8.8 MODULATION OF SEASONAL PRECIPITATION IN NORTHERN VENEZUELA AND ANTECEDENT RAINFALL TO THE FLOODS AND LANDSLIDES OF DECEMBER 1999

Bradfield Lyon*
IRI for Climate Prediction, Palisades, NY

1. INTRODUCTION

Rainfall in northern Venezuela (NVE) is highly influenced by local topography but in general displays strong seasonality with a May to November maximum. Rainfall in NVE during September-November 1999 was unusually heavy and local downpours the following month lead to devastating landslides. This suggests that the heavy antecedent rainfall served to precondition the soil well prior to the landslide events. Investigating what factors influence seasonal rainfall in NVE is the main focus of our study. If precursors to above average seasonal rainfall can be identified which exhibit some potential predictability then conceivably the problem of risk assessment for the region could itself be advanced.

2. DATA and METHODOLOGY

Observational data consisting of gridded monthly sea surface temperature (SST) from Kaplan , gridded monthly precipitation from Hulme and various atmospheric variables from the NCEP-NCAR Reanalysis are utilized. In addition, monthly rainfall data for stations in NVE were obtained from the Global Historical Climatology Network. The base period of the study is 1950-1999.

To investigate the potential influence of the tropical ocean basins on rainfall in NVE we first compute simple linear, contemporaneous and lagged correlations between monthly and seasonal rainfall anomalies averaged across NVE (60-70W, centered on 10N) and tropical SST anomalies in both the tropical Atlantic and Pacific. We define the seasons as the 3-month periods DJF, MAM, etc.

Next, low-level moisture flux composites are constructed as we investigate cases of extreme seasonal rainfall in NVE during the JJA and SON seasons. Corresponding oceanic conditions are also examined and results are compared with the SON 1999 season.

*Corresponding author address: Dr. Bradfield Lyon, IRI for Climate Prediction, 110 Monell Building, LDEO, Palisades, NY 10964; e-mail: blyon@iri.columbia.edu

3. RESULTS

3.1 Contemporaneous Correlations

We focus on the JJA and SON seasons. Fig. 1 indicates the contemporaneous linear correlation between anomalous rainfall in NVE and SST anomalies. For the JJA season, the figure indicates the only statistically significant correlations are found in the tropical North Atlantic and Caribbean, while negative correlations, mainly in the eastern tropical Pacific and Caribbean, dominate during SON. The boxes in Fig. 1 indicate the Nino 3 region in the eastern Pacific and a region in the tropical North Atlantic that we will call the NATL region, after Enfield (1996).

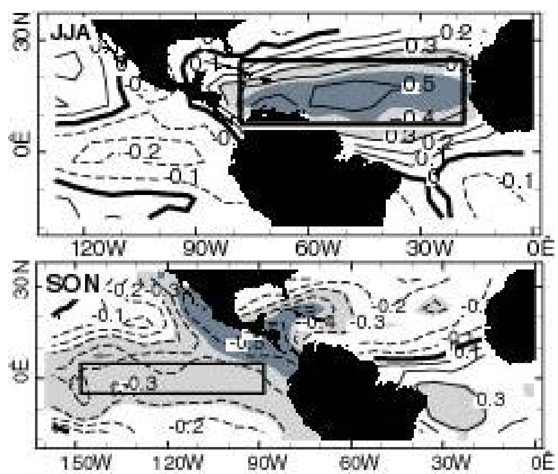

Figure 1. Linear correlation between NVE precipitation anomaly and SST anomaly for JJA (top) and SON (bottom) seasons. Light and dark shading indicates statistical significance at the 95 and 99% confidence levels, respectively.

3.2 Lagged Correlations

Figure 2 shows the lagged correlations between seasonal precipitation anomalies in NVE and the SST anomalies for the Nino 3 and NATL regions at 0 to 6 months lag. The results indicate that the influence of these respective ocean basins on seasonal rainfall in NVE varies with season with Nino 3 SSTs dominating in DJF and SON with the NATL region being most influential during JJA. The correlations are negative for the Nino 3 region and positive for the NATL region, consistent with other studies in the region (see Enfield and Alfaro 1999, Giannini et al., 2000).

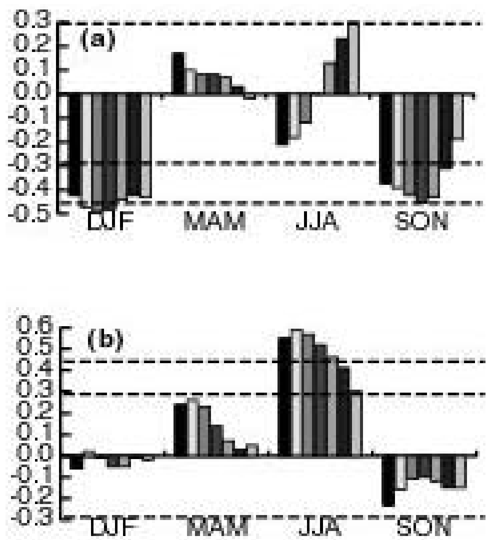

Figure 2. Zero to 6 month lagged correlations between rainfall anomalies in NVE region and SST anomalies in the a) Nino 3 and b) NATL regions. Left-most bar is for 0 lag while successive bars indicate lags increasing by 1 month. Dashed lines indicate statistical significance at the 95% and 99% confidence levels.

3.3 *Seasons with Extreme Rainfall and ENSO*

For the JJA and SON seasons we selected those years where rainfall in NVE was at or above the 90^{th} percentile (from 1950-1999) for further analysis. An interesting result for the JJA season is that 5 out of the 6 cases with greatly enhanced seasonal rainfall occurred during years when there was a transition from the warm to cold phase of ENSO. Our previous results indicated JJA rainfall in NVE is correlated with anomalously warm SSTs in the NATL region. Here we see that the oceanic influence is enhanced when temperatures in the tropical Pacific are of opposite sign. This is similar to the result found by Enfield and Alfaro (1999) for rainfall in the Caribbean and Central America.

For the SON season, 5 of the 6 seasons with greatly enhanced rainfall occurred during cold ENSO events. We note, however, that the correlation shown earlier between Nino 3 SST anomalies and rainfall in NVE is modest. Other, perhaps more transient, factors must therefore be important as well.

3.4 Low-Level Moisture Flux Composites

For seasons with greatly enhanced rainfall in NVE the mean and anomalous 925 hPa moisture flux was computed from the NCEP-NCAR Reanalysis data. For JJA the 5 ENSO transition cases were used in the composites while for SON we examined the 5 cold ENSO cases. In Fig. 3 the anomalous flux vectors are shown along with regions with anomalous moisture flux convergence for the SON season. The figure indicates an anomalous westerly moisture flux from the eastern Pacific into the Caribbean with anomalous moisture flux convergence along the northern coast of South America. The SON 1999 season (not shown) had similar features with the main exception of an anomalous northerly moisture flux across the Caribbean in 1999.

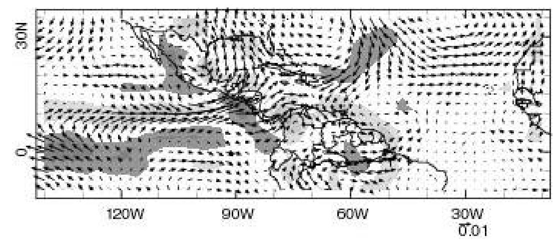

Figure 3. Anomalous 925 hPa moisture flux vector and regions of anomalous convergence (light gray) and divergence (dark gray) for 5 SON seasons with greatly enhanced rainfall in NVE region.

4. CONCLUSIONS

Given that the devastating floods and landslides in NVE of December 1999 were proceeded by a season of exceptionally heavy rainfall, we focused on factors which influence rainfall in NVE during these two seasons. We find, consistent with other studies, that seasonal rainfall in NVE is influenced by both the tropical Pacific and North Atlantic basins. The tropical North Atlantic appears to be the dominant influence during JJA while it is the eastern Pacific – though to a lesser extent – during SON. In addition, JJA rainfall appears to be enhanced during transitions from the warm to cold phase of ENSO which results in SST anomalies of opposite sign in the two basins. Moisture flux composites indicate there is a large scale signature to the low level flow during seasons with enhanced rainfall with coherent regions of enhanced moisture flux convergence along the northern coast of South America.

5. REFERENCES

Enfiled, D. B., 1996: Relationships for inter-american rainfall to tropical Atlantic and Pacific SST variability. *Geophys. Res. Let.* **23,** 3305-3308.

Enfield, D. B., and E. J. Alfaro, 1999: The Dependence of Caribbean Rainfall on the Interaction of the Tropical Atlantic and Pacific Oceans. *J. Climate*, **12**, 2093-2103.

Giannini, A., Y. Kushnir, and M.A. Cane, 2000: Interannual Variability of Caribbean Rainfall, ENSO and the Atlantic Ocean. *J. Climate,* **13**, 297-311.