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Probabilistic Flood Hazard Maps at Ungauged Locations Using Multivariate Extreme Values Approach

Kiran Kezhkepurath Gangadhara[1] and Srinivas Venkata Vemavarapu[2]
[1]Department of Civil Engineering, Indian Institute of Science, India (kirankg06@gmail.com)
[2]Interdisciplinary Centre for Water Research (ICWaR), Indian Institute of Science, India (vvs@iisc.ac.in)

Flood hazard maps are essential for development and assessment of flood risk management strategies. Conventionally, flood hazard assessment is based on deterministic approach which involves deriving inundation maps considering hydrologic and hydraulic models. A flood hydrograph corresponding to a specified return period is derived using a hydrologic model, which is then routed through flood plain of the study area to estimate water surface elevations and inundation extent with the aid of a hydraulic model. A more informative way of representing flood risk is through probabilistic hazard maps, which additionally provide information on the uncertainty associated with the extent of inundation. To arrive at a probabilistic flood hazard map, several flood hydrographs are generated, representing possible scenarios for flood events over a long period of time (e.g., 500 to 1000 years). Each of those hydrographs is routed through the flood plain and probability of inundation for all locations in the plain is estimated to derive the probabilistic flood hazard map. For gauged catchments, historical streamflow and/or rainfall data may be used to determine design flood hydrographs and the corresponding hazard maps using various strategies. In the case of ungauged catchments, however, there is a dearth of procedures for prediction of flood hazard maps. To address this, a novel multivariate regional frequency analysis (MRFA) approach is proposed. It involves (i) use of a newly proposed clustering methodology for regionalization of catchments, which accounts for uncertainty arising from ambiguity in choice of various potential clustering algorithms (which differ in underlying clustering strategies) and their initialization, (ii) fitting of a multivariate extremes model to information pooled from catchments in homogeneous region to generate synthetic flood hydrographs at ungauged target location(s), and (iii) routing of the hydrographs through the flood plain using LISFLOOD-FP model to derive probabilistic flood hazard map. The MRFA approach is designed to predict flood hydrograph related characteristics (peak flow, volume and duration of flood) at target locations in ungauged basins by considering watershed related characteristics as predictor/explanatory variables. An advantage of the proposed approach is its ability to account for uncertainty in catchment regionalization and dependency between all the flood hydrograph related characteristics reliably. Thus, the synthetic flood hydrographs generated in river basins appear more realistic depicting the observed dependence structure among flood hydrograph characteristics. The approach alleviates several uncertainties found in conventional methods (based on conceptual, probabilistic or geomorphological approaches) which affect estimation of flood hazard. Potential of the proposed approach is demonstrated through a case study on

catchments in Mahanadi river basin of India, which extends over 141,600 km^2 and is frequently prone to floods. Comparison is shown between flood hazard map obtained based on true at-site data and that derived based on the proposed MRFA approach by considering the respective sites to be pseudo-ungauged. Coefficient of correlation and root mean squared error considered for performance evaluation indicated that the proposed approach is promising.