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

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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 have analyzed two 16 years (1979 to 1994) date sets for the summer season over South America. One of this data set was derived from the LMD model, with double CO2 and another one from re-analyzed ECMWF data. The main objective of this Part I is to verify if the model is able to reproduce the mean atmospheric patterns. Comparing these two climatologies, it was observed that LMD overestimates the wind at low levels (850 hPa) as well as in upper levels (200 hPa) mainly over the ZCIT region at 850 hPa and in the south part of the Bolivian High at upper levels. The OLR LMD field is also more intense over ZCIT region than observation. However LMD underestimates the wind in some regions when compared with observed data. All differences in the results of the LMD model compared to observations may be associated with the double CO2 conditions and also from systematic model biases.

Key Word: Simulation, ZCAS, Climatology

1 - Introduction

The Southeast Region of South America (SSA) continent is an important region in food productions. This area is affected by several meteorological systems. One of them is named South Atlantic Convergence Zone (SACZ). The SACZ is a strong band of convection, which extends over South America to the South Atlantic Ocean with orientation NW/SE. This zone shows an interaction between tropical and extratropical systems. The main characteristics of this band is the deep and strong convection over the tropical South America that produce, many times, heavy precipitation mainly in the summer season and for several consecutive days. A review of SACZ can be found in Rocha and Gandu (1996). Kousky and Casarin (1986) related periods with deficit of precipitation in the south region of Brazil with enhanced precipitation over South Atlantic. Paegle and Mo (1997) evidenced in their studies that the intensification of the SACZ is associated with rainfall deficits over the subtropical plains over South America. When the SACZ weakens, precipitation over these plains is abundant. These results are in agreement with those of Kousky and Casarin (1986). Quadro (1994) in his study about SACZ found that during El Niño events the SACZ is inhibited or it is localized further to the South of its preferred position (north of 25°S over coast of South America). Cavalcanti and Rowntree (1998) used 100 years integration of the Hadley Center Climate Model (HADAM2b) to study SACZ and they found that when the SACZ is active, the region to the south has deficit in humidity and high positive values in the Outgoing

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Longwave Radiation (OLR) anomalies. Liebman et al (1998) studied OLR fluctuations with period less than 90 days. The correlation between submonthly OLR in the vicinity of the SACZ and 200 hPa streamfunction reveal the preferred path of Rossby wave energy impinging on the SACZ from the mid latitudes of the Southern Hemisphere. They speculate also that the stable position of the SACZ may be associated with a Rossby wave guide, which is ultimately related to the large scale circulation driven by sources and sinks of diabatic heating. It also appears that the SACZ forms when the northwesterly flow associated with a low level trough is able to tap moisture from the Amazon.

In Part I we investigate the ability of the Laboratoire de Météorologie Dynamique (LMD) Global Circulation Model (GCM) to reproduce the main climatological atmospheric patterns of South Hemisphere summer over South America using a long integration from 1979 to 1994, experiment performed at LMD (Le Treut and Li, 1994). The results of the model will be referred as LMD. In Part II, the interannual variability and composites with extreme SACZ cases as well as the behavior of this phenomenon in El Niño and La Niña years, will be analyzed.

2 - Model description and Data

The dynamical part of this GCM is written in difference finite using an Arakawa C grid. This grid is a regular grid in sine of latitude and longitude. The model covers all globe and the standard resolution of the LMD GCM experiments analyzed here has 96 points in longitude and 72 points in sine of latitude with 15 levels in the vertical resolution. Over land, a model for hydrological transfers with different vegetation types, the SCHIBA scheme is used, Poltcher and Laval (1994). The model vertical coordinate is the classical sigma coordinate, equal to the pressure normalized by the surface pressure. A technical description in more details about LMD GCM is found in Seluchi et al (1998) and Le Treut and Li (1994). We have used here the results of 2 CO_2 experiment, described in details in Le Treut and Li (1994).

To analyse the performance of the LMD GCM, re-analyses data of geopotential high and winds at low and upper levels available from the European Centre for Medium-Range Weather Forecasts (ECMWF) were used. OLR data were obtained from From National Center for Environmental Prediction (NCEP). The climatological precipitation was provided by Legates and Willmott (1990).

3 - Mean Performance of the LMD GCM over South America

The climatology of the LMD model for the South America was carried out for the summer season (December, January and February) of the period from 1979 to 1994. A climatology of the reanalyses data from ECMWF was used as a reference. During the period from December to February the summer pattern is established with low values (180 to 200 W/m2) mainly over SSA, characterizing the presence of the SACZ with main orientation NW/SE, Fig 1a. The seasonal mean shows the minimum OLR values approximately over the region from 15°S to 20°S and 50°W to 40°W. Over south of Brazil and north of Argentina the values were higher than over SSA, around 260 W/m2, indicating that these regions had lower convection than the SSA region. The OLR OBS field (Fig 1b) shows a minimum centered over Amazon Region. Analyzing the monthly fields, the minimum values remain from December until February (200 W/m2) and experience a slight displacement towards the SSA region, characterizing an increase of convective activity. The comparison of LMD OLR with analyzed data, shows that over SACZ region LMD underestimate OLR with differences around -10 to -20 W/m2. In the ITCZ region occurs an inverse situation with LMD overestimating observed data around 20 W/m2 over tropical Pacific and Atlantic. The precipitation field calculated by LMD (Fig 1c) shows a similar behavior. The maximum values are over SSA region during the summer months, with values around 15 and 20 mm/day. The climatological observed precipitation (Fig 1d) performed by Legates and Willmot (1990), shows maximum values over Amazon region, during the 3 summer months, and an extension of these maximum values over SSA region indicating the SACZ activity. LMD overestimates the precipitation mainly in the ITCZ and SACZ regions.

The simulated winds (Fig 2a-b), show pretty well a defined summer circulation pattern over South America. At low levels (850 hPa) the LMD model simulated the Anticyclonic circulation in both oceans (Fig 2a). These anticyclonic circulations seems however to be stronger than in observations data (Fig 2b) as well as the strong winds over tropical Atlantic directed to the continent, during all three months. However the model shows a good positioning of the systems and directions of the circulation. In the upper levels the climatological field from the LMD GCM (Fig 2c) represents very well the Bolivian High (Anticyclonic circulation in upper level) over South America as well as the trough over the Northeast coast of Brazil. The same pattern is shown in ECMWF data (Fig 2d). The difference between model results and observations shows that LMD model simulated the winds in the south part of the Bolivian High with more intensity than the observations. The LMD simulations are stronger than the observed values systematically, except in the OLR fields.

In the climatological soil moisture field the highest values are found over the SSA region during the 3 consecutive months and these values are over the same region where SACZ occurred in the LMD's precipitation and OLR fields. The fields of Specific Humidity at 700 and 850 hPa follow the same patterns observed in the others LMD's surface fields, with the highest values over SSA region and spreading also northwestwards over Amazon region.

4 - Conclusions

In Part I two 16 years data set for the summer season over South America were analyzed. One of this data set consists of LMD model results (considering an experiment using double CO2) and another re-analyzed ECMWF data. Comparing these two climatologies, it was observed that LMD overestimates the wind magnitude at low levels (850 hPa) as well as at upper levels (200 hPa). Over the analyzed region the largest difference occurs over Equatorial Atlantic at 850 hPa and to the south of Bolivian High at upper levels. The OLR LMD field is also more intense over ZCIT region than the observed values. However, in the SACZ region, LMD underestimates the observed data. All these differences between the model results and observations may be due to the double CO2 conditions and also from systematic model biases.

5 - References

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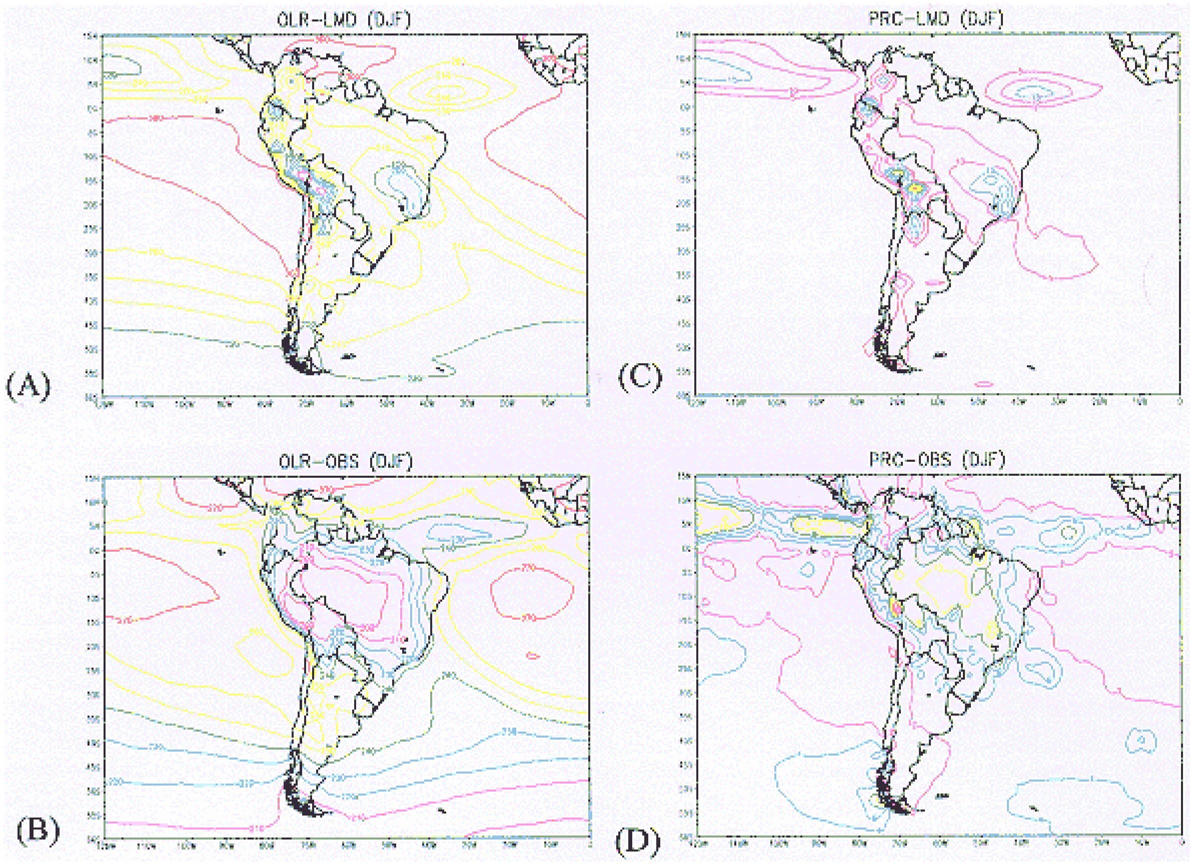

Fig 1 – Climatological OLR for LMD (A) and OBS (B). Climatological Precipitation for LMD (C) and OBS (D).

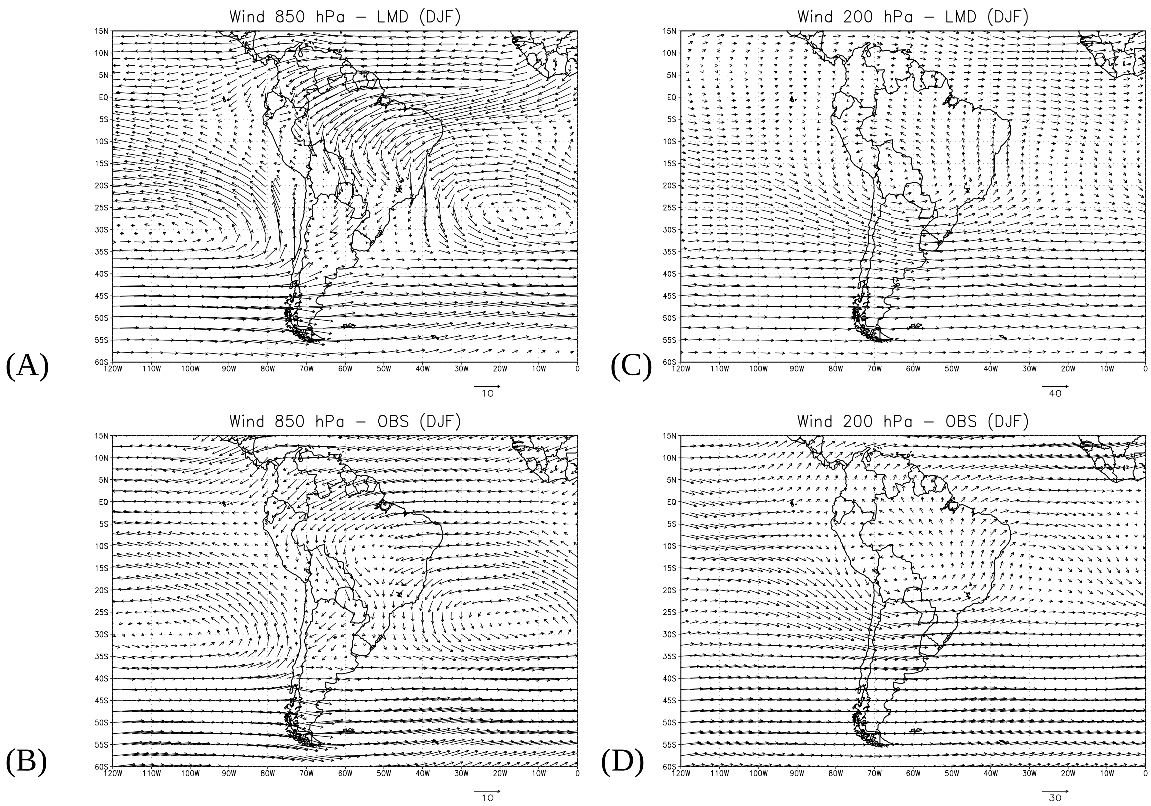

Fig 2 – Climatological Wind at 850 hPa for LMD (A) and OBS (B). Climatological Wind at 200 hPa for LMD (C) and OBS (D).