticas.net.br/coproducao-camila-ramos/
O que se pode aprender com as florestas sobre comunicação? (What can be learned from forests about communication?)
http://climacom.mudancasclimaticas.net.br/o-que-se-pode-aprender-com-as-florestas-sobre-comunicacao-camila-ramos/
Espécies invasoras representam perigo global à biodiversidade e à saúde humana (Invasive species pose a global danger to biodiversity and human health-clima/.

Professor Susana Dias wrote the project "Novas sensibilidades diante das catástrofes socioambientais: criação de materiais de divulgação científica das mudanças climáticas" (New sensibilities in the face of socio-environmental catastrophes: creation of materials for the scientific dissemination of climate change) for the BAS scientific initiation scholarship program at Unicamp and it was approved. We have had two scholarship holders, Larissa Bellini and Karolyne Souza, working for the ClimaCom Journal since March 2021.

Professor Gabriel Cid de Garcia has published the book Ciência em foco, vol. 3: Cinema, cultura e pensamento (Science in focus – vol. 3: Cinema, culture and thought), with Garamond Editors. The researcher did not take on the II Ciclo (Im)permanências – Diálogos entre artes, mudanças climáticas e humanidades at FE/UFRJ (Cycle II (Im)permanences – Dialogues between the arts, climate change and the humanities), due to the isolation measures imposed by the context of the Covid-19 pandemic.

Prof. Leandro Belinaso has published the book "Na pele do mundo: educações ambientais" (In

the skin of the world: environmental educations), released in August 2020. The book brings together different generations of people dedicated to environmental education in interviews. Environmental education becomes a multiplied concept in the interviews, it is broken down, it is born and reborn again. This publication highlights and empowers the quotidian clashes related to climate change and the virulences of our present time. It sprouts as it is traversed by books, music, movies, stories, places, controversies, conversations, encounters, loves, and affections.

The researcher Susana Dias has organized two virtual meetings to release the book "Conversas infinitas: divulgação científica, educação, mudanças climáticas e…" (Infinite conversations: scientific dissemination, education, climate change and…) with roundtables that addressed the following themes: "Clima, vida e negacionismo" (Climate, life and negationism), with the participation of Antonio Carlos Amorim; Elenise Cristina Pires de Andrade; Carlos José Martins and Bruno Moreno; and "Antropoceno, modos de existência e mundo comum" (Anthropocene, modes of existence and the common world), with the participation of Gabriel Cid de Garcia, Laura Garcia Oviedo and Susana Dias.

Researcher Susana Dias and biologist Alessandra Penha have organized the series of meetings "Segundas com a Floresta" (Mondays with the forest) to multiply the findings of the Floresta book, published in partnership with the Food security subcomponent coordinated by Eduardo Assad and released last year. The meetings had as themes: "Medir e imaginar" (Measure and imagine), with the participation of Eduardo Assad, Carolina Cantarino Rodrigues, Fábio Scarano, David Lapola; "Perspectivas ameríndias e africanas" (Amerindian and African perspectives), with the participation of Alik Wunder, Bené Fonteles, Tadeu de Paula Souza, Viviane Kruel, Pajé Awa Dxitsapeá Guaír and Cacique Arildo Awa Guyra Ruitxa; "Semeadores e polinizadores" (Seeders and pollinators), with the participation of Walmor Corrêa, Daiane Carreira, Santiago Arcila and Felipe Amorim; and "Mulheres e ancestralidades" (Women and Ancestry) with the participation of Marli Wunder, Alessandra Ribeiro, Márcia Tait and Sheyla Smanioto.

Professor Susana Dias wrote the project "Experiências do arvorecer" (Treelike experiences), for the production of a book with the same name, which was approved (R$20,000.00) by the Secretariat of Culture of Campinas-SP, in accordance to the Law Aldir Blanc.
It was approved the Master Dissertation called 'Abençoado seja o fruto: uma análise de *the handmaid's tale* e *o conto da aia* à luz dos estudos culturais'', written by Thamires Mattos, into the Master of Scientific and Cultural Popularization at Unicamp, supervised by Antonio Carlos Amorim.

The Master Dissertation "Public perception of climate change". Master in Science, Technology and Innovation scholarship - SECTYP Secretariat of Research, International and Postgraduate, National University of Cuyo - designed by Laura García Oviedo. Supervisor: Sandra Murriello of the National University of Río Negro, Argentina, was defended.

Under supervising of Prof. Dr. Carlos José Martins, the student Bruno Stramandinoli Moreno defended his Ph.D Qualification Project named "No olho do furacão: Reconfigurações laborais e produção de subjetividade na "Era do Acesso".

We did not continue the cycle of seminars "SIMBIOSES - ciências, filosofias, artes e mudanças climáticas" (SIMBIOSES - sciences, philosophies, arts and climate change) through virtual platforms due to the project characteristics that involved face-to-face participation.

5. Integration among components of the project in Year 4

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 Nortrheast Brazil, as well as intense rainfall that have triggered landslides and flash floods shows how vulnerable are some sectors of the population, and also the biodiversity as in the Pantanal and Amazonia.

So the challenge of the INCT MC Phase 2 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 will appear soon, but they already 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, unliveable heat, ecosystem collapse, cities menaced by risingseas -- these and other devastating climate impacts are accelerating.

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. We plan to have a workshop in 2022 and a final conference in 2023, both with people present.

Plans for the fifth year include further approximation with researchers from the subcomponents “Natural Disasters” and “Water Security”, to further develop joint projects. The contribution of the INCT for Climate Change Phase2 was fundamental for the development of the studies on impacts, vulnerabilities and adaptation for the 4th National Communication (4CN) to UNFCCC, that will be launched at the zcop-26 in Glasgow, UK.

Under the leadership of the Energy component, A task force was created to write a conceptual paper on integration of various components of the INCT Climate Change Phase 2. This group was created in a meeting on April 2021.

Lastly, Prof. Jailson Andrade from the UFBA came with the initiative of having Meetings of Coordinators of INCTs, to discuss synergies, collaboration and also problems related to logistics and procedures with the funding agencies. The first meeting took place in October 2018 in Brasilia. These meetings will take place once a year.

In September 2020 we had another meeting of the Coordinators of INCTs, and it was proposed a creation of a “Comitê Gestor/Conselho de Coordenação” with representatives of basic sciences, technology, human and social dimensions, medicine, environmental and ocean science from all INCTs. Other issues discussed on this meeting included consultation s with CNPq and CAPES about cuts in the number of “bolsas” or INCTs and the possibility of reduction in the

number of INCTs, as well as a joint action with the Brazilian Academy of Sciences ABC for the Brazilian Congress to try to eliminate the vetoes proposed by the government for the FNDCT that would definitely affect science in Brazil, including the development of COVID-19 vaccines (Vetos & PL 135/2020). These vetoes were made without any effect because a majority vote against it by Congress in March 2021.

6. Plans for Year 5 of the project

6.1 Food security

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

6.2 Water security

After a second period under COVID-19 pandemic impacts endured in the period 2020/2021, 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, in the fifth year, INCTMC2 water security scientists will promote actions for :

- strengthening eLearnging and Webinars with key partners of Braz Council of Water Resources (CNRH) and around the Brazilian National Water Resources Plan 2022-2040, especially revisiting, merging and updating database of CEMADEN's river catchment of flood risk prone areas;
- developing activities on INCTMC2 water security indices in PNRH's basins, with prospective water infrastructure linked to the new sanitation framework (Act # 14.026) and payment for ecosystem services (Act # 14.119);
- enhancing better nationwide science-and-policy cross-partnership promoted by ANASB and CEMADEN with APAC in Pernambuco, FUNCEME in Ceará, DAEE & CETESB in Sao Paulo;
- supporting statewide climate-and-resilience science centers with CEMADEN, i.e. 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 through the Brazilian Water Resources Association Technical Commissions (ABRHidro/Ensino, /Sociohydrology) linked to the UNESCO Chair on Water Security,
- coauthoring new original papers with more INCTMC2's affiliated institutions,
- leading training courses with other INCTMC2's subcomponents, especially around the water-energy-food-biodiversity nexus addressing the integration of SDG's, DRRs and COP/IPCC's recommendations,
- managing INCTMC2 activities with the Center of Applied Maths for Industry (CeMEAI), the Center for Artificial Intelligence (C4AI) and the Theory Of Change Observatory (Belmont Forum) to optimize startups and spinoffs;
- merging insights of INCTMC2 water securrity with Global Climate Research Program (WMO/UNESCO/ISC) and UNEP WWQA;
- 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.

6.3 Impacts on Brazilian ecosystems in view of changes in land use and biodiversity

The ecosystems component, throughout its Year 5 of execution, should continue its studies on the impacts of climate change, focusing on the Amazon and Cerrado biomes. We will continue to analyze the impact of burning and quantify greenhouse gas emissions in these biomes. The studies at the ATTO tower (Amazon Tall Tower Observatory) will continue, with experiments along the 325 meters of the tower, measuring the vertical profile of gases and aerosol particles. An important focus will be the study of the optical properties of aerosols, and the atmospheric radiative balance in Amazonia. Innovative methods for obtaining radiation absorbing components, such as black carbon and brown carbon, will be studied in detail along the profile of the ATTO tower. We will continue the operation of the NASA/AERONET solar photometer network, which measure the optical depth of aerosols at 8 wavelengths and measure the main components of aerosol microphysics in the Amazon.

6.4 Health and climate change

1. Modeling recent and future bioclimatic niches of vector species to predict the relationship between climate and other environmental changes in the transmission of leishmaniasis;
2. Evaluate the relationship between the occurrence of leishmaniasis vectors and impacts in climate change associated to land use in the country;
3. Estimate the municipality vulnerability to the occurrence of leishmaniasis in Brazil in climate change scenarios;
4 . Surveillance and Control of American Visceral Leishmaniasis in the State of Rio de Janeiro: spatial distribution and analysis of municipal vulnerability;
5. Evaluation of "Sentinel Areas" for monitoring environmental changes in the face of climate impacts in the municipality of Barbalha, State of Ceará, Brazil. Pilot project for the Brazilian Northeastern Region;
6. Elaboration of the systematic review with the theme "Relationship between climate and Covid 19 transmission".
7. Participation in technical meetings for discussion and dissemination of results.
8. Technical meetings with a researcher from Unifei who will also collaborate with data analysis.
9. Statistical analysis data
10. Scientific publications on research findings

6.5 Energy Security

For the IAM 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 Energy Meteorology team, a new evaluation of climate change impacts on energy resources will be performed using most recent scenarios from CMIP6 experiments. In this activity a novel uncertainty analysis, tailored for brazilian renewable energy sector, will be introduced. The strategy is to focus on uncertainty reduction departing from a higher number of global climate models, in opposition to a few downscaled high resolution models. Another important action is the build up of a new historical climate energy dataset from a combinations of global reanalysis to be used in energy planning models by the brazilian energy planning company (EPE). This dataset will help to assess climate models skillness in simulating energy relevant variables. Finally, the studies on complementarity and hybridization of power will continue focusing on climate resilient portfolios. The evaluation of hydro-solar hybridization of major brazilian hydroelectric water reservoirs through floating photovoltaics is ongoing and will be finished in a few months. In addition, the water-food-energy nexus is being assessed for most

stressed semiarid basins in Brazil through local energy security indexes for present and future climate

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

The next steps to be developed during the year 5 of the subcomponent are detailed below.

– Continue to collect and to assess the needed information and data initiated in year 4 to subsidize the proposition of adaptation measures at the local level.
– Continue the research developed in Year 3. In particular, continue the analysis in more detail of extreme precipitation and streamflow in pilot municipalities that lead to natural disasters. For drought events, we will assess severity, duration and frequency of droughts, and its impacts on Brazil's water, food and energy security. Also continue investigating the characteristics (frequency, intensity and duration) of land heatwaves and their impacts on human health and of marine heatwaves in the western South Atlantic and their impact on marine ecosystems in coastal urban areas, which in turn can affect fisheries and food security.
– Assessment of socioeconomic and environmental impacts of extreme events in pilot municipalities: present and future, continuing 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.
-Assessment of the impact of flash floods in the period 2010 - 2016, considering all 24 municipalities in the study area, in terms of human and environmental damage. In addition, the inclusion of drought-related disasters data of municipalities located in the states of Ceará and Pernambuco from 2002 to 2020 in the database will be continued, as well as the assessment of socioeconomic impacts of droughts in the municipalities of study area in the semi-arid region.
– Regarding **risk communication,** the redesigning of the survey of qualitative data will be elaborated, as previously described. It will include choosing an online platform; definition of the guide questions to discuss on focus groups; identification and invitation of the participants; organization of the focus group; analysis of the results.
– As a next step in the context of assessing drought impacts, a methodology will be developed to assess the "Drought Risk" in municipalities previously defined as priorities due to the recurrence of drought events. Such methodology should include the physical aspects of the drought (already shown in the previous reports) associated with the vulnerabilities and adaptive capacities to cope with the effects of the drought.
–The vulnerability tool shall 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.

6.7 Economy and impacts in key sectors

Plans for the fifth year include further approximation with researchers from the subcomponents "Natural Disasters" and "Water Security" to develop joint projects further. Moreover, as pointed in the second year 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 has been signed. 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.

The fifth year of the research project will be devoted to 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 will serve as inputs to the CGE model in order to address the following questions:

-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 will team up with researchers from FEA-USP to incorporate these findings as a shock to the CGE model. We expect to evaluate the impact of improvements in land-use efficiency on macroeconomic aggregates (sectoral and overall GDP, agricultural employment, etc.)

-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.

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

- It is planned to complete the generation suite of the CMIP6 SSP's scenarios protocol, encompassing the period of 1985-2100, with BESM3.0 model version (the scenarios which were planned to be generated with the previous version of BESM2.9 were aborted, as a persistent model bias of AMOC circulation strength was detected).
- Development of the Coupled Eta based model with MOM6 ocean model (RESM – Eta Model);
- Finish Coupling and evaluation of the Radiation-Convection scheme in the RESM (Eta Model)
- Finish Coupling and evaluation of the Lightning-precipitation and NOx production schemes in the RESM (Eta Model)
- Finish Coupling and evaluation of the dynamic vegetation + Carbon cycle in the RESM (Eta Model)
- Conclude evaluation with the new model version of the Eta Model
- Generation of projections using new model version and new SSP’s emission scenarios.

6.9 Communication, dissemination of knowledge and education for sustainability

- We did not continue the cycle of seminars “SIMBIOSES - ciências, filosofias, artes e mudanças climáticas” (SIMBIOSES - sciences, philosophies, arts and climate change) through virtual platforms due to the project characteristics that involved face-to-face participation.
- We will request the renewal of our second FAPESP TT3 scholarship in order to have someone responsible for writing the news on the papers produced by the researchers from the various INCT subcomponents, and for conducting interviews with authors and other researchers

for the ClimaCom Journal and the INCT website. The materials can be produced in different formats, from news to interviews and reports, to podcasts and videos, among others. Besides, there will be readings and collaborative analysis of the problems involving communication and climate change. The idea is that the issues to be worked on arise from the relationship among the researchers of this INCT, the production of materials and the proposed bibliographies. Through these relationships, we intend to explore and broaden the understanding of the efficiency and the effectiveness of the communication on climate change. We assume that a dialogue with the philosophy of science and the social studies of science, especially with the works of Bruno Latour, Isabelle Stengers and Donna Haraway, is useful for this project.

- As part of the scholarship holder's actions, the Interdisciplinary Cycle of Seminars of the INCT on Climate Change will be organized with the online participation of all subcomponents and produced in partnership with the Water Security subcomponent coordinated by researcher Mário Mendiondo.
- Three new ClimaCom dossiers will be published with articles, essays, journalistic materials and artistic productions with the themes: “Diante dos negacionismos” (in the face of denials), “Este mundo, que não é meu?” (This world, which is not mine?) and another topic still to be defined. The participation of the researchers from the various components of the INCT in the journal will be encouraged through the production of articles, interviews, participation in news, and so forth.
- We will write and present projects to obtain other forms of financing.
- We will produce publications (for conferences, articles, books, etc.) by researchers on this cross cutting theme.
- We will diagram the pdfs of the ClimaCom Journals produced during the INCT for Climate Change Phase 2.

7. Events organized by the INCT MC Phase 2 and its components with interaction among sub components of the project in Year 2

1. Reunião Virtual de Lideres e Membros do CC do INCT-MC Fase 2, Marco 11 2021,
2. Reunião com o Vice coordenador do projeto INCT MC Fase 2 Tercio Ambrizzi, 17-20 Junho 2021, USP Sao Paulo.
3. Reunião com o Vice coordenador do projeto INCT MC Fase 2 Tercio Ambrizzi , 17-19 Agosto 2020, USP SP.
4. Reunião com o Vice coordenador do projeto INCT MC Fase 2 Tercio Ambrizzi , 12-13 Novembro 2020, USP Sao Paulo.
5. Reunião com Dra Marta Barata do IOC/FIORUZ na Cidade de Rio de Janeiro, no período de 22-26 de novembro 2020. 13-15 de Agosto 2020
6. Reunião com Dra Marta Barata do IOC/FIORUZ e Elizabeth Rangel da UFMG na Cidade de Rio de Janeiro, no período de 13-15 de outubro 2020
7. Reunião – Força Tarefa para publicação de artigo integrando várias componentes. 01/04: Reunião virtual em Plataforma ZOOM e, num segundo momento, Google MEET.9See annex)
8. Meeting of the Health component with researchers from the Federal University of Itajubá / Fiocruz. February 02, 2021.
9. Meeting of the Health component with researchers from the Federal University of Itajubá / Fiocruz. May 15, 2021.
10. Reunião do Grupo de Trabalho INCT Saúde – MG, 2/02, 2020, (see annex)
11. Internal discussions and actions toward the development of the Eta model to MOM6 regional climate model were taken. The regional coupled Eta model shall enhance the capability of high resolution coupled downscalling over South America and the Tropical/South Atlantic Ocean.
12. Meeting among INCT-MC2 PIs of the Hydrology, Climate Modeling, Energy, Economy and Society components toward generating an integrative article on the water-energy-food Nexus. 1/April/2021.

8. Participation in scientific events relevant to the INCT MC Phase 2 with accepted abstracts or presentations

1. 9th German-Brazilian Dialogue on Science, Research and Innovation: Cities and Climate – The Multi-Level Governance Challenge, Panel 1: Understanding the Impacts and Driving Forces between Cities and Climate, São Paulo, 17 – 20 May 2020
2. Webinário: A Crise Climática e a Amazônia, 10th mostra Ecofalante São Paulo, 7 Junho 2021
3. Seminário RESTAURAÇÃO ECOSSISTÊMICA e ADAPTAÇÃO ÀS MUDANÇAS CLIMÁTICAS - Experiências na Amazônia, Mata Atlântica e Semiárido Clima e extremos na Amazônia, Pantanal e Semiárido do Nordeste, Seminario READAPT, São Paulo, 21 Junho 2021
4. 1º Seminário Capixaba sobre Mudanças Climáticas do IEC-UFES, Mudanças Climáticas e Zonas Costeiras, Julho 2020
5. II Encontro Nacional de Desastres, 2020.Anzolin, G., Oliveira, D.Y., Chaffe, P.L.B. 'Incerteza e não estacionariedade na análise de frequência de precipitações máximas anuais no Sul do Brasil".

6. XXIII Simpósio Brasileiro de Recursos Hídricos, 2019, Anzolin, G., Oliveira, D.Y., Chaffe, P.L.B. Incerteza e não estacionariedade na análise de frequência de precipitações máximas anuais no Sul do Brasil.

7. XXIII Simpósio Brasileiro de Recursos Hídricos, 2019. Anzolin, G.; Oliveira, D.Y.; Chaffe, P.L.B. Incerteza na determinação das curvas IDF na bacia do Itajaí.

8. XXIII Simpósio Brasileiro de Recursos Hídricos, 2019., Chaffe, P.L.B.; Silva, P.G.; David, P.C.; Filho, A.F.H.F.; Mendez, F.J.; Klein. A.H.F. Uso de cópulas e weather types para análise de eventos compostos de cheia da bacia do Itajaí.

9. XXIII Simpósio Brasileiro de Recursos Hídricos, 2019, Pereima, M.F.R.; Borges, P.A; Rodrigues, R.R.; Chaffe, P.L.B. Análise e correção de viés da precipitação de modelos de circulação geral do CMIP5 do sul do Brasil.

10. XXVII International Union of Geodesy and Geophysics General Assembly, 2019. Chaffe, P.L.B.; Oliveira, D.Y.; Bartiko, D.; Chagas, V.B. Prediction of extreme flood events in Brazil: accounting for uncertainty and (non)stationarity.

11. The **MEETING NEXUS**, on March 10, 2021 was online on Youtube "Rede Clima – Mudanças Climáticas". In this meeting were presented the impacts of climate change on agricultural production; CHG and C emissions from soil; water resources in the extended São Francisco Basin;

12. 11º Congresso Brasileiro de Epidemiologia. (Submitted), Santos, R.B. ; Menezes, J. A.; Margonari, C. S.; Confalonieri, U.; Freitas, C. M. Reflexões sobre utilização dos sistemas de informação de saúde em desastres.

13. 11º Congresso Brasileiro de Epidemiologia. (Submitted), Santos, R.B. ; Menezes, J. A.; Margonari, C. S.; Confalonieri, U.; Freitas, C. M Vigilância em saúde, articulação intersinstitucional e fluxo de informação em desastres. 11º Congresso Brasileiro de Epidemiologia. (Submitted**)**

14. XXVII Congresso da Sociedade Brasileira de Parasitologia. Parasito 2021Simone Miranda da Costa, Monica de Avelar Figueiredo Mafra Magalhães, Renata de Saldanha da Gama Gracie Carrijo, Elizabeth Ferreira Rangel. Uso do geoprocessamento na distribuição geográfica de *Lutzomyia* (*Nyssomyia*) *whitmani* (Diptera: Psychodidade: Phlebotominae) em associação com a cobertura vegetal e os impactos no processo de expansão da Leishmaniose Tegumentar Americana no Brasil.. ISBN 978-65-5941-182-5. Pág. 66.

15. 13th IAMC Annual Meeting – December 2020, Virtual Event. Water-energy-land-use nexus in a decarbonization scenario using the BLUES model. Eveline VASQUEZ ARROYO (COPPE), Gerd Angelkorte (COPPE), Pedro R.R. Rochedo (COPPE), André Lucena (COPPE), Roberto Schaeffer (COPPE), Alexandre Szklo (COPPE)

16. 13th IAMC Annual Meeting – December 2020, Virtual Event. The role of biomaterials in a Brazilian integrated assessment model Camilla OLIVEIRA (COPPE), Gerd Angelkorte (COPPE), Pedro R. R. Rochedo (COPPE), Alexandre Szklo (COPPE)
17. 13th IAMC Annual Meeting – December 2020, Virtual Event. The role of climate finance flows in national mitigation strategies: allocation effects on recipient economies Rafael GARAFFA (COPPE), Andre Lucena (COPPE), Alexandre Szklo (COPPE), Angelo Gurgel (Getúlio Vargas Foundation), Bruno Cunha (COPPE), Roberto Schaeffer (COPPE)
18. 13th IAMC Annual Meeting – December 2020, Virtual Event. Bioenergy and carbon capture and storage spatially explicit modelling in Brazil Isabela SCHMIDT TAGOMORI (COPPE), Vassilis Daioglou (UU/PBL), Pedro Rochedo (COPPE), Alexandre Szklo (COPPE), Detlef van Vuuren (UU/PBL), Roberto Schaeffer (COPPE)
19. 13th IAMC Annual Meeting – December 2020, Virtual Event. The demand hiding in the shadow: impacts on modelling passenger activity Camila CALLEGARI (COPPE), Roberto Schaeffer (COPPE), Alexandre Szklo (COPPE)
20. 13th IAMC Annual Meeting – December 2020, Virtual Event. Long-term climate scenarios from the COVID-19 pandemic global economic response Lilia CAIADO COUTO (UCL), Bruno S. L. Cunha (COPPE), Rafael Garaffa (COPPE), Angelo C. Gurgel (Sao Paulo School of Economics and Fundaçao Getulio Vargas), Eveline Vasquez (COPPE), Fabio A. Diuana (COPPE), Gerd Angelkorte (COPPE), Luiz Bernardo Baptista (COPPE), Joana Portugal-Pereira (COPPE), Pedro R. R. Rochedo (COPPE), André F. P. Lucena (COPPE), Alexandre Szklo (COPPE), Roberto Schaeffer (COPPE).
21. 13th IAMC Annual Meeting – December 2020, Virtual Event. Better representing international shipping in the IMAGE model Eduardo MÜLLER-CASSERES (COPPE, PBL), Oreane Edelenbosch (PBL), Alexandre Szklo (UFRJ), Roberto Schaeffer (COPPE), Detlef van Vuuren (PBL).
22. 13th IAMC Annual Meeting – December 2020, Virtual Event. Implementation of integrated cropland-livestock-forestry systems in a national IAM Gerd ANGELKORTE (COPPE), Pedro Rochedo (COPPE), Roberto Schaeffer (COPPE), Alexandre Szklo (COPPE), Taisa Morais (COPPE)
23. Congresso Brasileiro de Planejamento Energético, 2020, Rio de Janeiro. Impactos das Mudanças Climáticas na disponibilidade do recurso energético solar. COSTA, RODRIGO SANTOS ; COSTA, G. L. ; LIMA, FRANCISCO JOSÉ LOPES DE ; GONÇALVES, ANDRÉ RODRIGUES ; MARTINS, FERNANDO RAMOS ; PEREIRA, Enio Bueno ; CASAGRANDE, M. S. G.
24. Congresso Brasileiro de Planejamento Energético, 2020, Rio de Janeiro. Impactos das Mudanças Climáticas na disponibilidade futura do recurso eólico. COSTA, RODRIGO SANTOS; COSTA, G. L. ; LIMA, FRANCISCO JOSÉ LOPES DE ; GONÇALVES, ANDRÉ RODRIGUES ; MARTINS, FERNANDO RAMOS ; PEREIRA, Enio Bueno ; CASAGRANDE, M. S. G.
25. Congresso Brasileiro de Planejamento Energético, 2020, Rio de Janeiro. Rede SONDA de Dados de Recursos de Energia Solar e Eólica. PES, MARCELO P. ; PEREIRA, Enio Bueno ; COSTA, RODRIGO SANTOS ; GONÇALVES, ANDRÉ RODRIGUES ; MARTINS, FERNANDO RAMOS ; MACHADO, G. B. M. ; LOPES, F. L. ; PEREIRA, Silvia V .
26. Congresso Brasileiro de Planejamento Energético, 2020, Rio de Janeiro. Variações na frequência de ventos extremos e seu impacto no setor de energia. LIMA, FRANCISCO JOSÉ LOPES DE ; GONÇALVES, ANDRÉ RODRIGUES ; COSTA, RODRIGO SANTOS ; MARTINS, FERNANDO RAMOS ; PEREIRA, ENIO BUENO .
27. Congresso Brasileiro de Planejamento Energético, 2020, Rio de Janeiro. Incremento da irradiância solar incidente na superfície do reservatório da hidroelétrica Serra da Mesa no centro-oeste. MARTINS, FERNANDO RAMOS; LIMA, FRANCISCO JOSÉ LOPES DE; GONÇALVES, ANDRÉ RODRIGUES ; COSTA, RODRIGO SANTOS; COSTA, G. L. ; PEREIRA, ENIO BUENO ; CASAGRANDE, M. S. G.
28. Congresso Brasileiro de Planejamento Energético, 2020, Rio de Janeiro. . Estudo do perfil de complementariedade entre a geração eólica e solar no semiárido brasileiro. GONÇALVES, A. R.; COSTA, R. S. ; MARTINS, F. R. ; PEREIRA, E. B.

29. Congresso Brasileiro de Energia Solar, 2020, Rio de Janeiro. Limitações materiais e espaciais do aproveitamento do recurso solar fotovoltaico em escala global WELLINGTON WINÍCIUS FERREIRA FONSECA, ROBERTO ZILLES, MARTINS, FERNANDO RAMOS; LIMA, FRANCISCO JOSÉ LOPES DE
30. Congresso Brasileiro de Energia Solar, 2020, Rio de Janeiro. Análise da variabilidade da incidência solar na superfície com base em dados de superfície e de satélite. MARTINS, FERNANDO RAMOS; Luiz, E. W. ; GONÇALVES, ANDRÉ RODRIGUES ; COSTA, RODRIGO SANTOS ; LIMA, FRANCISCO JOSÉ LOPES DE ; CASAGRANDE, M. S. G. ; PES, MARCELO P. ; PEREIRA, E. B. .
31. Congresso Brasileiro de Energia Solar, 2020, Rio de Janeiro. Avaliação da variabilidade do recurso solar em território brasileiro. ROCHA, V. R. ; GONÇALVES, ANDRÉ RODRIGUES ; COSTA, RODRIGO SANTOS ; PEREIRA, Enio Bueno ; MARTINS, FERNANDO RAMOS ; INACIO, C. O. ; FONTENELE, L. F. A. ; FERREIRA, P. H. F.
32. Congresso Brasileiro de Energia Solar, 2020, Rio de Janeiro. Limitações materiais e espaciais do aproveitamento do recurso solar fotovoltaico em escala global. FONSECA, W. W. F. ; MARTINS, FERNANDO RAMOS ; LIMA, FRANCISCO JOSÉ LOPES DE ; ZILLES, R.
33. Congresso Brasileiro de Energia Solar, 2020, Rio de Janeiro. Previsão de curto prazo da radiação solar no brasil usando movimento das nuvens com base em dados de satélite. LIMA, FRANCISCO JOSÉ LOPES DE ; COSTA, R. S. ; PEREIRA, E. S. ; GONÇALVES, ANDRÉ RODRIGUES ; RAMOS, D. N. S. ; CASAGRANDE, M. S. G. ; MARTINS, FERNANDO RAMOS ; Souza, Jefferson G. ; PEREIRA, ENIO BUENO.
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47. MURRILELLO, S. Antropoceno, modos de existência e mundo comum - Conversas infinitas: divulgação científica, educação, mudanças climáticas e... (mesa redonda), 25 de nov de 2020, no canal youtube da revista ClimaCom.
48. RODRIGUES, C. C. Perspectivas ameríndias e africanas - Segundas com as florestas (ciclo de encontros). 26 de out. de 2020, no canal do youtube da revista ClimaCom.
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62. DIAS, S. (ministrando oficina) Plantas companheiras - In: Oficina 'Plantas companheiras, arte e cultura ameríndia' com o Pajé Guaíra da aldeia Awa Porungawa Dju e a artista Isilda Oliveira e pesquisadora Susana Dias para grupo de educação de jovens e adultos. EMEF Maria Pavanatti Fávaro Disponível em: https://www.youtube.com/watch?v=Mxa6z-kvvAAOficinas na escola pavanatti
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67. André Lyra: Participation in the workshop: CORDEX Central America and South America Online Paper-Writing Workshop on Regional Climate, 24-25 November and 8-9 December, 2020.
68. Chou Sin Chan: "Climate change modeling: when is it necessary to use high spatial resolution?". In Ciclo de Seminários do Programa de Pos Graduação em Meteorologia da UFRJ, 02/June/2021.
69. Chou Sin Chan: "Projections of Climate Change in Brazil". In Brazil Water Week. Session 81 – Climate Change – Securing Water Futures and Building the Resilience. 01 Oct 2020.
70. Chou Sin Chan: ""From weather forecasts to climate change projections at CPTEC/INPE" in CIDACS-Fiocruz-Bahia, Salvador, BA, 11/02/2020.Isabel Pilotto: Improvements in the land-surface parameterization scheme in the Eta Model. INPE's Earth System Modeling Division Workshop on July 2020.
71. Isabel Pilotto: "Effects of Amazon deforestation on local and regional climate", as part of one of the lectures on the Subject "Biosphere and atmosphere interactions" in the taught course given by Antonio Manzi in the post-graduate program in meteorology of INPE.
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79. Nobre, P., 2021: Meio Ambiente, Saúde e Sociedade em tempos de pandemia: *qual é o nosso bem comum?* Uma perspectiva histórica de nosso futuro! UNIRIO, 11/June/2021. https://docs.google.com/presentation/d/1MYUrXgW32xRf128YEWCjMBAyfN-Rd2Du1kBZol5XQ4/edit?usp=sharing

80. NEREUS at FEAUSP hosts a weekly seminar, on Mondays, during the academic year. In 2020-2021, the events started in presence but had to move online due to the pandemic. 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)The economy Component plan to organize a Workshop in 2022 focusing on "The Economy of Mantiqueira", involving different components of the INCT. The first part of the workshop would take place in Itajubá (UNIFEI), where the focus would be on discussions with local policymakers, and the second part would take place in Gonçalves, MG, where the discussion would be more technical.

81. Benso et al (2021) Leveraging Humanitarian Sociohydrology in a Post-Pandemic Society: Interdisciplinary Dialogues on Water Justice Studies through Panta Rhei Open Science for Future Earth, Accepted ,Theme 1, 1st SocioHydrology Conference, Delft, Sept 6-8, 2021

82. Sass, K et al (2021) Economic impacts of droughts under future projections of climate change: a case study for São Paulo Metropolitan Area, Accepted, Theme 3, 1st SocioHydrology Conference, Delft, Sept 6-8, 2021

83. Richmond-Navarro, F A et al (2021) Soft variables can explain uncertainties in discharges of South-American large rivers, Accepted, 4 th International Conference on the Status and Future of the World's Large Rivers, Moscow, 3-6 August.

84. Benso, M et al (2021) On a paradox of coevolutionary adaptation toward resilient trajectories, livable habitats and learning attitudes under simultaneous water crises in transboundary basins, Accepted ,Theme 5, 1st SocioHydrology Conference, Delft, Sept 6-8, 2021

85. Mendiondo, E M et al (2021) How can we scale a learning mandala of strategies on participatory sociohydrology using a 'Theory Of Change Observatory on Disaster Resilience' ?, Accepted ,Theme 2, 1st SocioHydrology Conference, Delft, Sept 6-8, 2021

86. Passos, V E A et al (2021) Social Participation and Integrated Methodologies: A new way to understand urban resilience into extreme hydrological events in Latin America, Accepted, Theme 1, 1st SocioHydrology Conference, Delft, Sept 6-8, 2021

87. Souza, B et al (2021) Brazilian citizen perceptions on the application of stormwater best management practices as a form of adaptation to floods, Accepted, Theme 04, 1st SocioHydrology Conference, Delft, Sept 6-8, 2021

88. Souza, F A A et al (2021) Trade-off between water supply, environmental protection and hydropower production in a national transboundary river, Accepted, Theme 04, 1st SocioHydrology Conference, Delft, Sept 6-8, 2021

89. Sarmento-Buarque, A C et al (2021) Socio-hydrological Flood Risk Assessment with Reinforcement Learning and Agent-Based Modelling for Partially Monitored and Ungauged River Basins, Accepted, Theme 3, 1st SocioHydrology Conference, Delft, Sept 6-8, 2021

9. List of publications

The papers published within the Year 4 of the INCT-MC Phase 2 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 last years.

1. Pivello V, Vieira I, Christianini A, Ribeiro D, Silva Menezes, Berlinck C, , Melo, F, Marengo JA, Tornquist G, Moraes Tomas W, Overbeck GE (2021) Understanding Brazil's Catastrophic Fires: Causes, Consequences, and Policy needed to prevent future tragedies, Perspectives in Ecology and Conservation, (Accepted).

2. Marengo JA, Cunha AP, Cuartas LA, Deusdará Leal KR, Broedel E, Seluchi ME, Michelin CM, De Praga Baião CF, Chuchón Ângulo E, Almeida EK, Kazmierczak ML, Mateus NPA, Silva RC and Bender F (2021) Extreme Drought in the Brazilian Pantanal in 2019–2020: Characterization, Causes, and Impacts. *Front. Water* 3:639204. doi: 10.3389/frwa.2021.639204

3. Marengo JA, Camarinha PI, Alves LM, Diniz F and Betts RA (2021) Extreme Rainfall and Hydro-Geo-Meteorological Disaster Risk in 1.5, 2.0, and 4.0◦C Global Warming Scenarios: An Analysis for Brazil. *Front. Clim*. 3:610433. doi: 10.3389/fclim.2021.610433

4. Menezes, J.A.; Madureira, A.P.; Santos, R.B.d.; Duval, I.d.B.; Regoto, P.; Margonari, C.; Barata, M.M.d.L.; Confalonieri, U. Analyzing Spatial Patterns of Health Vulnerability to Drought in the Brazilian Semiarid Region. Int. J. Environ. Res. Public Health 2021, 18, 6262. https://doi.org/10.3390/ ijerph18126262

5. COVEY, KRISTOFER; SOPER, FIONA; PANGALA, SUNITHA; BERNARDINO, ANGELO; PAGLIARO, ZOE; BASSO, LUANA; CASSOL, HENRIQUE; FEARNSIDE, PHILIP; NAVARRETE, DIEGO; NOVOA, SIDNEY; SAWAKUCHI, HENRIQUE; LOVEJOY, THOMAS; MARENGO, JOSE; PERES, CARLOS A.; BAILLIE, JONATHAN; BERNASCONI, PAULA; CAMARGO, JOSE; FREITAS, CAROLINA; HOFFMAN, BRUCE; NARDOTO, GABRIELA B.; NOBRE, ISMAEL; MAYORGA, JUAN; MESQUITA, RITA; PAVAN, SILVIA; PINTO, FLAVIA; ROCHA, FLAVIA; DE ASSIS MELLO, RICARDO; THUAULT, ALICE; BAHL, ALEXIS ANNE; ELMORE, AURORA (2021) Carbon and Beyond: The Biogeochemistry of Climate in a Rapidly Changing Amazon. Frontiers in Forests and Global Change. , v.4, p.1 - , 2021.

6. MARENGO, JOSÉ ANTÔNIO; RODRIGUES-FILHO, SAULO; SANTOS, DIOGO VICTOR. 2021. Impacts, vulnerability and adaptation to climate change in Brazil: an integrated approach In SUSTENTABILIDADE EM DEBATE. , v.11, 14-23

7. VASQUEZ-ARROYO, EVELINE; SILVA, FÁBIO DA; SANTOS, ALBERTO; CORDEIRO, DEBORAH; MARENGO, JOSÉ ANTÔNIO; LUCENA, ANDRÉ F. P. (2021) Climate impacts in the Brazilian energy security: analysis of observed events and adaptation options. SUSTENTABILIDADE EM DEBATE. , v.11, p.157 - 196, 2021.

8. DUNN, ROBERT J. H.; ALEXANDER, LISA V.; DONAT, MARKUS G.; ZHANG, XUEBIN; BADOR, MARGOT; HEROLD, NICHOLAS; LIPPMANN, TANYA; ALLAN, ROB; AGUILAR, ENRIC; BARRY, ABDOUL AZIZ; BRUNET, MANOLA; CAESAR, JOHN; CHAGNAUD, GUILLAUME; CHENG, VINCENT; CINCO, THELMA; DURRE, IMKE; GUZMAN, ROSALINE; HTAY, TIN MAR; IBADULLAH, WAN MAISARAH WAN; IBRAHIM, MUHAMMAD KHAIRUL IZZAT BIN; KHOSHKAM, MAHBOBEH; KRUGER, ANDRIES; KUBOTA, HISAYUKI; LENG, TAN WEE; LIM, GERALD; *et al* . 2020. Development of an updated global land in-situ-based dataset of temperature and precipitation extremes: HadEX3 In JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES. , v.125, 147

9. Almazroui M, M Ashfaq, M. Islam, I Rashid, S Kamil, M Abid, E O'Brien, M Ismail, M Reboita, A Sorensson, P. A. Arias, L Alves, M K. Tippett, S Saeed, R Haarsma, F. Doblas-Reyes, F Saee, F Kucharski, I Nadeem, Y Silva-Vidal, J A. Rivera, M A Ehsan (2021) Assessment of CMIP6 Performance and Projected Temperature and Precipitation Changes Over South America, Earth Systems and Environment https://doi.org/10.1007/s41748-021-00233-6

10. SANTOS, DIEGO JATOBÁ DOS; PEDRA, GEORGE ULGUIM; SILVA, MARCELO GUATURA BARBOSA DA; GUIMARÃES JÚNIOR, CARLOS AUGUSTO; ALVES, Lincoln Muniz; SAMPAIO, GILVAN; MARENGO, JOSÉ ANTÔNIO. 2020. Future rainfall and temperature changes in Brazil under global warming levels of 1.5ºC, 2ºC and 4ºC In SUSTENTABILIDADE EM DEBATE. , v.11, 57-90

11. Santos E; MARENGO, JOSE A,. 2020. Impacts of climate change on tourism and challenges: the Brazilian scenario. In Estudios y Perspectivas em Turismo. , v.29, 864

12. CARVALHO, ANDRÉ LUIZ DE; SANTOS, DIOGO VICTOR; MARENGO, JOSÉ ANTÔNIO; COUTINHO, SONIA MARIA VIGGIANI; MAIA, STOÉCIO MALTA

FERREIRA. 2020. Impacts of extreme climate events on Brazilian agricultural production In SUSTENTABILIDADE EM DEBATE. , v.11, 197-224

13. PENNA, ANA CAROLINE; TORRES, ROGER RODRIGUES; GARCIA, SÂMIA REGINA; MARENGO, JOSÉ ANTÔNIO. 2020. Moisture Flows on Southeast Brazil: Present and Future Climate In INTERNATIONAL JOURNAL OF CLIMATOLOGY. , v.40, joc.6738

14. Rangel EF, Margarete Martins dos Santos Afonso, Adriana Sotero-Martins, Aline Campos, Wagner Nazário Coelho, Eric Lopes da Gama, Geane Lopes Flores, Marilda Mendonça Siqueira, Maria de Lourdes Aguiar-Oliveira. Can Climate and Environmental Factors Putatively Increase SARS-Cov2 Transmission Risks? *American Journal of Biomedical Science & Research*, v. 11, p. 294-299. ISSN: 2642-1747 Mini Review. 2021

15. VIGGIANI COUTINHO, SONIA MARIA; SANTOS, DIOGO VICTOR; BURSZTYN, MARCEL; MARENGO, JOSÉ ANTÔNIO; RODRIGUES-FILHO, SAULO; LUCENA, ANDRÉ F. P.; RODRIGUEZ, DANIEL ANDRÉS; MAIA, STOÉCIO MALTA FERREIRA. 2020. The Nexus+ approach applied to studies of Impacts, vulnerability and adaptation to climate change in Brazil In SUSTENTABILIDADE EM DEBATE. , v.11, 24-56

16. PEREIRA, VÂNIA ROSA; RODRIGUEZ, DANIEL ANDRÉS; COUTINHO, SONIA MARIA VIGGIANI; SANTOS, DIOGO VICTOR; MARENGO, JOSÉ ANTÔNIO. 2020. Adaptation opportunities for water security in Brazil In SUSTENTABILIDADE EM DEBATE. , v.11, 91-121

17. PEREZ, LETÍCIA PALAZZI; RODRIGUES-FILHO, SAULO; MARENGO, JOSÉ ANTÔNIO; SANTOS, DIOGO VICTOR; MIKOSZ, LUCAS. 2020. Climate change and disasters: analysis of the Brazilian regional inequality In SUSTENTABILIDADE EM DEBATE. , v.11, 260-296

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19. Marengo, J, Alves, L, Ambrizzi, T, Young, A, Barreto, N, Ramos (2020) Trends in extreme rainfall and hydrogeometeorological disasters in the Metropolitan Area of São Paulo: a review. *Annals of the New York Academy of Sciences*, doi: 10.1111/nyas.14307, Ann. N.Y. Acad. Sci. xxxx (2020) 1–16

20. DA SILVA PINTO VIEIRA, RITA MARCIA; TOMASELLA, JAVIER; BARBOSA, ALEXANDRE AUGUSTO; POLIZEL, SILVIA PALOTTI; OMETTO, JEAN PIERRE HENRY BALBAUD; SANTOS, FABRÍCIA CRISTINA; DA CRUZ FERREIRA, YARA; DE TOLEDO, PETER MANN. Land degradation mapping in the MATOPIBA region (Brazil) using remote sensing data and decision-tree analysis. SCIENCE OF THE TOTAL ENVIRONMENT. , v.782, p.146900 - , 2021.

21. CHIQUITO GESUALDO, GABRIELA; SONE, JULLIAN SOUZA; GALVÃO, CARLOS DE OLIVEIRA; MARTINS, EDUARDO SÁVIO; MONTENEGRO, SUZANA MARIA GICO LIMA; TOMASELLA, JAVIER; MENDIONDO, AND EDUARDO MARIO. Unveiling water security in Brazil: current challenges and future perspectives. HYDROLOGICAL SCIENCES JOURNAL-JOURNAL DES SCIENCES HYDROLOGIQUES. , v.66, p.759 - 768, 2021.

22. SILVA PINTO VIEIRA, RITA MARCIA; TOMASELLA, JAVIER; BARBOSA, ALEXANDRE AUGUSTO; MARTINS, MINELLA ALVES; RODRIGUEZ, DANIEL ANDRÉS; REZENDE, FERNANDA SILVA; CARRIELLO, FELIX; OLIVEIRA SANTANA, MARCOS. Desertification risk assessment in Northeast Brazil: Current trends and future scenarios. LAND DEGRADATION & DEVELOPMENT. , v.32, p.224 - 240, 2021.

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10. Books and book chapters 2020-2021

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20. TADDEI, RENZO ROMANO. Sertão-terapia para velhas certezas (ambientais) em crise. In: Gabriel Cid Garcia. (Org.). Cinema em Foco, Vol. III. 1ed.Rio de Janeiro: Garamond, 2020, v. 3, p. 247-258.
21. DIAS, S.; RORIGUES, C. C,; BELLINI, L.; SOUZA, K. Coexistências e cocriações. Maio de 2021. Disponível em: http://climacom.mudancasclimaticas.net.br/apresentacao-editorial-dossie-epidemiologias-ano-7-n-19-2020/

11. Other activities and web sites of reports, art exhibitions and courses/seminars online and videos

J. Marengo and T. Ambrizzi were interviewed by Elton journalist of the Agencia FAPESP about this paper and these rainfall extremes and this is listed in the Annex. On another interview, Marcos Pivetta from Agencia FAPESP interviewed them about climate change and natural disasters in Brazil and about drought and fire in Pantanal. Some parts of its are also listed in the Annex section.

Entrevistas com Jose Marengo

-Audiencia Publica Comissão Externa Queimadas em Biomas Brasileiros, Crise de escassez hídrica na Bacia do Rio Paraguai e as ameaças ao bioma Pantanal Câmara dos Deputados Brasília DF,15 de julho de 2021

--3ª Anual Virtual da SBPC Mesa-Redonda: O PROJETO DE DESMONTE DAS POLÍTICAS NACIONAIS NA ESFERA AMBIENTAL: CONSEQUÊNCIAS E AÇÕES DE MITIGAÇÃO NO CENÁRIO PÓS COVID 19 (ABLimno, SBPC)

Quinta-feira, 22/7/2021 - das 14h00 às 16h00

Coordenadora: Luciana Gomes Barbosa (UFPB)

Palestrantes: Dep. Rodrigo Agostinho (CD), Jose Antonio Marengo Orsini (CEMADEN) e Mercedes Maria da Cunha Bustamante (UnB)

https://revistapesquisa.fapesp.br/risco-de-mais-desastres-naturais/
https://revistapesquisa.fapesp.br/um-brasil-mais-vulneravel-no-seculo-xxi/
https://www.youtube.com/watch?v=5q8wyKkh8Fo
https://www.youtube.com/watch?v=VV5hoWgTLAs&t=9s
https://www.youtube.com/watch?v=YUC4SG9vYIk
https://www.youtube.com/watch?v=h51fu-a5g6U
https://www.youtube.com/watch?v=9JuBpAGm9gU
https://twitter.com/ukinbrazil/status/1407349778783031303
https://www.facebook.com/ukinbrazil/posts/4348139281876246
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Entrevistas com Regina Alvala and team

ALVALÁ, R. C. S. Câmera Record revela situação de famílias que sofreram com desastres climáticos. 2021.
(Interview for TV Record).
(https://www.facebook.com/CameraRecord/videos/c%C3%A2mera-record-fam%C3%ADlias-vivem-em-%C3%A1reas-de-risco-de-desastres-naturais/179524830609650/)

ALVALÁ, R. C. S.; NAJAR, A.; COUTO, G. ; RAMOS, C. . #119 ? Escuta Clima ? Ep 3: Vulnerabilidade: desigualdade social e estruturas urbanas. 2021.
Podcast created within the scope of the Escuta Clima series, produced by Camila Ramos, from the Specialization course in Scientific Journalism at the Laboratory for Advanced Studies in Journalism (Labjor), at Unicamp's Creativity Development Center (Nudecri). The podcast aimed to disseminate research and researchers associated with the National Institute of Science and Technology on Climate Change (INCT-MC-II).
(#119 - Escuta Clima - Ep 3: Vulnerabilidade: desigualdade social e estruturas urbanas - Oxigênio (comciencia.br))
ALVALÁ, R. C. S.; RAMOS, C. ; NAJAR, A. ; COUTO, G. ; SANTOS, R. ; MENEZES, J. A. . #122- Escuta Clima ? ep. 4 ? Vulnerabilidade: as vítimas das mudanças climáticas. 2021.
Podcast created within the scope of the Escuta Clima series, produced by Camila Ramos, from the Specialization course in Scientific Journalism at the Laboratory for Advanced Studies in Journalism (Labjor), at Unicamp's Creativity Development Center (Nudecri). The podcast aimed to disseminate research and researchers associated with the National Institute of Science and Technology on Climate Change (INCT-MC-2).
(#122- Escuta Clima - ep. 4 - Vulnerabilidade: as vítimas das mudanças climáticas - Oxigênio (comciencia.br))
ALVALÁ, R. C. S.; TRAJBER, R. Segunda Edição do MAST ConeCTI. 2021.
Chat addressing the activities developed at CEMADEN/MCTI, in response to the invitation of the Museum of Astronomy and Related Sciences (MAST), in the scope of the MAST ConeCTI project, through the MAST channel on YouTube. In the edition of the ConeCTI project, information about Cemaden's mission, monitoring activities, early warning alerts, research and prevention of natural disaster risks were presented. Additionally, a video related to the Cemaden Education Program) were presented.
(Mast coneCTI - Pesquisadora Regina Alvalá (Cemaden) - YouTube)
(https://www.youtube.com/watch?v=DowgGPBVVeA)

ALVALÁ, R. C. S.; ANDERSON, L.; SALLUM, M. A. Webinário 4 #AprenderParaPrevenir. 2020.
(Participation in the #AprenderParaPrevenir Campaign webinar, disseminating relevant information about disasters in the context of Disasters, disasters, disasters! What can we do? What about education?).
(https://www.youtube.com/watch?v=WkuWNmn7hW0)
ALVALÁ, R. C. S.; BRAUN, A.; PIMENTEL, J.; CASTILHO, A.; Stenner, C.; ROMAN, V. Advances in Disaster Science and the Importance of Interinstitutional Cooperation.
Round Table held within the scope of the National Month of Science, Technology and Innovation - CEMADEN. 10/04/2020.
(Avanços na Ciência dos desastres e importância das Cooperações interinstitucionais - YouTube)
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Podcast Oxigênio: Jornal e Rádio Unicamp. #107 – Escuta Clima ep1. – Ciência em busca de matrizes renováveis. Roberto Schaeffer e André R. Gonçalves. Em 06/11/2020. Disponível em: http://oxigenio.comciencia.br/107-escuta-clima-ep1-ciencia-em-busca-de-matrizes-renovaveis/

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TÍTLE	DATA	NEWSPAPER	LINK
Pecuária intensiva e integrada à soja faz fazenda ecológica multiplicar produção	4 de janeiro de 2020	O Estado de S. Paulo	https://sustentabilidade.estadao.com.br/noticias/geral,pecuaria-intensiva-e-integrada-a-soja-faz-fazenda-ecologica-multiplicar-producao,70003143151
Pecuária intensiva e integrada à soja faz fazenda ecológica multiplicar produção	4 de janeiro de 2020	Estadão online	https://sustentabilidade.estadao.com.br/noticias/geral,pecuaria-intensiva-e-integrada-a-soja-faz-fazenda-ecologica-multiplicar-producao,70003143151
Pecuária intensiva e integrada à soja faz fazenda ecológica multiplicar produção	4 de janeiro de 2020	Estado de Minas online	https://www.em.com.br/app/noticia/nacional/2020/01/04/internanacional,1112183/pecuaria-intensiva-e-integrada-a-soja-faz-fazenda-ecologica-multiplica.shtml
Pecuária intensiva e integrada à soja faz fazenda ecológica multiplicar produção	4 de janeiro de 2020	UOL	https://noticias.uol.com.br/ultimas-noticias/agencia-estado/2020/01/04/pecuaria-intensiva-e-integrada-a-soja-faz-fazenda-ecologica-multiplicar-producao.htm
Pecuária intensiva e integrada à soja faz fazenda ecológica multiplicar produção	4 de janeiro de 2020	Revista ISTOÉ	https://istoe.com.br/pecuaria-intensiva-e-integrada-a-soja-faz-fazenda-ecologica-multiplicar-producao/
Pecuária intensiva e integrada à soja faz fazenda ecológica multiplicar produção	4 de janeiro de 2020	ISTOÉ Online	https://istoe.com.br/pecuaria-intensiva-e-integrada-a-soja-faz-fazenda-ecologica-multiplicar-producao/
Pecuária intensiva e integrada à soja faz fazenda ecológica multiplicar produção	4 de janeiro de 2020	ISTOÉ Dinheiro Online	https://www.istoedinheiro.com.br/pecuaria-intensiva-e-integrada-a-soja-faz-fazenda-ecologica-multiplicar-producao/
Pecuária intensiva e integrada à soja faz fazenda ecológica multiplicar produção	4 de janeiro de 2020	Terra	https://www.terra.com.br/noticias/ciencia/sustentabilidade/pecuaria-intensiva-e-integrada-a-soja-faz-fazenda-ecologica-multiplicar-producao,65230752efb86bc041fc3e7e3ac86bf6lkw03wjo.html
Pecuária intensiva e	4 de janeiro de	Tribuna do	https://www.tribunapr.com.br/notici

integrada à soja faz fazenda ecológica multiplicar produção	2020	Paraná Online	as/brasil/pecuaria-intensiva-e-integrada-a-soja-faz-fazenda-ecologica-multiplicar-producao/
Pecuária intensiva e integrada à soja faz fazenda ecológica multiplicar produção	4 de janeiro de 2020	Tarobá News	https://tarobanews.com/noticias/brasil/pecuaria-intensiva-e-integrada-a-soja-faz-fazenda-ecologica-multiplicar-producao-q7Mgj.html
Com 70 mil cabeças fazenda é destaque em produção sustentável	7 de janeiro de 2020	Compre Rural	https://www.comprerural.com/com-70-mil-cabecas-fazenda-e-destaque-em-producao-sustentavel/
Seca atinge em cheio o RS e produtores pedem ajuda do governo	29 de março de 2020	TV Globo / Globo Rural	https://globoplay.globo.com/v/8441044/
Por que o futuro do agronegócio depende da preservação do meio ambiente no brasil	1 de abril de 2020	Conteúdo Animal	https://www.conteudoanimal.com.br/noticias/ver.php?id=26029
Sul do Brasil enfrenta, além da pandemia, forte seca e reflexos na economia	3 de abril de 2020	Agrolink	https://www.agrolink.com.br/noticias/sul-do-brasil-enfrenta--alem-da-pandemia--forte-seca-e-reflexos-na-economia432139.html
Sul do Brasil enfrenta, além da pandemia, forte seca e reflexos na economia	3 de abril de 2020	Portal Palotina	http://portalpalotina.com.br/artigo/sul-do-brasil-enfrenta-alem-da-pandemia-forte-seca-e-reflexos-na-economia-C-31957
Agricultura brasileira precisa se adaptar às mudanças climáticas	15 de maio de 2020	Canal Agroanalysis / FGV Agro	https://www.youtube.com/watch?v=0msvpmVOoEo
FGV EESP realiza debate online sobre agricultura de baixo carbono: desenvolvimento verde, justiça e clima	26 de maio de 2020	JE Online	https://jeonline.com.br/noticia/21994/fgv-eesp-realiza-debate-online-sobre-agricultura-de-baixo-carbono-desenvolvimento-verde-justica-e-clima
Destaques do dia: o que foi notícia nesta quinta - Dia do Meio Ambiente	4 de junho de 2020	Globo Rural	https://revistagloborural.globo.com/Noticias/noticia/2020/06/destaques-do-dia-o-que-foi-noticia-nesta-quinta-feira-46.html
Meio ambiente na perspectiva da ciência e da política é tema da Live Globo Rural desta sexta	4 de junho de 2020	Globo Rural	https://revistagloborural.globo.com/Noticias/noticia/2020/06/meio-ambiente-na-perspectiva-da-ciencia-e-da-politica-e-tema-da-live-globo-rural-desta-sexta.html
Instituto de Estudos Climáticos promove 1º Seminário	23 de junho de 2020	Universidade Federal do Espírito	http://portal.ufes.br/conteudo/instituto-de-estudos-climaticos-promove-1o-seminario-capixaba-sobre-

Capixaba sobre Mudanças Climáticas		Santo	mudancas-climaticas
Novo sistema do Inpe consolida liderança do Brasil	23 de julho de 2020	O Estado de S. Paulo	https://economia.estadao.com.br/noticias/geral,novo-sistema-do-inpe-consolida-lideranca-do-brasil,70003373122
Sustentabilidade - Uma década de Plano Abc	28 de julho de 2020	Revista Globo Rural	-
Inpe e 'a perda de protagonismo que está em curso'	3 de agosto de 2020	Head Topics – Brasil	https://headtopics.com/br/inpe-e-a-perda-de-protagonismo-que-est-em-curso-mar-sem-fim-14749868
Santander/Carlos Aguiar: nossos economistas preveem queda do PIB de 5,5 a 6% e alta do PIB agro de 3%	13 de agosto de 2020	Agência Estado	http://institucional.ae.com.br/cadernos/agro/?id=YUtueUs2QXQ4dUVUYktOMi9JZzNWZz09
Ameaça ou oportunidade? Especialistas discutem balanço de carbono na pecuária	13 de agosto de 2020	Giro do Boi	https://www.girodoboi.com.br/noticias/ameca-ou-oportunidade-especialistas-discutem-balanco-de-carbono-na-pecuaria/
Economistas preveem queda do PIB de 5,5 a 6% e alta do PIB Agro de 3%	13 de agosto de 2020	Portal KLFF	http://www.portalklff.com.br/noticia/economistas-preveem-queda-do-pib-de-55-a-6-e-alta-do-pib-agro-de-3-1063385
Após uma década de Plano ABC, mensurar resultados e ampliar acesso são desafios	15 de agosto de 2020	Globo Rural	https://revistagloborural.globo.com/Noticias/Sustentabilidade/noticia/2020/08/apos-uma-decada-de-plano-abc-mensurar-resultados-e-ampliar-acesso-sao-desafios.html
Aquecimento global não prejudica produção agropecuária no Brasil...	15 de agosto de 2020	Revista Agropecuária	http://www.revistaagropecuaria.com.br/2014/02/06/aquecimento-global-nao-prejudica-producao-agropecuaria-no-brasil/?utmsource=feedsite&utmmedium=feed&utmcampaign=feedsite/
13º Webinar Giro do Boi - Balanço de carbono da pecuária no Brasil: ameaça ou oportunidade?	20 de agosto de 2020	Giro do Boi	https://www.girodoboi.com.br/destaques/13o-webinar-giro-do-boi-balanco-de-carbono-da-pecuaria-no-brasil-ameaca-ou-oportunidade/
Mato Grosso terá estudo de vulnerabilidade para o soja, milho, algodão e pecuária	5 de setembro de 2020	Cenário MT	https://www.cenariomt.com.br/agro/mato-grosso-tera-estudo-de-vulnerabilidade-para-o-soja-milho-algodao-e-pecuaria/
Fórum apresenta estudo de	5 de setembro de 2020	Jornal Estadão	https://estadaomatogrosso.com.br/cidades/forum-apresenta-estudo-de-

vulnerabilidade na agropecuária de Mato Grosso		Mato Grosso	vulnerabilidade-na-agropecuaria-de-mato-grosso/12215
7 videos abordam a agricultura e as mudanças climáticas	15 de setembro de 2020	Ciência e Clima	https://cienciaeclima.com.br/7-videos-abordam-a-agricultura-e-as-mudancas-climaticas/
Clima extremo. Ondas de calor derretem também a economia brasileira, alerta cientista	12 de outubro de 2020	O Globo	https://oglobo.globo.com/sociedade/ondas-de-calor-tambem-podem-derreter-economia-brasileira-alerta-cientista-1-24688285#:~:text=O%20calor%20derrete%20a%20balan%C3%A7a,R%24%2010%20bilh%C3%B5es%20ao%20Paran%C3%A1.
Ondas de calor também podem derreter a economia do Brasil, alerta cientista	12 de outubro de 2020	Blog do Seridó	http://blogdoserido.com.br/noticias/ondas-de-calor-tambem-podem-derreter-a-economia-do-brasil-alerta-cientista/?utmsource=rss&utmmedium=rss&utmcampaign=ondas-de-calor-tambem-podem-derreter-a-economia-do-brasil-alerta-cientista
Inclusão de irrigação no Plano ABC está no radar	13 de outubro de 2020	Valor Econômico	https://valor.globo.com/agronegocios/noticia/2020/10/13/inclusao-de-irrigacao-no-plano-abc-esta-no-radar.ghtml
Inclusão de irrigação no Plano ABC está no radar	13 de outubro de 2020	Valor Online	https://valor.globo.com/agronegocios/noticia/2020/10/13/inclusao-de-irrigacao-no-plano-abc-esta-no-radar.ghtml
Confinamentos poderão entrar em linha de crédito do Plano ABC	13 de outubro de 2020	Beef Point	https://www.beefpoint.com.br/confinamentos-poderao-entrar-em-linha-de-credito-do-plano-abc/#utmsource=rss&utmmedium=rss
Clima é questão acadêmica?	13 de outubro de 2020	Affonso Ritter	http://www.affonsoritter.com.br/Controle?Comando=VisualizarNoticia&gruposNoticia=1,2&ID=101008
Plano ABC: Confinamentos poderão ter linha de crédito	13 de outubro de 2020	Compre Rural	https://www.comprerural.com/plano-abc-confinamentos-poderao-ter-linha-de-credito/
Governo enviou espiões à COP25	13 de outubro de 2020	Brasil Amazônia Agora	https://brasilamazoniaagora.com.br/governo-enviou-espioes-a-cop25/
Ondas de calor já causaram perdas de R$ 25 bi ao RS e PR, calcula Embrapa	13 de outubro de 2020	Brasil 2 Pontos	https://br2pontos.com.br/nacional/ondas-de-calor-ja-causaram-perdas-de-r-15-bi-ao-rs-e-r-10-bi-ao-pr-calcula-embrapa-perdas-podem-se-ampliar-para-outros-estados-incentivo-oficial-disfarcado-a-

			queimadas-e-desmatamentos-prejudica-b/
Onda de calor derrete economia	19 de outubro de 2020	Canal MyNews	https://www.youtube.com/watch?v=1FnDB4T4LA&list=PL0Ttp04MDYJd1Kl9agXhHFc5Q2M-pKIEp
Ouça o Solo Saudável, episódio do podcast EstúdioAgro	27 de outubro de 2020	Terra	https://www.terra.com.br/noticias/climatempo/ouca-o-solo-saudavel-episodio-do-podcast-estudioagro,1ae69f48327b12cc47d455a7ccb426b6xqqpqlle.html
Agronegócio: Campo precisa cuidar do meio ambiente	30 de outubro de 2020	Valor Online	https://valor.globo.com/valor-1000/noticia/2020/10/30/agronegocio-campo-precisa-cuidar-do-meio-ambiente.ghtml
AGRONEGÓCIO - Campo precisa cuidar do meio ambiente	3 de novembro de 2020	Revista Valor Setorial	--
Liga do Araguaia prova que pecuária 'sequestra' carbono	2 de dezembro de 2020	O Estado de S. Paulo	https://economia.estadao.com.br/noticias/geral,liga-do-araguaia-prova-que-pecuaria-sequestra-carbono,70003536031
Liga do Araguaia prova que pecuária 'sequestra' carbono	2 de dezembro de 2020	Estadão Online	https://economia.estadao.com.br/noticias/geral,liga-do-araguaia-prova-que-pecuaria-sequestra-carbono,70003536031
Embrapa contribui para o quarto inventário nacional de emissões de gases de efeito estufa	16 de dezembro de 2020	Jornal Garopaba	https://jornalgaropaba.com.br/embrapa-contribui-para-o-quarto-inventario-nacional-de-emissoes-de-gases-de-efeito-estufa/
Mudanças climáticas	17 de dezembro de 2020	Blog do Hélcio Silva	https://blogdohelciosilva.blogspot.com/2020/12/mudancas-climaticas.html
Embrapa contribui para o quarto inventário nacional de emissões de gases de efeito estufa	20 de dezembro de 2020	Mundo e Meio	https://mundoemeio.com/2020/12/20/embrapa-contribui-para-o-quarto-inventario-nacional-de-emissoes-de-gases-de-efeito-estufa/
Não estamos longe de atingir um ponto de não retorno na Amazônia, diz Carlos Nobre	23 de dezembro de 2020	Blasting News Brasil	https://br.blastingnews.com/ambiente/2020/12/nao-estamos-longe-de-atingir-um-ponto-de-nao-retorno-na-amazonia-diz-carlos-nobre-003252028.html
ILPF converte áreas degradas das pastagens em solos férteis e produtivos, diz Eduardo Assad/Embrapa	10 de março de 2021	Notícias Agrícolas	https://www.noticiasagricolas.com.br/videos/agronegocio/282316-ilpf-converte-areas-degradas-das-pastagens-em-solos-ferteis-e-produtivos-diz-eduardo-assadembrapa.html
Agricultores podem	12 de março de	Notícias	https://www.noticiasagricolas.com.b

virar o jogo com o ILPF e sustentabilidade, diz Eduardo Assad, da Embrapa	2021	Agrícolas	r/videos/agronegocio/282572-agricultores-podem-virar-o-jogo-com-o-ilpf-e-sustentabilidade-diz-eduardo-assad-da-embrapa.html
É preciso cuidar da água hoje para não faltar amanhã	2 de abril de 2021	Canal Agro	https://summitagro.estadao.com.br/agro-no-brasil/colunistas/e-preciso-cuidar-da-agua-hoje-para-nao-faltar-amanha/
100 inovadores contra as mudanças climáticas - Pioneiro nos estudos de agroclimatologia	7 de abril de 2021	Revista Época Negócios	--
Uma nova lógica	17 de abril de 2021	AESBE – Notícias	https://aesbe.org.br/opiniao-uma-nova-logica/
A pecuária que combate o aquecimento global	27 de abril de 2021	O Estado de S. Paulo	https://summitagro.estadao.com.br/agro-no-brasil/uncategorized/a-pecuaria-que-combate-o-aquecimento-global/
Confira o Terraviva DBO na TV na íntegra desta sexta-feira (07)	7 de maio de 2021	TV TerraViva	https://tvterraviva.band.uol.com.br/noticia/1000001004253/confira-o-terraviva-dbo-na-tv-na-integra-desta-sexta-feira-(07).html
Confira o Terraviva DBO na TV na íntegra desta sexta-feira (07)	7 de maio de 2021	BOL	https://videos.bol.uol.com.br/video/confira-o-terraviva-dbo-na-tv-na-integra-desta-sextafeira-07-04024C1A3664C8C96326
Aumento do desmatamento pode acabar com meta do Brasil	14 de maio de 2021	Diário do Pará	https://www.diarioonline.com.br/noticias/brasil/653121/aumento-do-desmatamento-pode-acabar-com-meta-do-brasil
Amazônia teve desmatamento recorde em abril de 2021	14 de maio de 2021	Diário do Pará	http://www.portal.diarioonline.com.br/noticias/brasil/653121/amazonia-teve-desmatamento-recorde-em-abril-de-2021
Amazônia teve desmatamento recorde em abril de 2021	14 de maio de 2021	Blog da Rádio Berokan fm	http://radioberokanfm.blogspot.com/2021/05/amazonia-teve-desmatamento-recorde-em.html
EFEITO ESTUFA - Amazônia teve desmatamento recorde em abril de 2021	14 de maio de 2021	Blog Thonny Santos	http://blogthonnysantos.blogspot.com/2021/05/efeito-estufa-amazonia-teve.html
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Aumento do	14 de maio de	Revista	https://revistacenarium.com.br/aume

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Agência FAPESP - Aumento do desmatamento na Amazônia põe em risco metas climáticas do Brasil	14 de maio de 2021	Ecoa	https://ecoa.org.br/agencia-fapesp-aumento-do-desmatamento-na-amazonia-poe-em-risco-metas-climaticas-do-brasil/
Desmatamento na Amazônia aumenta emissões e ameaça metas climáticas do Brasil	16 de maio de 2021	Portal EcoDebate	https://www.ecodebate.com.br/2021/05/16/desmatamento-na-amazonia-aumenta-a-emissoes-e-ameaca-metas-climaticas-do-brasil/
Aumento do desmatamento na Amazônia põe em risco metas climáticas do Brasil	16 de maio de 2021	Ecoamazônia	https://www.ecoamazonia.org.br/2021/05/aumento-desmatamento-amazonia-poe-risco-metas-climaticas-brasil/
Desmatamento na Amazônia põe em risco metas climáticas do Brasil	16 de maio de 2021	Modais em Foco	https://www.modaisemfoco.com.br/noticias/desmatamento-na-amazonia-poe-em-risco-metas-climaticas-do-brasil
Desmatamento na Amazônia põe em risco metas climáticas do Brasil	17 de maio de 2021	Ciclo Vivo	https://ciclovivo.com.br/planeta/crise-climatica/desmatamento-na-amazonia-poe-em-risco-metas-climaticas-do-brasil/
Desmatamento põe em risco metas do NDC	17 de maio de 2021	Saneamento Ambiental	https://www.sambiental.com.br/noticias/desmatamento-p%C3%B5e-em-risco-metas-do-ndc
Aumento do desmatamento na Amazônia põe em risco metas climáticas do Brasil	17 de maio de 2021	Plurale	https://www.plurale.com.br/site/noticias-detalhes.php?cod=18545&codSecao=14
Desmatamento na Amazônia põe em risco metas climáticas do Brasil	19 de maio de 2021	Tecnologia, Sustentabilidade e Verdades Ocultas	http://tecnologiaporummundomelhor.blogspot.com/2021/05/desmatamento-na-amazonia-poe-em-risco.html
Aumento do desmatamento na Amazônia põe em risco metas climáticas do Brasil	21 de maio de 2021	Brasil Amazônia Agora	https://brasilamazoniaagora.com.br/aumento-do-desmatamento-amazonia-poe-em-risco-metas-climaticas-brasil/
Amazônia está mais perto de se tornar savana; soluções são	27 de maio de 2021	UOL	https://www.uol.com.br/ecoa/colunas/noticias-da-floresta/2021/05/27/amazonia-esta-

incertas			mais-perto-de-se-tornar-savana-solucoes-sao-incertas.htm
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

Virtual Conferences with participation of the water security responsible Mario Mendiondo

Mendiondo, E M (2020) Actions and Demonstrative Pilot Projects for a Post-pandemic Resilient Society by Comparative World Water Quality Nature-based Solutions, 2nd WWQA Annual Global Meeting, 27-28 Jan., 2021 (link)
Mendiondo, E M, Aldana-Valverde, A L (2021) PROHIMET - Ibero-American Network for the Monitoring and Forecasting of Hydrometeorological Phenomena, In: WMO-APFM/GWP, Bi-Annual APFM SBPs virtual Forum, 4 March, 2021
Open Science Repository, Popularization Outreach and Citizen Literacy on Interdisciplinary Water Security Under Global Changes:
International Seminar of Global Health - IEA/USP, Dez/2020
https://www.youtube.com/watch?v=zbVNIaeydK0
Panta Rhei Open Science for a Future Earth Colloquium, CEPED. Dez/2020
Introduction - 2nd Webinar of Resilient Municipalities, CEPED Dez/2020
https://www.youtube.com/watch?v=9AnRjSolJYw
Following Parts (Sessions I, II, III and IV), CEPED+CEMADEN, Dez/2020
https://www.youtube.com/watch?v=6Ems71VFuX8
3rd Webinar of Resilient Municipalities, Regulation, March/2021
https://www.youtube.com/watch?v=Rom_k0L6v9E
Save The Water Podcast - May 2021:
https://anchor.fm/savethewater/episodes/Mario-Mendiondo--Global-Water-Resources-e127rsn/a-a3vgkau
"One Drop of Science, One Dose of Resilience":
1st Webinar - "Parana River Under Zero" - July, 2021
https://youtu.be/QCGzaZ0e3LE
2nd Webinar - "Virtuous Water People" - July, 2021
https://youtu.be/nBQHrrGewZg

Interviews with Paulo Artaxo

https://revistapesquisa.fapesp.br/a-prova-da-eficacia-das-mascaras/
https://revistapesquisa.fapesp.br/mais-desmatamento-menos-chuva-e-menor-producao-agricola/
https://revistapesquisa.fapesp.br/contra-o-aquecimento-global/
https://revistapesquisa.fapesp.br/ciencia-de-impacto-2/
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News and interview from the Communications team

1. PÉREZ, G.; DIAS, S.. O desafio de dar visibilidade às complexas relações entre humanos e rios. **ClimaCom**. 2020a. Disponível em: http://climacom.mudancasclimaticas.net.br/relacoes-humanos-rios/
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mudanças climáticas para além do já dado. **ClimaCom**. 2020b. Disponível em: http://climacom.mudancasclimaticas.net.br/conversasinfinitas/

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9. PÉREZ, G.; DIAS, S. Pesquisas com a Amazônia se esforçam para garantir dados e análises vitais para a sociedade. **ClimaCom**. 2020c. Disponível em: http://climacom.mudancasclimaticas.net.br/fapesp/

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12. PÉREZ, G.; DIAS, S. Residências reúnem indígenas e não indígenas em criações conjuntas de arte digital. **ClimaCom**. 2020c. Disponível em: http://climacom.mudancasclimaticas.net.br/aire/

13. PÉREZ, G.; DIAS, S. Estudo considera consequências da Covid-19 para o desenvolvimento sustentável. **ClimaCom**. 2020c. Disponível em: http://climacom.mudancasclimaticas.net.br/ods/

14. PÉREZ, G.; DIAS, S. Projeto Ecolume no semiárido pernambucano visa integrar água, energia e alimento para a população. **ClimaCom**. 2020c. Disponível em: http://climacom.mudancasclimaticas.net.br/projeto-ecolume/

15. PÉREZ, G.; DIAS, S. Desafios do Brasil para a conservação da floresta e mudanças no uso da Terra. **ClimaCom**. 2020c. Disponível em: http://climacom.mudancasclimaticas.net.br/ndc-fapesp/

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18. RAMOS, C; DIAS, S. Coprodução e a natureza especulativa das modelagens computacionais nas pesquisas em mudanças climáticas. **ClimaCom** 2020. Disponível em: http://climacom.mudancasclimaticas.net.br/coproducao-camila-ramos/

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20. DIAS, S.; PÉREZ, G. O desafio de dar visibilidade às complexas relações entre humanos e rios. (vídeo reportagem). 14 de out. 2020. Disponível em: https://www.youtube.com/watch?v=INCRihEWxMI

21. DIAS, S. Conversas infinitas: divulgação científica, educação, mudanças climáticas... Revista Climacom. 2 de nov. de 2020. Disponível em: https://www.youtube.com/watch?v=q520bNFf2L8
22. DIAS, S. Como formei-me pajé? Arvorecer de casa em casa. 9 de abr. De 2021. Disponível em: https://www.youtube.com/watch?v=yHae3Y9fZaM&t=71s
23. DIAS, S. Aldeia Awa Porungawa Dju diz sim à vida, sim à vacina! Arvorecer de casa em casa. 31 de jan. de 2021. Disponível em: https://www.youtube.com/watch?v=e9M0zTg2GFA&t=7s
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25. Artistic productions

26. DIAS, Susana; WIEDEMANN, Sebastian. Cintilações [Scintillations]. ClimaCom – Coexistências e cocriações [online], Campinas, ano 8, n. 20. abril 2021. Available from: http://climacom.mudancasclimaticas.net.br/cintilicoes/
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35. QUEIROZ FILHO, Antonio Carlos. Conversas infinitas - poesia sonora. ClimaCom, nov. de 2020. Disponível em: http://climacom.mudancasclimaticas.net.br/livros-principal/conversas-infinitas/
36. PALLONE, S.; RAMOS, C.; DIAS, S. #1 – Escuta Clima: Segurança Energética. ClimaCom. Disponível em: http://climacom.mudancasclimaticas.net.br/serie-escuta-clima/1-escuta-clima-ciencia-em-busca-de-matrizes-renovaveis/
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ALLONE, S.; RAMOS, C.; DIAS, S. #2 – Escuta Clima: Rios urbanos e conta-gotas. Revista ClimaCom. Disponível em: http://climacom.mudancasclimaticas.net.br/2-escuta-clima-rios-urbanos-e-conta-gotas/
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ALLONE, S.; RAMOS, C.; DIAS, S. #3 – Escuta Clima: Vulnerabilidade: desigualdade social e estruturas urbanas. Revista ClimaCom. Disponível em: http://climacom.mudancasclimaticas.net.br/3-escuta-clima-vulnerabilidade-desigualdade-social-e-estruturas-urbanas/
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http://climacom.mudancasclimaticas.net.br/4-escuta-clima-vulnerabilidade-as-vitimas-das-mudancas-climaticas/
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ALLONE, S.; RAMOS, C.; DIAS, S. #5 – Escuta Clima: A produção de alimentos nos dois lados da porteira. Revista ClimaCom. Disponível em: http://climacom.mudancasclimaticas.net.br/5-escuta-clima-a-producao-de-alimentos-nos-dois-lados-da-porteira/
41. PALLONE, S.; RAMOS, C.; DIAS S. #6 Escuta Clima – Amazônia e Cerrado: a importância dos biomas para o clima. Revista ClimaCom. Disponível em: http://climacom.mudancasclimaticas.net.br/6-escuta-clima-amazonia-e-cerrado-a-importancia-dos-biomas-para-o-clima/

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

- MASTER – CAPES
PROCESS NUMBER: 88887.318111/2019-00
TITLE: Downscaling de Modelos Climáticos na Bacia do Rio Itajaí e eventos extremos
NAME: Maria Fernanda Rodrigues Pereima
PERIOD: 01/03/2019-28/02/2021
INSTITUTION: UFSC
- 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: UFSC
- VISITING RESEARCHER – CAPES
PROCESS NUMBER: 88887.477406/2020-00
TITLE: Desastres Naturais, Área Urbana, Infraestrutura Física e Desenvolvimento Urbano
NAME: Martha Macedo de Lima Barata
PERIOD: 01/03/2020 a 28/02/2021
INSTITUTION: Centro Clima-COPPE-UFRJ
- DOUTORADO CAPES
TITLE: Potential effects of climate change and human actions on the dynamics of the Alter do Chão Aquifer in central Amazonia, Manaus region and surroundings.
NAME: Alderlene Pimentel de Brito
PERIOD: 2020
INSTITUTION: INPE
- DOUTORADO CAPES
TITLE: Potential effects of climate change and human actions on the dynamics of the Alter do Chão Aquifer in central Amazonia, Manaus region and surroundings.
NAME: Ana Carolina Paiva.
PERIOD: 2020
INSTITUTION: INPE
- DOUTORADO Netherlands foundation for the Advancement of Tropical Research
TITLE: . Effects of land use and land cover change on the water cycle in the Amazon basin under a changing climate
NAME: Rita de Cassia Silva von Randow.
PERIOD: 2020
INSTITUTION: CNPq
- MSC. Netherlands foundation for the Advancement of Tropical Research
TITLE: Extreme events in the Amazon and their effect on the hydrological dynamics of floodplain rivers and lakes.

NAME: Nayanndra Carvalho da Silva
PERIOD: 2020
INSTITUTION: CAPES
- MSC. Netherlands foundation for the Advancement of Tropical Research
TITLE: Impact of climate change in a basin in the south of the state of Minas Gerais
NAME: Estefânia Maria Sousa Zhákia.
PERIOD: 2020
INSTITUTION: UF Lavras
-TT: FAPESP **Processo:** 2020/07175-4
Títle: Divulgação jornalística do INCT Mudanças climáticas - 2ª fase
Name: Gláucia Catalina Pérez de Almeida
Períod: 01/08/2020 a 31/07/2021
INSTITUTION: UNICAMP
-POST DOCTORAL, FAPESP 465501/2014-l
Title: Research on climate change and food security
Name: Gabriela dos Santos Eusébio,
Period: April 2019 until March 2020.
Institution: UNICAMP
-Post Doctoral, FIOCRIUZ : VPGDI-016-FIO-20
Title: The importance of "Sentinel Areas" associated with climate change in the context of epidemiological surveillance of American Cutaneous Leishmaniasis in Brazil.
Name: Simone Miranda da Costa
Period 2020-2021
Institutioon: FIOPCRZU
-Post Doctoral, FIOCRUZ : VPGDI-017-FIO-20
Title: Surveillance and Control of American Visceral Leishmaniasis in the State of Rio de Janeiro: spatial distribution and analysis of municipal vulnerability. context of epidemiological surveillance of American Cutaneous Leishmaniasis in Brazil.
Name: Margarete Martins Afonso dos Santos
Period 2020-2021
Institution: FIOCRUZ
-Ph.D. CAPES 88887.136402/2017-00 - 465501/2014-1
Title: A proposal to adapt the Brazilian coal industry to fit in a low carbon world economy
Name: Fábio Teixeira Ferreira da Silva
Period: From 01/03/2017 To 28/02/2021
-Ph.D. CAPES 88887.136402/2017-00 - 465501/2014-1
Title Incorporating and improving the water-energy-land-use nexus into an energy model - Brazilian case study
Name: Fabio Amendola Diuana
Institution: INPE
Period: 01/03/2017 To 28/02/2021
-Ph.D. FAPESP 2019/05361-8
Title Impacto dos aerossóis no potencial de energia solar Brasileiro
Name: Madeleine Sánches Gácita Casagrande
Period: 01/08/2019 To 31/07/2021
Instotution: COPPE UFRJ
-Ph.D. FAPESP 2020/15754-4
Title MÉTODOS DE REFINAMENTO ESTATÍSTICO DE PROJEÇÕES CLIMÁTICAS PARA QUANTIFICAÇÃO DOS POTENCIAIS SOLAR E EÓLICO NO BRASIL
Name: Francisco José Lopes de Lima
Period01/02/2021 To 31/01/2023
Institution: INPE
-TT3, FAPESP
Titulo: Divulgação jornalística do INCT Mudanças climáticas – 2ª fase (Journalistic

dissemination of the INCT for Climate Changes – Phase 2)
Name: – Glaucia Pérez
Period: 1 year
Institution: LabJor UNICAMP
-Scientific initiation, BAS-Unicamp
Title – Novas sensibilidades diante das catástrofes socioambientais: criação de materiais de divulgação científica das mudanças climáticas (New sensibilities in the face of socio-environmental catastrophes: creation of materials for the scientific dissemination of climate change)
Name - Larissa Bellini
Period: 1 year
Institution: LabJor UNICAMP
-Scientific initiation, BAS-Unicamp
Title – Novas sensibilidades diante das catástrofes socioambientais: criação de materiais de divulgação científica das mudanças climáticas (New sensibilities in the face of socio-environmental catastrophes: creation of materials for the scientific dissemination of climate change)
Name: Karolyne Souza
Period – 1 year
Institution: LabJor UNICAMP
-TT3 FAPESP
Title: Science communication of INCT for Climate Change Phase 2
Name: Gláucia Pérez.
Period-2021-2021
Institution: LabJor UNICAMP
-Ph.D.
Francisco Agustinho Neto, Doctoral Student developing Antarctic Ice modeling studies with BESM. Advisor: Paulo Nobre.
-Ph.D.
Pedro Regoto, Doctoral Student developing global climate modeling abrupt climate change. Advisor: Paulo Nobre
-Ph.D.
Diego de Andrade Campos, Doctoral Student. Coupling Radiation-Convection in the Eta Model. Advisor: Sin Chan Chou
-Ph.D.
José Davi de Moura, Doctoral Student. .Parameterization of lightning in the Eta Model. Advisor: Sin Chan Chou

- ***Paula Carvalho Pereda***

"Assessing the climate and weather effects in Brazil using panel data"
Scholarships abroad - Research
Paula Carvalho Pereda
Link: https://bv.fapesp.br/en/bolsas/179293/assessing-the-climate-and-weather-effects-in-brazil-using-panel-data/

-Michael Tulio Ramos de França

"Fertility and inequality: evidence from Brazil"
Scholarships in Brazil - Doctorate
Eduardo Amaral Haddad
Link: https://bv.fapesp.br/en/bolsas/174909/fertility-and-inequality-evidence-from-brazil/

- ***Eduardo Amaral Haddad***

"Agricultural and agro-industrial sustainability in Chile: modeling the impacts of climate change and natural disasters in an integrated framework"
Regular Research Grants

Eduardo Amaral Haddad
Link: https://bv.fapesp.br/en/auxilios/102276/agricultural-and-agro-industrial-sustainability-in-chile-modeling-the-impacts-of-climate-change-and/

- ***François Claude Prado Boris***
"A spatial impact analysis of water accessibility on farming in the Brazilian semiarid"
Scholarships in Brazil - Scientific Initiation
Eduardo Amaral Haddad
Link: https://bv.fapesp.br/en/bolsas/181818/a-spacial-impact-analysis-of-water-accessibility-on-farming-in-the-brazilian-semiarid/

- ***Karina Simone Sass***
"Urbanization and climate change: impact evaluation in the Metropolitan Region of São Paulo"
Scholarships in Brazil - Doctorate
Eduardo Amaral Haddad
Link: https://bv.fapesp.br/en/bolsas/183721//

- ***Inácio Fernandes de Araújo Junior***
"Agricultural and agro-industrial sustainability in Chile: modeling the impacts of climate change and natural disasters in an integrated framework"
Scholarships in Brazil - Technical Training Program - Technical Training
Eduardo Amaral Haddad
Link: https://bv.fapesp.br/en/bolsas/184227/agricultural-and-agro-industrial-sustainability-in-chile-modeling-the-impacts-of-climate-change-and/

- Alderlene Pimentel de Brito. Potential effects of climate change and human actions on the dynamics of the Alter do Chão Aquifer in central Amazonia, Manaus region and surroundings. 2020. Tese (Clima e Ambiente) - Instituto Nacional de Pesquisas da Amazônia. Inst. financiadora: Coordenação de Aperfeiçoamento de Pessoal de Nível Superior
-Ana Carolina Paiva. Water security in the Paraiba do Sul Basin. 2020. Tese (CIÊNCIA DO SISTEMA TERRESTRE) - Instituto Nacional de Pesquisas Espaciais. Inst. financiadora: Coordenação de Aperfeiçoamento de Pessoal de Nível Superior
-Sass, K (2021) Climate Change, Droughts and Economic Impacts: An Analysis in the Sao Paulo Metropolitan Region, Supervisors: E Haddad (FEA/USP) & E M Mendiondo (EESC/USP),
-Rita de Cassia Silva von Randow. Effects of land use and land cover change on the water cycle in the Amazon basin under a changing climate. 2020. Tese (Faculty of Agricultural and Environmental Sciences) - Wageningen University. Inst. financiadora: Netherlands foundation for the Advancement of Tropical Research
-Nayanndra Carvalho da Silva. Extreme events in the Amazon and their effect on the hydrological dynamics of floodplain rivers and lakes. 2020. Dissertação (Clima e Ambiente) - Instituto Nacional de Pesquisas da Amazônia. Inst. financiadora: Conselho Nacional de Desenvolvimento Científico e Tecnológico
-Estefânia Maria Sousa Zhákia. Impact of climate change in a basin in the south of the state of Minas Gerais. 2020. Dissertação (Recursos Hídricos) - Universidade Federal de Lavras Inst. financiadora: Coordenação de Aperfeiçoamento de Pessoal de Nível Superior
-Scientific Initiation - graduation
Oziel Rodrigues Pedrosa – in progress. Estudo de atributos hidrológicos como suporte à gestão de recursos hídricos no estado de Pernambuco. Started in: 2020. National Council for Scientific and Technological Development.
José Gustavo da Silva. – Completed. Estudo de processos hidrológicos em áreas experimentais e representativas em Pernambuco: monitoramento e experimentação. 2020. Federal University of Pernambuco; National Council for Scientific and Technological Development.

FAPESP 2019/05129-8 Assessing the key-factors to water-energy-food recycling through bioretention practices in different scales and climates, BEPE/DO, Marina B de Macedo, Set/2019-Jun/2020 (Monash University, Australia).

13. Changes in Personnel

Food Security

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

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

Insertion of a researcher in the CEMADEN team: Dra. Olga Lucia Calderon.
Insertion of the following researchers in the FIOCRUZ team: Denise Silva e Souza

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

Use of the RT:

	Valor cada Componente	Valor Gasto	Descrição	SALDO
COORDENAÇÃO				
DESASTRE NATURAIS	-	-	-	-
ECONOMIA	-	-	-	
SEGURANÇA ALIMENTAR	-	-	-	-
ENERGIA				
COMUNICAÇÃO				
ECOSSISTEMA		**8.500,00**	**Trabalhos de inclusão de dados coletados na amazônia**	
HIDROLOGIA				
SAÚDE				
MODELAGEM				

Use of the BC: Year 2020-2021

PI	BC individual para PIs	Valor Gasto	Descrição	Saldo
JOSÉ ANTÔNIO MARENGO ORSINI	R$ 12.000,00			
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	-	-		-

15 Collaboration with other INCTs, projects and Research networks

This INCT MC Phase 2 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
Instituto Nacional de Ciência e Tecnologia da Criosfera
Coordinator: Jefferson Cardia Simões
UFRGS - Universidade Federal do Rio Grande do Sul

Process: 465319/2014-9
Instituto Nacional de Ciência e Tecnologia do Bioetanol
Coordinator: Marcos Silveira Buckeridge
USP - Universidade de São Paulo

Process: 2015/03804-9
Project 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, Univ of Leeds.

VILELA, M; DIAS, S. Experiências de arvorecer. Projeto aprovado na Lei Federal no. 14.017, de 29 de junho de 2020 – Lei de Emergência Cultural Aldir Blanc, secretaria de Cultura de

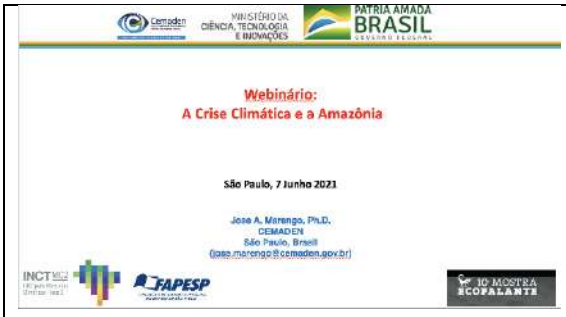
Campinas-SP. Valor: 20.000,00. De fev a abril de 2021. (Treelike experiences. Project approved within the Federal Law no. 14,017, of June 29, 2020 – The Aldir Blanc Cultural Emergency Law, Secretary of Culture of Campinas-SP. Value: R$ 20,000.00. From Feb to April 2021.)

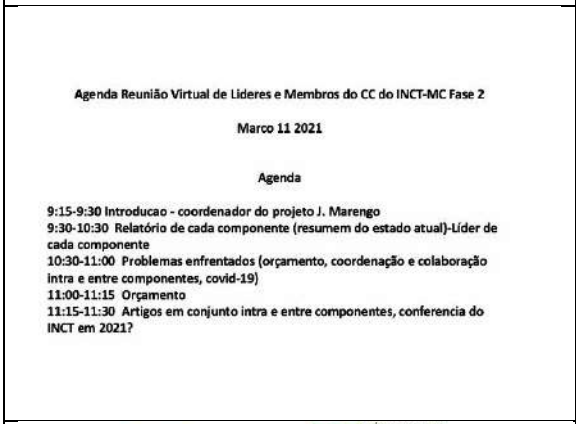
DIAS, S. Projeto "Novas sensibilidades diante das catástrofes socioambientais: criação de materiais de divulgação científica das mudanças climáticas", aprovado no SAE-Unicamp. Valor: 16.272,00. De fev de 2021 a fev de 2022. (The project "New sensibilities in the face of socio-environmental catastrophes: creation of materials for the scientific dissemination of climate change", approved by SAE-Unicamp. Value: R$ 16,272.00. From Feb 2021 to Feb 2022.)

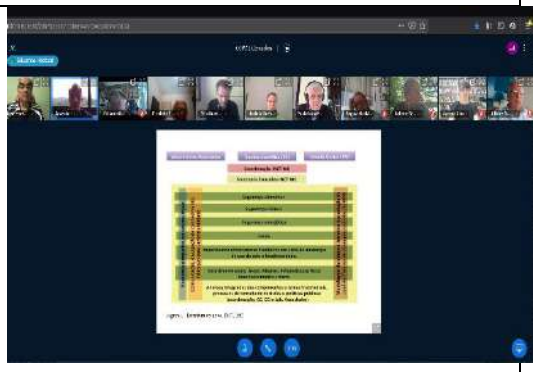
Resources from the CNPq project led by Paulo Nobre awarded funds from CNPq call for proposals 6/2020 allowed the hiring of one PostDoc researcher to develop the coupling of Eta-MOM6, with the support of members of the INCT-MC2 Modeling component.

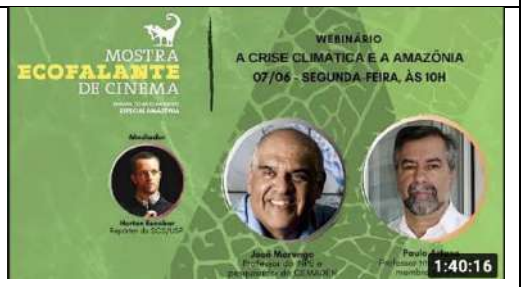
Annexes

Presentations of the INCT MC Phase 2 at meetings and conferences (presential and virtual)

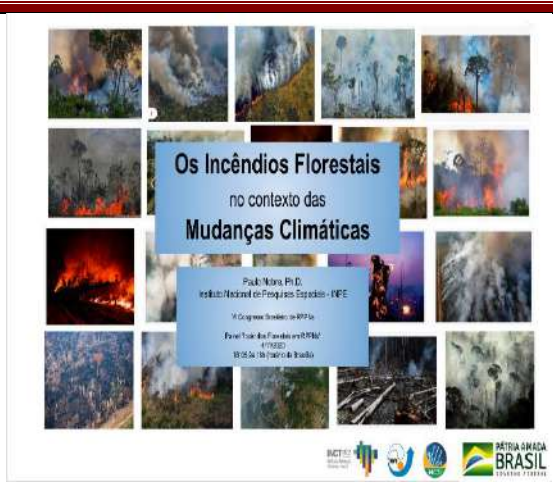


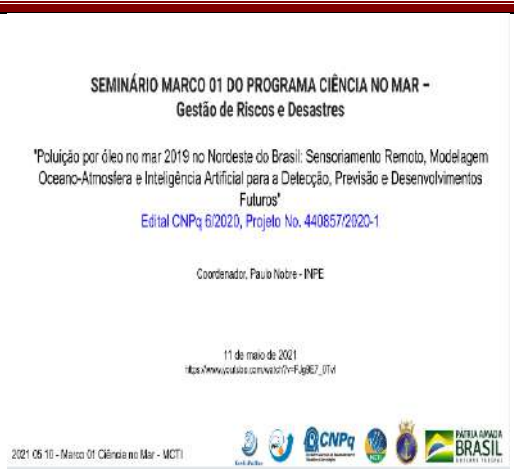




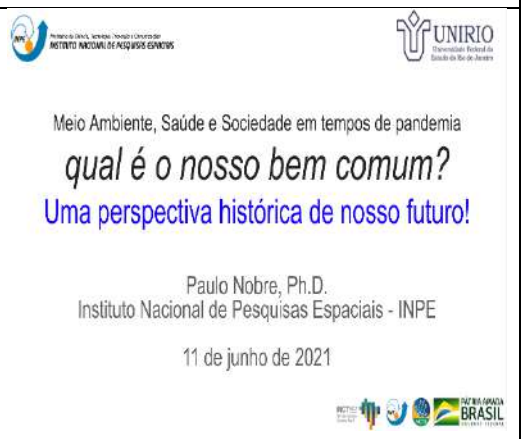


Presentation cover "Emissões de GEE e C do solo na Bacia Estendida do São Francisco".


Os Incêndios Florestais
no contexto das
Mudanças Climáticas
Paulo Nobre, Ph.D.
Instituto Nacional de Pesquisas Espaciais - INPE
PÁTRIA AMADA BRASIL


SEMINÁRIO MARCO 01 DO PROGRAMA CIÊNCIA NO MAR –
Gestão de Riscos e Desastres
"Poluição por óleo no mar 2019 no Nordeste do Brasil: Sensoriamento Remoto, Modelagem Oceano-Atmosfera e Inteligência Artificial para a Detecção, Previsão e Desenvolvimentos Futuros"
Edital CNPq 6/2020, Projeto No. 440857/2020-1
Coordenador, Paulo Nobre - INPE
11 de maio de 2021
2021 05 10 - Marco 01 Ciência no Mar - MCTI
CNPq
PÁTRIA AMADA BRASIL


Monitoramento da
Amazônia Azul:
Uma Visão de Futuro
Paulo Nobre, Ph.D.
Instituto Nacional de Pesquisas Espaciais - INPE
Ministério da Ciência, Tecnologia e Inovações - MCTI
1a Sessão Ordinária da Comissão Técnico Científica - ComTecPol Óleo
Rio de Janeiro, 7 Dezembro 2020
PÁTRIA AMADA BRASIL


UNIRIO
Meio Ambiente, Saúde e Sociedade em tempos de pandemia
qual é o nosso bem comum?
Uma perspectiva histórica de nosso futuro!
Paulo Nobre, Ph.D.
Instituto Nacional de Pesquisas Espaciais - INPE
11 de junho de 2021
PÁTRIA AMADA BRASIL


A base científica das
Mudanças Climáticas Globais
Paulo Nobre, Ph.D.
Instituto Nacional de Pesquisas Espaciais – INPE
Webinário A visão científica e da sociedade brasileira sobre as mudanças do clima
26 de março de 2021
PÁTRIA AMADA BRASIL


INSTITUTO AGRONÔMICO DE PERNAMBUCO
Pernambuco
Produção Sustentável na
Caatinga e a interface entre
Biodiversidade e Clima
Dra. Francis Lacerda
Instituto Agronômico de Pernambuco – IPA
Dr. Paulo Nobre
Instituto Nacional de Pesquisas Espaciais – INPE
10/Junho/2021
Diálogo Brasil - Post 2020 Biodiversity Framework
https://www.youtube.com/watch?v=KEqTuAkFPOM&ab_channel=ICLEISAMS

Brazil - United States Workshop
Oil Spill Response and Restoration

Monitoring Oil Spill in Brazil

Paulo Nobre, Ph.D.
National Institute for Space Research - INPE
Ministry of Science, Technology and Innovations - MCTI

24 May 2021
https://www.youtube.com/watch?v=QSdpvKCIZAA

US Workshop Research on Oil at Sea

"Poluição por óleo no mar 2019 no Nordeste do Brasil: Sensoriamento Remoto, Modelagem Oceano-Atmosfera e Inteligência Artificial para a Detecção, Previsão e Desenvolvimentos Futuros"

Projeto Edital CNPq 6/2020, No. 440857/2020-1

PIs: Paulo Nobre[1], Laercio Namikawa[1], João Lorenzzetti[4], Jorge Gomes[1], Angelo Lemos[1]

1 - Instituto Nacional de Pesquisas Espaciais - INPE
2 - Universidade Federal do Sul da Bahia - UFSB
3 - Diretoria de Gestão de Programas da Marinha do Brasil - DGePM/MB
4 - Universidade Federal do Espírito Santo - UFES
5 - Universidade Federal do Maranhão - UFMA
6 - Instituto de Estudos Avançados - IEAv/DCTA/FAB
7 - Instituto Oceanográfico da Universidade de São Paulo - IO/USP
8 - Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - IBAMA
9 - Empresa Brasileira de Aeronáutica - VISIONA/EMBRAER
10 - Oregon State University - OSU

Webinário ComTecPetróleo - Poluição por Derramamento de Óleo no mar -13 de Abril de 2021

Crise de escassez hídrica na Bacia do Rio Paraguai e as ameaças ao bioma Pantanal

Comissão Externa Queimadas em Biomas Brasileiros
Câmara dos Deputados
Brasília DF

15 de julho de 2021

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

CÂMARA DOS DEPUTADOS
COMISSÃO EXTERNA - QUEIMADAS EM BIOMAS BRASILEIROS

Painel:
O PROJETO DE DESMONTE DAS POLÍTICAS NACIONAIS NA ESFERA AMBIENTAL
CONSEQUÊNCIAS E AÇÕES DE MITIGAÇÃO NO CENÁRIO PÓS COVID-19

22/7/2021

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

Reports, interviews, pod casts, and press communications where results of the INCT MC Phase 2 were mentioned

Aumento do desmatamento na Amazônia põe em risco metas climáticas do Brasil

Elton Alisson | Agência FAPESP – O aumento do desmatamento ilegal na Amazônia põe em risco as metas de redução das emissões de gases de efeito estufa (GEE) estabelecidas na Contribuição Nacionalmente Determinada (NDC) do Brasil em 2015, por ocasião do assentuno do Acordo de Paris, e revisadas em dezembro de 2020.

A derrubada de floresta para conversão em pastagens no bioma amazônico tem impulsionado as emissões de GEE do país e se tornou, desde 2017, a principal fonte de geração no Brasil desses gases que contribuem para o aquecimento global, apontaram pesquisadores participantes do webinário "Contribuição Nacionalmente Determinada (NDC) Brasileira: metas nos setores estratégicos – florestas, agricultura e energia", realizado pelo Programa FAPESP de Pesquisa sobre Mudanças Climáticas Globais (PFPMCG) no último dia (11/05).

"Se o desmatamento continuar, isso é sinônimo para natureza do aumento de gases de efeito estufa no Brasil para os próximos anos", disse Eduardo Assad, pesquisador da Embrapa Informática Agropecuária, durante o evento.

De acordo com dados apresentados pelo pesquisador, em 2018, o setor agropecuário foi responsável por 33,23% das emissões de GEE do Brasil e as mudanças de uso da terra, liderados pelo desmatamento, por 27,1%. A partir de 2017 essa situação mudou e o

Revista ClimaCom, Epidemiologias | jornalismo – reportagem | ano 6, no. 19, 2020

http://climacom.mudancasclimaticas.net.br/relacoes-humanos-rios/

O desafio de dar visibilidade às complexas relações entre humanos e rios.

Por: Gláucia Pérez

Editora: Susana Dias

A água é um elemento que participa intensamente da vida dos humanos, numa e complexa "coevolução" entre sistemas hídricos dos rios e as sociedades. Um caminhar junto que está repleto de padrões", avalia Mário Mendiondo, o engenheiro e coordenador do programa de pós-graduação em engenharia hidráulica e saneamento (PPG-SHS) da Escola de Engenharia de São Carlos da USP. É com essa visão, de que as águas e os humanos caminham juntos, que Mendiondo lidera um grande grupo de pesquisa que trabalha com hidrologia e desastres naturais na Escola de São Carlos da USP, o Wadi-Lab (Water Adaptive Design & Innovation Lab). Fomos visitar esse laboratório e conhecer os pesquisadores, projetos, materiais, questões de pesquisa, os desafios teóricos e metodológicos enfrentados.

O vídeo que acompanha a reportagem pode ser acessado no canal do Youtube da ClimaCom: https://youtu.be/INCfbhEWcMI

Iniciamos a conversa com o pesquisador e engenheiro civil Felipe Augusto Arguello de Souza, doutorando em Engenharia Hidráulica e Saneamento EESC - USP, que no momento está

Risco de mais desastres naturais : Revista Pesqui... https://revistapesquisa.fapesp.br/risco-de-mais-d...

MUDANÇAS CLIMÁTICAS

Risco de mais desastres naturais (https://revistapesquisa.fapesp.br/risco-de-mais-desastres-naturais/)

Aquecimento global deve favorecer aumento de inundações bruscas e deslizamentos de terra causados por chuvas extremas no Sul, Sudeste e leste do Nordeste

1 of 7 13/05/21 10:12

Número de dias com chuva forte na Grande SP aumentou 6 v... https://g1.globo.com/sp/sao-paulo/noticia/2020/03/10/numero...

SÃO PAULO

Número de dias com chuva forte na Grande SP aumentou 6 vezes nos últimos anos

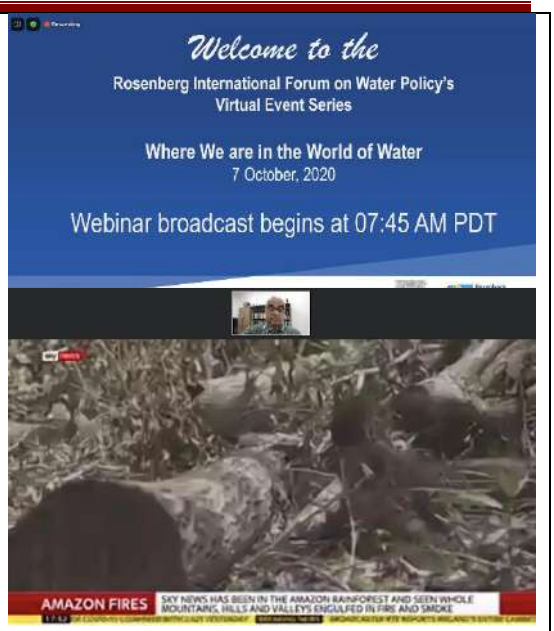
Chuvas acima de 100 milímetros, como a que alagou as marginais há um mês, estão mais comuns, de acordo com pesquisa do Cemaden.

Por Patrícia Figueiredo, G1 SP — São Paulo

La Niña e desequilíbrio na Amazônia dificultam saída da crise hídrica

Climatologistas apontam sinais de agravamento da seca na Bacia do Paraná, que concentra hidrelétricas, desde 2014

OS RIOS VOADORES DA AMAZÔNIA



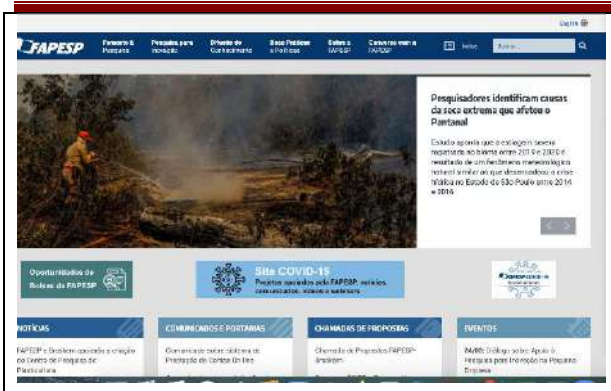
As causas da seca extrema do Pantanal

Pantanal teve pior seca em 50 anos, revela estudo

Últimas Notícias

Forte enchente agrava crise no Acre

Pantanal teve pior seca em 50 anos, revela estudo


FAPESP
Pesquisadores identificam causas da seca extrema que afetou o Pantanal
Site COVID-19
NOTÍCIAS
COMUNICADOS E PORTARIAS
CHAMADAS DE PROPOSTAS
EVENTOS


Nadia
13/03/2021 11:10
Todas as mídias
Ciência e Cultura: vamos brincar?
Jacque Baumgratz
Wilson Nomen
13/03/21
SÁBADO 16H
MUDANÇAS CLIMÁTICAS
programawash


MATO GROSSO
Pior seca dos últimos 50 anos no Pantanal foi causada por fenômeno meteorológico, diz pesquisa


MATO GROSSO
Mais MT
MAIOR


GALILEU
MEIO AMBIENTE
Pesquisadores identificam causas da seca extrema no Pantanal em 2020
EU QUERO


GALILEU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jornal.usp.br — Privado
Cientistas estudam seguro que ameniza prejuízos causados por secas e enchentes
Pesquisadores da USP trabalham no desenvolvimento de modelos do chamado seguro indexado, que tem seu valor definido a partir de estimativas dos danos que um desastre em iminência pode gerar
Ciências / Ciências Ambientais - 11/05/2021 -
https://jornal.usp.br/?p=412074


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SEMANA DAS MUDANÇAS CLIMÁTICAS
CONFERÊNCIA SOBRE AS MUDANÇAS CLIMÁTICAS E IMPACTOS NAS ÁREAS URBANAS
15/3 | 2ª feira
18h30 às 20h15
SÃO CARLOS
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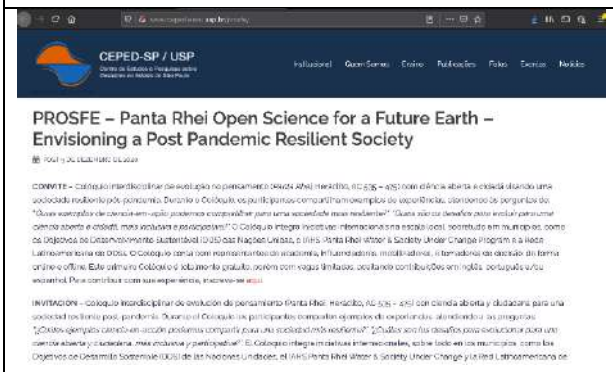
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PROSFE – Panta Rhei Open Science for a Future Earth – Envisioning a Post Pandemic Resilient Society


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O que deixou o Brasil à beira de uma crise hídrica histórica?

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NOTÍCIAS MEDIATECA APRENDER ALEMÃO

MUNDO BRASIL ALEMANHA ECONOMIA CULTURA CIÊNCIA E SAÚDE TURISMO ESPORTE COLUNAS

BRASIL

O que deixou o Brasil à beira de uma crise hídrica histórica?

Irregularidade das chuvas ameaça abastecimento de água, impacta agricultura e encarece conta de energia. Há 91 anos não se via tão pouca água nos reservatórios do país, e especialistas temem nova crise do apagão.

A chegada do inverno no Brasil nesta segunda-feira (21/06), a época mais seca do ano, pode também trazer dias mais quentes que o habitual para a estação. A combinação deve agravar a já crítica situação hídrica no país, que vê o volume dos reservatórios afundarem a níveis prévios à crise de 2015.

"Se a situação está grave neste momento é porque o verão, que é chuvoso, não foi chuvoso", afirma José Marengo, climatologista e coordenador-geral de pesquisa e desenvolvimento do Centro Nacional de Monitoramento e Alertas de Desastres Naturais (Cemaden).

Há 91 anos não se via tão pouca água, diz o Comitê de Monitoramento do Setor Elétrico (CMSE). Os danos não se restringem à geração de eletricidade nas usinas hidrelétricas, que contam atualmente com um volume médio útil de 54%, calculado pelo Operador Nacional do Sistema (ONS).

Na agricultura, o aumento em 7% da área plantada do milho, segundo tipo de grão mais cultivado no país, não foi suficiente para aliviar o peso da seca. A safra deve cair 6% em relação à anterior, com produção estimada em 96,4 milhões, prevê a Companhia Nacional de Abastecimento (Conab) em seu último boletim.

Enquanto a pouca chuva preocupa no Sudeste, no Norte a população sofre com a maior cheia do rio Negro em 119 anos. Os dois eventos são considerados extremos climáticos – um cenário que não surpreende cientistas que estudam o tema.

"O que estamos experimentando agora – muita chuva na Amazônia, verões com chuvas abaixo da média no Sudeste – são exemplos de extremos climáticos, que, de certa forma, são consequências de uma variabilidade muito irregular do clima. Uma consequência do aquecimento global", afirma Marengo.

The New York Times https://www.nytimes.com/2021/06/19/world/americas/brazil-drought.html

Brazil, Besieged by Covid, Now Faces a Severe Drought

Brazilians are paying more for electricity, dealing with the possibility of water rationing and expecting a destructive fire season in the Amazon in the worst dry spell in at least 90 years.

By Manuela Andreoni and Ernesto Londoño

Published June 19, 2021 Updated June 21, 2021, 2:14 p.m. ET

RIO DE JANEIRO — Crops have shriveled up under searing heat. Immense water reservoirs, which generate the bulk of Brazil's electricity, are growing alarmingly shallow. And the world's largest waterfall system, Iguaçu Falls, has been reduced from a torrent to a trickle.

As Brazil approaches 500,000 deaths from Covid-19, a worsening drought is imperiling the country's ability to jump-start its beleaguered economy, and may set the stage for another intensely destructive fire season in the Amazon rainforest.

Several states in the country are facing the worst drought in at least 90 years. The crisis has led to higher electricity prices, the threat of water rationing and a disruption of crop growing cycles. Agriculture, an economic engine of the nation — which relies heavily on hydropower — is now at risk.

Experts said the arid landscape, which coincided with a rise in illegal deforestation over the past months in the Amazon rainforest, could lead to a devastating fire season. Enforcement of environmental regulations is weak in the rainforest, and fire season traditionally begins in July.

"We're left with a perfect storm," said Liana Anderson, a biologist who studies fire management at Brazil's National Center for Monitoring and Early Warning of Natural Disasters. "The scenario we're in will make it very hard to keep fires under control."

Brazil's National Meteorological system sounded the alarm about the severity of the drought in a bulletin issued in May. It noted that five states — Minas Gerais, Goiás, Mato Grosso do Sul, Paraná and São Paulo — would face chronic water shortages from June to September.

By The New York Times

President Jair Bolsonaro played down the risk of the pandemic last year and has been widely criticized for his cavalier handling of the crisis. But he warned that the drought would disrupt lives and livelihoods in Brazil in the months ahead.

"What we've been trying to show is that with its environmental approach, Brazil is shooting itself in the foot," he said. "Agriculture is one of the industries most susceptible to climate variability, especially when it comes to rain."

Humid air that flows into the Amazon from the Atlantic Ocean has tended to flow south, generating rain, a cycle that scientists call "flying rivers." Climate change has upended those patterns, said José A. Marengo, a climate change expert in São Paulo who helped coin the term "flying rivers."

"Over the past 20 years in the Amazon, we had three droughts that were considered the drought of the century, and three floods that were also considered the floods of the century," he said. "So many events in a century that is only 20 years old is strange, showing that the climate is becoming more extreme."

Fernando Cadore, a farmer in Mato Grosso who leads an association of soy and corn producers in the state, has seen the effects of climate change firsthand. The drought has disrupted normal crop cycles, which is likely to reduce the yield of corn this year by at least 20 percent.

Yet Mr. Cadore, 41, said he did not see a clear link between deforestation and the challenges he and his peers are experiencing. That view is widely shared in rural communities in Brazil, where farmland is expanding aggressively year after year at the expense of biomes.

"We all know that periods of unstable climate have been happening forever," he said. "You even have tales in the Bible about crops lost to climate adversity."

Brasil, entre la sequía y el coronavirus - The New York Times https://www.nytimes.com/es/2021/06/22/espanol/brasil-entre-la-sequia...

The New York Times https://www.nytimes.com/es/2021/06/22/espanol/brasil-entre-la-sequia-y-el-coronavirus.html

Brasil, entre la sequía y el coronavirus

Las tarifas de electricidad aumentan en el país y los brasileños enfrentan la perspectiva del racionamiento de agua mientras se avecina la temporada de incendios y la peor sequía en casi un siglo.

Por Manuela Andreoni y Ernesto Londoño

RÍO DE JANEIRO — Los cultivos se han marchitado bajo un calor abrasador. Los inmensos embalses de agua, que generan la mayor parte de la electricidad de Brasil, están perdiendo profundidad de una manera alarmante. Y el sistema de cascadas más grande del mundo, las Cataratas del Iguazú, se ha reducido de un torrente a un chorrito.

Después de que Brasil superó las 500.000 muertes por COVID-19, una sequía que empeora pone en peligro la capacidad del país para reactivar su atribulada economía y podría estar preparando el escenario para otra temporada, intensamente destructiva, de incendios en la selva amazónica.

Varios estados del país se enfrentan a la peor sequía de los últimos 90 años. La crisis ha provocado un aumento de los precios de la electricidad, la amenaza del racionamiento del agua y la interrupción de los ciclos de cultivo. La agricultura, un motor económico de la nación — que depende en gran medida de la energía hidroeléctrica — ahora está en riesgo.

Los expertos dijeron que el paisaje árido, que coincidió con un aumento de la deforestación ilegal de la selva amazónica en los últimos meses, podría conducir a una temporada de incendios devastadores. El cumplimiento de las regulaciones ambientales es deficiente en la

1 of 11 25/06/21

PODCAST, SÉRIE ESCUTA CLIMA, TEMÁTICO

#119 – Escuta Clima – Ep 3: Vulnerabilidade: desigualdade social e estruturas urbanas

21 DE JANEIRO DE 2021

#ALIMENTOS, #CDCEN, #DIVULGAÇÃO CIENTÍFICA, #LABJOR, #MEIO AMBIENTE, #MUDANÇAS CLIMÁTICAS, #NUDECRI, #SAÚDE, #VULNERABILIDADE

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A alteração climática tem um forte componente que é a ação humana e que afeta direta e indiretamente sua própria espécie. No entanto, a forma que cada pessoa é atingida pelos desastres naturais causados e intensificados pelo aquecimento global é muito diferente. A vulnerabilidade é um fator determinado pela desigualdade social e isso fica claro ao analisar as estruturas urbanas, um fator decisivo para indicar se o indivíduo vai sobreviver ou não em um evento extremo. Essa é a primeira parte do tema Vulnerabilidade Humana frente às Mudanças Climáticas.

A série Escuta Clima é produzida pela Camila Ramos e está ligada ao curso de Especialização em Jornalismo Científico do Laboratório de Estudos Avançados em Jornalismo (Labjor), do Núcleo de Desenvolvimento da Criatividade (Nudecri) da Unicamp. O projeto tem o objetivo de divulgar as pesquisas e pesquisadores do Instituto Nacional de Ciência e Tecnologia sobre Mudanças Climáticas (INCT-MC) e é apoiado pela bolsa Mídia Ciência da Fundação de Amparo à Pesquisa do Estado de São Paulo (Fapesp).

PODCAST, SÉRIE ESCUTA CLIMA, TEMÁTICO

#122– Escuta Clima – ep. 4 – Vulnerabilidade: as vítimas das mudanças climáticas

11 DE FEVEREIRO DE 2021

#CLIMA, #COCEN, #LABJOR, #MEIO AMBIENTE, #MUDANÇAS CLIMÁTICAS, #MULHERES CIENTISTAS, #NUDECRI, #PODCAST, #SAÚDE, #SOCIEDADE, #VULNERABILIDADE

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No episódio anterior, descobrimos como a desigualdade social afeta determinados grupos urbanos durante a iminência de um desastre natural. No episódio de hoje, vamos identificar quem faz parte desses grupos mais vulneráveis e como os eventos extremos no Brasil afetam suas saúdes e os colocam em risco de morte. É importante lembrar, também, que tais eventos de ordem climática são intensificados pelo aquecimento global e ficarão mais fortes e frequentes a cada ano.

A série Escuta Clima é produzida pela Camila Ramos e está ligada ao curso de Especialização em Jornalismo Científco do Laboratório de Estudos Avançados em Jornalismo (Labjor) e ao Núcleo de Desenvolvimento da Criatividade (Nudecri) da Unicamp. O projeto tem o objetivo de divulgar as pesquisas e pesquisadores do Instituto Nacional de Ciência e Tecnologia sobre Mudanças Climáticas (INCT-MC) e é apoiado pelo programa Mídia Ciência da Fundação de Amparo à Pesquisa do Estado de São Paulo (Fapesp).

#4 – Escuta Clima: Vulnerabilidade: as vítimas das mudanças climáticas

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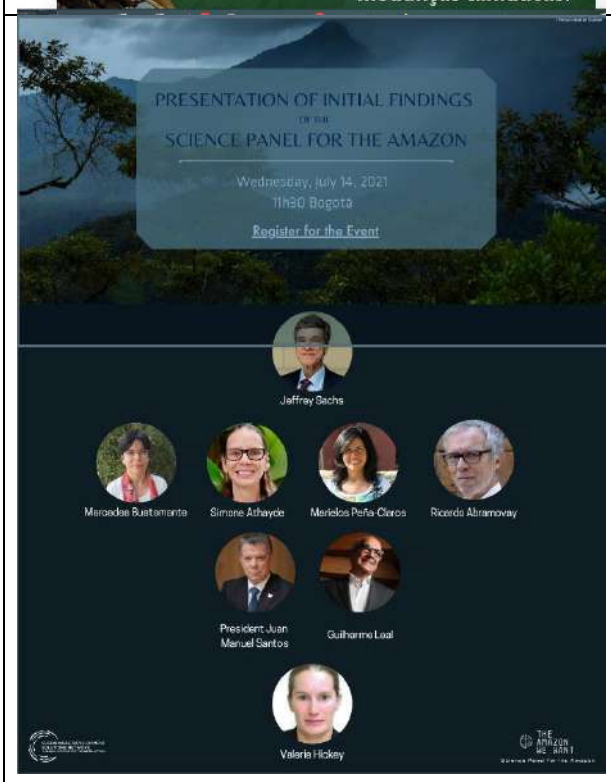
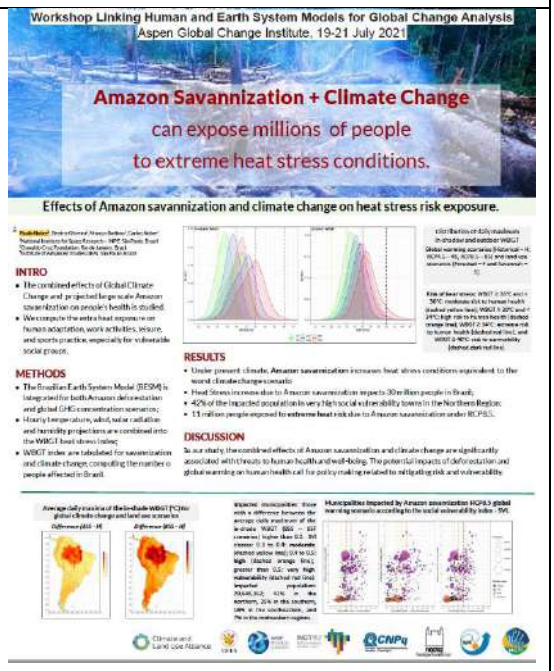
#1 – Escuta Clima: Segurança Energética

#3 – Escuta Clima:Vulnerabilidade: desigualdade social e estruturas urbanas.

#2 – Escuta Clima: Rios urbanos e conta-gotas

#4 - Escuta Clima: Vulnerabilidade: as vítimas das mudanças climáticas.





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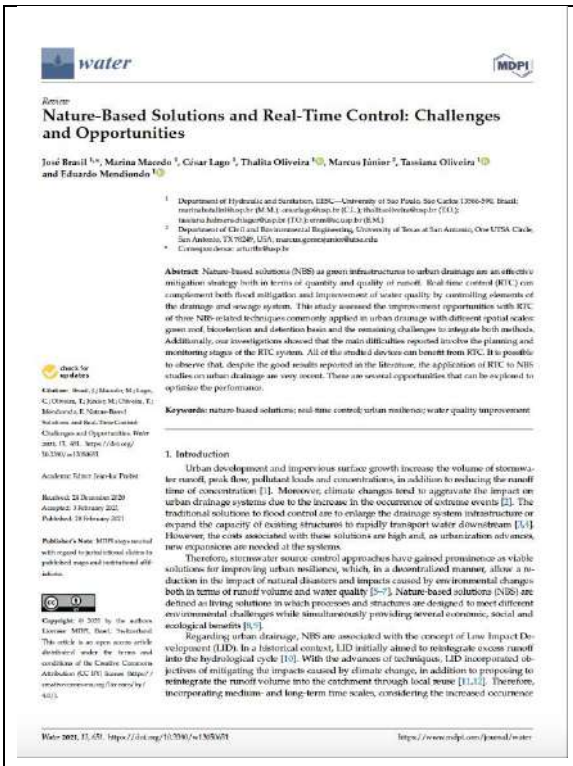

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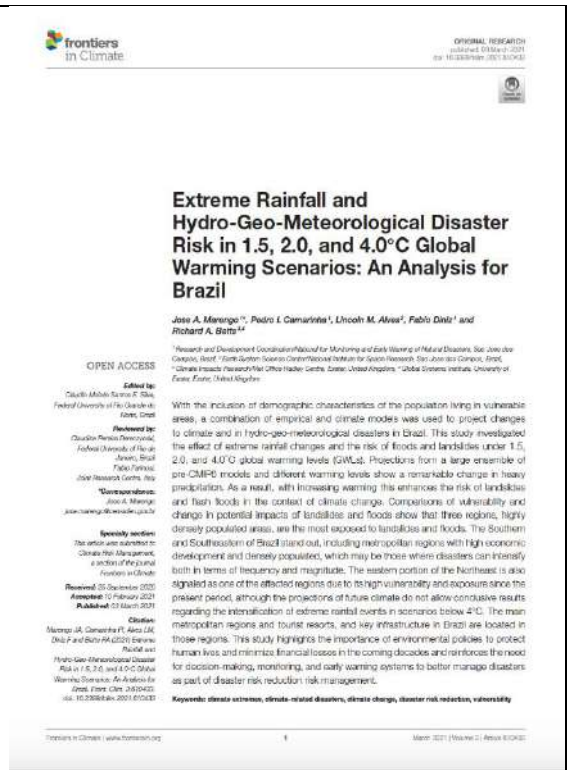

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ORIGINAL RESEARCH

Extreme Rainfall and Hydro-Geo-Meteorological Disaster Risk in 1.5, 2.0, and 4.0°C Global Warming Scenarios: An Analysis for Brazil

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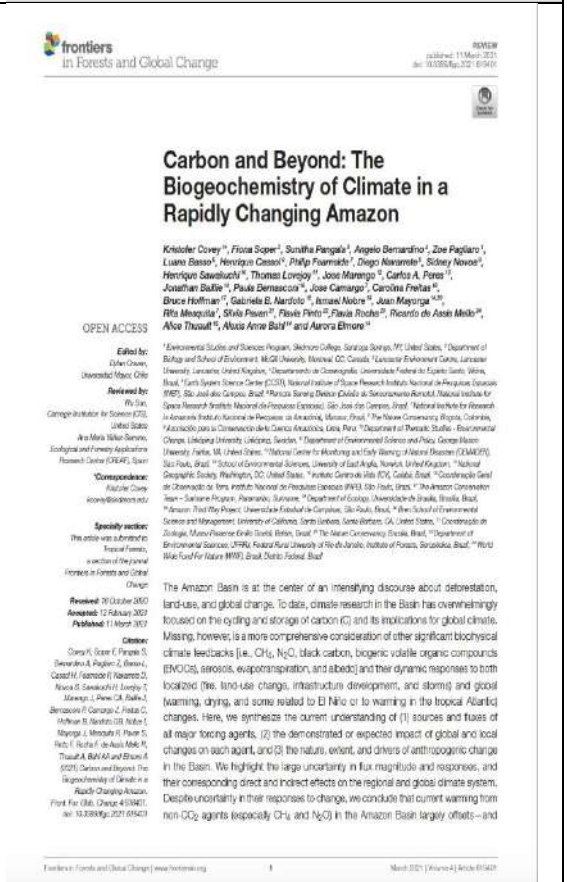
ORIGINAL RESEARCH

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



frontiers in Forests and Global Change

REVIEW

Carbon and Beyond: The Biogeochemistry of Climate in a Rapidly Changing Amazon

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Artigo

Avaliação do Balanço de Água na Bacia do Rio Madeira Simulado Pelo Modelo Regional Climático Eta e o Modelo Hidrológico de Grandes Bacias MGB

Leonardo Alves Vergasta[1], Francis Wagner Silva Correia[2], Sin Chan Chou[3], Paulo Nobre[3], André de Arruda Lyra[3], Wesllley de Brito Gomes[3], Vinicius Capistrano[3], José Augusto P. Veiga[1]

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Recebido em 17 de Abril de 2020 - Aceito em 25 de Agosto de 2020

Resumo

Simulações climáticas para o clima presente (1960-2005) utilizando o Modelo Climático Regional Eta e o Modelo Hidrológico de Grandes Bacias (MGB). Forçado com o Brazilian Earth System Model Ocean-Atmosphere (BESM-AO 2.5) foram realizadas. O objetivo deste trabalho é avaliar o desempenho do Modelo Regional Eta e o Modelo Hidrológico de Grandes Bacias (MGB) na representação do balanço de água (precipitação, evapotranspiração, convergência de umidade, vazão, cota e área de inundação) sobre a bacia do rio Madeira. A característica de consumo de umidade (P > E) foi simulada pelo modelo regional. Entretanto, o modelo subestimou a precipitação (31%), a evapotranspiração (12%) e a convergência de umidade (6%). O MGB-IPH consegue representar o ciclo anual das vazões, níveis do rio (cota) e área de inundação. Também consegue reproduzir a translação e amplitude das cotas de cheia, e o início de 3 meses entre os máximos da área de inundação e a precipitação sobre a bacia do Madeira. O MGB-IPH mostra-se uma ferramenta útil para estudos de variabilidade climática, mudanças no clima e no uso da terra, e também para sistemas operacionais de previsão hidrológica na bacia Amazônica.

Palavras-chave: Bacia do rio Madeira, balanço de água, vazão, níveis d'água, área de inundação.

Assessment of the Water Budget in Madeira River Basin Simulated by the Eta Regional Climate And MGB Large-Scale Hydrological Models

Abstract

Downscaling climate simulation for present climate (1960-2005) based on the Eta Regional Climate Model and MGB Large-scale Hydrological Model, forced by Brazilian Model of the Terrestrial System (BESM-AO 2.5), was carried out. The objective of this work is assessment the performance of the Eta regional model and MGB-IPH on the representation of the components of the water budget in Madeira River Basin. The moisture sink characteristic (P> E) was simulated by the regional model. In the terrestrial branch, the MGB-IPH hydrological model was able to represent the annual cycle of discharge, water level and floodplain inundation. The performance of the hydrological model and the regional model was satisfactory in the simulation of the seasonal dynamics of hydrological processes and water budget in Madeira river basin, indicating that the hydrological model is a useful tool for studies of climatic variability, changes in climate and land use and for hydrological forecasting operational systems in the Amazon basin.

Keywords: Madeira River Basin, water balance, flow rate, water levels, flood area.

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Mini Review

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Can Climate and Environmental Factors Putatively Increase SARS-Cov2 Transmission Risks?

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Abstract

After the identification of the first SARS-COV-2 infected cases in China, the virus was rapidly disseminated among the distinct continents and the COVID-19 pandemics was announced by the WHO in March 2020. Over time, the epidemiological scenarios varied among countries, according to the adopted mitigation measures and epidemic phase. Recently, a recrudescence of the epidemics has been observed in distant countries. SARS-CoV-2 can be transmitted by direct or indirect contact. The viral RNA has been detected in stool and other clinical specimens from infected patients and a putative fecal-oral transmission has been argued. Viruses are shed in human excreta, further disposed into the sewerage system or into the environment, in poor sanitation settings. Thus SARS-CoV-2 RNA has been regularly detected in wastewater and surface water impacted by the direct discharge of sewage, so far studies have reported an association between climatic parameters and an increase in COVID-19 incidence. However, conclusive evidence based in full science is needed so far.

This mini review briefly discusses the putative role of climate and environmental factors on SARS-CoV-2 exposure, transmission and circulation patterns. Moreover, some additional challenges in middle and low-income settings are highlighted. Efforts must be driven to comprehensively understand the relationships between SARS-CoV-2 infection, circulation patterns and climatic parameters, as the putative implications of viral persistence and stability in distinct environmental matrices. This information is crucial for COVID-19 control and prevention, especially in middle and low-income settings, already weighed by social inequity, inadequate sanitation and deficient health care admission.

Keywords: SARS-CoV-2 transmission; COVID-19; Climate; Wastewater; Surface water; Public health

Introduction

After the identification of the first severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) infected cases in Wuhan, China, in December 2019 [1,2], the virus was rapidly disseminated among the distinct continents and led the World Health Organization to announce the COVID-19 pandemics in March 2020 [3]. Over time, the epidemiological scenarios varied among countries, according to the adopted mitigation measures and epidemic phase [4-7]. Recently, a recrudescence of the epidemics has been observed in Europe [8] and in the Americas, where the highest new cases and deaths figures have been reported in the United States, followed by Brazil, Mexico, Colombia and Argentina [9].

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This article is also available online at: www.sustenere.co

Avaliação de projeções climáticas para uma bacia experimental, localizada na região sul de Minas Gerais

Evaluation of the climatic forecast for an experimental basin, located in the southern region of Minas Gerais

Tópico: Meteorologia, Climatologia e Mudanças Climáticas

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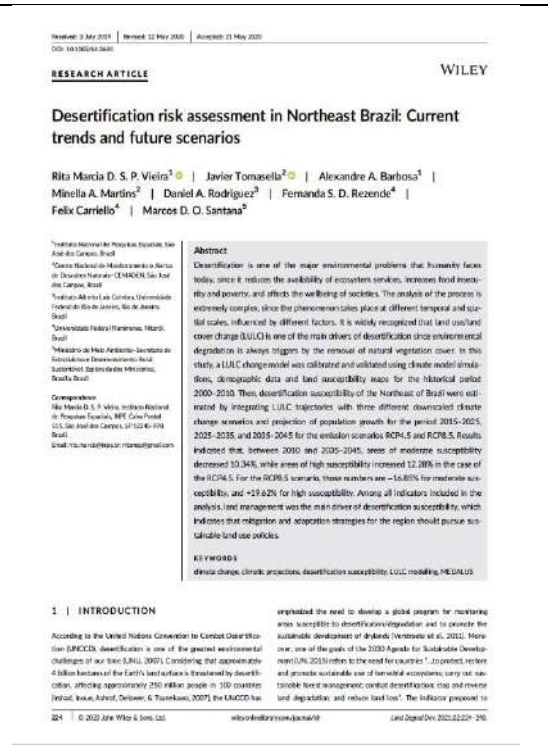

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RESEARCH ARTICLE

WILEY

Desertification risk assessment in Northeast Brazil: Current trends and future scenarios

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Abstract

Desertification is one of the major environmental problems that humanity faces today, since it reduces the availability of ecosystem services, increases food insecurity and poverty, and affects the well-being of societies. The analysis of the process is extremely complex, since the phenomenon takes place at different temporal and spatial scales, influenced by different factors. It is widely recognized that land use/land cover change (LULC) is one of the main drivers of desertification since environmental degradation is always triggers by the removal of natural vegetation cover. In this study, a LULC change model was calibrated and validated using climate model simulations, demographic data and land susceptibility maps for the historical period 2000-2010. Then, desertification susceptibility of the Northeast of Brazil were estimated by integrating LULC trajectories with three different downscaled climate change scenarios and projection of population growth for the period 2015-2025, 2025-2035, and 2035-2045 for the emission scenarios RCP4.5 and RCP8.5. Results indicated that, between 2010 and 2035-2045, areas of moderate susceptibility decreased 10.34%, while areas of high susceptibility increased 12.28% in the case of the RCP4.5. For the RCP8.5 scenario, those numbers are −16.85% for moderate susceptibility, and +29.62% for high susceptibility. Among all indicators included in the analysis, land management was the main driver of desertification susceptibility, which indicates that mitigation and adaptation strategies for the region should pursue sustainable land use policies.

KEYWORDS
climate change, climatic projections, desertification susceptibility, LULC modelling, MEDALUS

1 | INTRODUCTION

According to the United Nations Convention to Combat Desertification (UNCCD), desertification is one of the greatest environmental challenges of our time (UNU, 2007). Considering that approximately 4 billion hectares of the Earth's land surface is threatened by desertification, affecting approximately 250 million people in 100 countries (Reynolds, Stafford Smith, Scholes, & Herrick-Davis, 2007), the UNCCD has emphasized the need to develop a global program for monitoring areas susceptible to desertification/degradation and to promote the sustainable development of drylands (Verstraete et al., 2011). Moreover, one of the goals of the 2030 Agenda for Sustainable Development (UN, 2015) refers to the need for countries "...to protect, restore and promote sustainable use of terrestrial ecosystems; carry out sustainable forest management; combat desertification; stop and reverse land degradation; and reduce land loss". The indicator proposed to

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Hydrological simulation with SWAT and VIC Models in the Verde River Watershed, Minas Gerais

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ABSTRACT

Successful streamflow forecasts depend on an adequate performance evaluation of the hydrological model. In this study, the hydrological responses were compared using two hydrological models, physic-based and semi-distributed, Soil and Water Assessment Tool (SWAT) and Variable Infiltration Capacity (VIC), using input data from the Verde River Watershed, located in the Minas Gerais state in southern Brazil. This is a study of one of the most important headwater watershed regions of Brazil (Mantiqueira Range). Both models were suitable for streamflow simulation, with values of R^2 (determination coefficient) and NSE (Nash-Sutcliffe) higher than 0.8, NSELog higher than 0.35 (Nash–Sutcliffe Efficiency of the logarithmic values of discharge) and P_{BIAS} (percentage deviation) less than 25%. The integration of SWAT and VIC models can be useful in different water-resource assessment studies. Therefore, based upon this study further investigations should be conducted using various hydrological models and climate, land-use and land-cover changes scenarios in the region.

Keywords: hydrological modeling, performance evaluation, streamflow forecasts, SWAT model, VIC model.

Simulação hidrológica com os modelos SWAT e VIC na bacia hidrográfica do rio Verde, Minas Gerais

RESUMO

Previsões de vazão bem-sucedidas dependem de uma adequada avaliação de desempenho do modelo hidrológico. Neste estudo, as respostas hidrológicas foram comparadas usando dois modelos hidrológicos, físico-baseados e semi-distribuídos, Water Assessment Tool (SWAT) e Variable Infiltration Capacity (VIC), utilizando dados de entrada da bacia hidrográfica do rio

Science of the Total Environment

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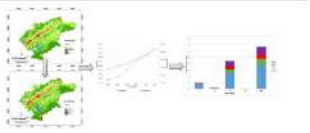
Urban expansion and its impact on water security: The case of the Paraíba do Sul River Basin, São Paulo, Brazil

Ana Carolina da Encarnação Paiva[a,*], Nathália Nascimento[a], Daniel Andres Rodriguez[b], Javier Tomasella[c], Felix Carriello[d], Fernanda Silva Rezende[d]

HIGHLIGHTS

- To estimate water consumption, we integrated IBGE scenarios with demographic data.
- Results showed good agreement of the estimation of urban spread and water consumption.
- The main driver of urban sprawl expansion is the access to the main operation network.
- IBGE scenarios indicate a 70% growth in consumption and withdrawal flows by 2040.

GRAPHICAL ABSTRACT



ARTICLE INFO

ABSTRACT

Increasing demand for water is one of the most challenging problems that human societies face today and has encouraged new studies to examine water security and water management. Seeking to discuss this important issue in the Brazilian context, we analyzed the impacts of urban expansion on water security in a basin located in the most populated region of Brazil. To quantify increased water demand, we combined urban sprawl and regional population forecast projections. In this context, our study contributes to discussions on water security by addressing the importance of integration between water and urban planning. Results on Brazilian good performance in reproducing actual water system conditions. The finely gridded results that urban expansion in the region is mainly driven by road proximity. Urban expansion is projected to increase in 170% by 2040. Increasing water demands for domestic use in 2040. Results indicate the basin level including landscape and socioeconomic constraints in order to allow a potential domestic water demand scenarios by using land use and land cover change modelling to assess urban expansion and population growth. For the study region, our findings suggest that although urban sprawl increases water demand, urban supply will not be compromised given the large volume of available water in the basin. However, the indirect consequences of urban sprawl, such as intensification and agricultural intensification, may compromise the quality of the resource and request further water management in the region.

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SECAS E OS IMPACTOS NA REGIÃO SUL DO BRASIL

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RESUMO: Embora eventos de secas sejam menos estudados na Região Sul, se comparado com outras regiões do Brasil, quando ocorrem impactam o abastecimento de água, produção agrícola e a geração de energia elétrica. Portanto, a avaliação dos impactos da seca no setor agrícola e nos recursos hídricos, são de extrema importância para a gestão de riscos nesta região. Neste estudo avaliou-se os principais eventos de secas e seus impactos entre 1998 e 2020 (maio) na Região Sul do Brasil. Para isto, foram utilizados índices de secas calculados a partir de dados de precipitação, vazão e dados derivados de satélite. De acordo com o Índice de Precipitação Padronizado (SPI), o evento mais severo de seca ocorreu no estado do Paraná em 2006. Como consequência, registrou-se valores de área agro-produtivas afetados acima de 80% e seca hidrológica excepcional na bacia hidrográfica afluente (BHA) à usina hidrelétrica (UHE) Segredo, segundo o Índice de Vazão Padronizada (SSFI), além de vazões afluentes abaixo do percentil 90 durante 50% do ano. Em Santa Catarina e no Rio Grande do Sul, os eventos de secas de maior severidade ocorreram em 2012/2013. Apesar disso, os percentuais de áreas agro-produtivas afetadas foram inferiores aos verificados para 2019/2020. Com relação aos recursos hídricos, o SSFI indicou seca excepcional na BHA ao reservatório da UHE Passo Real, e foi observada vazão abaixo do percentil 90 no primeiro semestre de

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Drivers and impacts of the most extreme marine heatwave events

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Prolonged high-temperature extreme events in the ocean, marine heatwaves, can have severe and long-lasting impacts on marine ecosystems, fisheries and associated services. This study applies a marine heatwaves framework to analyse a global sea surface temperature product and identify the most extreme events, based on their intensity, duration and spatial extent. Many of these events have yet to be described in terms of their physical attributes, generation mechanisms, or ecological impacts. Our synthesis identifies commonalities between marine heatwave characteristics and seasonality, links to the El Niño-Southern Oscillation, triggering processes and impacts on ocean productivity. The most intense events preferentially occur in summer, when climatological oceanic mixed layers are shallow and winds are weak, but at a time preceding climatological maximum sea surface temperatures. Most subtropical extreme marine heatwaves were triggered by persistent atmospheric high-pressure systems and anomalously weak wind speeds, associated with increased insolation, and reduced ocean heat losses. Furthermore, the most extreme events tended to coincide with cooler-than-normal conditions at low and mid-latitudes. Understanding the importance of the ocean's background state, local and remote drivers and the ocean productivity response from past events are critical steps toward improving predictions of future marine heatwaves and their impacts.

Prolonged periods of anomalously warm ocean temperature, marine heatwaves (MHWs), are a major threat to marine ecosystems and their functioning that have resulted in devastating and long-lasting impacts across scales from hundreds to thousands of kilometers[1–4]. Although these extreme events are by definition rare, marine heatwaves with notable ecological impacts have been occurring more frequently in recent years[5–11]. Globally, over the last century, the annual number of MHW days has increased by more than 50%[12], explained primarily by the long-term warming of the upper ocean, although changes in variability are important in certain regions[13]. Moreover, future projections indicate order of magnitude increases in the number of MHW days by the end of the century even under scenarios of strong greenhouse gas emissions mitigation[14]. Hence there is a need to better understand mechanisms responsible for MHW occurrence and their ecological impacts.

MHWs are a rapidly developing area of research. There is growing literature examining what constitutes a MHW[15,16], the local processes that generate and maintain them[17–19], the large-scale climate drivers that remotely

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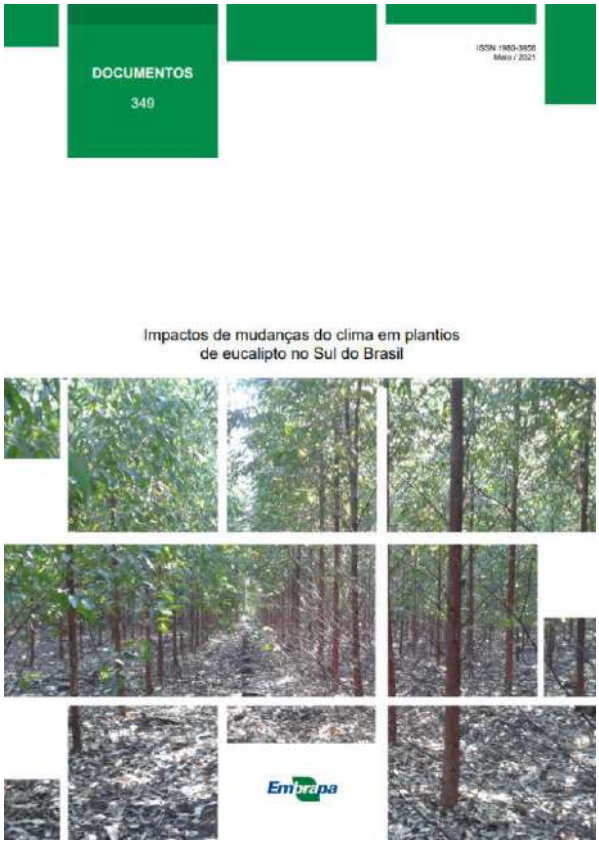

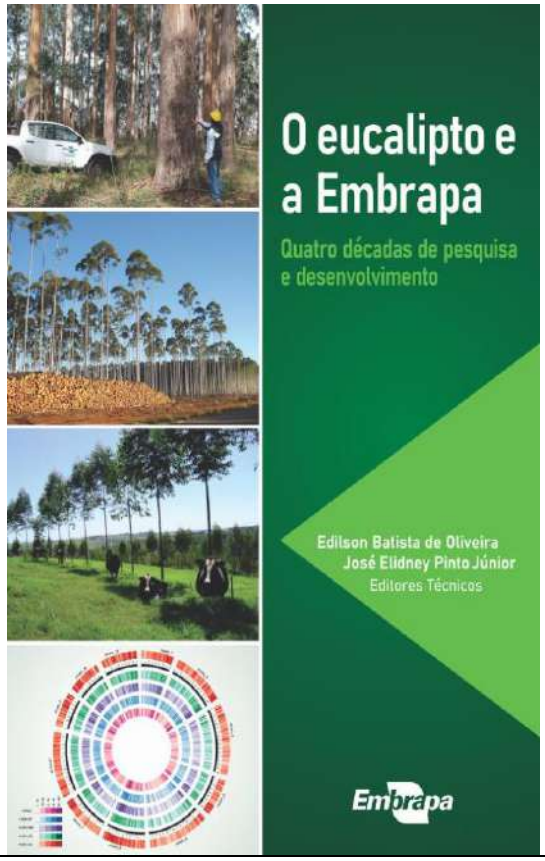

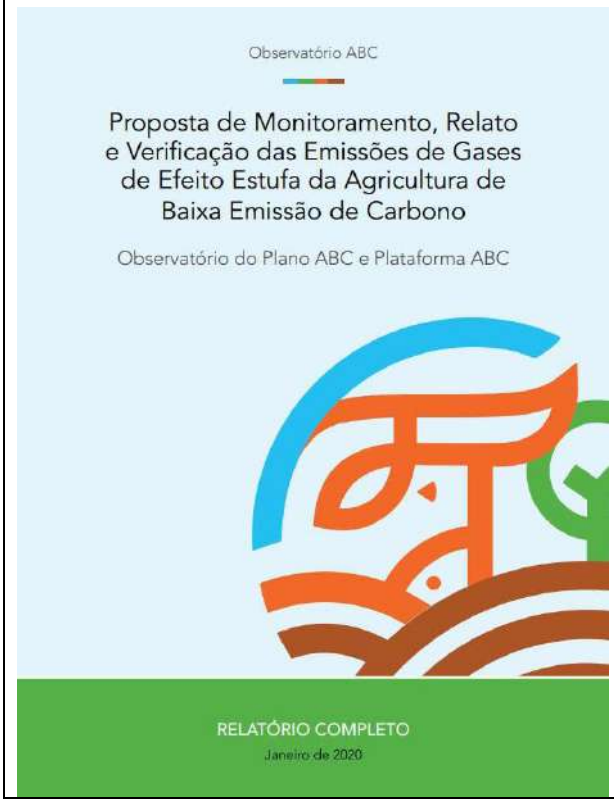

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Mini Review
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Can Climate and Environmental Factors Putatively Increase SARS-Cov2 Transmission Risks?

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Abstract

After the identification of the first SARS-CoV-2 infected cases in China, the virus was rapidly disseminated among the distinct continents and the COVID-19 pandemics was announced by the WHO in March 2020. Over time, the epidemiological scenarios varied among countries, according to the adopted mitigation measures and epidemic phase. Recently, a recrudescence of the epidemics has been observed in distinct countries. SARS-CoV-2 can be transmitted by direct or indirect contact. The viral RNA has been detected in stool and other clinical specimens from infected patients and aerosolize fecal oral transmission has been argued. Viruses are shed in human excreta, further disposed into the sewerage system or into the environment, in poor sanitation settings. Thus, SARS-CoV-2 RNA has been regularly detected in wastewater and surface water impacted by the direct discharge of sewage. Some studies have reported an association between climatic parameters and an increase in COVID-19 incidence. However, conclusive evidence based in influenza is needed so far.

This mini review briefly discusses the putative role of climate and environmental factors on SARS-CoV-2 exposure, transmission and circulation patterns. Moreover, some additional challenges in middle and low-income settings are highlighted. Efforts must be driven to categorically understand the relationships between SARS-CoV-2 infection, circulation patterns and climate parameters, as the putative implications of viral persistence and viability in distinct environmental matrices. This information is crucial for COVID-19 control and prevention, especially in middle and low-income settings, already wedged by social inequality, inadequate sanitation and deficient healthcare admission.

Keywords: SARS-CoV-2 transmission; COVID-19; Climate; Wastewater; Surface water; Public health

Introduction

After the identification of the first severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infected cases in Wuhan, China, in December 2019 [1,2], the virus was rapidly disseminated among the distinct continents and led the World Health Organization to announce the COVID-19 pandemics in March 2020 [3]. Over time, the epidemiological scenarios varied among countries, according to the adopted mitigation measures and epidemic phase [4-7]. Recently, a recrudescence of the epidemics has been observed in Europe [8] and in the Americas, where the highest new case and deaths figures have been reported in the United States followed by Brazil, Mexico, Colombia and Argentina [9].

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Early Stages of the Coronavirus Disease (COVID-19) Pandemic in Brazil: National and Regional Contexts

Rhuvena 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, favoring 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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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,

Journal of Environmental Management
Hybrid power generation for increasing water and energy securities during drought: Exploring local and regional effects in a semi-arid basin

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ABSTRACT

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Enhancement of Cloudless Skies Frequency over a Large Tropical Reservoir in Brazil

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Abstract: Several studies show the effects of lake breezes on cloudiness over natural lakes and large rivers, but only few contain information regarding large flooded areas of hydroelectric dams. Most Brazilian hydropower plants have large water reservoirs that may induce significant changes in the local environment. In this work, we describe the prevailing breeze mechanism in a Brazilian tropical hydropower reservoir to assess its impacts on local cloudiness and incoming surface solar irradiation. GOES-16 visible imagery, ISCCP database products, and ground measurement sites operated by INMET and LABREN/INPE provided data for the statistical analysis. We evaluate the cloudiness frequency assuming two distinct perspectives: spatial distribution by comparing cloudiness over the water surface and areas nearby its shores, and time analysis by comparing cloudiness prior and after reservoir completion. We also evaluated the solar irradiance enhancement over the water surface compared to the border and land areas surrounding the hydropower reservoir. The results pointed out daily average cloudiness increases moving away from the reservoir in any of the four cardinal directions. When looking at the afternoon-only cloudiness (14h to 16h local time), 4% fewer clouds were observed over the flooded area during summer (DJF). This difference reaches 8% during autumn (MAM) and spring (SON). Consequently, the irradiance enhancement at the water surface compared to external areas was around 1.75% for daily average and 4.59% for the afternoon-only average. Our results suggest that floating solar PV power plants in hydropower reservoirs can be an excellent option to integrate both renewable energy resources into a hybrid power generation due to the high solar irradiance in Brazilian territory combined with the prevailing breeze mechanism in large tropical water reservoirs.

Keywords: lake breeze influence; hydropower reservoir; solar irradiance enhancement; solar energy resource

1. Introduction

Lake breeze circulation is one of the most well-known thermally-induced phenomena in mesoscale meteorology. The onset of a lake breeze depends on the ratio between the thermal to inertial driving forces, as discussed by Biggs and Graves [1]. Despite the well-described physical mechanism, the evaluation of its occurrence and strength is not a simple task due to surface heterogeneity, terrain effects, and synoptic patterns superimposed on the flow.

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ANÁLISE DA VARIABILIDADE DA INCIDÊNCIA SOLAR NA SUPERFÍCIE COM BASE EM DADOS DE SUPERFÍCIE E DE SATÉLITE

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1 Radiação Solar – 1.1 Recursos solares e meteorologia da radiação solar

Resumo. A intermitência do recurso solar é um dos desafios científicos que vem sendo avaliado e investigado para dar suporte ao crescimento da geração fotovoltaica e solarimétrica sem reduzir a qualidade e a segurança dos serviços de transmissão e distribuição de eletricidade. Este estudo teve como objetivo principal avaliar a variabilidade da incidência da radiação solar na superfície utilizando o índice VS proposto por Lave et al. (2015) com base de dados radiométricos coletados em três estações de referência da rede SONDA: Petrolina (PE), Cachoeira Paulista (SP) e São Martinho da Serra (RS). O estudo aplicou a mesma metodologia para avaliar a variabilidade do coeficiente de cobertura de nuvens obtido a partir de imagens de satélite. Os resultados demonstram que as localidades apresentam padrões distintos de variabilidade em escalas de tempo menores que 20 minutos. No entanto para intervalos maiores, ocorre uma translação da variabilidade de modo que os valores de VS são próximos para todas as localidades. O estudo também verificou a existência de uma relação de linearidade entre os índices de variabilidade para a cobertura de nuvens e a irradiação incidente na superfície. Essa relação aponta para a possibilidade de desenvolvimento de metodologia de previsão da variabilidade. Por fim o estudo apresentou um mapeamento do índice de variabilidade do coeficiente de cobertura de nuvens para todo o território brasileiro em um mês representativo da estação seca e outro da estação chuvosa.

Palavras-chave: Intermitência do Recurso Solar, Variabilidade do cobertura de nuvens, Modelagem numérica, Rede SONDA, Geração solar.

1. INTRODUÇÃO

Dados recentes mostram que a participação de fontes renováveis atingiu cerca de 30% da capacidade instalada de geração de eletricidade no mundo sendo que, desde 2015, assiste-se no mundo mais novas de fontes renováveis (solar, eólica, hidrelétrica e geotérmica) do que usinas baseadas em combustíveis fósseis e nucleares (IRENA, 2019). A integração de fontes intermitentes de energia, definidas como aquelas em que a disponibilidade do recurso energético varia em função das condições ambientais, tem mobilizado a comunidade científica internacional (EIA, 2016; Koutroulis e Blaabjerg, 2014; ICSU, 2016). Na medida em que a participação de fontes tradicionalmente seguras e 'despacháveis' (hidrelétricas e termoelétricas) é substituída fontes intermitentes como a solar, crescem a demanda para desenvolvimento de novas estratégias de planejamento e gerenciamento do sistema elétrico (IRENA, 2019).

No Brasil, a expansão da geração solar vem experimentando um taxa de crescimento elevada com base em tecnologia fotovoltaica (IRENA, 2019), tanto com grandes centrais geradoras com capacidade superior a 1 MW quanto em geração distribuída por prosumidores (consumidores habilitados a gerar sua própria energia e conectá-la à rede elétrica) (IRENA 2019, ANEEL, 2012). A intermitência da incidência de energia solar pode causar transtornos incompatíveis com os padrões exigidos para sistemas de distribuição de eletricidade, incluindo variabilidade de tensão, distúrbios de frequência causados pelo desequilíbrio entre geração de energia e demanda de carga e estresse térmico nos dispositivos sólidos (Hoffmann *et al.*, 2014; Kazantzidis *et al.*, 2012; Kleissl, 2013). O Plano Decenal de Expansão de Energia 2026 (EPE, 2016) aponta para a possibilidade futura da política de contratação de usinas com remuneração não apenas da capacidade instalada (garantia física) mas, também, da habilidade de estabilização do grid.

A irradiância solar na superfície depende de vários fatores naturais, de caráter determinístico ou estocástico, que são investigados para dar suporte ao crescimento da geração fotovoltaica e heliotérmica (Arir e Baghzouz, 2013, Lave *et al.*, 2015; Perez *et al.*, 2016). Os fatores determinísticos incorporam a variação diurna e sazonal ligada aos movimentos de rotação e translação da Terra. Os aspectos estocásticos estão relacionadas às condições atmosféricas (vapor de água, turbidez atmosférica e nebulosidade) e são responsáveis pela variabilidade de alta frequência de geração de energia

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Generating Solar Irradiance Data Series with 1-minute Time Resolution Based on Hourly Observational Data

Thaiane G. Soares, Francisco J. L. Lima, and Fernando R. Martins

***Abstract*—The large-scale integration of intermittent renewable energy sources into electricity distribution is one of the significant challenges in meeting energy demand in the near future. The solar energy resource has a fluctuating spatial and temporal character intrinsic to the radiative processes with the atmosphere and the Earth's surface. Efficient use of solar energy requires technologies that consider such variability and its impacts on the electrical system. In this context, a reliable computational model to estimate the surface solar irradiance is beneficial for operational issues. This work presents a methodology based on Markov chains for the generation of a global irradiance time series with one-minute temporal resolution using observational database acquired by a basic weather station. The statistical model was developed using irradiance data acquired in São Martinho da Serra/RS and Petrolina/PE to verify their performance in two different climates. The transition probability matrices were determined for the following cloud conditions: cloudy, partly cloudy or clear sky using ten years of observational data. Next, Markov's walking technique was used to generate a data series with one-minute temporal resolution taking into account the cloudiness classification. Model validation was performed using solar irradiance data not considered to calculate the transition probability matrix (MPT). The mean squared deviation of the relative distribution frequencies indicated a deviation of only 1.5%, and the Kolmogorov-Smirnov test indicated that the synthetic and observational series presented similar cumulative frequency distributions. Thus, the proposed methodology showed high reliability in reproducing the temporal variability due to the stochastic nature of the incoming solar energy in both sites.*

***Index Terms*—Markov Processes, Numerical simulation, Remote sensing, Renewable energy sources, Solar energy.**

I. Introduction

O sol é fonte de energia renovável e inesgotável; e o aproveitamento dessa energia é uma das alternativas energéticas no Brasil uma vez que a incidência de radiação solar no território brasileiro é elevada durante todo o ano [1] [2] e, o país possui grandes reservas de quartzo, matéria-prima utilizada na fabricação de painéis fotovoltaicos para conversão de energia solar em eletricidade [3].

Um dos maiores desafios para o atendimento da demanda crescente de energia será a integração em larga escala de fontes renováveis de energias intermitentes às redes de distribuição de eletricidade [4]. As fontes renováveis de energia, como a solar e a eólica, possuem um caráter flutuante espacial e temporal intrínsecos aos processos físicos da natureza e a sua utilização de forma eficiente na geração de eletricidade deve adotar tecnologias operacionais que considerem essa variabilidade [5] de forma criteriosa tanto do ponto de vista econômico quanto do ponto de vista de segurança do sistema elétrico [6]. No Brasil, cabe ao Operador Nacional do Sistema Elétrico (ONS) e as companhias de distribuição de eletricidade lidar com dificuldades associadas às variações rápidas de inserção de energia intermitente e com sobrecargas no sistema de distribuição de eletricidade.

O aproveitamento do recurso de energia solar integrado ao sistema nacional de eletricidade apresenta desafios tecnológicos associados com as características intrínsecas de variabilidade espacial e temporal da fonte energética e que, em alguns momentos, pode proporcionar um desequilíbrio na relação geração/consumo de eletricidade, flutuações de tensão e outros aspectos técnicos com impacto direto na qualidade da energia distribuída aos consumidores. Com o crescimento da participação da energia solar na matriz elétrica brasileira, a confiabilidade do sistema elétrico torna-se dependente da capacidade do sistema para acomodar a variabilidade intrínseca do recurso solar, ao mesmo tempo em que mantém a qualidade e a continuidade do serviço aos consumidores [6] [7].

Neste contexto, um modelo numérico confiável de estimativa de irradiância solar incidente na superfície é bastante útil [6] [8]. A informação sobre a irradiância solar incidente na superfície pode contribuir no gerenciamento e na operação de uma planta solar, principalmente quando um sistema de armazenamento da energia excedente está disponível ou a tarifação da eletricidade é realizada com base em horários de ponta de consumo [9].

Um método numérico eficiente para estimativa da irradiância solar para horizontes de tempo curtos (dezenas de minutos) ou curtíssimos (alguns minutos) ajudará tanto o gerenciamento quanto o planejamento e a otimização dos regimes de operação das instalações de geração solar e do sistema elétrico considerando eventos repentinos (rampas de crescimento ou decrescimento) da incidência solar [6]. Os eventos repentinos estão associados principalmente com a passagem de nebulosidade e é um fenômeno presente em todo o território brasileiro, mesmo na região mais árida localizada no Nordeste do Brasil [10].

Os modelos físicos resolvem numericamente as equações de transferência radiativa que descrevem os processos de absorção e espalhamento de radiação solar na atmosfera e requerem a disponibilidade de dados observados em estações meteorológicas e dados observados por satélites [11]. Além

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VARIAÇÕES NA FREQUÊNCIA DE VENTOS EXTREMOS E SEU IMPACTO NO SETOR DE ENERGIA

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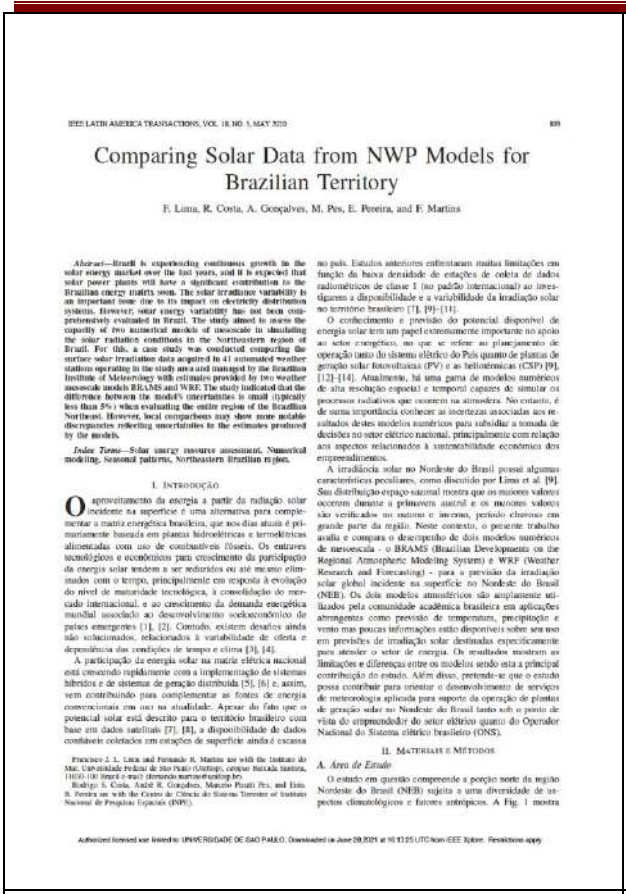
RESUMO

Eventos extremos de vento causam prejuízos diversos à sociedade, tais como destelhamentos, danos a coberturas, prédios, pontes e queda de árvores mas, especificamente no setor de energia, estes eventos podem danificar torres de transmissão e aerogeradores, além de outros componentes do sistema de geração e transmissão. Este trabalho busca quantificar a frequência de extremos de rajadas de vento utilizando modelos climáticos ajustados com dados medidos em superfície para o período de 1961 a 2005. Posteriormente, foram utilizadas as projeções futuras dos mesmos modelos para identificar alterações na frequência dos ventos extremos até o ano de 2070. As projeções mostraram um aumento na frequência de rajadas de vento acima de 20 m/s. O aumento pode ser comprovado pelo índice FAR (*Fraction Atributable Risk*), e percentil 99 (P99).

Palvras-chave: Eventos extremos, Modelos climáticos e período de retorno.

ABSTRACT

Extreme wind events cause various damage to society, such as desolations, damage to roofs, buildings, bridges and falling trees, but specifically in the energy sector these events can damage transmission towers, wind turbines and other components of the generation and transmission system. This work quantifies the frequency of extremes of wind gusts using historical series of data observed on the surface, adjusted by climatic models, for the period from 1961 to 2005. It later uses future projections derived from these models to identify variations



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Comparing Solar Data from NWP Models for Brazilian Territory

F. Lima, R. Costa, A. Gonçalves, M. Pes, E. Pereira, and F. Martins

Abstract—Brazil is experiencing continuous growth in the solar energy market over the last years, and it is expected that solar power plants will have a significant contribution to the Brazilian energy matrix soon. The solar irradiance variability is an important issue due to its impact on electricity distribution systems. However, solar energy variability has not been comprehensively evaluated in Brazil. The study aimed to assess the capacity of two numerical models of mesoscale in simulating the solar radiation conditions in the Northeastern region of Brazil. For this, a case study was conducted comparing the surface solar irradiation data acquired in 41 automated weather stations operating in the study area and managed by the Brazilian Institute of Meteorology with estimates provided by two weather mesoscale models BRAMS and WRF. The study indicated that the difference between the model's uncertainties is small (typically less than 5%) when evaluating the entire region of the Brazilian Northeast. However, local comparisons may show more notable discrepancies reflecting uncertainties in the estimates produced by the models.

Index Terms—Solar energy resource assessment, Numerical modeling, Seasonal patterns, Northeastern Brazilian region.

I. Introdução

O aproveitamento da energia a partir da radiação solar incidente na superfície é uma alternativa para complementar a matriz energética brasileira, que nos dias atuais é primariamente baseada em plantas hidroelétricas e termelétricas alimentadas com uso de combustíveis fósseis. Os entraves tecnológicos e econômicos para crescimento da participação da energia solar tendem a ser reduzidos ou até mesmo eliminados com o tempo, principalmente em resposta à evolução do nível de maturidade tecnológica, à consolidação do mercado internacional, e ao crescimento da demanda energética mundial associado ao desenvolvimento socioeconômico de países emergentes [1], [2]. Contudo, existem desafios ainda não solucionados, relacionados à variabilidade de oferta e dependência das condições de tempo e clima [3], [4].

A participação da energia solar na matriz elétrica nacional está crescendo rapidamente com a implementação de sistemas híbridos e de sistemas de geração distribuída [5], [6] e, assim, vem contribuindo para complementar as fontes de energia convencionais em uso na atualidade. Apesar do fato que o potencial solar está descrito para o território brasileiro com base em dados satelitais [7], [8], a disponibilidade de dados confiáveis coletados em estações de superfície ainda é escassa no país. Estudos anteriores enfrentaram muitas limitações em função da baixa densidade de estações de coleta de dados radiométricos de classe 1 (no padrão internacional) ao investigarem a disponibilidade e a variabilidade da irradiação solar no território brasileiro [7], [9]–[11].

O conhecimento e previsão do potencial disponível de energia solar tem um papel extremamente importante no apoio ao setor energético, no que se refere ao planejamento de operação tanto do sistema elétrico do País quanto de plantas de geração solar fotovoltaicas (PV) e as heliotérmicas (CSP) [9], [12]–[14]. Atualmente, há uma gama de modelos numéricos de alta resolução espacial e temporal capazes de simular os processos radiativos que ocorrem na atmosfera. No entanto, é de suma importância conhecer as incertezas associadas aos resultados destes modelos numéricos para subsidiar a tomada de decisões no setor elétrico nacional, principalmente com relação aos aspectos relacionados à sustentabilidade econômica dos empreendimentos.

A irradiância solar no Nordeste do Brasil possui algumas características peculiares, como discutido por Lima et al. [9]. Sua distribuição espaço-sazonal mostra que os maiores valores ocorrem durante a primavera austral e os menores valores são verificados no outono e inverno, período chuvoso em grande parte da região. Neste contexto, o presente trabalho avalia e compara o desempenho de dois modelos numéricos de mesoescala - o BRAMS (Brazilian Developments on the Regional Atmospheric Modeling System) e WRF (Weather Research and Forecasting) - para a previsão da irradiação solar global incidente na superfície no Nordeste do Brasil (NEB). Os dois modelos atmosféricos são amplamente utilizados pela comunidade acadêmica brasileira em aplicações abrangentes como previsão de temperatura, precipitação e vento mas poucas informações estão disponíveis sobre seu uso em previsões de irradiação solar destinadas especificamente para atender o setor de energia. Os resultados mostram as limitações e diferenças entre os modelos sendo esta a principal contribuição do estudo. Além disso, pretende-se que o estudo possa contribuir para orientar o desenvolvimento de serviços de meteorologia aplicada para suporte da operação de plantas de geração solar no Nordeste do Brasil tanto sob o ponto de vista do empreendedor do setor elétrico quanto do Operador Nacional do Sistema elétrico brasileiro (ONS).

II. Materiais e Métodos

A. Área de Estudo

O estudo em questão compreende a porção norte da região Nordeste do Brasil (NEB) sujeita a uma diversidade de aspectos climatológicos e fatores antrópicos. A Fig. 1 mostra

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ENTOMOLOGIA E MALACOLOGIA

Uso do geoprocessamento na distribuição geográfica de *Lutzomyia (Nyssomyia) whitmani* (Diptera: Psychodidade: Phlebotominae) em associação com a cobertura vegetal e os impactos no processo de expansão da Leishmaniose Tegumentar Americana no Brasil

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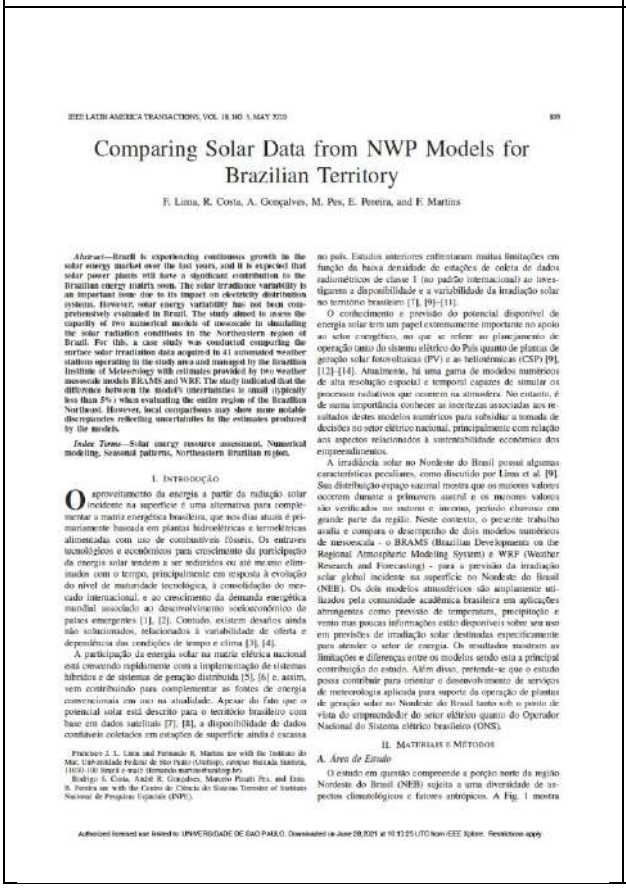
No Brasil, devido aos novos e complexos cenários epidemiológicos, as transmissões focais e dinâmicas da Leishmaniose Tegumentar Americana ocorrem em diferentes padrões, dependendo da localização. Um exemplo importante desse fenômeno é a ampla distribuição geográfica e diferentes comportamentos apresentados por *Lutzomyia (Nyssomyia) whitmani*, vetor que transmite três tipos de leishmanioses dermatrópicas no Brasil: *Leishmania (Viannia) braziliensis*, *Leishmania (Viannia) shawi* e *Leishmania (Viannia) guyanensis*. Este estudo visa correlacionar diferentes tipos de vegetação brasileira com a distribuição espacial de *Lutzomyia (Nyssomyia) whitmani* nas áreas representativas dos Circuitos Espaciais de Produção de Leishmaniose Tegumentar Americana. Para avaliar o cenário de vigilância e monitoramento da Leishmaniose Tegumentar Americana no Brasil, o Ministério da Saúde acrescentou o Circuito Espacial de doença em 2011, adotando atualmente uma classificação de transmissão da Leishmaniose Tegumentar Americana em municípios baseada no Indicador Composto de Leishmaniose Tegumentar. Para este estudo, um Sistema de Informação Geográfica foi utilizado para integrar as camadas de distribuição geográfica de *Lutzomyia (Nyssomyia) whitmani*, com a cobertura vegetal e Circuitos Espaciais de Leishmaniose Tegumentar Americana em municípios brasileiros. Dos 5.570 municípios brasileiros analisados, foram encontradas informações sobre *Lutzomyia (Nyssomyia) whitmani* em 862 municípios. O vetor ocorreu em quase todos os tipos de vegetação, com ampla distribuição em: Florestas Ombrófilas Densas, Florestas Ombrófilas Abertas (ou transição florestais), Florestas Decíduais Sazonais (ou matas ciliares), Florestas Semidecíduais Sazonais (matas semidecíduais) e Estepe. O vetor não foi encontrado na Vegetação Lenhosa Higrofítica dos Pântanos e de Acúmulo de Areia. Essa ampla presença do vetor reforça a hipótese de que *Lutzomyia (Nyssomyia) whitmani* é uma espécie sentinel, que pode se adaptar facilmente a diferentes ambientes.

Palavras-chave: *Lutzomyia (Nyssomyia) whitmani*, Leishmaniose Tegumentar Americana, Cobertura vegetal, mudanças ambientais

Fomento: FAPERJ E-26 / 111.618 / 2011; E-26 / 111.577 / 2014; INCT para Mudanças Climáticas; Rede Brasileira de Pesquisa em Mudanças Globais do Clima (Rede CLIMA)



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Original Article

Impacts of teleconnection patterns on South America climate

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Oceanic heat sources disturb the atmosphere, which, to come back to its initial state, disperses waves. These waves affect the climate in remote regions, characterizing the teleconnection patterns. In this study, we describe eight teleconnection patterns that affect South America climate: the El Niño–Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), the Atlantic Multidecadal Oscillation (AMO), the Tropical Atlantic Dipole (TAD), the South Atlantic Dipole (SAD), the Southern Annular Mode (SAM), the Madden–Julian Oscillation (MJO), and the Indian Ocean Dipole (IOD). Precipitation and winds at 850-hPa anomalies, considering these teleconnection patterns in ENSO neutral periods, are also presented. Overall, southeastern South America and the north sector of the North and Northeast regions of Brazil are the most affected areas by the teleconnection patterns. In general, there is a precipitation dipole pattern between these regions during each teleconnection pattern.

Keywords: precipitation; South America; teleconnection patterns; climate indices

Introduction

Atmospheric and/or oceanic patterns, such as the El Niño–Southern Oscillation (ENSO), develop over a specific region and affect the weather and climate of remote areas globally. The link between the atmospheric patterns and climate anomalies over great distances is called *teleconnection*;[1,2] and this word by itself is representative of these anomalies globally since "tele" means distant and "connection" means relationship.

As Liu and Alexander[1] stated, "Teleconnections enable the atmosphere to act like a 'bridge' between different parts of the ocean and enable the ocean to act like a 'tunnel' linking different atmospheric regions." Oceanic heat sources disturb the atmosphere. When it occurs, waves for energy dissipation are created in order to restore the original (basic) state of the atmosphere. Hence, waves traveling in the atmosphere are the cause of some teleconnection patterns. However, there are other mechanisms that disturb the atmosphere and contribute to teleconnections, such as the Antarctic ozone depletion, which can affect the Southern Annular Mode (SAM).[3]

The relationship between local climate anomalies and remote forcing can be identified through statistical methods like correlation analysis and empirical orthogonal functions (EOFs).[4] Sir Gilbert Walker was the first to apply statistical methods to the problem of teleconnections without knowing this phenomenon, and he became the reference in the use of correlation in meteorology (Ref. 5, p. 164). With the correlation method, Walker[6] discovered a tendency of the atmospheric pressure to

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frontiers in Earth Science

ORIGINAL RESEARCH

South America Climate During the 1970–2001 Pacific Decadal Oscillation Phases Based on Different Reanalysis Datasets

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In this paper, circulation and precipitation climate patterns over the South American domain obtained from NCEP-NCAR reanalysis I, JRA-55, and ERA-40 reanalysis datasets were intercompared within the period 1970–2001 in order to verify their climatic association with the Pacific Decadal Oscillation, PDO. Although all three datasets showed similar climatic patterns during each PDO phase, they showed distinct intensities for circulation and precipitation variables. The mean low frequency flow propagation over the South Pacific during negative and positive PDO phases reached central-eastern South America with opposite signals, contributing to the modulation of the local climate. During the negative PDO phases, the northerly flow over South America is intensified, while during the positive phase it is weakened. NCEP-NCAR reanalysis I, in comparison with JRA-55 and ERA-40 values, always indicates the strongest signal for circulation and precipitation variables. NCEP-NCAR reanalysis I meridional wind at the low-level jet area was about 5 and 12% larger than the respective JRA-55 and the ERA-40 values. For the positive and negative PDO phases, only NCEP-NCAR and ERA-40 high-level zonal wind anomalies showed divergent (positive PDO) and convergent (negative PDO) patterns close to 140° W at equatorial latitudes of the Pacific Ocean, respectively. This one indicated distinct representations of the positioning of Walker cells in the three reanalysis datasets. GPCC dataset, NCEP-NCAR, JRA-55, and ERA-40 reanalysis showed, in general, the dipole precipitation pattern over eastern South America, with signs of changes between the central-eastern and southeastern areas during PDO reversal phases. Over the central-eastern South American region, NCEP-NCAR precipitation is, on average, 52% larger than GPCC values, and 35 and 46% larger than JRA-55 and ERA-40 values, respectively. The observed patterns of anomalies for different PDO phases appeared in all reanalysis datasets, leading us to conclude that the physical meaning is independent from the datasets. Even considering the JRA-55 climate signal over South America associated with the PDO influence as the weakest one, the ability of JRA-55 to calculate monthly precipitation provided the highest linear correlation coefficient values in tropical areas, leading us to consider this dataset as the most reliable for the studied area.

Keywords: South America climate, PDO, NCEP-NCAR I, JRA-55, ERA-40, GPCC

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atmosphere

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Article

Dry and Wet Climate Periods over Eastern South America: Identification and Characterization through the SPEI Index

Anita Drumond [1,*], Milica Stojanovic [2], Raquel Nieto [3], Luis Gimeno [3], Margarida L. R. Liberato [2,4], Theotonio Pauliquevis [1], Marina Oliveira [1] and Tercio Ambrizzi [5]

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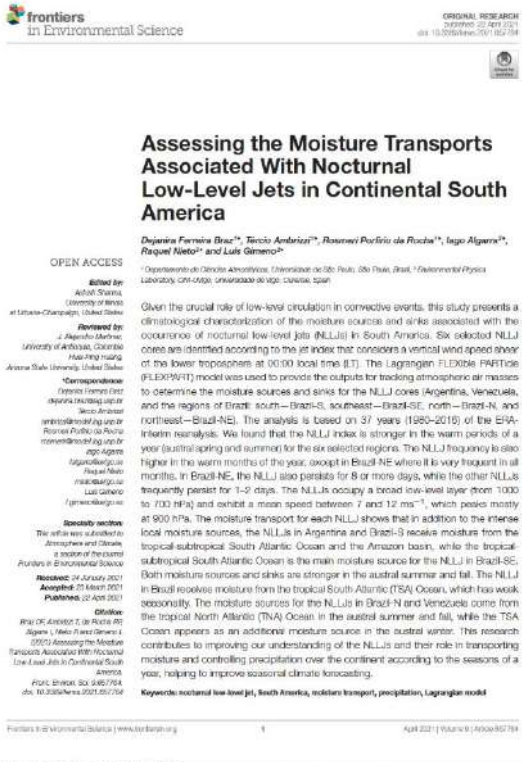
Abstract: A large part of the population and the economic activities of South America are located in eastern regions of the continent, where extreme climate events are a recurrent phenomenon. This study identifies and characterizes the dry and wet climate periods at domain-scale occurring over the eastern South America (ESA) during 1980–2018 through the multi-scalar Standardized Precipitation-Evapotranspiration Index (SPEI). For this study, the spatial extent of ESA was defined according to a Lagrangian approach for moisture analysis. It consists of the major continental sink of the moisture transported from the South Atlantic Ocean throughout the year, comprising the Amazonia, central Brazil, and the southeastern continental areas. The SPEI for 1, 3, 6, and 12 months of accumulation was calculated using monthly precipitation and potential evapotranspiration time series averaged on ESA. The analyses of the climate periods followed two different approaches: classification of the monthly SPEI values as mild, moderate, severe, and extreme; the computation of the events and their respective parameters (duration, severity, intensity, and peaks). The results indicate that wet periods prevailed in the 1980s and 2010s, while dry conditions predominated in the 2010s, when the longest and more severe dry events have been identified at the four scales.

Keywords: SPEI; eastern South America; extreme climate conditions; drought; wet episodes

1. Introduction

It is known that climate change may affect the frequency and intensity of extreme climate events [1]. In recent decades, South America has suffered from the alternations of extremely wet and dry climate conditions [2–5]. Droughts have affected different regions of Brazil such as Southeastern Brazil in 2014 [6–8] and the Amazon in 2010 and 2016 [9,10]. The Amazon region is especially vulnerable to the effects of extreme weather events such as prolonged droughts, changes in the rainy and dry seasons, and the risk of fire due to its ecosystem sensitivity. Two droughts in 2010 and 2016 and intense floods in 2012 and 2014 and their impacts on population and biodiversity have been well described in the literature [9–11]. Another important extreme climatic event that occurred in the 21st century was the prolonged drought in northeast Brazil during 2010–2016, which strongly affected the local agriculture and water reservoirs and has impacted the economy in the region [12,13]. Currently, the dry conditions observed over the Amazon rainforest and the Pantanal wetlands during 2020 are examples of how dry periods can enhance the propagation of fires, with enormous socio-economic and environmental damages, e.g., [14].



frontiers in Environmental Science

ORIGINAL RESEARCH

Assessing the Moisture Transports Associated With Nocturnal Low-Level Jets in Continental South America

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Given the crucial role of low-level circulation in convective events, this study presents a climatological characterization of the moisture sources and sinks associated with the occurrence of nocturnal low-level jets (NLLJs) in South America. Six selected NLLJ cores are identified according to the jet index that considers a vertical wind speed shear of the lower troposphere at 00:00 local time (LT). The Lagrangian FLEXible PARTicle (FLEXPART) model was used to provide the outputs for tracking atmospheric air masses to determine the moisture sources and sinks for the NLLJ cores (Argentina, Venezuela, and the regions of Brazil: south—Brazil-S, southeast—Brazil-SE, north—Brazil-N, and northeast—Brazil-NE). The analysis is based on 37 years (1980–2016) of the ERA-Interim reanalysis. We found that the NLLJ index is stronger in the warm periods of a year (austral spring and summer) for the six selected regions. The NLLJ frequency is also higher in the warm months of the year, except in Brazil-NE where it is very frequent in all months. In Brazil-NE, the NLLJ also persists for 8 or more days, while the other NLLJs frequently persist for 1–2 days. The NLLJs occupy a broad low-level layer (from 1000 to 700 hPa) and exhibit a mean speed between 7 and 12 ms^{-1}, which peaks mostly at 900 hPa. The moisture transport for each NLLJ shows that in addition to the intense local moisture sources, the NLLJs in Argentina and Brazil-S receive moisture from the tropical-subtropical South Atlantic Ocean and the Amazon basin, while the tropical-subtropical South Atlantic Ocean is the main moisture source for the NLLJ in Brazil-SE. Both moisture sources and sinks are stronger in the austral summer and fall. The NLLJ in Brazil receives moisture from the tropical South Atlantic (TSA) Ocean, which has weak seasonality. The moisture sources for the NLLJs in Brazil-N and Venezuela come from the tropical North Atlantic (TNA) Ocean in the austral summer and fall, while the TSA Ocean appears as an additional moisture source in the austral winter. This research contributes to improving our understanding of the NLLJs and their role in transporting moisture and controlling precipitation over the continent according to the seasons of a year, helping to improve seasonal climate forecasting.

Keywords: nocturnal low-level jet, South America, moisture transport, precipitation, Lagrangian model

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Climate Dynamics

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Assessing changes in the atmospheric water budget as drivers for precipitation change over two CORDEX-CORE domains

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Abstract
This study evaluates the projected changes in the atmospheric water budget and precipitation under the RCP8.5 scenario over two CORDEX-CORE domains: South America (SAM) and Europe (EUR). An ensemble of five twenty-first century projections with the Regional Climate Model version 4 (RegCM4) and their driving Global Climate Models (GCMs) are analyzed in terms of the atmospheric water budget terms (precipitation, P; evapotranspiration, ET; and moisture flux convergence, C). Special focus is on four subregions: Amazon (AMZ), La Plata basin (LPB), Mid-Europe (ME) and Eastern Europe (EA). The precipitation change signal in SAM presents a dipole pattern, i.e. drier conditions in AMZ and wetter conditions in LPB. Over the two European regions a seasonality is evident, with an increase of ~ 25% in precipitation for DJF and a decrease of ~ 35% in JJA. The atmospheric water budget drivers of precipitation change vary by region and season. For example, in DJF the main drivers are related to the large-scale moisture flux convergence, while in JJA over the AMZ atmospheric moisture flux convergence plays only a minor role and local processes dominate. For JJA in the GCMs the high values of the residual term do not allow us to assess which mechanisms drive the precipitation change signal over the AMZ and LPB, respectively. Same conclusions are found for the RegCM4 JJA simulations over the LPB and EA. This points to the importance of the spatial resolution of climate simulations and the role of parameterization schemes in climate models. Our work illustrates the usefulness of analyzing regional water budgets for a better understanding of precipitation change patterns around our globe.

Keywords Atmospheric water balance · CORDEX-CORE · Climate change · RegCM4

1 Introduction

Changes in precipitation around the globe have been assessed by the Fifth Assessment Report from Intergovernmental Panel on Climate Change (IPCC-AR5 [20] 13). Regional climate studies for South America (SAM; Rebeita

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ARTICLE

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Why do extreme events still kill in the São Paulo Macro Metropolis Region Chronicle of a death foretold in the global south

Luciana Travassos, Pedro Henrique Campello Torres, Gabriela Di Giulio, Pedro Roberto Jacobi, Edmilson Dias De Freitas, Isabela Christina Siqueira and Tércio Ambrizzi

This paper contributes to the study of climate change and environmental justice with a particular focus on a Global South case-study in the São Paulo Macro Metropole of Brazil. We also aim to contribute to mandatory critical dialogue between (anticipatory) governance and environmental justice. This study focuses on the rainy seasons from 2015 to 2019. We examine the incidence of 61 extreme precipitation events, as well as 47 deaths caused by rain events, considering their location based on vulnerability indicators. The correlations among these data allow us to reveal the socio-environmental patterns within the relationships between social vulnerability and deaths caused by general rainfall and, more specifically, extreme events. Based on this, we demonstrate that current infrastructure on its lack is one of the reasons why death tolls remain due to the absence of anticipatory governance.

ARTICLE HISTORY
Received 18 October 2019
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KEYWORDS
Macro metropolis São Paulo; climate change; environmental justice; anticipatory governance

Introduction

The debate on justice and social inequalities related to climate change has intensified throughout the past decade, mainly due to the growing incidence of extreme climate events, as suggested by evidence for global warming published in the latest IPCC report (IPCC 2018). This debate tends to expand, exposing unequal territorial cartographies of those most impacted by these events (Birkland and Waterman 2008; She et al. 2016; Angeloudis et al. 2016; Bell et al. 2018; Pelling and Garschagen 2019).

For small oceanic islands that have begun to disappear, underscoring the process of immigration and climate refugees from areas devastated by hurricanes, floods, and droughts has increasingly exposed the reality of the social and environmental inequalities present in the contemporary production of space.

In Brazil, ~85 of natural disasters are related to rainfall or a lack of it. Flash floods, landslides (usually caused by soil saturation), and prolonged droughts produce events that have resulted in more than 10,000 deaths in the last 20 decades (Pivetta 2016). With climate change, such events tend to increase in frequency and spatial scope. Climate scenarios for 2100 indicate that in the state of São Paulo, either there may be a 10 increase in torrential rainfall or a decrease in total rainfall (Marengo 2007).

In the state of São Paulo, as in other parts of the world, especially in the Global South, tragedies are already a certainty when discussing extreme events. This study aims to address the following question: Why do extreme events still kill in the São Paulo Macro Metropolis (SPMMR (Figure 1). Macro Metropolis is a specific terminology coined by the São Paulo State Government, based on previous

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Aumentar zoom

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SPECIAL ISSUE ARTICLE

Spatial distribution of spectral SST oscillations over the equatorial pacific in the period 1888–2014

Carlos Batista Silva | Maria Elisa Siqueira Silva | Tércio Ambrizzi | Natália Nunes Patucci | Bruna Simões Lima | Wesley Campos Correa

Abstract

This study identified and analysed the spatial and temporal patterns of spectral oscillation ranges of the monthly sea surface temperature, SST, over the tropical Pacific region, from 1888 to 2014, through wavelet analysis. The strategic steps considered the variance analysis, obtained from the wavelet computation, for each single grid point instead of the analysis of a spatial mean variance, as is commonly done, allowing us to visualize the spatial distribution of SST variance during different time periods. The mean results indicate that lower-frequency oscillations (2–4 and 4–8 years) over the considered area are becoming more intense while higher-frequency oscillations (1–12 months) are becoming less intense through time, which can lead to more persistent climates around the globe. While the 1–2 year oscillations feature the highest positive trend along the equatorial belt over central and eastern locations, the 4–8 year oscillations feature the strongest signal closer to the western South American coast, and the 2–4 year oscillations present positive signals over areas closer to the continental coast and over more distant western locations intercalated by negative signals. Throughout time, the position of the highest EN signals occurs either over central or eastern areas of the equatorial Pacific. The SST variance in the Niño areas mainly oscillates within the 2–4 and 4–8 year spectral ranges. Niño1 + 2 and Niño3 regions, in opposition to Niño3 and Niño3 + 4 regions, present the highest SST variance values for the four considered spectral ranges. The strongest El Niño events present their main oscillations in the 2–4 and 4–8 year spectral ranges, especially in the Niño1 + 2 and Niño3 regions, while weaker El Niño events show more association with the 1–2 year spectral range. Although there are some patterns identified for distinct El Niño/Southern Oscillation, ENSO, intensities and the associated frequency oscillations, the distinct spatial spectral energy distribution over the equatorial areas suggests the importance of the spatial distribution of the spectral energy through time in order to better characterize the ENSO events.

KEYWORDS

SST variability, tropical Pacific Ocean, wavelet analysis

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Atmospheric Chemistry and Physics — EGU

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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As três emergências que nossa sociedade enfrenta: saúde, biodiversidade e mudanças climáticas

PAULO ARTAXO

Introdução

NOSSA SOCIEDADE está simultaneamente convivendo com três emergências importantes: 1) a crise na saúde; 2) a crise de perda de biodiversidade; e 3) a crise climática. Salienta-se que essas crises têm ligações profundas entre si, e diferenças importantes, mas todas provocam impactos sociais e econômicos fortes e afetam nosso planeta globalmente.

Entre os pontos comuns mais relevantes cita-se um modelo de desenvolvimento econômico que é orientado pelo maior lucro no menor espaço de tempo, não importando as consequências futuras. Outro ponto comum importante é que, nas três crises, em geral, governos vão contra as recomendações da ciência. A ciência coloca há mais de duas décadas que uma pandemia como a da Covid-19 poderia chegar e atingir nossa sociedade com pesados prejuízos socioeconômicos. A ciência também vem alertando para o risco das mudanças climáticas, desde muito antes da Conferência Rio-92, principalmente sobre os riscos que a perda da biodiversidade provoca em muitas áreas da vida no planeta. Existem milhares de vírus desconhecidos da ciência que ainda estão em equilíbrio na flora e fauna. Todavia, com a continuidade da perda das florestas tropicais por meio do desmatamento, é só questão de tempo para que um novo vírus migre da Amazônia para outras regiões, com prejuízos enormes, como os causados pelo Sars-CoV-2.

Entre as diferenças importantes nas três crises está a questão temporal: enquanto a crise na saúde associada ao Sars-CoV-2 pode durar cerca de dois anos, o impacto das mudanças climáticas pode durar séculos, a perda de biodiversidade é para sempre. Não há possível *lockdown* como aplicado na pandemia da Covid-19, nas crises climáticas e de biodiversidade.

Importante salientar que as mudanças climáticas têm fortes ligações com a perda da biodiversidade que observamos em praticamente todos os ecossistemas terrestres, aquáticos e no ambiente marinho (IPBES 2019). A resiliência dos ecossistemas e sua capacidade de reagir a mudanças dependem, em grande par-

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Geoscientific Model Development Discussions

Improvements to the representation of BVOC chemistry-climate interactions in UKCA (vn11.5) with the CRI-Strat 2 mechanism: Incorporation and Evaluation

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Abstract We present the first incorporation of the Common Representative Intermediates version 2.2 tropospheric chemistry mechanism, CRI v2.2, combined with stratospheric chemistry, into the global chemistry-climate United Kingdom Chemistry and Aerosols (UKCA) model to give the CRI-Strat 2 mechanism. A rigorous comparison of CRI-Strat 2 with the earlier version, CRI-Strat, is performed in UKCA in addition to an evaluation of three mechanisms, CRI-Strat 2, CRI-Strat and the standard UKCA chemical mechanism, StratTrop vn1.0, against a wide array of surface and airborne chemical data.

CRI-Strat 2 comprises a state-of-the-art isoprene scheme, optimised against the NCAR v5.3-1, which includes isoprene peroxy radical isomerisation, HO_x-recycling through the addition of photolabile hydroperoxy aldehydes (HPALDs) and IEPOX formation. CRI-Strat 2 also features updates to several rate coefficients for the inorganic chemistry including the reactions of inorganic nitrogen and $O(^1D)$.

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Atmospheric Chemistry and Physics Discussions

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 hemispheric high altitude experiment on particle nucleation and growth" (SALTENA) to identify where sampled air masses originate and to quantify the influence of the boundary layer 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 either by boundary layer or free troposphere air masses. We find that on average, 9% of the air sampled at CHC at any given observation time, has been in contact with the surface within 4 days prior to arriving at CHC, 24% of the air was located below 1.5 km above ground level and consequently, 76% of the measured air masses at CHC represent free tropospheric air. However, pure free-tropospheric influences are rare and often samples are concurrently influenced by both boundary layer and free tropospheric

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Biogeosciences Discussions

Measurement and modelling of the dynamics of NH_3 surface-atmosphere exchange over the Amazonian rainforest

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Abstract. Local and regional modelling of NH_3 surface exchange is required to quantify nitrogen deposition to, and emissions from, the biosphere. However, measurements and model parameterisations for many remote ecosystems—such as tropical rainforest—remain sparse. Using one month of hourly measurements of NH_3 fluxes and meteorological parameters over a remote Amazon rainforest site (Amazon Tall Tower Observatory, ATTO), six model parameterisations based on a bi-directional, single-layer, canopy compensation point resistance model were developed to simulate observations of NH_3 surface exchange. Canopy resistance was linked to either relative humidity at the canopy level (RH_{cl}), vapour pressure deficit, or a parameter value based on leaf wetness measurements. The ratio of apoplastic NH_4^+ to H^+ concentration, Γ_a, during this campaign was inferred to be 38.5 ± 15.8. The parameterisation that reproduced the observed net exchange of NH_3 most accurately was the model that used a cuticular resistance (R_{cu}) parameterisation based on leaf wetness measurements and a value of $\Gamma_a = 50$ (Pearson correlation $r = 0.71$). Conversely, the model that performed the worst at replicating measured NH_3 fluxes used an R_w value modelled using RH_{cl} and the inferred value of $\Gamma_a = 38.5$ ($r = 0.45$). The results indicate that a single layer, canopy compensation point model is appropriate for simulating NH_3 fluxes from tropical rainforest during the Amazonian dry season, and confirmed that a direct measurement of (a non-binary) leaf wetness parameter improves the ability to estimate R_w. Current inferential methods for determining Γ_a were noted as having difficulties in the humid conditions present at a rainforest site.

1 Introduction

The global cycling of nitrogen is of critical importance to Earth's biogeochemistry. One of the major contributors to the global atmospheric reactive nitrogen (N_r) budget is ammonia (NH_3), which is primarily generated from anthropogenic sources (Galloway et al., 2003). The emission of NH_3, and the subsequent deposition of NH_3 or other forms of reactive nitrogen, have impacts on terrestrial and marine ecosystems (Erisman et al., 2013). In particular, forests can be impacted through changes to N input in several ways. Fowler et al. (2013) detail how increased deposition of N can lead to increased vegetation growth rates in forests, leading to potentially greater carbon sequestration rates. This potential positive impact, however, is offset by the effect

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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_{asym}), 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 Manaquiry (T3), as well as the U.S. Department

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Atmospheric Chemistry and Physics

Impact of biomass burning aerosols on radiation, clouds, and precipitation over the Amazon: relative importance of aerosol–cloud and aerosol–radiation interactions

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Abstract. Biomass burning (BB) aerosols can influence regional and global climate through interactions with radiation, clouds, and precipitation. Here, we investigate the impact of BB aerosols on the energy balance and hydrological cycle over the Amazon Basin during the dry season. We performed simulations with a fully coupled meteorology–chemistry model, the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem), for a range of different BB emission scenarios to explore and characterize nonlinear effects and individual contributions from aerosol–radiation interactions (ARIs) and aerosol–cloud interactions (ACIs). The ARIs of BB aerosols tend to suppress low-level liquid clouds by local warming and increased evaporation and to facilitate the formation of high-level ice clouds by enhancing updrafts and condensation at high altitudes. In contrast, the ACIs of BB aerosol particles tend to enhance the formation and lifetime of low-level liquid clouds by providing more cloud condensation nuclei (CCN) and to suppress the formation of high-level ice clouds by reducing updrafts and condensable water vapor at high altitudes (> 8 km).

For scenarios representing the lower and upper limits of BB emission estimates for recent years (2002–2016), we obtained total regional BB aerosol radiative forcings of −0.2 and 1.5 W m^{-2}, respectively, showing that the influence of BB aerosols on the regional energy balance can range from modest cooling to strong warming. We find that ACIs dominate at low BB emission rates and low aerosol optical depth (AOD), leading to an increased cloud liquid water path (LWP) and negative radiative forcing, whereas ARIs dominate at high BB emission rates and high AOD, leading to a reduction of LWP and positive radiative forcing. In all scenarios, BB aerosols led to a decrease in the frequency of occurrence and rate of precipitation, caused primarily by ACI effects at low aerosol loading and by ARI effects at high aerosol loading. The dependence of precipitation reduction on BB aerosol loading is greater in a strong convective regime than under weakly convective conditions.

Overall, our results show that ACIs tend to saturate at high aerosol loading, whereas the strength of ARIs continues to increase and plays a more important role in highly polluted episodes and regions. This should hold not only for BB aerosols over the Amazon, but also for other light-absorbing aerosols such as fossil fuel combustion aerosols in industrialized and densely populated areas. The importance of ARIs at high aerosol loading highlights the need for accurately characterizing aerosol optical properties in the investigation of aerosol effects on clouds, precipitation, and climate.

1 Introduction

Biomass burning as a main source of fine particles can influence weather and climate through complex feedbacks with radiation and clouds on regional and global scales (Ramanathan et al., 2001; Kaufman and Koren, 2006; Rosen-

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Biogeosciences Discussions

Bioaerosols in the Amazon rain forest: Temporal variations and vertical profiles of Eukarya, Bacteria and Archaea

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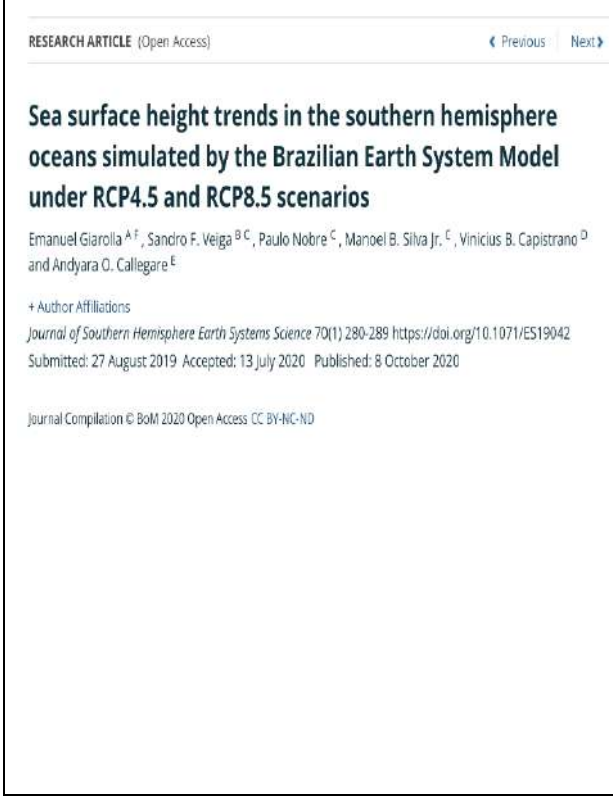

RESEARCH ARTICLE (Open Access) ‹ Previous Next ›

Sea surface height trends in the southern hemisphere oceans simulated by the Brazilian Earth System Model under RCP4.5 and RCP8.5 scenarios

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An inter-hemispheric seasonal comparison of polar amplification using radiative forcing of a quadrupling CO_2 experiment

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ORIGINAL ARTICLE

Assessment of CMIP6 Performance and Projected Temperature and Precipitation Changes Over South America

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Abstract
We evaluate the performance of a large ensemble of Global Climate Models (GCMs) from the Coupled Model Intercomparison Project Phase 6 (CMIP6) over South America for a recent past reference period and examine their projections of twenty-first century precipitation and temperature changes. The future changes are computed for two time slices (2040–2059 and 2080–2099) relative to the reference period (1995–2014) under four Shared Socioeconomic Pathways (SSPs, SSP1–2.6, SSP2–4.5, SSP3–7.0 and SSP5–8.5). The CMIP6 GCMs successfully capture the main climatic characteristics across South America. However, they exhibit varying skill in the spatiotemporal distribution of precipitation and temperature at the sub-regional scale, particularly over high latitudes and altitudes. Future precipitation exhibits a decrease over the east of the northern Andes in tropical South America and the southern Andes in Chile and Amazonia, and an increase over southeastern South America and the northern Andes—a result generally consistent with earlier CMIP (3 and 5) projections. However, most of these changes remain within the range of variability of the reference period. In contrast, temperature increases are robust in terms of magnitude even under the SSP1–2.6. Future changes mostly progress monotonically from the weakest to the strongest forcing scenario, and from the mid-century to late-century projection period. There is an increase in the seasonality of the intra-annual precipitation distribution, as the wetter part of the year contributes relatively more to the annual total. Furthermore, an increasingly heavy-tailed precipitation distribution and a rightward shifted temperature distribution provide strong indications of a more intense hydrological cycle as greenhouse gas emissions increase. The relative distance of an individual GCM from the ensemble mean does not substantially vary across different scenarios. We found no clear systematic linkage between model spread about the mean in the reference period and the magnitude of simulated sub-regional climate change in the future period. Overall, these results could be useful for regional climate change impact assessments across South America.

Keywords CMIP6 · Climate change · Global climate models · South America

1 Introduction

Like many other regions across the planet, South America has experienced environmental changes during the twentieth century, including increasing surface temperatures (Salviano et al. 2016; de Barros Soares et al. 2017; Dereczynski et al. 2020; Pabon-Caicedo et al. 2020), shifting precipitation patterns (Espinoza et al. 2019; Paca et al. 2020; Marrafon et al. 2020; Carvalho 2020; Giráldez et al. 2020; Pabon-Caicedo et al. 2020), vanishing Andean glaciers (Schauwecker et al. 2014; Malmros et al. 2016; Dreikhan et al. 2018; Vuille et al. 2018; Somers et al. 2019; Masiokas et al. 2020), and an increase in weather and climate extremes, such as droughts, floods, and wildfires (Barros et al. 2015; Martins et al. 2018; Viganó et al. 2018; Cunha et al. 2019; Feron et al. 2019; Lemes et al. 2020; Debortoli et al. 2020; Zubieta et al.

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Interstate input-output model for Mexico, 2013[1]

Modelo interestatal de insumo-producto para México, 2013

(Received: 03/March/2020; accepted: 09/July/2020; published: 04/September/2020)

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ABSTRACT

The aim of this paper is to describe in detail the process of estimation of the interregional input-output system for Mexico, for the year 2013. This is the first exercise of the type since no regional model has been built including all states of Mexico. With this paper, we make available not only the details of the methodological procedures adopted to generate the interregional system, but also the database itself to be used by other researchers and practitioners.

Keywords: interregional input-output, methodology, data, Mexico.
JEL Classification: C67; D57; R15.

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Climate change in Brazil: dealing with uncertainty in agricultural productivity models and the implications for economy-wide impacts

Bruno Souza [a] and Eduardo Haddad [b]

ABSTRACT
This paper estimates the economic impacts of climate change over the Brazilian regions until the end of the century. We estimate the direct and indirect impact of the projected changes in climate on the yield of the country's main crops. The results point to a broad spatial heterogeneity of impacts across the country. Using the extreme scenarios created by the Intergovernmental Panel on Climate Change (IPCC) (RCP 2.6 and 8.5), our predictions indicate that the average annual losses due to climate change range from 0.4% to 1.8% of Brazilian gross domestic product until the end of the century.

KEYWORDS
climate change, agricultural productivity, spatial economics, Brazil

JEL C68, O54, R11, R15
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INTRODUCTION

The intensity, spatial variability and potential effects of climate change on agricultural productivity are central concerns in the policy debate. Agriculture is one of the economic sectors most affected by changes in climate. Permanent changes in the global climate system can seriously affect crop productivity worldwide, and these effects on agriculture can influence other sectors in the economy. Hence, the study of the impacts of climate change on agricultural productivity is fundamental from a policy perspective. The different patterns of these impacts on space must also be considered. Some regions might observe an increase in productivity for some crops and a decrease for other crops. The general equilibrium effect of such changes is not easy to anticipate.

Brazil, a country with continental dimensions, is an excellent example of how spatial variability can play an important role in assessing the economic effects of climate change on agricultural output. The country's economic and political importance and its preponderant position in the world's agricultural system make this analysis essential. In this paper, we estimate the effects of climate change on the yield of the leading Brazilian crops. We call these *direct impacts*. We also

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Research

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THE ROYAL SOCIETY PUBLISHING

Degraded pastures in Brazil: improving livestock production and forest restoration

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Degraded pasture is a major liability in Brazilian agriculture, but restoration and recovery efforts could turn this area into a new frontier to both agricultural yield expansion and forest restoration. Currently, rural properties with larger degraded pasture areas are associated with higher levels of technical inefficiency in Brazil. 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. Regional identification of degraded pastures would facilitate the targeting of agricultural extension and advisory services and rural credit efforts aimed at fostering pasture recovery. Since only 1% of Brazilian municipalities contain 25% of degraded pastures, focusing pasture recovery efforts on this small group of municipalities could generate considerable benefits. More efficient allocation of degraded and native pastures for meat production and forest restoration could provide land enough to fully comply with its Forest Code requirements, while adding 9 million heads to the cattle inventory. Degraded pasture recovery and restoration is a win-win strategy that could boost livestock husbandry and avoid deforestation in Brazil and has to be the priority strategy of agribusiness sector.

1. Introduction

Global population is expected to reach 10 billion people in the next 30 years. The Food and Agriculture Organization projects that additional 52 million tons of nitrogen fertilizer and 165 million ha of new agricultural land will be required to meet global food, feed, fibre and biofuel demand by 2050. These variations

WEATHER SHOCKS AND LABOR ALLOCATION: EVIDENCE FROM RURAL BRAZIL

DANYELLE BRANCO AND JOSÉ FÉRES

We examine the effects of rainfall shocks on household work decisions in Brazil. We show that rural farming households increase labor supply in non-agricultural sectors during drought episodes. An additional drought month per year is associated with greater likelihood of holding more than one job, lower share of agricultural employment, and more time spent performing a secondary job. Together, these findings suggest that households alter their labor decisions to mitigate the consequences of weather shocks.

Key words: Agricultural households, drought shocks, labor allocation, Northeastern Brazil.

JEL codes: O13, Q10, R23.

A consolidated body of research suggests that the frequency and intensity of extreme weather events will increase during the current century due to global warming (IPCC 2013; Coates et al. 2014). The economic costs of droughts, floods, and other weather-related events may be far reaching. Previous studies provide strong evidence that fluctuations in weather may have a significant effect on agricultural productivity by directly affecting crop yields (Schlenker and Roberts 2006; Deschênes and Greenstone 2007; Felkner, Tazhibayeva, and Townsend 2009; Cabas, Weersink, and Olale 2010; Dell, Jones, and Olken 2012; Fisher et al. 2012; Powell and Reinhard 2016). This finding has opened the way for a literature that aims at understanding how households might cope *ex ante* and *ex post* with income variability related to adverse weather events (Dercon 1996; Pattanayak and Sills 2001; Kazianga and Udry 2006; Marchiori and Schumacher 2012; Mukherjee and Schwabe 2014; Skoufias, Bandyopadhyay, and Olivieri 2016; Manning, Goemans, and Maas 2017). If household responses are salient, the resulting economic damages could be minimized. But if households are unable to adjust to weather shocks, then overall damages could be substantial (Burke and Emerick 2016).

Several works have investigated risk mitigation and adaptation strategies adopted by rural households. Such strategies include precautionary savings (Paxson 1992; Dercon 1996), access to credit markets (Udry 1994; Skoufias, Bandyopadhyay, and Olivieri 2016), livestock and asset sales (Fafchamps, Udry, and Czukas 1998; Kazianga and Udry 2006), cultivation of more weather-resilient crops (Seemero, Ricker-Gilbert, and Cook 2018), and migration (Marchiori and Schumacher 2012; Bohra-Mishra, Oppenheimer, and Hsiang 2014; Gröger and Zylberberg 2016).

Labor supply adjustments constitute another coping strategy to weather-related income shocks. This short-term adaptation strategy may be important in the case of developing countries, which face restricted adaptation options. Rural establishments in these regions have limited social safety nets and limited access to credit markets. They cannot

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FULL ARTICLE

The internal geography of services value-added in exports: A Latin American perspective

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Abstract

We estimate the contents of services value-added incorporated in goods exports in different countries in Latin America, exploring the local dimension of the results. We use inter-regional input–output analysis to trace and map domestic value-added embedded in those countries' exports. We add to the discussion of global value chains the internal, within-country geography of trade in value-added, since the set of locational preferences that help understanding the spatial patterns of natural resource-intensive activities differ dramatically from that for services.

KEYWORDS
global and local value chains, services, trade in value-added

JEL CLASSIFICATION
R12; F12; F60

1 | INTRODUCTION

Services are becoming more and more important all over the world, with their share in global GDP reaching 65% in 2018, according to World Bank data. In Latin America and the Caribbean, services accounted for 60.3% of the region's GDP (e.g. Brazil: 62.6%; Chile: 57.9%; Colombia: 57.8%; and Mexico: 60.2%). Moreover, services also present a large and increasing share of value-added in global and regional value chains, with an overall contribution to the value of global manufacturing exports above 60% (Miroudot & Cadestin, 2017).

The rise of global value chains (GVCs) has led to production stages for individual goods being scattered across countries. For measuring GVCs linkages, there has been progress in data and methods, especially through the input–output analysis (Johnson & Noguera, 2012a; Koopman, Wang, & Wei, 2014; Los, Timmer, & de Vries, 2016). This has allowed the tracing of the value-added content of trade flows in vertically linked stages of the production process and the development of a coherent empirical portrait of GVCs (Johnson, 2018). A fact about trade in value-added is

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REGULAR ARTICLE Open Access

A weighted travel time index based on data from Uber Movement

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Abstract

In this paper, we combine data from Uber Movement and from a representative household travel survey to constructs a weighted travel time index for the Metropolitan Region of São Paulo. The index is calculated based on the average travel time of Uber trips taken between each pair of traffic zone and in each hour between January 1st, 2016 to December 31, 2016. The index is weighted based on trips reported in a household travel survey that was designed to be statistically representative of all trips made in the city during a typical business day. We show that the index has a strong correlation with traditional measures of congestion, however, with a broader coverage of the road network. Finally, we use the index to run a multivariate ex post analysis that estimates the effect of different events on traffic congestion in the city, including holidays, public transit strikes, road shutdowns, rain and major sport events.

Keywords: Traffic congestion; Travel time index; E-hailing data

1 Introduction

Traffic congestion is a major component of transport systems efficiency. With higher levels of congestion, more time is spent in traffic and less time is available for productive activities and for leisure [1]. Therefore, congestion represents a major source of costs and inefficiency for urban economies. Because of that, measuring congestion is a key element for monitoring and evaluating transport systems and for supporting policy decisions aimed to improve them. Traditional methods for measuring congestion such as loop detectors are important tools for road segment monitoring and for traffic signal control. However their coverage is limited to the locations where they are placed, thus, these are not ideal tools for tracking congestion with a highly granular temporospatial coverage [2]. Measuring congestion at the personal trip level requires other types of tools, such as probe vehicles or taxis. However, such methods are costly and are not commonly available in developing country cities where traffic agencies face stricter financial constraints [3].

With technological improvements and the ubiquitous spread of cellphones with geographical tracking and transportation applications, other types of in vehicle data are now broadly available, creating the opportunity for the development of alternative methods to measure characteristics of transport systems with detailed coverage both in terms of time

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Water content in trade: a regional analysis for Morocco

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ABSTRACT

This paper aims at evaluating the virtual water content in trade in an intra-country perspective and discussing potential tradeoffs between the use of natural resources and value added creation. We develop a trade-based index that reveals the relative water use intensities associated with specific interregional and international trade flows. The index is calculated considering the measures of water and value added embedded in trade flows associated with each regional origin-destination pair using an interregional input-output matrix for Morocco together with information on sectorial water use. We add to the literature on virtual water by encompassing the subnational perspective in a country that shows a clear 'climate divide'. Furthermore, we contribute to the literature by proposing an index that may be applied to different economies to evaluate multidimensional tradeoffs associated with the pressure of specific economic flows to the use of natural resources relative to its economic relevance.

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Water accounting; integrated ecologic-economic modelling; interregional input–output

JEL
Codes: Q25; Q56; C67; D57; R15

1. Introduction

Considered as one of the most poorly endowed countries in water resources, Morocco has intimately linked its economic and social development to the control of its natural resources. The country has developed strategies and policies aiming at the best management and valorization of such resources. It has built, in the last decades, a large system of hydropower infrastructure consisting of approximately 139 large dams, with a storage capacity of more than 17 billion m^3, and several transfer systems that allow the physical transposition of water to the driest areas (Court of Audit, 2018).

These strategies have played a key role in food, water, and energy security for the population, particularly through improved access to drinking water and hydroelectric power, as well as protection against floods and droughts. Nevertheless, good governance of water resources requires continuing attention in Morocco, especially in the face of a significant increase in the demand for water and its multiple uses in the context of a growing population and an expanding economy (Global Nexus, 2017). Moreover, adding to the long-term changes to recent dry conditions in Morocco, global climate change is projected to increase

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Pesquisa FAPESP – Interviews Agencia FAPESP

Agência FAPESP NOTÍCIAS AGENDA VÍDEOS ASSINE

Pesquisadores identificam causas da seca extrema que afetou o Pantanal

17 de março de 2021

Estudo aponta que a estiagem severa registrada no bioma entre 2019 e 2020 é resultado de um fenômeno meteorológico natural similar ao que desencadeou a crise hídrica no Estado de São Paulo entre 2014 e 2016 (*foto: Mayke Toscano/Secom-MT*)

Elton Alisson | Agência FAPESP – Um fenômeno meteorológico natural similar ao que causou a crise hídrica no Estado de São Paulo, entre 2014 e 2016, foi responsável pela seca extrema no Pantanal registrada entre 2019 e 2020 e considerada a pior dos últimos 50 anos.

A constatação foi feita por pesquisadores do Centro Nacional de Monitoramento e Alerta de Desastres (Cemaden), do Instituto Nacional de Pesquisas Espaciais (Inpe) e da Universidade Estadual Paulista (Unesp) por meio de um **projeto** apoiado pela FAPESP no âmbito do Programa de Pesquisa sobre Mudanças Climáticas Globais (**PFPMCG**).

Os resultados do estudo foram **publicados** na revista *Frontiers in Water*.

"A seca recente no Pantanal foi causada por um fenômeno que chamamos de bloqueio meteorológico, caracterizado pelo surgimento de uma área de alta pressão que impediu a formação de chuva em toda a região do Centro-Oeste da América do Sul. Consequentemente, a temperatura ficou muito alta, e a umidade relativa, muito baixa", diz à **Agência FAPESP** **José Marengo**, pesquisador do Cemaden e coordenador do estudo.

Agência FAPESP NOTÍCIAS AGENDA VÍDEOS ASSINE

"A combinação de falta de chuva com temperaturas altas e umidade relativa muito baixa levou ao aumento de risco de fogo, que se estendeu não somente sobre áreas agrícolas como também naturais do bioma", explica Marengo.

O uso do fogo para limpar terreno para pecuária contribui para aumentar os focos de incêndio na região, que ficam mais difíceis de serem combatidos em razão da falta de chuvas, avalia o pesquisador. "O fogo causado de um lado pelo ar mais quente e a falta de chuvas no Pantanal e de outro pelo queima de áreas para pecuária na região resultou no desastre ambiental que vimos no bioma", afirma Marengo.

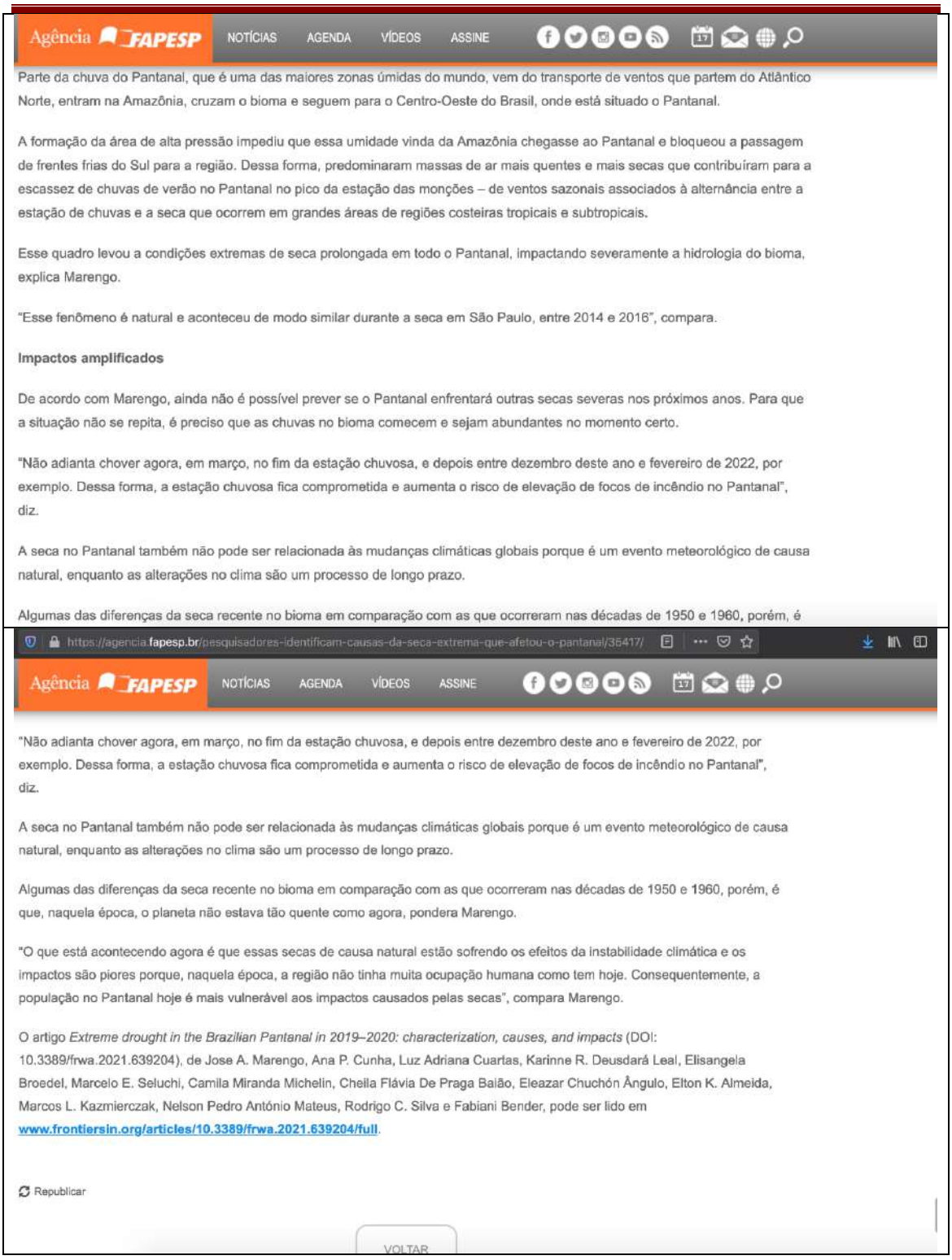
Fontes de dados observacionais

A fim de investigar as causas hidroclimáticas da seca no Pantanal, os pesquisadores usaram uma ampla gama de fontes de dados observacionais de hidrologia (referentes ao nível do rio Paraguai) e também sobre chuva, clima e índices de teleconexões atmosféricas (uma estimativa de como fenômenos climáticos extremos estão conectados) para identificar mudanças na circulação de ventos. Além disso usaram informações sobre o uso da terra e empregaram índices derivados de fontes de sensoriamento para caracterizar o estresse hídrico e a seca no bioma.

Com base nesse conjunto de dados, foi possível descrever a variabilidade interanual da precipitação, do fluxo do rio Paraguai e variáveis relacionadas com a seca. As análises dos dados indicaram que uma complexa combinação de teleconexões hidroclimáticas esteve por trás da seca recente na região.

"A falta de chuvas durante os verões de 2019 e 2020 no Pantanal está relacionada com a redução do transporte de ar quente e úmido do verão da Amazônia para a região", afirma Marengo.

Parte da chuva do Pantanal, que é uma das maiores zonas úmidas do mundo, vem do transporte de ventos que partem do Atlântico



Agência FAPESP NOTÍCIAS AGENDA VÍDEOS ASSINE

Parte da chuva do Pantanal, que é uma das maiores zonas úmidas do mundo, vem do transporte de ventos que partem do Atlântico Norte, entram na Amazônia, cruzam o bioma e seguem para o Centro-Oeste do Brasil, onde está situado o Pantanal.

A formação da área de alta pressão impediu que essa umidade vinda da Amazônia chegasse ao Pantanal e bloqueou a passagem de frentes frias do Sul para a região. Dessa forma, predominaram massas de ar mais quentes e mais secas que contribuíram para a escassez de chuvas de verão no Pantanal no pico da estação das monções – de ventos sazonais associados à alternância entre a estação de chuvas e a seca que ocorrem em grandes áreas de regiões costeiras tropicais e subtropicais.

Esse quadro levou a condições extremas de seca prolongada em todo o Pantanal, impactando severamente a hidrologia do bioma, explica Marengo.

"Esse fenômeno é natural e aconteceu de modo similar durante a seca em São Paulo, entre 2014 e 2016", compara.

Impactos amplificados

De acordo com Marengo, ainda não é possível prever se o Pantanal enfrentará outras secas severas nos próximos anos. Para que a situação não se repita, é preciso que as chuvas no bioma comecem e sejam abundantes no momento certo.

"Não adianta chover agora, em março, no fim da estação chuvosa, e depois entre dezembro deste ano e fevereiro de 2022, por exemplo. Dessa forma, a estação chuvosa fica comprometida e aumenta o risco de elevação de focos de incêndio no Pantanal", diz.

A seca no Pantanal também não pode ser relacionada às mudanças climáticas globais porque é um evento meteorológico de causa natural, enquanto as alterações no clima são um processo de longo prazo.

Algumas das diferenças da seca recente no bioma em comparação com as que ocorreram nas décadas de 1950 e 1960, porém, é

https://agencia.fapesp.br/pesquisadores-identificam-causas-da-seca-extrema-que-afetou-o-pantanal/35417/

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Algumas das diferenças da seca recente no bioma em comparação com as que ocorreram nas décadas de 1950 e 1960, porém, é que, naquela época, o planeta não estava tão quente como agora, pondera Marengo.

"O que está acontecendo agora é que essas secas de causa natural estão sofrendo os efeitos da instabilidade climática e os impactos são piores porque, naquela época, a região não tinha muita ocupação humana como tem hoje. Consequentemente, a população no Pantanal hoje é mais vulnerável aos impactos causados pelas secas", compara Marengo.

O artigo *Extreme drought in the Brazilian Pantanal in 2019–2020: characterization, causes, and impacts* (DOI: 10.3389/frwa.2021.639204), de Jose A. Marengo, Ana P. Cunha, Luz Adriana Cuartas, Karinne R. Deusdará Leal, Elisangela Broedel, Marcelo E. Seluchi, Camila Miranda Michelin, Cheila Flávia De Praga Baião, Eleazar Chuchón Ângulo, Elton K. Almeida, Marcos L. Kazmierczak, Nelson Pedro António Mateus, Rodrigo C. Silva e Fabiani Bender, pode ser lido em www.frontiersin.org/articles/10.3389/frwa.2021.639204/full.

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MUDANÇAS CLIMÁTICAS
Risco de mais desastres naturais
Aquecimento global deve favorecer aumento de inundações bruscas e deslizamentos de terra causados por chuvas extremas no Sul, Sudeste e leste do Nordeste
Estudo prevê que o risco de enchentes na Região Metropolitana de São Paulo pode aumentar até 15% em razão do aquecimento global
Fabio Vieira / FotoRua / NurPhoto via Getty Images

Marcos Pivetta

Edição 303
mai. 2021

Ambiente

O aumento gradual do aquecimento global ao longo deste século deve intensificar progressivamente a incidência de chuvas extremas e elevar o risco de deslizamentos de terras e inundações bruscas nas regiões Sul e Sudeste e na faixa leste do Nordeste, onde ficam os maiores centros urbanos e se concentram mais de dois terços da população do Brasil. Se a temperatura média do planeta subir 4 graus Celsius (°C) em relação ao valor apresentado no final do século XIX, logo após a Revolução Industrial, a probabilidade de, por exemplo, ocorrer enxurradas na Região Metropolitana de São Paulo, que atualmente já é considerável, cresce quase 15%. A elevação do risco de deslizamentos de terra na maior megalópole brasileira é um pouco menor, mas ainda assim significativa, da ordem de 10%. Essas são algumas das conclusões de um artigo de modelagem climática publicado em 3 de março no periódico *Frontiers in Climate* por pesquisadores do Centro Nacional de Monitoramento de Desastres Naturais (Cemaden), localizado no interior paulista, e do Met Office Hadley Centre for Climate Science and Services, do Reino Unido.

O aumento de 10% a 15% no risco de haver desastres, como o previsto para a Grande São Paulo, pode parecer pouco, mas sua relação com os impactos das calamidades não é linear. "Vimos que o potencial de ocorrer mais inundações e deslizamentos de terra aumenta sobretudo nas regiões onde hoje esse risco já é alto", comenta um dos autores do artigo, o climatologista José Antonio Marengo, coordenador de pesquisa e desenvolvimento do Cemaden. "Se a temperatura global subir 1,5 ou 2 °C, o custo de se adaptar a essa situação será muito elevado. Caso o aumento seja de 4 °C, o

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Entrevista: José Antonio Marengo

00:00 / 19:40

Na porção ocidental da região Norte e em setores do Centro-Oeste, deslizamentos e inundações também tendem a se tornar mais frequentes com o avanço de temporais decorrentes do aquecimento global ao longo deste século, segundo o estudo. Mas,

As projeções do artigo se baseiam em uma abordagem ligeiramente diferente da que usualmente tem sido adotada em trabalhos similares. Em vez de se preocupar em determinar em que década deste século a temperatura média global, em razão do aumento do chamado efeito estufa, vai alcançar um certo nível, os pesquisadores direcionaram o foco de seu estudo para outra questão: qual será o impacto no risco de haver inundações e deslizamentos de terra quando, independentemente do ano, o aquecimento global atingir três cenários possíveis, aumentos de 1,5°, 2° e 4 °C na temperatura média planetária em relação ao valor registrado em 1880, de 13,7 °C?

Para responder a essa pergunta, a equipe do Cemaden e do Hadley Centre usou os parâmetros atuais de ocupação e demografia do território nacional e calculou o risco atual de haver enchentes e deslizamentos de terra em todo o país. Em seguida, sem alterar o tamanho da população brasileira e sua distribuição geográfica, inseriu os três cenários de aquecimento global em seis modelos climáticos globais, desenvolvidos por diferentes centros de estudo, entre os quais o Hadley Centre. No fim do processo, cada modelo forneceu para diferentes pontos do país e, para os três distintos graus de aumento de temperatura, novos índices referentes ao risco de haver enchentes e grandes deslizamentos de terra.

A vulnerabilidade da Região Metropolitana de São Paulo não é um caso extremo e isolado. Em quase todas as áreas em torno das capitais do país há elevação da probabilidade de haver deslizamentos de terra e inundações, de acordo com as simulações. Em Curitiba, se a temperatura subir 4° C, o risco de ocorrer deslizamentos sobe cerca de 10%. Em Porto Alegre e no Vale do Itajaí, em Santa Catarina, duas áreas que atualmente apresentam os maiores níveis de risco para deslizamentos de terra no país, o aumento da temperatura planetária faz o risco desse tipo de desastre crescer entre 2% e 7%. A situação é semelhante quando o foco são as inundações. Como São Paulo, Florianópolis é outra capital em que o estudo aponta um aumento acima de 10% no risco de incidência de inundações por causa do aquecimento global.

Das grandes capitais, Recife parece ser uma exceção. As simulações não apontaram risco aumentado de ocorrer inundações e deslizamentos. No caso da capital pernambucana e de outros pontos do Nordeste, não se trata apenas de a região apresentar uma menor propensão natural a ser alvo de desastres decorrentes de chuvas extremas. Há também uma falta de consenso dos modelos climáticos sobre como o aquecimento global vai afetar o regime de chuvas na região e, por conseguinte, impactar a probabilidade de haver enchentes e deslizamentos. "Nosso grau de confiança para fazer previsões em boa parte do Nordeste é menor do que no Sul e Sudeste", diz o pesquisador Pedro Camarinha, especialista em mudanças climáticas e desastres do Cemaden, outro autor do estudo. "Para essas duas regiões, geralmente cinco dos seis modelos climáticos que usamos no estudo apontam

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Desde a Revolução Industrial, em razão do acúmulo dos chamados gases de efeito estufa, como o dióxido de carbono e o metano, o planeta se tornou, em média, 1,1 °C mais quente. As previsões mais recentes feitas no âmbito de trabalhos que vão embasar o próximo relatório do Painel Intergovernamental sobre Mudanças Climáticas (IPCC), que deve ser lançado no segundo semestre de 2021, apontam que o marco de 1,5 °C deve ser atingido em no máximo duas décadas. "Mesmo que agora reduzíssemos a zero todas as emissões de gases de efeito, provavelmente iríamos ultrapassar esse limite nos próximos anos", diz Marengo. "Precisamos adaptar nossas cidades a essa nova realidade."

Projeto
INCT 2014: INCT para Mudanças Climáticas (INCT-MC) (nº 14/50848-9); **Modalidade** Projeto Temático; **Programa** Pesquisa sobre Mudanças Climáticas Globais; **Acordo** CNPq-INCTs; **Pesquisador responsável** José Antonio Marengo (Cemaden); **Investimento** R$ 4.212.831,77.

Artigo científico
MARENGO, J. A. *et al.* Extreme rainfall and hydro-geo-meteorological disaster risk in 1.5, 2.0, and 4.0 °C global warming scenarios: An analysis for Brazil. **Frontiers in Climate**. 3 mar. 2021.

AQUECIMENTO GLOBAL

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Matérias relacionadas

PESP 2 ANOS

Agência FAPESP NOTÍCIAS AGENDA VÍDEOS ASSINE

Secas na América do Sul podem aumentar até o fim do século, sugere estudo

12 de julho de 2021

Se as emissões de gases de efeito estufa continuarem no patamar atual, temperatura média tende a subir até 4 °C em algumas regiões. Nesse cenário, os extremos climáticos se tornarão mais intensos e frequentes, indicam projeções feitas com os novos modelos climáticos do IPCC (*foto: Fernando Frazão/Agência Brasil*)

Elton Alisson | Agência FAPESP – Se as emissões de gases de efeito estufa (GEE) continuarem no patamar atual, a temperatura média na América do Sul pode subir até 4 °C até o fim do século, em um cenário mais pessimista, tornando os eventos climáticos extremos – como secas, inundações e incêndios florestais – mais frequentes e intensos na região.

As projeções foram feitas no âmbito de um estudo internacional, com a participação de pesquisadores brasileiros.

Os resultados do trabalho, apoiado pela FAPESP por meio de um Projeto Temático ligado ao Instituto Nacional de Ciência e Tecnologia para Mudanças Climáticas, foram publicados na revista *Earth Systems and Environment*.

"A América do Sul e, em particular, o Brasil já mostram sinais das mudanças climáticas, incluindo o aumento das temperaturas da superfície, mudanças nos padrões de precipitação, derretimento das geleiras andinas e elevação no número e intensidade de extremos climáticos. Essas variações nas características climáticas são precursoras do que pode estar por vir nas próximas [illegible]entes nas emissões de gases de efeito estufa continuar", diz à **Agência FAPESP** Lincoln Muniz

https://agencia.fapesp.br/agencia-novo/imagens/noticia/38305.jpg

Agência FAPESP NOTÍCIAS AGENDA VÍDEOS ASSINE

"Isso tem impactos nos setores agrícola e de geração de energia, por exemplo, que fazem seus planejamentos com base nos volumes de chuvas", diz.

Diminuição das incertezas

De acordo com o pesquisador, a nova geração de modelos climáticos permite estimar os impactos da mudança do clima com maior acurácia na América do Sul por considerar mais elementos do sistema climático.

O clima no continente varia amplamente de Norte a Sul e de Oeste a Leste, devido à grande extensão latitudinal e à heterogeneidade topográfica do continente, o que torna sua representação um desafio para os modelos climáticos.

"Com essa nova geração de modelos climáticos foi possível quantificar as incertezas nas projeções de determinadas regiões do continente", afirma Alves.

O artigo *Assessment of CMIP6 performance and projected temperature and precipitation changes over South America* (DOI: 10.1007/s41748-021-00233-6), de Mansour Almazroui, Moetasim Ashfaq, M. Nazrul Islam, Irfan Ur Rashid, Shahzad Kamil, Muhammad Adnan Abid, Enda O'Brien, Muhammad Ismail, Michelle Simões Reboita, Anna A. Sörensson, Paola A. Arias, Lincoln Muniz Alves, Michael K. Tippett, Sajjad Saeed, Rein Haarsma, Francisco J. Doblas-Reyes, Fahad Saeed, Fred Kucharski, Imran Nadeem, Yamina Silva-Vidal, Juan A. Rivera, Muhammad Azhar Ehsan, Daniel Martínez-Castro, Ángel G. Muñoz, Md. Arfan Ali, Erika Coppola e Mouhamadou Bamba Sylla, pode ser lido na revista *Earth Systems and Environment* em **https://link.springer.com/article/10.1007/s41748-021-00233-6#citeas**.

Transdisciplinar Meeting

INCT Mudanças Climáticas Fase 2

Reunião – Força Tarefa para publicação de artigo integrando várias components.
Data: 01/04 – 10hs
Local: Reunião virtual em Plataforma ZOOM e, num segundo momento, Google MEET.

Participantes:

- Arcilan Assireu
- Chou Sin Chan
- Eduardo Amaral Hadad
- Eduardo Mario Mediondo
- Enio Bueno Pereira
- Fernando Ramos Martins
- Paulo Nobre
- Roberto Schaeffer
- Rodrigo Santos Costa

Artigo:

1. Reunião teve início com Enio abordando o foco de trabalho para a formação do grupo presente na reunião – Elaboração de um artigo conceitual que integre as atividades de algumas das components do INCT Mudanças Climáticas;
2. Após apresentação de uma proposta inicial por Enio, foi realizado uma chuva de ideias pelos participantes que resultou na seguinte proposta de elaboração de um artigo que investigue como as Mudanças Climáticas afetarão os cenários de disponibilidade energética necessários para o país alcançar uma condição macroeconômica compatível com o planeta num patamar de temperatura com 1.5˚C, 2˚C, ou "net zero".
3. Para tal, a seguinte agenda de atividades foi delineada:
    a. Hadad: elabora cenários macroeconômicos para um Brasil compatível com um mundo 1.5˚C, 2˚C, ou "net zero" em algum momento (por exemplo 2050 ou 2060);
    b. Schaeffer: elabora a modelagem estabelecendo tipo de setor energético e de uso do solo seria compatível com os cenários fornecidos por Hadad, mas sem considerar os aspectos relativos aos impactos de cenários climáticos
    c. Paulo e Chou: diria qual seria o choque climático para estes cenários para diferentes regiões do Brasil;
    d. LabREN, UNIFESP, e UNIFEI: convertem os cenários combinados em em disponibilidade para solar, eólico, hídrico;
    e. Colegas envolvidos poderiam também converter em agricultura (disponibilidade de biomassa)
    f. Schaeffer: realimenta modelo COPPE com os recursos energéticos indicados nas etapas anteriores;
    g. Hadad: reavalia cenários macroeconômicos em conformidade com cenários energéticos produzidos;
    h. Schaeffer : realimenta modelo COPPE para gerar resultados finais;
    i. Todos: elaboração do artigo

Reunião do Grupo de Trabalho INCT Saúde - MG	
Data: 02 de fevereiro de 2021	**Horário:** 15:00 (zoom)
Participantes: Ulisses, Marcelo, Júlia e Rhavena	
Assunto: Andamento do projeto "Analisando a epidemia de Sars-cov 2 sob uma perspectiva socioclimática"	
Objetivo: Discutir aspectos relacionados e escala e variáveis utilizadas no estudo	
Principais pontos abordados: • Iniciou-se a reunião com a discussão sobre qual a melhor escala a ser adotada na pesquisa. Considerou-se as regiões de planejamento de saúde, porém, sua adoção foi questionada já que a	

mesma não retrata as diferenças climáticas existentes no território mineiro. O professor Ulisses sugeriu análises iniciais em todo território e ajustes sequentes para uma área menor, caso necessário. O Marcelo considerou que seria interessante a divisão do estado em três grandes regiões (norte, central e sul), devido suas diferenças climáticas.

- A discussão seguiu com a colocação do Marcelo sobre sua experiência na submissão de um artigo que abordava apenas variáveis meteorológicas e Covid 19, o que ratificou a importância da ideia inicial de realizar análises que abordem também variáveis socioeconômicas e de saúde.
- Abordou-se ainda a importância da mobilidade das pessoas na propagação da COVID e as dificuldades existentes em se mensurar essa movimentação, principalmente quando relacionadas a visitas domiciliares de familiares e amigos. Até o presente momento a variável a ser trabalhada com essa perspectiva é a REGIC.
- A utilização da variável da concentração de ozônio como proxy da radiação UV também foi discutida. Segundo o Marcelo os valores são estimativas que podem não sofrer grandes variações entre as regiões do estado. A utilização desta variável como proxy para síntese de vitamina D foi associada a grandes incertezas relacionadas ao período de síntese da vitamina após a exposição ao sol e a fatores biológicos, impedimentos relevantes para a análise da variável UV como proxy da vitamina D. Análises da radiação UV relacionadas ao tempo de permanência do vírus no ambiente foram consideradas.
- A possibilidade de disponibilizar os dados de UV para todo o estado e também para os municípios do estudo de caso foi discutida, assim como o período de análise de dados, a necessidade de se coletar dados de um ano completo para avaliar características de sazonalidade e a definição a posteriori de qual o período integrará a pesquisa.
- A discussão seguiu com a colocação da necessidade de interpolação dos dados para que dados de saúde e meteorológicos estivessem na mesma escala (microrregiões de saúde). Definiu-se que Marcelo e Ivana iriam pesquisar a melhor forma de fazer a interpolação.
- Agendar a próxima reunião
- Dar continuidade a solicitação da bolsa para Isabela (responsável: Rhavena)
- Consultar o Dr. Marengo sobre o cronograma de dispêndios para o ano de 2021 (responsável: Professor Ulisses)
- Abordou-se a necessidade de dados para as capitais dos estados a fim de originar um estudo de casos que abordará as capitais do país.
- Pactuou-se criar uma pasta no google drive para alocação dos dados

Encaminhamentos:

- Agendar a próxima reunião para acompanhamento da coleta de dados dentro de um mês (Responsável: Rhavena)
- Dar continuidade a coleta de dados de saúde (Responsável: Isabela)
- Definir o método de interpolação de dados (Responsável: Ivana e Marcelo)
- Dar início a interpolação dos dados (Responsável: Ivana)
- Consultar a Secretaria Estadual de Saúde sobre as notificações negativas que constam no banco de dados sobre Covid e o que elas significam (Responsável: Isabela)
- Coletar dados sobre as capitais dos estados (Responsável: Isabela e Ivana)
- Criar uma pasta no google drive para alocação dos dados (Responsável: Marcelo)

Reunião do Grupo de Trabalho INCT Saúde - MG

Data: 18 de maio de 2021 **Horário:** 14:00 (zoom)

Participantes: Ulisses, Marcelo, Rhavena, Ivana e Isabela

Assunto: Andamento do projeto "Analisando a epidemia de Sars-cov-2 sob uma perspectiva sociocimática"

Objetivo: Discutir aspectos relacionados à escala e variáveis utilizadas no estudo

Principais pontos abordados:

- Iniciou-se a reunião com a apresentação dos histogramas confeccionados pela Ivana sobre a disponibilidade e qualidade dos dados meteorológicos.
- A Isabela apresentou os dados da saúde coletados até a data e colocou a limitação da qualidade do dado.
- Discutiu-se os dados negativos de Covid notificados e seu significado para a pesquisa.

Encaminhamentos:

- Agendar a próxima reunião.
- Dar continuidade a solicitação da bolsa para Isabela (responsável: Rhavena)
- Consultar o Dr. Marengo sobre o cronograma de dispêndios para o ano de 2021 (responsável: Professor Ulisses)


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17. Coordenadores de INCTs se reúnem para avaliar situação do programa no País
Cerca de 50 coordenaoras de Institutos Nacionais de Ciência e Tecnologia se reuniram remotamente no dia 7 de agosto. Entre os problemas levantados, estão insuficiência de recursos e cortes de bolsas para pós-doutores e de estágios sanduíche
Na tarde de 07 de agosto reuniram-se remotamente cerca de 50 coordenadores de Institutos Nacionais de Ciência e Tecnologia (INCTs), para realizarem uma avaliação da situação deste importante programa de apoio e fomento à pesquisa científica em todas as áreas do conhecimento coordenado pelo Conselho Nacional de Ciência e Tecnologia (CNPq) do Ministério de Ciência Tecnologia e Inovações (MCTI).
O professor Jailson de Andrade coordenou as discussões que tangenciaram diversas questões cruciais ao desempenho e cumprimento de metas dos INCTs, entre recursos de agências de fomento federais e estaduais, neste caso especificamente as Fundações de amparos à Pesquisa dos Estados. A insuficiência dos recursos federais alocados pelo CNPq, que tem uma dívida de aproximadamente 30% dos valores aprovados para os INCTs, ainda não honrada, foi uma das vertentes debatidas. Não distante desta situação de carência a contribuição das FAPs, parceiras no
Sociedade Brasileira para o Progresso da Ciência
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1. CNPq responde carta da SBPC sobre item incluído na Chamada 25/2020
2. Sócio da SBPC: Fique em dia com a Sociedade
3. Brasil tem mais de 2 milhões de curados de covid-19: o que o número indica na luta contra a pandemia do coronavírus
4. Não há motivo para alívio nos números brasileiros de coronavírus, diz OMS
5. Em São Paulo, 22% dos moradores dos bairros mais pobres já pegaram coronavírus

Pauta apresentada ao CNPq
Memória da Reunião Coordenadores dos INCTs e Presidente do CNPq:
10 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.