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THE IMPORTANCE OF THE LOW-LEVEL JET EAST OF ANDES ON MOISTURE TRANSPORT OVER SOUTH AMERICA

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Introduction

In different regions of the globe strong winds are observed at low levels of the atmosphere. These winds exhibit maximum speed at about surface-850 hPa layer and sometimes are referred as Low-Level Jet (LLJ). Over South America, this circulation that is detected to the east side of Andes, is known as the South American Low-Level Jet (SALLJ). SALLJ affects weather and climate for regions located east of the Andes as this circulation represents a mechanism of mesoscale circulation that transports moisture from the Amazon basin into the Paraná-Prata basin (Paegle, 1998). Human activities in the La Plata basin, such as the agriculture and hidro-electric power generation are very sensitive to the weather and climate. This work analyzes the moisture flux on the South America. The results are analyzed in terms of meridional and zonal vertically integrated moisture flux at the boundaries of the studied area. In this work, events of intense SALLJ were detected locations to the east of the Andes where the core of the SALLJ is located.

Data and Methodology

In this study, SALLJ episodes were detected in Santa Cruz de la Sierra-Bolivia (16.5S, 63W) and in Mariscal Estigarribia,-Paraguay (22S, 60W), applying the Bonner criterion 1 (Bonner, 1968) to daily data coming from the NCEP (National Center for Environmental Prediction) reanalysis.

These are the conditions that must be meet to detect a SALLJ: a) northerly 850-hPa winds with speeds equal or larger than 12 $m.s^{-1}$, b) vertical wind shear larger or equal than 6 $m.s^{-1}$ between 850 and 700 hPa, and c) a meridional component larger than the zonal component, and with the meridional winds from the north, in order to exclude southerly wind events. This criterion has been used in different studies (Nicolini et al., 2002 and Marengo et al., 2004).

Wind, pressure and specific humidity of reanalysis data from NCEP have been used for the period of 1961 up to 1990 with $2.5^{o}X2.5^{o}$ (lat/lon) spatial resolution and 6-hour temporal resolution.

The study area (shown by the red dot-line in the figures), was defined in the region of exit of the SALLJ and encloses the La Plata Basin. The vertically integrations have been computed from the surface until 700hPa. The lateral limits had been fixed by the following boundaries: north (23S; 62-48W), south (33S; 62-48W), east (48W; 33-23S) and west (62W; 33-23S). Moisture flux have been integrated along those boundaries. Seasonal means had been computed for : DJF = December, January and February, MAM = March, April and May, JJA = June, July and August and SON = September, October and November.

Discussion

Vertically integrated moisture flux

FIG. 1 shows the mean of the seasons of vertically integrated moisture flux. During DJF (summer) (Fig 1.a), we can observed an intense moisture transport coming from the Amazon region and steady trade winds in the north tropical Atlantic. During the winter (JJA) (Fig 1.c), moisture transport from tropical latitudes is reduced. At this time, fluxes associated with the subtropical south Atlantic anticyclone are more intense as this anticyclone is more active and stands closer to the continent. The flux associated with this anticyclone is also important during the spring (SON).

By comparing the composites of SALLJ (FIG. 2) with the mean over the period of study (FIG. 1), we can observed a increase of the moisture flux in direction to La Plata Basin for every period of the year. During DJF and MAM there is greater intensity of the moisture flux towards the region of the SALLJ. This is associated with the moisture transport coming from the tropical region. During the winter, the observed pattern also shows a contribution of the south Atlantic anticyclone.

FIG.2 also shows that the north and east boundaries are the ones that receive greater flux of moisture in the low atmosphere. The northern boundary receives moisture associated with the SALLJ transport. On the other hand, the south Atlantic anticyclone provides more humidity on the eastern boundary.

In the presence the SALLJ, the pattern of convergence and moisture north of 20 S shows penetration from the north (FIGs. 1a e 2a).

When SALLJ events are detected in Santa Cruz and Mariscal Estigarribia at the same time, it causes bigger impact in the moisture flux on Bolivia, Paraguay and north and northeast of Argentina. (set of the FIGs. 1 and 2). Apparently the SALLJ does not have direct influence in the moisture flux over the south of Brazil.

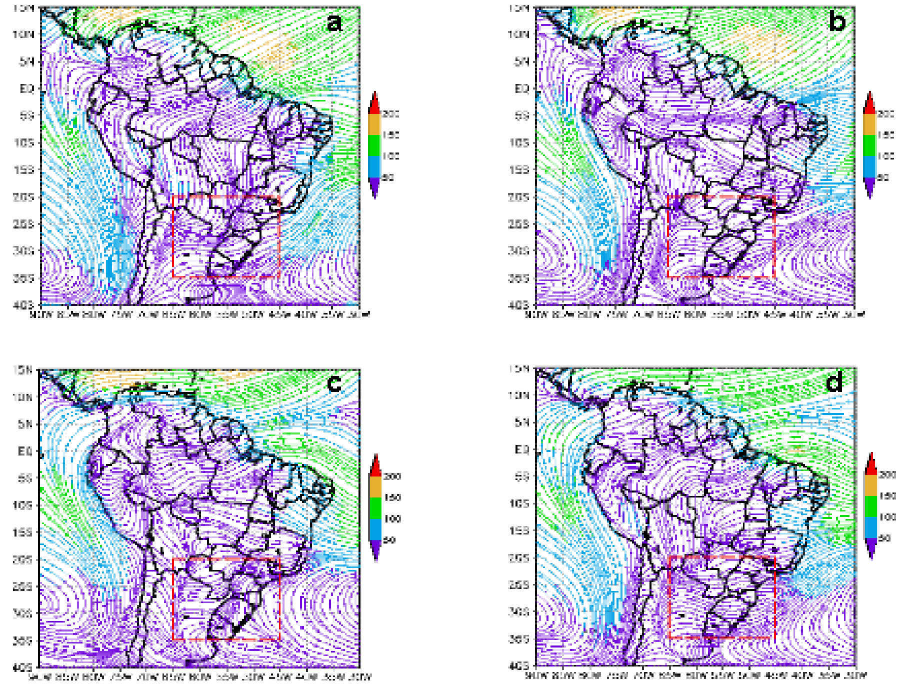

FIG. 1 – Stream lines of vertically integrated moisture flux during the following mean periods: a) DJF, b) MAM, c) JJA and d) SON. The color scale shows the values in kg.$(m.s)^{-1}$.

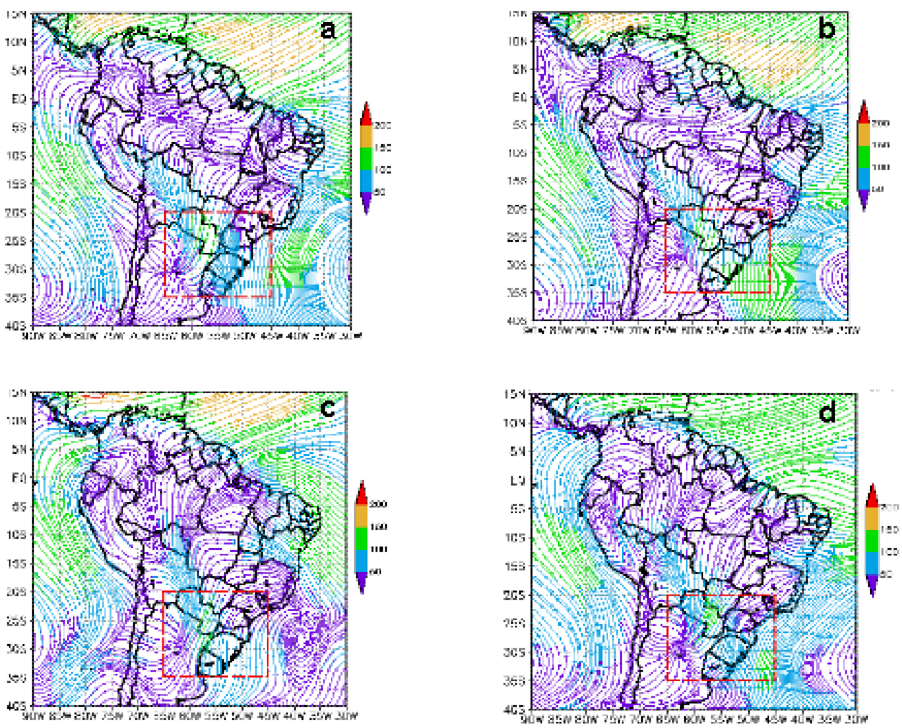

FIG. 2 – Stream lines of vertically integrated moisture flux for SALLJ composites detected in Santa Cruz and Mariscal Estigarribia at the same time. SALLJ composites for: a) DJF, b) MAM, c) JJA and d) SON. The color scale shows the values in kg.$(m.s)^{-1}$.

Preferential paths of moisture fluxes in low atmosphere over South America

The conceptual models of FIG.s 3 and 4 illustrated the contribution of Amazon moisture in direction to the region to the exit of SALLJ during the SON and with maximum in DJF. In MAM and JJA, the contribution comes more from the south Atlantic. In composites of jets (FIG. 4), SALLJ events are associated with the transport from Amazon all year long. However those maps do not analyze the frequency of these events, that according to Marengo et al., (2004) are more frequents during the summer that during the winter. The contribution of the subtropical Atlantic anticyclone is also present all the year long, being more obvious during JJA. Hence, the preferential ways of moistures fluxes are considered as the two regions (Amazon and south Atlantic) as sources of water vapor.

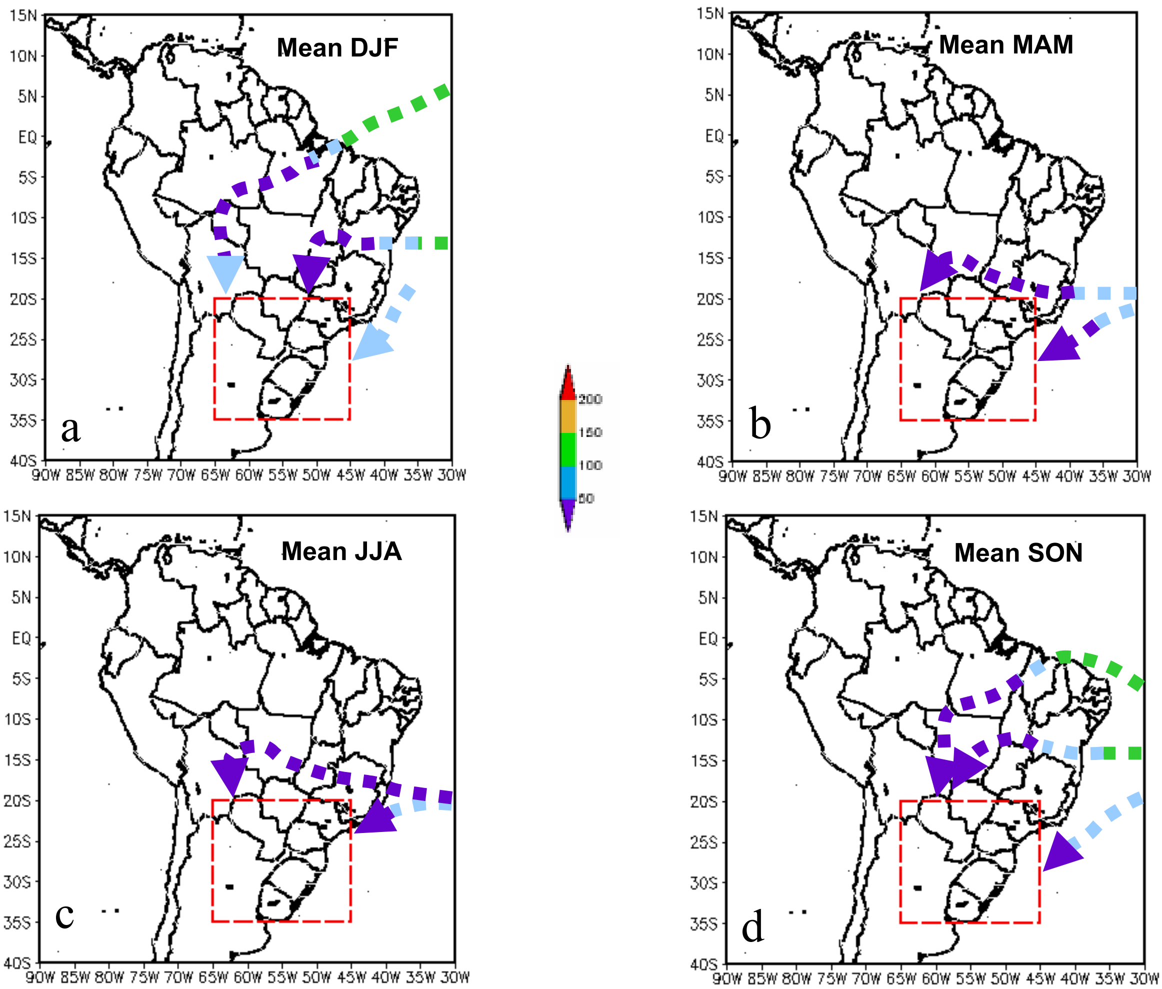

FIG. 3 - Preferential paths, in direction the region of exit of the SALLJ, of the vertically integrated moisture flux between the surface and 700hPa. Mean during: a) DJF, b) MAM, c) JJA and d) SON. The color scale shows the values in kg.$(m.s)^{-1}$.

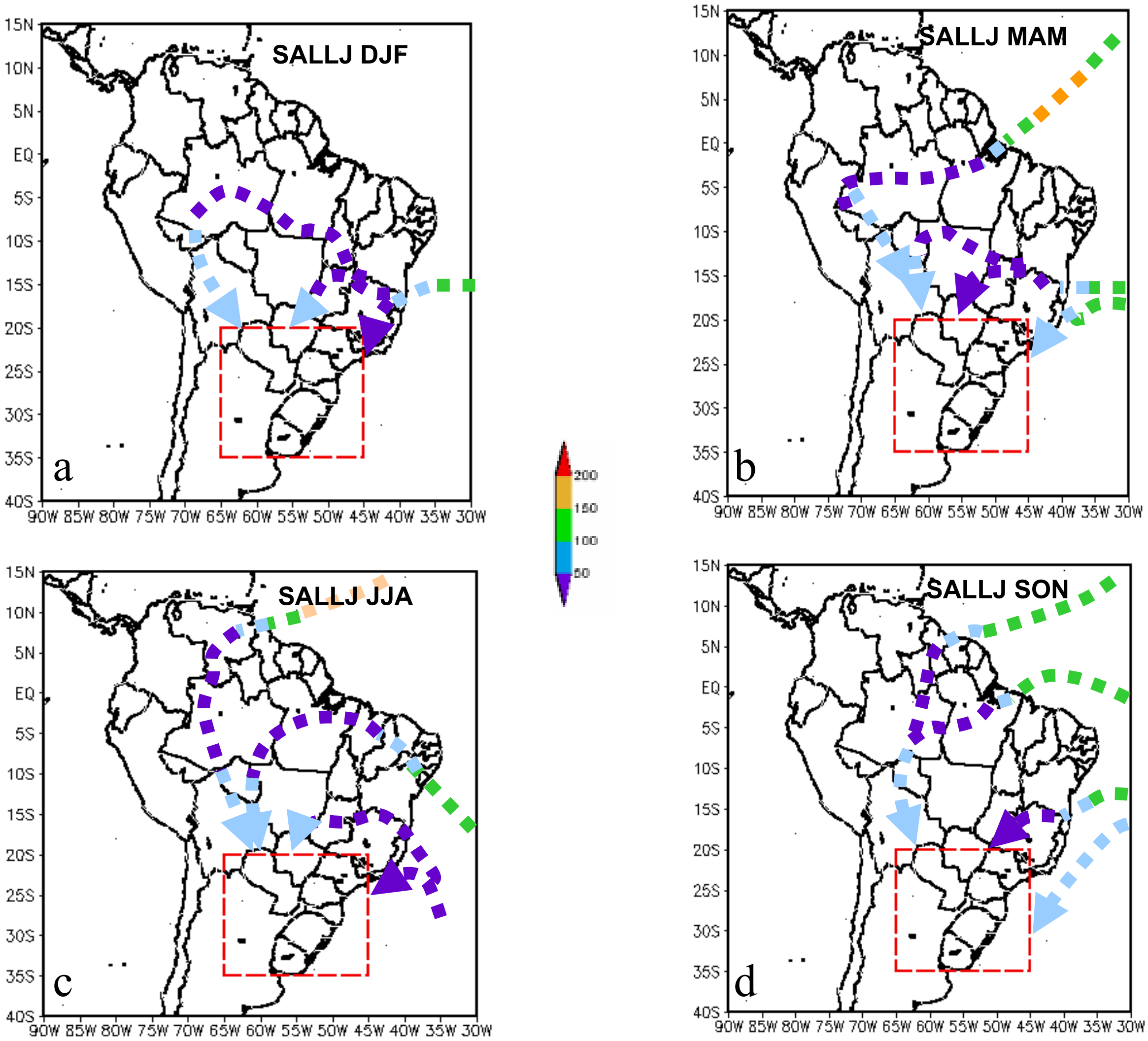

FIG. 4- Preferential paths, in direction the region of exit of the SALLJ, of the vertically integrated of moisture flux between the surface and 700hPa. SALLJ composites during: a) DJF, b) MAM, c) JJA and d) SON. The color-scale shows the values in kg.(m.s)$^{-1}$.

Moisture fluxes in the lateral boundaries of the study area

The FIG. 5a and b shows the vertically integrated moisture fluxes (zonal, meridional and total) below of 700hPa along the east, west, north and south boundaries of the study area.

For the DJF months (FIG. 5a) we can observe, that the zonal moisture flux at the east boundary is weaker in the presence of SALLJ events (FIG. 5b). Thus, as the total flux is larger in the SALLJ composite. The meridional component which is contributing to the increment of moisture transport at this boundary. This can be confirmed by looking at the FIGs. 1 and 2 where it is observed greater predominance in the north-east flux over the ocean with strong southern component. The FIG. 5a shows in the SALLJ composite, a great increase (more than the double) in the total flux in relation to the mean. This flux comes mostly from the Atlantic ocean as it is observed in the FIG. 2a, east of 45W.

The west boundary of the FIG. 5a, shows changes in the direction of the zonal flux. It is the case oriented towards the East. This can be explained looking at the FIG. 1a. It shows a band of convergence between ~66 and 67W in the west side of this boundary, with east zonal flux crossing it. FIG.2a also shows a west flux at the west boundary. On the other side, the east boundary does not suffer great influences of the north flux. Therefore the total flux well is approached by the zonal flux mainly of the composite of SALLJ. The difference observed in the values of the total flux of the mean and the composite of jets is small. This means that the SALLJ does not have a noticeable influence in the moisture transport at this boundary.

At the north boundary the total moisture flux during SALLJ is the more than the double than during the mean. The meridional component is responsible for more than 90% of the flux that crosses this boundary. The FIGs. 3a and 4a show that there are a flux from the ocean and another from the continent (east side of Andes) which is associated with the SALLJ. The FIG 5a shows that the south boundary gets influences of the moisture fluxes from the Atlantic ocean (see FIG. 1a and b).

The values presented here (FIG 5a) are coherent the one obtained by Saulo et al., (2000), who used regional modeling and they obtained a moisture flux in lower atmosphere of -1.84×10^8 kg.s^{-1} in an north boundary fixed in 15S, during the summer of 1997/1998. The value of the moisture flux at the north boundary at 20S obtained from NCEP reanalysis is -1.5×10^8 kg.s^{-1} (see FIG.5a).

FIG. 5b (JJA), shows at east boundary an increase of total moisture flux. It comes from the Atlantic ocean in the composite of jets. In the SALLJ composites, the south Atlantic anticyclone is more evident than when it is compared with the mean (FIGs. 1c and 2c).

The difference between the 2 signals observed in zonal flux in DJF does not occur during JJA at this boundary. The zonal moisture flux that goes through this boundary is from west (both in the mean and the composite). This can be observed looking at the FIGs. 1c and 2c.

The north boundary also shows a increase of the moisture flux, that as for the case of the DJF, is almost completly due to the north component. The shape of the convergence presented in SALLJ inclines in the north-south direction the flux soon above this boundary. This is observed when the FIGs 1c and 2c is compared.

In the south boundary a great increase in the moisture flux (~5 times) is observed in the SALLJ presence.

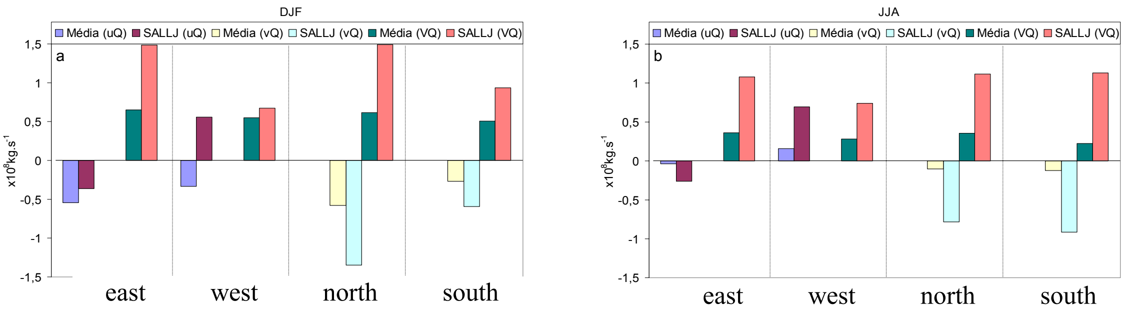

FIG. 5- Vertically integrated moisture flux along the lateral boundaries. a) DJF, b) JJA . uQ is the zonal moisture flux, vQ is the meridional moisture flux and VQ is the total moisture flux. The units are 10^8 kg.s^{-1}.

Conclusions

The seasonal SALLJ composites shows the intensification in the pattern of the annual mean cycle of moisture fluxes in the low levels of the atmosphere in direction of the La Plata basin.

The northern and eastern boundaries of the area that represents the La Plata basin receive greater moisture flux in low atmosphere. The configuration of the stream lines shows a moisture transport from northwest (east side of the Andes) on the continent and north-east in east of 45W coming from the Atlantic ocean.

The presence of the SALLJ causes bigger impact on moisture flux on Bolivia, Paraguay and north and northeast of Argentina. The configuration of the moisture flux in the east side of Andes favors the penetration of moisture coming from the Atlantic ocean towards the exit of the SALLJ (southeastern/south of Brazil).

The conceptual models have shown that the Amazon is the main source of the moisture to be carried by the SALLJ during the SON and with maximum in DJF. The south Atlantic ocean plays an important role during the coldest months of the year.

The SALLJ does not have great influences in the moisture transport in west boundary. However the north boundary shows a strong increase in the total moisture flux in the SALLJ presence. This shows the importance of the SALLJ whose meridional component is responsible for more than 90% of the flux that crosses this boundary.

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Acknowledgments

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