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THE REGIONAL PRECIPITATION OVER THE EASTERN AMAZON/NORTHEAST BRAZIL MODULATED BY TROPICAL PACIFIC AND ATLANTIC SST ANOMALIES ON WEEKLY TIMESCALE

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RESUMO

Vinte anos (1982-2001) de dados provenientes de estações pluviométricas são usados para investigar a variabilidade da precipitação regional sobre leste da Amazônia/Nordeste do Brasil (EAM/NEB) numa escala de tempo semanal. A variabilidade de precipitação sobre o EAM/NEB durante a estação chuvosa do outono austral é examinada sob o contexto do efeito combinado de ambos os modos do ENSO no Pacífico e do Gradiente de TSM inter-hemisférico no Atlântico. Assim, dois cenários climáticos anômalos contrastantes referidos como *desfavorável* (manifestações simultâneas de El Niño no Pacífico e do gradiente de TSM para norte no Atlântico intertropical) e *favorável* (ocorrências concomitantes de La Niña e do gradiente de TSM para sul no Atlântico) são considerados neste trabalho. Com base em composições para estes dois cenários, a evolução semanal dos padrões de precipitação estatisticamente significantes sobre o EAM/NEB, bem como os padrões anômalos de TSM, convecção e circulação troposférica sobre a porção intertropical do Atlântico/América do Sul são examinados. O objetivo principal deste artigo é mostrar evidências de que variações pluviométricas semanais significativas em escala regional ocorrem sobre o EAM/NEB durante o regime chuvoso de outono. Os aspectos dinâmicos da evolução da ZCIT sobre o Atlântico são também analisados

Palavras-chave: Leste da Amazônia, Nordeste do Brasil, Anomalias de precipitação, Escala semanal, ZCIT

ABSTRACT: THE REGIONAL PRECIPITATION OVER THE EASTERN AMAZON/NORTHEAST BRAZIL MODULATED BY TROPICAL PACIFIC AND ATLANTIC SST ANOMALIES ON WEEKLY TIMESCALE

Twenty years (1982-2001) of raingauge-based data are used to investigate the regional precipitation variability over the Eastern Amazon/Northeastern Brazil (EAM/NEB) on weekly timescale. The rainfall variability over the EAM/NEB during the austral autumn rainy season is examined in the context of the combined effect of both the Pacific ENSO and Atlantic interhemispheric SST gradient modes. Thus, two contrasting anomalous climatic scenarios referred to as *unfavorable* (simultaneous manifestations of the El Niño in the Pacific and the northward SST gradient in the intertropical Atlantic) and *favorable* (concomitant occurrences of the La Niña and the southward SST gradient in the Atlantic) are considered in this paper. Based on composite for these two scenarios, the weekly evolution of the statistically significant precipitation patterns over the EAM/NEB and the associated anomalous SST, convection and tropospheric circulation patterns over the intertropical Atlantic/South America are examined. This paper aims to provide evidence that significant weekly pluviometric variations on regional scale occur over the EAM/NEB during the autumn rainy regime. The dynamical aspects related to the evolution of the Atlantic ITCZ are also analyzed

Key words: Eastern Amazon, Northeast Brazil, Precipitation anomalies, Weekly timescale, ITCZ

1. INTRODUCTION

The regional precipitation over Eastern Amazon (EAM) and Northeast Brazil (NEB) shows similar seasonal percentages of the annual total during the austral autumn season (March to May). Values between 35% and 50% of the annual pluviometric total are observed over most of the EAM and the NEB during the autumn rainy regime (Souza et al., 2000; Rao et al., 2002). Such rainy regime is modulated by the Atlantic Intertropical Convergence Zone - ITCZ (Souza and Ambrizzi, 2003), which reaches its southernmost position in the equatorial south Atlantic around March-April (Waliser and Gautier, 1993; Xavier et al., 2000; Zhou and Lau, 2001).

The EAM/NEB rainfall exhibits interannual (IA) variations, which are related to near-global atmospheric circulation anomalous patterns associated with the El Niño-Southern Oscillation (ENSO) (Ropelewski and Halpert, 1987; 1989; Kiladis and Diaz, 1989; Kousky and Ropelewski, 1989). The ENSO oceanic component features an anomalous warming (El Niño) or cooling (La Niña) of the surface waters in the central and eastern Pacific Ocean, that dynamically links to the Southern Oscillation, a global-scale predominantly standing wave with the sea level pressure (SLP) action centers over Indonesia and the southeastern Pacific (Trenberth and Shea, 1987). Previous studies showed that most of the EAM/NEB tends to receive negative (positive) precipitation anomalies during the El Niño (La Niña) episodes (Hastenrath, 1976; Kousky et al., 1984; Kayano et al., 1988; Rao and Hada, 1990; Alves and Repelli, 1992; Coelho et al., 1999; Souza and Ambrizzi, 2002).

In addition, the EAM/NEB rainfall IA variations might also be modulated by the sea surface temperature (SST) anomalies in the tropical Atlantic Ocean. For this oceanic sector, one of the dominant modes for the SST in the IA scale features an interhemispheric north-south SST gradient mode during the austral autumn (Hastenrath and Heller, 1977; Nobre and Shukla, 1996). A northward (southward) SST gradient mode features simultaneous positive/negative (negative/positive) SST anomalies in the northern/southern sectors of the tropical Atlantic (Servain, 1991). The SST gradient mode hydrostatically control the SLP and wind patterns over the intertropical Atlantic (Hastenrath and Greischar, 1993), and influence the ITCZ latitudinal positioning (Nobre and Shukla, 1996; Souza and Nobre, 1998). Through the ITCZ, the southward (northward) SST gradient mode relates to wetter (drier) than normal conditions over the EAM/NEB (Hastenrath and Heller, 1977; Moura and Shukla, 1981; Hastenrath and Greischar, 1993; Nobre and Shukla, 1996; Souza et al., 1998, 2000).

The aforementioned studies provided empirical evidences that both the El Niño (La Niña) and the northward (southward) SST gradient mode favor a predominantly deficient (abundant) rainy season over the EAM/NEB (Souza et al., 2004). Since these studies are based on seasonal analyses, important subseasonal variations are smoothed (Grimm, 2003). Therefore, this paper explores further the subseasonal aspects of the EAM/NEB rainfall IA variations. The weekly evolving features of the unfiltered anomalous precipitation over the EAM/NEB related to both the Pacific ENSO and Atlantic SST gradient modes are investigated. In addition, the associated atmospheric circulation patterns over the intertropical portion of the South America/Atlantic Ocean are also analyzed.

2. DATA AND METHODOLOGY

The data used consist of 20 years (1982-2001) of reanalyzed daily-mean vertical velocity and horizontal wind fields at 11 pressure-levels (1000, 925, 850, 700, 600, 500, 400, 300, 250, 200 and 150 hPa), produced by the Climate Data Assimilation System/Reanalysis Project (Kalnay et al., 1996). The outgoing longwave radiation (OLR) daily data derived from the National Oceanic and Atmospheric Administration polar-orbit meteorological satellites are used as proxies of tropical convection (Liebmann and Smith, 1996). In addition, the weekly gridded SST data obtained from the Climate Prediction Center of the National Centers for Environmental Predictions are also used (Smith et al., 2002). The reanalyzed and OLR data are gridded into a global 2.5º × 2.5º grid and the SST data into a global 1º × 1º grid. The OLR, SST and reanalyzed variables are selected in the 20°N-20°S band of the western hemisphere for the 1982-2001 period.

Daily precipitation records from the raingauge stations network in the EAM/NEB for the same period (1982-2001) are also used. These data were obtained from the Instituto Nacional de Meteorologia and Agência Nacional de Energia Elétrica of Brazil and also from some regional meteorological centers. A quality control procedure, to check for possible errors in this dataset, is based on daily standard deviation (σ) obtained for each month of the year. Following Higgins et al. (1996) criterion, the daily rainfall value greater than 3σ of the daily

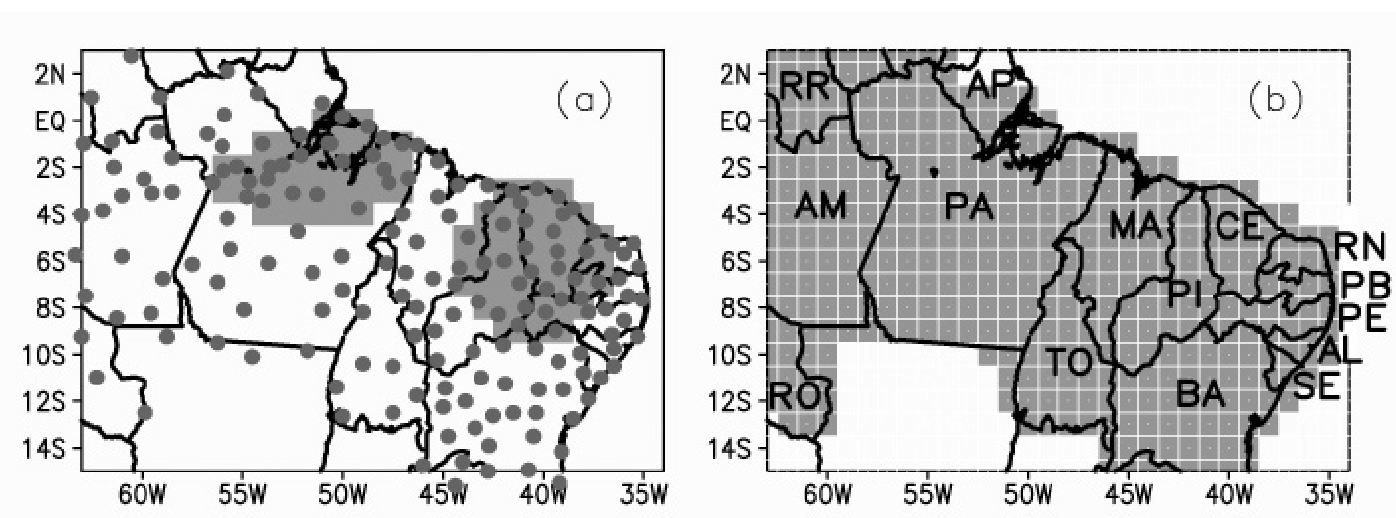

Figure 1: a) Locations of the raingauge stations; b) 1º × 1º horizontal grid in which the station data are spatially interpolated. Acronyms in (b) represent the name of the states. RR (Roraima), AM (Amazonas), RO (Rondônia), AP (Amapá), PA (Pará), TO (Tocantins), MA (Maranhão), PI (Piauí), CE (Ceará), RN (Rio Grande do Norte), PB (Paraíba), PE (Pernambuco), AL (Alagoas), SE (Sergipe) and BA (Bahia).

climatology for each station has been replaced by the missing data code. The stations with three or more subsequent days with missing data are eliminated. After that, 172 stations with uninterrupted daily observations from 1982 to 2001 period are selected. Figure 1a shows the geographical locations of these raingauge stations, which are well distributed over the NEB and over the mid-east of the EAM. In order to get precipitation data in the domain between 3ºN-15ºS and 63ºW-35ºW, the scattered stations data (Figure 1a) are spatially interpolated, using the method of the inverse of the quadratic distances, into a regular grid (Figure 1b) with horizontal resolution of 1º × 1º. Precipitation analyses are only considered in the continental areas.

The divergent wind components are obtained from the horizontal winds at each pressure level. The divergent zonal (meridional) wind and the vertical velocity meridionally (zonally) averaged in the 5°N-10°S (57.5°W-35°W) band are displayed as vectors in the pressure-longitude (latitude) cross-sections. They represent the divergent zonal (meridional) atmospheric circulations that describe the local Walker (Hadley) cell (Hastenrath, 2001).

Except for the SST, weekly average values are computed for each variable for the 1982-2001 period and following the calendar dates[1] considered by Smith et al. (2002). The SST horizontal resolution was changed from 1º×1º to 2.5º × 2.5º. The horizontal resolution for the precipitation was maintained at 1º × 1º. For each variable and grid point, weekly climatologies and standard deviations are computed for the 1982-2001 period.

The standardized SST indices are obtained by averaging in area the standardized weekly SST anomalies for selected areas. These areas are in the equatorial Pacific for the Niño 1.2 (90°W- 80°W/5°S-5°N), Niño 3 (150°W-90°W/5°S-5°N), Niño 3.4 (170°W-120°W/5°S-5°N) and Niño 4 (160°E- 150°W/5°S-5°N) indices, and in the tropical Atlantic for the north basin - TNA (50°W-20°W/2.5°N-17.5°N) and south basin - TSA (30°W-0°E/17.5°S-2.5°S) indices. The difference of the SST indices in the tropical Atlantic (TNA minus TSA) is defined here as the Atlantic difference index. It is traditionally very known that the Niño's indices indicate

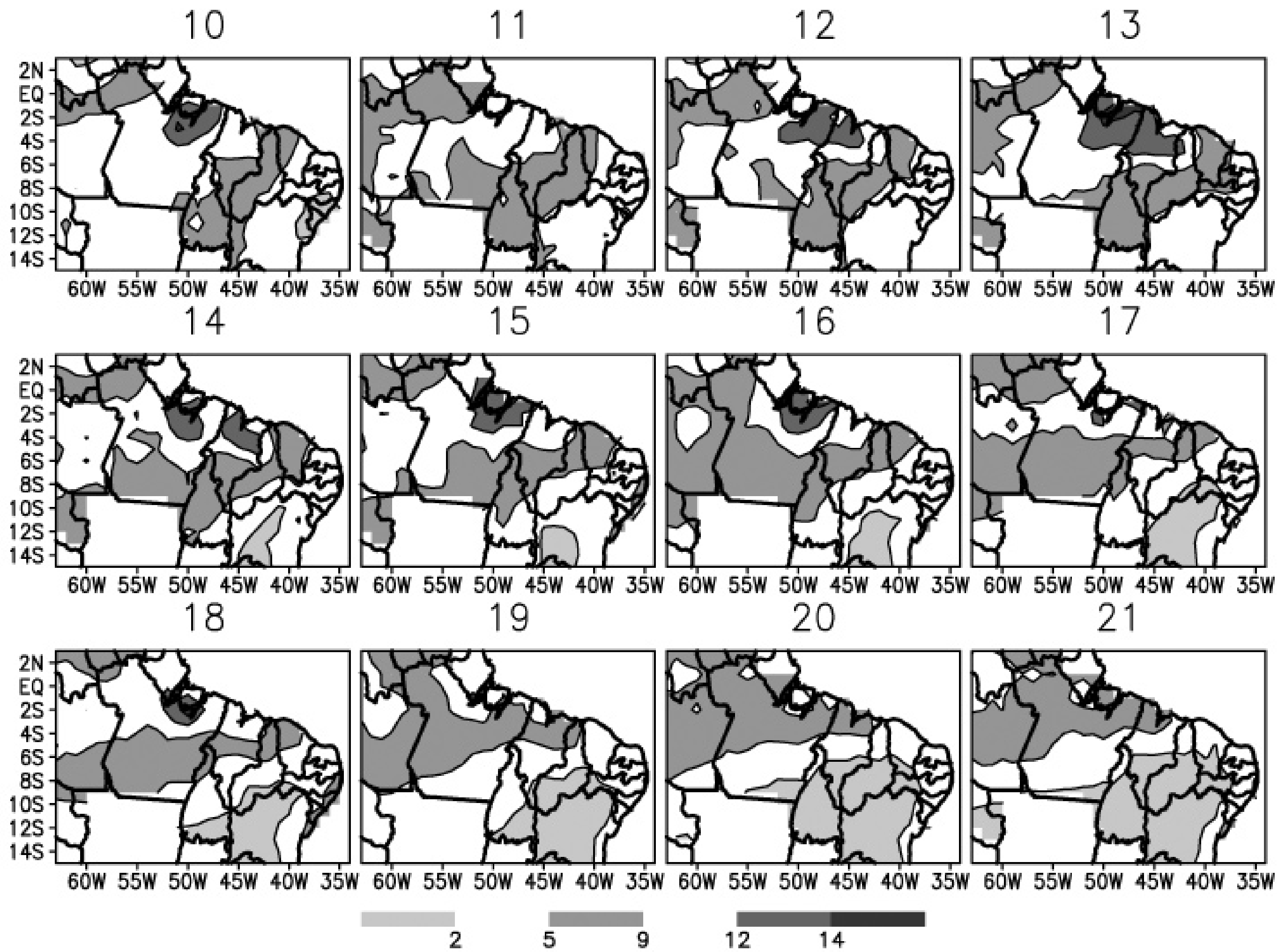

Figure 2: Climatological weekly precipitation over the EAM/NEB. Shaded contours are mm with magnitudes given by the grayscale at bottom of figure. The numbers at the top of each panel refer to the weeks during the autumn season.

[1] Smith et al. (2002) defined the center of the week as Sunday in the 1980s and Wednesday from 1990 to the present.

objectively the occurrences of the El Niño or La Niña episodes (Trenberth, 1997). Similarly, the Atlantic difference index provides an objective measure of the phases of the Atlantic interhemispheric SST gradient mode (Servain, 1991). In addition, the regional rainfall indices are obtained by averaging in area the standardized weekly precipitation anomalies over the key-areas located at the mid-east EAM and the northern NEB, where there is a good coverage of raingauge stations (Figure 1a).

3. WEEKLY CLIMATOLOGY

Figure 2 shows the migration of the climatological weekly precipitation over the EAM/NEB during the autumn season. Precipitation values exceeding 12 mm are found in the northeastern Pará and Marajó Island, and values between 5 mm and 9 mm in Piaui, the northern Ceará, the southern Maranhão and Tocantins, during the week 10. In the subsequent weeks, these rainy areas expand southeastward until the weeks 13-14 when is noticed the peaking of the NEB rainy season. From the week 15 onwards the largest precipitation values gradually move to the northwest sector of the domain. At the same time, values less than 2 mm progressively advance from the south to the interior of the NEB, indicating the end of the rainy season (Figure 2).

Taking into account that the OLR values less than 240 Wm^{-2} in the tropics represent deep convection (Kousky, 1988), the OLR patterns (Figure 3b) over the tropical South America are consistent with the regional precipitation evolution. The area of the central tropical South America with lower OLR is northwest/southeast oriented (typical of the summertime convection) during the week 11 and more zonally oriented by the week 13 onwards. The OLR and upper level circulation climatological patterns are consistent over the continent. As the deep convection moves northwestward (weeks 11-17), the Bolivian high and the associated downstream trough move

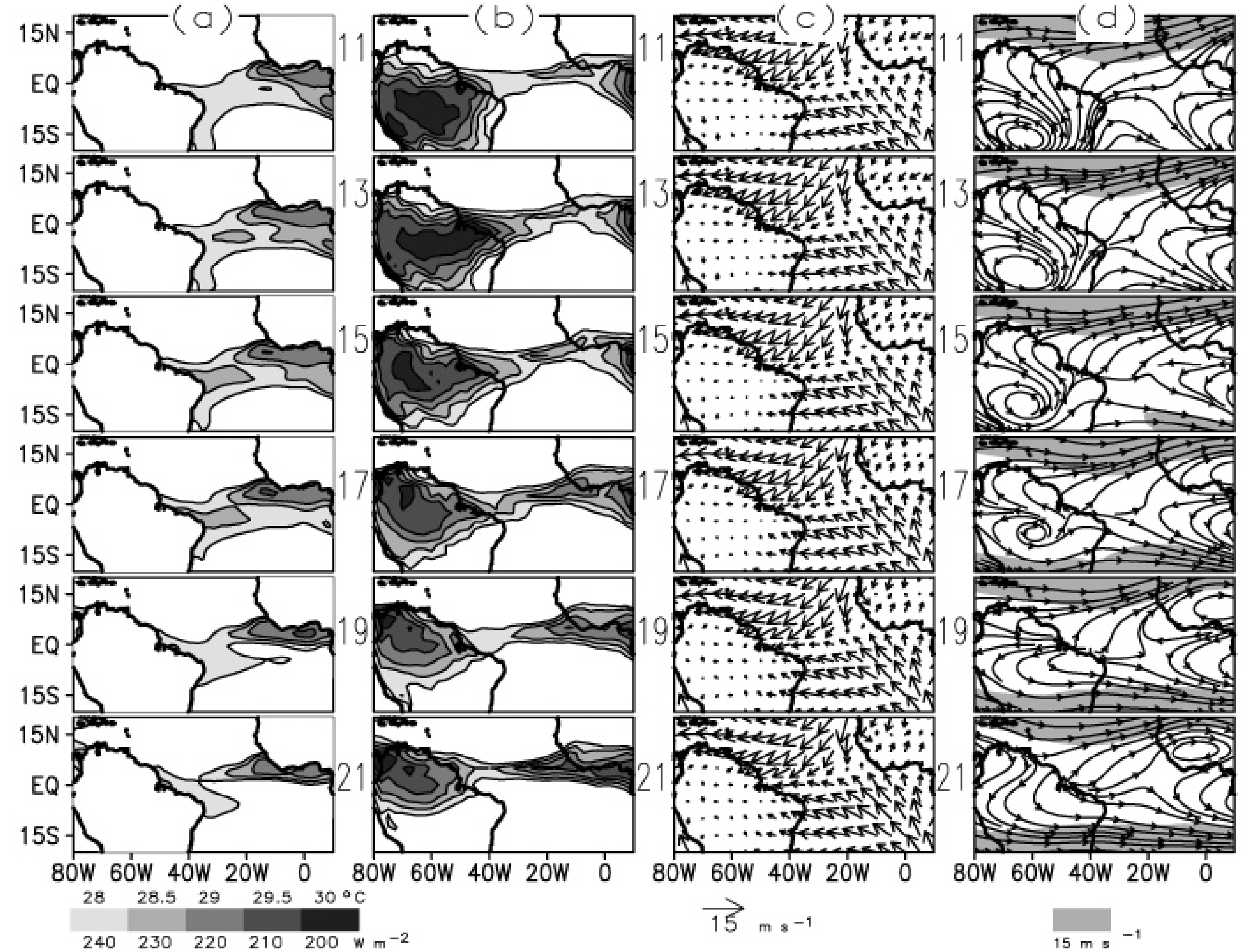

Figure 3: Weekly climatologies for: a) SST; b) OLR; c) 1000-hPa wind; and d) 200-hPa wind. The OLR and SST contours interval is 10 W m^{-2} and 0.5°C so that only values less than 240 Wm^{-2} and greater than 28°C are plotted and shaded. Shaded areas in (d) show magnitude of the wind greater than 15 m s^{-1}. Weeks are indicated by numbers between the panels and only odd weeks are displayed.

equatorward and these systems disappear during the last 3 weeks of the autumn season (Figure 3d). The OLR patterns in the oceanic areas are related to the positioning and intensity of the Atlantic ITCZ. In fact, the OLR values less than 240 Wm^{-2} are found along the ITCZ, as indicated by the SST greater than 28°C (Figure 3a) and by the confluence of the easterlies near the surface (Figure 3c) in the Atlantic low latitudes. The strong convection along the NEB coast during the weeks 13-17 (Figure 3b) contributes to organize the regional rainfall in the EAM/NEB (Figure 2). These conditions are accompanied by the wind confluence at 1000-hPa to the south of equator and SST greater than 28°C over most of the equatorial Atlantic, including the northern NEB coast (Figure 3a and 3c).

The climatological tropospheric circulation evolution related to the local Walker and Hadley cells is shown in Figure 4. Strong ascending motion within troposphere over the Amazon and Atlantic adjacent longitudes is observed in the pressure-longitude cross-sections (Figure 4a). This upward motion reaches upper levels where an outflow directed westward and eastward occurs. The upper-level westward flow converges downstream and contributes to enhance the subsidence in the eastern Pacific (sector not shown). The upper-level eastward flow diverges aloft and sinks over the eastern Atlantic, between 5°W and 10°E (Figure 4a). The ascending motion over the equatorial Atlantic centered on 15°W from the week 15 to 17 is associated with warm waters (SST greater than 28°C) in the eastern Atlantic (Figure 3a). In the lower troposphere, the easterlies prevail over the equatorial Atlantic. In the pressure-latitude cross-sections, the tropical air rises over most of the South American latitudes, diverges northward and southward at the 150-hPa and then descends around 15°N and 30°S during the weeks 11-15 (Figure 4b). Ascending motions over equatorial areas (10°S-5°N), diverging flow in the upper troposphere, sinking motions in the subtropical areas of the North Atlantic and Brazil and equatorward flow in the lower troposphere are observed from the week 17 to 21. The latitudinal positions of the upward and downward motions, in particular in the Southern Hemisphere (SH), are consistent with the climatological shifts of the South American convection (Figure 3b) and the rainfall over the

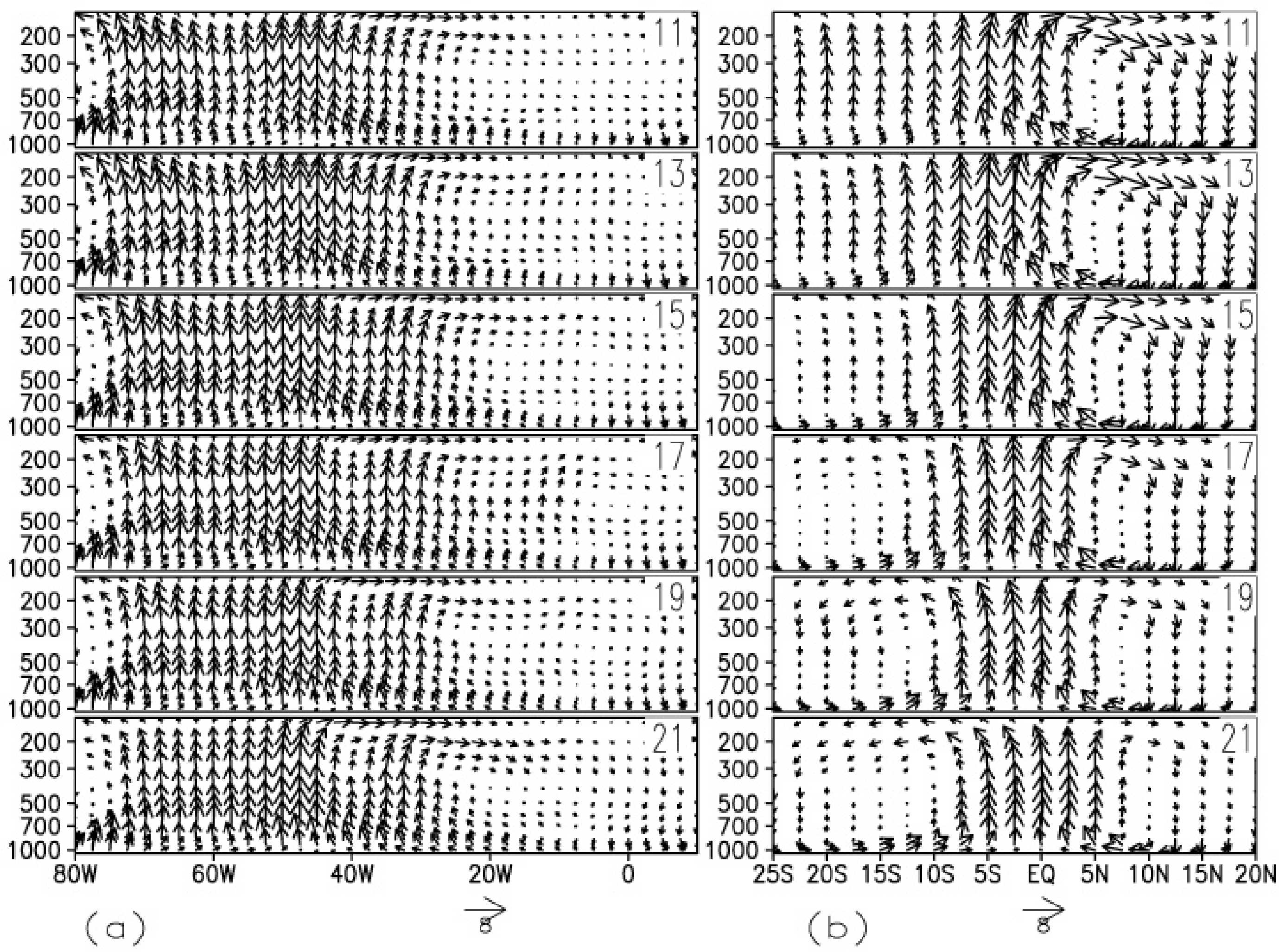

Figure 4: Weekly climatologies for: a) divergent zonal tropospheric circulation averaged in the 10°S-5°N band; b) divergent meridional tropospheric circulation averaged in the 57.5°W-35°W band. Vectors are scaled according to the 8 m s^{-1} (10^{-4} hPa s^{-1}) vector at the bottom of figure. Numbers in the upper left corner in each panel refer to weeks and only odd weeks are displayed.

EAM/NEB (Figure 2).

4. COMPOSITES ON WEEKLY TIMESCALE
4.1. SST and Precipitation Indices

Figure 5 shows weekly SST and precipitation indices for each autumn season from 1982 to 2001. The SST indices reveal two contrasting climatic scenarios: *(i)* simultaneous occurrences of the El Niño (large positive Pacific indices) and the northward SST gradient mode in the Atlantic (large positive Atlantic difference index) during 1983, 1987, 1992 and 1998; and *(ii)* simultaneous occurrences of the La Niña (large negative Pacific indices) and the southward SST gradient mode in the Atlantic (large negative Atlantic difference index) during 1984, 1985, 1989 and 1999. Other scenarios feature a neutral SST condition in the equatorial Pacific and a southward SST gradient mode during 1986, 1988, 1991, 1994 and 1995 and a northward SST gradient mode during 1982, 1990 and 2001. The phases of the Atlantic meridional SST gradient mode and the El Niño and La Niña episodes identified here are in agreement with previous works (e.g., Servain, 1991; Nobre and Shukla, 1996; Souza et al., 2000; Trenberth, 1997).

Precipitation indices show weekly variations superimposed to the IA variations, which are associated with the combined effect of both the tropical Pacific and Atlantic large-scale climate IA modes. This issue is explored further by calculating the autumn weekly anomaly composites for the years of the scenarios *(i)* and *(ii)*. A composite value is statiscally significant at the 95% confidence level if its absolute value is greater than $(z_{95}(n) \times \sigma_c)/(n)^{1/2}$, where n is the number of values used in the composite, σ_c is the standard deviation of these values and z_{95} is the value of t-distribution for n degrees of freedom and 95% confidence level (Harrison and Larkin, 1998). Composites for the years of scenario (*i*) are referred to as *unfavorable* composites and for the scenario *(ii)* as *favorable* composites.

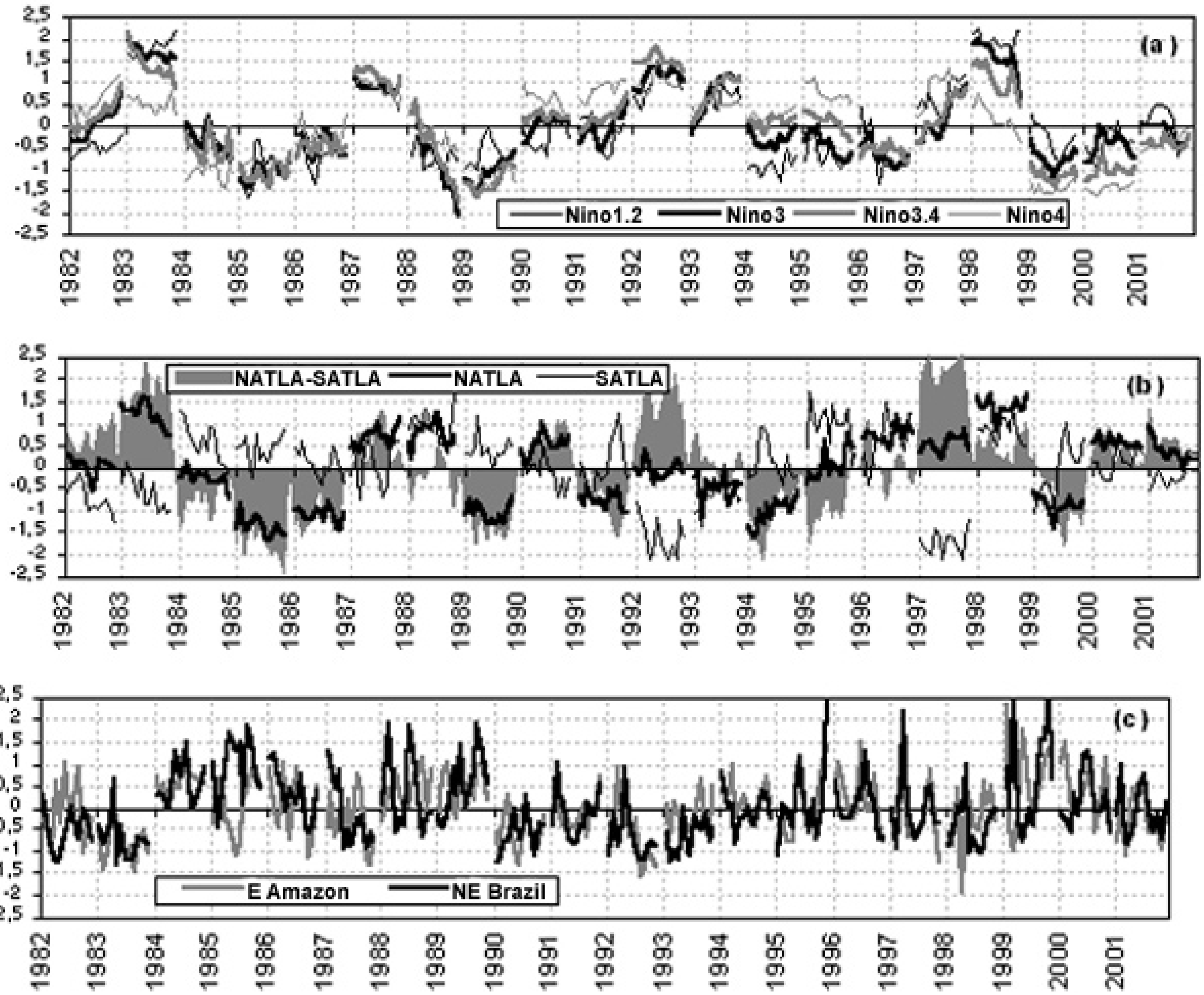

Figure 5: a) Pacific SST indices; b) Atlantic SST indices; and c) regional precipitation indices for each autumn season from 1982 to 2001. See text for details.

4.2. Unfavorable composite (El Niño and Atlantic northward SST gradient)

Negative precipitation anomalies over the eastern Pará, Marajó Island and NEB semiarid region are accompanied by positive SST anomalies in most of the north Atlantic during the first 5 weeks. At the same period, negative SST anomalies are seen in a narrow area in the equatorial and eastern South Atlantic (weak northward SST gradient) and cross-equatorial anomalous southeasterly trade winds in the 7.5°N-7.5°S band (Figures 6, 7a and 7c). As the negative SST anomalies intensify and expand westward along the equatorial south latitudes, the northward SST gradient mode and the cross-equatorial southeasterly trades are strengthened and the negative precipitation anomalies magnitudes increase (up to -6 mm) during the weeks 15-21 (Figure 6, 7a and 7c). The OLR anomalous patterns show consistent evolving features. A well-defined band with positive OLR anomalies stretching from the EAM/NEB regions towards the entire equatorial South Atlantic indicates a suppression of the tropical convective activity in this region due to an early northward displacement of the Atlantic ITCZ between the weeks 13-15 (Figure 7b). Positive OLR anomalies in the tropical Brazil and in the equatorial Atlantic and negative OLR anomalies to the north of this area clearly indicate the anomalously northern positioning of the Atlantic ITCZ compared to its climatological position (Figure 3b) during the subsequent weeks.

The anomalous sinking motions in the EAM/NEB regions, in the Atlantic longitudes (Figure 8a) and between equator and 10°S (Figure 8b) during most of the autumn weeks reflect the weakening of the climatological upward branch of the Hadley cell in the equatorial latitudes and of the Walker cell in the tropical longitudes of the South America/Atlantic region. These anomalous sinking motions agree with the precipitation deficit in the EAM/NEB regions (Figure 6) and with the positive OLR anomalies in the equatorial Atlantic (Figure 7b).

Despite of the dominance of negative precipitation anomalies for the unfavorable composites, positive precipitation anomalies are noted for some small areas and weeks: in the Neb semi-arid portion during the week 13; in the NEB eastern coast during the weeks 11 and 12; in the southern Pará during the weeks 12 and 14; in the norther Amazonas and eastern Pará during the week 15; in the Amazonas and Roraima during the weeks 15 and 17 (Figure 6). These patterns are related to the anomalous rising motions observed in the troposphere centered in 10S during week 13; over the equator durong weeks 15 and 17; over the 60°W-50°W band during the week 15; and from 700-hPa to 200-hPa in the 60°W-50°W band during the week 17 (Figures 8a and 8b).

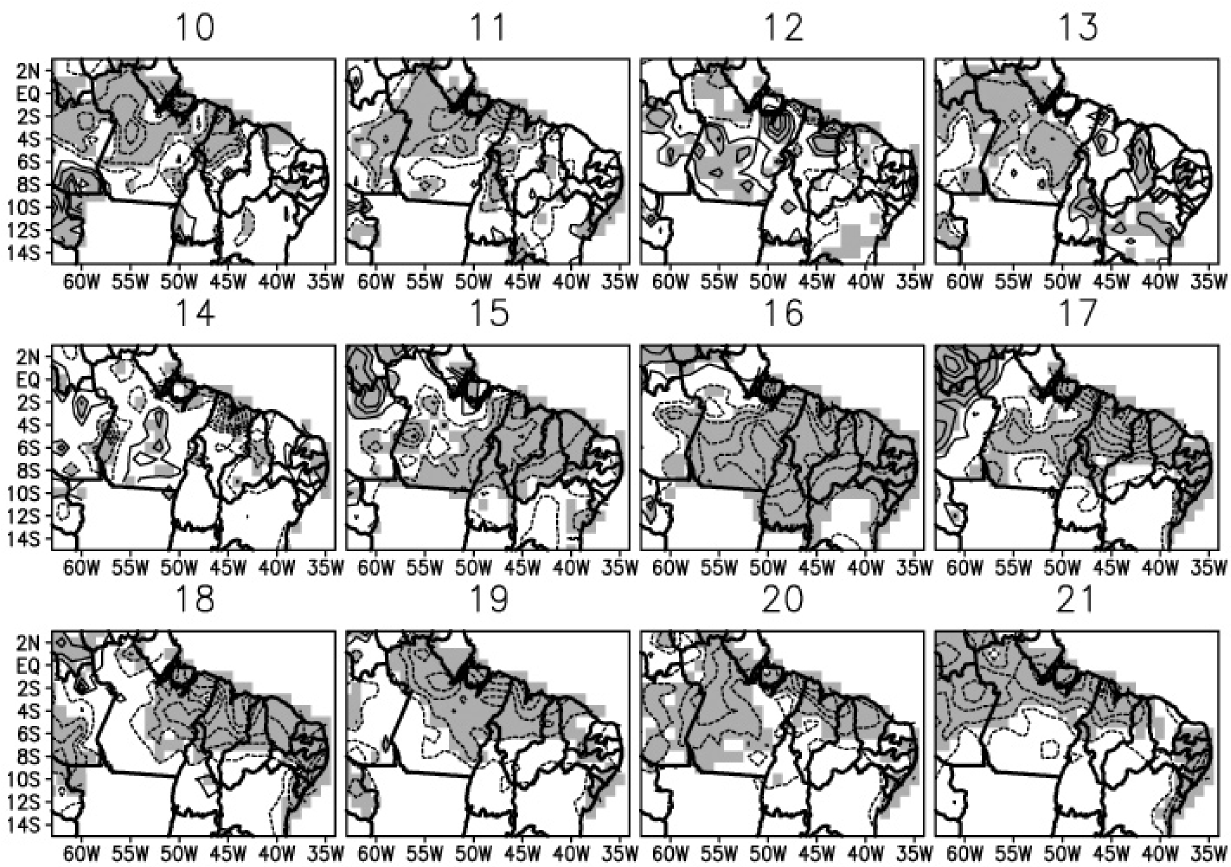

Figure 6: Precipitation anomaly composites for unfavorable climate scenario. Contour interval is 1 mm with solid (dashed) contours for positive (negative) anomalies. The zero line has been omitted. Shading indicates areas with statistically significant anomalies at the confidence level of 95%. Week numbers are displayed as in Figure 2.

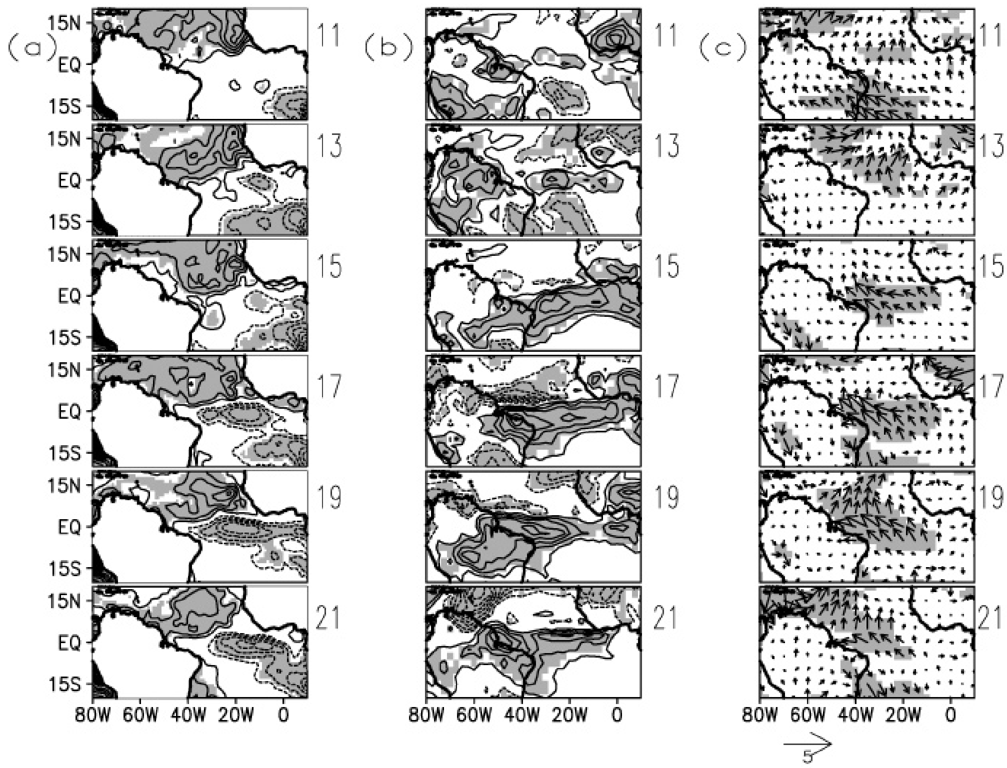

Figure 7: Anomalous composites for unfavorable climate scenario of the: a) SST; b) OLR; and c) 1000-hPa winds. The contour intervals are 5 W m^{-2} for OLR and 0.2°C for SST. The zero line has been omitted in (a) and (b). Shading indicates areas with statistically significant anomalies at the confidence level of 95%. The week numbers are displayed as in Fig 3 and only odd weeks are displayed.

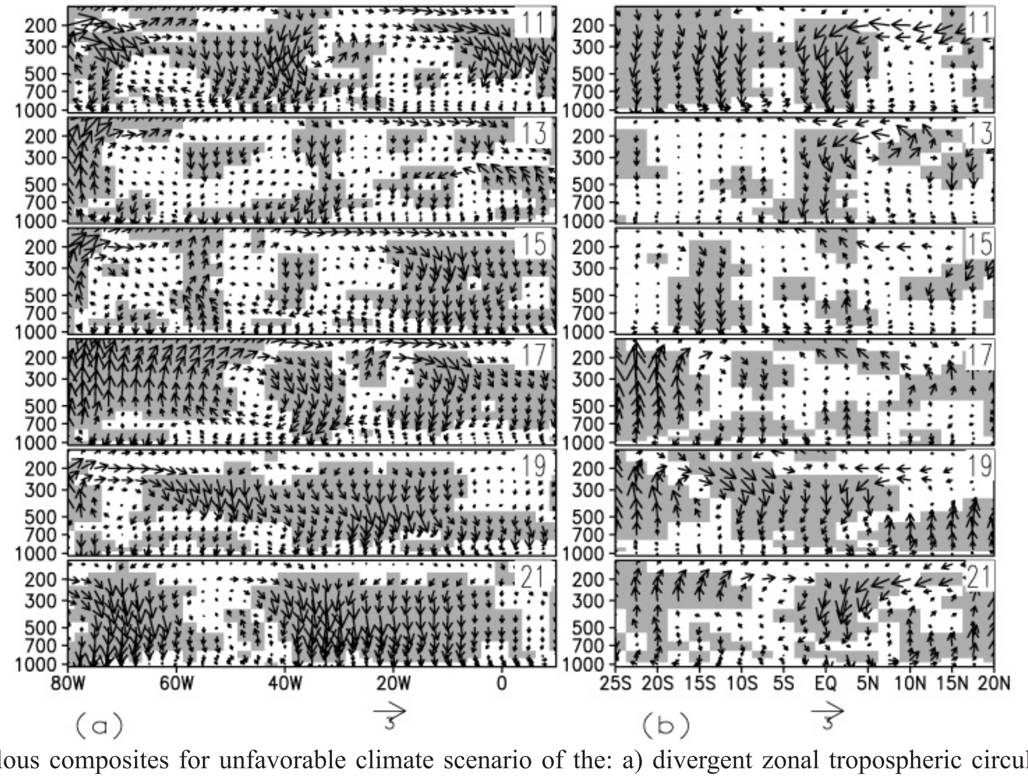

Figure 8: Anomalous composites for unfavorable climate scenario of the: a) divergent zonal tropospheric circulation averaged in the 10°S-5°N band; b) divergent meridional tropospheric circulation averaged in the 57.5°W-35°W band. Vectors are scaled according to the 3 m s^{-1} (10^{-4} hPa s^{-1}) vector at the bottom of figure. Shading indicates areas with statistically significant anomalies at the confidence level of 95%. The week numbers are displayed as in Figure 4 and only odd weeks are displayed.

4.3. Favorable composite (La Niña and Atlantic southward SST gradient)

The unfavorable and favorable composites show approximately reversed sign patterns for the corresponding variables. Indeed, positive precipitation anomalies in a large area of the EAM/NEB regions during the autumn weeks are consistent with the cross-equatorial southward SST gradient relatively weak during March and strong during April and May weeks. It is also observed an anomalously reduced/accelerated southeasterly/northeasterly trade winds characterizing intense cross-equatorial flow coming from the Northern Hemisphere (NH) in the intertropical Atlantic during most of the autumn weeks (Figures 9, 10a and 10c). In agreement with this pattern, the negative OLR anomalies in a zonally elongated band from the central Amazon to the eastern equatorial Atlantic and the positive OLR anomalies to the north/northeast of this band indicate an enhanced and anomalous southward displaced Atlantic ITCZ during the last 5 weeks (Figure 10b). This anomalous ITCZ contributes to the rainfall excess in large portions of the EAM/NEB regions during most of the autumn weeks. Consistently, the anomalous ascending motions in the 60°W-35°W band are particularly conspicuous during the last 3 weeks (Figure 11a). The anomalous upward motions in the equatorial and southern latitudes and the anomalous downward motions in the latitudes north of the equator are consistent with the positive SST anomalies in the north Atlantic and the negative SST anomalies along the equatorial south Atlantic (Figures 10a and 11b). These upward anomalous motions favor a southward displaced and intensified ITCZ.

Although there is the predominance of anomalously excessive rainfall over the EAM/NEB during the favorable scenario, areas over the Roraima and northern Amazonas present significant pluviometric deficiency on regional scale during the weeks 11, 12, 13, 15, 16 and 17; and also over the eastern Pará during the week 13 (Figure 9).

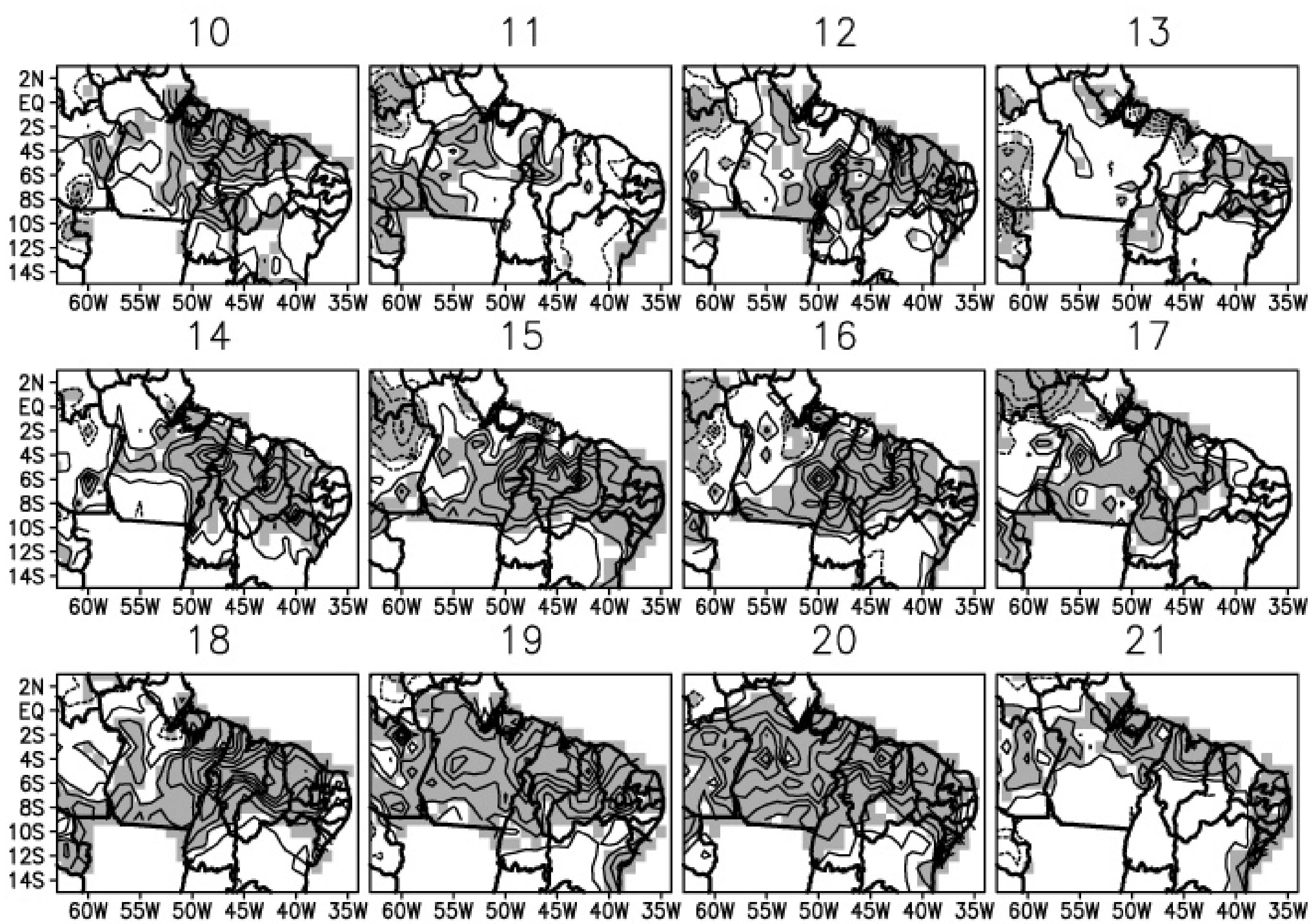

Figure 9: As in Figure 6 but for the favorable climate scenario.

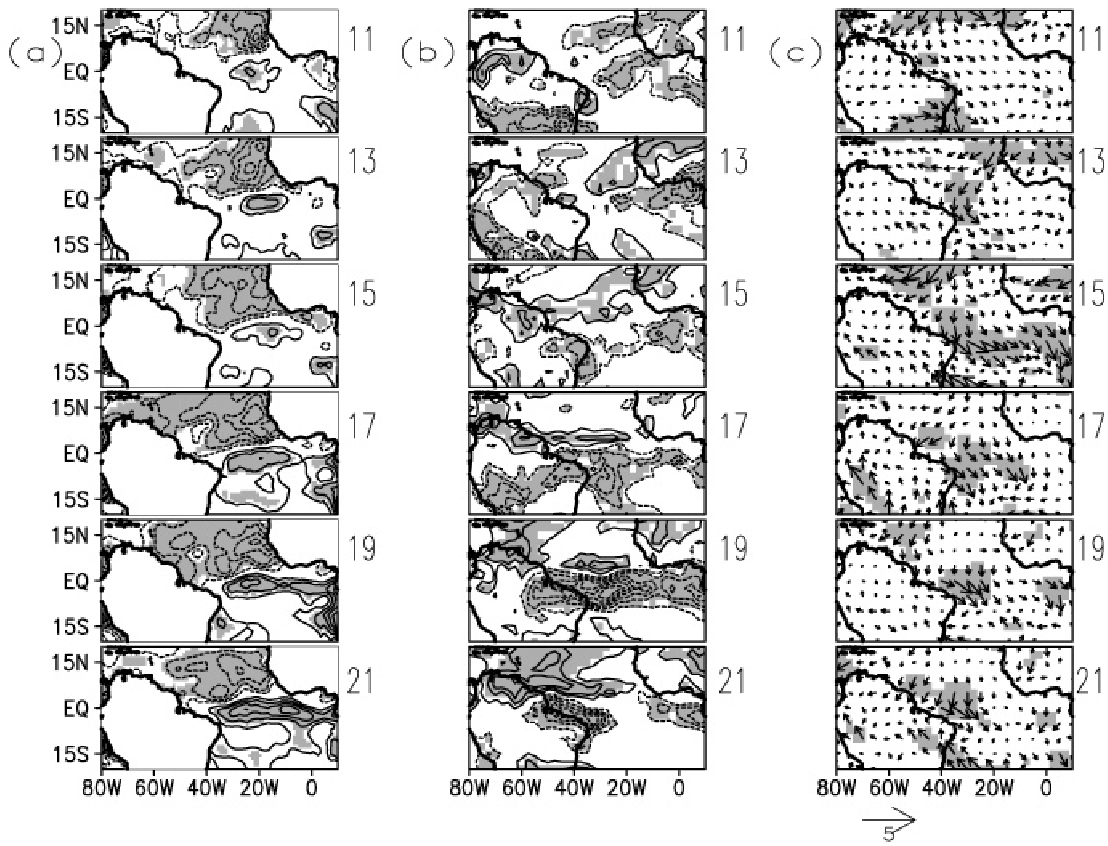

Figure 10: As in Figure 7 but for the favorable climate scenario.

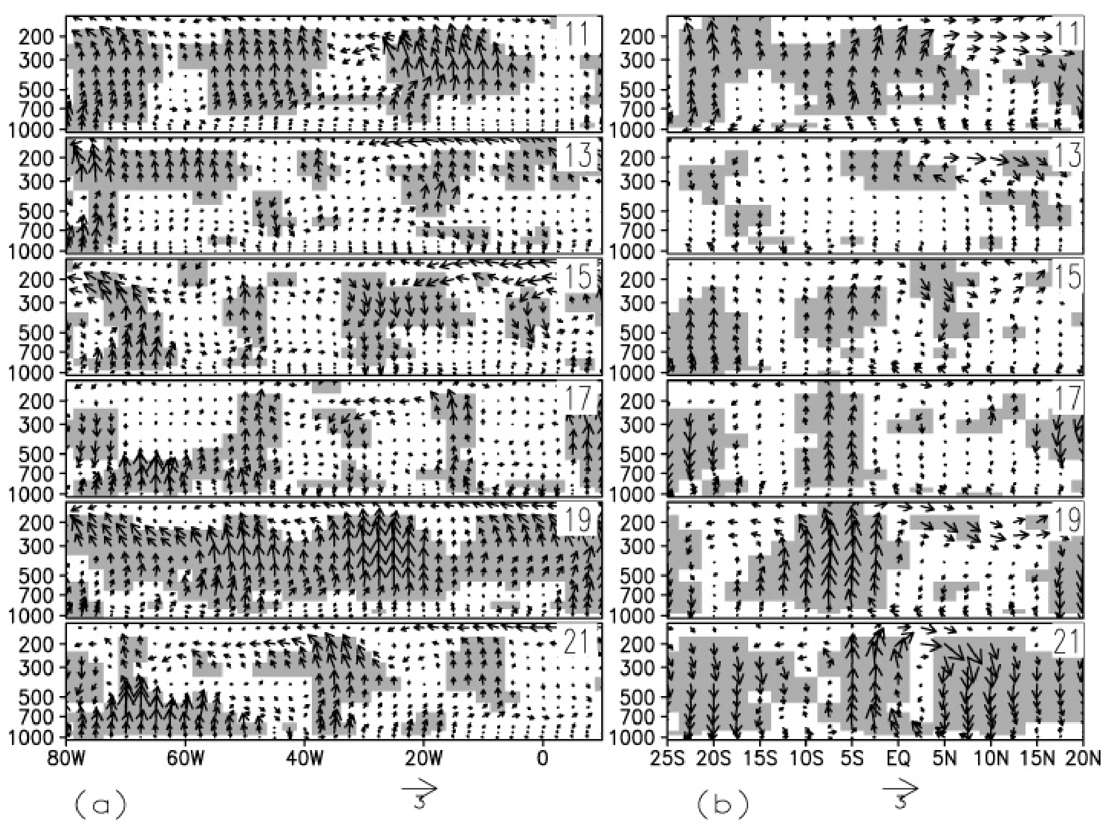

Figure 11: As in Figure 8 but for the favorable climate scenario.

5. DISCUSSIONS AND CONCLUDING REMARKS

The regional precipitation variability over the Eastern Amazon/Northeastern Brazil (EAM/NEB) is examined in the context of the combined effect of both the Pacific ENSO and Atlantic SST gradient modes on weekly timescale. The Pacific and Atlantic standardized SST indices from 1982 to 2001 allowed to identify two contrasting anomalous climatic scenarios, which are characterized by: *(i)* the simultaneous occurrences of the El Niño and the northward SST gradients in the intertropical Atlantic, and *(ii)* the simultaneous occurrences of the La Niña and the southward SST gradients in the intertropical Atlantic. The scenarios *(i)* and (*ii)* are, respectively, unfavorable and favorable to modulate the autumn rainy season over the EAM/NEB regions. Based on composite for these two contrasting scenarios, the weekly evolution of the statistically significant precipitation patterns over the EAM/NEB, and the anomalous patterns for the SST, OLR and vertical structure of the atmospheric circulation over the intertropical portion of the South America and Atlantic Ocean are documented.

The dominant features of the weekly composites for scenarios *(i)* and *(ii)* are consistent with previous findings that were based on seasonal or monthly data. However, the present paper aims to provide evidence that significant weekly pluviometric variations on regional scale occur over the EAM/NEB during the autumn rainy season.

For the unfavorable (favorable) scenario, negative (positive) precipitation anomalies prevails over the eastern Pará, the Marajó island and the NEB semiarid region during the first 5 weeks of autumn. These anomalies enhance and expand over most of the EAM/NEB from the mid to the last weeks of the autumn. This weekly evolution of the regional precipitation is consistent with the anomalous patterns of the oceanic and atmospheric variables over the intertropical Atlantic/South America. Indeed, relatively weak northward (southward) SST gradient and cross-equatorial anomalous southeasterly (northeasterly) winds are observed over the intertropical Atlantic from week 10 to 13. These anomalous SST and wind patterns intensify from the middle to the end of the season. As a result, an anomalously northward (southward) shifted Atlantic ITCZ establishes during the week 13 and remains during the subsequent weeks. This system contributes directly to the deficient (abundant) rainy season over the EAM/NEB.

This work also illustrates that under an unfavorable (a favorable) scenario, some small areas in the EAM/NEB regions receive excessive (deficient) rainfall during the first weeks of the autumn, due to local features of the zonal and meridional divergent circulations.

The analyses of IA variations on weekly basis shown in this paper provide important climatic information for the management of many economical activities, particularly in the agriculture.

6. ACKNOWLEDGMENTS

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