Probing Question: How well do we predict floods?

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There was no Ark involved and it didn't last 40 days -- but when the remnants of Tropical Storm Lee dumped more rain on the already saturated Northeast, the result was the Susquehanna River's worst flooding in nearly 40 years. Thousands were evacuated, a number of lives were lost, and damage to homes and businesses is said to be in the hundreds of millions of dollars.

Given that floods are the most common natural disaster in the United States, could we be doing more to predict them and safeguard flood-prone communities?

"We are continuing to improve flood forecasts but we have more work to do," said Chris Duffy, Penn State professor of civil engineering. There are several key problems, he noted.

One issue is that "many models still do not adequately take into account the physical landscape features or land-use changes that shape the flood response," said Duffy.

Much of today's flood prediction technology relies on computer models created by simulation software that can be customized to a region's rivers, floodplains, and urban features. These programs use "flood routing algorithms"-- mathematical formulas for predicting the changing magnitude, speed and shape of a flood wave along a river -- as their main predictive tool. Yet, "Models cannot be expected to perform well unless they are based on the best historical data," reminded Duffy.

“One of the serious problems,” he said, is the continued loss of that data. “The United States Geological Survey (USGS) has a hard time convincing Congress to maintain funding for the national network of streamgages,” a system with over 7,000 devices in American rivers that measure real-time water levels and transmit data back to USGS every few hours. “State and local governments also are cutting back on support for this network,” Duffy added.

The best flood forecasting is costly, he acknowledged. “Some areas of the country are adopting new technologies to gauge river flow based on acoustic and radar methods. However, these methods require an investment which seems to be hard to come by.”

Typically, Duffy notes, flood prediction methods have focused on the main stems of the largest rivers, while overlooking the tributary networks where flooding occurs, and where flash floods threaten lives and property.

“It is my opinion that we will not improve flood and drought prediction in the U.S. until we begin to look beyond the stream and include measurements that tell us about the state of the entire watershed,” he said. “We must look beyond the point where flooding takes place to see what happened upstream in the watershed. New measurements for soil moisture, groundwater levels, coordinated with current rainfall radar and stream measurements would greatly improve our ability to forecast.”

Said Duffy, “At Penn State researchers are attempting to develop the next-generation forecasting tools that take a more scientific approach to flood/drought forecasting. These models will include spatial features of topography, land-use, and vegetation, incorporating satellite data and new watershed instrumentation as part of a Critical Zone Observatory funded by the National Science Foundation, the National Oceanic and Atmospheric Association, and the Environmental Protection Agency.”

Predicting floods more accurately is not our only task, reminds Duffy. We can also do a better job with our urban and land use planning. “The land surface is the interface between the atmosphere and the soil and subsurface,” he explained. “When we change that surface by making it less permeable or less able to store rain water temporarily in the soil or groundwater, we change the likelihood for surface flooding,” he noted. “Local floods due to poorly designed culverts can get you just as wet as a large river flood.”

The Susquehanna is a good case in point, said Duffy. “The physiography of the watershed of the river basin, along with shallow bedrock rivers that want to spread out and leave their banks, has always been recognized.” What is often not recognized, he pointed out, are the impacts of land-use changes (such as dams and pavement) that have altered the water cycle and changed where the water goes. “I think the best thing we can do is to educate the public on the scientific basis for the water cycle, including all its uncertainty.”

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