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Real-time flood forecasting of an extreme storm event using NWP rainfall ensemble with data assimilation

Jia Liu, Jiyang Tian, Chuanzhe Li, and Fuliang Yu

State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin, China Institute of Water Resources and Hydropower Research, Beijing, China (hettyliu@126.com)

Nowadays Numerical Weather Prediction (NWP) models are increasingly used in real-time flood forecasting to provide high-resolution rainfall forecasts. This is of great help in extending the forecast lead time, which is especially meaningful for small mountainous catchments vulnerable to extreme flash floods. In this study, the flood caused by an extreme storm event that occurred in July of 2012 in the Beijing-Tianjin-Hebei region of Northern China is forecasted by using the ensemble rainfall forecasts from the newest generation mesoscale NWP model, i.e. the Weather Research & Forecasting (WRF) model. The extreme storm event has received wide attention in China due to its high intensity and the significant flood losses. The 24 h rainfall accumulated in the small mountainous catchment of Zijingguan, which has a drainage area of 1760 km2, is regenerated using the WRF model with data assimilation. Observations from an S-band Doppler weather radar that completely covers the Zijingguan catchment are assimilated with the assistance of the WRF three-dimensional variational (WRF-3DVar) data assimilation system. Conventional meteorological observations, including surface weather station, pilot balloon, sonde, aircraft observations from the Global Telecommunication System (GTS) are also assimilated together with the radar data. Data assimilation is used update the initial and lateral boundary conditions of the WRF model in order to provide more reliable rainfall forecasts. Five different combinations of WRF physical parameterisations are adopted to generate a forecast rainfall ensemble.

The WRF forecast rainfall ensemble is then input into a rainfall-runoff model to produce the real-time flood forecasts. The results show that appropriate data assimilation has positive effect on improving the accumulation process of the forecast rainfall which therefore helps effectively increase the forecast flow accuracy through rainfall-runoff transformation. The average relative error of the 24 h rainfall accumulation is 32.19%, which is reduced by 11.07% after data assimilation; and the average relative error of the forecast peak flow is reduced by 31.93%. Although the performance of the forecast ensemble members shows a relatively large range, the ensemble forecasts can provide a valuable reference for decision makers of flood risk control. Further investigations are needed in order to reduce the uncertainties in the ensemble forecasts, such as exploring the effect of data assimilation on different combinations of the WRF physical parameterisations.

Keywords: real-time flood forecasting, extreme storm, numerical weather prediction, rainfall ensembles, data assimilation.