AN EL NIÑO EPISODE CONJUGATED WITH A POSITIVE DIPOLE IN THE ATLANTIC: TROPOSPHERIC CIRCULATION AND IMPACTS OVER TROPICAL SOUTH AMERICAN

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ABSTRACT

A comprehensive diagnostic analysis of the atmospheric circulation associated to an El Niño episode conjugated with a positive Dipole Pattern in the Atlantic, observed during 1991-92 austral Summer and 1992 Fall, is presented. The results evidenciated a dramatic change in the large-scale atmospheric circulation patterns over tropics, with anomalous descending branches of the Walker and Hadley Cells extending from the northeastern South American to the southern tropical Atlantic, and explains the very deficient rainy seasons observed in the Amazon and northeastern Brazil during 1991-92.

INTRODUCTION

Nowadays is consensual that the low-frequence variability in the Amazon region and northeastern Brazil is dominated by interannual variations of sea surface temperature (SST) in the equatorial eastern Pacific, associated with the El Niño/Southern Oscillation – ENSO cycles. In addition, the interannual variations of the SST in the tropical Atlantic, associated with an anomalous north-south Dipole Pattern may also contribute to the low-frequency variability in these regions. Both of these atmosphere-ocean coupled modes are closely related to the precipitation variations in these regions. Droughts (floods) in the eastern Amazon and northestern Brazil have strong links with warming (cooling) in the equatorial eastern Pacific (Kousky *et al.*, 1984; Kayano and Moura, 1986; Aceituno, 1988; Kousky and Ropelewski, 1989; Rao e Hada, 1990; Alves e Repelli, 1992; Marengo and Hastenrath, 1993; Ropelewski and Halpert, 1987; Souza *et al.*, 1998b). On the other hand, a positive (negative) Dipole Pattern, characterized by simultaneous occurrences of positive (negative) SST anomalies in the tropical north Atlantic and negative (positive) SST anomalies in the tropical south Atlantic, is related to droughts (floods) in the northeastern Brazil (Hastenrath and Heller, 1977; Moura and Shukla, 1981; Nobre and Shukla, 1996; Uvo *et al.*, 1998, Souza *et al*., 1998a).

This paper provides a comprehensive diagnostic analysis of the atmospheric circulation observed during 1991-92 austral summer (December to February – DJF) and the 1992 fall (March

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to May – MAM), when a warming (El Niño) in the Pacific and a positive Dipole in the tropical Atlantic were observed.

DATA AND METHODOLOGY

The monthly global dataset for the 1991 and 1992 years was extracted from NCAR/NCEP reanalysys project, that created a very long global dataset compilated by Kalnay *et al.* (1996), using a state-of-the-art global data assimilation system. The variables used, suh as the SLP, long-wave radiation (OLR), zonal and meridional wind components, vertical velocity (ω) and specific humidity (q) for twelve tropospheric levels (1000, 925, 850, 700, 600, 500, 400, 300, 250, 200, 150 and 100 hPa) are disposed in the 2,5°x2.5° horizontal grid. The monthly SST data observed in the 1991 to 1992 years were derived of the monthly global fields rotinely available at the NCEP, whose horizontal resolution is 1°x1°. Monthly data of precipitation totals observed over Brazil in the 1991 to 1992 years are from Instituto Nacional de Meteorologia of Brazil.

Various seasonal fields was ploted using whole variables mentioned above, in order to analyse the atmospheric circulation at the surface and in the tropospheric high levels, associated with 1991-92 El Niño and the 1992 Atlantic positive Dipole Pattern.

RESULTS AND DISCUSSIONS

During the years of 1990 to the beginning of 1995, was observed one of the longest El Niño events on record of the last 50 years (Trenberth and Hoar, 1996). In this period, the SST anomalies in the center-east Pacific were more intense starting from middles of 1991 to the end of 1992 (Cavalcanti, 1996). Concomitantly, during the first semester of 1992 was observed the positive Dipole in the tropical Atlantic. In the Figure 1 can be clearly observed, during the 1991-92 summer and 1992 fall, the spatial configuration of the positive SST anomalies associated with El Niño and the spatial configuration of SST anomalies associated with positive Dipole Pattern.

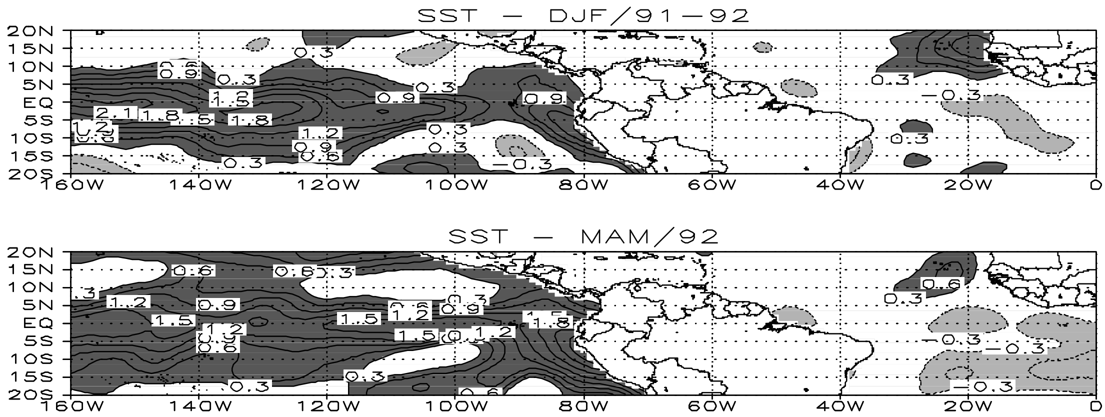

Figura 1: Seasonal SST anomalies observed during 1991-92 summer and 1992 fall. Light shading represents negative SST anomalies and dark shading represents positive anomalies.

During 1991-92 summer and 1992 fall was observed in the tropical Pacific basin the manifestation of trade winds weaker than normal associated to the presence of negative SLP anomalies and positive SST anomalies. On the other hand, in the tropical Atlantic basin, due to presence of anomalies SST positive/negative in the north/south basin, are verified northeat/southeast trade winds more weak/intense than normal in both seasons (figure not shown).

The changes in the zonal atmospheric circulation pattern (Walker Cell) over tropics, associated to the presence of the El Niño event, were analyzed by zonal cross sections (longitude versus height), shown in the Figure 2, considering the mediated variables between 5°N-5°S latitudes. Over whole high troposphere in the center-east Pacific basin (region containing SST hotter than the normal and low pressures) is observed the presence of anomalous air ascending (upward arrows in the Figure 2) and q above of normal (positive isolines in the Figure 2). Those anomalies are more intense in the central Pacific during the summer, while during the fall are extended to the whole center-east Pacific. On the other hand, over high troposphere between the east of South America and Atlantic are observed anomalous air descending (downward arrows in the Figure 2) and q below of normal (negative isolines in the Figure 2). Therefore, during the 1991-92 summer and 1992 fall, was evidenced over center-east Pacific the prevalence of an ascending branch of the Walker Cell, while over east of South America and Atlantic ocean prevailed the descending branch of the Walker Cell.

The changes in the meridional atmospheric circulation pattern (Hadley Cell) over area of Atlantic and northeast of South America, associated to the presence of positive Dipole event, were analyzed by meridional cross sections (latitude versus height), shown in the Figure 3, considering the mediated variables between 40°W-30°W longitudes. During the summer and fall are noticed the manifestation of anomalous ascending air and q above of normal on the high troposphere of north tropical Atlantic (area contends SST hotter than normal), mainly in the area located among 5°N-10°N. Inversely, in the region placed from equator to south tropical Atlantic (area contends SST colder than normal), mainly in the 0° to 15°S, is observed anomalous air descending and q below of normal. Therefore, during the 1991-92 summer and 1992 fall, was evidenced over north Atlantic the prevalence of an ascending branch of the Hadley Cell, while over south Atlantic, including northeast of South America, prevailed the descending branch of the Hadley Cell.

Thus, these results evidenciated a dramatic change in the large-scale atmospheric circulation patterns over tropics, with anomalous desceding branches of the Walker and Hadley Cells extending from the northeatern Amazon to the southern tropical Atlantic. This patterns explains in great part the very deficient rainy seasons observed in the Amazon and northeastern Brazil during 1991-92 summer and the 1992 fall, as can be noticed in the seasonal precipitation anomalies fields shown in the Figure 4. The recent numerical simulations performed by Pezzi and Cavalcanti (1999) also shown the same configurations studied in this work. The same anomalous patterns analysed in this work, were observed during 1957-58 and 1969-70 too, and can be responsible for the remarkable severe droughts verified on the brazilian northeastern during 1958 and 1970.

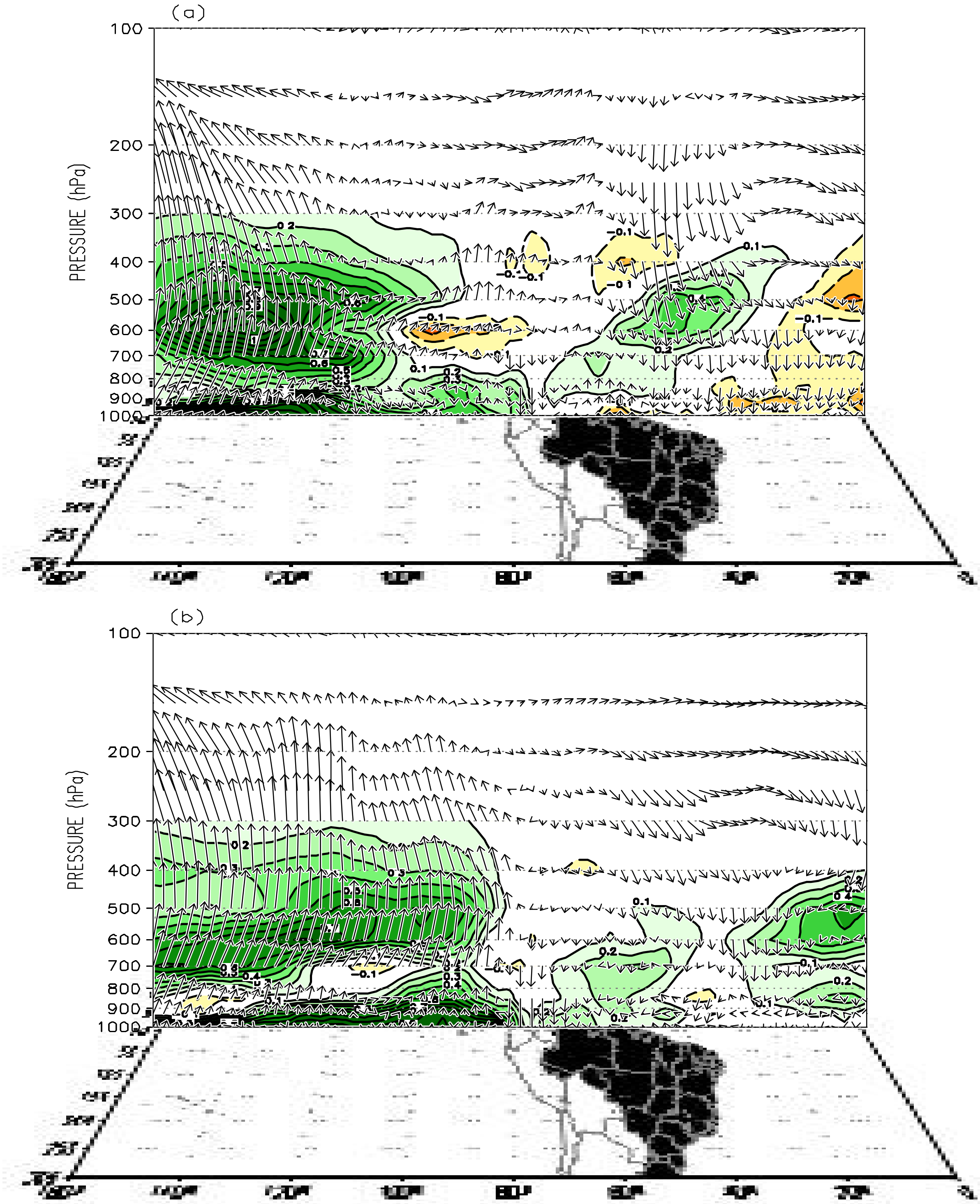

Figura 2: View in perspective of the zonal cross sections (longitude x height) of the seasonal ω and q anomalies mediated over equator (5°N/5°S), during **(a)** 1991-92 summer and **(b)** 1992 fall. Yellow to dark red shading represents negative q anomalies and green to dark green shading represents positive q anomalies. The Brazil is highlighted with black shaded.

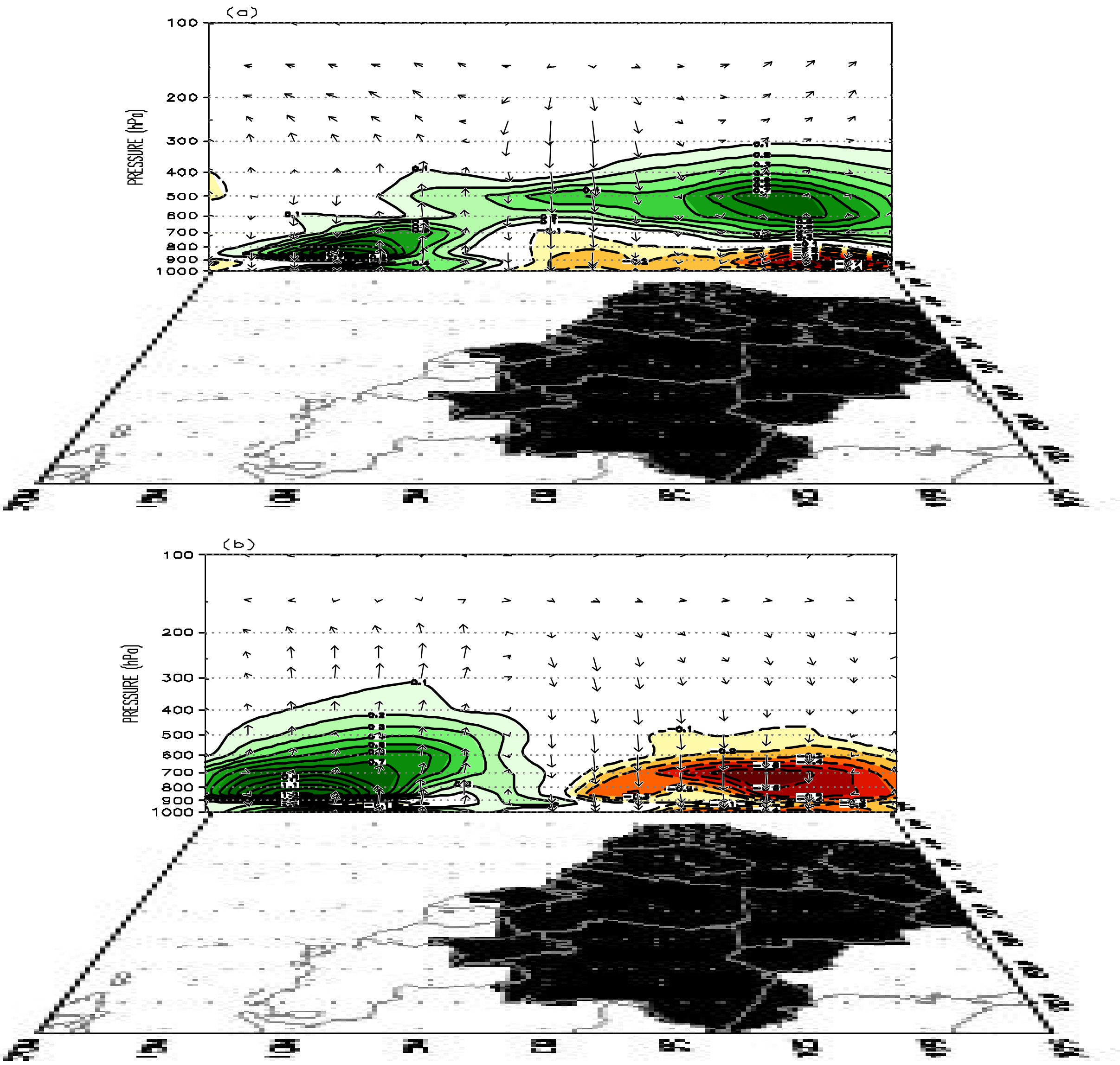

Figura 3: View in perspective of the meridional cross sections (latitude x height) of the seasonal ω and q anomalies mediated over 30°W/40°W region, during **(a)** 1991-92 summer and **(b)** 1992 fall. Yellow to dark red shading represents negative q anomalies and green to dark green shading represents positive q anomalies. The Brazil is highlighted with black shaded. Look at figure turning 90° counterclockwise your vision.

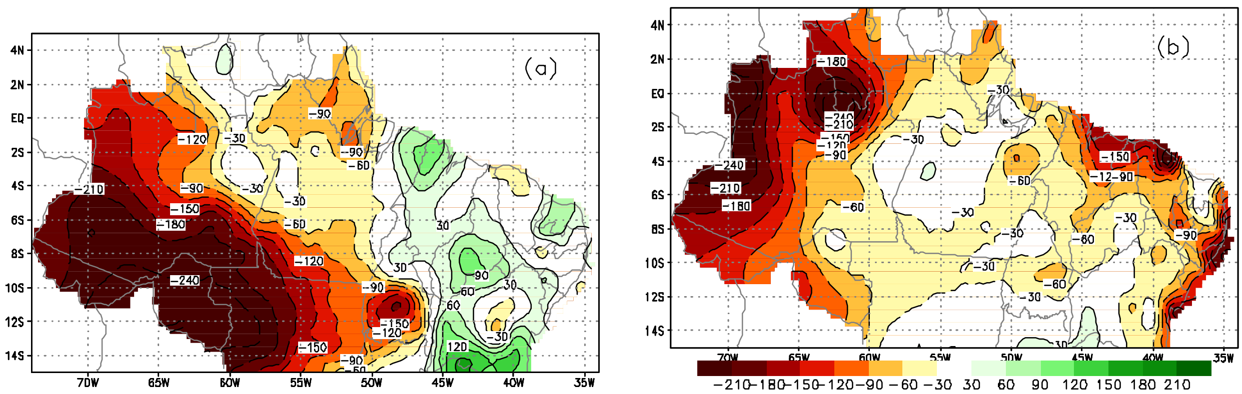

Figura 4: Seasonal precipitation anomalies observed in the Amazon region and northeastern Brazil during **(a)** 1991-92 summer and **(b)** 1992 fall. Yellow to dark red shading represents negative precipitation anomalies and green to dark green shading represents positive anomalies.

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