Subseasonal Rainfall Variability in the Vicinity of the South American Low-Level Jet

Brant Liebmann
NOAA-CIRES Climate Diagnostics Center
Boulder, Colorado USA
bl@cdc.noaa.gov

George N. Kiladis
NOAA Aeronomy Laboratory
Boulder, Colorado USA

Carolina Vera and Celeste Saulo
Centro de Investigaciones del Mar y la Atmósfera (CIMA) and
Departmento de Ciencias de la Atmósfera de la Universidad de Buenos Aires
Buenos Aires, Argentina

The South American low-level jet is believed to be the main source of moisture for southern South America (e.g., Wang and Paegle 1996), yet its variability is still not well-understood. The jet is most pronounced in summer, although it also exists during winter and some researchers have suggested that its southward moisture transport is stronger in winter than summer (e.g., Li and Le Treut 1999). The study reported here will focus on summer.

Figure 1 shows the December - February (DJF) rain and 850 mb wind (from the NCEP Reanalysis) and rain (from individual stations averaged onto at 2.5° grid) climatology for 1976 - 1997. The rainfall maximum is centered in southern Amazonia, extending southeastward towards the South Atlantic convergence zone. Between 15°S and 20°S the northerly winds over the eastern continent are associated with the South Atlantic high, while a separate region of northerlies near the Andes are a reflection of the low-level jet system. Longitude-height profiles show the maximum northerly winds in the vicinity of the jet to be between 850 and 925 mb (e.g., Sugahara 1996, Douglas et al. 2000).

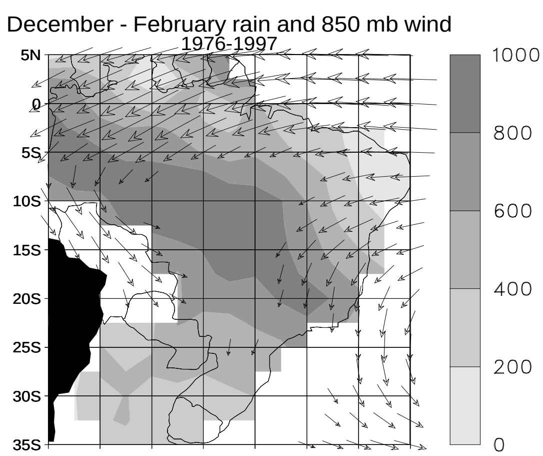

Fig. 1. Climatology of December - February rain and 850 mb winds. Scale shows rainfall in mm. Vectors indicate winds greater than 3 m/s. Darkest shade shows topography greater then 1500 m.

The variability of winds (defined as either the variance of speed or as the "vector" variance which takes into account both variations in speed and direction) is larger in the jet than elsewhere in domain north of 30°S. The maximum in variability associated with the jet is slightly southeast of the wind speed maximum.

In order to explore the relationship between variability of the jet and precipitation downstream, the winds at 20°S, 60°W were selected as representative of the jet. It is near the jet exit and within the region of large variance. At this point the mean 850 mb wind direction is northwesterly. Fig. 2 shows the percent of DJF rainfall associated with days when the northwesterly component of the 850 mb wind there is more than 1 standard deviation above the mean, which includes 16% of the days. When the jet is strong there is more

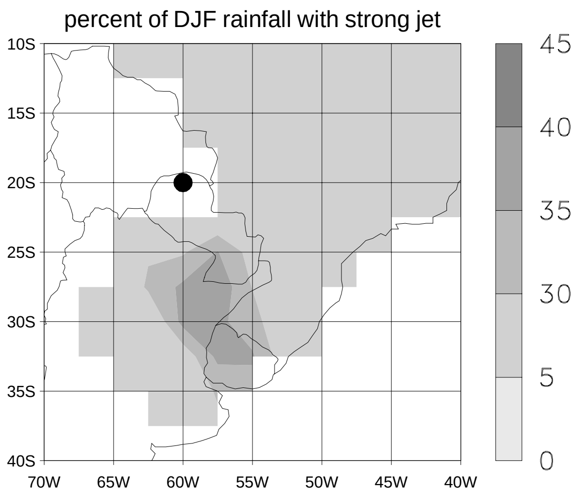

Fig. 2. Composite of percent of DJF climatological rainfall occurring on the 16% of days that the northwesterly component of 850 mb wind at 20°S, 60°W exceeds 1 standard deviation of its climatology.

than a doubling of the daily average precipitation south and slightly east of the composite point. This is consistent with previous studies and with the notion of moisture transport by the jet from the Amazon basin into southern South America (e.g, Salio et al. 2001, Saulo et al. 2000, Wang and Paegle 1986). Composites before the day of maximum wind reveal that the rainfall anomaly moves into its position shown in Fig. 2 from the south as it increases in amplitude.

A problem with using wind anomalies to study the evolution of the jet and its impact on precipitation is that specifying both direction and level will bias the result. Since rainfall anomalies appear to occur in conjunction with a strong jet, however, it seems reasonable to composite dynamical fields on the basis of rainfall.

Figure 3 shows composites of 200 mb and 850 mb height and wind field anomalies associated with daily DJF rainfall that is more than one standard deviation above its climatology at 30°S, 60°W. This point is near the location of maximum rainfall anomaly shown in Fig. 2a. Anomalies are computed by removing the DJF climatology. It is recognized that these anomalies do include interannual variability. This does not seem to be a problem, however, because the sample includes dates from each year, and because regressions using 2-30 day band-passed data (not shown) yielded qualitatively consistent results (although the wave lengths appeared to be slightly shorter).

The 200 mb pattern (Fig. 3a) indicates clearly that a midlatitude wave train is propagating over South America from the west. Lagged composites (not shown) show the anomalies to originate in the midlatitudes of the western Pacific. As the zonally oriented wave train approaches South America it turns sharply equatorward, following a well-documented wave guide in that region (e.g., Hoskins and Ambrizzi 1993). Following the simultaneous composite, the wave continues to propagate equatorward.

The 850 mb pattern initially is aligned barotropically with that at 200 mb. As the pattern evolves, however, the 850 mb low over South America, which one would expect to develop in support of the 200 mb low, primarily develops farther to the south, continuing its zonal propagation, evident on the simultaneous composite (Fig. 3b), and resulting in an equatorward tilt with height, which is a commonly observed there. Presumably the presence of the mountains inhibits the intensification of the low-level low signal over the continent. In addition, evidence of a frontal system moving from the south is noticable in Fig. 3b near the rain maximum. Northwesterly winds associated with enhanced precipitation over that region are favored by the proximity of the front.

Figure 4 is a cross-section of meridional wind at 20°S from the same rainfall index used to composite Fig. 3. The northernly anomalies are centered at the level and longitude of the mean jet, and the anomalies at its core are as large as the mean.

The results shown are entirely consistent with the work of Garreaud and Wallace (1998). Their interest was in summer cold surges, which propagate northward east of the Andes.

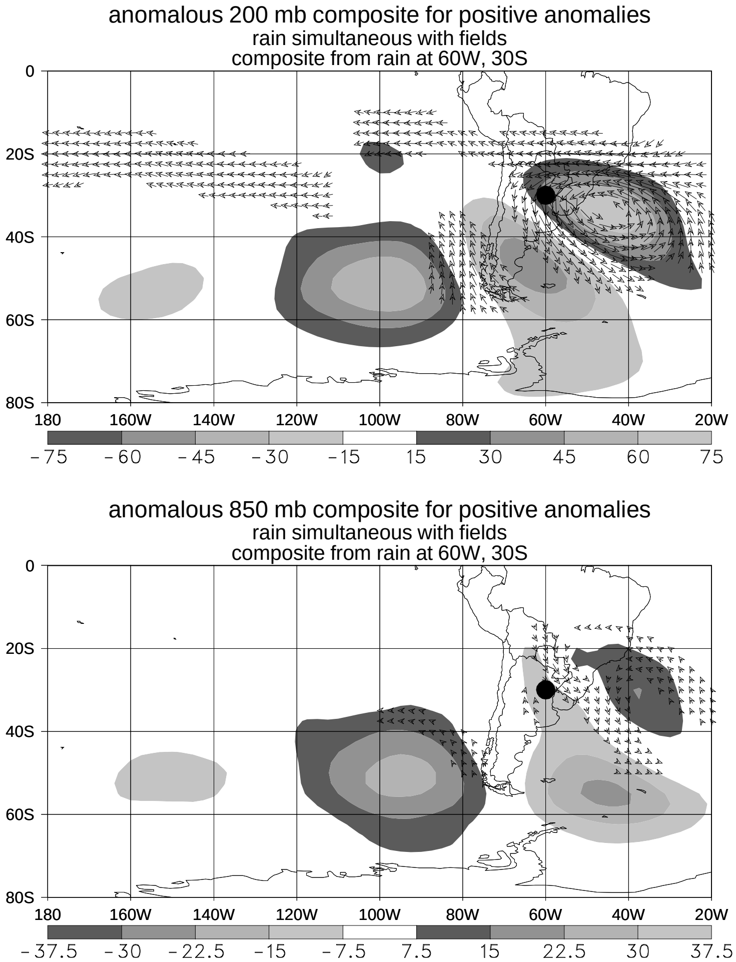

Fig. 3. (a) Composite 200 mb height and vector wind anomalies associated with daily rainfall greater than one standard deviation above the DJF climatology at the base region (heavy dot). Anomalies are defined as the difference from the long-term DJF mean daily precipitation. Scale for heights is in meters. Vectors are plotted for speed anomalies greater than 4 m/s. (b) As in (a) except for 850 mb anomalies, and vector are plotted for anomalies greater than 2 m/s.

Their composites were based on an index of convection near 15°S. Many of the features of the present study appear in the work of Garreaud and Wallace, but at 1.5 days before their day 0. It appears as though the composite on their day 0 lags that of the present study by half a wave length. The dynamical difference between the two situations is that, in their study, the high pressure observed along the east flank of the Andes propagates equatorward remniscent of a trapped wave, while in the present study there is tongue of low pressure observed to push northward. In the present study the low does not propagate north of about 20°S.

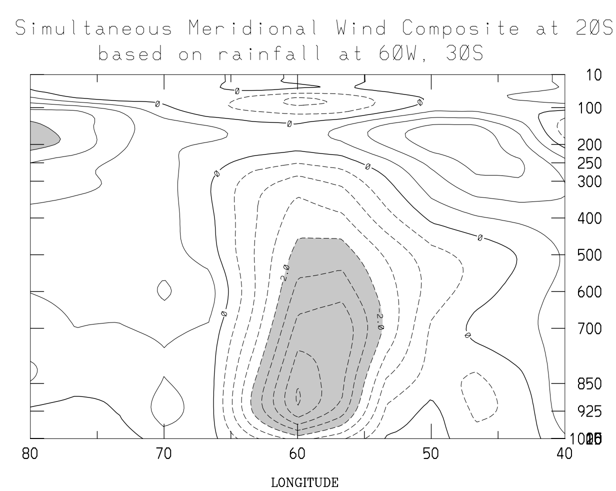

Fig. 4. Composite of meridional wind anomalies at 20°S for same dates as in Fig. 3. Shading begins at 2 m/s. Negative contours are dashed.

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