Proceedings of 8 ICSHMO, Foz do Iguaçu, Brazil, April 24-28, 2006, INPE, p. 1355-1358.

CLIMATE VARIABILITY OVER SOUTH AMERICA AND SOUTH ATLANTIC ASSOCIATED TO SEA SURFACE TEMPERATURE (SST) ANOMALIES IN TROPICAL PACIFIC AND SUBTROPICAL SOUTH ATLANTIC OCEANS

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1. Introduction

The variability of SST in the south Atlantic Ocean, in the region of the Brazil-Malvinas confluence zone (BMCZ), is not so well understood as in the tropical oceans**.** This in part is due to the fact of lack of data in this region, especially south of 35ºS (Palastanga et al, 2002). The oceanic circulation in the southwest south Atlantic plays an important role in regional climate and marine resources of Argentina, Uruguay and Brazil, with significant social and economic impacts on these countries. Some studies (Robertson et al., 2003, Paegle and Mo, 2002, Garzoli, 1999, Doyle and Barros, 2002, Campos et al., 1999) had detected strong relations between precipitation variability in South America and SST conditions in south Atlantic. This way, the objective of this work is to investigate effects caused by SST variation in the south Atlantic confluence zone (30-40ºS) in the precipitation pattern on South America in summer months (December, January and February), which represent the rainy season for most part of the continent. This study was realized with an atmosphere general circulation model (AGCM) so in situations of normality in the tropical Pacific as in years of occurrence of ENSO phenomenon.

2. Model Description

This study used the version 3.2 of LMD atmosphere general circulation model, which is an improved version of the initially written by Sadourny & Laval (1984). Model is based on finite differences and it uses variables staggered on an Arakawa C-grid (Arakawa & Lamb, 1977). The details of physical parameters are described in Li (1995) and Li (1998). This work used a horizontal spatial resolution of 73 points in longitude and 48 in latitude (5º X 3,75º). The vertical coordinate is the sigma coordinate (σ=p/pS), which it's the normalized pressure according with your value at surface. In the current version, model has 19 irregularly spaced levels in the vertical, with more detailing in the lower atmosphere (Harzallah & Sadourny, 1995).

3. Methodology and Data

In this work, five experiments with LMD model had been realized. All of them had been run since October until February using ensemble forecast with ten members each one**.** Results had been generated for December/January/February trimester and have the objective to verify the effects of SST anomalies in the tropical Pacific and subtropical Atlantic Oceans (in the region of the BMCZ) on the South America and south Atlantic climate.

The SST data, which correspond to monthly means between 1971-2000, are of optimum interpolation (OI) sea surface temperature (SST) analysis (REYNOLDS and SMITH, 1994). A subjective analysis was made with SST data between December and February of each year to verify the existence of significant anomalies in tropical Pacific and subtropical Atlantic Oceans (in the region of the BMCZ). In relation to the tropical Pacific, years of 1997/1998 and 1988/1989 had been chosen to represent El Niño and La Niña phenomenon, respectively. In the case of subtropical Atlantic, the most significant SST anomalies had been found in 1983/1984 and 1984/1985, representing cases of heating and cooling, respectively. These SSTs had been applied to the model in the place of the climatological ones in the respective regions. Table 1 shows details of SSTs used in each one of the five experiments carried out in this work and figure 1 shows the observed SSTs anomaly fields that had been applied in the model in the respective regions between December and February. In October and November months, climatological SSTs had been used in all regions.

4. Results

Figure 2 shows precipitation anomalies (mm/day) for DJF between the following experiments: (a) NINO and CLIMATE, (b) NINO and CLIMATE, (c) BR and CLIMATE and (d) MV and CLIMATE. In relation to the precipitation pattern in El Niño years (figure 2a) compared to normal years (NINO-CLIMATE), it is clearly noticed a reduction of precipitation in center-north of the continent and also in the Atlantic. The greatest reductions are found in the SACZ region (less than -9 mm/dia), which suggests that El Niño phenomenon inhibits its occurrence. Moreover, ITCZ has also its pattern reduced by El Niño events. Precipitation reduction reaches values less than -4 mm/dia. In general, precipitation patterns for El Niño years have been simulated well by the model, because many studies show that in years of this type of phenomenon occur a reduction of precipitation in the center-north of South America and an increase in the south regions of it (Kousky et al, 1984, Aceituno, 1988, Kousky and Ropelewsky, 1989, Rao and Hada, 1990, Ropelewsky and Halpert, 1987).

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Table 1: Details of SSTs used in each of the five experiments.

Regions / Experiments	tropical Pacific (10N-15S / 80-180W)	Subtropical Atlantic (30-41,25S / 30-60W)	Other regions
CLIMA	Climatological	Climatológicas	
BR	Climatological	83/84	
MV	Climatological	84/85	Climatological
NINO	97/98	Climatological	
NINA	88/89	Climatological	

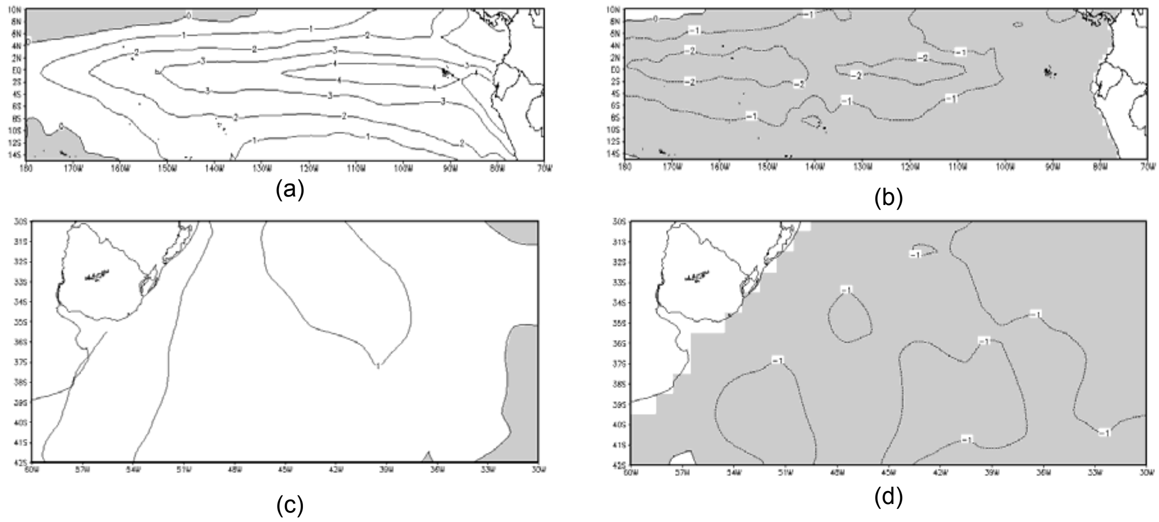

Figure 1: Observed SST anomalies (ºC) in DJF period (a) in 1997/1998 and (b) in 1988/1989 in the tropical Pacific Ocean, (c) in 1983/1984 and (d) in 1984/1985 in the subtropical Atlantic Ocean. Negative values are shaded.

The precipitation anomaly field for La Niña years (figure 2b) presents increase over the center-north of the continent (up to 3 mm/day) when compared to normal years in tropical Pacific (NINA-CLIMATE).It is also observed a low intensification of the precipitation band in the ITCZ region. In Argentina, Uruguay and south parts of Brazil and in some parts of the Atlantic, occurs precipitation reduction (less than 1 mm/day), suggesting the weakness of the SACZ in this region. The model simulated similar situation for the SACZ region when comparing experiments NINO and CLIMATE (figure 2a). Despite the similarities in qualitative terms the El Niño seems to have a greatest effect on the SACZ behavior than La Niña. These results are according with the results presented by Roque da Silva (2002), which have simulated La Niña effects in 1998 on the South America climate in DJF.

Figure 2c shows anomalous precipitation associated to the southwestern Atlantic heating (BR-CLIMATE). In fact, the model simulated precipitation reduction in the SACZ region, mainly on the ocean. This reduction reaches values less than -2 mm/day, which represents a reduction of more than 180 mm in the summer period (DJF). In the region of SST increase in the Atlantic there is a fast trend of precipitation increase associated with greater humidity convergence(c).

Robertson et al. (2003) have simulated the South America climate between November and March with an ensemble of nine members using prescribed SST between 50ºS-0º and 70ºW-20ºE. Their results indicate that there is an increase of anticyclonic circulation centered in 30ºS, penetrating over the South America continent, and also a precipitation reduction in the SACZ region, mainly on the ocean. In fact, the result presented here (figure 2c) is very similar to the result of Robertson et al. (2003). That turns possible to believe that alterations in the atmospheric patterns in the SACZ region can suffer influences from positive SST anomalies between 30º and 40ºS.

The precipitation differences between experiments MV and CLIMATE are shown in figure 2d. The model simulated precipitation increase in the SACZ region, especially on the center of South America where are found values above 3 mm/day, which represents about 270 mm in the summer period (DJF). Over the Atlantic the precipitation increase was little significant. In the region of SST cooling, the model detected a precipitation reduction, however the greatest values are over southern Brazil (-1 mm/day) and over the ocean, a little to the north of region of SST modification (-2 mm/day).

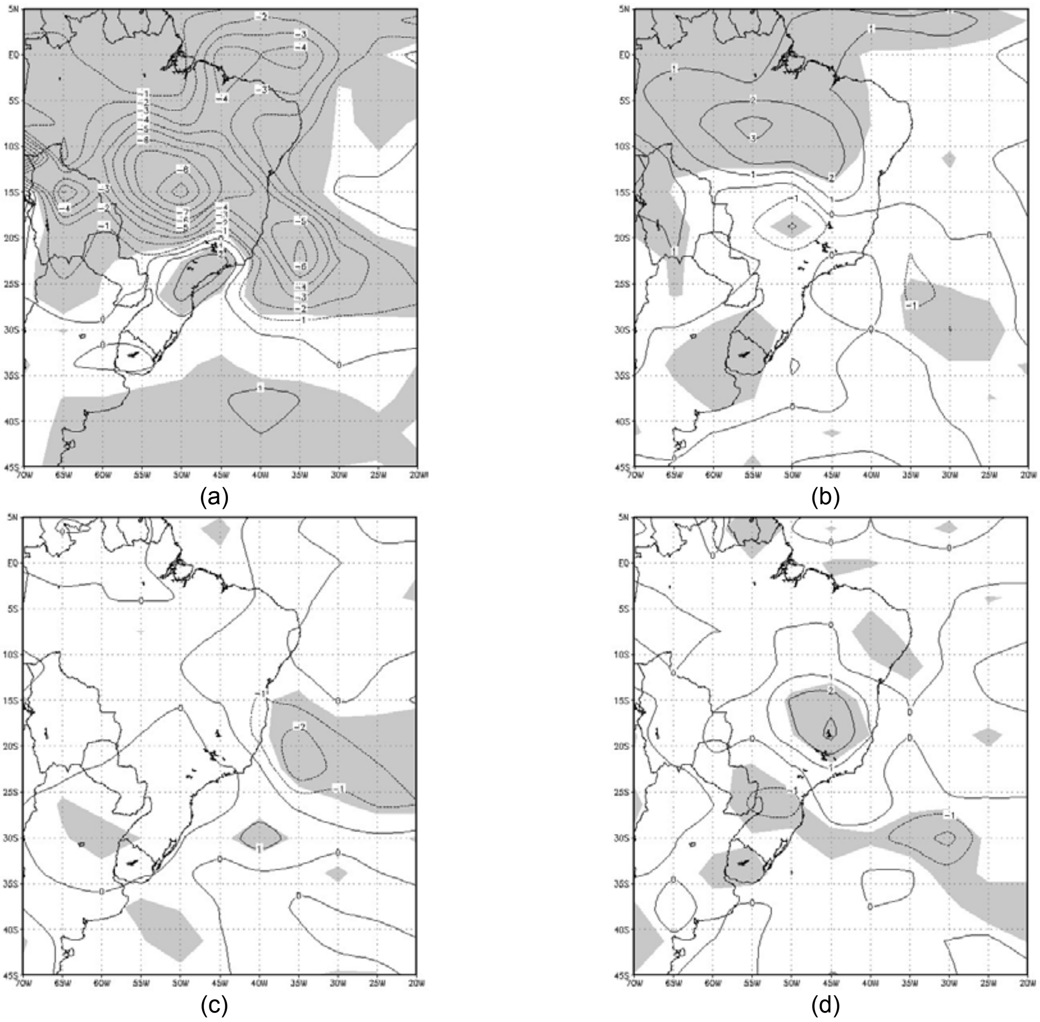

Figure 2: Precipitation anomalies (mm/day) for DJF between experiments (a) NINO and CLIMATE, (b) NINA and CLIMATE, (c) BR and CLIMATE e (d) MV and CLIMATE. Shaded areas indicate 90% statistical significance.

5. Conclusions

In this study five experiments were realized with LMD model. The objective was to verify the effect of SST anomalies in the tropical Pacific and subtropical Atlantic Oceans (in the region of BMCZ) on the South America climate in DJF trimester.

In relation to forced cases only in the tropical Pacific Ocean (NINO and NINA), model has simulated precipitation anomalies for DJF that are very similar to observations during ENSO years (Kousky and Ropelewsky, 1989, Rao and Hada, 1990, Ropelewsky and Halpert, 1987). For the El Niño case, model has simulated a precipitation reduction in the center-north of South America, also in the SACZ region, and an increase in the southern parts of the continent. In the La Niña case, model has also detected a precipitation reduction in the SACZ region, but in quantitative terms, El Niño seems to have a greater effect on the SACZ behavior than La Niña. Over the center-north of the continent and also in the ITCZ region model has forecasted precipitation increase, what it is in accordance with results of Roque da Silva (2002), that had simulated La Niña effects in 1998 on the South America climate in DJF.

Comparison between forced cases in the subtropical Atlantic Ocean in the BMCZ region (BR and MV) and climatology (CLIMATE) showed that SST anomalies in this region play important influence in the SACZ behavior. The BR minus CLIMATE difference simulates the case of Brazil Current extending more to the south (positive SST anomalies), while the MV minus CLIMATE one refers to Malvinas Current reaching areas more to the North (negative SST anomalies). When there is SST increases in the southwest Atlantic, model has simulated precipitation reduction in the SACZ region, mainly on the ocean. This reduction reaches values less than -2 mm/day, which represents a reduction of more than 180 mm in the summer period (DJF). This fact seems to be associated to the intensification of the South Atlantic High in the SACZ region. In the region of SST increase in the Atlantic there is a slight trend of precipitation increase associated to a greater humidity convergence. In the case of negative SST anomalies in the Atlantic, model has forecasted a precipitation reduction in the BMCZ region, however a little more to the north of the region of SST alteration (-2 mm/day), associated to a pressure increase at surface. In the SACZ region model has detected precipitation increase, with values above of 3 mm/day, which represents about 270 mm in the summer period (DJF).

In fact results have shown that SST anomalies in the BMCZ region, although they are not so intense, they seem to have some influence on the precipitation variability in the SACZ region and also in the region of Brazil and Malvinas Currents confluence. These results show the importance of studying thermodynamic mechanisms responsible for the variability of these currents, which is in turn, associated to the existence of warm and cold SST anomalies in the BMCZ region, respectively.

Acknowledgements

This study received financial support from the Inter American Institute for Global Change Research (IAI), through a fellowship granted by SACC (South Atlantic Climate Change) Consortium. All the experiments of this study have been done at the High Performance Computing Center (NACAD) of Federal University of Rio de Janeiro (COPPE-UFRJ).

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