INTRASEASONAL EVOLUTION OF INTERANNUAL VARIATIONS OF SOUTH AMERICAN SUMMER MONSOON

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1. Introduction

There is not yet a well defined picture of the El Niño/La Niña (EN/LN) impact on summer rainfall in Brazil and there seem even to be some discrepancies between different studies. Grimm et al. (1998, 2000) showed that the impact in summer is much weaker than in spring over southern Brazil, and there is even a tendency to anomalies of reverse sign in January. Lau and Zhou (2000) argue that the monsoon circulation enhances in DJF along the eastern foothill of the Andes, the Bolivian high is stronger, the rainfall intensifies and shifts poleward (southern Brazil, northern Argentina). According to Robertson and Mechoso (2000), there is no ENSO related variability in the JFM circulation mode associated with the SACZ variability.

If the South American monsoon circulation is influenced by the latent heating over Amazonia, then this circulation must be impacted by the decrease (increase) of the convection there during EN (LN) events.

The present study seeks to give a comprehensive view of the EN impact on summer precipitation over Brazil, and to characterize the mechanisms responsible for this impact, so that partial views can be understood as part of a more general picture and eventual discrepancies can be explained.

In order to get a consistent picture of the EN impact on summer precipitation, a higher temporal resolution than seasonal means is used, because there is a significant subseasonal evolution in this impact. The seasonal means smooth out the subseasonal variation and diminish the magnitude and consistency of anomalies that last for less than a season.

2. Data

The impact of EN events on precipitation is analyzed using monthly precipitation totals from more than 1000 stations in the period 56-92, selected to span at least 5 EN. The anomalies of atmospheric circulation are analyzed with the NCEP/NCAR Reanalysis data from 1963 to 1992.This different period was chosen because many of the raobs series in the region started after 1963.

3. Methods

a. Impact of El Niño on precipitation:

The EN-related median precipitation is calculated for every station for each month of the summer and for whole season (DJF). This amount is expressed as a percentile of the gamma distribution for each station and a map of percentile isolines is generated.

b. Consistency of the impact

To test the consistency of the relationship EN-wet conditions of a population that contains r EN episodes and k of them are dry, the probability of obtaining more than k dry cases in a sample of *r* episodes taken at random from this population is computed (i.e., the cumulative probability of obtaining *k*+1, *k*+2, ..., up to *r* dry cases). This will give the significance level of this relationship. The hypergeometric distribution gives the probability of obtaining *p* dry (wet) episodes in *r* trials from a population of n_1 dry and n_2 wet samples.

c. Mechanisms of precipitation

The mechanisms responsible for precipitation anomalies are sought through an analysis of perturbations to the essential ingredients of precipitation: moisture source and the force to lift the moist air to the condensation level (dynamic lift via upper-level winds, thermal forcing, large scale divergence/convergence). Composites for EN events of anomalies of moisture flux and its divergence (vertically integrated), and the rotational and divergent components of the wind at 850 and 200 hPa show perturbations in these ingredients.

4. Results and discussion.

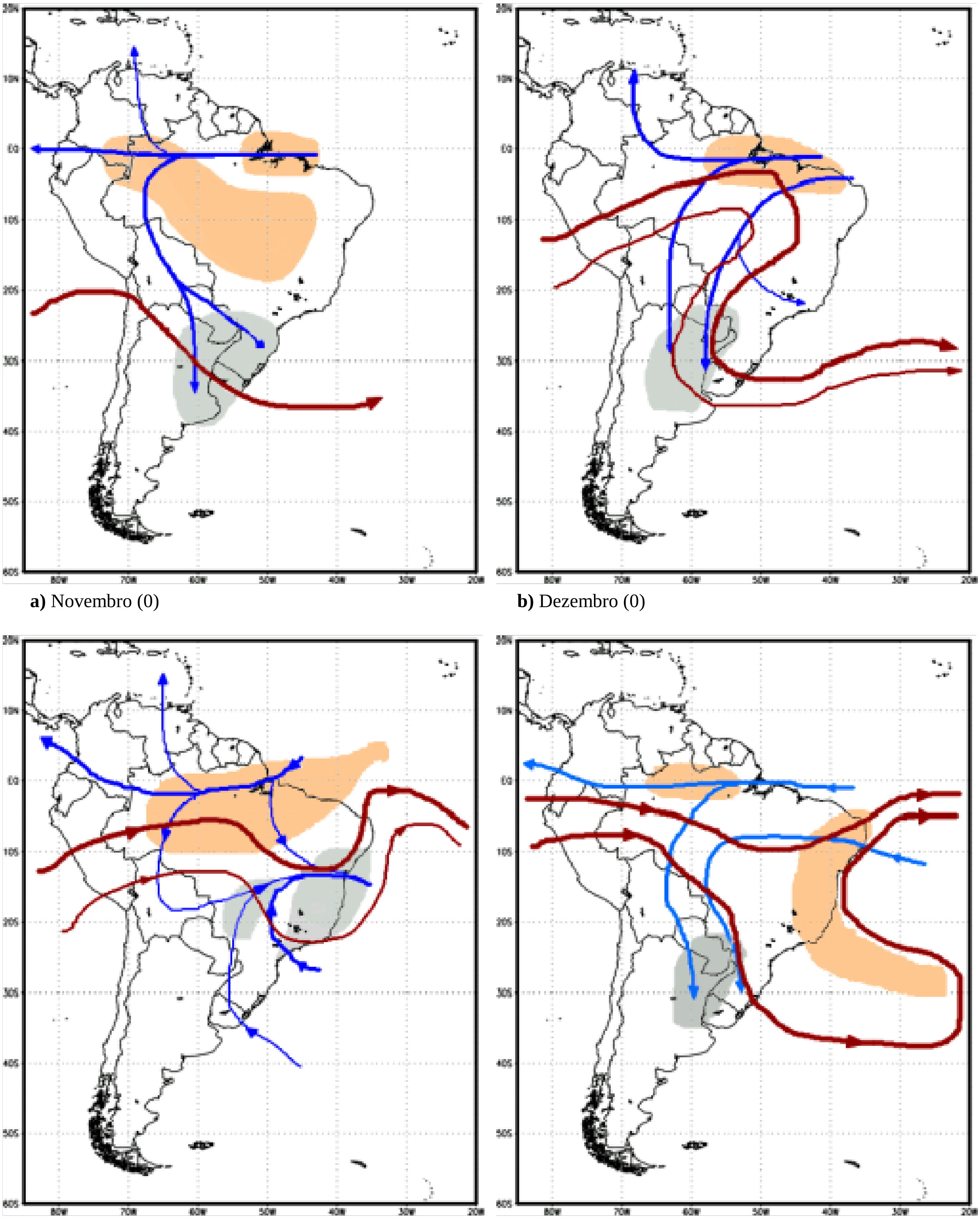
The seasonal analysis for DJF (figures not included) shows that there are consistent negative precipitation anomalies in northern Brazil and positive anomalies in Central-East Brazil. No consistent anomalies are present in southern Brazil, although there are anomalies in Central-North Argentina. The moisture flux and moisture divergence anomalies are weak, and not very coherent with the precipitation anomalies in Central-East Brazil. The divergent wind shows anomalous upper-level convergence over Amazonia and the North Atlantic ITCZ and correspondent subsidence and low-level divergence. Accordingly, there are pairs of anomalous upper-level cyclones straddling the equator over South America and the Atlantic Ocean. The cyclonic anomalies are also present over the climatologic position of the Bolivian High. Low-level anticyclonic anomalies are present over Northeast Brazil and northern South America, enhancing the moisture inflow into the continent.

The monthly analysis shows that the seasonal mean fields actually smooth out a strong and significant subseasonal variation. In early and late summer there are anticyclonic low-level anomalies over the eastern part of Brazil, from the subtropics to the equator, produced mainly by the subsidence over Amazonia, but also due to the barotropic component of the large-scale circulation anomalies in the subtropics. The moisture inflow from the Atlantic is favored, but diverted towards Southern Brazil (Fig. 1a, b, d). There are negative precipitation anomalies in Central-East Brazil, and positive ones in Southern Brazil.

In January, probably due to the anomalous surface heating in East Brazil, there is low-level anomalous convergence in Southeast Brazil as well as anomalous cyclonic circulation. Therefore, the anomalous moisture flux is now directed towards Central-East Brazil, where moisture convergence consistently takes place (Fig. 1c). There is enhanced precipitation over this region and no precipitation anomalies in Southern Brazil.

In February, after the strong precipitation anomalies of January, the precipitation is again controlled by large scale dynamic perturbations (Fig. 1d). There are negative rainfall anomalies in northern Brazil and in the SACZ, and positive ones in southern Brazil.

It is not clear whether surface-atmosphere interactions produce thermodynamic conditions responsible for regional circulation anomalies in January that predominate over large scale perturbations or whether the atmospheric basic state in January is conducive to different perturbations with respect to the other months in summer, leading to enhanced rainfall in central-east Brazil.



a) Novembro (0)

b) Dezembro (0)

c) Janeiro (+)

d) Fevereiro (+)

Fig. 1 - Schematic illustration of the moisture flux anomalies (in blue) and streamfunction anomalies at 200 hPa (in brown) for El Niño events. The grey (orange) areas indicate schematically the regions with moisture convergence (divergence).