01

WHAT IS THE GEOGRAPHIC APPROACH TO WATER?

The dynamic movement of water is driven by global and local forces. Globally, water flows through the hydrologic cycle from land to ocean to atmosphere and back to land again. Locally, water flows through the landscape in rivers and streams, reacting to the rocks and stream banks surrounding its flow pathways.

THE GEOGRAPHIC APPROACH TO WATER FORECASTING

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It is life, I think, to watch the water.

Nicholas Sparks
The Notebook

Forecasting water flow in streams and rivers today has become as ubiquitous as weather forecasting—available everywhere, all the time. It wasn’t always that way, but in 2015 a new National Water Center opened on the Tuscaloosa campus of the University of Alabama. The National Weather Service established the center to provide a national focus for water forecasting in the United States. A year later, the release of the nation’s first National Water Model allowed the National Weather Service to continually forecast water flows that eventually covered 3.2 million miles of streams and rivers in the continental United States.

Fast-forward to early April 2025: When rain-swollen floodwaters swept across swaths of the Midwest and South, the National Water Prediction Service published flood inundation maps on its website that went viral, with more than 20 million hits per day. With those maps, real-time flood information had entered the public consciousness.

Just three months later, on the Fourth of July, 2025, a devastating flood struck the Guadalupe River in central Texas as dawn approached. In 90 minutes, water levels rose more than 32 feet where the river runs through Kerrville in the Texas Hill Country, northwest of San Antonio. The flooding killed more than 130 people, including many children at a summer camp along the river. The tragedy showed that flood maps by themselves are not enough to save lives. People in the path of floods also must receive warnings and other information derived from these maps quickly so they can escape danger in time.

We still face many challenges when it comes to communicating flood forecasts in a timely and accurate way. However, the transformative story of how we forecast and model water flow would have been almost inconceivable a decade ago. How did these advances come about? What do they mean for the future? I was engaged from the beginning in these developments, so I’d like to describe what has happened, and what I see going forward.

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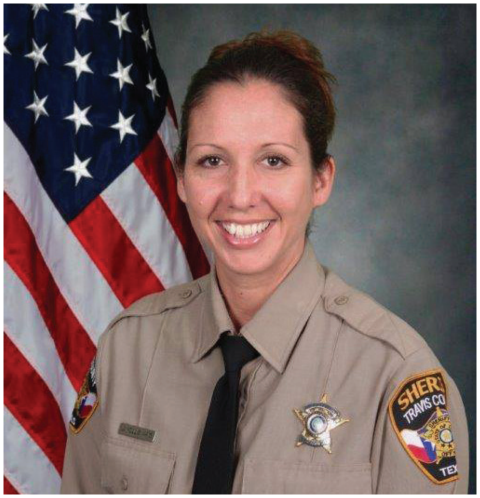
Catastrophic flooding near Kerrville, Texas. On Friday, July 4, 2025, rain peaked at 15 inches in some regions and impacted families and children.

A PERSONAL JOURNEY

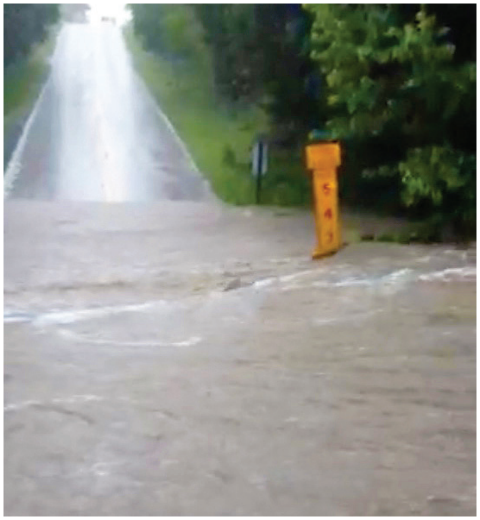
Let me begin by telling you a personal story. In September 2014, a Travis County Senior Sheriff's Deputy named Jessica Hollis was driving down a country lane in pitch darkness at 2 a.m. during a heavy rainstorm. As she reached a low-water crossing at the bottom of a valley, a flooded stream washed her patrol car away, and she lost her life. This tragedy happened just a few miles from my home. Her death affected the local community deeply, and more than 2,000 people attended her funeral. Her death struck me profoundly because she was 35 years old and had a son. I have two daughters, then aged 34 and 36, each with a son. I felt Jessica's death personally, and I've never gotten over it. More than that, I was convinced that her life could have been saved with real-time flood information sent to her patrol car with a repeated audible warning, "Don't go there." I have worked ever since to help provide such information and prevent tragedies like this in the future.

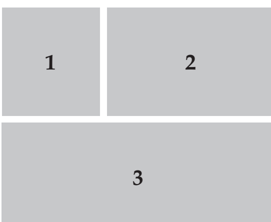


Travis County Senior Sheriff's Deputy Jessica Hollis.

I was at that time working at the University of Texas at Austin on the prototype of what came to be called the National Water Model. After participating in the first meeting held at the National Water Center in May 2014, I proposed that the National Weather Service collaborate with the academic community in the United States to create a new national flood system for data, modeling, and forecasting—spanning the atmosphere to the oceans, with high spatial resolution, in near-real time—and complete this task in one year. This was a daunting endeavor and stressful experience at the time. However, we made great strides with significant help from colleagues at the University of Texas at Austin, National Weather Service, National Center for Atmospheric Research, and a private company, the GIS software and service company Esri. In less than a year, we showed that we could compute the water flow in the 2.7 million stream reaches in the continental United States in 10 minutes—or about 5,000 stream reaches per second—a task considered inconceivable at the time. This was *big data* before the term came into fashion. To do that, we used the fastest academic supercomputer available at that time: the Stampede supercomputer at the university's Texas Advanced Computing Center.

I also proposed to the National Weather Service the creation of a summer institute at the university's National Water Center for graduate students from across the United States to research ways to improve and expand the capabilities of the National Water Model. We presented the prototype flood simulation model at the first National Water Center's Innovators Program Summer Institute in 2015. The National Weather Service subsequently improved the model, which became the first operational version of the National Water Model in August 2016.





1. Screen capture from a phone video of the low-water crossing where floodwaters swept away Deputy Hollis shortly before 2 a.m. on September 18, 2014. The gauge board on the upstream side of the road shows the water depth at almost three feet when this image was made. Water flowing at a depth of one foot or even less can sweep a car from a road.
2. Water flows from the spillway of Barton Springs pool in Austin, Texas.
3. Search operations, September 19, 2014. Responders recovered the deputy's body later that day.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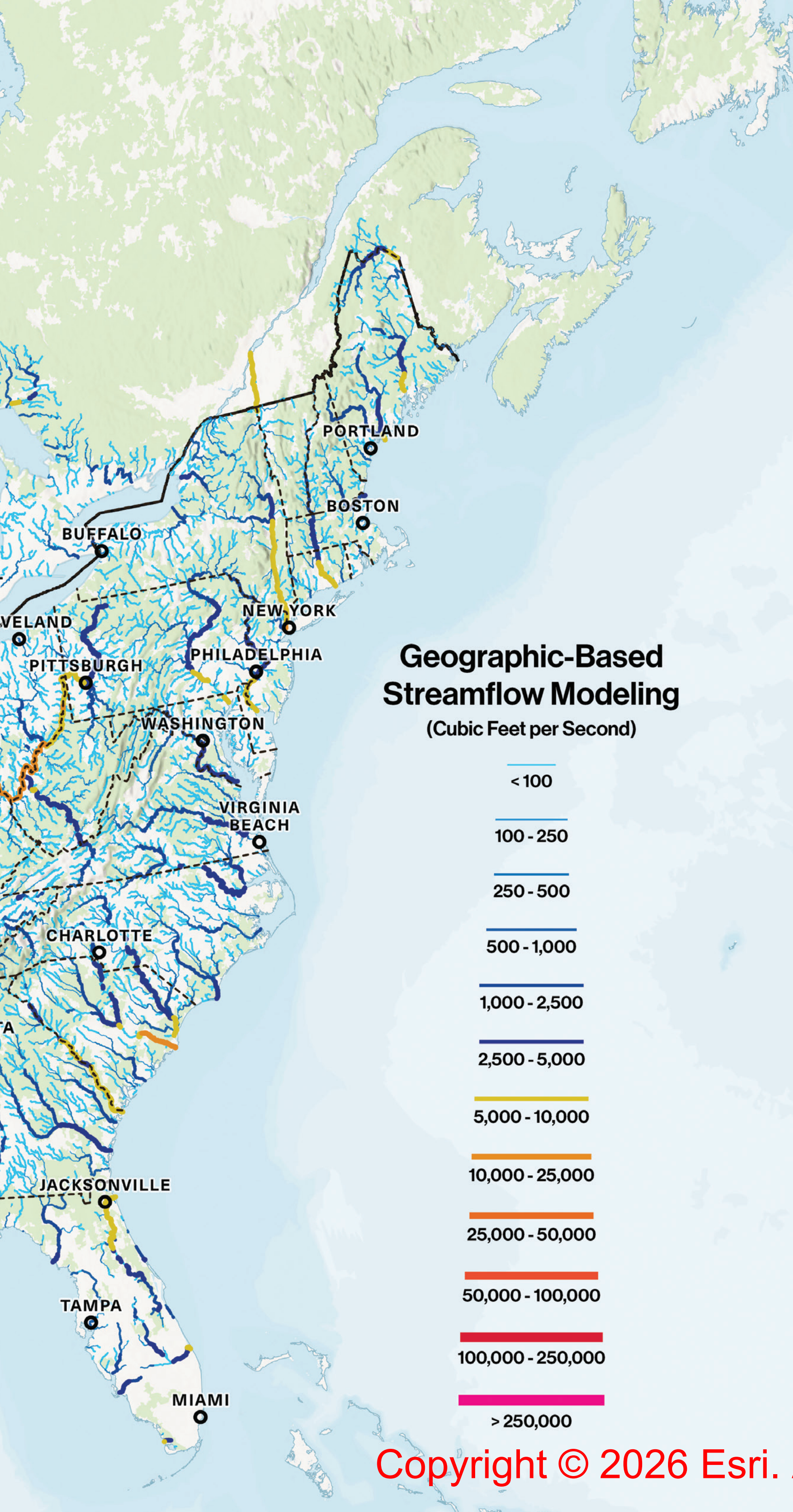

The Stampede supercomputer reigned as one of the most powerful computers in the world for open science research when it computed streamflow on the National Water Model. It could complete 9.6 quadrillion floating-point operations per second.

The summer institutes, held on the University of Alabama's Tuscaloosa campus since 2016, have drawn more than two hundred graduate students since then. The strong engagement of the academic community has played a significant role in the changes that have come to water forecasting in the United States. Insights from their research are translated into practice by the National Weather Service in a process called Research to Operations.

Today, the National Water Model has advanced by several versions and currently forecasts stream reaches beyond the continental United States to cover Alaska, Hawaii, and US overseas territories. Hurricane storm surge modeling from the National Ocean Service combines with river forecasting to predict flooding in coastal rivers during hurricane events. Four versions of the National Water Model are run simultaneously for current conditions and for short-range, medium-range, and long-range forecasting.

LEFT

Geospatial data forms the foundation of the National Water Model, which simulates the water cycle with mathematical representations of the different processes of rainfall, evaporation, infiltration, streamflow—and how they fit together.