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ON THE INFLUENCES OF THE *EL NIÑO*, *LA NIÑA* AND ATLANTIC DIPOLE PATTERN ON THE AMAZONIAN RAINFALL DURING 1960-1998

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1. INTRODUCTION

Most of the annual total rainfall over the Amazon occurs during the austral summer (December to February) and autumn (March to May) months. The summer rainfall accounts for the highest percentages of the annual total with the largest values increasing from the northern sector towards the central and southern sectors. The autumn shows an inverse pattern, i.e., with the highest percentages ranging from 40% to 48% in the northern sector (particularly the oriental Amazon) and the lowest values spanning from 24% to 27% in the southern sector. The strong seasonal superficial heating during the austral summer and autumn causes deep convection and defines the Amazon rainy period. Some of these systems are mainly related to the seasonal cycle of the atmospheric circulation, such as the Bolivian upper-tropospheric high and the Intertropical Convergence Zone (ITCZ), witch migrates southward during the austral summer and autumn inducing widespread precipitation mainly in the center-eastern Amazon by the end of the summer and beginning of the autumn (Nobre and Shukla, 1996). The cold fronts originating in the austral extratropics may also affect the convection in the Amazon. In addition, squall lines trigged by sea breezes along the eastern coast which moving into the central Amazon intensify the convection over the Amazon (Fisch et al., 1998). In the present work precipitation data over the Amazon and of tropical SST data are used to investigate the relationship between tropical SST variations and anomalous rainfall distribution over the Amazon, in particular during the austral summer and autumn seasons.

2. DATA AND METHODOLOGY

The data used consist of monthly precipitation records for the period 1960-1998 for 82 raingauge stations in the Amazon obtained from the Instituto Nacional de Meteorologia (INMET) of Brazil. Due to a poor coverage of raingauge stations in the central and northern Amazon sectors the data are interpolated into a regular grid of 0.25° latitude and longitude resolution using the Kriging method. Monthly SST data are obtained from two datasets. The SST data for the period 1960-1993 are extracted from the version compiled by Da Silva *et al.* (1994) of Comprehensive Ocean-Atmosphere Data Set (COADS) which contains monthly global fields in a grid of 1° latitude and longitude resolution. The SST data for the period 1994-1998 are obtained from the monthly global fields with horizontal resolution of 1° in latitude and longitude routinely made available at the National Centers for Environmental Prediction. As recommended by Trenberth (1997), *El Niño* (*La Niña*) years are defined as those with occurrences of monthly SST anomalies averaged in the NINO3 area (5° N - 5° S and 145° W - 90° W) ≥ +0.5°C (≤-0.5°C) consecutively on October, November and December. For the selection of dipole years monthly SST anomalies are averaged in two areas, one in the North Atlantic limited at 5°N, 25°N, 50°W and 20°W and another in the South Atlantic limited at 5°S, 25°S, 30°W and the Greenwich meridian.

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The warm dipole years are defined as those with simultaneous occurrences of monthly SST anomalies ≥+0.2°C over the North Atlantic area and monthly SST anomalies ≤-0.2°C over the South Atlantic area, consecutively on March, April and May (period with a better definition of the dipole pattern mode), inverse to the cold dipole years. Table 1 is derived from Figure 1 and displays the years included in the period 1960-1998 with occurrences of *El Niño*, *La Niña*, warm and cold dipoles in the Atlantic. The years listed in Table 1 are then used as the basis to compute the Amazon precipitation composites for the austral summer and autumn seasons. For the austral summer composites and for ENSO cases, December is taken on the onset year of *El Niño* (or *La Niña*), and for the dipole cases, it is taken on the previous year of the onset of warm (or cold) dipole.

Table 1. Years of the occurrences of *El Niño*, *La Niña* events and warm and cold dipole in the tropical Atlantic during the period from 1960 to 1998.

Phenomenon:	*EL NIÑO*	*LA NIÑA*	WARM DIPOLE	COLD DIPOLE
Years of occurrence:	63, 65, 68, 69, 72, 76, 79, 82, 86, 87, 91, 94, 97	61, 64, 67, 70, 71, 73, 75, 84, 85, 88, 95	66, 70, 78, 79, 80, 81, 92, 97	64, 65, 71, 72, 73, 74, 77, 85, 86, 89, 94

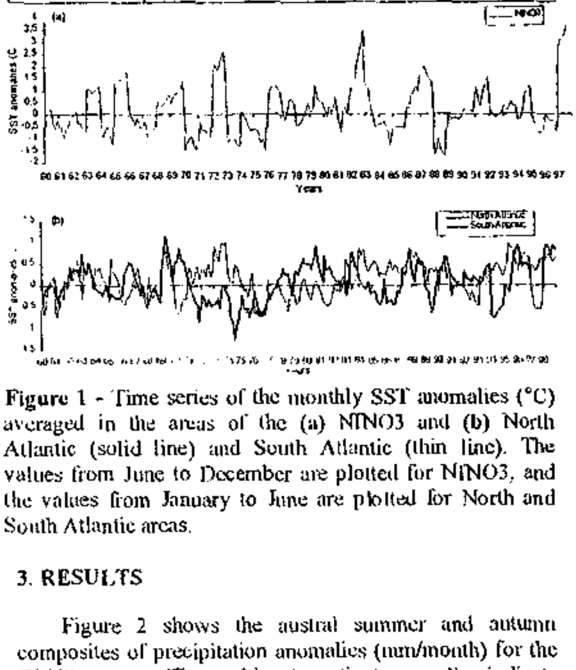


Figure 1 - Time series of the monthly SST anomalies (°C) averaged in the areas of the (a) NINO3 and (b) North Atlantic (solid line) and South Atlantic (thin line). The values from June to December are plotted for NINO3, and the values from January to June are plotted for North and South Atlantic areas.

3. RESULTS

Figure 2 shows the austral summer and autumn composites of precipitation anomalies (mm/month) for the *El Niño* years. The positive (negative) anomalies indicate precipitation above (below) the climatological values for each season. *El Niño* events affect more strongly the summer precipitation than the autumn precipitation in the Amazon. Indeed, most of the Amazon experiences deficient precipitation during summer with negative anomalies in almost the whole area and values lower than -50 mm/month in its central and northern parts. In both seasons, positive anomalies are found over the southeastern

Amazon (Mato Grosso and Tocantins). It is worthwhile to mention the occurrence of positive anomalies over northeastern Pará centered near Altamira area during autumn. This might be related to the action of meso-scale systems, such as squall lines along the eastern coast of the Amazon.

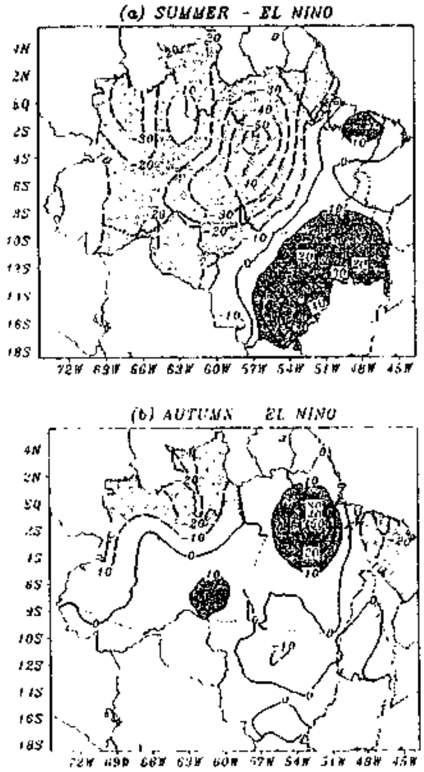
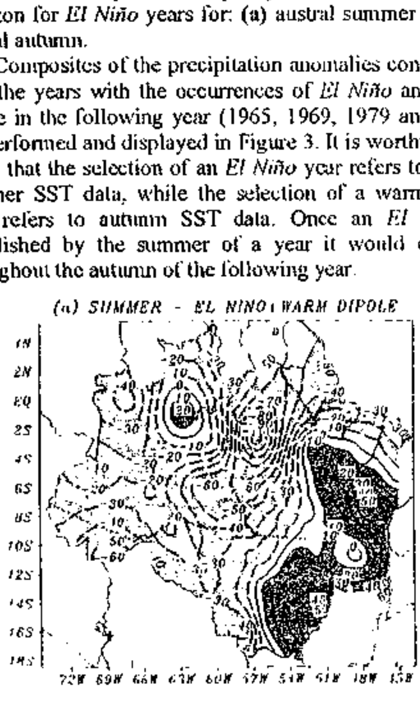


Figure 2 - Composites of precipitation anomalies over Amazon for *El Niño* years for: **(a)** austral summer and **(b)** austral autumn.

Composites of the precipitation anomalies considering only the years with the occurrences of *El Niño* and warm dipole in the following year (1965, 1969, 1979 and 1991) are performed and displayed in Figure 3. It is worthwhile to recall that the selection of an *El Niño* year refers to austral summer SST data, while the selection of a warm dipole year refers to autumn SST data. Once an *El Niño* is established by the summer of a year it would continue throughout the autumn of the following year.



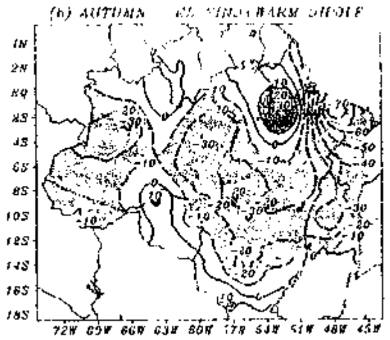


Figure 3 - As in Fig. 2 but for years (1965, 1969, 1979 and 1991) of simultaneous occurrences of *El Niño* events and warm dipole.

Comparisons of Figures 2 and 3 show that the *El Niño* and warm dipole have a stronger combined effect in reducing precipitation over the center-northern and western Amazon and in increasing precipitation in the eastern Amazon during austral summer than the two events acting individually. In fact, the lowest negative values over center-northern Amazon are -50 mm/month, -30 mm/month and -100 mm/month. This result reveals also a relatively weak effect of the *El Niño* on the autumn rainfall in the Amazon region.

4. CONCLUSIONS AND SUGGESTIONS

The combined effect of *El Niño* and warm dipole in the Atlantic has been analyzed. For summer, these two climatic modes have a stronger combined effect in reducing the precipitation over center-northern and western Amazon and in increasing precipitation over eastern Amazon than each mode acting individually. Otherwise, the deficient autumn precipitation over the Amazon is rather due to the warm dipole than due to the *El Niño* episode. The results above suggest that the effects of *El Niño, La Niña*, warm dipole and cold dipoles in the Atlantic as reflected in the anomalous rainfall distribution over the Amazon contain a seasonal component defined by the regional atmospheric circulation, which in turn relates to the seasonal variations of the Hadley and Walker Cells. This aspect seems to be a relevant factor in climate monitoring tasks.

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