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ATMOSPHERIC PATTERNS ASSOCIATES TO DRY AND WET PERIODS OVER SOUTH AND SOUTHEAST OF BRAZIL DURING THE AUSTRAL SUMMER: ANALYSIS OF CLIMATIC SIMULATIONS

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1. INTRODUCTION

In the last years several observational studies have been done to characterize the atmospheric patterns associated with extreme and persistent precipitation events on the South and Southeast of Brazil (Casarin and Kousky 1986, Sugahara 1991; Nogués-Paegle and Mo 1997; Lenters and Cook 1999; Gan et al. 2004; Liebmann et al. 2004; Carvalho et al. 2004; Muza 2005). These studies are of extreme importance in broadening the understanding of the atmospheric dynamics associated with dry and wet conditions, which have strong impact in the society and economy, mainly in agricultural areas. A recent example occurred in the 2004/2005 summer when the precipitation deficit in the South of Brazil carried great damage for the agricultural production. According to National Company of Supply (ConabA) the Brazilian crop of grains in this summer was 13 million of tons lower than the foreseen. The biggest damages occurred in the state of Rio Grande do Sul, where the drought decreased the production from 5,5 million to 2,2 million of tons, an unequal breakage of 60%.

According to Misra et al. (2003), the main source of knowledge on the South America climate has been acquired through studies that use reanalysis and/or observations, with relatively few studies using climatic models over this region. Over South America, seasonal and climatological validations of simulations with regional climatic models (Menéndez et al. 2001; Nicolini et al. 2002; Teixeira et al. 2002; Roads et al. 2003; Fernandez et al. 2005) and their interanual variability (Druyan et al. 2002, Misra et al. 2002; Misra et al. 2003; Seth and Rojas 2003; Cuadra and Rocha 2006) were yet performed by several authors. However, there is a lack of the validation of the circulation patterns associated with extremes of precipitations simulated by regional climate models. In this context, the goal of the present work is to investigate if the circulation anomaly patterns simulated by the Regional Climate Model version 3, hereafter referred to RegCM3, during the precipitation extreme events over Southeast and South regions of Brazil are coherent to the patterns documented in the literature. For this purpose, we performed 10 seasonal simulations for the austral summer (December-January-February months, DJF) initiated and forced in the boundaries by NCEP-DOE reanalysis (National Center for Atmospheric Research; Kanamitsu et al. 2002).

2. METHODOLOGY

2.1 RegCM3 model

The climatic simulations used the RegCM3 regional model that is described in various papers (Giorgi et al., 1993 a-b; Giorgi and Mearns, 1999) and the last model modifications are documented by (Elguindi et al., 2004) and Pal et al. (2005). As RegCM3 have several options to the treatment of convection and turbulent fluxes over the ocean, for present study we used the convective scheme of Grell (1993) with Fritsch-Chappel closure (Elguindi et al. 2004) and the Zeng et al. (1998) scheme for ocean turbulent flux calculations.

2.2 Simulation design

The initial and lateral boundary conditions were obtained from NCEP-DOE reanalysis for the ten, from 1989 to 1998, summertime (DJF) seasonal simulations. The RegCM3 simulations employed 50 km of horizontal resolution, 18 sigma-pressure vertical levels (model top at 80 hPa) and three layers in the soil. The runs were initialized at 0000 UTC on November 1st and last 4 months. The November month was considered as the spin-up period of atmosphere component and was not included in the analysis. The model domain covers great part of South America (38^{o}S-3 ^{o}S e 80^{o}W-28^{o}W), as shown in Figure 1. This Figure also presents the topography used in the simulations and two subdomains that represent the South (SO) and Southeast (SE) parts of Brazil.

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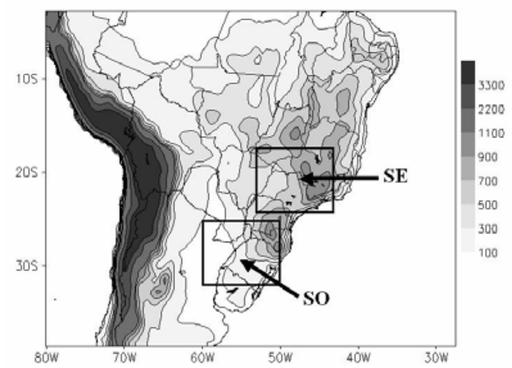


Figure 1. Model domain and topography (The unit for contour and shaded is m) used in the simulations. The subdomains SE and SO indicate the Southeast and South regions of Brazil.

2.3 Extreme precipitation events

The criterion to select periods of persistent rainy extremes considers an interval of 3 days for classification. A given day is considered as wet when the daily precipitation (DP_i) in the current (i), previous (i-1) and following (i+1) days exceed the 75th percentile (in other words, DP_{i-1}, DP_i and DP_{i+1} > 75th percentile).

3. RESULTS

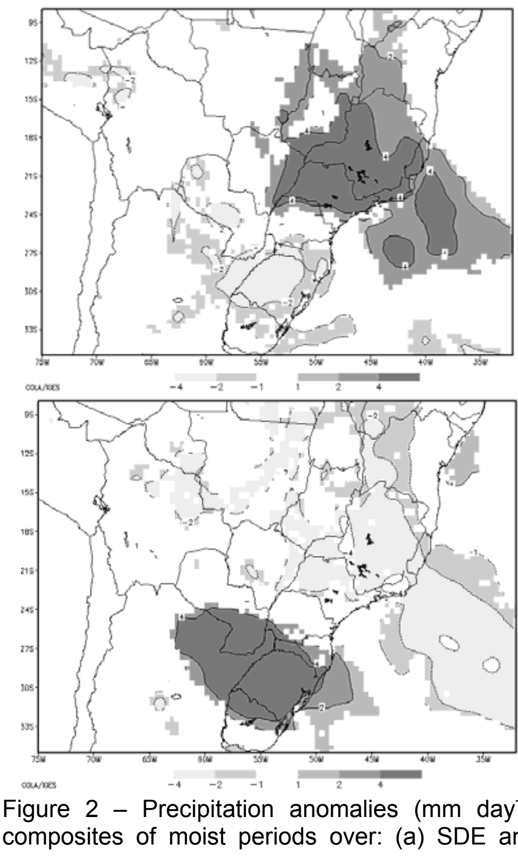
Figure 2 and 3 show the precipitation and moisture flux anomalies, respectively, for moist periods in the SE and SO subdomains. The anomalies were calculated as the difference between the moist period mean and the climatology (from 10 summers) obtained from RegCM3 simulations.

The precipitation anomalies, statistically significant in the confidence interval of 95% (Wilks, 1995), for the composition of the moist days in SE region (Fig. 2a) show a pattern very similar to that found during the active SACZ over Southeast of Brazil and Atlantic Ocean. In this composite, one cannot find any anomaly over the midwest of Brazil. The pattern shown in Figure 2a is coherent to that presented by Nogués-Paegle and Mo (1997), i.e., the active SACZ, identified through composites, presents two OLR maximums: one over the Southeast of Brazil and the other over subtropical Atlantic ocean.

The RegCM3 results present the same pattern found in other observational studies that suggest that intense convective activity in the SACZ is accompanied by dry conditions over South Brazil and Northern part of Argentina. For example, the first variability mode of OLR anomalies during austral summer found by Barros et al. (2000) from observations presents a similar distribution to that shown in Figure 2a. Through composites of the GPCP pentadal precipitation data set, Muza (2005) also found a similar pattern to Figure 2a in the submontly time scale (11-30 days) for intense precipitation events. According to Gandu and Silva Dias (1993), the intense upward convective motion in the SACZ induces compensatory subsidence over South Brazil that is responsible for the negative precipitation anomalies over this region (Figure. 2a).

During the moist phase in the Southern part of Brazil (Fig. 2b), RegCM3 simulated anomalies above 4 mm day^{-1} over the extreme South of Brazil, northeast of Argentina and South of the Paraguay and negative anomalies over SACZ (more intense over Atlantic). This is in agreement with the observational results of Lenters and Cook (1999), Liebmann et al. (2004) and Muza (2005).

This variability mode, with precipitation anomalies of opposite signal between the region of SACZ and Southern part of Brazil and northeast of Argentina, is referred to precipitation seesaw pattern and has been reported by several authors (Nogués-Paegle and Mo 1997; Liebmann et al. 2004; Muza 2005; among others). As illustrated in Figures 2a-b, it is also correctly simulated by RegCM3.



(a)

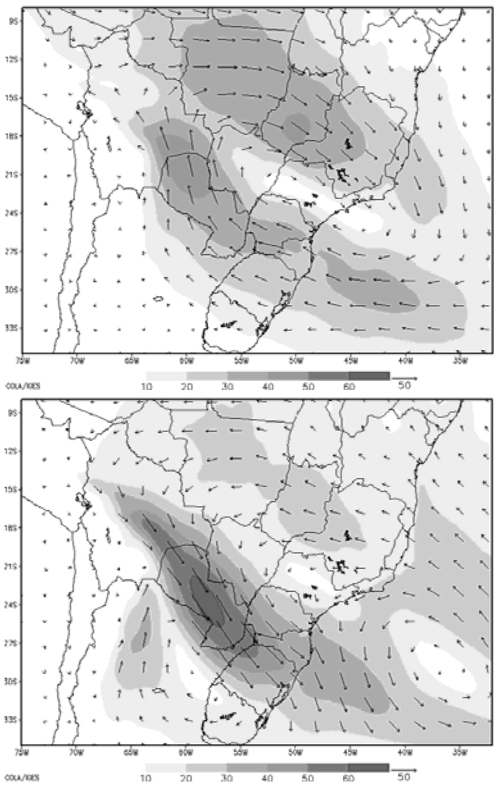
(b)

Figure 2 – Precipitation anomalies (mm day^{-1}) for composites of moist periods over: (a) SDE and (b)

SUL regions. The interval and intensity scale are shown in the bottom of the figure. The values displayed are statistically significant in the confidence interval of 95%.

During the moist periods over SE region the moisture flux anomalies (Figure 3a) present cyclonic circulation, centered on 22°S and 50°W (over the state of São Paulo), which intensify the moisture fluxes from Amazon basin to the active convective zone associated with ZCAS. The anomalous circulation presented in Figure 3a is coherent with several observational works, such as Casarin and Kousky (1986), Nogués-Paegle and Mo (1997) and Gan et al. (2004).

Composite for moist periods in the South of Brazil (Figure 3b) have also been documented in other studies (Lenters and Cook 1999; Liebmann et al. 2004; Muza 2005). Composite for theses periods (Figure 3b) show the dominance of an anomalous anticyclone centered over the South Atlantic Ocean (~ 30°S-37°W), that intensifies the northwest moisture flux from Bolivian Altiplano to the Southern part of Brazil. This flux anomaly, that transports moister and warm air to the South, has also been reported in observational studies (Marengo et al. 2004; Liebmann et al. 2004).



(a) (b)

Figure 3 – Vertically integrated moisture fluxes anomalies (from surface to the 700 hPa) for composites of moist periods over: (a) SE and (b) SO regions. The unit for vector and shaded is kg m^{-1} s^{-1}, the scale is showed in the bottom of the figure.

The results presented here suggest that the atmospheric patterns associated with persistent periods of precipitation over South and Southeast of Brazil, as described by Casarin and Kousky (1986), Sugahara (1991), Nogués-Paegle and Mo (1997), Lenters and Cook (1999), Gan et al. (2004), Liebmann et al. (2004) Carvalho et al. (2004) and Muza (2005), are coherently simulated by the RegCM3 climatic regional model.

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