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The influence of ENSO and interdecadal variability on the frequency of extreme precipitation events in South America

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Different phases of the El Niño–Southern Oscillation (ENSO) produce significant impacts on monthly and seasonal precipitation over several regions of South America (SA), as shown by previous studies. This paper examines how El Niño (EN) and La Niña (LN) episodes, as well as interdecadal oscillations, modify the frequency of extreme precipitation events in South America, and the reason for this modification.

Gamma distributions are fit to precipitation series for each day of the year, in the period 1956-2002, provided by about 10,000 stations. Daily station data are gridded to 1.0º to achieve more homogeneous distribution of data. Daily precipitation data are then replaced by their respective percentiles. Extreme events are those with a three-day average percentile above 90. The number of extreme events was computed for each month of each year. Years were classified as EN, LN, and normal years, and the mean frequency of extreme events for each month, within each category of year, is computed. Maps of the difference (and its statistical significance) between these mean frequencies for EN and normal years, and for LN and normal years show that EN and LN episodes influence significantly the frequency of extreme events in several regions in Brazil during certain periods.

The relationships between large-scale atmospheric perturbations and variations in the frequency of extreme precipitation events are sought through composites of anomalous atmospheric fields during extreme events in EN and LN episodes, in three regions

in which there is significant change in the frequency of these events. The general features of those anomalous fields are similar for extreme events in any category of year (EN, LN or normal). They show the essential ingredients for much precipitation: moisture convergence and mechanisms for lifting the air to the condensation level. In the regions where the frequency of extreme events increases (decreases) during EN or LN episodes the anomaly composites during extreme events show similarity (difference) with respect to the mean anomalies during those episodes. This indicates that the frequency of extreme events increases (decreases) when the large-scale perturbations favor (hamper) the circulation anomalies associated with these events.

The EOF analysis of the monthly totals of extreme events, filtered to retain only decadal/ interdecadal variability, discloses slow variations in the frequency of extreme events. The first PC shows a remarkable oscillation with phase transition in the 1970's. Periods of opposite phases of this oscillation are analyzed with respect to mean atmospheric circulation, mean frequency of extreme precipitation events, and characteristics of the extreme events. The correlation of the first PC with sea surface temperature and indices of known modes of interdecadal variability indicates strong connections with the North Atlantic Oscillation and Pacific Interdecadal Oscillation.

The present analysis discloses significant influence of ENSO episodes on the frequency and magnitude of extreme precipitation events is several regions of South America. These events are also strongly modulated by interdecadal modes of climate variability.