
# The National Water Center and the National Water Model

**Figure 1.** The National Water Center in Tuscaloosa, AL, located on the University of Alabama campus

## The National Water Center

Approximately ten years ago, Congressional leaders noted the growing risks of flooding and severe weather across the country, leading them to call for a new national center to address our Nation's growing water challenges. At the same time, the National Oceanic and Atmospheric Administration (NOAA) was already collaborating with the U.S. Geological Survey (USGS) and U.S. Army Corps of Engineers (USACE) through the Integrated Water Resource Science and Services (IWRSS) consortium to develop shared plans for a national center to advance water resources prediction nationwide. The Federal Emergency Management Agency (FEMA) joined the consortium in 2015. When Congressional vision met agency planning, the National Water Center was established. The National Water Center (NWC) is the cornerstone facility of the Office of Water Prediction (OWP) within NOAA's National Weather Service (NWS). Designed and built at the University of Alabama in Tuscaloosa (UA), the facility opened on May 26, 2015, receiving a Leadership in Energy and Environmental Design (LEED) Gold certification.

The mission of the NWC is to promote collaboration across the scientific community, serving as both a catalyst to accelerate the transition of research into operations and a center of excellence for water resources science, information, and prediction services. These services inform essential emergency management and water resources decisions across all time scales, including drought, low-flow risks, and information needs for routine and long-range water management and planning. These services will:

- Strengthen the Nation's water forecast capabilities by serving as an innovation incubator and research accelerator to bring the most cutting-edge technologies to bear on national water challenges;
- Improve national preparedness for water-related disasters through delivery of high-resolution flood forecast inundation maps and other associated services;
- Support integrated water resource management at the local, state, regional, and national levels;
- Inform event-driven, high impact, and routine, high-value water decisions at the local, state, regional, and national levels; and
- Provide water information that supports and promotes informed water stewardship.

Since the ribbon cutting, the NWC has developed a cadre of Federal staff, contractors, and scientists from the University Corporation for Atmospheric Research (UCAR) and has hosted more than 80 scientific and technical meetings with over 2,600 participants. These meetings have included four Summer Institutes planned with the National Science Foundation (NSF) and the Consortium of Universities for the Advancement of Hydrologic Sciences Inc. (CUAHSI). The Summer Institutes, held annually at the NWC, recruit the best and brightest graduate students from around the world to work hand-in-glove with leading Federal scientists and academics to address challenging water resources problems and transform water prediction.

## NWC Operations Center

The NWC Operations Center is designed to facilitate state-of-the-science, water information services for high-impact events and routine decision-making across our national infrastructure in support of building a Weather-Ready Nation. Once fully staffed, the Operations Center will support water-related services across other parts of NOAA, as well as other agencies across the federal government, to ensure a seamless suite of integrated water resource prediction services. The primary functions of the Operations Center include:

- **Impact-based Decision Support Services** – Ability to proactively support and respond to stakeholder-defined needs and requirements to enable critical decision making for the nation, from floods to water supply and droughts.
- **National Operating Picture** – Facilitate collaboration across all levels of the NWS and NOAA, as well as with other federal partners, to develop and define a common, national operating picture for water resources. This work will involve continuous monitoring, assessment, and interpretation of hydrologic data, model output, emerging geospatial intelligence, and decision support activities.
- **Data Analysis and Integration** – Provide an integrated production, analysis, and delivery of a suite of national hydrologic data and services.
- **Continuity of Operations** – Provide a service backup capability for River Forecast Centers (RFCs) to support continuity of service and forecast operations when necessary. A significant responsibility of the Operations Center will be to provide access to the vast subject matter expertise within the OWP and make that expertise available to the field offices.

The staff in the Operations Center will work with NWS field offices, as well as with Federal, state, and local agencies, to combine all aspects of these functions and deliver fully-integrated, timely, and relevant water-resource services to partners and customers across the country.

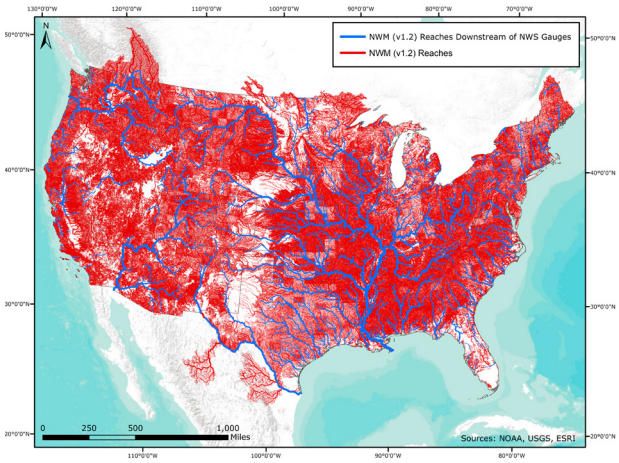



**Figure 2.** U.S. rivers and streams downstream of NWS Advanced Hydrologic Prediction Service (AHPS) forecast locations (shown in blue), represent only 3% of the total U.S. rivers and streams accounted for in the NWM (shown in red)

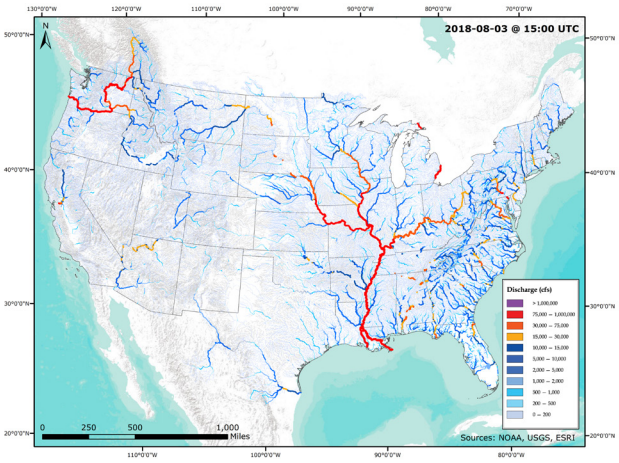



**Figure 3.** The National Water Model forecasts streamflow for ~5 million miles of rivers and streams across the continental U.S.

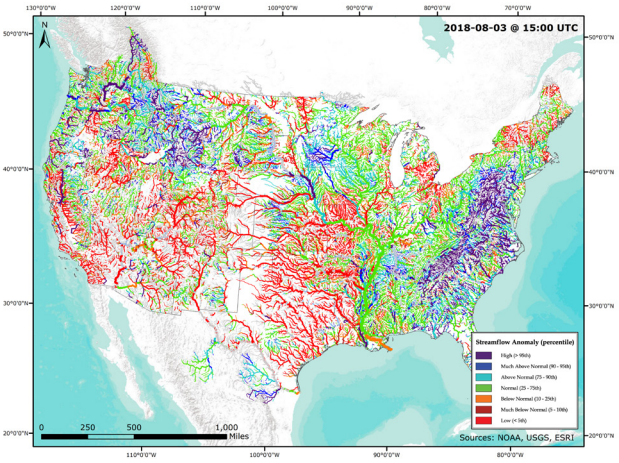



**Figure 4.** National Water Model streamflow anomaly (percentile) for 13Z on May 23, 2018

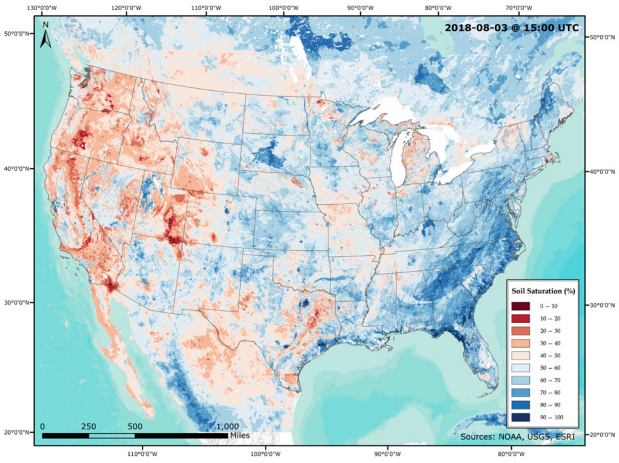



**Figure 5.** National Water Model near-surface (top-40cm) soil moisture saturation (%) for 15Z on June 4, 2018

## Key Partnerships

Anchored by the NWC, NOAA Line Offices have come together under the NOAA Water Initiative, achieving an unparalleled level of internal collaboration to enhance the agency's capability to develop and deliver better water information services. At the Federal level, NOAA is working closely with its partner agencies, academia, and the private sector in the development and delivery of these new information services. In addition to close collaboration with USGS, USACE, FEMA, and NSF, Federal advisors include representatives of the Environmental Protection Agency (EPA), the US Department of Agriculture (USDA), and the Department of Energy (DOE). In addition to CUAHSI, UCAR, and the UA, other academic partners include the University of Texas, Duke University, Columbia University, Utah State University, Tufts University, and the Water Institute of the Gulf. Private sector advisors include Esri, Kisters, Microsoft, and Booz Allen Hamilton. These advisors are assembled by UCAR in the Community Advisory Committee for Water Prediction (CAC-WP), which provides independent review of the OWP's strategic plans. These partnerships leverage investments from numerous researchers and developers worldwide to transform the Nation's water prediction capabilities. Together, NOAA and its partners are building a boundary-spanning partnership across multiple agencies and sectors to create and deliver water information to meet the needs of the 21st century.

## The National Water Model

After rapid development, and following an initial demonstration during the Annual Innovators Program and Summer Institute at the National Water Model (NWM) in 2015, NOAA released Version 1 of the NWM in August of 2016. This new, continental scale, state-of-the-science water prediction model creates forecast guidance for over 5 million miles of rivers and streams nationwide *(see Figures 2 and 3)*. This guidance is provided to NOAA RFCs and other field offices to support the delivery of expanded water services, as part of NOAA's integrated environmental intelligence and prediction capabilities. The NWM runs on the NOAA Weather and Climate Operational Supercomputing System (WCOSS) at the NWS National Centers for Environmental Prediction (NCEP) in College Park, Maryland. The NWM provides high resolution hydrologic guidance which significantly expands geographic coverage and provides water budget information *(Figures 4 and 5)*. It produces a full range of hydrologic fields, which can be leveraged by a multitude of stakeholders ranging from emergency responders and drought and water resource communities to transportation, energy, recreation, and agriculture interests, to other water-oriented applications in the government, academic, and private sectors.

# Why it Matters:
# Hurricanes Harvey, Lane, and Florence

## Hurricane Harvey

On the morning of August 27, 2017, Nim Kidd, Chief of the Texas Division of Emergency Management (TDEM), contacted the Director of the NWS, Louis Uccellini, and requested additional information beyond the official forecast services of the NWS, specifically outputs from the prototype NWM. The NWC was immediately mobilized, and development staff took on a temporary operational posture and began creating products. These products were considered experimental and supplemented the official forecast activities in the West Gulf RFC in Fort Worth, TX.

The NWC provided a number of NWMI-based experimental products, including worst-case forecast flood inundation maps depicting areas of inundation based upon peak forecast streamflows for the next five day period (Figure 6). Other products requested by TDEM included time to forecast peak streamflow, and time to forecast stream bankfull condition (to ascertain the time of flood inundation initiation). These products were used by the TDEM to stage resources, recovery encampments, evacuation areas, and other relief activities all safely outside of the areas of likely flooding.

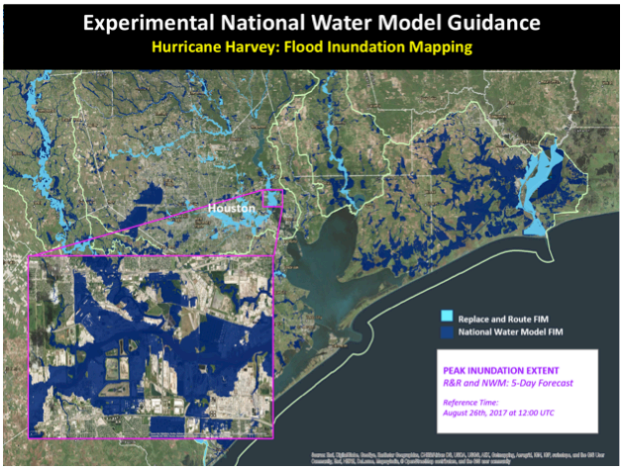



**Figure 6.** Example experimental Flood Extent Map developed by the National Water Center

## Hurricane Lane

On August 22 and 23, 2018, recognizing the imminent threat to the Hawaiian Islands posed by Hurricane Lane, the NWC initiated coordination with Pacific Region Headquarters and the Alaska-Pacific RFC to provide flood-related guidance and support to WFO Honolulu during Hurricane Lane. This guidance leveraged the latest version of the NWM, which was in its final phase of testing and not yet fully operational. This NWM-based guidance included peak streamflow over the next 60 hours and time to peak flow in the forecast period (Figure 7). This allowed greater awareness of heightened flood threats and enhanced decision support services across the islands. This was the first time hydrologic model forecast information was available for the Hawaiian Islands.

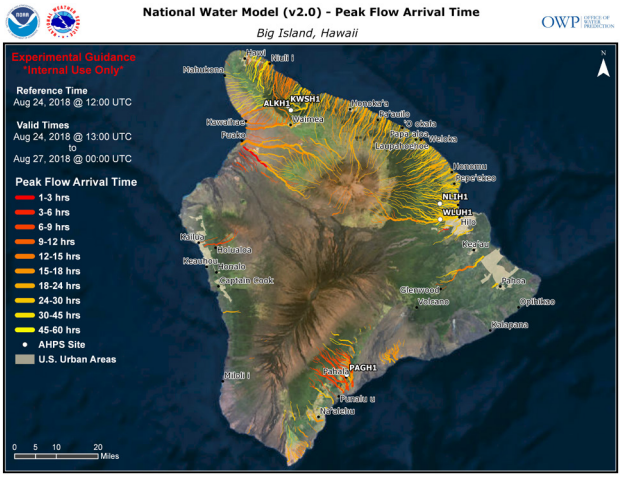



**Figure 7.** Experimental National Water Model guidance over Island of Hawaii

## Hurricane Florence

On September 7, 2018, the team at the NWC Operations Center – including the first 3 of an initial cadre of 12 Federal employees, augmented by NWC development staff – began planning to support NWS field offices as the East Coast braced for major flooding. During the week leading up to the landfall of Hurricane Florence on September 14, and the days that followed, the team at the NWC worked extended hours to aid the Southeast RFC, FEMA, and other national partners, including the USGS.

In addition to reinforcing and strengthening NWS field capacity during this event, the NWC created River Flooding Overview maps for areas at risk in North Carolina and South Carolina, describing the forecast magnitude and trend along major rivers at RFC forecast locations. At the request of FEMA Region IV, the NWC also provided flood inundation extent maps indicating areas where flooding was possible as well as locations that were likely to remain dry (Figure 8). This information was used by emergency managers to manage asset relocation to higher ground, assess potential impact to shelter locations, and inform decisions about NOAA infrastructure. NWC also participated in daily calls with NASA and FEMA and provided guidance based upon flood inundation mapping, using both the RFC official forecast and NWM guidance, to identify specific locations to be surveyed by NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) data collection.

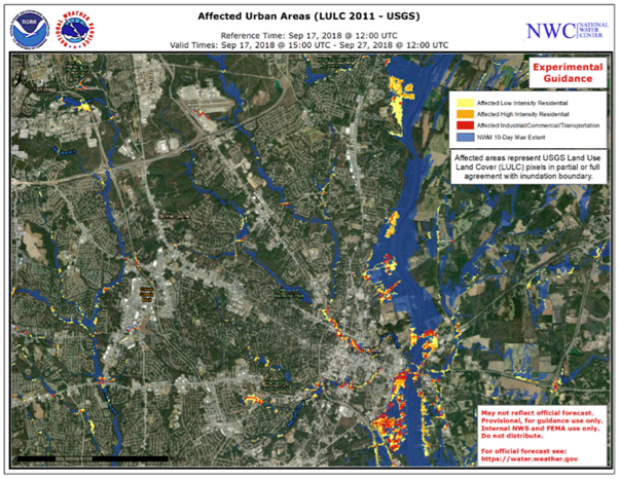
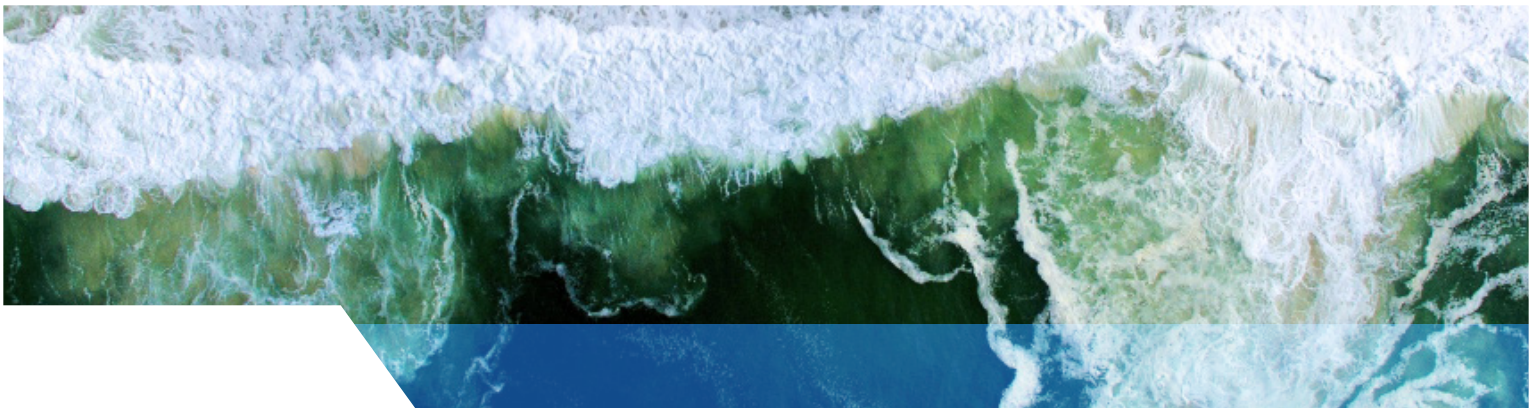



**Figure 8.** Experimental National Water Model flood extent map



## Future Plans

Version 1.2 of the NWM was implemented in March 2018. This upgrade included extensive model calibration, an improved hydrofabric (geospatial representation of terrain and stream connections), code revision, and improved data assimilation, which set the stage for future enhancement of the NWM. Interdisciplinary teams are now working to develop several capabilities that are key to water resources stakeholders, which include:

1. Nationwide flood inundation mapping, providing actionable, street-level information needed by emergency managers to inform critical decisions that save lives and property;
2. Coastal coupling, to support joint freshwater-estuary-ocean modeling to provide accurate total water level forecasts for 120 million Americans living in the coastal zone, which will enable improved emergency response via accurate simulation of the additive impacts of freshwater and storm surge flooding;
3. Hyper-resolution modeling to resolve the fine-scale processes that impact flooding and capture hydrologic and hydraulic processes in urban environments and areas of high terrain relief in mountainous regions;
4. Machine learning-based simulation of reservoir processes to accurately account for reservoir operations and other water management activities, which have a profound impact on the accuracy of streamflow forecasts;
5. Groundwater modeling, to represent shallow aquifer processes, which can have a significant impact on streamflow and forecast accuracy;
6. Expanded terrain and bathymetric analysis for specification of stream channel geometry and improved forecast accuracy, necessary to enhance comprehensive flood inundation mapping capabilities;
7. Improved data assimilation, to optimally integrate and leverage the best available water observation information; and
8. Big data and geospatial analytics, to integrate and process the large volume and broad spectrum of forecast data generated by the NWM with other geospatial information to inform the increasingly challenging decisions faced by water resources stakeholders.

Advances in each of these areas address critical gaps in operational water prediction for emergency response while also improving the information needed manage the Nation's water resources.

Version 2.0 of the NWM is scheduled for release in March 2019, which will provide first-time stream and river forecasts for Hawaii. In addition, the NWM code in V2.0 will be organized into a series of modular libraries, making them easier to use by individuals and organizations across and outside of the Federal government, creating an open-source development community. This will accelerate the transformation of water prediction and deliver next generation water information to meet the growing needs of our Nation. Version 2.1 of the NWM is scheduled for release within 2 years, which will expand the NWM to Puerto Rico, the U.S. Virgin Islands, and the entire Great Lakes basin.

## Conclusion

The establishment of the NWC and the launch of the NWM represent a quantum leap forward towards informing decisions for all manner of water resources challenges, from extreme floods, to devastating droughts, to ensuring the optimal use of our increasingly limited water supply in the face of competing demands. NOAA will accomplish this through continued partnerships and collaborative development with other Federal agencies, academia, and the commercial sector. The revolutionary set of information and services flowing from the NWC, which will harness the power of a fully realized NWM, will fundamentally change the face of water prediction for this Nation. This new intelligence will transform decision-making to help the Nation face the water challenges of tomorrow.

## For More Information:

- National Water Center Innovators Program: Summer Institute
- Water at NOAA
- Community Advisory Committee for Water Prediction