Probabilistic Flash Flood Forecasting using Stormscale Ensembles

Jill Hardy[1,2], Jonathan J. Gourley[2], Jack Kain[2], Adam Clark[2], Dave Novak[3], and Yang Hong[4]

[1]School of Meteorology, University of Oklahoma
[2]NOAA/National Severe Storms Laboratory
[3]NOAA/NWS/NCEP/Hydrometeorological Prediction Center
[4]Civil Engineering and Environmental Science, University of Oklahoma

1. Introduction

Flash flooding is one of the most costly and deadly natural hazards in the US and across the globe (Figure 1). The loss of life and property from flash floods could be mitigated with better guidance from hydrological models, but these models have significant limitations with typical applications.

- They are commonly initialized using rainfall estimates derived from weather radars, but the time interval between observations of heavy rainfall and a flash flood can be on the order of minutes, particularly for small basins.

Figure 1. Left: Photo of the Albert Pike Campground near Langley, Arkansas after a flash flooding event occurred on the morning of June 11, 2010. Seven children and 20 adults were killed at this site during that event (AP/US Geological Survey). Right: nearby flooded convenience store in Glenwood, AR (AP).

- Increasing the lead time for these events is critical for protecting life and property.

Therefore, this study advances the use of quantitative precipitation forecasts (QPFs) from a stormscale NWP ensemble system into a distributed hydrological model setting to yield basin-specific, probabilistic flash flood forecasts (PFFFs).

2. Datasets and Models

- NWP ensemble: University of Oklahoma (OU) Center for Analysis and Prediction of Storms (CAPS) ensemble of 4-km/hourly resolution members, during the Hazardous Weather Testbed Experiment (Clark et al., 2012) from 2010-2012 at the National Weather Center in Norman, OK. (Figure 2)
- Hydrological model: Coupled Routing and Excess Storage (CREST) distributed hydrological model (Wang et al., 2011) under the Ensemble Framework For Flash Flood Forecasting (EF5) system.
- QPE observations: National Centers for Environmental Prediction (NCEP) Stage IV 4-km/hourly QPE product over the CONUS. (Figure 3)

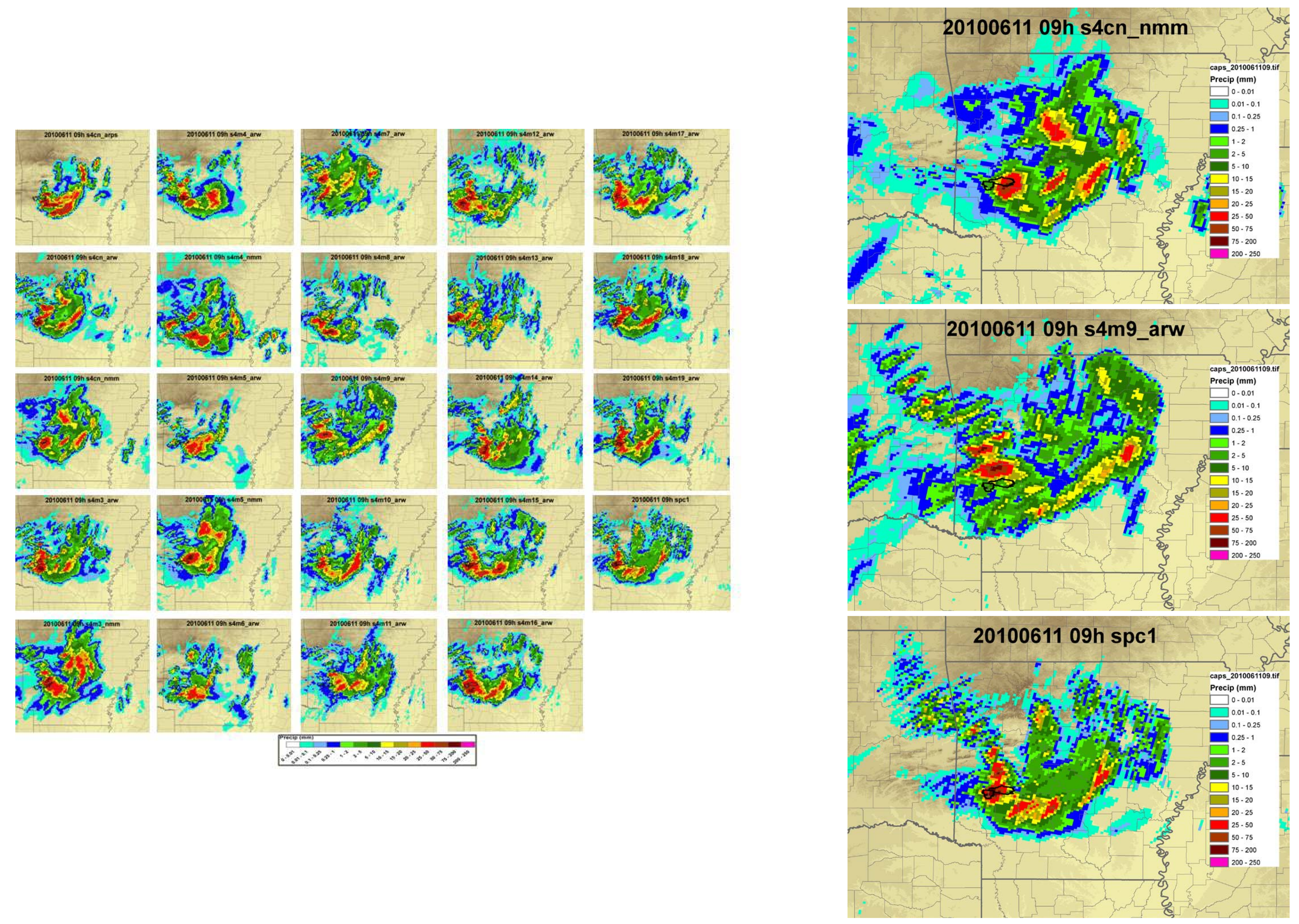

Figure 2. Left: CAPS members used during the 2010 experiment. These images are from June 11, 2010 at 9Z, during the Albert Pike Campground event. Right: enlarged images of three members at the same time period. Note the Caddo and Little Missouri basins that flooded are outlined in black.

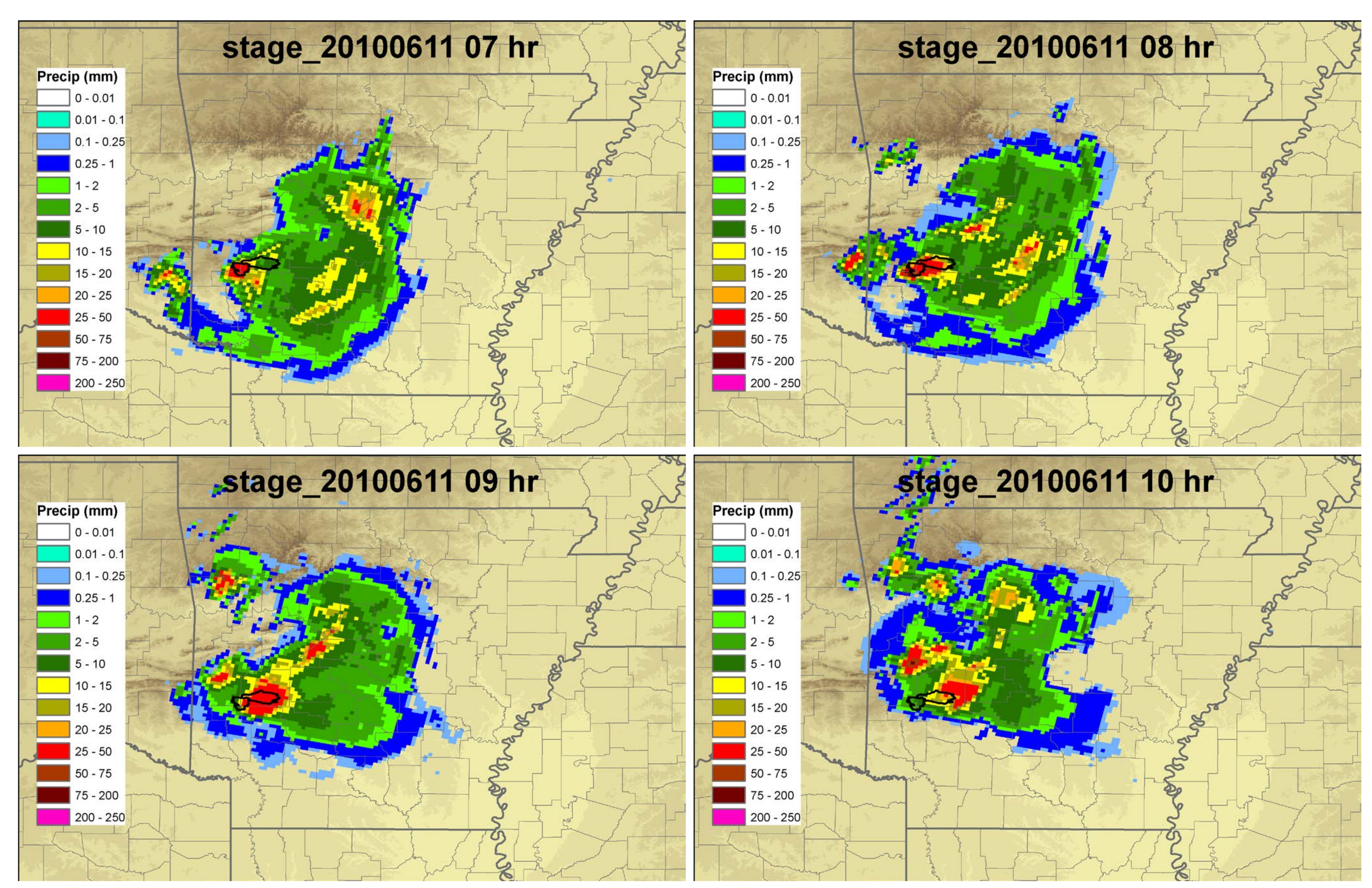

Figure 3. Stage IV images for June 11, 2010 from 7Z-10Z, during the Albert Pike Campground event. Note the Caddo and Little Missouri basins that flooded are outlined in black.

3. Quantifying Rainfall Error Characteristics

- Error in individual CAPS members is based on structure, amplitude, and location (SAL; Wernli et al., 2008).
  - Assume the CAPS ensemble captures:
    - Storm mode
    - Structure: fine scale is consistent with radar-observed rainfall
    - Amplitude: readily-correctable
  - But often, the location error is large.
- Location is essential for flash flood forecasting.
  - Even a small location error can cause a small, flash flood-prone basin to be missed.
- Use an elliptic smoother (as in Marsh et al., 2012) to produce probabilistic QPFs (Figure 4, left).
  - Smoother decides the region of interest (based on ensemble).
  - We want to maintain stormscale details (i.e. structure and amplitude), which are important for flash flood forecasting, so run the individual members through the hydrological model.
  - Account for location error by moving the QPF within the elliptic region using Monte Carlo sampling.
  - This yields an ensemble of flash flood simulations.
- These simulations are compared to historical flow thresholds at each grid point to identify basin scales most susceptible to flash flooding, therefore, creating probabilistic flash flood forecasts (PFFFs) (Figure 4, right).

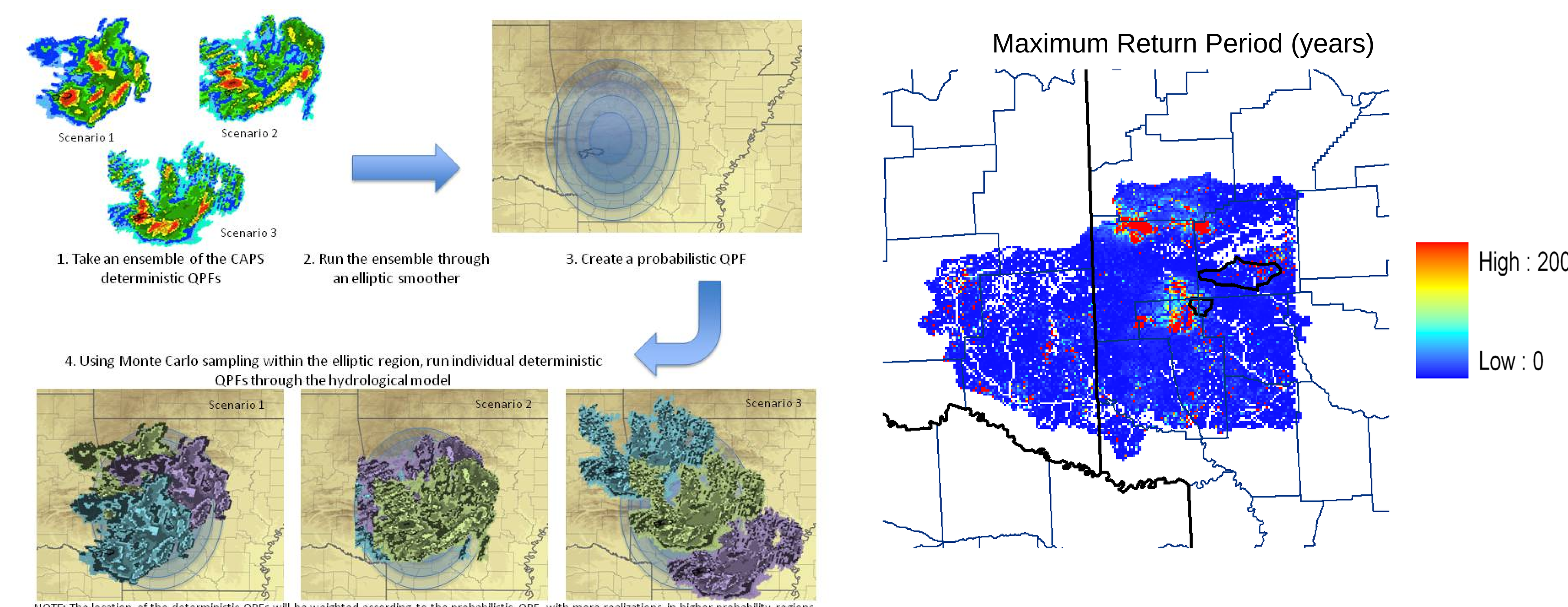

Figure 4. Left: schematic of the quantification of location errors. Right: example of what the probabilistic flash flood forecast (PFFF) would look like for an individual member after it has been run through the hydrological model using Monte Carlo sampling.

4. Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. . Thank you to the University of Oklahoma and National Severe Storms Laboratory for providing the facilities and data necessary to complete this project.

5. References

Clark, Adam J., et al. "An overview of the 2010 hazardous weather testbed experimental forecast program spring experiment." *Bulletin of the American Meteorological Society* 93.1 (2012): 55.

Marsh, Patrick T., et al. "A method for calibrating deterministic forecasts of rare events." *Weather and Forecasting* 27.2 (2012): 531-538.

Wang, Jiahu, et al. "The coupled routing and excess storage (CREST) distributed hydrological model." *Hydrological sciences journal* 56.1 (2011): 84-98.

Wernli, Heini, et al. "SAL-A novel quality measure for the verification of quantitative precipitation forecasts." *Monthly Weather Review* 136.11 (2008): 4470-4487.

Questions? Email: jill.hardy@ou.edu