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UPPER TROPOSPHERIC VORTICITY AND THE OLR STRUCTURE OVER SOUTH AMERICA

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1. Introduction

The basic objective of this paper is the analysis of the relationship between the convective activity and the upper level circulation over South America. Previous modelling and observational studies have indicated that the upper anticyclonic circulation over tropical South America and the tropical upper tropospheric trough of the NE coast of Brazil are related to the presence of deep tropospheric heating over the tropical part of the continent (Gutman and Schwerdtfeger, 1965; Silva Dias et al., 1983).

2. Data and Methodology

The data consists of monthly averages of the OLR (outgoing longwave radiation) and zonal and meridional components of wind at the 200 hPa level with 5^{o} resolution. The upper level winds were extracted from the NMC (National Meteorological Center) tropical strip analysis. Monthly averages based on a ten year period (1974-1984) were computed at each grid point excluding 1978 in the OLR case due to lack of information. Mean values of the OLR and relative vorticity fields were then computed over the Amazon region and over the climatological position of the Bolivian High (BH) for each monthly average. The correlation coefficients between the time series of the regional averages of OLR and relative vorticity were also calculated.

The corre ation coefficients of the relative vorticity field at specified grid points and the remaining data points were computed. The matrix correlation of the vorticity field at a single level allows the determination of teleconnections in the vorticity field.

3. Results

Over Central South America during southern hemisphere summer (November, December, January February and March) positive values of the vorticity field higher than $2x10^{-6}$ s^{-1} (Fig. 1) are observed in association with the BH system (Gutman and Schwerdtfeger, 1965; Dean, 1971 and Virji, 1981). Negative values are observed to the NE side of the BH, representing the presence of the upper level tropical Atlantic trough. This upper level pattern has already been discussed by (Dean, 1971; Kousky and Gan, 1981; Silva Dias et al., 1983 and Buckmann et al., 1986).

Positive values of the order of $10^{-6}s^{-1}$ are located over the South Atlantic Ocean extending from the SE part of Brazil and oriented along the NW/SE direction. Upper level divergence is associated with this region (not shown). During the southern hemisphere summer there are several episodes of stationary frontal systems in this region, also known as the South Atlantic Convergence Zone (SACZ).

The mean monthly averages of the OLR depict quite clearly the annual cycle of the convective activity in South America as discussed by Miller and Feddes (1971). The low values of OLR (below $230Wm^{-2}$) are generally associated to the convective activity. The convective activity over tropical South America displaces from Central America to the central part of South America from August to February when the return of convective activity to the northern hemisphere takes place.

The positive values of relative vorticity associated to the BH are usually observed from October-November up to February-March. The maximum positive values are usually observed just to the south of the region of low values of OLR associated to the intense convection over the Amazon. The interannual and intraseasonal variability of the relative position of the relative vorticity maximum and the intense convective activity, measured by the OLR field, are consistent with the dynamical mechanisms revealed by theoretical studies on the role of tropical forcing in the upper level circulation (Silva Dias et al., 1983).

Table 1 shows the correlation coefficients between the average relative vorticity over ,an area representative of the BH system ($10^{o}S/24^{o}S$ and 50^{o} W/80^{o}W) and OLR over the Amazon ($10^{o}S/24$ ^{o}S and $55^{o}W$ 75^{o} W). The time series cover the December to February period.

Table 1. Latitudinal and longitudinal boundaries used to define the orizontal averages and the respective correlation coefficient.

Coef.	BH		OLR	
	lat.(°S)	long.(°W)	lat.(°S)	long.(°W)
-0.3	10/24	50/80	05/24	50/75
-0.4	10/24	50/80	10/24	50/75
-0.5	10/24	50/80	05/24	55/75
-0.5	00/24	45/75	10/24	55/75

The correlation tends to be negative (minimum value of -0.5). Thus, just part of the variability of the monthly averages of the vorticity associated with the BH system is associated with the Amazon OLR. The remaining portion of the variability seems to be related to the convective activity over other parts of South America, predominantly the areas influenced by the frontal activity along the SACZ (Virji and Kousky, 1983). In fact, the correlation matrix of the relative vorticity field (Fig. 2) shows positive correlation (0.4) between a reference point at 14.8° S/65° W over the BH and the climatological position of the SACZ.

Buckmann et al. (1986) and Paegle (1987) suggest that the intense convective activity over the Amazon region enhances the subsidence over the NE region of Brazil and bordering regions. The intraseasonal variability of the OLR field in the ITCZ indicates an increase in the OLR values (decrease of convective activity) during the summer months. This effect is probably related to the compensating subsidence caused by the concentration of precipitation over the Amazon and Central part of Brazil during the summer months.

The correlation coefficients between the OLR averages over the Amazon region and over the Tropical Atlantic upper tropospheric trough (Table 2) are of the order of -0.7. The negative value suggests that the convection over the Amazon is inversely related to the intensity of the Tropical Atlantic Upper Tropospheric Trough (TAT) in a climatological scale. This result does not agree with Buckmann et al. (1986) model analysis which suggest that by the time the convective activity over Amazon gets stronger, the upper trough should get deeper.

Table 2. Latitudinal and longitudinal boundaries used to define the horizontal averages and the respective correlation coefficient.

	TAT		OLR	
Coef.	Lat. (°S)	Long. (°W)	Lat. (°S)	Long. (°W)
-0.3	00/20	20/35	10/28	50/75
-0.4	05/15	20/35	10/28	50/75
-0.5	05/15	15/35	00/28	55/70
-0.7	05/15	15/35	00/28	50/75

4. Conclusions

The vorticity and OLR fields are consistently related during the southern hemisphere summer. The intensity of convective activity over the Amazon is directly related to the vorticity over the Bolivian High which is inversely related to the vorticity in the upper tropical Atlantic trough. Positive correlation is also detected between the vorticity field associated with the Bolivian High and the South Atlantic Convergence Zone where summer frontal systems tend to become stationary. Intraseasonal and interannual variations of the vorticity field and the convective activity are in close agreement with theoretical results except for the correlation between the convective activity in the Amazon region and the upper tropical Atlantic trough.

5. References

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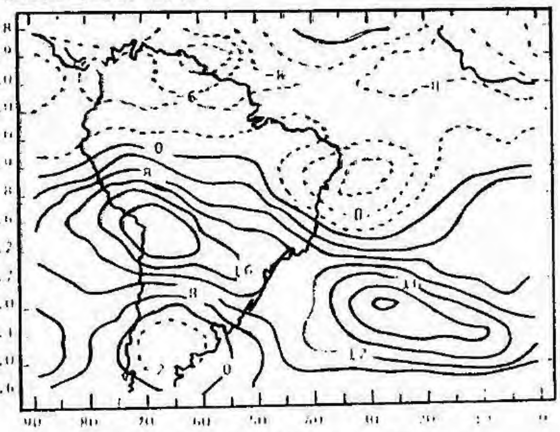

Fig. 1: Ten-year-average Relative Vorticity for January

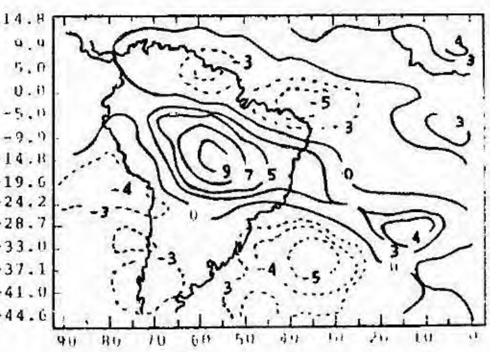

Fig. 2: Matriz-Correlation between BH and SACZ