The Effects of Pacific Decadal Oscillation and El Niño-Southern Oscillation on Annual Floods in Godavari River Basin, India

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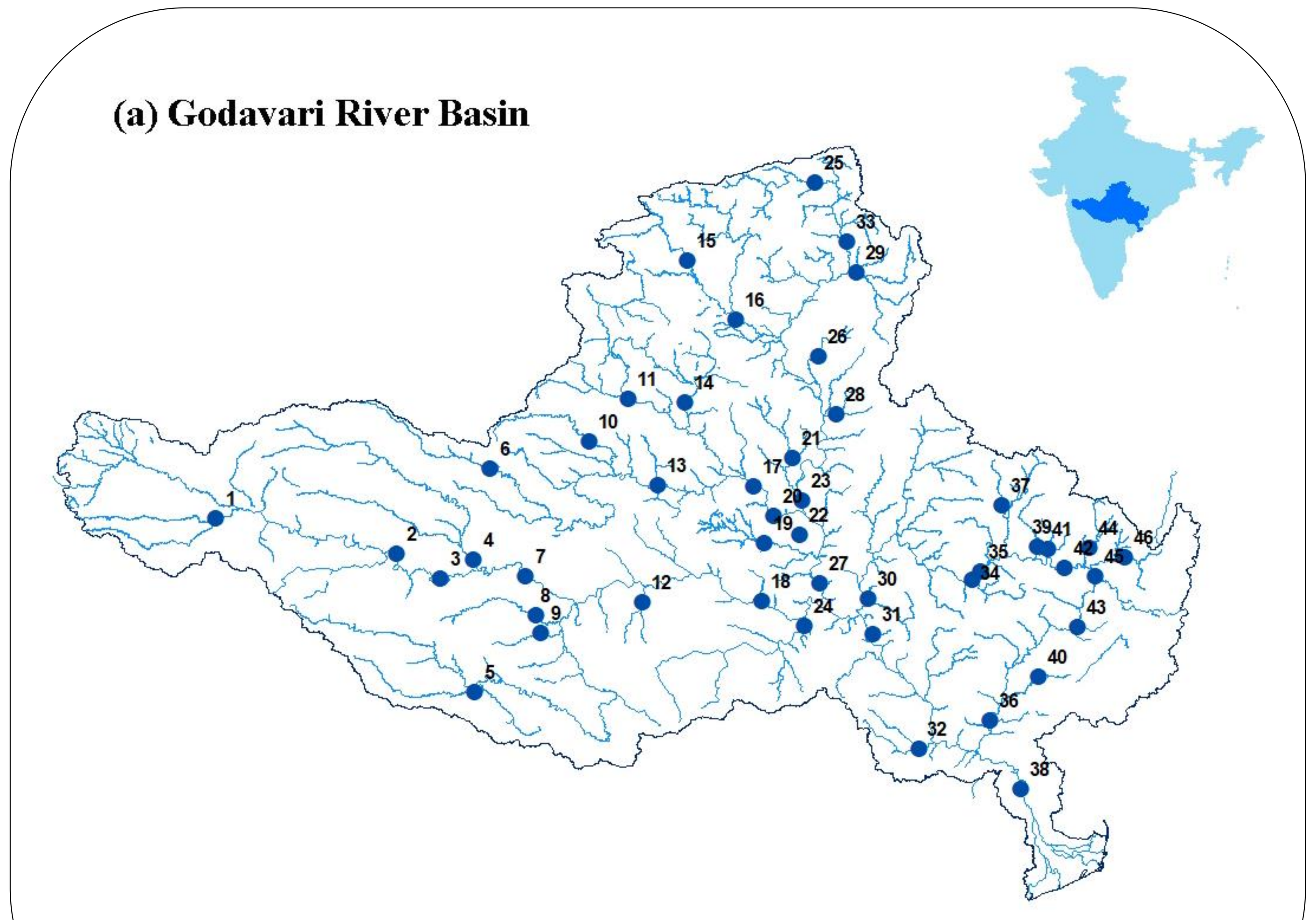
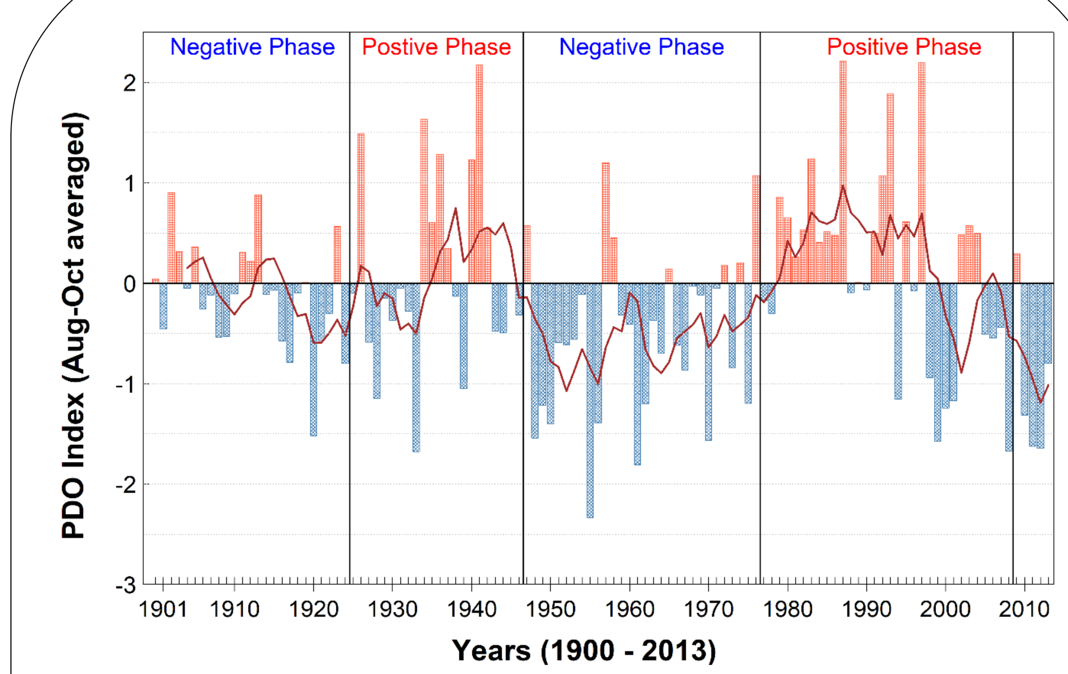
INTRODUCTION

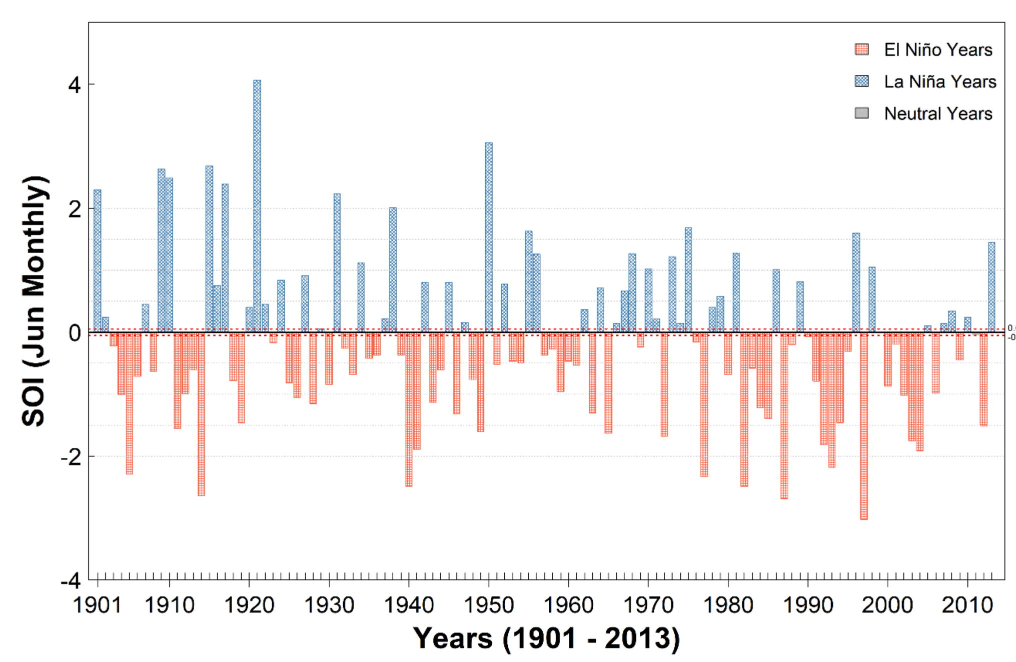
Indian summer monsoon rainfall is strongly influenced by large-scale atmosphere-ocean oscillations including Pacific Decadal Oscillation (PDO), El Niño-Southern Oscillation (ENSO). Researchers have shown that the negative phase of PDO or La Niña episodes of ENSO produce higher magnitude rainfall and hence relatively wetter years. This study is motivated by the observation that such teleconnections are not yet a key ingredient in planning and design of regional water resources and/or transportation infrastructure. This study is first of its kind to evaluate the impact of these low frequency oscillations, which are known to substantially control the magnitude and frequency of ISMR, on the annual peak flows in Indian watersheds.



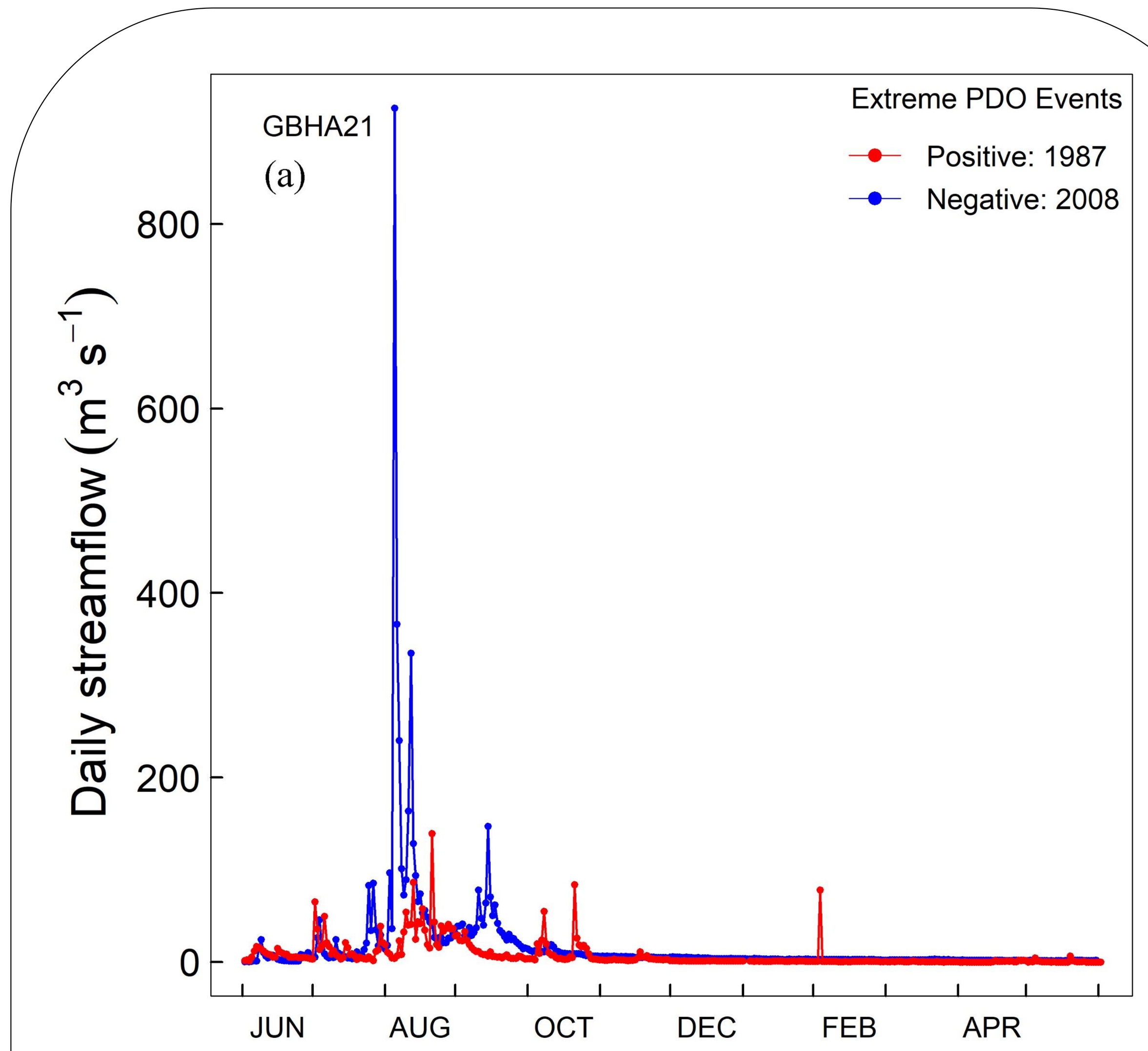
Locations of the selected streamflow Gauging station spread across Godavari River Basin



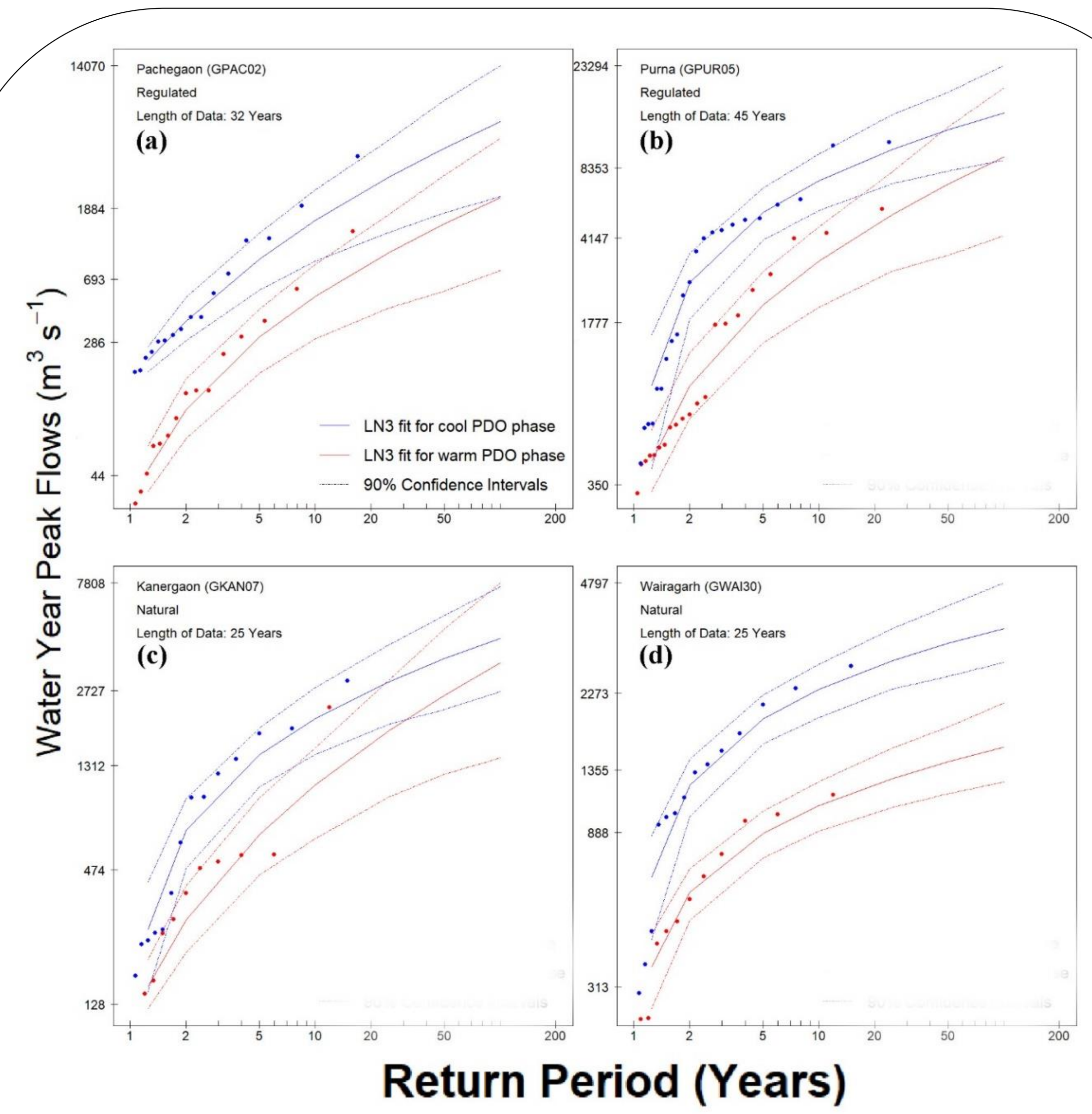
Variability of the Pacific Decadal Oscillation (PDO) averaged over August to October (1901 – 2010), together with a 5-year running mean (red line).



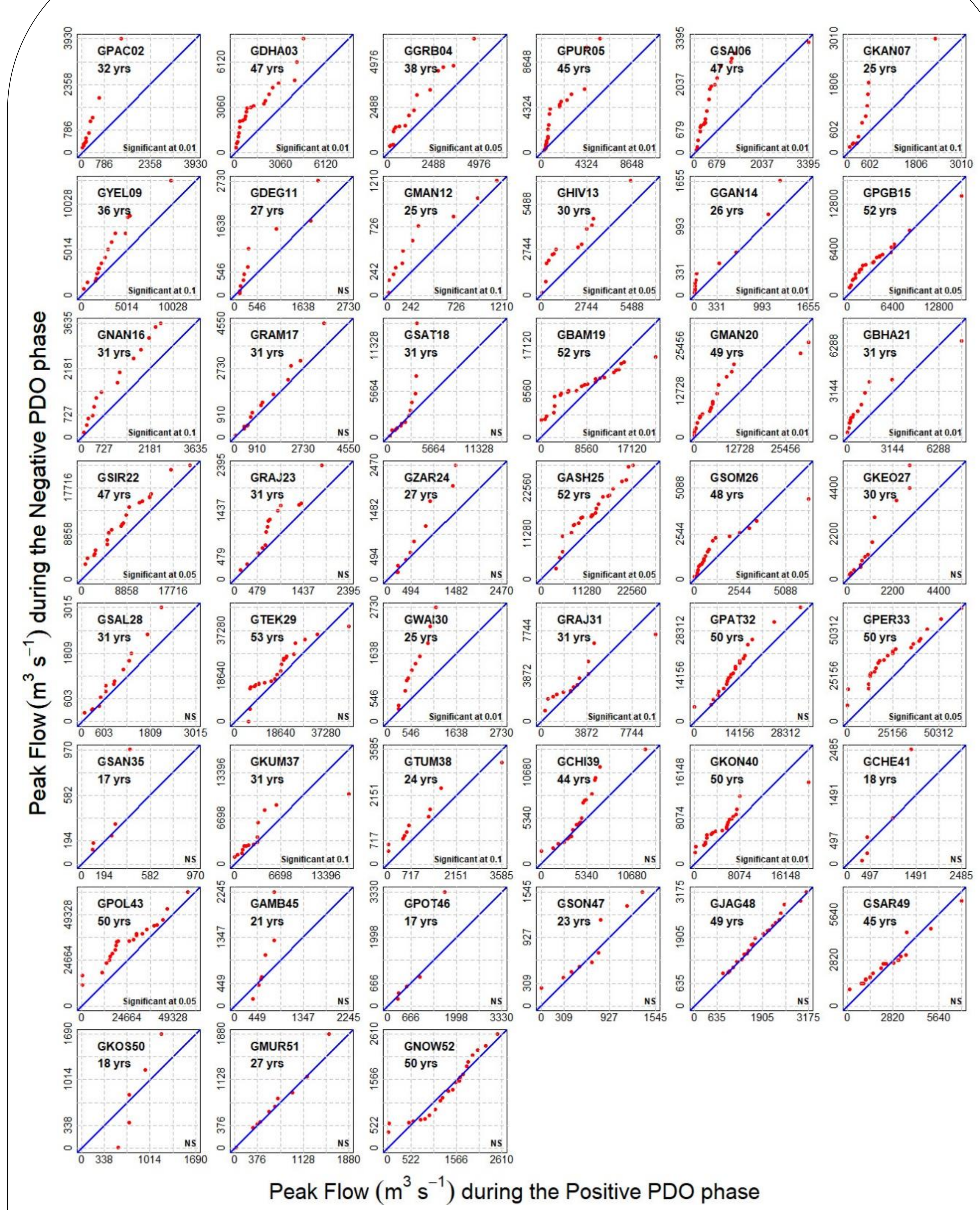
Variability of the El Niño-Southern Oscillation (ENSO) as defined by the June Monthly Southern Oscillation Index (SOI)



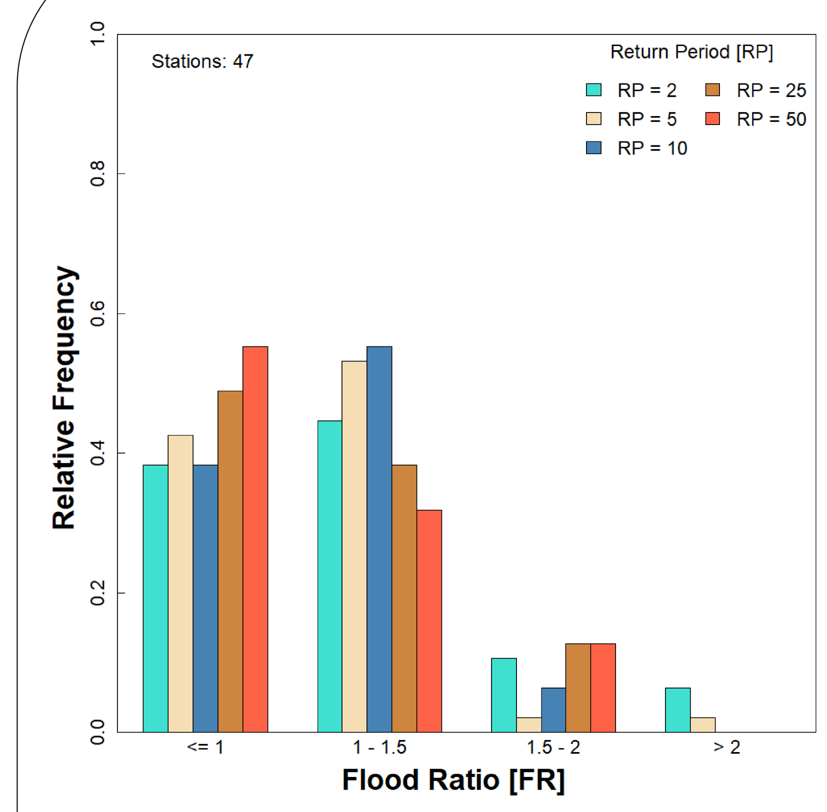
Streamflow hydrographs at a gauging station in Godavari River basin in response to the extreme PDO events, i.e. 1987 (Positive) and 2008 (Negative).



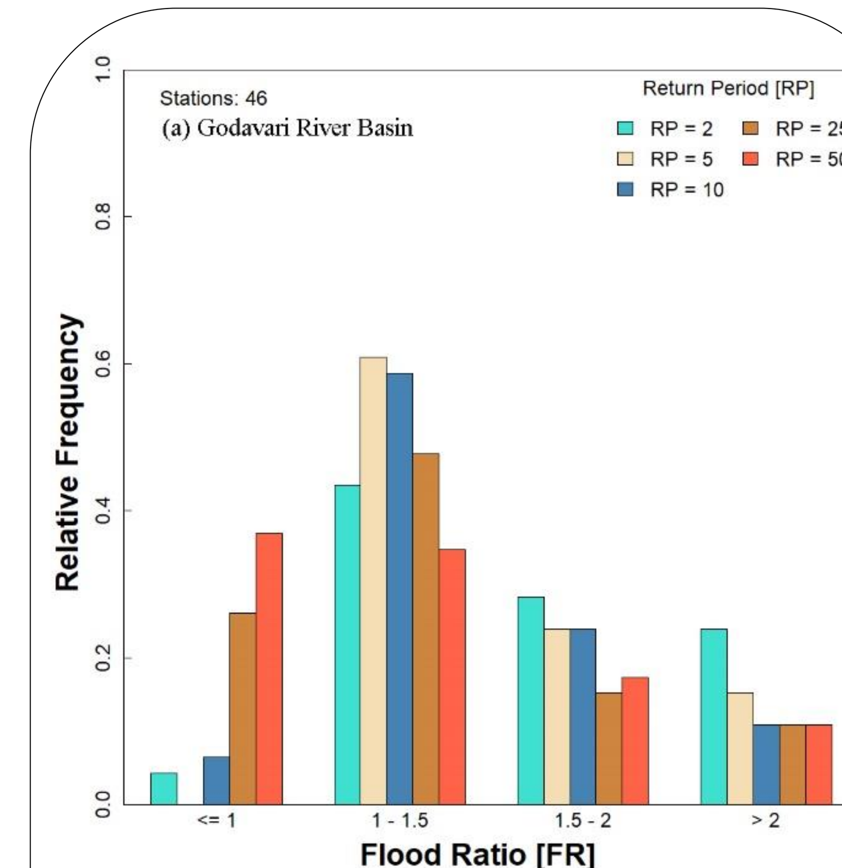
Log-Normal expected quantiles and their 90% confidence interval for the annual peak flows in selected gauging stations of Godavari River basin stratified according to cool and warm phases of PDO.



Quantile-Qantile (Q-Q) plots based on the annual peak flows stratified according to the PDO at 46 streamflow gauging stations located across Godavari River Basin. The length of data at gauging station is shown in the upper left corners.



Histogram of flood ratios, flood quantiles in La Niña episodes to those in El Niño episodes, for several return periods



Histogram of flood ratios, flood quantiles in negative PDO phase to those in positive PDO phase, for several return periods

CONCLUSIONS

The results indicate that the annual peak flows in the gauges spread across Godavari River basin indicate that the magnitude and frequency of annual peak flows is substantially influenced by the phase of PDO, ENSO, or IOD. In majority of the gauges, higher magnitude floods seem to be more common during the negative phase of PDO or during the La Niña episodes of ENSO pattern. Overall, the results from this study highlight the potential inadequacy of *i.i.d.* assumption and is not tenable where the hydroclimatology is strongly influenced by the low-frequency atmosphere-ocean oscillations. These results are in agreement with the observations made by other researchers across the globe. This is a manifest in Godavari and Narmada River basins in India and other parts across the globe including western Canada, California and eastern Australia. The extent of this problem in other Indian watersheds remains to be explored. Any region with a strong teleconnection with such large-scale atmosphere-ocean oscillations may be subject to under- or over-estimation of the design flood. Therefore, the knowledge of the regional hydroclimate with regards to phases of the large-scale atmosphere-ocean oscillations should be considered prior to estimating design flood. Furthermore, the effect of other atmosphere-ocean oscillations, e.g. North Atlantic Oscillation (NAO), Arctic Oscillation (AO) and Atlantic Multi-Decadal Oscillation (AMO), on extreme hydrology of Indian watersheds needs to be explored.