Comment

Faster Flood Forecasting to Improve Responses

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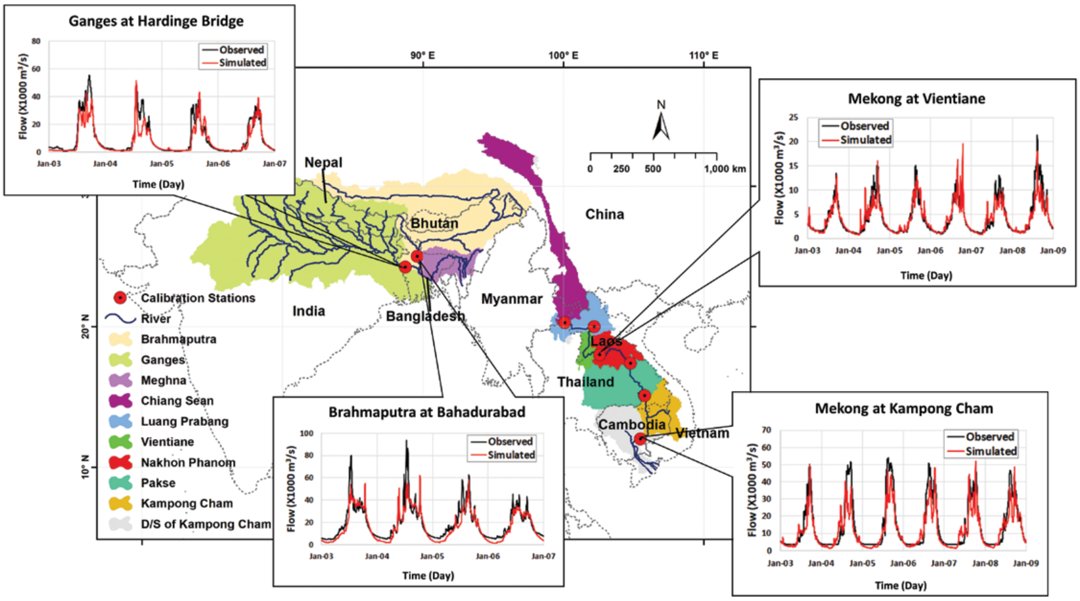
In August 2017, Hurricane Harvey battered the Houston area with torrential rains for days, triggering widespread catastrophic flooding that displaced tens of thousands of people from their homes and caused an estimated $125 billion in damage. In the storm's aftermath, much attention was focused on how forecasts had captured Harvey's behavior and impacts, and on how well — and how far in advance — emergency planners had conveyed those forecasts to the public.



Three of the largest river basins of South Asia — the Brahmaputra, Ganges and Mekong — that are dominated by large-scale and monsoonal driven flooding. The inset hydrographs show the level of skill of the hydrologic model in simulating river flow at different locations (red trace: simulated by hydrologic model; black trace: observed flow from streamgages).

Credit: Faisal Hossain

A key goal of weather forecasters is to spend less time generating forecasts so that more time is available to inform decision-makers and the public about how a potentially risky situation is unfolding. Recently, we examined the skill and efficiency of the standard Weather and Research Forecasting (WRF) model, a high-resolution numerical model employed by researchers and flood forecasting agencies worldwide to see how well we could have forecasted hourly precipitation amounts from Harvey and its impact on inundation in Houston for the local Harris County Flood Control District (HCFCD). The HCFCD is responsible for issuing flood warnings and guidance to improve decision-making regarding evacuation routes, for example.

Using a desktop computer affordable to most agencies like HCFCD, we found that it took about 30 hours to forecast precipitation amounts that the storm was likely to produce 48 hours from the start of the computation. This means that by the time the agency could have digested the forecast, interpreted the impacts and disseminated guidance, there would have been little time for people to act.

In flood disaster management, insufficient lead time is a typical problem agencies and users face. If the outputs from forecast models of acceptable skill are generated too late to be actionable, they have little value for the public and for use in real-world emergency planning and mitigation.

Generating reliable flood forecasts quickly for large river basins, where floods can happen as seasonal weather patterns cause rivers to swell over longer periods of time, is just as important as it is for urban areas prone to flash floods. However, flood impact forecasting for such regions, particularly in the developing world, has received little attention; and useful solutions for faster, near-real-time forecasts are sorely needed. In recent years, we've been working to create such solutions — and we've made some progress.

Forecasting in South Asia

Amid the large river basins of South and Southeast Asia, such as the Brahmaputra, Ganges and Mekong, the most flood-prone countries — Bangladesh, Cambodia, Thailand and Vietnam, for example — are typically those located far downstream. In addition to precipitation that falls within their borders, these countries receive a substantial amount of water from precipitation that falls outside their borders and then flows downriver, thus contributing to seasonally rising rivers and flood potential.

Because of this, operational flood forecasters in the developing world have increasingly been using hydrologic models of the river basins in conjunction with weather forecasts to predict flows and floods along these rivers. The outputs of the weather forecasting model, such as precipitation, temperature and windspeed, are used as inputs into the hydrologic model to forecast the flow in the rivers. However, if a forecaster is not careful, such forecasts can have very large uncertainties, due to compounded inconsistencies between the different models, as well as uncertainties in precipitation forecasts. To combat these uncertainties, forecasters often use more complex and very high-resolution weather forecasting models to, ideally, improve the accuracy of the weather forecast information input into a hydrologic model, which should then generate more accurate flow forecasts. The flood-forecasting agencies of Nepal, Bhutan, Bangladesh and Vietnam are currently using this approach. However, there is a downside: Models with higher resolution and greater complexity require more time and/or computing power to run. So, agencies in the developing world are limited in terms of how far into the future they can accurately forecast by the constraints of the computers they have available.

A Simple Approach for Rapid Flood Forecasts

Whether flood forecasting across large river basins truly benefits from the use of increasingly high-resolution, complex and computationally expensive weather models that slow down the generation of forecasts in operational settings is a question often overlooked by agencies trying to achieve the most accurate forecast. To examine the trade-off between accuracy and timeliness, we tested the relative skill in forecasting actual observed flows in the Ganges, Brahmaputra and Mekong river basins of a more complex and slower approach using a high-resolution WRF model against a simplified and faster approach using a publicly available, coarse-scaled global weather forecast model called the Global Forecasting System. Then we directly plugged the output into the hydrologic model. We applied our experience and understanding of the historical behavior of regional climate and weather patterns to statistically adjust the coarse-scale weather outputs to make them more realistic. Our assumption was that the use of the known weather history for any given day would make the coarse weather forecasts more accurate for that day in the future.

For forecast lead times of one to seven days, we found that the simplified technique, which is about two orders of magnitude faster, usually performed as well or, particularly in the case of the Ganges and Mekong basins, better than the complex and high-resolution technique.

If a computationally intensive forecasting approach requires several hours to generate a daily forecast, that means a similar number of hours are deprived from dissemination and disaster response when time is of the essence. As with the Hurricane Harvey example, when a 48-hour forecast took 30 hours to complete, a daily forecast that takes several hours to generate is largely meaningless for the at-risk public. Our simple technique can save about six to eight hours of CPU time every day for a developing country's weather agency, meaning more time is available for coordination, planning and responding if a major flood is imminent.

Applying Fast Forecasts

In initial results since October 2017, the simplified fast flow-forecasting scheme has demonstrated the ability to forecast a flood peak eight days ahead of time in the Mekong Basin with sufficient certainty and lead time to inform actions. Similarly, the faster forecast method was applied and demonstrated to have value for flood response near Guwahati, India, roughly 200 kilometers upstream from Bangladesh, along the Brahmaputra River. And since summer 2018, our fast-forecasting technique has been adopted operationally by the Bangladesh Water Development Board for the Ganges and Brahmaputra rivers (http://forecast.bwdb.gov.bd/). Vietnam's National Water and Planning Institute has also adopted the technique operationally (http://forecasting.vaci.org.vn). Up to 15-day experimental forecasts are being generated each day with the only CPU time required being that needed to download the weather forecast data and run the hydrologic model (about 30 minutes). Subsequently, these agencies have supported the transition of the more efficient forecast approach into routine application, maintained the forecasting system entirely in their operational budget, and made the uptake of our research sustainable.

Einstein once said that things should be "simple, but not simpler." Our technique is sufficiently reliable for generating actionable river forecasts in large river basins and continues to demonstrate its value in populous regions of Asia. Furthermore, it is anticipated that this approach can be extended and used in other river basins for broader societal value. For example, many of the upstream countries in the Ganges, Brahmaputra and Mekong basins are building dams on the rivers, which complicates flow forecasting, particularly early in a wet season when forecasters have little knowledge of how the dams are withholding or releasing water. Such information about dam operation is typically withheld from the public by dam operators but can be estimated using satellite or other remote sensing. Research using efficient and fast modeling approaches for flow forecasting that are also easy to test, operationalize and adopt can be expected to offer new opportunities to address emerging challenges of flow in river basins subject to both natural and engineered changes.


Credit: Safat Sikder

Credit: Faisal Hossain


Credit: NASA

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