

SOUTH ATLANTIC CONVERGENCE ZONE (SACZ) IN THE DOUBLING CO₂ RUN WITH LMD MODEL AND ECMWF RE-ANALYSIS DATA: PART II

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ABSTRACT

This paper presents results obtained in a study using a long term integration with the Laboratoire de Météorologie Dynamique (LMD) model. We analyze two 16 years data sets for the summer season over South America. One of this data set was derived from the LMD model, and another one from re-analyzed ECMWF data. The main objective of the Part II is to verify if the model is able to reproduce the interannual variability of the SACZ and analyze composites of the extremes SACZ cases as well as its behavior in El Niño and La Niña composites. The OLR anomalies were averaged over 3 areas and time series for both the LMD GCM and the observed data (OBS) were analyzed. Based on these time series, composites were performed with OLR, winds and geopotential high anomalies. The SACZ's composites analysis showed that the LMD was able to reproduce reasonably well the main patterns when compared with observed data. When the SACZ is active appears a precipitation deficit rear of convective band as well convection that affects mainly South of Brazil and Northeast of Argentine. The preferential region where SACZ occurred were Area 1 and 2. In El Niño composites, SACZ episodes appeared weaker than normal. To the south of SACZ (South of Brazil and North of Argentine) and SPCZ region occurred stronger convection than normal. In La Niña composites opposite behavior was found.

Key Word: Simulation, ZACS, Interannual Variability

1. Introduction

We now analyze the interannual variability of extreme SACZ events as well as the behavior of this phenomenon in EL Niño and La Niña.

2 - Interannual Variability

To analyze the SACZ episodes, 3 regions were chosen based in subjective analyses (satellite images and observed precipitation fields) taken into account that a displacement southwards or northwards happens in some cases. These 3 regions are the same as those defined by Cavalcanti and Rowntree (1998) and showed here in Tab. 1. A fourth region was chosen over Argentine and part of south of Brazil, Uruguay and Paraguay, to check the atmospheric behavior over this region when the SACZ is active.

Area 1: (50W-45W, 10S- 5S)
(45W-40W;15S-10S)
(40W-35W;20S-15S)

Area 2: (55W-50W; 15S-10S)
(50W-45W;20S-15S)
(45W-40W;25S-20S)

Area 3: (55W-50W; 20S-15S)
(50W-45W;25S-20S)
(45W-40W;30S-25S)

Area 4: (65W-50W; 40S-25S)

Tab.1 - Areas to represent 3 mean positions of the SACZ (1,2 and 3). Area 4 is over South of SA.

The spatial averages of the LMD GCM and observed (OBS) OLR anomalies in each area (1,2,3 and 4) are computed and monthly

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time series of these values are analyzed to study their interannual variability. In the LMD data the magnitude of the anomalies are higher than in OBS data. In almost all cases the values in areas 1,2 and 3 have the same phase in the timeseries however the area 4 shows an opposite phase in most cases. When the SACZ is active, the SSA region (area 1,2,3) has a strong convective activity and area 4 does not have.

All months with OLR anomalies below than -15 W/m^2 and -9 W/m^2 for LMD and OBS data, respectively, were averaged to obtain a SACZ's pattern for each month and season for the South America summer. These thresholds are approximately one standard deviation for each serie respectively. The areas 1 and 2 have the highest frequencies, with 13 and 11 cases respectively, during all seasons. This shows that SACZ is displaced (northward/southward) through the months and years. In the monthly analyses, January and February are the months with the largest number of cases in both data sets, LMD and OBS. February for LMD with 6 cases over areas 1 and 2, and January for OBS with 6 cases over area 2.

3 - Composites with extreme SACZ cases

Selected cases are based on the threshold mentioned above.

3.1 - OLR Patterns

The LMD composite for Area 1 (Fig. 1) indicates an extensive band of convection over the continent, with orientation NW/SE. Inside of this cloudiness band occurs a maximum over the continent close to the east coast. The analysis of OLR anomalies (OBS), shows a similar pattern when compared with LMD GCM results. During all months, including the seasonal means, the center with minimum values is located over the east coast of Brazil with an extension over the Atlantic Ocean. In the south of Brazil, north of Argentine, Uruguay, southern Paraguay and in the Intertropical Convergence Zone over the Tropical Atlantic positive anomalies are observed when SACZ is active. These positives values represent the subsidence regions

compensating the strong ascendent movement in the SACZ region. The composite for Area 2 (not shown) which is situated over part of the Southeast of Brazil represents the SACZ activity displaced slight southwards and shows a center with maximum convection displaced westwards in the central region of the continent, during December, January and also in the seasonal summer mean. The observation again shows a similar pattern of that observed in LMD results, however the magnitude of the observation values are smaller than LMD. When the SACZ occurs, there is an inhibition of convection over ITCZ region (shows positive anomalies) as well over south of Brazil, north of Argentine, Uruguay and southern Paraguay. The composite for Area 3, in the seasonal field presents a large band with positive anomalies in the North and Northeast regions during December. For Area 3 there is not any event during January in the observations, however December and February presents similar anomalies of those found in the model results.

3.2 - Winds at Low and Upper Levels

The LMD field at 850 hPa (not shown) reproduces well the main patterns of circulation. The model positioned well the anticyclonic circulation over Pacific and Atlantic subtropical Oceans. However the intensity of these winds seems to be stronger than reality when compared with reanalyses. The anomaly wind fields for all areas (1,2 and 3) LMD and OBS show a cyclonic circulation at low levels. Fig. 2 shows the wind field considering area 1. The LMD anomalies are stronger than OBS in some areas. Over the north region of Andes the wind and anomaly winds cross the mountains in the LMD results. This effect could be caused by the low resolution in the model orography. The wind at 200 hPa, from LMD shows an anticyclonic circulation (Bolivian High) and also a trough to the east coast of Northeast of Brazil considering the results of area 1. In the results of the areas 2 and 3 (not shown) occurs a stretching of the Bolivian High to the east. This feature is characteristic of the situation when the SACZ is active. The model presents circulation stronger in magnitude than

observations mainly to the south of the Bolivian High. The position of Bolivian High center in the LMD results is slightly southward than ERA (OBS) data. The model shows a strong anomalous anticyclonic circulation with anomalous wind to the northwest mainly over the Northeast and North of South America (Fig. 3) and anomalous cyclonic circulation over the Atlantic Ocean close to the south coast of SA. There is also an anomalous anticyclonic circulation over North Atlantic. The OBS data considering area 1 (Fig. 3) shows a cyclonic circulation over Pacific (near South America) a pair of anticyclonic and cyclonic circulation over South Atlantic. The cyclonic circulation over the continent close to SSA represents the trough to the south of the convective SACZ band. Over the SACZ there is an anomalous anticyclonic circulation.

3.3 - Geopotential High (500 hPa)

Over south of SA in the results of the seasonal LMD's composite for all three areas occurred a negative center of Geopotential anomalies (not shown). In almost all cases a center with positive anomalies over Southeast Pacific occurs close to the west coast of SA. In the re-analysis field, a similar pattern of negative anomalies is verified over SACZ region, however over the South Pacific the anomalies are negatives.

3.4 - Precipitation, Soil Moisture and Specific Humidity

The next fields were analyzed only for LMD data. The precipitation anomalies show similar patterns to those found in the OLR field, with a strong anomalous band of precipitation oriented NW/SW also extending over Atlantic. Over the Atlantic, close to the ITCZ region, appears a pronounced zone with negative anomalies as well as to the south of the SACZ position. The soil moisture shows positive anomalies in the region where occurs maximum anomalies of convection and precipitation for all three areas during all period. The maximum positive anomalies are found mainly in the southern of Amazon region and in the center of Brazil. These anomalous moisture excess in the SACZ region probably

helps to sustain the convective activity and the precipitation. Over south of Brazil and North/Northeast of Argentine where there are weak convection and low precipitation when the SACZ is active, a deficit of soil moisture is observed. Specific humidity at 850 and 700 hPa follow the same precipitation and OLR patterns.

4 - El Niño and La Niña Composites

The El Niño OLR anomalies composites were performed with 4 cases found during the period analyzed following Trenberth (1997) classification, 82/83, 86/87, 87/88, 91/92. LMD and OBS are in good agreement. During El Niño events a strong convective activity occur over Tropical Pacific as well as over the South Pacific Convergence Zone (SPCZ) and it is weakened over SACZ region. To the south of SACZ position (over South of Brazil and Northeast of Argentine) occurs an intense convection. The convective activity over southern SA is associated to frontal systems which some times remain blocked over these region during El Niño events. During La Niña years (composite performed with 2 cases, 84/85 and 88/89) LMD shows a good agreement with OBS. Over Tropical Pacific region the convection is weakened due to the presence of colder water at the sea surface. Over SACZ region there are negative OLR anomalies. Over south of Brazil and North of Argentine occurs positive OLR anomalies indicating a decrease in the convective activity. In this case the SPCZ is displaced westward. The analyses of La Niña and El Niño composites suggest that the SACZ and SPCZ are out of phase in El Niño. In La Niña, even with an intense SACZ, the SPCZ shows a displacement towards west. For OLR composite analysis LMD's magnitude is overestimated compared with OBS.

5 - Conclusions

The model was able to reproduce the main patterns observed with ECMWF data and OBS OLR. The composites showed that when the SACZ is active, to the south of the convective band occurs a deficit of precipitation over South Brazil and Northeast

Argentine. The preferential regions for SACZ to occur are Area 1 and 2. Precipitation, soil moisture and specific humidity (only for LMD results) followed a similar pattern of OLR. When the SACZ is active occurs positive anomalies of precipitation, soil moisture and specific humidity at 700 and 850 hPa. For the El Niño and La Niña composites, the model showed good pattern agreement with observed OLR, however with overestimated values. In El Niño cases the SACZ appeared weaker than normal, however over South of Brazil, North of Argentina and in the SPCZ occurred convection stronger than normal. During La Niña event the SACZ was stronger than normal and SPCZ was displaced to west.

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6 - References

- Cavalcanti, I. F. A. and Rowntree, P., 1998. South Atlantic Convergence Zone (SACZ) in the Hadley Centre Climate Model. Internal Report. CPTEC/INPE.
- Rocha, A., and Gandu. A., W., 1996. South Atlantic Convergence Zone. In: Climanálise Especial. CPTEC/INPE, pp. 140-142.
- Le Treut, H., Li, Z. X., 1994. Sensitivity of the LMD general circulation model to greenhouse forcings associated with two cloud water parametrizations. *J. Climate*, 7:1827-1841.
- Legates, D. R. and C. J. Willmott, 1990. Mean Seasonal and Spatial Variability in Gauge-Corrected, Global Precipitation. *Intern. Jour. of Climatology*. 10(2) 111-127.
- Liebmann, B., Marengo, J. A., Kiladis, G. N., Ambrizzi, T., Glick, J. D., 1998. Submonthly Convective Variability over South America and South Atlantic Convergence Zone. Accepted, *J. of Climate*.
- Menéndez, C. G., Serafini, V., Le Treut, H. 1997. The effect of Sea ice on the transient eddies of the southern Hemisphere. Accepted, *Climate Dynamics*.
- Peagle, J. N., and K. C. Mo, 1997. Alternating wet and dry conditions over South America during summer. *Mon. Wea. Rev.*, 125, 279-291.

Quadro, M. F. L., 1994. Estudo de Episódios de Zonas de Convergencia do Atlântico Sul sobre a América do Sul. Dissertação de Mestrado em Meteorologia. São José dos Campos (SP) (INPE-6341-TDI/593), 124p.

Tremberth, K. E., 1997. The Definition of El Niño. *Bull of the Amer. Met. Soc.* 78(12) 2771-2777

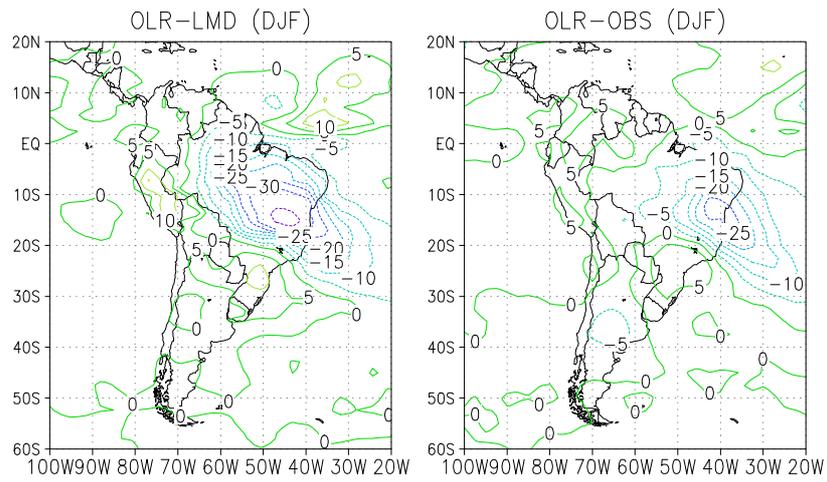


Fig. 1 – Composite for Southern Hemisphere summer OLR anomalies. LMD (Left) and OBS (Right)

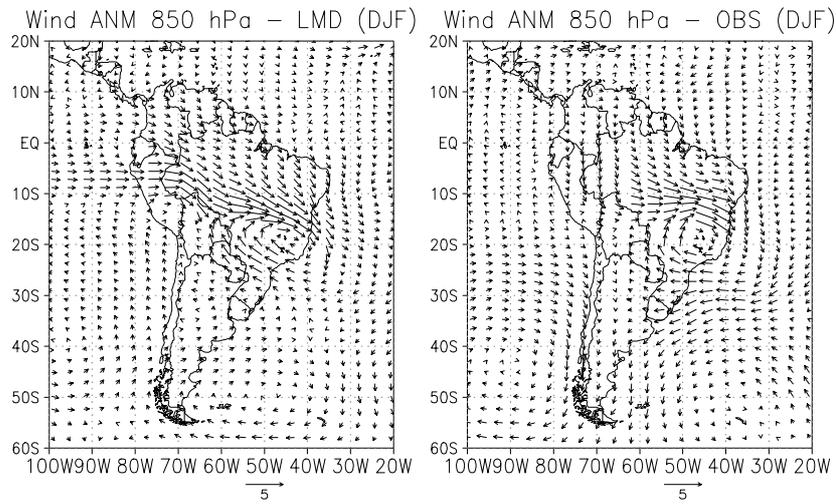


Fig. 2 – Composite for Southern Hemisphere summer Wind anomalies at 850 hPa. LMD (Left) and OBS (Right)

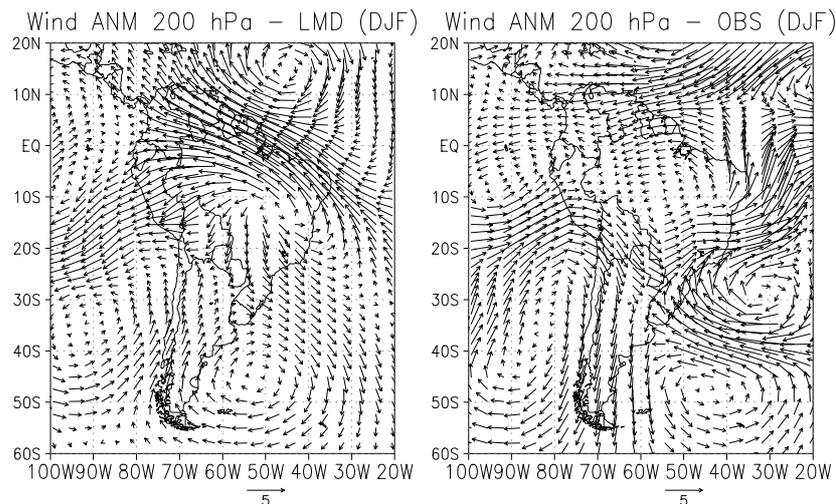


Fig. 3 – Composite for Southern Hemisphere summer Wind anomalies at 200 hPa. LMD (Left) and OBS (Right)