

Natural Climate Variability: Floods in Veracruz, Mexico in 2010:

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Summary: The hydroclimatic events that occurred in the state of Veracruz, Mexico during the period 1999-2010 make impossible to stop thinking about floods as a hazard for its inhabitants (Fig. 1). The present analysis is considered as a good opportunity to start an overdue talk with the local scientists and authorities on natural climate variability and its impacts on the regional hydroclimate. Climate records of the 20th century indicate that both the north and south of the state, which border the western side of the Gulf of Mexico, have large precipitation variability which has the potential of inducing droughts and floods (Fig. 2). Intrinsic phenomena to the natural climate variability have the potential of generating intense rainfall episodes, and eventually, floods in Veracruz (Figs. 3, 4). In spite of the increased frequency of these events, and their possibile connection with natural climate variability. The observed anomalous rainfall in the summer and fall of 2010 is analyzed within this context.

The concurrence of the anomalous rainfall in the northern and southern portions of Veracruz and the global sea surface temperatures in the summer and fall of 2010, suggests that climate phenomena of global scale such as La Niña and the Atlantic Multidecadal Oscillation (AMO) in its positive phase, may have induced the extreme rainfall (Fig. 1). The AMO, a low-frequency phenomenon operating at decadal scales, works in the background inducing anomalous rainfall in the southern portion of the state in its positive phase, mainly during summer and fall (Figs. 3, 4). El Niño-Southern Oscillation, a ligh-frequency phenomenon operating at interannual scales, can magnify/reduce the effect of the AMO through its La Niña/ElNiño phase in both northern and southern portions of the state (Figs. 3, 4). However, these phenomena on explain entirely the observed anomalies in 2010, mainly over the northern portion seen in fall (Fig. 1), which opens the door to other phenomena of atmospheric, oceanic or even man-made origin to explain them. This uncertainty exemplifies the work that still is needed in order to gain knowledge on the nature of the forcing of anomalous regional rainfall.

2010 Floods along Veracruz State



Figure 1. Floods in the state of Veracruz in 2010 caused more than 5,000 million dollars in damages, affected 114 out of 212 counties, and led to 130 deaths. Observed seasonal cainfal anomalies in 2010 (TRMM) are evident in the northern and southern halves of the state. Concurrent SST anomalies (ERSSTv3b) show an evolving ENSO from El Niño to La Niña conditions in the Pacific and a sustained AMO-like warm phase in the Atlantic. Shading: green/Yoomon (red/Dule) denotes +/- precipitation (SST) anomalies; contour interval: 0.4 mm/day (0.4°C). Increased vulnerability due to bad urban planning and mountain deforestation are contributing factors to increased flooding in the state.

ENSO , PDO & AMO Hydroclimate Impacts

Extreme Rainfall & ENSO, PDO, AMO



Figure 3. Seasonal regressions of ENSO, PDO and AMO indices on precipitation (CRUTS21) and SST in summer (left) and fall (right) for the period 1950-2001. Standardized summer and fall ENSO (orange), PDO (green) and AMO (violet) indices are displayed in the corresponding bottom penet ENSO indice is generated by taking the ENSO indice is generated by taking the NINO3.4 region (1770W-120W, SS-SFN); PDO is Mantua's index calculated as the imme series associated with first mode of SST variability to the north of 20° N NINO3.4 region company. Or 2004 (1870) detrended SST anomalies over the Altántio region (75W-5W, 0r-80%). Stading: green/brown (fac4blue) denotes +/- precipitation (SST) anomalies; contour interval: 01 mind/ay (0.1°).

Rainfall Variability: Recurrent Floods



Figure 4. Scatter plots of northern (985-5970; 20-21N)-elft panels) and southern (97-56'0; 17,5'-19'N)-right panels) regional precipitation anomalies versus standardized ENSO (aronge -upper), PDO (green -middle) and AMO (violet -bottom) indices in summer and fall for the period 1951-2001. Showing only values when precipitation exceeds one STD: 1.6 mm/day in the northern region for both summer and fall, and 2.0 and 1.4 mm/day in the sunthern region for summer and fall respectively.





Figure 2. Climatology (upper panels) and mean standard deviation (STD — lower panels) of precipitation in summer (left) and fall (right) for the period 1951-2001. Green shading in climatology (STD) starts at 5mm/day (0.5mm/day). Red and blue boxes define precipitation indices to the north (98.5⁻⁹⁷⁷O, 20⁻²11^N) and south (97⁻⁹⁶⁷O, 17.5^{-197N}) halves of state: all season correlation between the indices is 0.67. Summer/fall index values are highlighted with a filled/empty circle.