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SEASONAL DEPENDENCE OF SURFACE-ATMOSPHERE INTERACTIONS FOR SUBTROPICAL SOUTH AMERICA

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1. INTRODUCTION

Different studies have shown the relationship between the Low Level Jet (LLJ), the moisture transport and the precipitation in subtropical South America. Due to the relevance of these links for the region's climate, a field experiment, the South American Low-level Jet Field Experiment (SALLJEX) was carried out in the austral summer of 2002/2003 (Paegle et al., at http://www.met.utah.edu/jnpaegle/research/ALLS.html). Simulations with the Eta model have suggested that the South American LLJ can be stronger than the Great Plains LLJ in North America (Berbery and Collini 2000). Of relevance for the present study is the fact that the SALLJ is observed throughout the year, although revealing differences in location and strength (Berbery and Barros 2002).

The present work seeks to identify the role of soil moisture anomalies on the seasonal characteristics and the interannual variability of the atmospheric component of the hydrological cycle over subtropical South America. The objective is to investigate the feedbacks between soil moisture and precipitation over the South American Monsoon area during the El Niño-Southern Oscillation (ENSO) cycle 1982-83. To this end, simulations were performed with the regional mesoscale Eta model (Mesinger 1997; Mesinger et al. 1988; Black, 1994), using the NCEP/NCAR Reanalysis (Kalnay et al., 1996) as initial and boundary conditions. The sensitivity experiments of the model response to soil moisture changes involve the same initial field and boundary conditions but increasing or decreasing the values of the soil moisture field covering the entire model domain. For this study, illustrative months of the ENSO cycle were chosen.

2. RESULTS

Collini et al. (2005) have shown that changes in the soil moisture over South America affect the monsoon precipitation through modifications of the sensible and latent heat fluxes, and consequently the Bowen ratio, as well as the vertical structure of the boundary layer. Their results show that there is more sensitivity to the drier surface conditions than to the wetter ones.

Figure 1 shows the evolution of the strength and location of the Low Level Jet core, and the corresponding anomalies due to soil moisture reduction, along a cross section between (73º W, 15º S) and (34º W, 5ºS) for June and November 1982, and for January, March and June 1983. The SALLJ can be noticed during all months, although of weaker magnitude during March 1983. The anomalies show that the variations on the surface conditions (reduced soil moisture) impact in the low level circulation in a similar manner as it was shown for Octobers of different years (Collini et al., 2005). That is, with the LLJ tends to shift upwards, as indicated by the positive anomalies near surface and negative anomalies at higher levels (~700 hPa). Notice that January 1983 is the only month that does not follow this structure. During 1982, the negative anomaly spreads up 750 hPa, reaching 500 hPa, slightly tilt to the west of the core of the LLJ, however March 1983 appears to be the month when the largest anomaly is observed, centered where the maximum intensity of wind occurs. Unlike in mid-latitudes, where during the cold season the land and atmosphere tend to become uncoupled, this subtropical region exhibits interactions in all the months considered.

Figure 2 shows that as a consequence of the changes in the LLJ structure and the reduced availability of moisture due to lower evaporation, the moisture transport by the LLJ is reduced as well. The moisture flux was also calculated along a cross section between (73º W, 15º S) and (34º W, 5ºS) for consistency with the LLJ. The evolution in the location and intensity of the moisture flux shows a maximum of about 80 Kg m s^{-1} in the Northwest – Southeast direction during November 1982; the lowest moisture flux is found during March 1983.

To understand the impact of the surface variations on the troposphere, the evolution of the moisture flux anomalies during the ENSO 82-83 is shown in figure 3. As has been suggested by different authors, the LLJ and its diurnal oscillation are increased by dry surface conditions in the vicinity of the LLJ core (Paegle et al., 1996; Cook 1994). Those articles have

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shown that there is a considerable effect up to 500 hPa, with an increase of the southward flow and the LLJ core over the Andes slopes, while over the surface and part of the PBL there is northward flow reducing the moisture contribution. While similar behavior can be noticed here, it is apparent that in June 82 the impact of the reduction of soil moisture is more intense and affects a broader region than in June 83. During January 1983 the blend of the seasonal conditions and the ENSO characteristics may be the reason why the southward flow prevails over the whole lower troposphere.

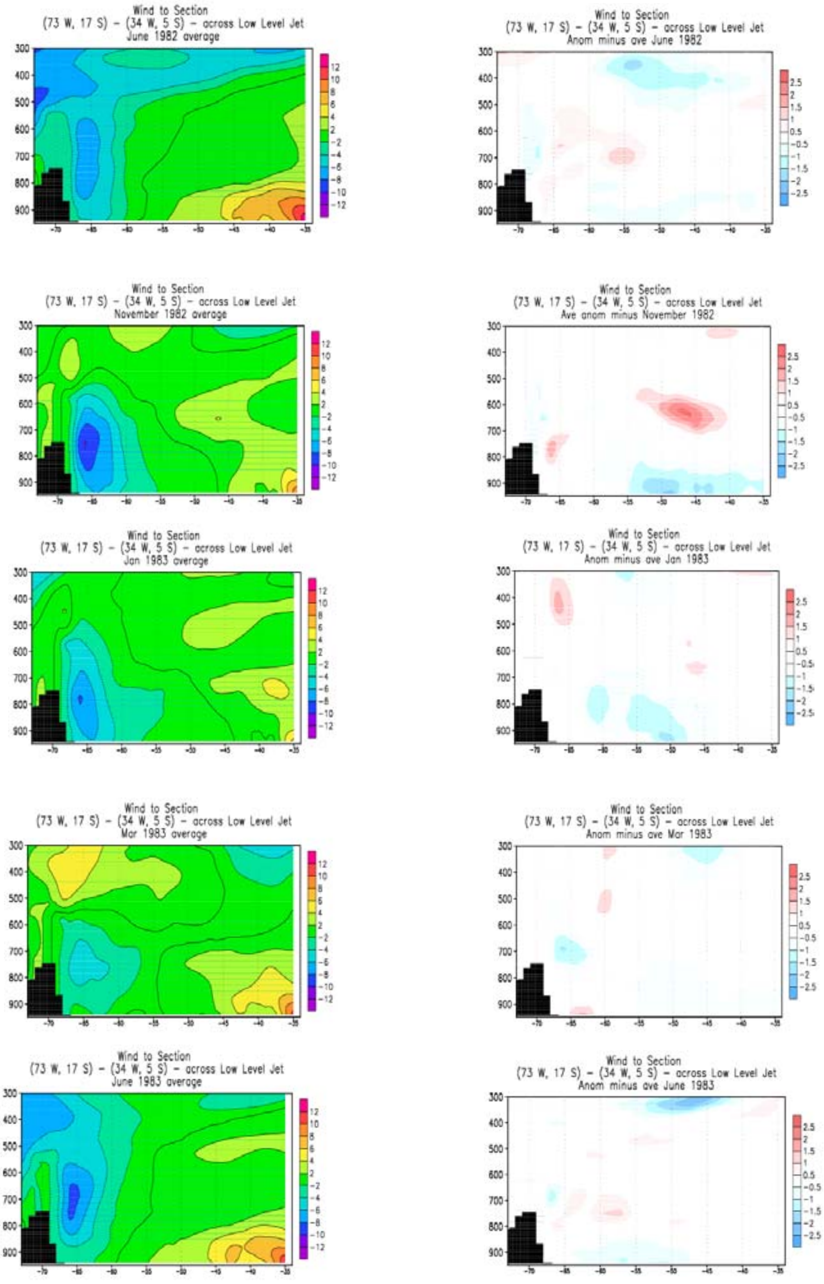

Figure 1. Left column: cross sections of average wind for June 1982, November 1982, January 1983, March 1983 and June 1983. Right column: cross sections of anomalies due to reduction of soil moisture. Units are m s^{-1} .

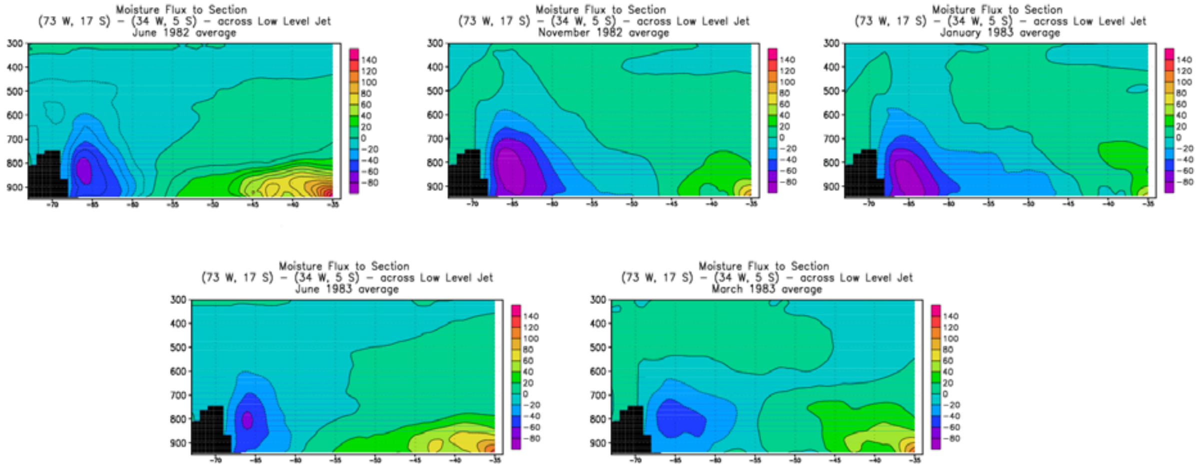

Figure 2. Cross sections of average moisture flux for June 1982, November 1982, January 1983, March 1983 and June 1983. Units are m s⁻¹ g kg⁻¹.

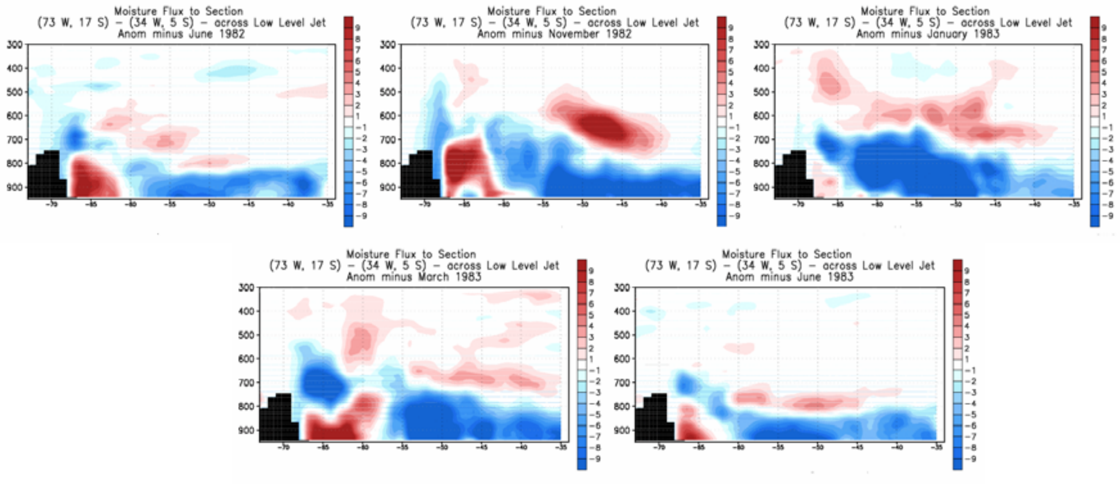

Figure 3. Cross sections of anomalies of moisture flux for June 1982, November 1982, January 1983, March 1983 and June 1983 due to soil moisture reduction. Units are m s⁻¹ g kg⁻¹.

The vertical integration of the Moisture Flux (MF) and the Moisture Flux Convergence (MFC) for the initial June and final June of the ENSO 82-83 episode is shown in figure 4 for the control and the reduced soil moisture experiments. To begin with, it should be noted the difference between both control Junes related to the intensity and extent of the MFC, in particular over the region of the Argentine Mesopotamia. The same is apparent for the moisture flux channeled by the Andes over Bolivia, whose outlet during June 1983 widens all the way through the South of Brazil reaching the region of the South Atlantic Convergence Zone (SACZ). The anomalies fields show an interesting feature; while during June of 1982 there is an increase of MFC over the Amazon basin and surrounding areas, for the same month of 1983 there is an enhancement of moisture over the Wet Plains of Argentina.

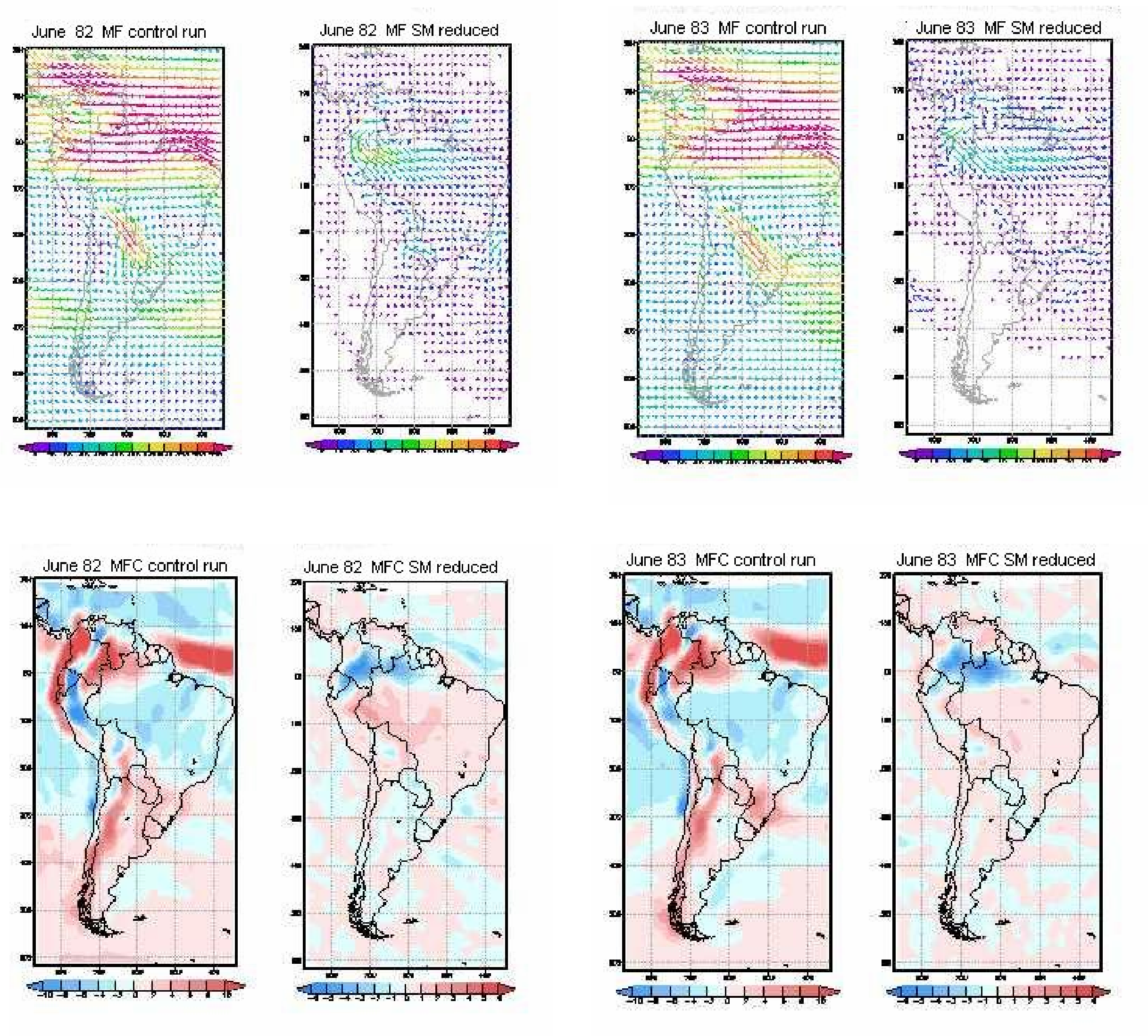

Figure 4. Upper panel: vertically integrated moisture flux for June 1982 and June 83 control run and with soil moisture reduction, units are kg (ms) $^{-1}$. Lower panel: vertically integrated moisture flux convergence for June 1982 and June 83 control run and with soil moisture reduction, units are mm day^{-1}.

3. SUMMARY AND CONCLUSIONS

This research shows preliminary results of the influence of the changes in the soil moisture on the low level circulation and the associated moisture transport in subtropical South America.

Simulations with the Eta model for selected month of the ENSO 1982-83 indicate that the location and strength of the LLJ, as well as the moisture transport variability during ENSO 82-83, reflect an influence of the surface conditions. March is the month when the largest anomaly is observed, whereas during summer the merge of the ENSO peculiarities with the seasonal conditions may well overcome the surface changes impact. This is an aspect that needs further analysis.

4. ACKNOWLEDGMENTS

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