American Monsoons Working Group

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The list of priority scientific regional issues include:

a) Exploiting the S2S database for the South American monsoon, in order to assess its possibilities for subseasonal prediction of several aspects of the American monsoons. In this regard, assess the skill of S2S participating models in:

a.1) simulating the MJO impacts on the American monsoons, regarding precipitation anomalies and associated teleconnections;

a.2) predicting the onset and demise of the monsoons;

a.3) predicting active and break periods of the monsoons;

a.3) predicting extreme events in densely populated regions during the monsoon season.
Goals II

The list of priority scientific regional issues also includes:

b) Development of metrics (indices) for active/break periods onset/demise of the monsoon, which are more skilfully predicted by the models and which provide dynamical linkages, so as to give some insight into model error.

c) Provision of some demonstration forecast products.

d) Assessment and attribution of climate variability and predictability on intraseasonal, interannual and interdecadal time scales, analysing the large-scale influence with its teleconnections, as well as local forcing mechanisms; evaluation of CMIP5 and/or future CMIP6 models in this regard on interannual and interdecadal time scales. Assessment of the relationship between climate variability and extreme events.
Other activities of the WG could include:

a) Collate existing knowledge and evidence of past monsoon activities in the region (e.g. relevant VAMOS work and CLIVAR Exchanges articles, white papers etc.);
b) Organize meetings of the WG during certain key congresses;
c) Organize sessions on American monsoons in these congresses;
d) Propose and/or contribute to training workshops;
e) Contribute to regional climate forecasts.
Other suggestions

1. Key meetings of interest that the WG or Panel could contribute to:
   - Brazilian Meteorological Congress
   - American Meteorological Society Annual Meeting
   - American Geophysical Union Fall Meeting
   - European Geophysical Union Annual Assembly
   - IUGG or IAMAS Meetings

2. Anything that the Panel or ICMPO can assist with or coordinate:
   - A workshop on South American monsoon;
   - Meetings of the WG to discuss about the proposed activities.
Annual cycles of precipitation

From Grimm 2011

From Vera, Higgins, Amador et al. 2006
General features of the SAMS

- In austral summer, a thermal low-pressure system intensifies over the Chaco region.
- The tropical northeasterly trade winds are enhanced.
- Cross-equatorial flow penetrates SA, becomes northwesterly at the Andes foothills, is channeled southward, and turns clockwise around the Chaco low.
- Low-level wind and moisture convergence associated with the interaction between the continental low, the South Atlantic high and the northwesterly winds result in enhanced precipitation in the Amazon, and Central and Southeast Brazil.
The onset of the convection is controlled by changes in the thermodynamic structure related to the moistening of the boundary layer and the lowering of temperature at its top.

They are brought about by changes in large-scale circulation that enhance low-level moisture convergence into the region, particularly a southward enhancement of the cross-equatorial flow.

The land surface warming increases the gradient of land-ocean temperature and drives the seasonal changes of circulation.

Changes of circulations are largely controlled by the SST in the adjacent oceans and southern Amazon.
Although the large-scale circulation patterns associated with the SAMS are driven by large-scale distributions of sensible and latent heating, with the Andes Mountains and other orographic features playing an important role in the dynamics of the monsoon system, there are numerous synoptic and mesoscale features embedded within these large-scale circulation patterns. These features are responsible for the day-to-day weather and high impact rainfall events. Extreme rainfall events that affect the most populous regions in South America are most frequent in the summer monsoon season.
Contribution of synoptic and intraseasonal timescales to total variance of summer rainfall

Synoptic variability

Intraseasonal variability

Ferraz and Grimm 2004
The Role of Synoptic and Intraseasonal Anomalies in the Life Cycle of Summer Rainfall Extremes over the SACZ
The role of synoptic and intraseasonal anomalies in the life cycle of summer rainfall extremes over South America

Fernando E. Hirata & Alice M. Grimm

Abstract The main goal of this study is to describe the role of synoptic and intraseasonal anomalies during the life cycle of summer rainfall extremes over South America. Eastward-propagating synoptic-scale midlatitude waves are the main drivers of extreme precipitation events south of the Amazon and their interaction with intraseasonal anomalies over South America is important for heavy rainfall over the South Atlantic convergence zone (SACZ) region and the La Plata basin. Madden-Julian Oscillation (MJO) convective activity in the western Pacific (phases 6 and 7) leads 31 out of 81 extremes over the SACZ region by nearly 10 days. The connection between the MJO and rainfall extremes in other regions is less robust. During El Niño seasons extremes are more frequent in the La Plata basin, with decreased importance of intraseasonal anomalies. Precipitation extremes over the La Plata basin tend to be less frequent and also shorter during La Niña summers and, consequently, less hazardous. In the SACZ and the southeastern Brazilian coast, heavy rainfall is also more frequent under El Niño conditions, while La Niña episodes also increase extreme events in the southeastern coast. Extremes over the southeastern coast during El Niño are favored by strong intraseasonal anomalies flanking the subtropical jet, while during La Niñas intraseasonal anomalies are not significant.

Keywords Precipitation - Extreme events - Synoptic disturbances - Intraseasonal variability - South Atlantic convergence zone

1 Introduction

Intense precipitation events cause severe floods and mudslides in densely populated regions of South America and affect thousands of people during the warm season (Cavalin et al. 2012). Forecasting those extremes is a difficult task. State-of-the-art numerical weather prediction systems and statistical techniques still face many problems when dealing with amplitude, timing and location of rainfall extremes (e.g., Saavedra et al. 2006; Dolfin and Nobre 2012). Cavalin et al. (2012) reviewed large scale mechanisms and synoptic features associated with extreme precipitation over South America and highlighted the importance of frontal systems and the South Atlantic convergence zone (SACZ) in producing excessive rainfall across the continent. The SACZ is usually defined as a band of deep convection oriented in the northeast-southwest direction and extending from the Amazon to the southwestern Atlantic (Fig. 1). Nearly half of heavy rainfall events are caused by frontal systems and the other half, by the SACZ (Lima et al. 2010). Seko and Chen (2000) showed that anomalies in the southeastern (SE) Brazilian coast are caused by frontal systems or the SACZ.

Over the La Plata basin, Zipser et al. (2006) identified some of the most intense thunderstorms in the world. Large mesoscale convective systems are frequent during the warm season over the basin (Pereira et al. 2010). A northerly low-level jet over Paraguay and a continental thermal low over northern Argentina are usually associated with heavy rainfall over southern Brazil (Tenerani and Satyamurti 2007). Intense precipitation over the La Plata basin is associated with a midlatitude wave in the upper levels and southerly moisture flux from the Amazon, while events over the core of the South American monsoon region (which includes the SACZ) are linked to similar, long-lasting patterns and an eastward shift of the low level jet (Silva and Berbery 2006).
Methods

Data used: The CPC Unified Gauge-Based Analysis of Global Daily Precipitation dataset at 0.5° horizontal resolution, and NCEP reanalysis data, at 2.5° horizontal resolution, are used to define precipitation extremes and to characterize their synoptic evolution from 1979 to 2013.

An extreme precipitation event is defined whenever the area-averaged rainfall rate exceeds the 95th percentile for at least one day (~17 mm/day).

Anomaly composites of several atmospheric fields, from 5 days before to the day of maximum rainfall, are calculated and the significance is assessed.

Computation of the climatological zonal stretching deformation (zonal variation of the summer climatological zonal wind, $\partial \bar{U} / \partial x$) at 200 hPa, which is related to the longitudinal (zonal) wavenumber of synoptic Rossby waves propagating eastward and wave energy density by Webster and Chang (1988). Negative zonal stretching deformation increases the longitudinal wavenumber, which leads to a reduction of the longitudinal wave speed and increases wave energy density (wave accumulation). This results in intense convective activity that forms the diagonal cloud band characteristic of the SPCZ (Widlansky et al., 2011).

To assess the contribution of synoptic and intraseasonal variability to extreme events, a band-pass Lanczos filter is used to split 200 hPa geopotential height in two frequency bands: synoptic (3-10 days) and intraseasonal (20-90 days).
Results SACZ (A)
Results SACZ

Composites of synoptic evolution of extreme rainfall events in the SACZ for days -4 (a), -2 (b) and day 0 (c), during neutral ENSO summers. Shading represents SLP anomalies, arrows represent 850 hPa anomalous wind vectors (only vectors significant at 95% are plotted), and red contours represent SLP significance (95%). Figure (d) displays the area-averaged 95th percentile rainfall rate (green), the 95th percentile + 5 mm day$^{-1}$ (yellow), and the 95th percentile + 10 mm day$^{-1}$ (red) on composite day 0.
Panels a-c: shading are 200 hPa geopotential height anomalies, with red contours indicating significant anomalies at 95%. Blue contours is 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. Panels d-f: shading represents 200 hPa \(\bar{U}\), and the contours represent filtered 3-10-day (blue) and 20-90-day (red) 200 hPa geopotential height anomalies at 10 m intervals.
MJO influence on SACZ extremes

(Left) Composite cycle of intraseasonal OLR anomalies, from day -10 to day 0 for SACZ extreme events during neutral ENSO phases. Magenta (green) lines represent negative (positive) anomalies. Contour interval is 2.5 Wm\(^{-2}\). These anomalies are reminiscent of phases 7, 8 and 1 of MJO.

(Right) 39% of all SACZ extreme events are preceded, 10 days before, by MJO convection on phases 6 and 7, especially phase 7.
Intraseasonal variability
MJO impact on South America

Observations
(and model simulations)
(Grimm, 2016, in preparation)
(The slides of this section were shown in the presentation at the Monsoon Panel Meeting, for discussion, but are not included in this file for the webpage)
MJO impact on South America

Simulated by models CFS v2 and ECMWF Reforecasts 1999-2010

(Grimm et al., 2016, in preparation)
(The slides of this section were shown in the presentation at the Monsoon Panel Meeting, for discussion, but are not included in this file for the webpage)
Connections between intraseasonal monsoon variability in South America and Southeast Africa

(Some slides of this section were shown in the presentation at the Monsoon Panel Meeting, for discussion, but are not included in this file for the webpage)
Precipitation regimes

South America

(S Grimm, 2003, J. Climate; Grimm, 2011, Stochastic Environmental Research and Risk Assessment)

Southeast Africa

Climatología (1974-1999)
Correlation between daily precipitation anomalies in summer and winter (1970-1999), in southern Africa and over South America (grey boxes with data), both filtered by a 20-90 day bandpass filter, using lags from 0 to 10 days for the southern Africa rainfall, show significant connection with rainfall over South America 4-5 days before, in regions with high precipitation in these seasons.

Grimm, A. M. e C. J. C. Reason, 2015: Intraseasonal teleconnections between South America and South Africa. *Journal of Climate*, v. 28, n. 23, 9489-9497. DOI: 10.1175/JCLI-D-15-0116.1

In this study, the analysis is extended to southeast Africa, including Mozambique, and connected with the Madden Julian Oscillation impacts over South America and Southeast Africa.

Some slides of this extended analysis are excluded from this file for the webpage
Selected regions in Southeast Africa and their lagged correlation with daily precipitation over South America in austral summer.
Summer Box 3
Observed anomalies
Simulation

Anomaly composites for the days of positive phases in Box 3, in summer: (a) OLR; (b) 200 hPa streamfunction; (c) OLR 5 days before; (d) vertically integrated moisture flux and its divergence. Shades indicate confidence levels higher than 90% for negative (positive) anomalies. (e) Influence function for action center 4, whose values in each location are proportional to the streamfunction response at the target point to a unitary upper-level divergence anomaly in this location. (f) Anomalous 200 hPa prescribed divergence and (g) corresponding streamfunction. (Grimm and Reason, 2015, J. Climate)
Significant correlation between South America and South Africa rainfall


(Upper panel) Selected regions and annual cycles of precipitation in South Africa. (Central panel) 1 degree boxes in South America with precipitation significantly correlated to lagged precipitation (5 days) in selected region 1 in South Africa. Dark squares (triangles) indicate confidence level higher than 90% for positive (negative) correlation; open squares (triangles) are for confidence levels between 85% and 90%. Ellipses indicate regions with maximum correlation. White areas are void of data. (Lower panel) MJO related anomalies for Phase 8.
Summary and conclusions

- Teleconnections exist between South American rainfall variability and that of various South African regions. The mechanisms by which these teleconnections occur involve the generation of wave trains across the South Atlantic that then impact on regional circulation and moisture flux convergence over South Africa. There are also an anomalous Walker type circulation in the tropical Atlantic region, associated with anomalous tropical convection.

- The strongest relationships between the intraseasonal variability of South American and South African rainfall exist at lags of 4-5 days of the South African rainfall behind that over South America. This aspect then suggests that there may be some possibilities for improving forecasting skill of wet and dry spells over South Africa based on near real-time monitoring of rainfall upstream over South America.

- Analysis of precipitation and circulation anomalies during certain phases of the Madden-Julian Oscillation indicate that these teleconnections are responsible for the MJO impacts in southeast Africa, especially for producing anomalous rainfall in phases 8 and 1.