

ON THE 2005 DROUGHT IN THE AMAZON RIVER BASIN

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ABSTRACT The regional meteorological conditions of a long lasting drought observed in Amazonia during 2005, as well as the main large-scale oceanic and atmospheric mechanisms associated are documented in this work. During rainy season (November 2004 to May 2005) and specially during dry season (June to September 2005), the spatial and temporal configuration of rainfall was very irregular with predominance of values below to very below of normal in most of Amazonian basin. The persistency of rainfall deficit was very accentuated particularly in western and southern Amazonia, including headboard regions of Solimões, Negro, Juruá, Purus and Madeira rivers, which give significant contribution to fluvial regime of Amazon River Basin. During this period, the large-scale patterns were associated with a persistency of oceanic water warmer than normal covering most of the north basin of Atlantic and also in subtropical portion of south Atlantic Ocean. These persistent and anomalous patterns resulted in significant changes in South American meridional tropospheric circulation related to Hadley cell, so that a compensatory subsidence branch was verified over southern Amazonia, which inhibited strongly the development of tropical convection, explaining the drought condition in the region.

1. INTRODUCTION

This work reports and preliminary diagnostic analysis of a long lasting drought observed in the Amazon River Basin (hereafter Amazônia) during 2005. Such drought event resulted in a significant reduction in riverflow throughout Amazonia basin, thereby provoking consequently serious environmental and social impacts especially in the states of Acre, Rondônia and Amazonas.

2. DATA AND METHODOLOGY

We used the monthly precipitation data from INMET meteorological stations as well as the $1^\circ \times 1^\circ$ gridded precipitation data over the Amazonia Legal region obtained from CPC/NCEP. The monthly mean fluviometric data of the rivers Acre, Madeira, Solimões (located at southern and western Amazônia) and Rio Negro (located at central Amazônia) collected in the

ANA/CPRM stations of Rio Branco-AC, Porto Velho-RO, Tabatinga-AM and Manaus-AM are also used. To characterize the large-scale atmospheric patterns it was used the $2.5^\circ \times 2.5^\circ$ gridded zonal (u) and meridional (v) components of the wind vector data (available at 10 tropospheric levels: 1000, 925, 850, 700, 600, 500, 400, 300, 250 and 200 hPa) produced by NCEP/NCAR reanalysis project. CPC/NCEP also provides the $1^\circ \times 1^\circ$ gridded monthly sea surface temperature (SST) data observed in the Pacific and Atlantic Oceans basins.

The percentile technique were employed on the data of CPC gridded precipitation data and also on the data of the fluviometric stations considering the historical time series varying since 1960 to 2005. Thus, the anomalies obtained in these data are presented regarding seven categories: very above, above, lightly above, normal, lightly below, below, and very below.

3. RESULTS AND DISCUSSIONS

3.1. Precipitation and riverflow observations from stations

Figure 1 shows the monthly evolution of the means values observed during 2005 as well as the minimum (3^o percentile) and maximum (7^o percentile) climatological values of the precipitation and river stage data in the Rio Branco, Porto Velho, Tabatinga and Manaus stations. Climatologically, the riverflow in the stations located at western and southern Amazônia presents a maximum during February to May and a minimum during June to August. These former maxima are preceded of maximum climatological precipitation peaks from two to three months lagged, while the latter minima accompany the minimum climatological precipitation approximately in the same months. In the central Amazon (Manaus), the river presents a maximum (minimum) during May to July (September to October), associated with maximum (minimum) climatological precipitation during February to April (July to September). Except during March, these stations registered monthly accumulation of the precipitation with values predominantly below normal during all months of 2005, besides during the rainy season. The persistency of significant rainfall

deficit in the headboard regions of Solimões and Madeira rivers resulted consequently in a significant reduction in river stage which registered values very below than normal during all months of 2005. In the Negro river it was verified from July to November 2005.

3.2. Spatial configuration of the precipitation over Amazon basin

Figure 2 displays the spatial configuration of the gridded precipitation observed during 2005 over the Amazônia. Although March and April have presented small areas with rainfall excess in the states of Amazonas and Pará, most of the Amazonian basin registered significant pluviometric deficit with a marked and very accentuated temporary persistence, especially in the west and south portions of the region (states of Acre, Rondônia, Mato Grosso and Amazonas). A reverse pattern occurred during December 2005, when the sign of the precipitation anomalies inverted for positive values, i.e., rainfall above than normal in most of the Amazônia, characterizing the end of the drought event.

3.3. Large-scale climate patterns

The 2005 monthly evolution of the SST anomalies in the equatorial Pacific basin and tropical north and south basins of the Atlantic Ocean is illustrated in Figure 3. An anomalous warming (positive SST) but with weak intensity it was evidenced over equatorial Pacific basin in a restricted area in central part between 160°E and 160°W, during August 2004 to March 2005. The eastern Pacific presents negative SST anomalies during most of 2005 year. On the other hand, a persistency of strong positive SST anomalies covering the north basin of the Atlantic Ocean is observed since middle 2004 to late 2005. The south basin of the Atlantic presents normal patterns during 2004, warmer than normal during January to April 2005, returning for normal values from May until the end of 2005.

These evidences are also noted in the Figure 4 which shows the spatial configuration of the SST anomalies observed during 2005 in the Pacific and Atlantic Oceans. By analyzing the overall pattern of these anomalies, it is clearly evident that the main climatic forcing during 2005, that presents magnitude of the anomalies with significant and strong sign persisting for twelve months, was the warming very above normal observed in most of the north basin of Atlantic Ocean.

This persistent and anomalous pattern resulted in significant changes in the large-scale circulation pattern over the South American troposphere. Figures 5 and 6 show the pressure-

longitude and pressure-latitude vertical cross sections of the large-scale circulation related to the Walker and Hadley cells within the troposphere of the Amazonian basin. Associated with that large region containing positive SST anomalies in the north Atlantic basin, there is a coincident anomalous ascending motion over these areas during May to October 2005. By dynamic compensation of the tropical circulation, the western and southern portions of the Amazônia present a predominance of the anomalous descending motions in the troposphere of these regions particularly during May to August 2005, when deficit rainfall also was stronger. Therefore, the compensatory subsidence branch related to the both Hadley and Walker large-scale circulation inhibited strongly the development of tropical convection, explaining the drought condition in the Amazonian basin.

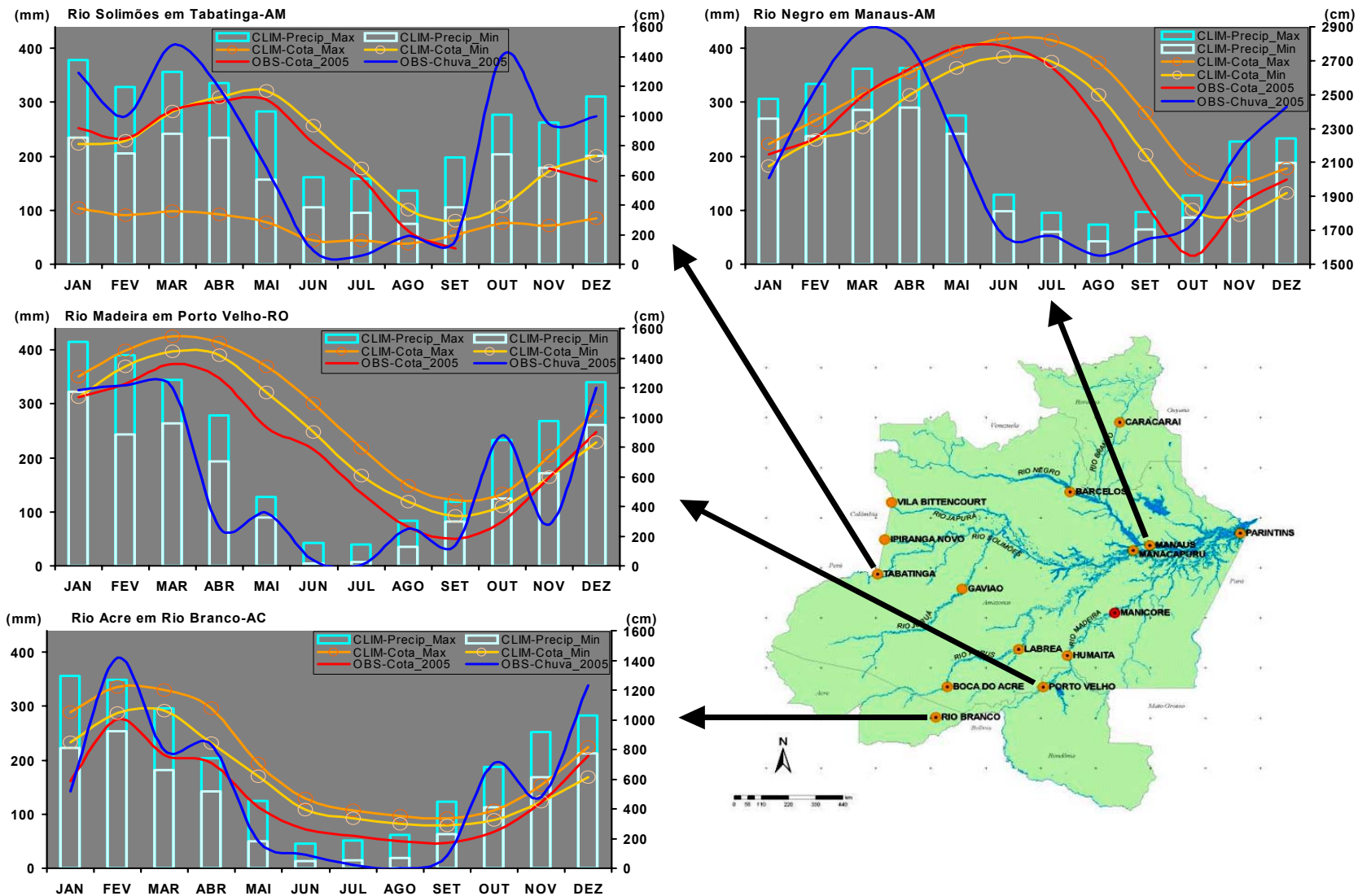


Figure 1. Monthly means of the pluviometric and fluvimetric data observed during 2005 in the stations over key-areas in the Amazônia basin. Climatological values refer to the 3° (CLIM_Min) and 7° (CLIM_Max) percentiles for precipitation and riverflow data.

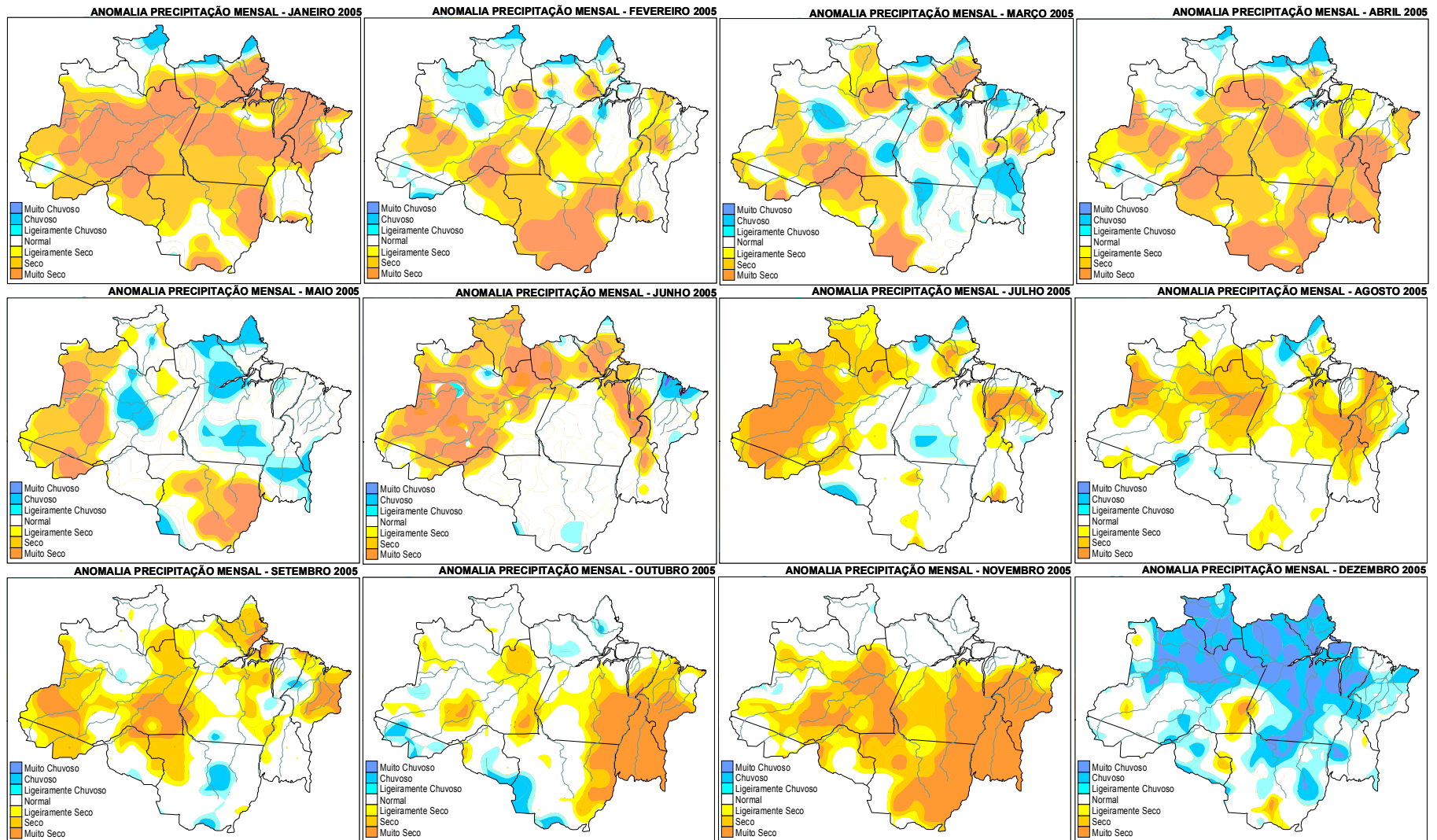


Figure 2. Monthly 1°x1° gridded precipitation observed during 2005 over the Amazônia. Shaded values represent anomalies categorized as very above, above, lightly above (dark to light yellow), normal (white), lightly below, below, and very below (dark to light blue).

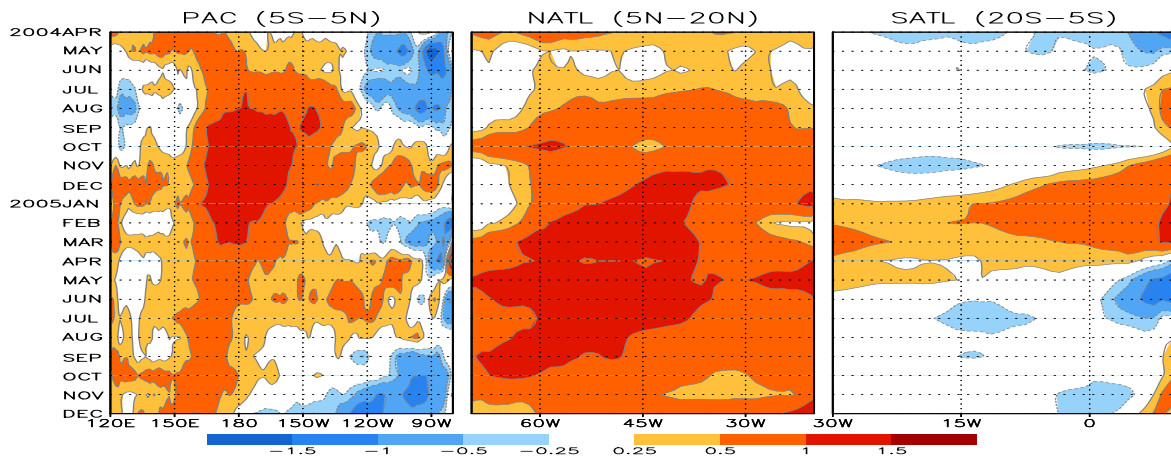


Figure 3. Monthly evolution of the SST anomalies averaged in the equatorial Pacific (5S-5N) and tropical north (5N-20N) and south (20S-5S) basins of the Atlantic during 2005.

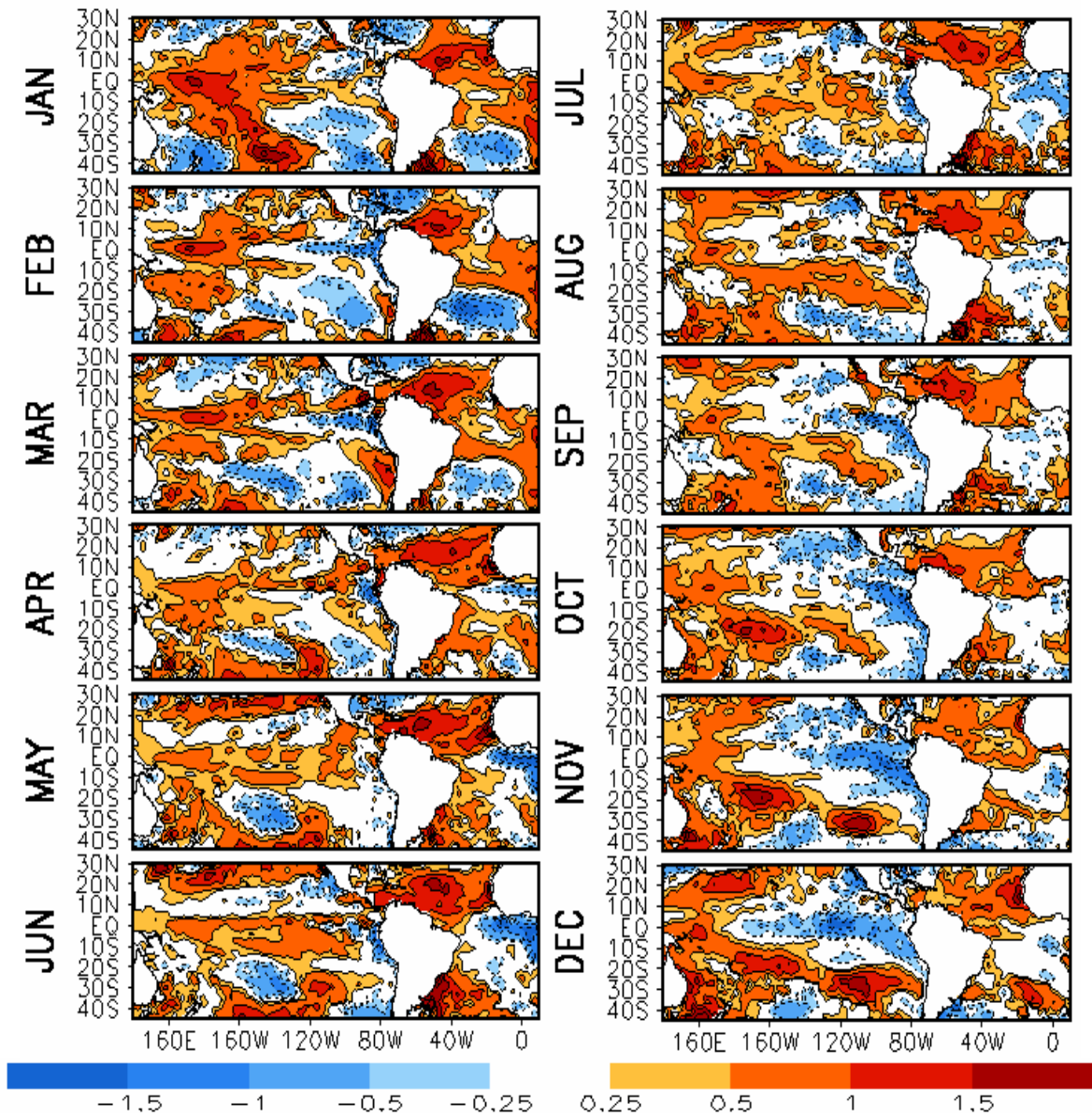


Figure 4. Monthly SST anomalies observed during 2005 in the Pacific and Atlantic Oceans.

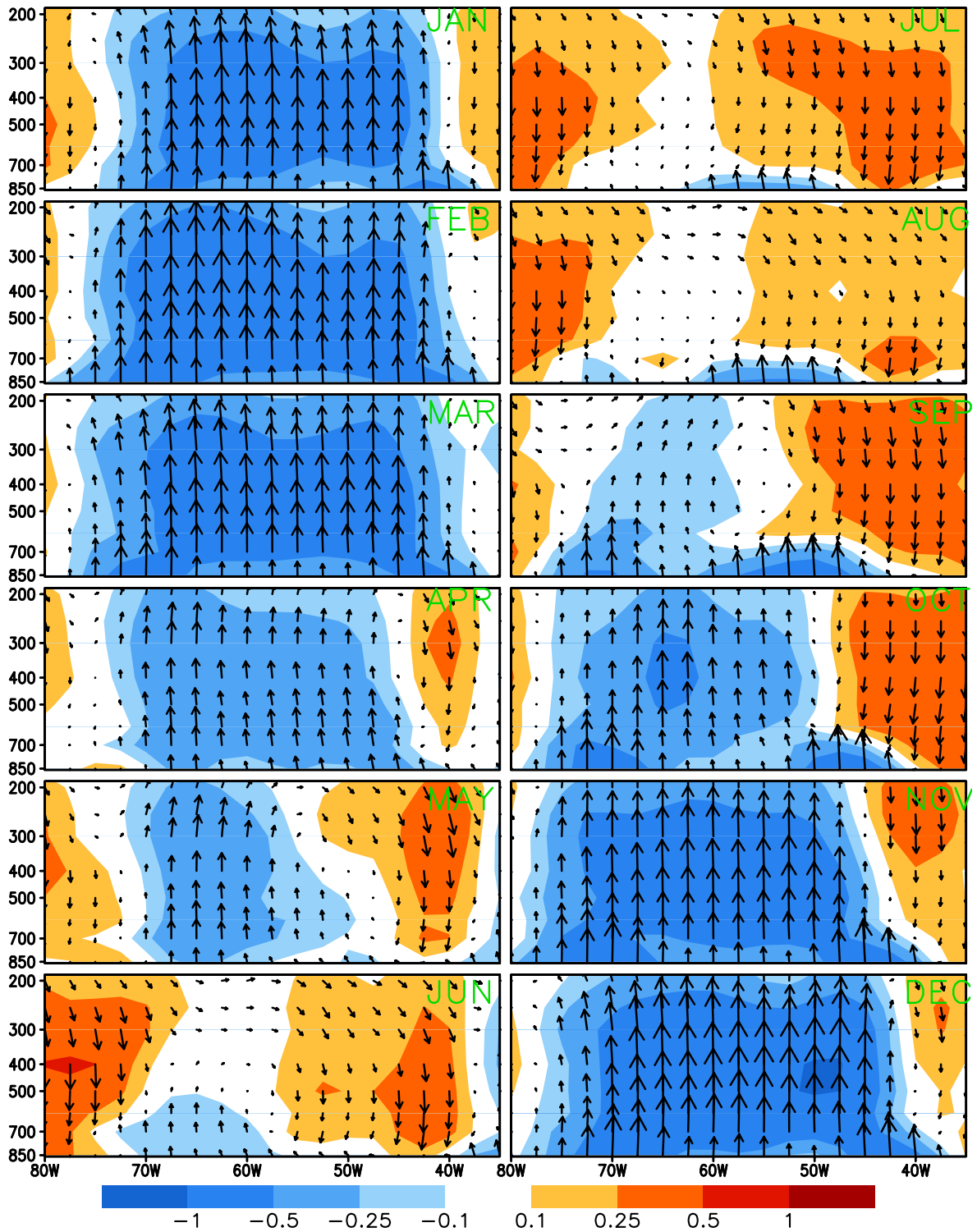


Figure 5. Longitude-vertical cross-sections of the monthly anomalous tropospheric circulation averaged between 10°S-0° over tropical Amazônia region, during 2005.

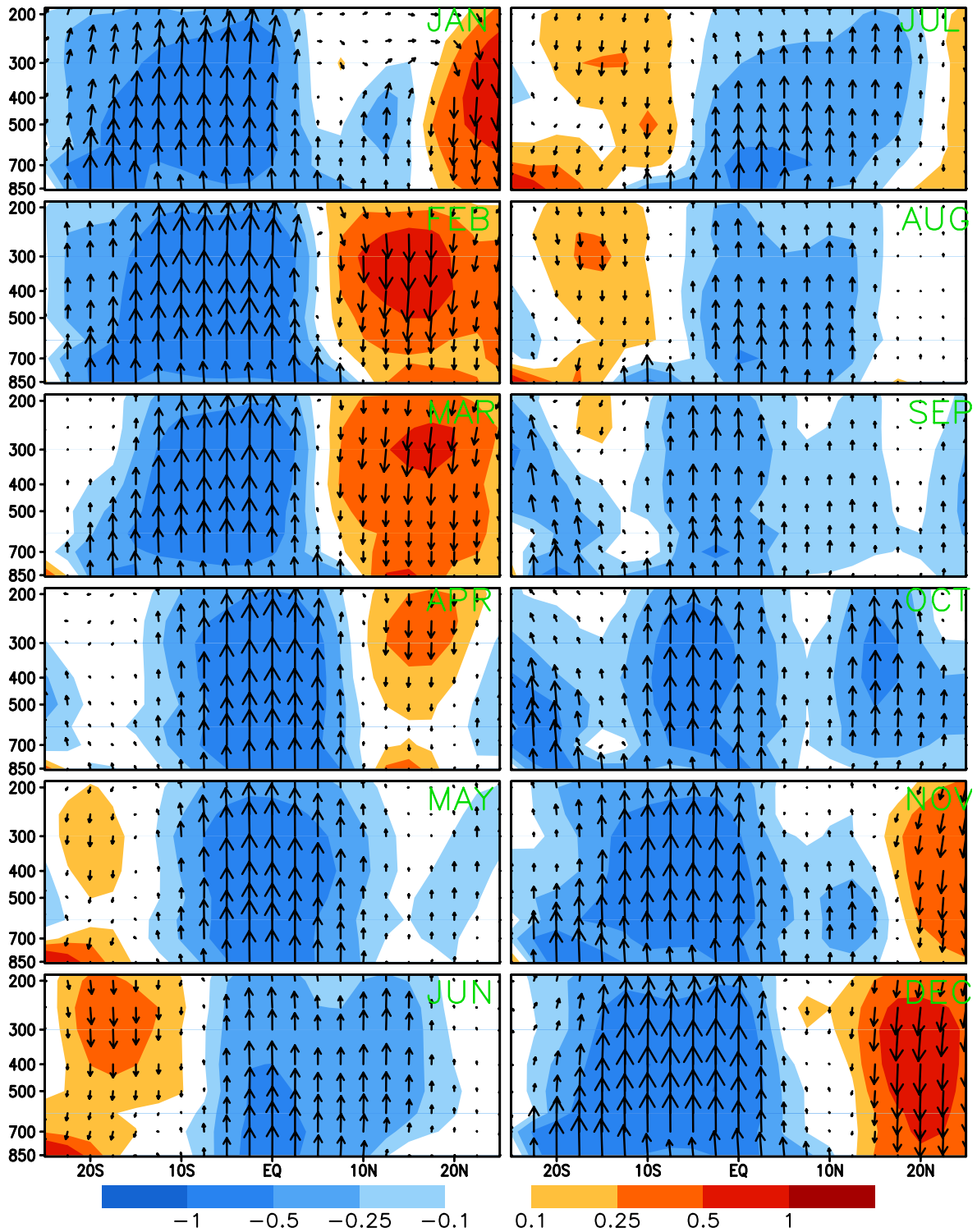


Figure 6. As in Fig. 5, but for the latitude-vertical cross-sections averaged between 70°W-50°W.