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Calibration and Evaluation of a Flood Forecasting System: Utility of Numerical Weather Prediction Model, Data Assimilation and Satellite-based Rainfall

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A fully-distributed, multi-physics, multi-scale hydrologic and hydraulic modeling system, WRF-Hydro, is used to assess the potential for skillful flood forecasting based on precipitation inputs derived from the Weather Research and Forecasting (WRF) model and the EUMETSAT Multi-sensor Precipitation Estimates (MPEs). Similar to past studies it was found that WRF model precipitation forecast errors related to model initial conditions are reduced when the three dimensional atmospheric data assimilation (3DVAR) scheme in the WRF model simulations is used. The study then undertook a comparative evaluation of the impact of MPE versus WRF precipitation estimates, both with and without data assimilation, in driving WRF-Hydro simulated streamflow. Several flood events that occurred in the Black Sea region were used for testing and evaluation. Following model calibration, the WRF-Hydro system was capable of skillfully reproducing observed flood hydrographs in terms of the volume of the runoff produced and the overall shape of the hydrograph. Streamflow simulation skill was significantly improved for those WRF model simulations where storm precipitation was accurately depicted with respect to timing, location and amount. Accurate streamflow simulations were more evident in WRF model simulations where the 3DVAR scheme was used compared to when it was not used. Because of substantial dry bias feature of MPE, streamflow derived using this precipitation product is in general very poor. Overall, root mean squared errors for runoff were reduced by 22.2% when hydrological model calibration is performed with WRF precipitation. Errors were reduced by 36.9% (above uncalibrated model performance) when both WRF model data assimilation and hydrological model calibration was utilized. Our results also indicated that when assimilated precipitation and model calibration is performed jointly, the calibrated parameters at the gauged sites could be transferred to ungauged neighboring basins where WRF-Hydro reduced mean root mean squared error from 8.31 m3/s to 6.51 m3/s.