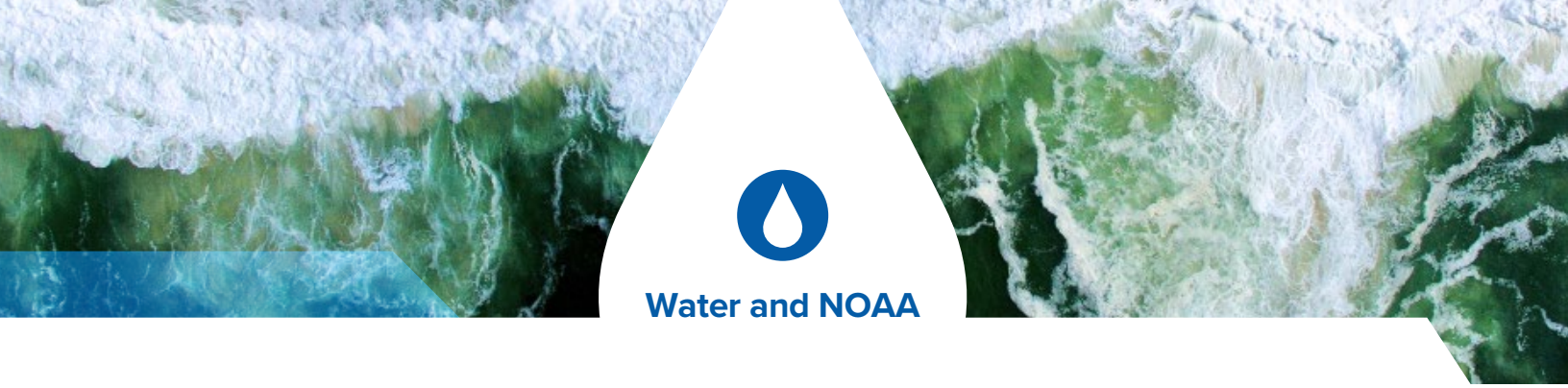
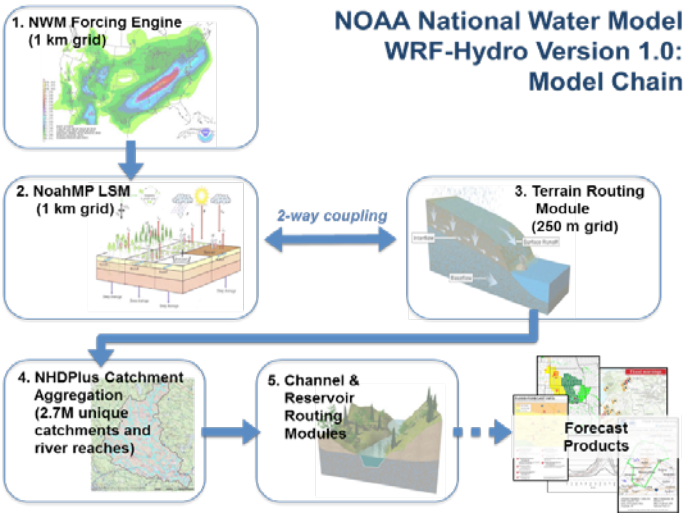


Water and NOAA

Transforming Water Prediction

Stakeholders increasingly request enhanced and integrated water resources forecasts and services to help them address more complex societal issues related to too much, too little, and poor-quality water. Mounting threats to water security stemming from population growth and economic development are stressing water supplies and increasing vulnerability; a changing climate is impacting water availability and quality, increasing uncertainty; an aging water infrastructure is forcing critical, expensive decisions; and the socio-economic risks of floods and droughts are escalating. Recent engagements with water resources stakeholders across the United States have revealed the need for consistent, high space- and time-resolution, integrated water analyses, predictions, and data to address critical unmet information and service gaps related to floods, droughts, water quality, water availability, and climate change. In response to these growing stakeholder demands and needs, the National Oceanic and Atmospheric Administration (NOAA) has begun a transformation of its operational water prediction capabilities.



NOAA National Water Model Version 1.0: Model Chain. Source: NCAR (https://ral.ucar.edu/projects/supporting-the-noaa-national-water-model)

National Water Model 1.0

As a significant step forward to transform NOAA's water prediction services, NOAA implemented Version 1.0 of a new National Water Model (NWM) in August 2016. A continental-scale water resources model, the NWM is an evolution of the WRF-Hydro architecture developed by the National Center for Atmospheric Research (NCAR) and its international collaborator community. WRF-Hydro is a community-based, Earth System Modeling Framework (ESMF)-compatible hydrologic modeling system.

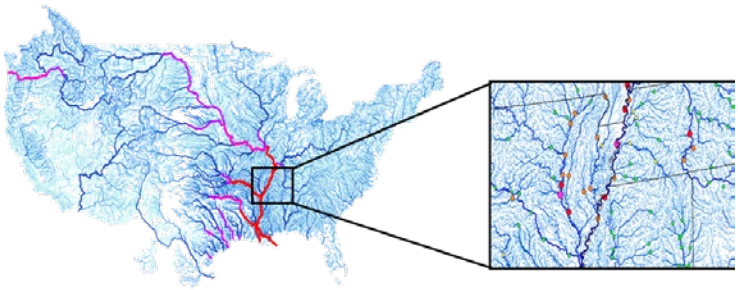
The NWM is a NOAA-led interagency effort that leverages model topology within the National Hydrographic Dataset-Plus (NHDPlus) version 2 from the U.S. Geological Survey (USGS) and the Environmental Protection Agency (EPA). Additionally, the NWM ingests and assimilates streamflow data each hour from approximately 8,000 gages in the USGS National Streamflow Information Program. The development and implementation of NWM Version 1.0 was the result of strong collaboration with NCAR and a partnership with the Consortium of Universities for the Advancement of Hydrologic Sciences, Inc. (CUAHSI), the National Science Foundation (NSF), and Federal Integrated Water Resources Science and Services (IWRSS) partners (USGS, U.S. Army Corps of Engineers (USACE), and the Federal Emergency Management Agency (FEMA)). Version 1.0 of the NWM provides a foundation that supports out-year growth in operational hydrologic forecasting capability.

Goals achieved by NWM Version 1.0 include:

- Forecasted streamflow guidance for under-served locations;
- Spatially continuous national estimates of hydrologic states (soil moisture, snow pack, etc.);
- Seamless and real-time hydrologic products within an advanced geospatial intelligence framework; and
- A modeling architecture that permits rapid infusion of new data, science, and technology.

National Water Model 1.1

Version 1.1 of the NWM was implemented in May 2017, with enhancements that included an increased model cycling frequency and forecast length, initial calibration of the NWM model parameters, and improved soil and snow physics. Version 1.2 is scheduled for a Spring 2018 release and will include extensive model parameter calibration, an improved hydrofabric (i.e., terrain and stream connections), and improved data assimilation. Version 2.0 is scheduled for implementation in Winter 2018-19 and is planned to include a domain expansion to Hawaii, a medium-range Global Forecast System-based ensemble configuration, increased modularity, further improvements to model calibration, and a longer analysis cycle look-back period. Subsequent versions of the NWM are planned to be implemented on an annual basis thereafter.



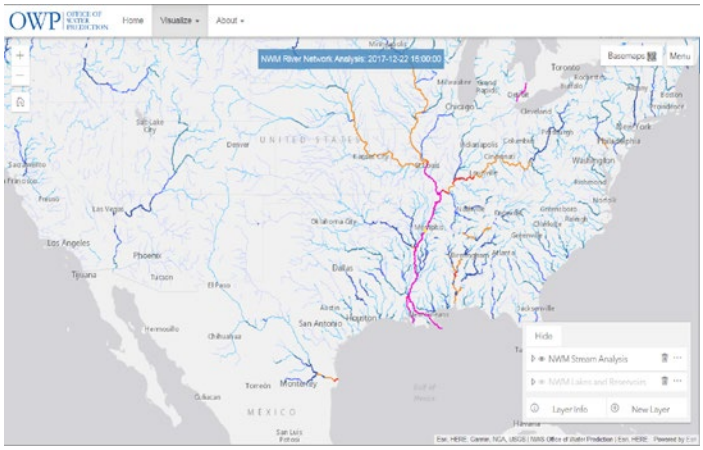
Left: Map of current NWM forecast locations/stream reaches. Right: Inset map of middle Mississippi River to show comparative spatial resolution of RFC AHPS streamflow forecast locations (circles) and NWM forecast locations/stream reaches.

The NWM represents NOAA's first foray into high-performance computing for water prediction and expands NOAA's current water quantity forecasts, at approximately 4,000 USGS stream gage sites across the country, to forecasts of flow at 2.7 million stream reaches nationwide. This new NWM guidance augments and supports the generation of official forecasts at NWS River Forecast Centers. NWM output also includes spatially-continuous forecasts of soil moisture, evapotranspiration, run-off, snow water equivalent, and other components of the water cycle. A subset of this new guidance is being provided to River Forecast Centers and other field offices, along with guidance for evaluation and validation, and tools to visualize these data. Initial NWM guidance available via NOAA's Office of Water Prediction (OWP) website includes streamflow, streamflow anomaly, and soil saturation (http://water.noaa.gov/tools/nwm-image-viewer and http://water.noaa.gov/map). The full output of the NWM simulations is available via the NOAA Operational Model Archive and Distribution System (NOMADS). Over time, continued NWM enhancements will improve NWS ability to deliver impact-based decision support services nationwide through the provision of short through extended range, high-fidelity, street-level water forecasts and warnings.

Early evaluation of the model at validation locations nationwide indicates promising skill, particularly in unregulated areas (natural flow). In addition, initial case studies have demonstrated valuable forecast skill at current Advanced Hydrologic Prediction Service (AHPS) locations and in areas which lack both stream gage observations and AHPS forecasts. Although these early results are promising, significant model development and validation remains to be done over the next several years. Planned out-year enhancements to the NWM include the assimilation of anthropogenic water management data; the incorporation of enhanced model forcings; the provision of real-time flood forecast inundation maps; an operational nest to provide higher resolution forecasts needed to account for the built environment in urban areas; two-way coupling of the NWM with coastal estuary models for "total water level" forecasts in coastal zones; coupling with advanced groundwater models to improve forecasts of low flow and drought; expansion to outside the contiguous U.S. domains including Hawaii, Puerto Rico, and Alaska; and tackling deeper challenges associated with water quality.

National Water Model 2.0

Perhaps the most significant of all near-term planned enhancements will be delivered with NWM Version 2.0, which will begin to pave the way for heightened NWM engagement with the broad development, academic, and research communities. The NWM code will begin to be modularized with Version 2.0; it will be organized into a series of callable libraries so that community members can bring individual modules into their own development environments, make suggested improvements to the code, and submit the improved code to NOAA for evaluation and possible inclusion into future versions of the NWM. Though plans have not been finalized, NOAA anticipates making the NWM code available in a well-documented and modular format for community development as early as Fall 2019. Until then, the operational source code is available from NOAA's National Centers for Environmental Prediction (http://www.nco.ncep.noaa.gov/pmb/codes/nwprod/nwm.v1.1.4/).



National Water Model point and click hydrographs now available on interactive map interface. Source: http://water.noaa.gov/map