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A Space-Time Modeling Framework for Streamflow Extremes

Alvaro Ossandon[1,2], Balaji Rajagopalan[1,3], and William Kleiber[4]
[1]University of Colorado at Boulder, Department of Civil, Environmental and Architectural Engineering, Boulder, United States of America (alvaro.ossandon@colorado.edu)
[2]Santa Maria University, Department of Civil Engineering, Valparaiso, Chile
[3]CIRES, University of Colorado at Boulder, Boulder, United States of America
[4]University of Colorado at Boulder, Department of Applied Mathematics, Boulder, United States of America

Streamflow extremes, especially, summer seasonal streamflow in monsoon climate makes a significant contribution to the reliability of water resources and the health of ecology. The summer extreme precipitation and streamflow also cause severe floods resulting in loss of life and property. Large scale climate drivers impart strong spatial and temporal variability in the flow extremes, which needs to be modeled for use in efficient management of resources. To this end, we developed a space-time model to capture the variability of –summer season 3-day maximum streamflow. In this, the extremes at each station are assumed to be distributed as Generalized Extreme Value (GEV) distribution with non-stationary parameters. Thus, the parameters are modeled as a linear function of suitable covariates – typically, large scale climate variables and regional mean precipitation. In addition, the spatial dependence of the extremes is modeled via a Gaussian copula. The parameters of the nonstationary GEV at each location are estimated via maximum likelihood, whereas those of the Copula are estimated via the Inversion of Kendall's tau estimator method. Ensembles of streamflow in time are based on the temporal varying covariates and from the Copula are generated, consequently, capturing the spatial and temporal variability and the attendant uncertainty. Furthermore, various return level can also be obtained from these simulations. The model is demonstrated by application to 3-day maximum summer streamflow in a representative basin from two different monsoonal climate – India and Southwest U.S. In addition to comparing the performance of the median of the simulations with the historic observations, we also compare the number of stations that exceed a specific level- say, 75th percentile which indicates the spatial performance. The model validation indicates that the model is able to capture the space-time variability, furthermore, it captures the variability in wet and dry years, consistent with observations. This framework can be applied to generate ensembles of at several lead times – week to seasonal, to provide risks of various levels of streamflow. This will be of immense use in water resources, agriculture and flood management and planning.