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Flow ensemble prediction for flash flood warnings at ungauged basins

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Flash floods, which are typically triggered by severe rainfall events, are difficult to monitor and predict at the spatial and temporal scales of interest due to large meteorological and hydrologic uncertainties. In particular, uncertainties in quantitative precipitation forecasts (QPF) and quantitative precipitation estimates (QPE) need to be taken into account to provide skillful flash flood warnings with increased warning lead time. In France, the AIGA discharge-threshold flood warning system is currently being enhanced to ingest high-resolution ensemble QPFs from convection-permitting numerical weather prediction (NWP) models, as well as probabilistic QPEs, to improve flash flood warnings for small-to-medium (from 10 to 1000 km^2) ungauged basins.

The current deterministic AIGA system is operational in the South of France since 2005. It ingests the operational radar-gauge QPE grids from Météo-France to run a simplified hourly distributed hydrologic model at a 1-km^2 resolution every 15 minutes (Javelle et al. 2014). This produces real-time peak discharge estimates along the river network, which are subsequently compared to regionalized flood frequency estimates of given return periods. Warnings are then provided to the French national hydro-meteorological and flood forecasting centre (SCHAPI) and regional flood forecasting offices, based on the estimated severity of ongoing events. The calibration and regionalization of the hydrologic model has been recently enhanced to implement an operational flash flood warning system for the entire French territory.

To quantify the QPF uncertainty, the COSMO-DE-EPS rainfall ensembles from the Deutscher Wetterdienst (20 members at a 2.8-km resolution for a lead time of 21 hours), which are available on the North-eastern part of France, were ingested in the hydrologic model of the AIGA system. Streamflow ensembles were produced and probabilistic flash flood warnings were derived for the Meuse and Moselle river basins and for significant events of the 2010-2013 period. The evaluation showed significant improvements in terms of flash flood event detection and effective warning lead-time, compared to warnings from the current AIGA setup (without any future precipitation). Various verification metrics (e.g., Relative Mean Error, Continuous Rank Probability Skill Score) show the skill of ensemble precipitation and flow forecasts compared to single-valued persistency benchmarks.

In addition to propagating the QPF uncertainty to streamflow forecasts, we discuss how to account for other sources of forecast uncertainty, including precipitation observational uncertainty (Caseri et al. 2014) and hydrologic uncertainties. Planned enhancements include ingesting other probabilistic nowcast and NWP products from Météo-France's convection-permitting AROME model, as well as developing comprehensive observational and post-event damage database to determine decision-relevant thresholds for flood magnitude and probability.

Caseri, A., Javelle, P., Ramos, M.H., Leblois, E., 2014. Generating precipitation ensembles for flood alert and risk management. Journal of Flood Risk Management (submitted).
Javelle, P., Demargne, J., Defrance, D., Arnaud, P., 2014. Evaluating flash flood warnings at ungauged locations using post-event surveys: a case study with the AIGA warning system. Hydrological Sciences Journal. doi: 10.1080/02626667.2014.923970