SPACE-TIME VARIABILITY OF RAINFALL OVER TROPICAL SOUTH AMERICA

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1. INTRODUCTION

The climatic rainfall variability over Tropical South America (TSA) has been studied mainly for interannual time scales, related to SST anomalies of the tropical oceans, whereas a few studies focused either on the seasonal or interdecadal scales. The 'El Niño-Southern Oscillation' (ENSO) episodes cause an anomalous rainfall pattern in TSA. In fact, during warm ENSO events drought conditions occur over northern Northeast Brazil (Uvo et al. 1998), while northern Peru and southern Brazil and Uruguay suffer with intense floods (Horel and Cornejo 1986; Pisciottano et al. 1994). On the other hand, interannual rainfall variability over Northeast Brazil and Amazonia are modulated by the Tropical Atlantic SST (e.g. Nobre and Shukla 1996). The interannual variability of rainfall at the east coast of Northeast Brazil is modulated by the position and strength of the South Atlantic Subtropical High (Rao et al. 1993).

Although more research is needed into explaining the physical mecanism responsible for those teleconnections. They display considerable complexity reflected by the lack of any obvious periodicity (e. g. 2-7 years of ENOS) and by the occurrence of a pattern forced by seemingly random, longitude-independent planetary waves (Pacific-South America Pattern) or by another interdecadal ocean/atmosphere interactions in the tropics. The principal aim of this study is to draw attention to the fact that it is important to adopt some robust and persistent patterns of rainfall variability over TSA, based on a more dynamical view of the underlying phenomena to further explore this for improved long-term forecast.

This work is based on monthly rainfall analysis for TSA east of the Andes from 1951 to 1990. The Principal Component Analysis of normalized data where the seasonal cycle was removed and spectral analysis of the expansion coefficients (PCs) of the EOFs are used in the analysis. To establish relationships between each EOF mode and either atmospheric or oceanic fields, NCEP reanalysis and COADS SST fields for the same period were used.

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2. SPACE AND TEMPORAL VARIABILITY

The first four modes of the monthly rainfall anomalies (27% of the total variance) are well separated according the "N-rule" criterion. The first, second and fourth modes are considered here.

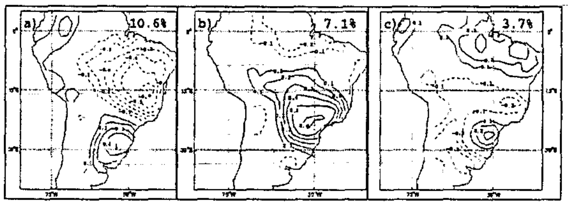

Fig. 1 Spatial pattern of the rainfall over Tropical South America. a) EOF1; b) EOF2; c) EOF4. The zero contour is not drawn. The fractions of variance are indicated in the upper right-hand corner of each map.

The EOF1 spatial pattern (Fig. 1a) exhibits a bipolar structure centered at around 16°S, 44°W and 30°S, 50°W and the spectral analysis of the first PC (PC1) shows a peak at 3.6 years, significant at 90%. This pattern seems to be related to meridional displacements of the South Atlantic Convergence Zone (SACZ) in interannual time scales. The correlation between PC1 and eddy stream function at 200 hPa (Fig. 2b) shows wave-train pattern that extends from South Pacific, amplifies downstream over Western Atlantic, where the correlation between the PC1 and the SST anomalies (Fig. 2b) is strongest. This pattern bears some resemblance to the Pacific-South American pattern (Mo and Higgins 1997)

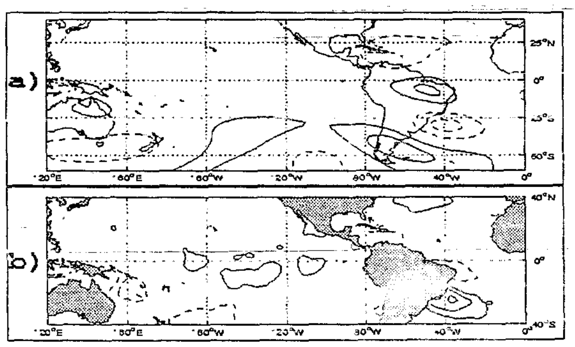

Fig. 2 Coefficient of correlation between the PC1 and eddy stream function at 200 hPa (a) and between PC1 and SST anomalies (b). Only regions where correlation is statistically sigificant at the 95% level are shown. Contour interval is 0.1, with negative values dashed.

The spatial pattern associated to EOF2 (Fig. 1b) presents a northwest to southeast oriented structure. Negative values along North and Northeast Brazil and from Bolivia to Uruguay separated by a band of positive values from Southeast Brazil to Peru. This pattern seems to be a response of the rainfall anomalies over TSA to the mature phase of ENOS episodes (Fig. 3b), where the climatological Walker circulation (Bjerknes 1969) is weakened or reversed. This is illustrated in Fig. 3a showing the vertical cross section of the correlation between the PC2 and ω, averaged from 5°N - 5°S. The spectral analysis of PC2 shows peak of 3.6 and 8.5 years, significant at 99%.

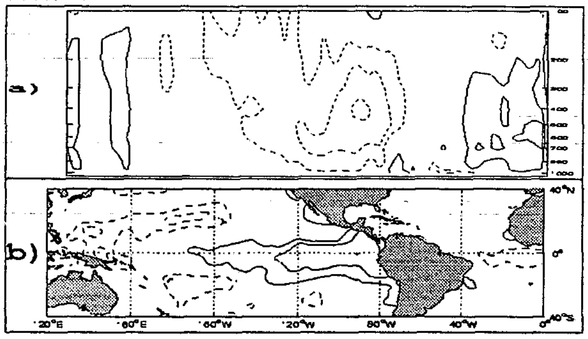

Fig. 3 Coefficient of correlation between the PC2 and ω (a) and between PC2 and SST anomalies (b). Only regions where correlation is statistically significant at the 95% level are shown. Contour interval is 0.1, with negative values dashed.

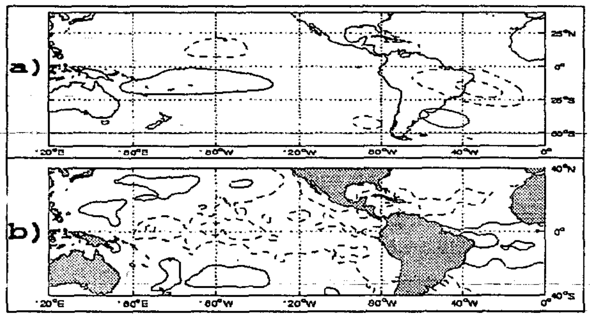

Fig. 4 As in Fig. 2, but for PC4.

The EOF4 spatial pattern (Fig. 1c) displays a "wave–like" pattern along the east coast of South America, and the spectral analysis of PC4 shows a peak at 14.2 years, significant at 99%. In addition, cross spectral analysis among the PC4 and another indices (IOS, NAO, Pacific and Atlantic SST) shows that only the Central Pacific SST (NIÑO4) and the difference between the Tropical South Atlantic SST index and the Tropical North Atlantic SST index show coherence, significant at 90%, at periods 12-15 years, whit ± π and zero phase lag, respectively. Therefore, this pattern seems to be a feature of decadal rainfall variability in TSA with markedly dependence on SST anomalies at both the Tropical Pacific and Atlantic (Fig. 4a). The correlation field between the PC4 and the eddy stream function at 200 hPa presents (not shown) a near equivalent barotropic vertical structure. The regions of maximun correlation of PC4 with eddy stream function lie close to regions where correlation with SST is also maximun (Fig. 4b).

4. CONCLUSIONS

Although only 22% of the time-space rainfall variability is explained by the three modes above, it is plausible to conclude that the principal mechanism leading to complex behavior of the inteannual and Interdecadal precipitation variability over TSA is strongly modulated by the SST anomalies of both the Tropical Pacific and Atlantic Oceans. The atmospheric teleconnections and its dynamic underlying becomes extremely important related to the timing and place of the SST anomalies

Regardless of how complex the teleconnections patterns are the results point out that in interannual time scales variations in meridional position of the SACZ pattern is the main mode of rainfall variability over TSA. This seems to be a response to the planetary waves linked to interannual fluctuation in convection over Western Pacific-Indian Ocean regions, intensified by the SST at Atlantic Ocean adjacent to Southeast Brazil. The second pattern seems to be modulated by the ENOS phenomenon itself, and the fourth pattern modulated principally by the gradient of Tropical Atlantic SST.

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