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Flood inundation maps with the associated uncertainty using sparse data in the Mediterranean region

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Flood inundation maps are important to understand flood hazard and the associated risk. Developing such maps is challenging in data-sparse regions where observational data are lacking, inconsistent, or uncertain, and are too sparse to meet hydrological and hydraulic models' requirements. We present a framework to develop flood inundation maps with the associated uncertainty using sparse data in the Mediterranean region. The framework is based on a coupled hydrological-hydraulic model (HEC-HMS/HEC-RAS) constrained by past storm events and post-event measurements in space. The study is applied on the Awali river catchment (301km2) in Lebanon. The hydrological model parameter bounds are minimized by calibrating the model with 12 extracted past storm events of relatively reliable rainfall and flow measurements. The hydrological model is then applied to simulate the early January 2013 extreme flood event with uncertainty analysis based on Monte Carlo simulation. The minimized parameter bounds are sampled based on a uniformly distributed probability density function. The resulting bounds of the flow hydrographs set are then transferred to the hydraulic model to simulate the possible bounds of the flood water levels. The hydrological model performance was variable with a Nash-Sutcliffe efficiency value ranging between 0.84 and 0.06, and a coefficient of correlation ranging between 0.93 and 0.58. For the hydraulic model, over 90% of the observed water levels fall within the simulated uncertainty bounds with an RMSE error of 0.26 m for the possible mean hydrograph simulation. The proposed framework minimizes the range of the hydrological model parameters at which the uncertainty sampling is performed and allows the validation of the hydraulic model results by post-event measurements in space. The good results show that the use of sparse-data in a classical modeling approach is encouraging and the framework can be extended to other data-sparse regions facing same problems.

Keywords: Sparse data; Flood map; Post-event measurements; Uncertainty; Lebanon; Mediterranean