Coping with Uncertainty of River Flood Forecasts

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Background

The National Weather Service (NWS) issues river forecasts up to five days ahead. Their accuracy decreases with increasing lead time and increasing deviance from the average gage height. There are five problems.

1. **The quality of river forecasts is poor.** Flood warnings beyond two days of lead time have little skill.
2. **The forecasts have not improved between 1983 and 2002** [2].
3. **NOAA has made the first steps to verify forecasts in 2006** [1] **but with unknown effect.**
4. **It is unknown how local emergency operators use these forecasts.** Studies on the use and benefits of river forecasts have failed to quantify their correct usage [4]. Discussing the use of climate forecasts by water resource managers Rayner *et al.* detect wide-spread ignorance as to the use of those forecasts [5].
5. **Despite the large uncertainties in forecast, there have been no studies on how to communicate its signifincat to decision makers.**

The National Oceanic and Atmospheric Administration (NOAA) has introduced systematic verification of river forecasts and initiated probabilitistic ensemble forecasting [3].

Without an integration of engineering and social sciences, NOAA´s technical improvements will not increase safety.

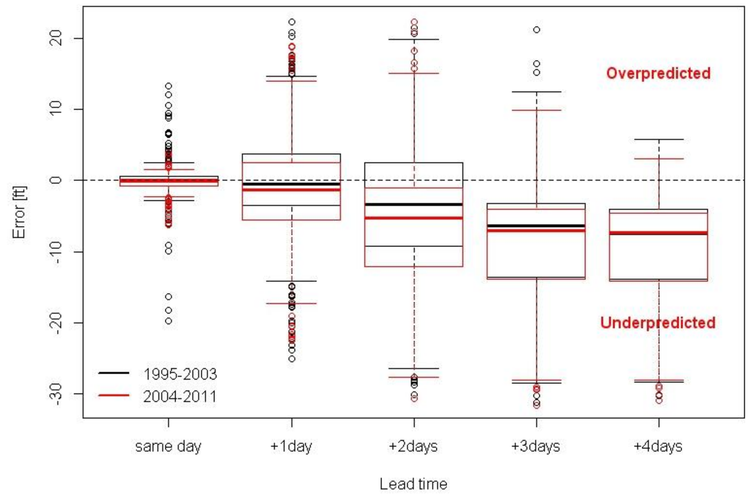

Figure 1: Comparison of error of river forecasts (forecast-observed) at Blackwell, OK on Chikaskia River for two time periods (1995-2003 and 2004-2011). Flood stage: 29ft., 90th percentile of observations: 7 ft. The difference between observation and forecasts increases with lead time. The error in the second time period is equal or worse than in the first. The variance decreased.

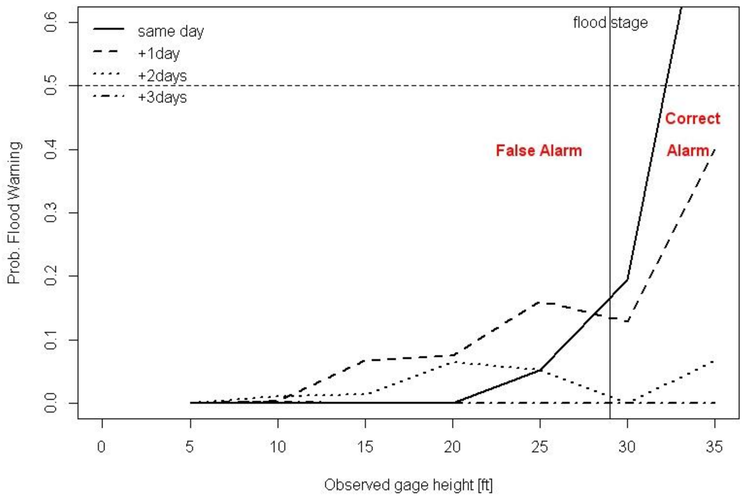

Figure 2: Probability that a flood warning was received depending on observed gage height for Blackwell, OK on the Chikaskia River 1995 –2011. It is unlikely that an emergency operator receives a flood warning. However, there are relatively many false alarms as well.

Objectives

- Update river forecast verification
- Quantify uncertainty in river forecasts
- Identify implications of uncertainty for emergency operators
- Assess emergency operators‘ handling of uncertainty
- Explore ways to communicate uncertainty
- Propose follow-up to NOAA‘s River Forecast Verification Plan

Preliminary Results

1. **Flood forecasts have not significantly improved between 1995-2011 (Figure 1).** It was previously found that forecasts did not improve from 1983-2002 [2].
2. **Flood forecasts underestimate the observed gage height (Figure 1).**
3. **The discriminability of flood forecasts is low.** Emergency operators are not warned for most floods. If they are warned, there is a considerable probability that no flood will occur (Figure 2).

Future Work

To make the efforts of verifiying flood forecasts and quantifying their uncertainty worth it, the following steps need to be taken.

1. **Examine the emergency operator‘s understanding of uncertainty.**
2. **Explore ways to ensure correct use of forecasts.**
3. **Quantify added value of improved forecasts.**

References

[1] National Oceanic and Atmospheric Administration (2006): *National Weather Service River Forecast Verification Plan,* Report of the Hydrologic Verification System Requirements Team. Silver Spring, MD

[2] Welles, E. *et al.* (2007): „Hydrologic Verification, A Call for Action and Collaboration“, *American Meteorological Society*, April 2007, p. 503-511.

[3] Brown, J. *et al* (2010): „ The Ensemble Verification System (EVS): A software tool for verifying ensembleforecasts of hydrometeorological and hydrologic variables at discrete locations“, *Environmental Modelling & Software* 25(7), July 2010, p. 854-872.

[4] National Hydrologic warning Council (2002): *Use and Benefits of the National Weather Service River and Flood Forecasts,* Prepared by EASPE, Inc., May 2002.

[5] Rayner S. *et al.* (2005): „Weather Forecasts Are For Wimps: Why Water Resource Managers Do Not Use Climate Forecasts“, *Climate Change* (2005) 69: 197-227.

Figure 3: Chikaskia River near Blackwell, OK. Flood Stage 29 feet; Left side: On 09/04/2002, stage 2.73 feet. Right side: On 10/05/2002, stage: 31.33 feet.

Acknowledgments

This work was supported by the Center for Climate and Energy Decision Making (SES-0949710), through a cooperative agreement between the National Science Foundation and Carnegie Mellon University and by Academic Funds through the Department of Engineering and Public Policy from the CIT Dean’s Office.