2.10 HADLEY AND WALKER CIRCULATIONS ASSOCIATED WITH THE ENSO EPISODES DURING 1970S, 1980S AND 1990S: IMPACTS ON THE SOUTH AMERICAN SEASONAL RAINFALL

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1. Introduction

Most of the annual total rainfall observed over the South America usually occurs during the austral summer (December to February - DJF) and autumn (March to May - MAM) months. The large and synoptic meteorological systems that modulate the rainfall in this period are related to the South Atlantic Convergence Zone - SACZ (e.g., Nogués-Paegle and Mo, 1997), Bolivian High and the upper tropospheric cyclonic vortices (e.g., Kayano et al., 1997). During MAM, the Inter Tropical Convergence Zone - ITCZ (e.g. Souza et al., 1998b) also plays an important role in modulating the rainfall. It is well known nowadays that ENSO (El Niño/Southern Oscillation) deflagrates changes in the general circulation of the atmosphere, resulting in climatic impacts in several continental areas located in the tropics and extratropics. These changes are basically related to the weakness, intensification and/or displacements of the large-scale atmospheric circulation in the meridional and zonal planes, mainly those linked to the Hadley and Walker circulations (Kidson, 1975; Kousky et al., 1984). The main goal of this study is to analyse the changes in the Hadley and Walker cells and their respective impacts on the South American rainfall during the ENSO episodes observed in the decades of 1970s, 1980s and 1990s. Following the same procedure as in Souza and Ambrizzi (2002a), cross-sections analyses of the atmospheric circulation in altitude, averaged in the zonal and meridional planes will be investigated.

2. Data and Analysis Procedure

The dataset used in this work for the 1970-1999 period consist of: (a) global grid data of zonal, meridional and vertical components of the wind vector in the pressure levels of 1000, 925, 850, 700, 600, 500, 400, 300, 250, 200, 150 and 100 hPa obtained from the National Centers for Environmental Prediction/National Center for Atmospheric Research - NCEP/NCAR reanalysis project (Kalnay *et al*., 1996); (b) global grid SST reconstructed Reynolds EOFs obtained from the optimum interpolation analyses of Reynolds and Smith (1994); and (c) the 50-years gauge precipitation dataset compiled by Chen *et al*. (2002), who put together a large number of monthly precipitation on a 2.5° latitude/longitude grid over the global land areas for the 1948-2000 period.

The seasonal climatology was based on the 29 years reanalysis data. A composite of ENSO events for each decade and season was made. The summer and autumn austral ENSO episodes were selected based on the CPC-NCEP-NOAA classification. The warm events chosen are: 1973, 1977, 1978, 1980, 1983, 1987, 1991, 1992, 1993, 1995, 1998; and for the cold events we have: 1971, 1974, 1975, 1976, 1984, 1985, 1989, 1996, 1999.

The large-scale atmospheric circulation patterns related to the Hadley and Walker cells were investigated, with emphasis to the Pacific, South America and Atlantic domain through the plotting and analyses of the vertical cross-sections of the upper atmospheric circulation (zonal, meridional and vertical components of the wind vector) and specific humidity from 1000 up to 200 hPa levels during DJF and MAM seasons. For brevity we will only be showing the El Niño circulation anomalies for the 1990s decade (Fig.1). The complete analysis will be presented in a companion paper later on.

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3. Results and Final Comments

In comparison to the other decades, the 90s can be considered as having a "typical" atmospheric circulation and precipitation anomalies pattern. A large upward vertical motion going from lower to the upper levels is observed on the equatorial region around 150°W and a maximum of the descending motion is seen around 50°W during DJF. In the next season (MAM), ascend motion seems spread over the equator and the subsidence is weaker over the Northeast Brazil. As a consequence of this anomalous Walker circulation, rainfall deficits are observed in the north of South America. The Hadley circulation anomalies show weak ascending motion between 10°N and Equator and around 35°S during DJF. The overall downward motion pattern has decreased during the autumn season. Positive precipitation anomalies are observed over the subtropical South America, particularly in the South of Brazil. This general pattern is in agreement with many previous studies (e.g., Ropelewski and Halpert, 1987).

The above described patterns vary significantly from one decade to other. In particular the ENSO composites of the 1980s have shown larger amplitudes in terms of Walker and Hadley circulation as well as rainfall deficits over the South America. On the other hand, the 1970s has presented a very different picture, particularly in the precipitation patterns, with reverse signs in the Northeast Brazil and South- Southeast, where positive anomalies were observed in the first and negative in the last regions. It seems that the Atlantic ocean has played a very import role during this decade.

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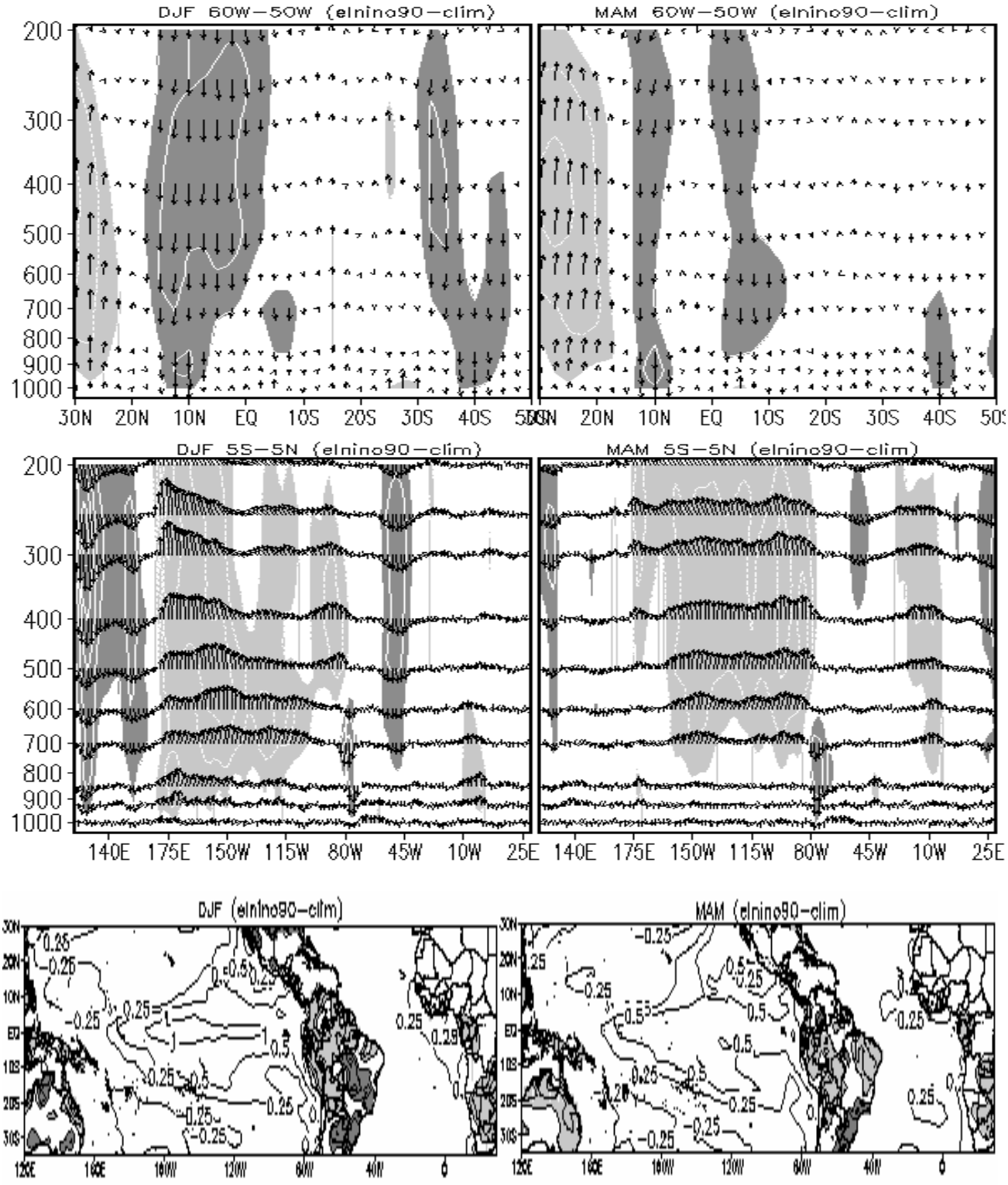

Figure 1: – Composite of El Niño episodes observed during the 1990s for the DJF (left) and MAM (right) seasons. Top figures are seasonal anomalies of omega (shaded contours) and meridional-vertical circulation (vectors). The intermediate figures are seasonal anomalies of omega (shaded contours) and zonal-vertical circulation (vector). Lower figures show seasonal anomalies of SST (contours) and precipitation (shaded contours). Darker (light) shaded contours represent positive (negative) anomalies of omega and precipitation.