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Flood Frequency Analysis based on the Metastatistical Extreme Value Distribution: Performance and Evaluation of ENSO Signal across the Continental United States

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Reliable flood frequency estimates, robust with respect to small samples and to possible inter-annual variability, are key to many different sectors and applications, from the design of hydraulic structures to flood insurance, to the quantification of economic and societal impacts in general. Traditional flood frequency analysis has often become a mere mathematical, statistical fitting exercise, with little attention for the possibly different flood-generating phenomena at play. Here we apply, for the first time to flood frequency analysis, the Metastatistical Extreme Value Distribution (MEVD), a recently-developed extreme value theory that was shown to significantly improve estimation uncertainty with respect to the traditional approach hinging on the Generalized Extreme Value distribution (GEV) in rainfall applications. We then use the MEVD formulation, which can explicitly include mixed distributions of the "ordinary" floods, to investigate the role of El Niño Southern Oscillation (ENSO), a major mode of climate variability involving changes in sea surface temperature and atmospheric circulations, in the generation of extreme floods.

We analyze ∼3000 U.S. Geological Survey stream gauge time series across the continental United States with at least 50 years of daily observations and that do not present abrupt or gradual changes. Compared to the observations, we find that flood frequency estimates based on MEVD perform better than those estimated using the GEV at ∼72% of the analyzed sites. This improvement is even more marked when the sample size used for the estimation of the parameters is limited. In terms of the role of ENSO, we find that only a small number of data records show statistical evidence that accounting for ENSO phases is beneficial in terms of extreme flood estimation accuracy.