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Diagnosis of the South American Monsoon Variability

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In order to understand the space-time evolution of the dominant modes that constitute the South American Monsoon System (SAMS), cyclostationary EOF analysis was applied in the region between 20°N-60°S and 0°-90°E and for 29 summers (from 1978/79 to 2007/08) to the Xie-Arkin pentad precipitation data and other synoptic variables during the life cycle of the SAMS (September to March). This analysis shows detailed features of the first three dominant modes.

The first mode of precipitation represents the seasonal cycle, the second mode explains the cold phase of El Niño-South Oscillation (ENSO) (La Niña) signal, and the third mode describes the transition phase of ENSO between La Niña and El Niño and possible interaction of the Madden Julian Oscillation (MJO). All three modes together explain about 26% of the total variance of the pentad precipitation data.

The most pronounced feature of the seasonal cycle is strongly associated with the positive anomalies of surface temperature during the rainy season onset that develop over the tropical region of the continent. Associated with these temperature anomalies changes in the sea level pressure (SLP) field are observed. During the end of the dry season, the surface temperature over the SAMS core increases and consequently SLP decreases. This initiates an cyclonic circulation over central region of South America (SA), known as Chaco low. The increased upward motion induced by the surface warming together with the anomalous cyclonic circulation results in the increased of low-level moisture transport from Amazon region toward central region of SA by the low-level northwesterly flow. This situation increases the amount of precipitation in SAMS core and starts the rainy season in this region. During the termination stage, these conditions over SA are reversed.

The ENSO mode reveals that the following factors affect the evolution of the SAMS system in La Niña years. (1) Negative 1000-hPa temperature anomalies over the Tropical Pacific Ocean that propagate to the continent since the early stage of SAMS until the mature phase. (2) As a result, the moisture transport by the low-level northwesterly flow from Amazon region to Central of SA becomes close to normal conditions providing no significant precipitation anomalies over the SAMS core. (3) The subtropical jet stream is weaker than normal over SA region.

The third mode shows the transition from negative 1000-hPa temperature anomalies over the Tropical Pacific during the early stage of the SAMS to positive anomalies during the withdrawn phase. The 1000-hPa temperature and precipitation fields show the configuration of a north-south dipole over SA in association with the South Atlantic Convergence Zone. A standard tripole northeast-southeast-south over SA is also identified in precipitation, 1000-hPa temperature and upper level zonal wind anomaly fields. A wave train with arc-shaped configuration similar to Pacific-South America pattern is observed in 200-hPa meridional wind anomalies.