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THE WAVE FOUR INTRASEASONAL VARIABILITY IN EXTRATROPICAL S.H. AND INFLUENCES OVER SOUTH AMERICA- THE BEHAVIOUR OF CPTEC/COLA AGCM.

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1. INTRODUCTION

The CPTEC/COLA Atmospheric General Circulation Model has been used for weather forecasting and seasonal prediction at CPTEC, which is a Center for Weather forecasting and Climate Studies, since 1995. Global climatological features and seasonal variability are reasonable well simulated by the model, as shown in Cavalcanti et al (2002). The analysis of interannual variability over several areas of South America, indicated that correlations between model precipitation anomalies and observed anomalies are very high in the North-Northeast and South Brazil, but very low or even negative in the Southeast region, implying in very low predictability compared to other regions of the continent. The dispersion among members of several integrations is very high and leads to errors when the ensemble is taken. The southeastern region is affected by the South Atlantic Convergence Zone (SACZ) that occurs from late spring to early autumn, being more intense in summer. The CPTEC/COLA AGCM overestimates precipitation in the southern sector of this band and underestimates in the tropical sector (Cavalcanti et al. 2002). Considering that intraseasonal anomalies can affect the SACZ through teleconnections, as the PSA wavetrain (Cunningham and Cavalcanti 2006, Nogues-Peagle et al. 2000, Carvalho et al 2004), it is important to analyze the role of the intraseasonal variability on SACZ in the model results. The model can represent the dominant modes of intraseasonal variability that affect South America and the southeast region (Cavalcanti and Castro, 2003), but still, the seasonal prediction is very poor for the SACZ region. A dominance of zonal waves 3 and 4 also occurs in the Southern Hemisphere in the intraseasonal timescale, discussed in Kiladis and Mo (1998). Therefore, additional studies, including the behaviour of waves around Southern Hemisphere have been performed to understand the model behaviour. The objective of this study is to analyze features of intraseasonal variability associated with teleconnection patterns in the Southern Hemisphere (SH), simulated by the model, and its influence on South America, mainly on SACZ.

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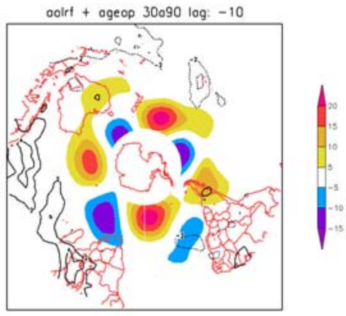
2. DATA AND METHODS

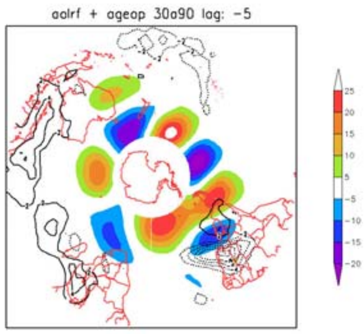
The data are 200 hPa daily geopotential heights from a model simulation with CPTEC/COLA AGCM (Cavalcanti et al. 2002) and from NCEP/NCAR reanalysis (Kalnay et al. 1996); and OLR from the model and from NOAA data (Liebman and Smith, 1996). The period is 1982-1991.The Lanczos filter was applied to remove frequencies less than 30 days and greater than 90 days to keep the intraseasonal variability. Harmonic analysis of geopotential at 200 hPa at middle latitudes of S.H., correlation analysis of OLR in the SACZ area and composites of extreme convection in SACZ and extreme amplitude of wave four were performed.

3. RESULTS

Composites of days with extreme intraseasonal OLR anomalies over SACZ region are shown in Fig. 1. The contribution of wave number four in the establishment of a trough over southeastern South Atlantic that intensifies and affects South America is noticed from day –10 to the period of maximum convection in the SACZ. As this trough intensifies and moves toward South America, the wave four weakens and the PSA pattern is dominant. The contribution of a middle latitude zonal wave train in the establishment of the PSA pattern in cases of SACZ occurrence was discussed in Cunningham and Cavalcanti (2006). In order to investigate the influence of the wave number four on the SACZ convection, other analysis were performed. To extract the dominant teleconnection patterns of DJF, an EOF analysis was applied to geopotential at 200 hPa, for two datasets: reanalysis and CPTEC/COLA AGCM results. The wave four structure was noticed in the third EOF of the reanalysis data, and in the first EOF of the AGCM data (Fig. 2). In both results there is an anomalous center over the southern tip of South America, and an opposite center downstream, which in the reanalysis case extends to the continent. In both results the strongest centers are located over South Pacific and southwest South Atlantic, which is consistent with previous studies that show the maximum activity of low frequency disturbances over South Pacific (Kiladis and Mo, 1998).



(a)



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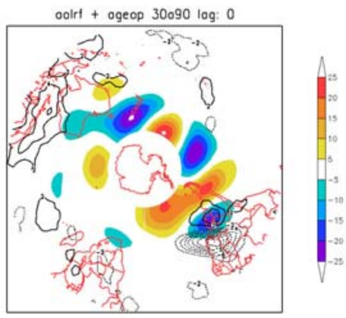
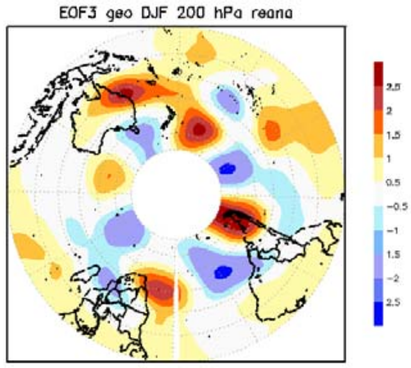
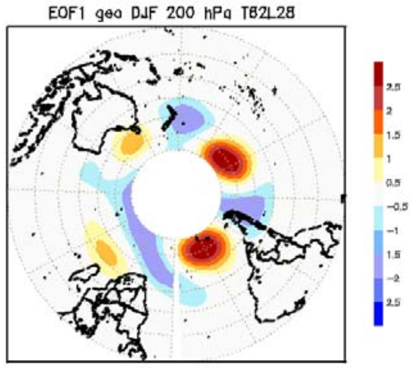


(c)

Fig.1- Composite of observed anomalous OLR and geopotential at 200 hPa for summer periods with filtered 30-90 days negative anomaly OLR in SACZ region, greater than one standard deviation. (a) Lag -10, (b) Lag -5, (c) Lag 0.



(a)



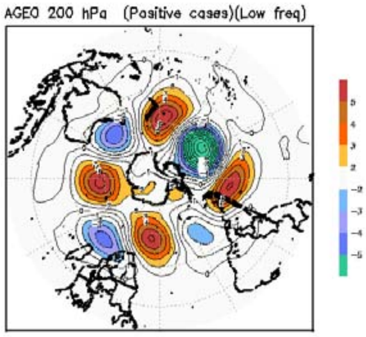
(b)

Fig.2- EOF of geopotential at 200 hPa in DJF. (a) EOF3 reanalysis; (b) EOF1 model results.

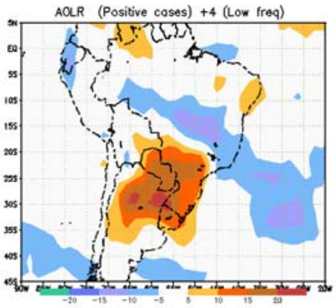
Only days with extreme amplitudes of wave four were selected to analyze the convective activity over South America. Five periods were identified, 2 when the anomalous center over southern tip of South America was positive (case 1) and 3 when it was negative (case 2). The cases show opposite centers over southwestern South Atlantic or over South-Southeastern South America, which were consistent with enhanced SACZ convective activity (trough) or reduction of SACZ activity (ridge) four days later. A composition of the two opposite patterns is shown in Fig. 3. There are 14 days in composition 1 and 17 days in composition 2. The typical north-south OLR dipole associated with the SACZ occurrence is well noticed in the cases and in the composites.

To investigate further the influence of the wave 4 on the maximum activity of SACZ, other analysis were performed. A persistent anomalous center occurs over Southeast South Pacific, discussed as blocking situations by several authors mentioned in Kiladis and Mo (1998). It is possible to identify this region as one center in the PSA pattern. When there is a persistent and amplified ridge at this location, there is a trough over southeastern South

America, which enhances convection in SACZ region.



(a)



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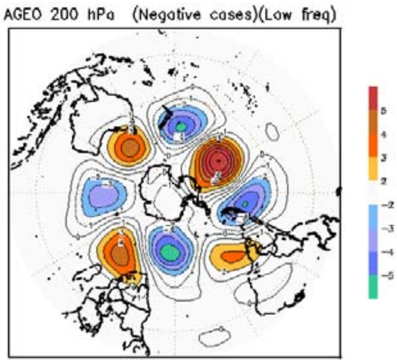

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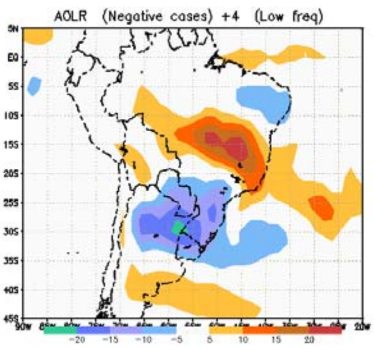
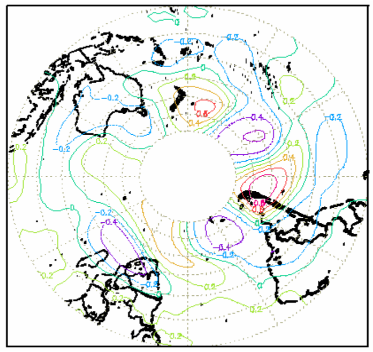


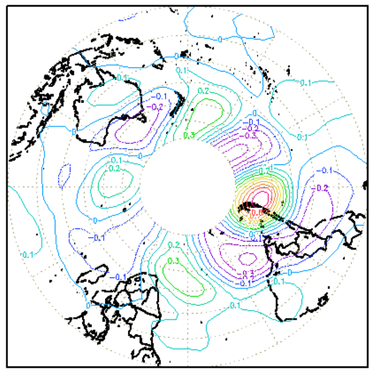
(d)

Fig.3- Composite of cases with extreme wave 4 amplitude in the model results (a) case 1 : 200 hPa geo.anom.; (b) case 1 : OLR anomaly four days later; (c) case 2: 200 hPa geo. anom.; (d) case 2: OLR anomaly four days later.

Correlations of 200 hPa geopotential height at grid point (85^0W,45^0S) with all the other S.H. grid points, display also a wave number four zonal structure around the SH in both model and reanalysis (Fig.4). An index with the geopotential values at the 4 centers was constructed by averaging the values at these centers (IWAVE4). Another index was considered taking the positive values at the center of action to the southwest of South America (IPAC). Days with extreme positive IWAVE4 and IPAC were selected and one common period is analyzed for both datasets, reanalysis and model results. In both results, the PSA pattern is identified and the stereographic projection reveals that this pattern is part of the wave 4 around the hemisphere. (Fig. 5 and Fig. 7). The unfiltered OLR anomaly for the periods, as well as the first and last days of the periods display the typical dipole pattern over South America associated with the SACZ (Fig.6 and Fig.8).



(a)



(b)

Fig.4- Anomaly correlations of 200 hPa geopotential of grid point 80^0W, 45^0S with all the other grid points (a) reanalysis; (b) CPTEC/COLA AGCM.

4. CONCLUSION

The contribution of zonal wave number four around Southern Hemisphere in cases of extreme convection in the SACZ is discussed, based on observed and model results data. The development of the wave 4 occurs prior to the maximum convection in SACZ. One of the wave 4 trough, over South Atlantic, intensifies and moves towards South America as the center over Indian Ocean weakens and the PSA pattern intensifies. Periods with extreme amplitude of wave 4 indicate that, at that time, the convection in the SACZ is already occurring, but has not reached the maximum value. Further studies are in development to clarify the mechanisms involved in the connection of wave 4, PSA and SACZ.

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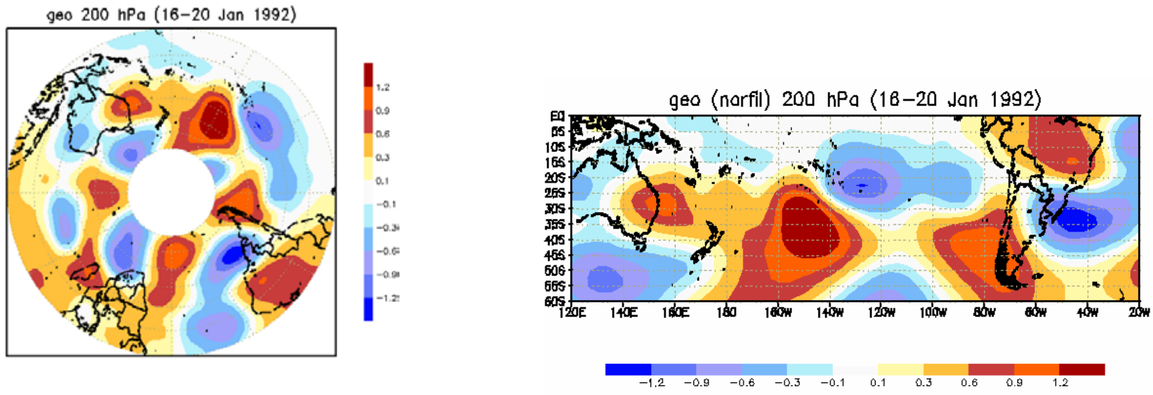
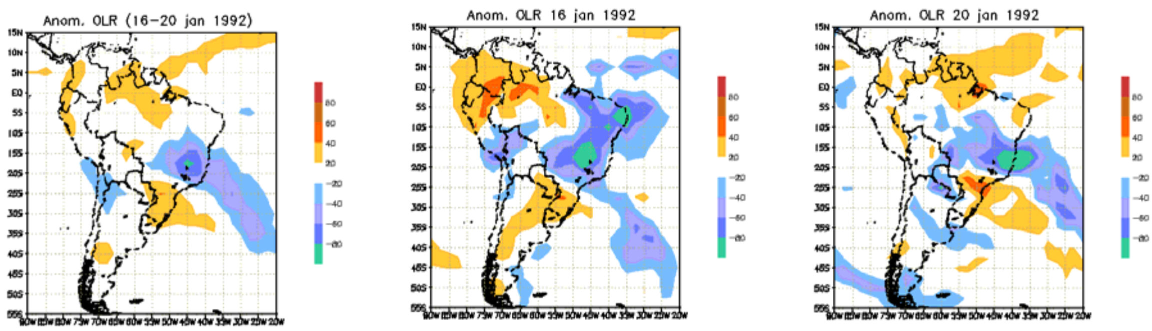


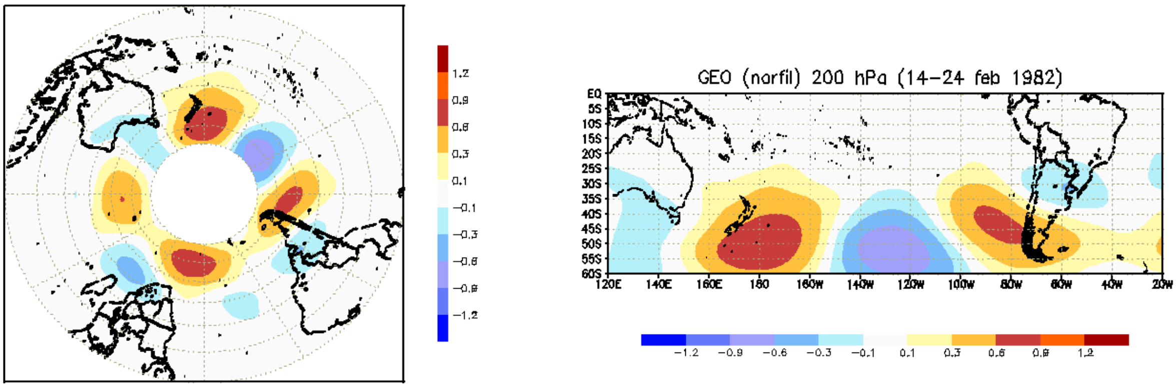
(a) (b)

Fig.5-Averaged 200 hPa geopotential intraseasonal filtered anomalies for the period of January 16th to 20 th , 1992 (reanalysis). (a) polar stereographic view; (b) Lat X Lon view.



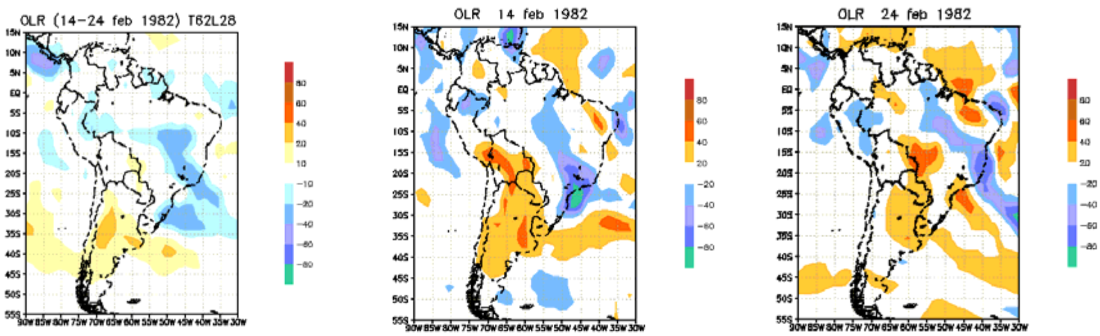
(a) (b) (c)

Fig. 6- Daily OLR anomalies (unfiltered) (a) Mean January 16th to 20 th , 1992; (b) day 16 th; (c) day 20th. (observations)



(a) **(b)**

Fig.7- Averaged 200 hPa geopotential intraseasonal filtered anomalies for the period of February 14th to 24th , 1982 (Model). (a) polar stereographic view; (b) Lat X Lon view.



(a) **(b)** **(c)**

Fig. 8- Daily OLR anomalies (unfiltered) (a) Mean February 14th to 24 th , 1982; (b) day 14 th; (c) day 24th. (Model)