BOOK OF ABSTRACTS

August 19-24, 2019

Instituto de Física Teórica – UNESP

São Paulo, Brazil

ORGANIZERS

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NOTE:

The order of the abstracts follows the order of the program, shown below, starting with the oral presentations (lectures and short talks each day) and ending with the poster presentations. A summary of the topics discussed during the sessions and of needs for future work is presented at the end.

Advanced School and Workshop on American Monsoons
Program

19/08 Monday	Introduction and main features of SAMS and NAMS	
09:00-09:20	Alice Grimm	Welcome and Introduction to American monsoons
09:20-10:10	Wenju Cai	ENSO under greenhouse warming
10:10-11:00	Manoel Gan	Main features and life cycle –SAMS - Observations
11:00-11:20		Coffee break
11:20-12:10	Iracema F.A.Cavalcanti	Main features and life cycle –SAMS - model results
12:10-13:00	Francina Dominguez	Main features of the North American monsoon
13:00-14:30		Lunch
14:30-15:40	Oral session	Short talks – 4 presentations of 20 minutes
15:40-16:00	Discussions	Summary and needs for future work
16:00-17:30	Poster Session+ Coffee break	

20/08 Tuesday	Variability on diurnal, mesoscale and synoptic time scales; subseasonal to seasonal variability	
09:00-09:50	Rong Fu	Connections between South and North American monsoons
09:50-10:40	Maria Assunção Silva Dias	Diurnal and local variability of the South American monsoon with possible effects of aerosol
10:40-11:00		Coffee break
11:00-11:50	Alice Grimm	Subseasonal variability of the South American monsoon
11:50-12:40	Marcelo Barreiro	Regional and remote controls of the South Atlantic Convergence Zone
12:40-14:10		Lunch
14:10-15:30	Oral session	Short talks – 4 presentations of 20 minutes
15:30-16:00	Discussions	Summary and needs for future work
16:00-17:30	Poster Session+ Coffee break	

21/08 Wednesday	Variability on interannual and decadal/interdecadal time scales; modulation of extreme events by climate variability; longer term variability and climate change	
09:00-09:50	Alice Grimm	Variability of the South American monsoon on interannual and decadal/ interdecadal time scales
09:50-10:40	Mary Kayano	Pacific and Atlantic multidecadal oscillations: relations to the ENSO and effects on the South American rainfall
10:40-11:00		Coffee break
11:00-12:20	Oral session	Short talks – 4 presentations of 20 minutes
12:20-13:50		Lunch
13:50-15:20	Poster Session+ Coffee break	
15:20-16:10	Pedro Silva Dias	Paleoclimatic aspects of the South American monsoon
16:10-17:00	Leila Carvalho	Present and future of the South American monsoon in a warming climate
17:00-17:30	Discussions	Summary and needs for future work

22/08 Thursday	Predictability and prediction (weather, sub-seasonal, seasonal and longer lead times); modelling studies	
9:00-9:50	Tereza Cavazos	Intercomparison of observed and simulated climatic trends in the North American monsoon
9:50- 10:40	Caio Coelho	Design and assessment of a Brazilian global sub-seasonal prediction system
10:40-11:00		Coffee break
11:00-11:50	Alice Grimm	Sub-seasonal prediction of South American summer monsoon active and break phases
11:50-12:20	Discussions	Discussions on the needs of modeling studies
12:20-12:40	Discussions	Interaction/feedbacks between students and lecturers
12:40-14:10		Lunch
14:10-15:30	Oral session	Short talks – 4 presentations of 20 minutes
15:30-16:00	Discussions	Summary and needs for future work
16:00-17:30	Poster Session+ Coffee break	

23/08 Friday	Impacts on society; future challenges; plans for observational studies, diagnostic analyses, and modelling activities.	
9:00-9:50	Christopher Cunningham	Climate and weather extremes during the South American monsoon season within the context of

		disaster risk reduction – The CEMADEN Experience
9:50- 10:40	Cecilia Hidalgo	Collaborative processes in action: climate services and impact-based forecasts for southern South America
10:40-11:00		Coffee break
11:00-11:50	Leila Carvalho	Statistical methods to analyze climate variability in the South America monsoon region
11:50-12:10	Discussions	Interaction with students and main “take home” messages
12:10-12:40	Discussions	Summary and needs for future work
12:40-14:10		Lunch
14:10-15:00	Poster Session+ Coffee break	
15:00-16:00		Closing session: Summary of the status of knowledge, future challenges and collaborative studies

24/08 Saturday	Discussions on future collaboration.
9:00-11:00	Meeting of the Working Group on American Monsoons

Short Talks (Oral Sessions):

19/08 Monday

1. Elisa Thomé Sena (Brazil, PhD): Shortening of the Amazon's rainy season detected using satellite cloudiness observations

2. Michelle Simões Reboita (Brazil, PhD): South American Monsoon System Lifecycle Simulated by RegCM4.7

3. Tessa Montini (USA, PhD student): Objective categorization of SALLJ events by a Principal Components Analysis of synoptic-scale conditions

4. Charles Jones (USA, PhD): Recent changes in the South America low-level jet

20/08 Tuesday

1. Johanna Yepes (Colombia, PhD Student): The diurnal cycle of precipitation and gravity waves over the rainiest place on Earth

2. Tania Katherine Ita Vargas (Peru, USA, MSc Student): Synoptic Patterns Associated with Wet Season Onset in the Tropical High Andes of Southern Peru and Bolivia

3. Yoel Alejandro (Mexico, PhD Student): Synoptic climatology and large-scale circulation patterns over Mexico

4. Paris Rivera (Guatemala, PhD Student): Influence of the MJO on the southern region of Guatemala

21/08 Wednesday

1. Luis Blacutt (Bolivia, PhD): Precipitation variability on the Mamoré Basin

2. Miguel Lovino (Argentina, PhD): Variability and changes of daily extremes over northeastern Argentina

3. Marcia Terezinha Zilli (Brazil, PhD): Attribution Analysis of Southwestward Shift of the South Atlantic Convergence Zone-related precipitation during the last decades

22/08 Thursday

1. Isabel Cristina Hoyos Rincón (Colombia, PhD): Interchange of atmospheric moisture among South America catchment basins

2. Armenia Franco-Diaz (Great Britain, PhD Student): The contribution of tropical cyclones to the atmospheric branch of Middle America's hydrological cycle

3. José Pablo Vega-Camarena (Mexico, PhD): Contrasting rainfall behavior between the Pacific coast and the Mexican Altiplano

4. Victor Manuel Torres Puente (Mexico, USA, PhD Student): The relationship between Easterly Waves over the Eastern Pacific and the Monsoon of North America

Posters:

19/08 Monday and 20/08 Tuesday

01. Renan Martins Pizzochero (Brazil, MSc Student): The Southern Annular Mode influence on South America Monsoon System

02. Luciana Figueiredo Prado (Brazil, PhD): Central Brazil precipitation variability during the last eight decades

03. Marilia de Carvalho Campos (Brazil, PhD Student): New insights about South American hydroclimate changes during Heinrich stadials

04. Marta Pereira Llopart (Brazil, PhD): Multimodel climate projections over South America CORDEX domain

05. Kenedy Cipriano Silverio (Mozambique, PhD student): The importance of South America monsoon system on Southern Africa monsoon rainfall variability

06. Nicole Cristine Laureanti (Brazil, MSc student): The influence of different scales of global SST variability modes on precipitation characteristics during the South American monsoon season

07. Laís Gonçalves Fernandes (Brazil, PhD student): MJO impacts on South American precipitation and extreme events in El Niño years

08. Naurinete Barreto (Brazil, PhD): The South American Monsoon System and the Madden Julian Oscillation

09. André Luiz Leturiondo Segundo (Brazil, Undergraduate student): Case Study of Extreme Precipitation Event in Manaus Associated with the Monsoon Regime and its Predictability

10. Mariah Sousa Gomes (Brazil, PhD student): Droughts in the South American Monsoon region

11. Cristian José Febre Pérez (Peru, Meteorologist): Cause of severe droughts in southern Peru (1961 – 2016)

12. Marilia Harumi Shimizu: (Brazil, PhD): Seasonal changes of the South American monsoon system during the Mid-Holocene in the CMIP5 simulations

13. Fernanda Cerqueira Vasconcellos (Brazil, PhD): Atmospheric variability related to extreme summer precipitation over Rio de Janeiro State

21/08 Wednesday and 22/08 Thursday

01. Isabel Ramos Parado (Peru, Meteorologist): Rainfall in the Peruvian Amazon_Andes associated with the South American monsoon

02. Fabio Pinto da Rocha (Brazil, Meteorologist): Identification of Moisture Convergence Zone (MCZ) in a select cases during the South America Moonson System (SAMS)

03. Vivian Bauce Machado Arsego (Brazil, PhD student): Preliminary evaluation of the seasonal forecasts of the Brazilian global atmospheric model during the rainy season of the South American Monsoon System

04. Eugenia Maria Garbarini (Argentina, PhD student): Connection between sea surface temperature and low-level geopotential height patterns in the South Atlantic Ocean

05. Alan García Rosales (Peru, MSc Student): Spatio-temporal variability of WRF precipitation associated with the regional and local circulation in the Tropical Andes (Rio Santa Basin, Peru)

06. Santiago Ignacio Hurtado (Argentina, PhD student): Precipitation variability over subtropical Argentina linked to SALLJ changes

07. Luana Aparecida Scheibe (Brazil, Undergraduate student): Subseasonal prediction of active and break episodes of South American monsoon

08. Thales Alves Teodoro (Brazil, MSc Student): Validation of the turbulent flows of latent and sensitive heat in the simulation of REGCM4.7

09. Renata Novaes Calado: (Brazil, PhD student): SACZ associated with extreme Rainfall in the Southeast Brazil: Synoptic Analyses and ensemble forecast evaluation

10. Jaci Maria Bilhalva Saraiva (Brazil, Meteorologist): The monsoon regime in several regions of the Brazilian Western Amazon

11. Furqon Alfahmi (Indonesia, PhD): The Impact of Concave Coastline on Increasing Rainfall Offshore Over Indonesian Maritime Continent

12. Douglas da Silva Lindemann (Brazil, PhD): Atlantic Multidecadal Oscillation (AMO) relations with the South Atlantic Convergence Zone (SACZ): past variations and future projections

13. Juan Neres de Souza (Undergraduate student): Evaluation of the Sea Surface Temperature anomalies in the Subtropical South Atlantic Ocean region

Introduction to the American Monsoons

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ABSTRACT

The Advanced School and Workshop on American Monsoons was planned to bring together scientists and students for presenting and discussing the progress in research on the American monsoons and their role in the global monsoon system, and for planning future activities. The American monsoons are important components of the global monsoon system.

The program covers the following topics:

- Introduction and main features of South America and North America monsoons systems;

- Variability on diurnal, mesoscale and synoptic time scales; subseasonal to seasonal variability;

- Variability on interannual and decadal/interdecadal time scales; modulation of extreme events by climate variability; longer term variability and climate change;

- Predictability and prediction (weather, sub-seasonal, seasonal and longer lead times); modelling studies;

- Impacts on society; future challenges; plans for observational studies, diagnostic analyses, and modelling activities.

The Advanced School and Workshop is part of the activities of the American Monsoons Working Group, which has been formed under the coordination of the CLIVAR/GEWEX Monsoons Panel.

As an introduction to the American monsoons, the classical as well as the more recent criteria used to define a monsoon regime are presented. The fundamental monsoon characteristics, such as their basic definition and geographic range, have undergone some changes. The modern definition of monsoon climate is based on both the annual reversal of surface winds and the contrast between rainy summer and dry winter seasons, in contrast to the classical definition of monsoon regime since the early 20th century, which was based solely on the annual reversal of surface winds. The classical definition does not classify any American region as having monsoonal climate. However, the most modern criteria delineate two such regions, one very extensive over South America, and another smaller region in southwest North America.

The modern definition is motivated in part by the considerable socio-economic and scientific importance of monsoon rainfall, and thus delineating monsoon domains based on precipitation is essential and beneficial. These domains extend across both the eastern and western hemispheres and include the North and South American, and southern African monsoons.

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ICTP South American Institute for Fundamental Research (ICTP-SAIFR);

Instituto de Física Teórica (IFT-UNESP).

Response of El Niño/La Niña to greenhouse warming

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ABSTRACT

The El Niño-Southern Oscillation (ENSO) is the dominant and most consequential climate phenomenon with global impacts. The response of ENSO sea surface temperature (SST) variability to greenhouse warming is one of the most important issues in climate change science, and has challenged scientists for decades. I will present recent findings showing that the frequency of extreme La Niña, and variability of eastern Pacific El Niño SST are expected to increase in response to unabated greenhouse gas emissions. With this projected increase, we should expect more occurrences of extreme weathers associated with ENSO events, with pronounced implications for the twenty-first century climate, extreme weather, and ecosystems.

Main features and life cycle of South American Monsoons

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ABSTRACT

A monsoon system is generally characterized by the wind reversal in the lower troposphere, but this is not observed in Sooth American monsoon due to the narrowness of the continent in extratropical latitudes. However the zonal wind changes its direction from easterly to westerly during the onset of rainy season, although the meridional wind only changes its intensity. In this study, main features and life cycle will be presented such as: before the monsoon onset, the atmosphere starts destabilizing through surface sensible heat flux and moisture transport from the Amazon. Intensified ascending motion transports moisture upwards and induces a higher level heat source through latent heat release. The low level northwesterly flow transports heat and moisture from the Amazon region to Central Brazil, contributing to the monsoon onset over this region in October/November, and the formation of the South Atlantic Convergence Zone. Soil moistening increases the latent heat flow, convective cells develop and the rainy season starts over that region. Sensible heat flux is reduced and latent heat flux is increased. At upper levels, the Bolivian High develops southwest of the maximum precipitation, due to latent heat release. This latent heat source also enhances the low pressure system to the north of the thermally induced Chaco Low. During the demise in early autumn, the low-level pressure over the continent increases, the low-level zonal winds return to easterlies, and the moisture flux from the Amazon region to Southeast Brazil is reduced.

Main features and lifecycle of the South America Monsoon System: Model Results

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ABSTRACT

The South America Monsoon System (SAMS) is the main driver of the rainy season in large areas of South America. Its variability affects several regions where droughts or floods have impacts in sectors like agriculture, hydropower and the economy. Therefore, prediction of SAMS lifecycle using climate models is a highly important task. To increase the confidence in model predictions, it is necessary to verify, first, how is the model climate variability behavior. A climate model contains a set of programs that uses equations related to the dynamics, physics and chemistry in the atmosphere and ocean to represent the real climate. Dynamical processes are related to wind, pressure and temperature. Physical processes are related to radiation, convection, surface processes. Chemistry processes represent the reactions in the atmosphere and oceans. A climate model needs to represent the interactions between atmosphere and ocean, atmosphere and land and all the processes that are part of a complex system. The monsoon features are shown in three models: The CPTEC/INPE atmospheric global model, which has prescribed monthly observed SST, HadGEM2-ES, which is an earth/ system model, CMIP5 models and Eta regional model, with lateral boundary conditions from HadGEM2-ES. The American monsoon regions are obtained using the criterion that the precipitation difference between DJF and JJA is >=2.5 mm/day. It is seen that all models represent well the regions, compared to GPCP observational precipitation data, unless for the southern areas. Eta regional model doesn't show the regions of Paraguay and central-norther Argentina as in the observations. CPTEC/INPE AGCM and HadGEM2-ES miss central Argentina. The annual cycle of precipitation in the SAMS core (southern Amazonia) is well represented by five of CMIP5 models. The main characteristics of the SAMS are well reproduced by the CPTEC/INPE AGCM, HadGEM2-ES and the regional ETA HadGEM2-ES, like the differences of precipitation from summer to winter, the changes in circulation at low and high levels and the changes in humidity flux over the continent. All models represent the main mode of precipitation variability in the summer, obtained from EOF1, similar to the observations, showing the South Atlantic Convergence Zone (SACZ) and opposite sign to the south and to northwest. The lifecycle of SAMS was obtained using a criterion based on vertical integrated zonal moisture flux in the monsoon core

to calculate an index. This is the area where the zonal wind changes from easterlies to westerlies during the onset. The onset and demise are identified when the normalized index changes sign. Both Global Model and Regional model show the same features during the onset and demise. The onset is characterized by a reduction of SLP over the continent and increase of humidity flux from NW to SE. During demise, there is SLP increase over the continent and a reduction of humidity flux southwards. Future researches include the relation of humidity flux in the SAMS core and precipitation in SE Brazil and the role of land processes- soil moisture, fluxes and evapotranspiration.

Main Features of the North American Monsoon

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ABSTRACT

The North American monsoon (NAM) characterizes the boreal summer climate of the Southwestern (SW) United States (US) and Northwestern (NW) Mexico. The NAM provides between 40% and 80% of the total precipitation that falls within this region, and is critically important for the ecological and socioeconomic well-being of the region. This talk presents a broad overview of the NAM, based on a review of the literature written in the past decades. The talk begins with a discussion about NAM climatological characteristics, then covering its spatio-temporal variability from the diurnal scale to interannual variability. The third part of the talk discusses long-term changes associated with climate change, based on the observed changes in monsoonal climate, and then the projections based on global climate models. The talk ends by discussing some of the outstanding questions regarding monsoon research, particularly regarding climate change, and critical directions that we need to take to answer some of these questions.

Shortening of the Amazon's rainy season detected using satellite cloudiness observations

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ABSTRACT

The Amazon rainforest is crucial in regulating the global climate system, recycling water vapor from the Atlantic Ocean, and transporting heat and moisture from the tropics to the subtropics. During the last decades, this region has been experiencing massive deforestation and biomass burning. Recently, two severe droughts occurred within a period of only 5 years, evidencing pronounced alterations in the Amazonian rainfall regime. We propose a new methodology to evaluate the onset and length of the Brazilian Amazon rainy season during the last decades using cloudiness observations from geostationary satellites. The advantage of this method is that it does not rely on rain-gauges (which are very sparse in the region). Trend analyses show that cloudiness has consistently reduced regardless of the time of the day or location, with more prominent trends of up to -6% per decade in the morning over the central and eastern Amazon. Previous studies that reported trends on wet and dry season lengths have focused on the southwestern Amazon, a region that has been severely deforested since the 1970s. However our study shows that the shortening rainy season is more significant over less-deforested areas, such as northern and central Amazon, where a reduction of up to 4 days per year in the wet season length is observed. This result suggests that large-scale influences on rainfall regimes in the Amazon are likely more relevant than local influences, such as the rate of deforestation. Our study examined the physical mechanisms that potentially trigger modifications in the variability of the seasonal cycle of convection. The results indicate that the El Niño/Southern Oscillation is related to delayed onsets and earlier demises of the wet season. The North Atlantic Tripole and larger areas of the Pacific Warm Pool are associated with delayed onsets over the western and northern Amazon, respectively. Positive sea surface temperature anomalies in the Tropical South Atlantic are linked to delayed demises over the western and central Amazon. The critical changes in cloud life cycle evidenced in this study potentially impact South America's hydrological cycle and climate, with important implications for the ecosystem and agriculture.

South American Monsoon System Lifecycle Simulated by RegCM4.7

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ABSTRACT

The performance of the Regional Climate Model version 4.7 (RegCM4.7) in simulating the South American Monsoon System (SAM) lifecycle is evaluated. RegCM4.7 with 25 km of grid spacing was nested in ERA-Interim reanalysis for the period 1979-2014. The Common Land Model 4.5 (CLM4.5) and the combination of two cumulus convective parameterization schemes, Tiedtke over the land and Kain-Fritsch over the ocean, were used in the simulation. SAM lifecycle was defined with a similar methodology from Liebman and Marengo published in 2001, which is based on the accumulated precipitation. For the period 2005-2014, the SAM was identified in the simulated and observed (from the Climate Prediction Center – CPC) precipitation. From southern Amazonia to southeastern Brazil, the SAM onset in CPC is registered between 57 and 59 pentads, while the model delays it to 60-pentad. On the other hand, the SAM demise occurs before in RegCM4.7 than in CPC, which led to a slightly shorter SAM duration in the model. Even though simulating a shorter SAM lifecycle, RegCM4.7 is able to reproduce the observed spatial pattern of SAM.

Objective categorization of SALLJ events by a Principal Components Analysis of synoptic-scale conditions

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ABSTRACT

Subtropical South America is a favorable region for the development of large, long-lived mesoscale convective systems that often bring substantial rainfall and severe weather over densely-populated areas. It is well-known that the South American Low-Level Jet (SALLJ) plays an important role in sustaining deep convection and precipitation in this region; however, the sensitivity of cyclogenesis to the spatial variability of the jet is less understood. This study presents an objective classification of atmospheric patterns related to SALLJ events in order to better understand dynamical linkages between synoptic-scale processes, the SALLJ, and mesoscale convective systems. A Principal Components Analysis is performed on circulation and moisture fields associated with warm-season SALLJ days during 1979-2016 identified by Montini et al. (2019). A clustering algorithm is applied in the subspace of the leading principal components to group SALLJ days by similar synoptic structures. Cluster-based composites are used to characterize the large-scale circulation, the location of convective development, and the intensity of precipitation associated with each type of SALLJ event.

Recent changes in the South America low-level jet

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ABSTRACT

The South America Low-level Jet (SALLJ) is a climatological feature with a critical role in the spatiotemporal distribution of precipitation in South America. While previous studies have focused on the mechanisms and variability of the SALLJ in the central Andes, the variability of the low-level jet in the Northern Andes has been much less explored. This study shows that the frequency of the SALLJ in the northern Andes is as high as in the central Andes, and the low-level jet can occur simultaneously or separately in both regions. When the SALLJ is active exclusively in the northern Andes, precipitation over the La Plata basin is reduced dramatically, whereas precipitation increases significantly over the Amazon, southeast Brazil and, especially, over the central Andes. Cold sea surface temperatures and suppressed convection in the tropical eastern Pacific enhances the North Atlantic subtropical high-pressure system and induces the formation of the SALLJ winds over the northern Andes. Further analysis shows that the frequency and intensity of the SALLJ in the northern Andes has substantially increased in the last 39 years, while the low-level jet in the central Andes has diminished. It is proposed here that changes in the low-level jet in South America are forced by the decadal cooling trend in the tropical eastern Pacific discussed in other studies.

Connection between the North and South American Monsoons

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ABSTRACT

Whether North and South American monsoons are connected is among one of the least understood questions in the research of American monsoons. In general, the importance of the cross-equatorial atmospheric dynamic processes in determining global teleconnections has been recognized for decades. However, most of the previous studies on this topic have focused on Rossby wave propagation through the "westerly duct" over the eastern equatorial Pacific during boreal winter. In contrast, far less attention has been given to the cross-equatorial teleconnection over the American-Atlantic sector. This presentation shows evidence in recent literature and from our ongoing research that suggest that the cross-equatorial influences of South America on the tropical and North Atlantic occur in all seasons and involve four different dynamic mechanisms, not just Rossby wave propagation in boreal winter over the eastern Pacific. The results suggest the follow three cross-equatorial teleconnection mechanisms that can potentially enable South American monsoon and weather and climate variability to influence weather and climate variability of the North Atlantic-American sector.

- *Northward cross-equatorial propagation of the Rossby waves generated by diabatic heating over the South American Monsoon can influence the North Atlantic Oscillation during boreal winter*.
- *Convective coupled Kelvin waves from Amazonia propagating eastward influence tropical Atlantic surface winds and sea-level height anomalies, and western Congo rainfall variability, especially during boreal spring. Such Convective coupled Kelvin waves from Amazonia enable or amplify the influences of extratropical South American and eastern Pacific disturbances on climate variability over the equatorial Atlantic-western Congo sector.*
- *Through a shallow cross-equatorial circulation, cold front incursions from the extratropical South America can significantly influence weather and climate variability of the tropical and subtropical North Atlantic during boreal summer. Such a cross-equatorial influence would depend on the southern hemispheric subtropical jets, thermodynamic instability and surface dryness over Amazonia.*

- These cross-equatorial teleconnection mechanisms are also central for a comprehensive characterization of the potential influences of rapidly changing Amazonian rainforests on global atmospheric circulation and climate.

Diurnal and local variability of the South American Monsoon with possible effects of aerosol

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ABSTRACT

This presentation covers aspects of diurnal variability of rainfall, Mesoscale Convective Systems, MCS and Mesoscale Cyclonic Vortices - MCV, and of aerosol effects on rainfall. The context is associated to the South American Monsoon System (SAMS), mainly focusing on the South Atlantic Convergence Zone (SACZ). Using data from the LBA experiments and from a network of weather radars operated by SIPAM, it is shown that the diurnal variability is a function of wind regimes, season and of geographical location. Several authors explore the features of more convective rainfall associated with easterly regimes in the southern part of the Amazon. In the Northern part there are indications that the northerly and southerly wind regimes associated mostly with the trade wind evolution are associated to more stratiform and more convective rainfall, respectively. MCS occur over the whole region of SAMS, equatorial, tropical and subtropical. Some of these MCS are of the more organized type, the Mesoscale Convective Complexes. These are observed mainly in the transitions seasons and summer. Some of the MCS are seen embedded in the SACZ eventually evolving into MCV which have a signature in the wind field, and present high rainfall rates. The MCV are detected in the lower troposphere. The evolution of MCS in the SAMS is affected by aerosol from biomass burning and from the large urban areas. This is most frequently observed by the end of the dry season and beginning of the wet season. Result from high resolution cloud modeling work indicates that the aerosol changes the cloud condensation nuclei size distribution and potentially impacts the depth of the raincloud, the strength of the updraft and downdraft as well as its lifetime.

Subseasonal variability of the South American monsoon

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ABSTRACT

Extreme precipitation/drought events in South America (SA) monsoon season are usually associated with extreme phases of intraseasonal oscillations (ISO) or subseasonal variability. They have great social and economic impacts. The ISO are especially important in the eastern part of SA. In all the intraseasonal time scales (periods within the interval 10-90 days), the first mode displays a dipole like structure with centers over Central-East and Southeast SA. Rotation of modes decomposes this first mode into two dipole-like modes with weaker southern centers. One of these dipoles has centers located more to the north, with highest variability in southern Northeast Brazil and much weaker in South Brazil, while the other has centers shifted to the south, with highest variability in Southeast Brazil (including the South Atlantic Convergence Zone, SACZ) and Southeast SA. These first two modes of precipitation seem to be related to wave-trains propagating southeastward from West or Central Pacific, rounding the southern tip of South America and turning toward the northeast, as part of larger scale systems, whose associated convection in Central-east Pacific may originate or modify those wave trains. The first mode is also related to equatorial Kelvin and Rossby wave propagation. In the first case, tropical dynamics also seems relevant, while in the second one extratropical teleconnections play a more important role. While ISO more concentrated in Central-East SA show connection with convection anomalies in central southern tropical/ subtropical Pacific, ISO with strongest components in South Brazil seem predominantly generated by internal variability of the atmosphere. Moreover, the higher frequency ISO bands seem to be associated with internal fluctuations of the atmospheric circulation, whereas the lower frequency band is associated with the Madden-Julian Oscillation (MJO). Among the precipitation subseasonal variability in SA, the most predictable is that associated with the MJO. MJO produces continental-scale daily precipitation anomalies and changes the frequency of extreme rainfall events throughout its cycle, which is divided into 8 phases, for characterization of its evolution and impact. The strongest and more extensive positive rainfall anomalies happen on phases 8 and 1, while dry conditions predominate in phases 4 and 5. Among other effects, the MJO increases the average daily precipitation by more than 30% of the climatological value and doubles the frequency of extreme events over central-east SA, including the SACZ. The evolution of the most intense

precipitation anomalies depends on the interplay between tropics–tropics and tropics–extratropics teleconnections, and the topography over central-east SA seems to play a role in enhancing low-level convergence. The maximum anomalies are produced by a tropics-extratropics wave train. It not only favors precipitation anomalies over the SACZ and subtropical SA, but also strengthens the anomalies over tropical SA when the system propagates northeastward. Influence function analysis and simulations of the responses to different components of upper-level anomalous divergence associated with the MJO anomalous convection indicate the probable origin of the anomalous circulation leading to the main precipitation anomalies over SA. It is triggered by secondary anomalous subtropical convection, while the main tropical anomalous circulation is produced by the strongest equatorial convection anomalies. There are indications that MJO-related anomalies over SA contribute to the impacts on other regions and to the initiation of the MJO in the Indian Ocean. Local forcing also seems to play some role in oscillations within the monsoon season, from spring to summer. Diagnostic results and simulations with a regional climate model show that there are links between soil moisture, surface temperatures and regional circulation that lead to observed intraseasonal oscillation creating opposite anomalies in spring and summer, especially in Central-East SA. Moreover, the topography in Southeast Brazil is important in shaping the associated circulation and precipitation patterns, as well as in anchoring the SACZ in its climatological location. Intraseasonal anomalies play an important role in modulating synoptic anomalies in the life cycle of summer rainfall extremes over SA, especially over SACZ. SACZ is a region of climatologically 200 hPa negative zonal stretching deformation ($\partial\bar{U}/\partial x < 0$). Negative zonal stretching deformation increases the longitudinal wavenumber, leading to a reduction of the longitudinal wave speed and increasing wave energy density (wave accumulation). This results in intense convective activity. In the area of upper-level negative zonal stretching deformation transient eddies can be trapped and subsequently generate deep convection. Modes of intraseasonal or interannual variability may influence the contribution of eddies to the SACZ by altering the background state within which eddies propagate.

Remote and regional control of the SACZ

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ABSTRACT

The talk is divided into two parts. In the first one I will present some results concerning the response of the South Atlantic Convergence Zone to an inter-hemispheric gradient of sea surface temperature anomalies. This is done using an AGCM coupled to a slab ocean with an anomalous heat flux included to mimic an increase in the ocean heat transport associated to the Atlantic meridional overturning circulation. The experiments show that when the NH warms up the SACZ weakens and shifts southward. The teleconnection from the NH to the SACZ involves a warming of the tropical Atlantic that shifts the ITCZ northward, inducing a change in the regional Hadley cell that impacts the SACZ. In the second part we address the role of air-sea interaction in SACZ dynamics using a complex network approach. Using the Granger causality estimator we find that while in the SACZ region the main local directional connection is from the atmosphere to the ocean, there is also a signal from the ocean to the atmosphere. Moreover, the nonlocal connectivity measured using the Area Weighted Connectivity shows that the SST in the SACZ region is the area with largest nonlocal influence to the atmosphere. To complement that study, we use a recently developed Regional coupled model (RegCM-ES) to demonstrate that during the Madden-Julian Oscillation atmospheric anomalies induce a warming of the ocean off Brazil that increases the persistence and intensifies the remote forcing thus leading to larger rainfall changes.

The diurnal cycle of precipitation an gravity waves over the rainiest place on earth

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ABSTRACT

The diurnal cycle of precipitation and thermodynamic profiles over far-western Colombia are examined in new GPM satellite rainfall products, first-ever research balloon launches during 2016 over both sea and land, and numerical simulations with the Weather Research and Forecasting Model (WRF). This paper evaluates the Mapes et al. (2003) hypothesis that midnight-early morning offshore convection is not driven by a PBL "land breeze", but rather by lower-tropospheric inhibition-reducing effects of propagating internal waves. Simulations on 36 and 12 km meshes exhibit internal waves of several km vertical wavelength propagating away from diurnally oscillating terrain heating. However, their parameterized convection fails to simulate the observed coastal rainfall, at any hour. An explicit 4 km simulation performs better, despite the problematic 12 km fields as boundary conditions, showing westward propagation of rain about 30% slower than the 15 m/s in Mapes et al. (2003) during August-September 1998. However, the wave temperature signature is weaker in that simulation, perhaps because it interacts with convection. Shipborne balloon launches show evening inhibition (capping of lifted parcel buoyancy) by a warm overhang in saturation moist static energy (SMSE). This feature relaxes overnight, consistent with the dis-inhibition hypothesis for early morning rains. In contrast, land soundings show near-surface MSE increases in late afternoon large enough to predominate over the overhang's inhibition effect on parcel buoyancy and convective initiation.

Synoptic Patterns Associated with Wet Season Onset in the Tropical High Andes of Southern Peru and Bolivia

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ABSTRACT

In the southern Andes of Peru and Bolivia, there is a clear distinction between the wet and dry season. Precipitation is one of the most relevant factors in determining glacier mass balance since the wet season onset interrupts the ablation period caused by low albedo and intense solar radiation at the end of the dry season. This study examines daily precipitation observations from 1979 to 2017 in Peru and Bolivia and identifies the wet season timing, annual variability, and tendencies. The ERA-Interim Reanalysis (0.75° Lat/Lon - 6 hours) provide insights into the seasonal variation of wind, moisture and geopotential height related to the wet season timing over the study area. We identify spatiotemporal variations in the wet season timing mostly associated with the distance to the equator and to the Amazon basin, in which onset dates exhibits a pronounced variability. Significant trends showing the delay of the wet season onset in0.4 to 0.8 days/year closely related to the occurrence of early/late wet season onset cases. A low-level northwesterly flow east of the Andes is the main feature in the lower troposphere related to the wet season onset, as well as an anticyclonic circulation in mid-troposphere and northwesterly winds in the upper troposphere. Changes in the position and strength of these circulations are observed during early vs late wet season onset cases. This result has implications for improving seasonal precipitation predictions from tropical high Andes and in the interpretation of tropical Andean ice cores.

Synoptic climatology and large-scale circulation patterns over Mexico

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ABSTRACT

ERA Interim reanalysis data was used to develop a synoptic climatology that influences weather behavior in Mexico. Surface fields of sea level pressure and surface temperature were used. Standardized anomalies were calculated for each variable for the period 1980-2016. The method used to detect synoptic patterns was Self-Organizing Maps (SOM), which allowed grouping clusters with similar spatial patterns. Frequency of occurrence, seasonality, persistence and transition of synoptic patterns were determined. The algorithm detected 20 annual synoptic patterns that describe weather behavior over Mexico. Cluster seasonality was detected in smaller temporal scales like periods (wet and dry), quarters (or seasons) and months. The annual synoptic pattern with the highest frequency of occurrence in the wet period (May-October) is SLP-AN16, which represents influence of the Atlantic Subtropical Anticyclone over the Caribbean Sea and Gulf of Mexico, with presence of a low pressure center localized to NW Mexico and a trough in surface over Central Mexico. During the dry period (November-April), SLP-AN06 synoptic pattern was observed as the most frequent, representing presence of extratropical lows over the Gulf of Mexico that lead to frontal systems through Central Mexico.Mean temperature behavior was similar for all the synoptic patterns and subregions of Mexico. Also, temperature patterns showed similarity for ERA Interim reanalysis as well as for stations data from National Meteorological Service.

Influencia de la OMJ en la región sur de Guatemala

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ABSTRACT

En Guatemala, como en muchas partes del mundo, el análisis del clima se basa principalmente en el monitoreo de El Niño, la Oscilación del Sur (ENOS), se generan pronósticos climáticos que a escala estacional muestran buenos resultados, pero cuando es necesario analizar y predecir el clima Dentro de las temporadas, es decir, mes a mes, estos pronósticos no suelen ser correctos. Por lo tanto, es muy importante comenzar a estudiar la variabilidad del clima intraestacional porque sería posible acercarse más a la predicción más precisa de cuándo comienza la lluvia, cuándo termina y cómo será la distribución temporal. En el caso de los pronósticos estacionales regionales, este resultado representa los promedios y acumulados de 3 o 4 meses, lo que deja sin conocer los procesos internos de esa temporalidad que pueden ser causados por alguna fluctuación interestacional. Este estudio tratará de encontrar la relación entre la OMJ y la lluvia en el territorio, y luego será posible identificar cómo influye en la distribución, la cantidad o la temporalidad de la misma en la Región Sur de Guatemala, donde las condiciones climáticas, que son un factor directo en todas las actividades, a veces por su escasez y en otras por sus excedentes, causan daños a diversas actividades agrícolas.

Variability of the South American monsoon on interannual and decadal/ interdecadal time scales

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ABSTRACT

ENSO is the strongest influence on the interannual variability of the South American precipitation in continental scale, as shown by the first variability modes for annual and seasonal precipitation totals, and the second mode for summer, as well as the correlation coefficients between the corresponding factor scores and SST. The strongest impacts coincide with rainy seasons in the most affected regions, thus influencing climate-dependent sectors. In the summer, regional influences of surface-atmosphere interactions seem to condition the first mode, but the second one is associated with ENSO. The most prominent impacts of ENSO among the subtropical continental regions occur in southeastern SA (SESA), being relatively stronger in austral spring and autumn. Among the equatorial continental regions, the most affected by ENSO is northern/northeastern SA, especially in austral autumn. The precipitation anomalies over SA associated with ENSO are produced by atmospheric perturbations caused by teleconnections across the tropics (equatorial Rossby and Kelvin waves) and between tropics and extratropics (Rossby waves), triggered by anomalous atmospheric heat sources generated by latent heat release over tropical SST anomalies. Besides, the rainfall anomalies over northeastern and southeastern SA are linked by local Hadley circulation. Notwithstanding, in certain regions local effects of SST anomalies directly or indirectly related to ENSO or other surface-atmosphere interactions enhanced during the austral summer also produce rainfall anomalies. Therefore, the ENSO impacts over SA show examples of different mechanisms for different regions and seasons. They need adequate temporal resolution for analysis, since seasonal resolution may smooth out impacts. The impacts of ENSO on SA can change with shifts in the position of the strongest SST anomalies in the tropical Pacific, because they can alter teleconnections and SST anomalies remotely produced. Therefore, El Niño with strongest SST anomalies in central Pacific (Central El Niño, CEN) can produce effects different from those produced by a canonical El Niño, centered on eastern Pacific (East El Niño, EEN). The differences are not very remarkable at the beginning of the ENSO cycle (austral winter and spring (0)). The differences are enhanced towards the austral autumn of the following year (+), partially due to remotely produced SST anomalies over the Atlantic Ocean. A monthly temporal resolution may be

needed for adequate description, since anomalies in one month may be different and/or much stronger than those in the other months of the season. This is true for November in spring(0), January in summer(+), and, with less intensity, May in autumn(+). In November(0) of EEN, a Rossby wave train extends from the eastern tropical Pacific towards subtropical SA at 200 hPa, strengthens the subtropical jet and produces a pair cyclone/anticyclone over the region, providing dynamic conditions for anomalous uplift over SESA. An Influence Function analysis for the three action centers confirms the importance of the eastern Pacific anomalous convection in producing these circulation anomalies. The monthly composite precipitation anomalies show an aspect that is less visible in the seasonal anomalies: the reversal of the anomalies in Central-East Brazil and the weakening of the anomalies in SESA from spring to summer, more clearly seen between the months of Nov(0) and Jan(+). It is stronger in EEN, and is an example of surface- atmosphere interactions enhanced during the austral summer and influenced by topography. Previous studies have shown that the precipitation anomalies in November and next January in Central-East Brazil hold significant inverse relationship when the spring precipitation anomalies are strongest, and mechanisms of surface-atmosphere interactions influenced by the topography in Central-East Brazil were proposed to explain this reversal. It is associated with the reversal of a rotational circulation anomaly over Southeast Brazil (the southern part of what is called Central-East Brazil) that either conveys moisture flux coming from the Atlantic, northwestern SA, and Amazon Basin into Central-East Brazil, decreasing its transport into SESA (if it is cyclonic), or increases the moisture transport into SESA (if it is anticyclonic). In spring, that rotational circulation anomaly is remotely forced, but after rainfall anomalies over Central-East Brazil in spring, it tends to reverse sign in peak summer, inverting the rainfall anomalies. This reversal is hypothesized to be locally forced by surface-atmosphere feedback triggered by the spring anomalies, as teleconnections in summer are weaker. ENSO changes the frequency of extreme events over extensive regions of SA during different periods of its cycle. Significant changes in extremes are frequently more extensive than the corresponding changes in rainfall totals, because the highest sensitivity to ENSO seems to be in the extreme range of daily precipitation. This is important, since the most dramatic consequences of climate variability result from changes in extreme events. Regarding interdecadal variability, it also shows a strong influence on the monsoon in SA. Opposite phases of the main modes show differences around 50% in monthly precipitation. As in interannual variability, there are significant relationships between the interdecadal variability in spring and summer, indicating local and remote influences. The first modes for both seasons are dipole-like, displaying opposite anomalies in central-east and southeast SA. They tend to reverse polarity from spring to summer. Yet the summer second mode and its related spring fourth mode, which affect the core monsoon region in central Brazil and central-northwestern Argentina, show similar factor loadings, indicating persistence of

anomalies from one season to the other, contrary to the first modes. The other presented modes describe the variability in different regions with great monsoon precipitation. Significant connections with different combinations of climatic indices and SST anomalies provide physical basis for the presented modes. However, the main modes show connections with more than one climatic index and more than one oceanic region, stressing the importance of combined influence. The first variability modes are connected with the Interdecadal Pacific Oscillation and the Atlantic Interdecadal Oscillation. These results were confirmed by an analysis with longer period. Besides, an analysis of the influence on extreme precipitation events showed that interdecadal oscillations change significantly the frequency of extreme events and the distributions of daily precipitation. The significant anomalies of the extreme event frequency in opposite phases of the interdecadal oscillations display spatial patterns very similar to those of the corresponding modes. In addition, the modes of extreme event frequency bear similarity to the modes of seasonal precipitation, although a complete assessment of this similarity is not possible with the daily data available. The Kolmogorov-Smirnov test is applied to the daily precipitation series in positive and negative phases of the interdecadal modes, in regions with high factor loadings. It shows, with significance level better than 0.01, that daily precipitation from opposite phases pertains to different frequency distributions. Further analyses disclose clearly that there is much greater relative impact of the interdecadal oscillations on the extreme ranges of daily rainfall than in the ranges of moderate and light rainfall. This impact is more linear is spring than in summer.

Pacific and Atlantic multidecadal oscillations: relations to the ENSO and effects on the South American rainfall

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ABSTRACT

We examine the oceanic mean states associated with the Pacific decadal oscillation (PDO) and the Atlantic multidecadal oscillation (AMO) and their relations to the El Niño-Southern Oscillation (ENSO). Firstly, we discuss the AMO and PDO mean states and the ENSO behavior under these mean states. Then we discuss the mean states with the simultaneous occurrences of warm (W) and cold (C) phases of these oscillations: WAMO/CPDO, CAMO/WPDO and CAMO/CPDO and their relation to the ENSO. For these combined AMO/PDO mean states, the SST anomaly patterns show a combination of the PDO and AMO related anomaly patterns in the Pacific Ocean, and the strongest AMO-related anomaly signals in the Atlantic Ocean with almost antisymmetric SST anomaly patterns in the northern and southern extratropical sectors of this Ocean. One of the most important result of this paper concerns the contrasting features between the CAMO/WPDO and the WAMO/CPDO mean states, which are noticeable for the sea surface temperature (SST), zonal circulation cell and precipitation during the austral autumn. Besides the opposite inter-basin equatorial Atlantic/eastern equatorial Pacific cells, the CAMO/WPDO and WAMO/CPDO mean states also feature, respectively, a weakened and strengthened Walker cell in the tropical Pacific during the austral autumn. The results here indicate that the inter-basin east-west cell between the equatorial Atlantic and eastern Pacific contributes to strengthen (weaken) the Walker cell during the austral autumn of the WAMO/CPDO (CAMO/WPDO) mean state. We also found that the mean states alter the ENSO features.

Paleoclimatic Aspects of the South American Monsoon System

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ABSTRACT

The natural climate variability is an important factor to be understood for exploring the predictive potential of the climate and to evaluate the role of the anthropogenic forcing. Paleoclimate records provide indications of the past variability and cover a much longer period than the instrumental era. Thus, it is natural to question whether climate models are able to reproduce paleoclimate monsoon variability in S. America in order to gain confidence in the climate models used to generate future climate scenarios and to predict seasonal, interannual and decadal climate. The main purpose of this presentation is to evaluate the changes of the South American Monsoon System (SAMS) since the Last Glacial Period in numerical simulations of TRACE21k and PMIP3 and to validate the results based on the available paleoclimate indicators. A review of current understanding of the ITCZ controlling effect on the monsoons will also be discussed in the context of understanding observed changes in the South American monsoon in the last 21k years. Large-scale aspects associated with the SAMS are explored both in models and paleoclimate proxies. The analyses have been based on the Large-scale Index for South American Monsoon (LISAM) applied in the weighted average set of the climate model simulations CCSM4-M, GISS-E2-R, IPSL-CM5A-LR, MIROC-ESM, MPI-ESM-P and MRI-ESM and TRACE21k. The LISAM is based on the analysis of combined Empirical Orthogonal Functions (EOFc) between the variables at 850 hPa: precipitation, temperature, humidity and wind. The first (second) mode of the EOFc represents the spatial patterns of the SAMS (South Atlantic Convergence Zone – SACZ). Regarding with the LISAM the patterns related of the first two modes (SAMS and SACZ, respectively) were similar to those found in the historical period. The temporal variability of the expansion coefficient series of the LISAM modes showed periods of variation associated with the variability of solar cycles and sunspots, as well as the systems internal oscillations. The internal variability of the SAMS and SACZ showed strong influences of the North and South Tropical Atlantic Ocean and the Pacific Ocean. Moreover, the time series of the first mode of EOFc proved to be a good indicator of climatic transition during the transition of the last Glacial Maxima to the mid-Holocene. The current understanding of the ITCZ position is based on the interhemispheric energy balance differences. Major changes in the ITCZ position are hypothesized to be connected to the variability of the Atlantic Meridional Overturning

Circulation (AMOC). It is observed that in the present climate the AMOC transports more heat than necessary to offset the net energy deficit in the Northern Hemisphere with respect to the Southern Hemisphere. Therefore, the ITCZ has to be located in the Northern Hemisphere in order to compensate for the excessive northward transport by the AMOC. However, in this presentation we discuss TRACE21k model results with the transient simulation of the last 21k years forced by fresh water input the Artic and Antarctic regions. The results indicate that the melting phases lead to significant southward changes in the ITCZ position. Paleo reconstructions of the NE Brazil Climate as well as in the SE and Central regions of Brazil indicate reasonable agreement with the TRACE21k indications on the LISAM and SACZ modes. Thus, current theoretical understanding of the ITCZ controlling mechanisms based on energy balance issues find model and observational support in paleoclimate indicators of the S. American monsoon evolution in the last 21k years.

Present and future of the South American Monsoon in a Warming Climate

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ABSTRACT

The South American Monsoon System (SAMS) The South American Monsoon system (SAMS) is characterized by the onset of deep convection and precipitation that accompany pronounced seasonal variations in moisture flux and heat content throughout the troposphere. Precipitation associated with SAMS peaks between December and February (DJF).The South Atlantic Convergence Zone, which is the main feature of SAMS, is characterized by persistent precipitation and convection driven by enhanced moisture transport from the tropics toward subtropical southwest Atlantic. Precipitation bands along the SACZ provide water supply for millions of people and are often related to high impact weather in populated areas. Additionally, SAMS and the SACZ are characterized by organized mesoscale convective systems (MCSs) that bring significant rainfall and severe weather to vast regions over tropical South America, including the Andes. This presentation shows that convection in the SAMS and the SACZ is modulated by coupled modes of variability on intraseasonal, interannual and decadal timescales. Tropical South America (SA) has experienced large warming rate in recent decades with possible consequences for the distribution of precipitation, particularly extreme rainfall. This review talk presents the most recent studies on the observed variations and changes in precipitation in the SAMS and the SACZ, with particular focus on extreme events. It is shown that the SACZ is shifting poleward and drier conditions have been observed in the equatorward flank of the zone, while wet conditions have intensified in the southern flank. These changes accompany trends in integrated moisture flux convergence, vertical velocity in 700hPa over the Eastern South Atlantic Ocean. Nonetheless, despite the observed shift in the SAZC, extreme daily precipitation has increased in most parts of the continent. CMIP5 models indicate that these trends may persist in the 21st century.

Precipitation variability on the Mamoré Basin

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ABSTRACT

The study of precipitation and discharge of rivers has had a recent impact on recurrent floods that occur in Beni. The components of the hydrological cycle on the Mamoré river basin are studied and compared with the measured flow at the Camiaco station. It was determined that the average annual flow cycle shows that the maximum occurs in the month of March and the minimum in September. However, the maximum precipitation according to the sets of dice (February) does not correspond to the maximum flow, although the size of the basin is relatively small. The correlation is higher between precipitation and flow shows two months of delay. The GLDAS data set was used to analyze the dynamics of the basin and it was demonstrated that it has the capacity to reproduce and explain this behavior.

VARIABILITY AND CHANGES OF DAILY EXTREMES OVER NORTHEASTERN ARGENTINA

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ABSTRACT

Climate in northeastern Argentina poses great challenges to the population that needs to cope with extreme events. Climate variability and changes are leading to an increased vulnerability which in turn can produce unprecedented disasters. This study investigates the long-term changes and interannual variability of daily temperature and precipitation extremes and assesses to what extent global reanalyses reproduce the observed variability. Climate extremes are characterized in space and time by relevant indices, like those proposed by the Expert Team on Climate Change Detection and Indices. The leading modes of variability were detected with a spectral analysis, and their spatial distribution was assessed through nonparametric trends. The results confirm that temperature extremes are changing towards warmer conditions. Since 1990 the number of warm days has been increasing, while the number of cold days has been decreasing. Likewise, warm and cold nights show a significant signal of warming, although the trend seems to be stabilizing in recent decades. The duration of heat spells increased while cold spells decreased in recent decades. At present, heat spells almost double the frequency and duration of cold spells. Longer heat spells are associated with longer dry spells impacting a region where intense agricultural activity is rainfed. Intense precipitation events in most of the region increased steadily since 1970. The intensity and frequency of annual maximum 1-day and 5-day precipitation events increased from the 1970s to the 2000s, stabilizing in recent years. The increased intensity of heavy precipitation events constitutes a growing risk for urban settlements where heavy rainfall may exceed the capacity of drainage systems, causing significant infrastructure losses and, in the most extreme cases, deaths. Intense precipitation events in the predominantly flat agricultural plains lead to extensive waterlogging with significant economic impacts due to loss of crops and decreased livestock productivity. A similar analysis based on reanalysis data (ERA-Interim and NCEP2 reanalysis) reveals mixed results. ERA-Interim can recognize temperature extremes in time and space, while the older NCEP2 presents systematic biases. Both reanalyses reproduce dry spells and the annual maximum 5-day precipitation with large biases, which are particularly noticeable at each observation station.

Although reanalyses would be expected to add information for climate extremes in areas of scarce observations, they still need to be used with great caution and only as a complement to observations.

Attribution Analysis of Southwestward Shift of the South Atlantic Convergence Zone-related precipitation during the last decades

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ABSTRACT

Evidence of changes in the South Atlantic Convergence Zone (SACZ) dipole have been identified in observational studies and historical and future scenarios of the models participating on the fifth phase of the Coupled Model Intercomparison Project (CMIP5), suggesting an increase (decrease) in the frequency of precipitation events related to the dipole over Southeastern South America (Eastern Brazil). The objective of this study is to evaluate the contribution of natural variability and anthropogenic-related forcing to precipitation trends over Eastern Brazil in the 20th century based on historical, natural, and pre-industrial simulations from CMIP5 models. Only CMIP5 models that accurately reproduced the observed precipitation climatology over the SACZ, as represented by the Global Precipitation Climatology Project Version 2.2 (GPCP), were considered. 3 out of 4 CMIP5 models that realistically simulated the precipitation rates over SACZ during summer (December to February) are able to correctly simulate the observed southwestward shift of the SACZ. These models also show good evidence of anthropogenic influence on the simulated precipitation trends, suggesting that the drying over Eastern Brazil is partially related to anthropogenic forcing. Over Southeastern South America, the agreement among models is larger and suggests that the wetting is due to anthropogenic forcing although partially offset by natural variability.

Intercomparison of observed and simulated climatic trends in the North American Monsoon

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ABSTRACT

An intercomparison of three regional climate models (RCMs) was performed over the Coordinated Regional Dynamical Experiment (CORDEX) - Central America, Caribbean and Mexico (CAM) domain to determine their ability to reproduce observed temperature and precipitation trends during 1980-2010. PRECIS-HadRM3P, RCA4, and two versions of RegCM4 were forced with ERA-Interim Reanalysis. Observations from the Climate Research Unit (CRU) and ERA-Interim show a generalized warming over most of the domain. The most significant warming trend (≥ 0.33°C decade^{-1}) is observed in the North American monsoon (NAM) region, which is moderately captured by the three RCMs, but with less intensity; each decade from 1970 to 2016 has become warmer than the previous ones, especially during the summer. Moreover, since the 1990s the 95th percentile threshold of summer temperatures in the NAM has also significantly increased. The warming trend is also observed in the 1950-2017 period and appears to be partially related to the positive phase of the Atlantic Multidecadal Oscillation (+AMO). There is a good agreement between observations (CRU, GPCP and CHIRPS) showing annual decreases of precipitation (less than -15% decade^{-1}) in parts of the Southwest United States and Northwestern Mexico, including the NAM region, and a positive trend (5% to 10% decade^{-1}) in June-September in eastern Mexico, the mid-summer drought region, and northern South America, but observed longer trends (1950-2017) in the NAM are not statistically significant. Some of the observed regional trends of precipitation are captured by the RCMs. During 1980-2010, observations and RCMs show a good consistency in the wintertime precipitation trends in most of the domain. However, summer precipitation trends from GPCP show opposite sign to those of CRU and CHIRPS over the Mexican coasts of the Gulf of Mexico, the Yucatan Peninsula, and Cuba, possibly due to data limitations and differences in grid resolutions. Summer precipitation trends from the RCMs also show more regional differences than during winter. Our results show the importance of evaluating several observational datasets and RCMs to determine the regions and seasons that show less uncertainty.

Design and assessment of a Brazilian global sub-seasonal prediction system

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ABSTRACT

This talk will present recent developments performed at the Center for Weather Forecast and Climate Studies (CPTEC) in Brazil, in collaboration with the University of Reading, U.K., for designing a global sub-seasonal prediction system in order to evaluate the ability of this system in producing predictions for the expected meteorological conditions for the following 1 to 4 weeks. Different configurations of the Brazilian Atmospheric Model (BAM) were tested in terms of vertical resolution, convection and boundary layer parameterizations, as well as soil moisture initialization in order to identify the model version with best performance when predicting weekly accumulate precipitation, weekly mean near surface temperature and the daily evolution of the Madden and Julian Oscillation (MJO), which is known to be a key source of predictability on the sub-seasonal time scale. The assessment was performed through a series of retrospective predictions produced for 12 extended austral summers (from November to March of the years from 2000 to 2011), which is an important period for the South American monsoon. The performance of the different model configurations will be presented by comparing measures such as the correlation and root mean squared error (RMSE) for the predicted and observed weekly anomalies, and bivariate correlation and bivariate RMSE for the MJO predictions.

Sub-seasonal prediction of South American summer monsoon active and break phases

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ABSTRACT

The summer monsoon is responsible for the rainy season in the most populated regions of South America (SA) and those with largest contribution to agricultural production and hydroeletric power generation. The core monsoon precipitation undergoes significant intraseasonal variability, with active and break phases. The skill of two models participating in the Subseasonal-to-Seasonal (S2S) Prediction Project (Vitart et al., 2017) in predicting these phases at multiweek lead times, and simulating the role of the Madden-Julian Oscillation (MJO) in driving these phases is assessed. Two indices are defined to represent the monsoon variability and to evaluate the models skill in predicting it: the monsoon precipitation index (MPI) and the monsoon wind index (MWI). The MPI is the standardized anomaly of rainfall in the core monsoon region and defines active and break monsoon periods when it is greater (less) than +1(-1). It captures well the subseasonal variability of the monsoon rainfall, since the anomaly patterns for active and break episodes reproduce the pattern of the first mode of synoptic and intraseasonal variability of the observed summer daily rainfall over SA. The two indices are dynamically linked, and the models simulate well the relationships between them. Active and break monsoon rainfall episodes are associated with circulation anomalies that are very similar to those associated with MJO-related positive and negative precipitation anomalies in the core monsoon region. Therefore, the MJO is a source of monsoon subseasonal predictability. The observed connection between the MJO phases and the active and break episodes is well represented by the models up to week 3, but shifted by one phase, showing highest number of active episodes in phase 8, while observations show it in phase 1. Coherently, the crucial teleconnection between the central subtropical Pacific and SA is stronger in observations (models) in phase 1 (8), apparently taking shorter time in the models. A review of the observed MJO impact on SA monsoon shows that it is a significant source of predictability. Its influence is confirmed by the proportion of active (or break) monsoon days in each phase of the MJO days, and in neutral days. This highlights the importance of using models skillful in simulating the MJO as well as its impacts on SA monsoon. The selected S2S models reproduce the relationships between the MPI and zonal wind at 850 hPa, as well as the proportions of monsoon

active (or break) days in MJO phases. The correlation coefficients between observed and predicted monsoon indices show small prediction skill after week 2 for MPI, but higher for MWI, providing motivation for further research.

Climate and weather extremes during the South American Monsoon season within the context of Disaster Risk Reduction – The Cemaden Experience

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ABSTRACT

It is well-known that the South American Monsoon System (SAMS) is one of the main water's providers for agriculture-related activities and hydro-power generation that ultimately benefit millions every year. However, extremes associated with the SAMS can also represent threatening conditions for vulnerable populations, many times leading to a scenario of social-economic disaster. The presentation will summarize activities and research led by the Centre for Monitoring and Early Warning for Natural Disasters (Cemaden), which aims to assess and mitigate the associated risk of a disaster during the extreme events related to the SAM variability.

Collaborative processes in action: climate services and impact-based forecasts for southern South America

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ABSTRACT

To enhance society's capacity to act on climate information progress in climate knowledge must match with a better understanding of how science can inform climate-resilient decisions and policy. The gradual inclusion of climate issues in the political national and regional agendas has created exciting opportunities for scientific collaboration. Success and actionability of climate knowledge and services depend largely on strategic partnerships between a broad disciplinary spectrum of scientists, practitioners and stakeholders coming from government and civil society. In southern South America the aim to provide climate services has demonstrated the need for innovation at institutional levels. The presentation revisits the conceptual and historical road that lead to the configuration of the new paradigm of climate services. Two experiences of collaboration were analyzed. First, the vision and achievements of a Collaborative Research Network (CRN3035) sponsored by the Inter-American Institute for Global Change Research (IAI) that carried out the project entitled "Towards usable climate science: Informing sustainable decisions and provision of climate services to the agriculture and water sectors of southeastern South America." The CRN3035 is composed of a balanced team of investigators from natural and social sciences along with a wide range of stakeholders (governmental agencies and nongovernmental organizations) from Argentina, Brazil, Paraguay, and the USA. The project focused on the design, implementation and dissemination of climate services in the region. Main achievements of the project were reviewed (i.e. the successful compilation of a consolidated set of climate data, consistently controlled for quality, and the support of a great number of bright, highly-motivated early-career scholars). Core lessons learned were summarized. These involve understanding that the actual use of climate information to support decision-making requires not only the availability of new knowledge but also of innovative partnerships. The second experience of "collaboration in action" corresponds to a pilot project in the southwest of the argentine province of Buenos Aires exploring the linkage of drought indicators with impacts, in the framework of the establishment of an early warning and drought mitigation system in the region. Improving the understanding of the potential impacts of severe hydrometeorological events poses new challenges to climate scientists and meteo-

hydrological governmental institutions and their partner agencies, particularly disaster reduction and civil protection agencies. Finally, a special mention received the recent collaboration needed to the successful establishment of a South American Drought Information System (in Spanish SISSA, Sistema de Información sobre Sequías para SudAmérica). Crucial in the experiences analyzed has been the close collaboration established with the Regional Climate Center for southern South America (RCC-SSA) that is jointly led by Brazil and Argentina and includes Paraguay, Uruguay, Bolivia and Chile. The strategic partnership between the RCC-SSA and the IAI project is described as an eloquent example of the kind of novel institutional arrangements necessary to foster effective implementation of regional climate services. The synergistic partnership, also illustrated in the second collaborative experience, provides the multi-disciplinary expertise necessary to conduct the research and development necessary for effective provision of climate services while, at the same time, it offers a real-world, operational structure that facilitates the transition from scientific knowledge to practice. Lessons learned involve reflections and examples on how the best available natural and social science, and stakeholders' knowledge can be "translated" not only into predictions or projections of regional climate, but also into products able to inform science-based climate policies. The essential contribution of social scientists to build capacities for collaborative research and reflection on the inter/transdisciplinary is highlighted.

Interchange of atmospheric moisture among South America catchment basins

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ABSTRACT

This study presents a preliminary assessment of atmospheric moisture transference among the main South American catchment basins: Magdalena, Orinoco, Amazonas, and La Plata. The FLEXPART model is used as a methodological tool to quantify the portion of moisture originated from each one of these terrestrial sources and taken to the others, at a seasonal time scale. This procedure allows the establishment of continental teleconnections that can be used as a key for developing integrated environmental management plans.

The contribution of tropical cyclones to the atmospheric branch of Middle America's hydrological cycle

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ABSTRACT

Middle America is affected by tropical cyclones (TCs) from the Eastern Pacific and the North Atlantic Oceans. We characterize the regional climatology (1998-2016) of the TC contribution to the atmospheric branch of the hydrological cycle (rainfall and moisture transport), including the TC contribution to extreme rainfall from May to November. TC contribution to rainfall is quantified using TRMM Multisatellite Precipitation Analysis (TMPA) 3B42 and TC tracks derived from three sources: the International Best Track Archive for Climate Stewardship (IBTrACS), and an objective feature tracking method applied to the Japanese 55-year and ERA-Interim reanalysis. During July to October, TCs contribute 10-30% of the monthly total rainfall over the west and east coast of Mexico and central Mexico, with the largest monthly contribution during September over the Peninsula of Baja California (up to 60%). TC contributions to daily extreme rainfall (above the 95th percentile) can reach 50%–60% over the west coast of Mexico, 40%-50% over the centre and east coast of Mexico, and as high as 90% over Baja California. Most of the agreements (differences) of TC contributions to Middle America's rainfall between IBTrACS and both reanalyses were found over the Atlantic Ocean (continent); the differences over the continent are mainly attributed to the discrepancies of the TC tracks in proximity to the coast. The moisture transported by TCs is calculated using ERA-Interim reanalyses for 1979-2014. Moisture transports extend inland compared with rainfall and are likely an important source for the regional water budget during the TC season. TCs may influence the sign of the vertically integrated moisture flux (VIMF) divergence when the VIMF divergence from the mean circulation is weak. We discuss deficiencies in both the observed and reanalysis TC tracks, which limit our ability to quantify robustly the contribution of TCs to the regional hydrological cycle.

Contrasting rainfall behavior between the Pacific coast and the Mexican Altiplano

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ABSTRACT

Summer rainfall along the coast Nayarit, Mexico, behaves in a contrasting way to rainfall observed on the Mexican Altiplano. The mechanism for this behavior originates in the wind flow and moisture content of the atmospheric column. By using field observations from 2015, this study analyzed wind and rainfall characteristics in the interior of the San Pedro-Mezquital river basin, which connects the Pacific coast and the Mexican Altiplano. At the surface, the characteristics of humidity transport that explain rainfall in one region hinder its transport to the other. This has not been previously documented. We further analyzed different scenarios with sets of daily data, using composite maps of average wind and specific humidity at 500, 700, and 1000 hPa to explain these anomalies. In 2015, a pattern resembling the midsummer drought occurred at a weather station located on the coast. The corresponding time series of precipitation, which was derived from an analysis of orthogonal empirical functions with varimax axis rotation, showed that from 1970−2012, there were 3 years (1978, 2000, and 2002) with droughts. The mechanism that caused this behavior originates in the gap in the occurrence of mesoscale convective systems (MCSs), with environmental conditions that provide more convection and enhanced rainfall in September over coastal areas. The September rainfall in these 3 years contrasts that over the Mexican Altiplano, giving more evidence of a seesaw rainfall pattern between these 2 regions.

The relationship between Easterly Waves over the Eastern Pacific and the Monsoon of North America

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ABSTRACT

Easterly Waves (EWs) are characteristic elements of the tropical atmosphere during the boreal summer, where they frequently serve as seeds of Tropical cyclones (TCs). While most of the research on EWs has focused on the African region, EWs over the Eastern Pacific (EPAC) have only recently received attention. However, current research focuses on their basic features, intraseasonal variability, and genesis mechanisms, leaving aside the impacts of EWs once they are present over the EPAC. After genesis, EWs over the EPAC follow three main pathways: a zonal path into the Central Pacific, a parallel path to the coast of Mexico and Central America, or a path that impacts the region of the monsoon of North America (NAM). Of particular interest are the conditions under which EWs impact the NAM region, given that some authors have considered that moisture and rainfall associated with EWs drive the moisture fields within the NAM region. This study aims to explain first to what extent EWs influences rainfall on the NAM region. After this, this research addresses what are the mechanisms associated for this EW deflection: if large-scale synoptic elements, or the steering winds from the NAM.

The Southern Annular Mode influence on South America Monsoon System

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ABSTRACT

The goal of this study is to analyze the impacts of the Southern Hemisphere Annular Mode (SAM) phases over South America (SA), including the South America Monsoon System (SAMS) region, in the months of December, January and February. Composite analyses were performed excluding ENSO years. Southeastern SA (SESA), part of Southeastern and Central-West of Brazil seem to be more affected by this mode. However, SAM influences are different for each month and there are also differences of the influences between SAM phases (not always opposite). For air temperature, February and December present a temperature anomaly dipole, with positive (negative) anomaly at SESA and negative (positive) northward, in the negative (positive) SAM phase. January has a different behavior compared with other months but also presents a nearly opposite signal between SAM phases. Precipitation anomalies composites indicate a weakening (strengthening) of South Atlantic Convergence Zone configuration at negative (positive) SAM phase in January. SESA region shows positive (negative) precipitation anomalies at negative (positive) SAM phases, during December. In February there are positive anomalies with the same orientation of the South Atlantic Convergence Zone in both phases.

Central Brazil precipitation variability during the last eight decades

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ABSTRACT

Previous studies have identified interannual to decadal variability in the South American Monsoon System (SAMS) related to the El Niño Southern Oscillation (ENSO) and to the Pacific Decadal Oscillation (PDO). The PDO phase shift in 1976-1977 is related to global climatic changes, as in SAMS wet season length and Amazonian precipitation regime. Central Brazil is situated under the SAMS axis and its precipitation regime reflects the SAMS variability. However, surface rainfall measurements started only in the 1960's, impeding the identification of low frequency periodicities. Here we analyze changes in Central Brazil precipitation variability from 1937 to 2016 (80 years) using monthly and annual precipitation anomalies from Global Precipitation Climatology Centre (GPCC) reanalysis dataset version 2018 with horizontal resolution of 0.25°. We also used the PDO monthly index provided by the National Oceanic and Atmospheric Administration (NOAA). Spectral analysis with the Multitaper Method (MTM) revealed a low frequency cyclicity (~20-yr) in the precipitation anomalies time series. This cyclicity was related to the PDO index via wavelet transform coherence analysis. The coherence analysis suggests a phase relationship between the PDO index and the precipitation anomalies in Central Brazil during austral summer (December to February).

New insights about South American hydroclimate changes during Heinrich stadials

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ABSTRACT

Heinrich stadials (HS) are cold Northern Hemisphere abrupt millennial-scale events frequently related to decreases in the strength of the Atlantic meridional overturning circulation (AMOC). Model simulations and paleoclimate records have suggested that the heat not transported to the north during periods of weak AMOC cools down the North Atlantic and warms up the South Atlantic. This perturbation in the cross-equatorial heat transport would in turn affect tropical rainfall. Indeed, South American hydroclimate records have suggested marked precipitation changes during HS of the last glacial and deglacial periods. However, the scarcity of high-resolution marine records off South American margin, especially between 5 and 20°S, hampers a comprehensive understanding of the continental hydroclimate responses to HS. Here we investigate piston core M125-95-3 collected at ca. 10.5°S (off eastern South America) from a site subjected to the delivery of terrigenous sediments from the São Francisco River for the last ca. 70,000 years. In order to reconstruct changes in precipitation over the São Francisco River drainage basin we determined the major elemental composition along the piston core. Our new record shows events of marked precipitation increase over a region that is currently dominated by dry conditions. In this way, we intend to contribute to improving the knowledge regarding past precipitation changes and drivers of South American hydroclimate.

Multimodel climate projections over South America CORDEX domain

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ABSTRACT

Future climate projections over South America (SA) are investigated considering ensembles of global climate models (GCMs) and regional climate models (RCMs) for the RCP8.5 scenario. GCMs are provided by Coupled Model Intercomparison Project - Phase 5 (CMIP5), while RCMs came from Regional Climate Downscaling Experiment (CORDEX). The study focuses on the present climate validation, future climate trends and their uncertainties (spread), and in the identification of how evapotranspiration contributes to the precipitation climate change signal over six key regions, including Amazon and La Plata Basin, over SA. In general, both GCMs and RCMs ensembles agree in the trend signals projected to future, but there is a great spread among the ensemble members, indicating large uncertainties in the projections. Regarding the most important watershed in SA, the ensembles agree on the signal of the precipitation decrease in the southern Amazon throughout the year and in the increase (decrease) in austral summer (winter) in La Plata basin. For the air temperature, it is projected an increase over all SA, being the warming more intense over Amazon and northern SA. In the six key regions, in general, the precipitation overtakes the evapotranspiration as in the present as in the future climate, indicating that the precipitation is driven by local and remote moisture sources.

The importance of South America monsoon system on Southern Africa monsoon rainfall variability

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ABSTRACT

The people's livelihood and economy of most of Southern Africa (SAF) and South America (SA) are tied to the seasonal monsoon rainfall, whose bulk occurs during the December-January-February (DJF) season. The seasonal distribution of this rainfall over SA is highly affected by the variability of the SA monsoon system (SAMS) which, on the other hand, has also shown influencing SAF monsoon rainfall (SAFMR) through teleconnections. Thus, understanding the processes governing the SAMS is not only important for SA, but also for SAF. Applying S-mode principal component analysis with varimax rotation to Mozambique gridded gauge daily rainfall anomalies (1979-2005), filtered in three frequency bands (10-25, 10-90 and 20-90 days, respectively), we found four dominant patterns of intraseasonal rainfall variability over Mozambique, all showing strong intraseasonal peaks at periods of 20–30 days, and weaker peaks in the 50–60 day band, as revealed by power spectral density. The former peaks seem to be a possible reason for the appearance of the first 3 modes in all bands. Similar peaks also appear in the SA monsoon rainfall, although its origin is still unclear, probably related to internal variability. Based on the mode 3, whose spatial pattern in these three bands is stronger in the monsoon core region over Mozambique (20°S–13.75°S; 32°E–38°E) and whose associated anomalous circulation seems to be more related to variations in monsoon circulation (enhanced low-level westerlies and northerlies), we constructed a Mozambican precipitation monsoon index (MPMI) and its associated low-level monsoon circulation indices to characterize the active and break periods of monsoon. Composite anomalies of 20–90-day band positive MPMI phases show that the circulation anomalies, responsible for enhanced rainfall over Mozambique may be associated with eastward propagating wave trains which passing over tropical SA/Atlantic Ocean are modulated by Madden-Julian Oscillation (MJO) related convective anomalies. Similar results are obtained by anomaly composites associated with mode 3, demonstrating the robustness of the proposed MPMI for characterization of monsoon variability over the study domain. These results corroborate previous studies, which have reported the existence of teleconnection between SA and SAF. Overall, these results demonstrate that a better understanding of SAMS variability may obviously lead to improvement of SAFMR knowledge, and hence its prediction.

The influence of different scales of global SST variability modes on precipitation characteristics during the South American monsoon season

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ABSTRACT

The study of climate variability modes and their influence on the precipitation characteristics is an important way to improving prediction methods. This study is aimed at documenting the impact of the Pacific and Atlantic interdecadal (PDO, IPO and AMO) and interannual (El Niño-Southern Oscillation; ENSO) modes on South American precipitation characteristics during the monsoon season (austral spring and summer). These are monthly total precipitation (PT), number of days with precipitation (ND), mean precipitation per day of precipitation (PM), number of extreme events (EXT). The variability modes are obtained using principal component analysis of sea surface temperature (SST) data. To identify their influence, the respective anomalies are obtained considering opposite phases (positive/negative; above 0.7/below -0.7) of one mode or two modes simultaneously. Furthermore, second order partial correlation between the three modes and the precipitation characteristics are calculated. The results show that the ND and PM anomalies during different oscillations contribute distinctly to the PT anomalies. Also, there are different patterns of precipitation for PDO and IPO. In summer, it is found that the PDO+ tends to increase precipitation over southeastern South America (SA) while for IPO+ the increase occurs in central-eastern SA, around the core monsoon region. In spring, PDO+ is associated with predominance of scattered small areas of enhanced rainfall over central-northern SA, while for IPO+ scattered areas of enhanced rainfall only occur in northern Brazil, while reduced rainfall predominates over central-east Brazil. For AMO+, the region affected in spring by increased rainfall comprises the south of Brazil, Paraguay and northern Argentina, and by reduced rainfall the northern part of SA, while for summer the anomalies change sign in central-east Brazil and the northernmost part of SA. The combined effect of ENSO, PDO, IPO and AMO produces different precipitation patterns.

MJO impacts on South American precipitation and extreme events in El Niño years

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ABSTRACT

Empirical Orthogonal Functions (EOF) of the combined fields of outgoing longwave radiation (OLR), 850-hPa zonal wind and 200-hPa zonal wind, provide an index in real time for monitoring the Madden-Julian Oscillation (MJO), available since 1978. As the oscillation occurs in intraseasonal time scale, there is interest in investigating how it is influenced by the El Niño-Southern Oscillation (ENSO) phenomenon in interannual time scale. This work analyzes the MJO impacts on precipitation and its extreme events over South America (SA) in the monsoon season, during El Niño (EN) years and neutral (NT) years of ENSO, between 1979 and 2009. The data used are precipitation data from rain gauge stations, MJO phases according to Wheeler and Hendon (2004), OLR, wind (850 hPa) and stream function (200 hPa) reanalysis data. ENSO phases are identified through EOF analysis of sea surface temperature (SST) data (HadISST1). To assess the MJO impacts, daily anomalies are calculated, then filtered in the 20-90 day band and their composites elaborated for each MJO phase during the summer monsoon in EN and NT years. The statistical significance of the composites is assessed with a Student's t-test, considering autocorrelation. The frequency of extreme events is evaluated, and 90th percentile used to characterize an event. In phase 1, the most significant positive precipitation anomalies are in the monsoon region (on central-east SA – CESA) in EN, but they are displaced to the north in NT, including the OLR anomalies. There is an increase in the frequency of extreme events in the same region of the anomalies, doubling in EN. Starting from phase 3, enhanced precipitation is expected south of the monsoon region (on southeast SA – SESA). The most intense anomalies are in phase 4 in NT, but in EN, the dipole of anomalies between CESA and SESA is more persistent, extending to phase 7. The transition from maximum negative to maximum positive anomalies over CESA is later and more abrupt in EN. The increase in frequency of extreme events over SESA in EN covers more extensive areas than positive precipitation anomalies. The teleconnection pattern between the subtropical central Pacific and the precipitation anomalies over SA in phases 8 and 1, reported by Grimm (2019) is stronger in EN years than in NT years.

The South American Monsoon System and the Madden Julian Oscillation

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ABSTRACT

The South American Monsoon System (SAMS) has been more studied in recent decades, especially relating to the modulation of the annual rainy season and the differences between summer and winter over South America. On the other hand, the Madden-Julian Oscillation (MJO) also shows a more pronounced signal during the austral summer months and is capable of influencing precipitation extremes associated with the South Atlantic Convergence Zone. In order to facilitate the detection, monitoring and prediction of this system, which is one of the typical features of SAMS, we evaluated the response of SAMS using the Multivariate Intraseasonal Rainfall Index to South America (MIRI.SA). This index can represent the effects associated with the MJO propagation and precipitation over the South American region, presenting more robust anomalies than the classical indexes used to characterize MJO. The MIRI.SA is composed of two scalar components, the first presents an atmospheric and precipitation pattern similar to that observed by the South American Summer Monsoon. Thus we selected two events considered to be intense for the first component of MIRI.SA, longer than 10 days and mean amplitude greater than ±3. We also evaluated the response of two S2S project models (ECMWF and NCEP) for these events and forecasts for 2, 3, 4 and 5 weeks in advance, and the ability of them to represent these events. Improving the diagnostic, prognostic and predictive capacity of the Summer Monsoon regime for South America is of crucial importance for sectors such as agriculture, energy and natural disaster management.

Case Study of Extreme Precipitation Event in Manaus Associated with the Monsoon Regime and its Predictability

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ABSTRACT

In the last decades, much has been studied about the monsoons of South America from a climatological point of view, where the causes of these monsoons have been sought and how they differ from well-studied monsoons such as those of India and South Asia. However, it remains to be understood more precisely how the extreme precipitation events associated with the active phase of the South American monsoon regime occur, in order to improve the prediction of these events through operational weather forecasting centers. In the present case study, the initial forecast for the city of Manaus (central Amazon region) was that of rainfall during the afternoon, but the intensity of this event was much higher than the numerical models initially pointed out, resulting in a precipitation of 110.0 mm in 5 hours which caused several damages to the city. Thus, the present work analyzed the set of meteorological data available in association with NCEP/NOAA reanalysis data in order to understand the predictive meteorological aspects for this type of event. Preliminary results showed west-southwest winds in the region, completely opposite to the east-northeast basic field, indicative of convergence in the region, but these west winds are not present in the meteorological station data or radiosonding. The analysis of the synoptic fields shows the action of a South Atlantic Convergence Zone, which causes organization of cloudiness and instability over the region, although during the forecasting time satellite images showed no evidence of extreme precipitation. In addition, with subsequent examinations made from the reanalysis data, the omega anomaly and wind divergence fields show upward movement and over-normal convergence in much of the area around the city, which may be a factor in common with other events of similar intensity.

Droughts in the South American Monsoon region

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ABSTRACT

Climate extremes have been observed with more frequency in several regions of the world. The understanding and prediction of these events are important issues that need to be addressed, not only for the interest of the scientific community but also from a socio-economic point of view. Droughts are examples of extreme events that affect the environment and the society. Periods with rainfall deficit perturb the agricultural production, livestock management and hydropower generation. The South American Monsoon System (SAMS), which has its mature stage in December-February, displays variability of the associated circulation features responsible for droughts or excessive rain. Recurrent droughts have been registered in January, the peak of the rainy season in large areas of SAMS, such as in 2014, 2015 and 2019. In the first two years, changes in the humidity fluxes, sea level pressure and atmospheric circulation were identified as the main drought drivers. These changes were related to tropical-extratropical teleconnections of atmospheric wave trains over the Pacific Ocean. In 2019, another drought took place in January, and the South Atlantic Convergence Zone, a system that belongs to SAMS, did not develop. Also, there were changes in the atmospheric circulation patterns that prevented the development of convection mechanisms over the region. The objective of this work is to analyze the atmospheric circulation patterns and the dynamic forcing of this case in order to explore similarities and differences with the other two cases, and explore how they can be monitored before the peak of the rainy season in the SAMS region.

CAUSE OF SEVERE DROUGHTS IN SOUTHERN PERU (1961 – 2016)

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ABSTRACT

The cause of severe droughts over the Southern Peru (SP) during the local wet season is investigated on the station rainfall data of the Peruvian Meteorology and Hydrology National Service and the Japanese 55-year Reanalysis (JRA-55) data during 1961 – 2016. The droughts are in general consistent with local anomalous descent in the middle troposphere and strong zonal westerlies winds across the Peruvian Andes. Among other regional forcings, the diagnosis of the vertical motion (omega) equation indicates that the local descent is primarily maintained by the anomalous cyclonic vorticity processes and minor action by cold temperature advection. A composite analysis shows the cyclonic circulation anomaly offshore and nearby the SP is induced by an anomalous jet off the coast of Peru which is controlled by remote forcing from the tropical Pacific. In this configuration, the SP zone is in the jet equatorward exit region, where downward motion is expected. During El Niño years, enhanced heating over the Equatorial Pacific Ocean (EPO) induces an strong upper-level tropospheric divergent dipole that enhances the moisture flux convergence to the east EPO alongside the anomalous equatorial Jet which in turn interacts with the Peruvian Andes increasing vertical cyclonic vorticity between 450hPa and 250hPa in balance with anomalous moisture flux divergence and subsidence over the SP where severe droughts occurred. Another possible route is through the South Pacific teleconnection, in which downstream Rossby wave energy propagation plays a crucial role blocking the normal eastern wind flow pattern across South America.

Seasonal changes of the South American monsoon system during the Mid-Holocene in the CMIP5 simulations

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ABSTRACT

The South American Monsoon System (SAMS) is the major climatic feature of the South America. The changes in the strength and life cycle of the SAMS, and the dynamical mechanisms associated, during the Mid-Holocene are investigated through simulations of ten Earth System Models. We observed that during the Mid-Holocene, the SAMS was weaker than in the present during austral summer, but stronger during austral spring. The increase of insolation during the austral spring contributed to a higher land-sea temperature contrast and an enhanced moisture flux to the continent, resulting in a strengthening of the upper-level atmospheric circulation and an increase of precipitation over the SAMS region, while the opposite occurred during the austral summer. These results suggest that the life cycle of the SAMS was altered, with an earlier onset and demise. Changes in precipitation and temperature near the Northeast Brazil indicated drier (wetter) conditions in the Mid-Holocene, in relation to the present, during the austral spring (summer), configuring a dipole pattern of precipitation between western Amazon and Northeast Brazil coast. Our results also showed a need for improvement of the models in order to better simulate the amount of precipitation over South America and the spring upper-level circulation over western Amazon, which are crucial for a more realistic representation of the SAMS. The reliability of the climate models simulations is crucial for future projections in a warming climate, which could modify the structure of the SAMS, impacting the precipitation amount, with potential serious societal consequences.

Atmospheric variability related to extreme summers precipitation over Rio de Janeiro State

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ABSTRACT

The Rio de Janeiro state plays a significant role in the economic activities of Brazil and has a large population contingent, which makes it really sensitive to climate conditions. Extreme climatological events, like severe droughts or anomalously rainy seasons, may cause losses in the agriculture, impacts in the electric energy system and in the water supply. The distribution of rainfall in the space and time are strongly influenced by the local atmospheric dynamics and by remote phenomena in various time and space scales. Therefore, the goal of this study is to identify main patterns of the atmospheric variability in the extreme precipitation summers (wet and dry) at Rio de Janeiro, between 1981 and 2010. The monthly means dataset used includes: precipitation from Global Precipitation Climatology Project (GPCP); ERA-Interim reanalysis from European Centre for Medium-Range Weather Forecasts (ECMWF); Sea Surface Temperature (SST) from Extended Reconstructed Sea Surface Temperature V5 (ERSSTv5) and interpolated outgoing longwave radiation from National Oceanic & Atmospheric Administration (NOAA). In this study, it was carried out an identification of the extremely dry and rainy summers, using respectively the 20% (very dry) and 80% (very rainy) quintiles of the precipitation averaged in the region of study. An analysis of the atmospheric features and the teleconnection patterns involving these extreme summers and their previous springs were made. Results obtained suggest that when a driest or rainiest summer occurs over Rio de Janeiro, the previous spring behaves oppositely. Extreme rainy (dry) summers are associated with the intensification (weakening) of SACZ. Extreme rainy summers are also defined by negative SST anomalies, i.e. La Niña conditions, in Niño 1 + 2, Niño 3 and 3.4 regions and with a negative SST anomaly dipole over Subtropical South Atlantic. In previous springs of extreme rainy summers, the La Niña condition is present only in Niño 3.4 region and, in the Subtropical South Atlantic, there is also a negative SST anomaly dipole, but, less defined than in the summer. The extreme dry summers are characterized by positives SST anomalies, i.e, El Niño conditions, at Niño 3 and Niño 3.4 regions, and with the presence of a positive SST anomaly dipole over Subtropical South Atlantic. This dipole is present in the previous springs too, as with a weak La Niña at Niño 3.4 and Niño 3 regions.

RAINFALL IN THE PERUVIAN AMAZON-ANDES ASSOCIATED WITH THE SOUTH AMERICAN MONSOON

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ABSTRACT

The rainfall period in the Peruvian jungle occurs from October to April, and coincide with the summer monsoon system, the strengthening of the Bolivian High, the displacement of the Intertropical Convergence Zone (ITCZ) and the low level jet, which together favor a substantial increase in rainfall on the western edge of the monsoon influence, due to the great transport of moisture from the Amazon basin and the tropics. In this study, six sub-regions of the Peruvian jungle have been differentiated: north, center and south, and each of these were divided into lowland (< 500 m.a.s.l.) and highland (> 500 m.a.s.l.) that interacts with the Andes; likewise, the climatology of 1981-2010 was used in most stations. From this analysis, it was found that largest accumulated occur between December-April; likewise, it was observed a well-defined spatial distribution from south to north and from east to west, according to average from January to March (austral summer): a) North highland jungle: 121 mm / summer, March the rainiest. b) North lowland jungle: 207 mm / summer, December and March. c) Central highland jungle: 310 mm / summer, January. d) Central lowland jungle: 304 mm / summer, December and February. e) South highland jungle: 852 mm / summer, January. f) South lowland jungle: Puerto Maldonado (Madre de Dios) with 297 mm / summer, December and January. Preliminary results indicate that rainfall occurs during the year in the jungle, and the largest accumulated rainfalls are observed between December-April. Likewise, a marked rainfall gradient was observed in the highland jungle from north (121 mm / summer) to south (852 mm / summer), while in the lowland jungle there is no clear gradient, which could be due to the scarce meteorological stations in the center and south. On the other hand, a significant gradient from east to west is notorious in the north and south, with a variation in the south approximate 550 mm/summer. This spatial and temporal distribution of the rainfall in the sub-regions are attributed to the monthly variability of the South American monsoon in conjunction with the other typical synoptic patterns of the austral summer, which are responsible for moisture transport, and the topographic factor also plays an important role.

Identification of Moisture Convergence Zone (MCZ) in a select cases during the South America Moonson System (SAMS)

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ABSTRACT

The objective of this work is show the criteria adopted in the CPTEC / INPE operational area to identify Moisture Convergence Zone (MCZ) that do not fully meet the criteria stipulated and recognized as SACZ (South Atlantic Convergence Zone) although can observed strong rain by a wide area from the south of the Amazon to the Southeast of Brazil, and can develop important role in the South America Monsoon System (SAMS) during the rainy season. Thus, we select some synoptic cases that shows this behavior. The results shows that some Moisture Convergence Zone (MCZ) have formed mainly by support at medium and high levels, without a clear and a convergent flow at 850 hPa and in phase with the lifting at 500 hPa. There are also situations where the stipulated minimum duration of the SACZ is not met. On the other hand, the flow in the low level has a new direction through Paraguay, northern of Argentina and South of Brazil, stimulated by another trough or a new cold front. Key words: SACZ (South Atlantic Convergence Zone), Moisture Convergence Zone (MCZ), rainy season

Preliminary evaluation of the seasonal forecasts of the Brazilian global atmospheric model during the rainy season of the South American Monsoon System

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ABSTRACT

The land surface is a fundamental component for the Numerical Weather and Climate Prediction models due to its control over the partitioning of energy and the water fluxes. The maximum influence of the land surface is observed tipically in the interval from weeks to months. Consequently, for seasonal forecasts, surface boundary conditions become a key determining factor. Furthermore, given that soil moisture has relatively longer memory when compared to the atmosphere, this variable exerts significant influence in the spinup of some prognostic variables at seasonal time scales. The main objective of this work is to evaluate seasonal forecasts during the rainy season of the South American Monsoon System (SAMS) using the operational version of the Brazilian Atmospheric Model (BAM) from CPTEC/INPE. The present study is part of a research that aims to understand the effects of soil moisture initialization on the BAM seasonal forecasts during the austral summer and its influence, mainly on South America. To reach that goal, seasonal forecasts will be made using persistent sea surface temperature anomalies, over the past 30 years (1988-2018). The period from November to March will be analysed, employing one initialization per month for periods of 9 months. The configuration adopted for the BAM is similar to the operational global deterministic model at CPTEC, with the following differences: Eulerian dynamic core; triangular truncation with resolution T0126L42 (approximately 111 km and 42 vertical levels); and initial conditions obtained from ERA-Interim reanalysis provided by ECMWF. The same reanalysis was also used as a reference to represent the observed states for evaluation of model performance and prognostics. The following statistical metrics were used for model evaluation: correlation coefficient, bias and RMSE. The Global Precipitation Climatology Project (GPCP) dataset was selected for precipitation validation as well as the Global Land Data Assimilation System (GLDAS) and South American Land Data Assimilation System (SALDAS) were used to assess the land surface states results. The preliminary results show that the main atmospheric features associated with the evolution of SAMS were well represented by the BAM, with slight differences in the intensity and location of the maximum values for some variables.

Connection between sea surface temperature and low-level geopotential height patterns in the South Atlantic Ocean

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ABSTRACT

The aim of this work is to study the relationship between sea surface temperature (SST) and the Atlantic High (AH) in the South Atlantic Ocean. Seasonal SST and geopotential height in 1000 hPa (HGT1000) from the NCEP/NCAR reanalysis were used for the 1981-2016 period and the 65°W – 20°E, 50°S – 0° domain. By using Principal Component Analysis in T-mode to seasonal anomalies for both variables, we obtained the independent modes of variability. Then, the patterns that explain more variance were correlated by using linear correlation to analyze the coupling between both variables and results were tested with a 95% level of confidence. Results have shown that during summer and spring, an intensification of the subpolar lows in southern South America is associated with a dipole of warmer SST in the central and north region of the basin and colder to the south. On the other hand, during autumn the opposite SST dipole can be found associated with intensified subpolar lows. Finally, during winter, positive anomalies of HGT1000 over the Argentinian coastline are connected to colder SST in the center of the South Atlantic basin and warmer SST over Africa's and South America's coasts.

Spatio-temporal variability of WRF precipitation associated with the regional and local circulation in the Tropical Andes (Rio Santa Basin, Peru)

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ABSTRACT

The estimation of precipitation in Tropical Andes is challenging for the low temporal scale of satellite data and the limited number of in-situ measurements. The precipitations patterns in the Tropical Andes region is important especially in the Santa Basin where the agriculture, hydrology, and glacier formation are strongly influenced for this variable. The variability of rainfall in the basin is associated with the large-scale circulation that makes up the South American monsoon establishing the weather conditions in the tropical summer. Satellite (product 3B42 of Tropical Rainfall Measuring Mission), in-situ observations and atmospheric model outputs (WRF-Weather Research and Forecasting), are compared for the austral summer (DJFM) to evaluate the temporal and spatial distribution of precipitation that is the main objective. ERA5 reanalysis data is used to drive one domain with a horizontal grid size 5km. ERA5 data with 30km of horizontal grid size allow getting high-resolution simulation without applying to nest in the WRF which is convenient to computational cost. In addition, different parameterization schemes are applying to the simulations to evaluate the differences between each other. WRF simulations overestimate the precipitation while reproducing correctly the longitudinal precipitation patterns between the Amazon, convective rainfall over the Andes and dry conditions in the coast in Peru. The precipitation is more intense over the basin valley during the night by the influence of east flux that transports the moisture from the Amazon. The intensification of this flux is associated with the presence of strong northerly winds in the east side of the Andes. The study demonstrates that different experiments show different patterns of large-scale circulation that are strongly associated with the adequate simulation of the precipitation diurnal cycle in the basin by the model. The presence by Goddard (microphysics), Betts-Miller-Janjic (cumulus parameterization) and Mellor–Yamada–Nakanishi–Niino Level 2(planetary boundary layer) improve considerably the simulation of the precipitation diurnal cycle, representing more parallel winds in the east of the Andes. In contrast, the other experiments simulate perpendicular winds to the east side of the Andes, showing the maxima precipitation many hours late compared to observations by meteorological stations.

Precipitation variability over subtropical Argentina linked to SALLJ changes

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ABSTRACT

The South American low level jet (SALLJ) plays an important role in moisture transport from lower tropical latitudes towards subtropical Argentina at daily scales. Since SALLJ is responsible for much of the available water for precipitation in the Argentine subtropics, studying SALLJ variability is key to understand precipitation variability there. Several studies have identified SALLJ events over tropical locations in which their frequencies peak, such as in the cities of Santa Cruz and Mariscal. This work aims at studying daily SALLJ events further extended into the subtropics to examine their differential influence on precipitation in subtropical Argentina. Four different localities were proposed to identify daily SALLJ events using ERA-Interim reanalysis nearest grid-points : one at San Salvador de Jujuy City (Jujuy Province, Arg.), another at Rivadavia City (Salta Province, Arg.), another near at Asuncion City(the Capital of Paraguay) and one near at Puerto Iguazu City (Misiones Province, Arg.). The locations widely represent the subtropics from east to west, and are close to available weather stations for verification of results. For each location, SALLJ day events were identify using a specific criterion on low-level winds intensity and persistence. Once established their mean monthly frequency, those months with high frequencies are further examined by compositing different meteorological parameters along through all SALLJ events within month.

Subseasonal prediction of active and break episodes of South American monsoon

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ABSTRACT

The monsoon system in South America (SA) is characterized by a seasonal reversal in zonal wind anomalies, and an annual cycle of precipitation of large amplitude (six dry months and six rainy months). During austral summer (rainy season) there is notable increase of rainfall in central SA, but monsoon precipitation in this region undergoes subseasonal variability, with "active" phases (rainy periods) and "break" phases (dry periods). We evaluate the performance of the model of ECMWF (European Center for Medium-range Weather Forecast) in predicting such phases up to four weeks in advance, using its reforecasts and observed weather data, in the period 1999-2010. The phases of the monsoon are defined by an index given by the daily rainfall anomaly area averaged over the core monsoon region, in 10º-20ºS; 45º-55ºW, where the rainfall is intense and its subseasonal variability is significant. The active and break days are defined by index values greater than or equal to (less than) one daily standard deviation. Another index is also described, based on the zonal wind at 850 hPa, in the region 7.5º-17.5ºS; 50º-60ºW, where its correlation with the rainfall index is higher. Composite anomalies of rainfall and low-level zonal wind, in the days of active monsoon for observed and predicted data can remain similar till lead times of respectively two and four weeks. There is skill in reproducing the observed modulation associated with active and break phases up to week 3. The ability of the model in reproducing the important role of Madden-Julian Oscillation (MJO) in the variability of the monsoon rainfall is verified through the proportion of active and break days in each phase of MJO in the observed data and in the model reforecasts with different lead times. Also the correlation coefficient between weekly mean monsoon index rainfall and 850 hPa zonal wind in predicted and observed data is analyzed. The results obtained for the monsoon index based on the zonal wind are better than for the rainfall index. Such correlations show acceptable skill until the third week, showing potential for obtaining better predictions that the current ones.

VALIDATION OF THE TURBULENT FLOWS OF LATENT AND SENSITIVE HEAT IN THE SIMULATIONS OF REGCM4.7

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ABSTRACT

The Regional Climate Model (RegCM) is an integral model of CORDEX and its version 4.7 is being used for physical process studies as well as for the generation of future climate scenarios. In this context, the simulations are being analyzing in which this model was directed with the ERA-Interim. Among the different validations, one is for the flows of latent and sensitive heat in the ocean and continent. For this will be used flow data of the ERA5 and Woods Hole Oceanographic Institution (WHOI). The projections with RegCM4.7 are being nested to three global climate models (MPI-ESM-MR, HadGEM2- ES and NorESM), and the periods of study will be: present climate (1979 to 2005) and climate of the next future (2020 to 2050). The scenarios considered are RCP2.6 and 8.5. Keywords: Latent and Sensitive Heat Flows, RegCM, South America.

SACZ associated with extreme Rainfall in the Southeast Brazil: Synoptic Analyses and ensemble forecast evaluation

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ABSTRACT

The seasonal cycle of precipitation in Brazil has monsoon characteristics since more than 50% of total annual precipitation occurs during the austral summer (Gan et al., 2003). The South Atlantic Convergence Zone (SACZ) is the mainly agent of heavy rainfall in the Southeast Brazil in the summer season (Carvalho et al., 2002; Dereczynski et al, 2009; Seluchi and Chou, 2009). The aim of this study is to analyze the characteristics and the predictability of 8 cases of SACZ associated with heavy rainfall in the Paraiba do Sul River Basin (PSRB), in Southeast Brazil. First, the synoptic characteristics of each event are described and the damages caused are presented. Second, an evaluation of the Eta-5km ensemble forecasts is made. The ensemble consists of four members with different convective and microphysics parametrizations. The evaluating scores used are the Categorical BIAS and the Equitable Threat Score. Furthermore, we present the standard deviation, the time correlation and the Root Mean Square Error, showed trough the Taylor Diagram. The synoptic analysis shows that the presence of a cyclonic vortex embebed in the SACZ circulation is an important feature to promote intense rainfall and consequently extreme events. The evaluation of the Eta-Ensemble shows that it has the 48h-simulations present slightly better performance than the 72h-simulations. The members using BMJ parametrization are better to simulate the precipitation´s spatial distribution, while members using KF are better to simulate heavy precipitation totals. In general, the CNTRL member presents better results, followed by the ensemble mean. Finally, we conclude that these Eta-5km members are useful to predict intense rainfall events over PSRB.

The monsoon regime in several regions of the Brazilian Western Amazon

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ABSTRACT

The South American monsoon system is defined by the great difference between winter and summer precipitation, similar to other regions of the world (Rao et al., 1996). Silva and Kousky, 2012 performed a study using reanalysis data of several models for an area that comprised 12.5 S to 17.5 S and 47.5 W to 52.5 W. In the article the average daily precipitation and the temperature at 850 hPa were plotted, showing clear precipitation versus dry regimes and the increase in temperature in this season. Using the same method, but with INMET climatological data (1981-2010), were plotted for eleven locations in the state of Amazonas and two locations in the state of Roraima. The results show that the stations in the northwest of the state (São Gabriel da Cachoeira, Fonte Boa) do not present dry season, not characterizing a monsoon regime. To the west and south of the state, the stations of Benjamin Constant, Eirunepé and Labrea have a well-defined dry season; however, due to the entry of cold air from high latitude systems, the lowest recorded temperatures are in the winter, June and July. The station in central and eastern Amazonas state (Tefé, Coari, Barcelos, Manaus, Parintins and Manicoré) show a characteristic monsoon regime, with a well defined dry and rainy season with the lowest temperatures recorded in the rainy season and the highest in the season dry season, with Parintins and Manaus respectively presenting 12 mm/day in the rainy season and 3 mm/day in the dry season with daily average temperature ranging from 27 C in rainy months increasing from July, from 29 C in October. In the state of Roraima, the stations of Boa Vista and Caracaraí, the monsoon pattern is also well visible, but with an inversion in the period of the year, with the dry season concentrating in the austral summer months, with high temperatures and the rainy season from May to August. The characterization of the monsoon regime for the different localities of the states that compose the Western Amazon is fundamental for the improvement of the weather forecast and also for the monitoring of extreme events of precipitation.

The Impact of Concave Coastline on Increasing Rainfall Offshore Over Indonesian Maritime Continent

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ABSTRACT

The Indonesian Maritime Continent has the second longest coastline length in the world after Canada, but the characteristics of coastal rainfall and coastline influences on coastal rainfall to date are not clearly understood. As an area with eighty percent area of the ocean, knowledge of impact coastline to coastal rainfall is very important to support coastal activities. There are 816 ports with around 2 million fishermen that always need marine rainfall information. This research uses WRF-ARW to simulate the impact of convace coastline to rainfall offshore and 15 year TRMM data to analysis characteristic of rainfall distribution and convective activity. The result show that the direction of the concave coastline has a significant influence on monthly convective activity. Peak convective activity on concave coastlines facing the north occurs during boreal winter while facing east concave coastlines during the boreal summer season. Concave coastline has increasing rainfall intensity than adjacent area. Cendrawasih Bay has highest rainfall intensity because it has ideal size of concave coastline and highest mountain arround oceans. Shifting of low level convergence and cool pool system induced convective more active during night until morning time over concave coastline. Squall line is a dominant mesoscale system that develops over the concave coastline with speed of movement approximately 5.4 m/s.

Atlantic Multidecadal Oscillation (AMO) relations with the South Atlantic Convergence Zone (SACZ): past variations and future projections

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ABSTRACT

The South Atlantic Convergence Zone (SACZ) is a phenomenon that directly affects the economic system of Brazil, since it acts on the main Brazilian cities, which are located in the Southeast (SE) region of the country, because it is the main system responsible for precipitation (PREC) during the period of austral summer. Using the historical simulation of the Brazilian Earth System Model, v. 2.5 (BESM-2.5), three periods of 30 years (1906-1935, 1936-1965 and 1966-1995), and climatology (1976-2005) were divided. It is verified that the period of 1936-1965 was characterized by low precipitation over the SE region of Brazil, when applying correlation tests, significant results were found between the Brazilian SE with the Sea Surface Temperature (SST) of North Atlantic (AMO) and the North Pacific (PDO). Unlike the other periods analyzed, the period of 1936-1965 showed no correlation with the equatorial region of the Pacific. In other words, the association of the positive phase of the AMO, with a change from the positive phase to the negative phase of the PDO, together with the absence of significant El Niño South Oscillation (ENSO) phenomena, contribute to the reduction of the PREC on the SE of Brazil. Analyzing the future projections of the BESM, using as basis the scenarios RCP4.5 and RCP8.5, a significant increase of the extreme events of PREC, as well as an increase of the consecutive days of PREC. However, for future climatic conditions, in addition to the North Atlantic Ocean, the Pacific and South Atlantic oceans are of much greater importance on the SACZ, maintaining a decadal pattern of variability. This influence occurs mainly due to the increase of SST (reaching 10 °C above the current climatology in scenario RCP8.5 during 2076-2105) on the oceans of the Southern Hemisphere.

Evaluation of the Sea Surface Temperature anomalies in the Subtropical South Atlantic Ocean region

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ABSTRACT

The Sea Surface Temperature (SST) of the Atlantic and Pacific Oceans affect the climate in various regions of South America (SA). In the last few years, a persistent positive SST anomaly has occurred over the Subtropical South Atlantic Ocean. The focus of this study is to analyze this anomaly and its influence on the SA climate. The monthly means dataset used includes: SST from National Oceanic and Atmospheric Administration (NOAA) Extended Reconstructed SST V5; precipitation from Global Precipitation Climatology Project (GPCP) and air temperature, Sea Level Pressure (SLP) and geopotential height from Era-Interim Re-Analysis from European Centre for Medium-Range Weather Forecasts (ECMWF). For all datasets, the period used was 1981-2018. For each variable, the anomalies correspond to the difference between the monthly values and climatological means (1981-2010) of the corresponding month. Time series graphics of the SST anomalies averaged at Subtropical South Atlantic confirm that there is an increasing tendency of SST in all seasons. Anomaly composites for the period 2014-2018 indicate that this SST increase affects the climate in the Subtropical South Atlantic region and in the AS. In this SST positive anomaly region, the composites show a low-level air temperature increase in all seasons; a positive SLP dipole in the summer and positive (negative) SLP anomalies in the autumn and winter (spring). Theses anomalies over the ocean might impact the SA Monsoon, which is confirmed by negative precipitation anomalies in Southeastern Brazil during summer. An extension of this study is to investigate if this SST increase is influencing the meteorological systems that affect SA Monsoon, for example, in the frequency of cyclogenesis, South Atlantic Convergence Zone and blocks.

Discussions

Summary of the topics discussed in the sessions and of needs for future work

a) About observational studies:

Establishment of fundamental questions.

Understanding the processes of onset and demise.

Verifying the influence of multidecadal variability (PDO, AMO) on the lifecycle of American monsoons.

Develop more studies of features linked to SAMS and NAMS- Subtropical Atlantic Highs, cross equatorial propagation of humidity flux, wave propagation, Atlantic and Pacific SST.

Develop more studies of relations between SAMS changes and NAMS changes.

Importance of synoptic systems on the monsoons variability.

Importance of extratropical influences.

Identify the main characteristics of Monsoons, considering the background of PDO and AMO – observations and models.

Interannual timescale: importance of teleconnections –tropics- extratropics.

Origin of the variability in bands of different frequencies.

Influence of the stratosphere- Study of stratosphere X troposphere interactions.

Influence of SST near the coast.

Study important mechanisms shaping the pick of SAMS: Spring to Summer relations- land X atmosphere interactions - fluxes, influence of topography, regional features.

MJO influences and local forcings.

Local conditions X large scale (remote control).

Study of diurnal cycle (surface conditions) X intraseasonal.

More studies on the role of multidecadal variability (PDO, AMO) on ENSO and SAMS and NAMS.

Propose a set of metrics for ONSET- DEMISE.

Study the surface processes- latent heat fluxes.

Analyze other areas of the monsoon – not only the core or central areas.

Analyze large scale changes related to global warming or natural variability.

More studies on LLJ and American monsoons.

Main changes in the SAMS and NAMS characteristics due to low frequency variability.

Analyze relations between higher frequency and intraseasonal variability.

Importance of Biosphere to Climate- Water cycle and the importance of the rainforest to understand SAMS.

Analyze the precursors of Monsoons- can use statistical predictions – use the knowledge of mechanisms to predict.

Analyze NAM + SAM as a system instead of individual monsoons.

Elaborate a big picture of the processes associated with SAMS and NAMS.

b) About modeling studies

Models reproduce the main features of American Monsoons.

Models reproduce teleconnections such as ENSO, Rossby waves patterns –PSA, PNA, annular modes in interannual, intraseasonal and multidecadal timescales.

Some models reproduce the MJO phases.

How models reproduce Atlantic and Pacific ITCZ? SACZ? Position and intensity.

Models have good performance in NE and South Brazil/ Uruguay, but low skill over Southeast – where the SACZ is.

How the models reproduce the processes- what physical processes need to be improved?

Modelling studies to analyze the models biases.

How the models reproduce the cross-equatorial flow?

How the models reproduce the origins of the variability in bands of different frequencies?

Extreme conditions are challenges in climate models – importance of right physical processes in the models.

Establish a hierarchy of models to understand the processes.

Identify the different processes that regulate the SACZ dynamics- which one dominates (remote, local)- isolate the processes – use simple models to study the processes. Use of ocean slab model

Analyze the predictability of low frequency variability- use dynamics and statistics to predict.

Rossby waves are more predictable- existence of Rossby waves propagation around the globe.

Study the important features of SAMS and NAMS: Atlantic Subtropical Highs, humidity fluxes in models.

How the models reproduce the atmospheric circulation in the Onset and Demise?

What indices the models reproduce well?

Monsoon features- How they change? Model simulations reproduce the patterns of SAMS and NAMS changes in a warming climate?

Need of improvements of diurnal cycle, improvements in the values of precipitation (reduce bias)

Do models reproduce PDO and AMO?

Investigate the lack of skill in the maritime continent- Which parameterizations should be investigated? Radiation, convection, surface processes?

With respect to NAMS, CORDEX is the first intercomparison for the Mexican monsoon region. Need of analyses to understand the biases.

In the SAMS, the tendency for reversal between Spring and Summer is not reproduced by the models (problems in land-atmosphere interactions?). Why is it not reproduced? Models show persistence, nature shows reversal. What are the processes to investigate? Terrestrial hydrology? Topography? Fluxes?

Analyze the reversal of precipitation pattern from Spring to Summer in model results- experiments to study the land-atmosphere interactions. Use Earth system models, regional models, ocean coupled regional models

c) Applications

Translate results to applications.

Can we take advantage of the latest datasets, including remote sensing, learning from the observations to produce a new product that can be useful?

Use of combined observed data X knowledge can be other kind of information to users.

Separate model results for research from model results to predict (research X operation).

Practical use of the models requires the evaluation of the models for specific variables/regions etc. depending on the user needs (operational use vs. climate studies).

Active and break phases are important information to stakeholders, mainly for agriculture and energy sectors.

There is a need to explore new ways of collaboration among institutions and to establish actions to strengthen the interactions between the academia and operations.

There is a need to provide more information to users- how to interpret the results, mainly with relation to probabilities and uncertainties.

Proposals

Propose a field experiment: South American Monsoon System Experiment - SAME (similar to NAME) to answer some questions about the features in the monsoon.

Propose a second workshop in two years' time in a place of NAMS, to involve more students and researchers in the subject of American Monsoons.

Publish results of the workshop (BAMS).

The group could work on a paper about the Big Picture of American Monsoons.