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THE ROLE OF THE LOW-LEVEL JET EAST OF THE ANDES IN EXTREME RAINFALL EVENTS OVER SOUTHERN SOUTH AMERICA

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1. INTRODUCTION

Extreme precipitation events such as summer floods have large economic and social impact. There are many works in the literature about the occurrence of extreme precipitation events in the southern part of South America. In Brazil the majority of them are concentrated in the Southeastern region, especially over the state of Sao Paulo and are related with the South Atlantic Convergence Zone (SACZ) (e.g., Liebmann et al. 2001; Carvalho et al. 2002; Carvalho et al. 2004). The relationship between extreme precipitation events and the the Low-Level Jet East of the Andes (SALLJ) is less studied. Liebmann et al. 2004 showed that on a daily time scale, a preference for rain in the SACZ should coincide with a weak jet and dry conditions downstream of it, and vice versa. The aim of this study is to investigate the relationship of the daily extreme precipitation events in the La Plata Basin region and southern Brazil, with the position, intensity and duration of the SALLJ. The present analysis will concentrate on the components of the circulation, convection and moisture transport of the Amazon region towards the south of the continent.

2. DATA AND METHODOLOGY

This study is focused in the period November to March (NDJFM), from 1979 to 1998. Rainfall data from approximately 1500 surface stations located below 20°S are used to obtain the extreme events. The data for analysis of circulation and moisture fields is from the National Centers for Environmental Prediction-National Center for Atmospheric Research (NCEP-NCAR) on a 2.5° grid. An extreme event is defined here when daily rainfall exceed the 95th percentile of its monthly total precipitation. In order to identify the SALLJ events the *Bonner criterion 1* was applied in the site 20°S-60°W.

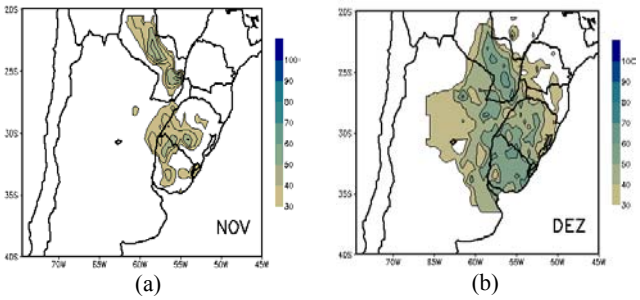
3. RESULTS

a) Percentage of extreme precipitation events in SALLJ days

From the total of wind days occurrences during NDJFM from 1979 to 1998, roughly 16% featured a low-level jet. Figura 1 shows the percent of extreme precipitation events that occurs in SALLJ days, for the months November to March.

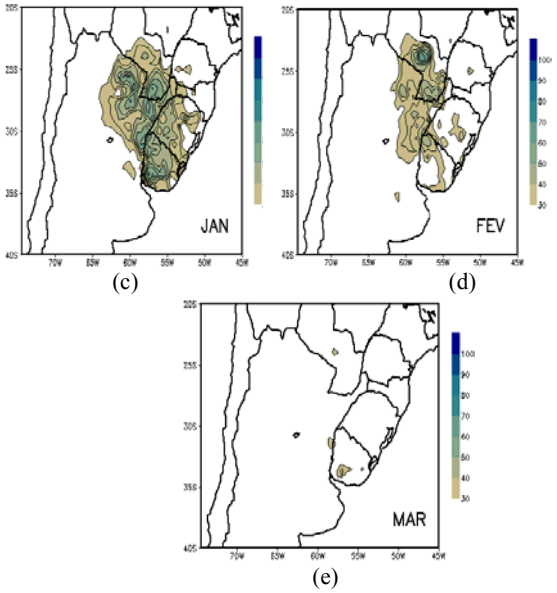
On the SALLJ days events in November (Figure 1a), the percentage of extreme precipitation events ocurrences is around 30% to 50% on some located areas in Paraguay, Rio Grande do Sul (RS) and Uruguay.

Figure 1b, shows the percentage of extreme precipitation events occurring during the SALLJ days in December. In this case, there is an increase in the area with occurrence of extremes, covering parts of Argentina, Santa Catarina (SC), Parana (PR) and all the RS and Uruguay. In some of these localities the extreme precipitation events is related to the SALLJ in up to 70% of the time. In the months of January and February (Figure 1c and 1d) the area with percentage above of 30% of extreme precipitation events is smaller in comparison with December (Figure 1b). In March (Figure 1e) the percentage is below 30%.



(a) (b)

Figura 1. Percentage of extreme precipitation events located below 20°S in SALLJ days. Shade begins at 30%.



(c) (d) (e)

Figura 1. (Continued)

b) Analysis on selected areas

To better understand the occurrence of the extreme precipitation events in the regions described above, and how important is the positioning and intensity of the SALLJ in each event, an analysis of the atmospheric circulation based on three distinct cases was carried out:

1° case - Extreme precipitation events occurrence in Paraguay and in the north of Argentina in simultaneous days of SALLJ (Area A1 in the Figure 2);

2° case - Extreme precipitation events occurrence in the South of Brazil in simultaneous days of SALLJ (Area A2 in the Figure 2);

3° case - Extreme precipitation events occurrence in the region of Uruguay and the northwest of Argentina in simultaneous days of SALLJ (Area A3 in the Figure 2);

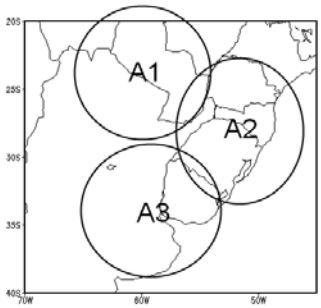


Figura 2. Areas selected for the study of the extreme precipitation events .

c) Atmospheric Circulation features associated to the occurrence of extreme precipitation events in SALLJ days for the three cases

Figure 3 shows the vertically integrated moisture flux and the vertically integrated moisture flux divergence for the period NDJFM during extreme precipitation events occurrencing in the SALLJ days to the three cases described in section 3b.

The NDJFM climatological features of the moisture flux is depicted in Figure 3a. This figure indicates that the moisture transport coming from tropical North Atlantic region, related to the trade winds, change its direction from northeast to northwest when it encounters the Andes. It also shows the convergence of the moisture transport from the subtropical Atlantic high toward the regions of Southeastern and South of Brazil. These features are quite similar to the conceptual model of SALLJ illustrated by Fig.1 of Marengo et al. (2004).

Figures 3b-d are related to the cases presented in section 3b. In general it is observed an overall intensification in the the circulation in comparison with the climatology, especially in the flow to the east of Andes. However, each one of the selected cases have some important differences. For the extreme precipitation events inside of A1 area (Figure 3b), the northeast flow of the tropical Atlantic and the subtropical Pacific high were less intense in comparison with the other cases (Figures 3a,c,d). On the other hand, in the events associated to A2 area (Fig.3c), the moisture convergence, particularly of the Southern Brazil is quite strong as well as the moisture flux coming from the Amazon region. There is some indication that the

circulation related to the Atlantic subtropical high pressure is also intense in this case, therefore contributing to the observed pattern. For the events inside of the A3 area (Figure 3d) the moisture convergence is also as intense as in the A2 but it is displaced southward, having its maximum over the Bolivian region and northern Argentina. Here, besides the subtropical high circulation, it seems that a trough over the middle of the Argentinean continent may be contributing to the intensification and displacement of the moisture flux in the region. Moreover, it is also important to observe that the moisture flow to the east of Andes and the trade winds are more intense than in the others cases (compare Figure 3d with Figures 3a-c).

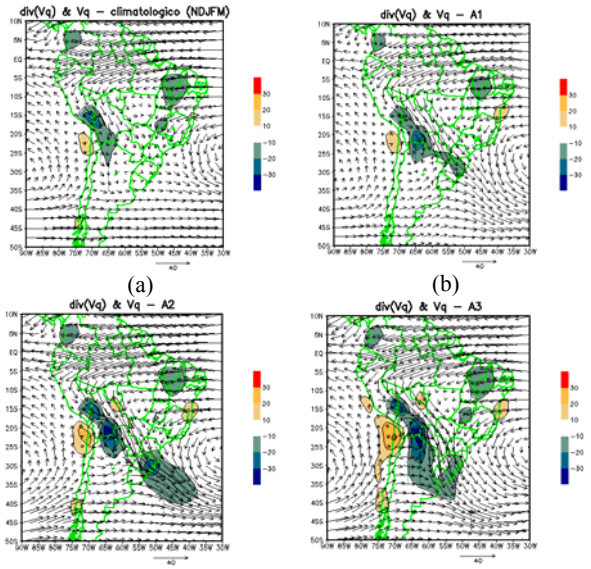


Figura 3. Vertically integrated moisture flux (vectors) and vertically moisture flux divergence (shaded) for (a) NDJFM climatology; (b) extreme precipitation events in SALLJ days on area A1; (c) as in (b) except area A2; (d) as in (b) except area A3. The vector unit is $kg.m^{-1}s^{-1}$ and the divergence is given by $m\ g\ s^{-1}\ kg^{-1}$.

4. DISCUSSION

The purpose of the present study is better to understand the relationship between the SALLJ and the extreme precipitation events in the south-southeastern of South America. Daily precipitation data for approximately 1500 stations located to the south of the 20°S were used. An extreme event is defined here when the daily rainfall exceeds the 95th percentile of its monthly total precipitation.

The monthly percentage of extreme precipitation events occurrence in SALLJ days was analyzed from November to March. The areas with percentage above 30% were different in each month. It was found that December presents the best relationship between extreme events and the presence of the LLJ. On the other hand, March did not present any significant relation between the events.

Composites of the vertically integrated moisture flux and vertically moisture flux divergence had been analyzed for the mean period of NDJFM and for three distinct cases of extreme precipitation occurrence in SALLJ days. The preliminary results showed here, indicate that the position and intensity of the moisture transport to the east of Andes and the intensity of the trade winds play an important role to modulate the rainfall extreme events over the La Plata basin.

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