Transforming NOAA Water Resources Prediction

OWP | OFFICE OF WATER PREDICTION

Presented to

Subcommittee on Disaster Reduction

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Presentation Outline

- NWS Mission
- Strategic Outcome
- Impetus for Change
- National Water Center
- Partnerships
- National Water Model
- Summary

NOAA NWS Strategic Outcome:

A Weather- and Water-Ready Nation

Building community resiliency in the face of increasing vulnerability to extreme weather, *water*, and climate events

Involves the entire US Weather, Water and Climate Enterprise working together

Integrated Water Resources Science and Services (IWRSS): Partners and Missions

Collaborative Science-Based Solutions to Address Societal Needs

USGS science for a changing world

Water Science and Information: **Collects and disseminates reliable, impartial, and timely information needed to understand the Nation's water resources to minimize loss of life and property from natural disasters**

US Army Corps of Engineers

Water Management: **Strengthens our Nation's security, energizes the economy, and reduces risks from disasters**

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

Water Prediction: **Provide weather, water, and climate data, forecasts and warnings for the protection of life and property and enhancement of the national economy.**

U.S. Department of Homeland Security FEMA

Response and Mitigation: **Supports our citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against respond to, recover from and mitigate all hazards**

IWRSS Partnership anticipated to expand over time

CUAHSI · NCAR National Center for Atmospheric Research · Department of Energy United States of America · USDA · NSF · NASA · U.S. Department of the Interior Bureau of Reclamation · United States Environmental Protection Agency · Forest Service US

Growing Water Stakeholder Information Needs

- Key Stakeholder Priorities
  - Flooding
  - Drought
  - Water Availability
  - Water Quality
  - Climate Change
- Need integrated understanding of near- and long-term outlook and risks
- Provide *consistent, high resolution ("street level") analyses, predictions* and data to address critical unmet information and service gaps
- Transform information into *actionable intelligence* by linking hydrologic, infrastructural, economic, demographic, environmental, and political data

Integrated Water Prediction

Setting the Stage for Transformation

Centralized Water Forecasting Demonstration (2015)	Enhanced Water Prediction Capability (2016)	Integrated Water Prediction (2017 Omnibus)
• National Water Model (NWM) Development and Demonstration • Centralized Water Resources Data Services • Water Resources Test and Evaluation Service	• Hyper-Resolution Modeling • Real-Time Flood Forecast Inundation Mapping • Enhance Impact-Based Water Resources Decision Support Services	• Stand up the National Water Center Operations Center/New service delivery model • Increase high performance computing capacity • Couple terrestrial freshwater and coastal estuary models for total water predictions in the coastal zone

National Water Center

Initial Operating Capacity: May 26, 2015

A Catalyst to Transform NOAA's Water Prediction Program

- **Center of excellence for water resources science and prediction**
- **Catalyst for Enterprise Collaboration**
- **Operations Center for water resources common operating picture and decision support services**

NWC has hosted more than 70 scientific meetings with over 2600 participants

NWC Annual Innovators Program

Partnership with the academic community via Interagency Agreement with the **NSF** and **CUAHSI** to host a competitive **Summer Institute**

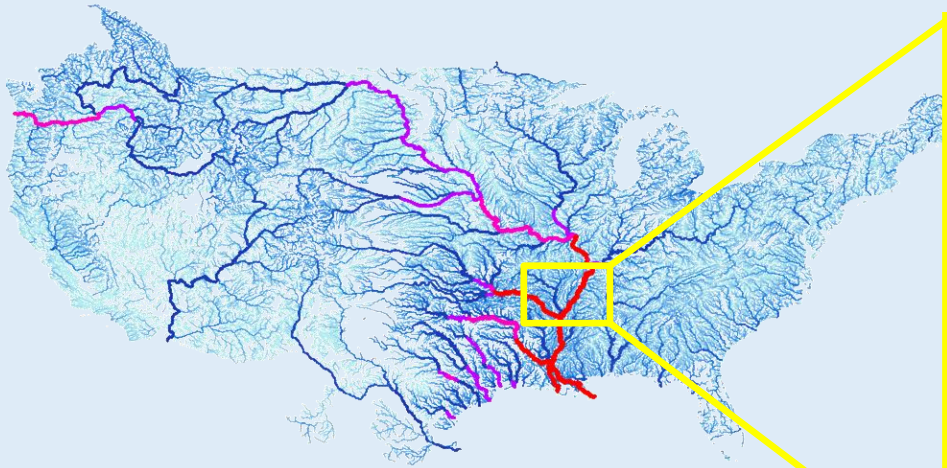
- **Year one included 44 graduate students from 19 Universities**, June - July 2015
  - Demonstrated ability to **simultaneously model the entire continental United States** river network at high spatial resolution, in near real-time for 2.7 million stream reaches
- **Year two included 34 graduate students from 21 Universities**, June - July 2016
  - Demonstrated the ability to generate **flood inundation maps** utilizing NWM output
  - **Engaged social scientists and stakeholders from the Fire, Police and Emergency Management Communities** to explore ways to best communicate water information
- **Year three includes 34 graduate students from 25 Universities**, June - July 2017
  - Refine the recently developed process to create **flood inundation maps** nationally in real time
  - Develop a strategy for a **hyper-resolution nest** of the NWM
  - Improve the **communication of water resources information**

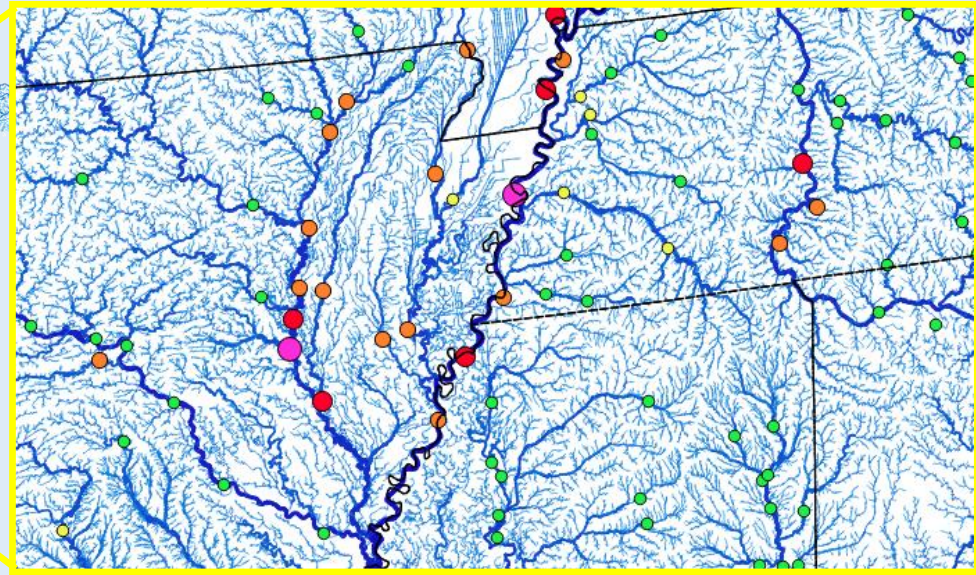
National Water Model

Initial Operating Capability – v1.0 implemented August 16, 2016

- **Spatially continuous estimates of major water cycle components** (e.g., snowpack, soil moisture, channel flow, major reservoir inflows, flood inundation)
- Operational forecast **streamflow guidance for currently underserved locations**: 3,600 forecast points → 2.7 million NHDPlus river reaches (700 fold increase in spatial density)
- Employs an **Earth system modeling architecture** that permits rapid model evolution of new data, science and technology (i.e. **WRF-Hydro**)

Current NWS River Forecast Points overlaid with NWM Stream Reaches





NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

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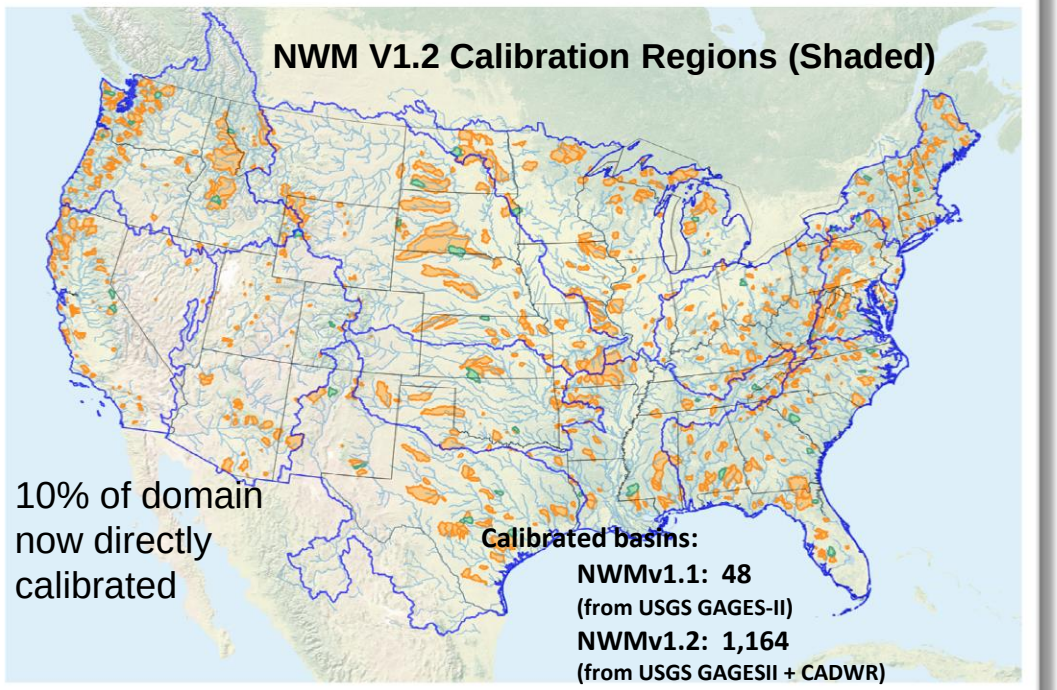
Upgrading to NWM V2.0 and Beyond

v1.0 → v1.1 → v1.2

Foundation Established
August 2016
Water Resource Model for 2.7 Million Stream Reaches

First Upgrade
May 2017
Increased cycling freq. and forecast length, initial calibration, improved soil/snow physics

Second Upgrade
March 2018
Extensive calibration, improved hydrofabric (terrain and stream connections), improved data assimilation



V2.0 (January 2019): Ensemble medium range forecast, Hawaii domain, longer Analysis period driven by hourly MPE blend, targeted calibration, increased code modularity for community development

Beyond V2.0: Flood inundation mapping, water regulation, coastal coupling, hyper-res modeling, water quality, Great Lakes, Puerto Rico and AK domains

National Water Model V1.1/V1.2

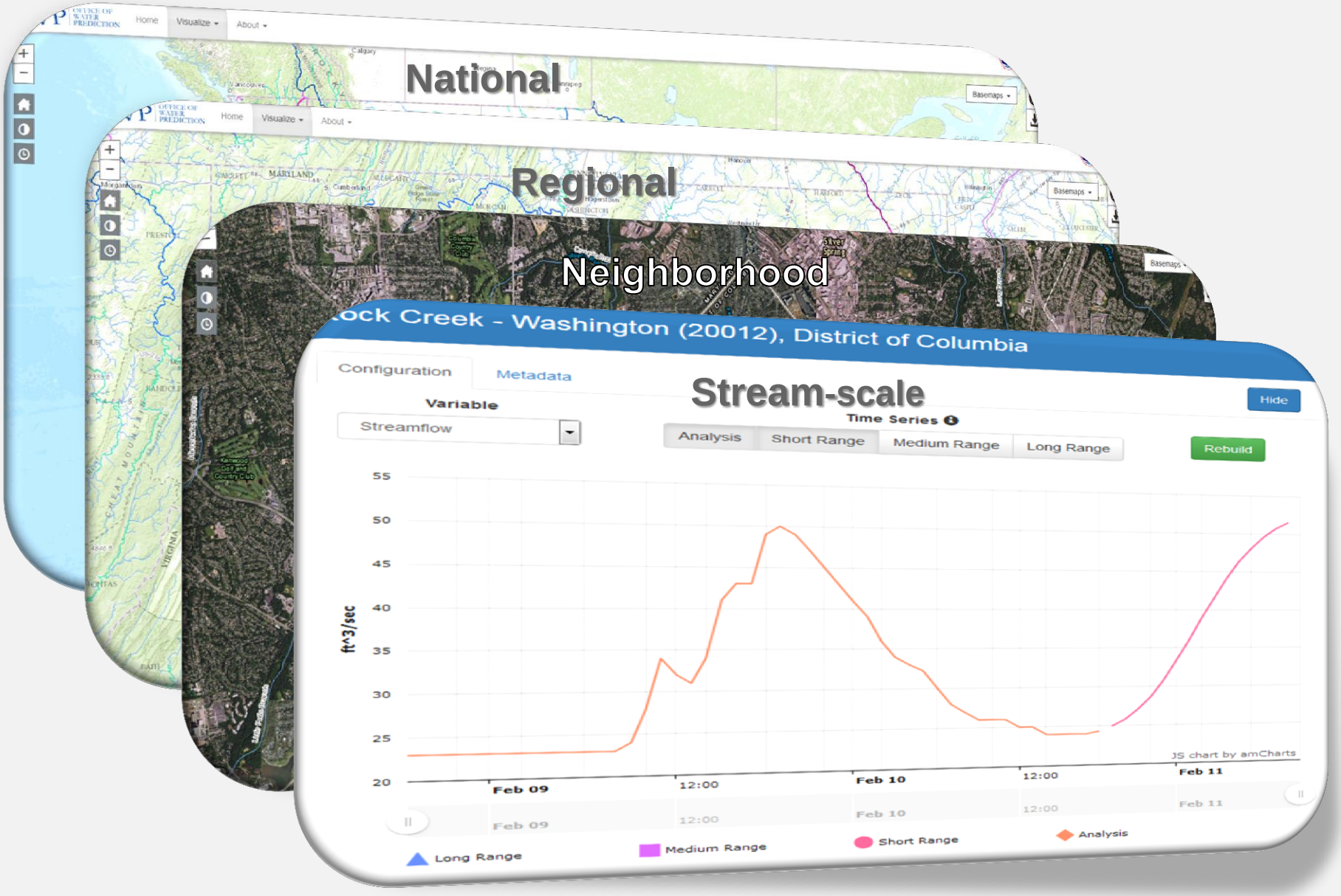
Analysis and Forecast Operational Cycling Configurations

	Cycling	Forecast	Forcing	Outputs
Analysis & Short-Range	Hourly	18 hours	MRMS QPE Downscaled HRRR/RAP Blend	1km Land States, 250m Sfc Routed Water, NHDPlus Streamflow
Medium-Range	4 x Day	10 days	Downscaled Global Forecast System (GFS)	1km Land States, 250m Sfc Routed Water, NHDPlus Streamflow
Long-Range	Daily Ensemble (16 members)	30 days	Downscaled and Bias-Corrected Climate Forecast System (CFS)	1km Land States, NHDPlus Streamflow

Analysis assimilates ~7,000 USGS Observations

All configurations include reservoirs (1200+ water bodies parameterized with level pool scheme)

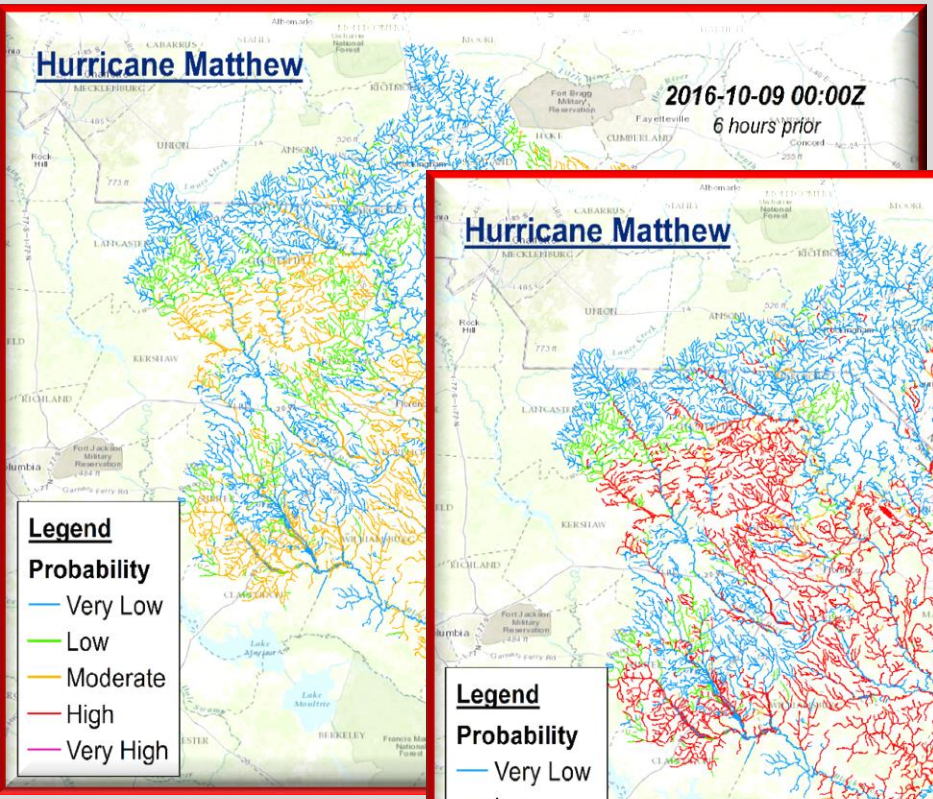
NWM Provides Multi-Scale Hydrologic Forecast Guidance

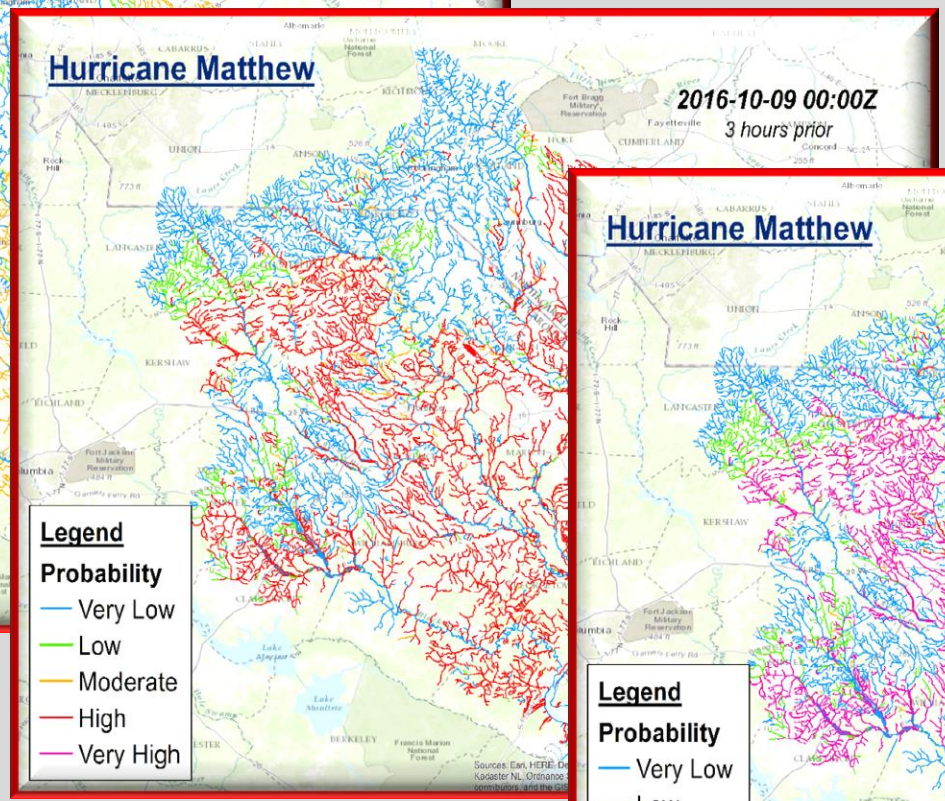


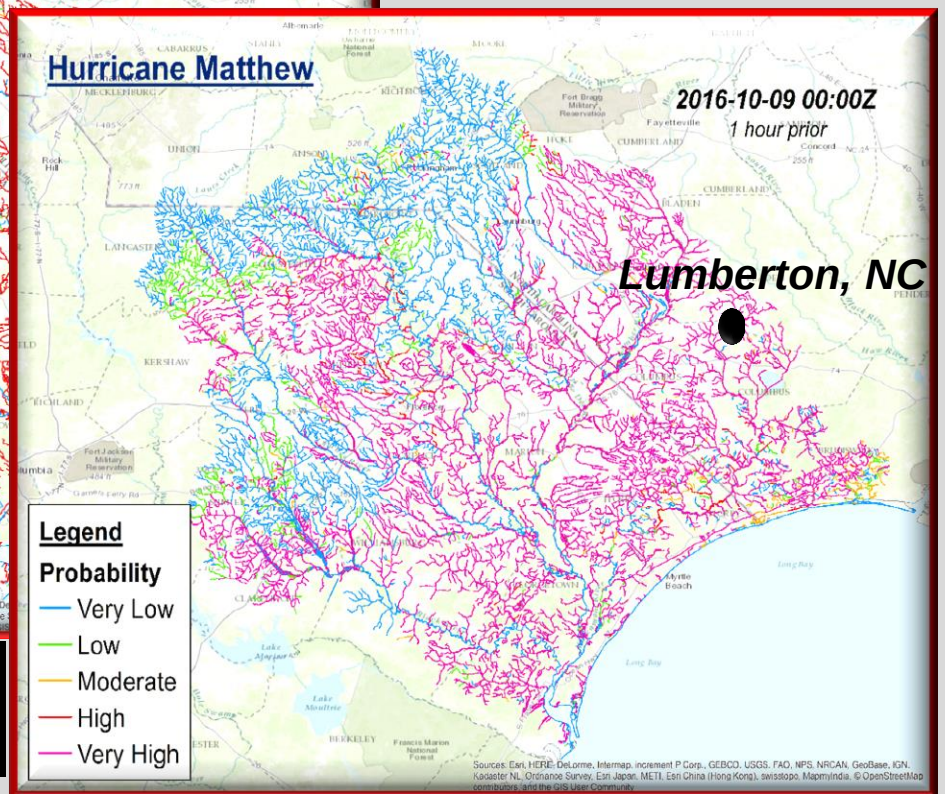
National Water Model Output

Near-Term Capabilities:
Probabilistic Inland Streamflow Forecast Guidance

Probability that streamflow will exceed high flow threshold based on time-lagged ensemble of NWM short-range forecast, forced by the High Resolution Rapid Refresh (HRRR) Atmospheric Model.







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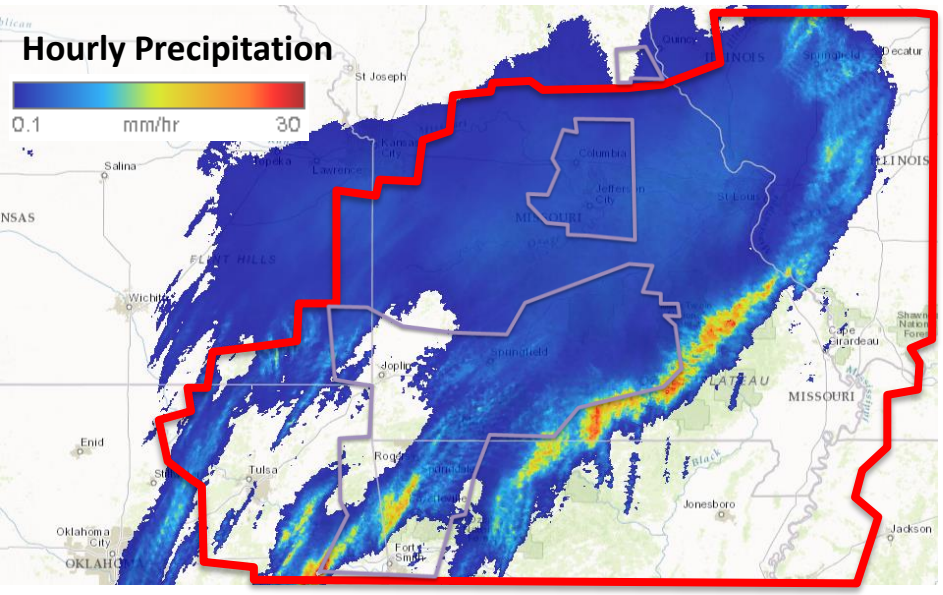
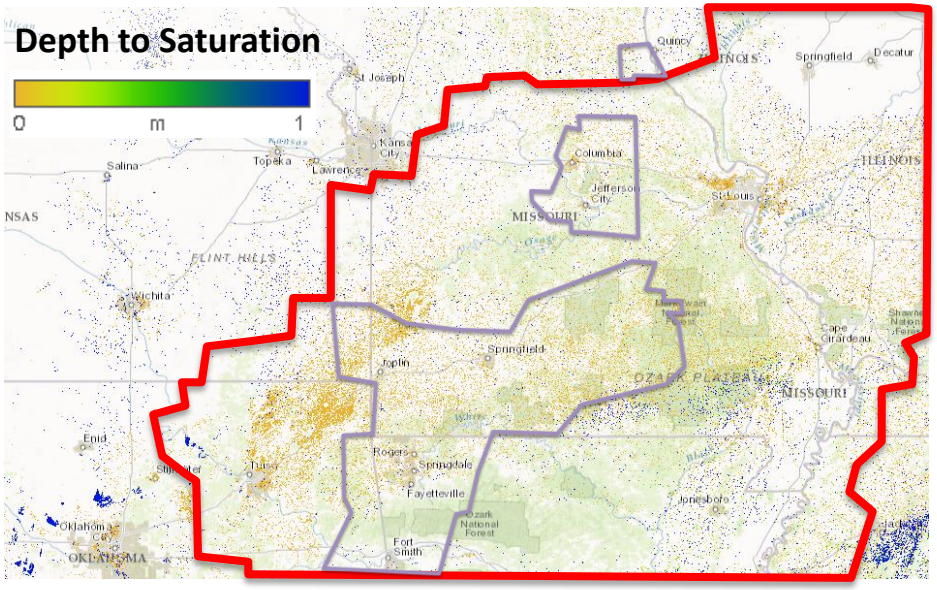
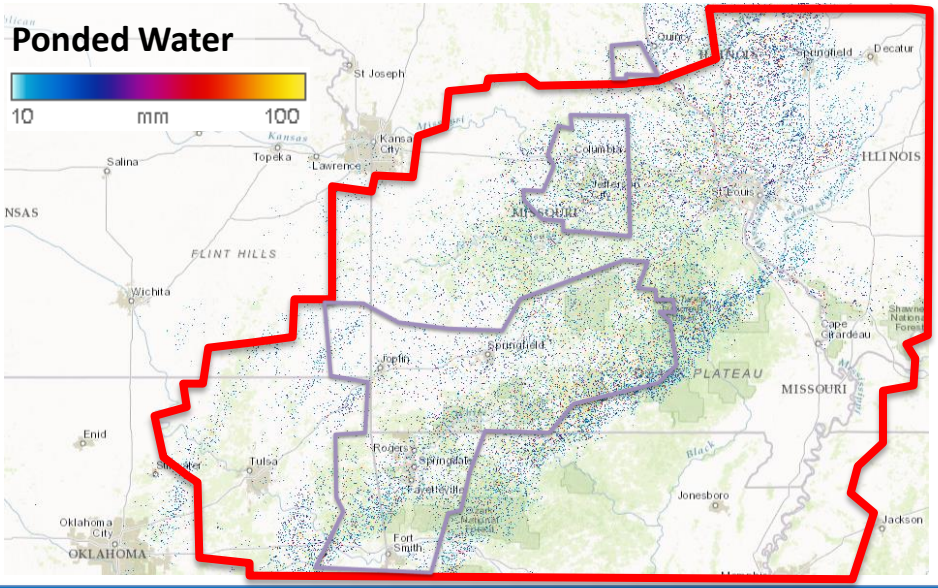
Valid Time:
00Z Oct 9, 2016

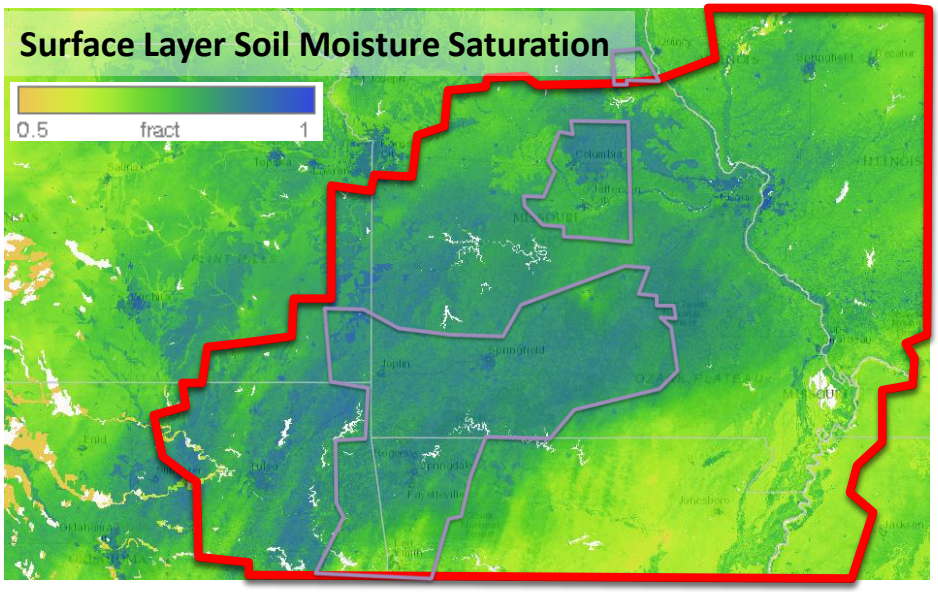
Beyond Streamflow...Additional NWM Hydrologic Guidance

NWM Gridded Analyses for 23Z on April 29th, 2017







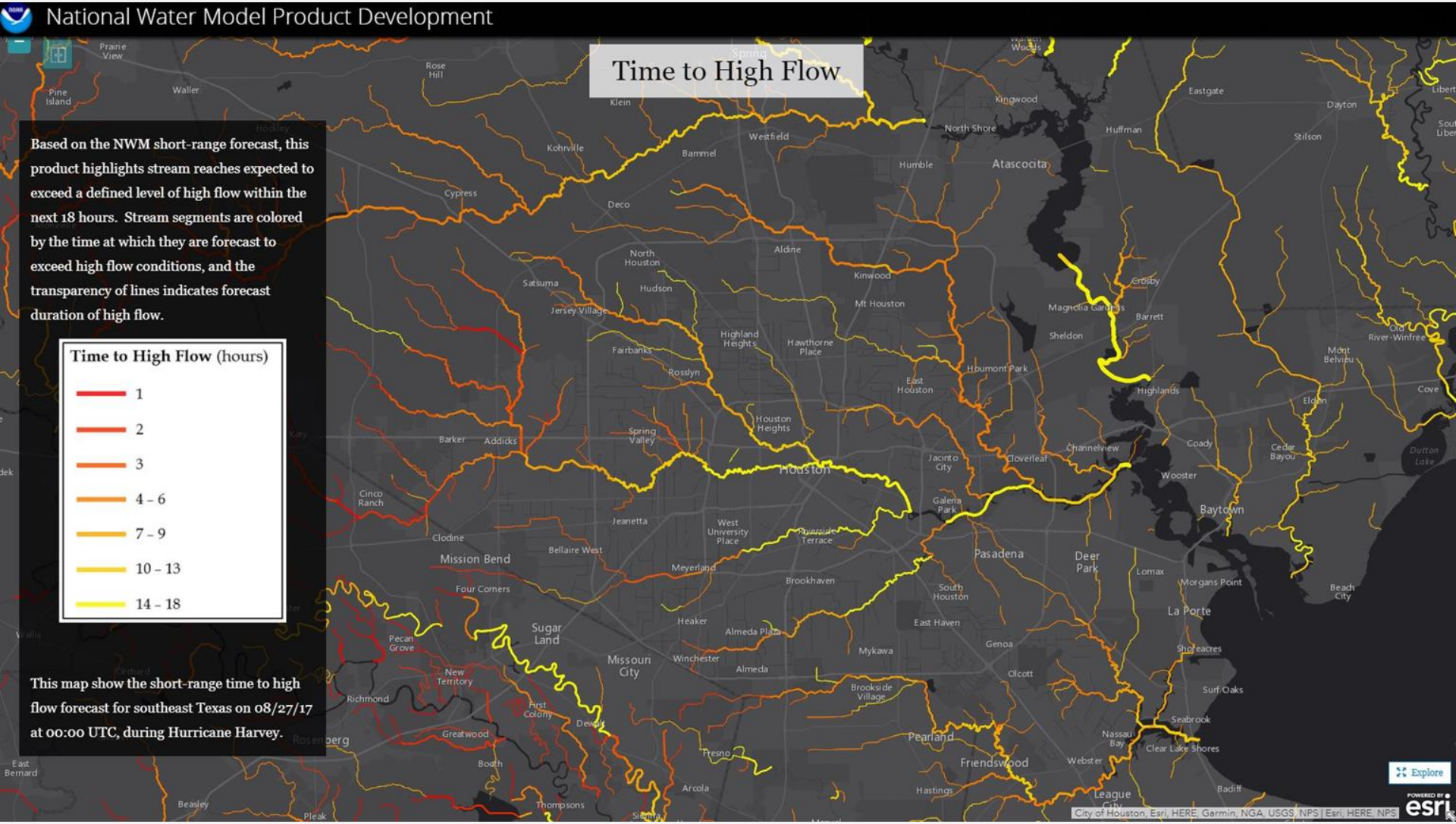


Flash Flood Watch

Flash Flood Warning

Experimental NWM-based Guidance for Hurricane Harvey

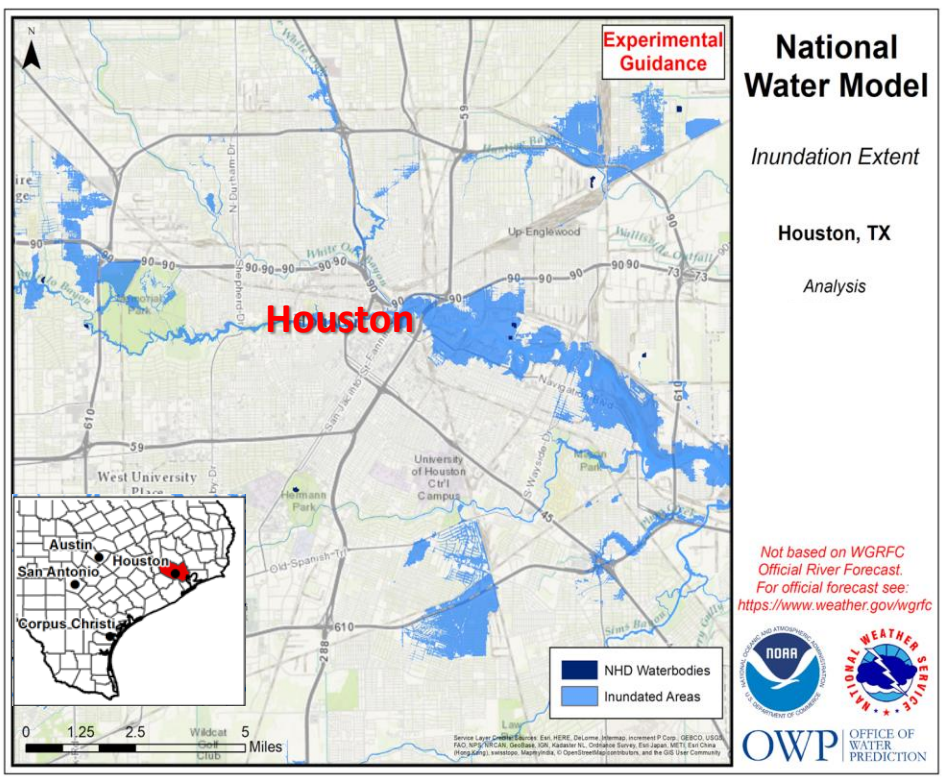
Time to High Flow based upon Short-Range (HRRR Forced) NWM Configuration

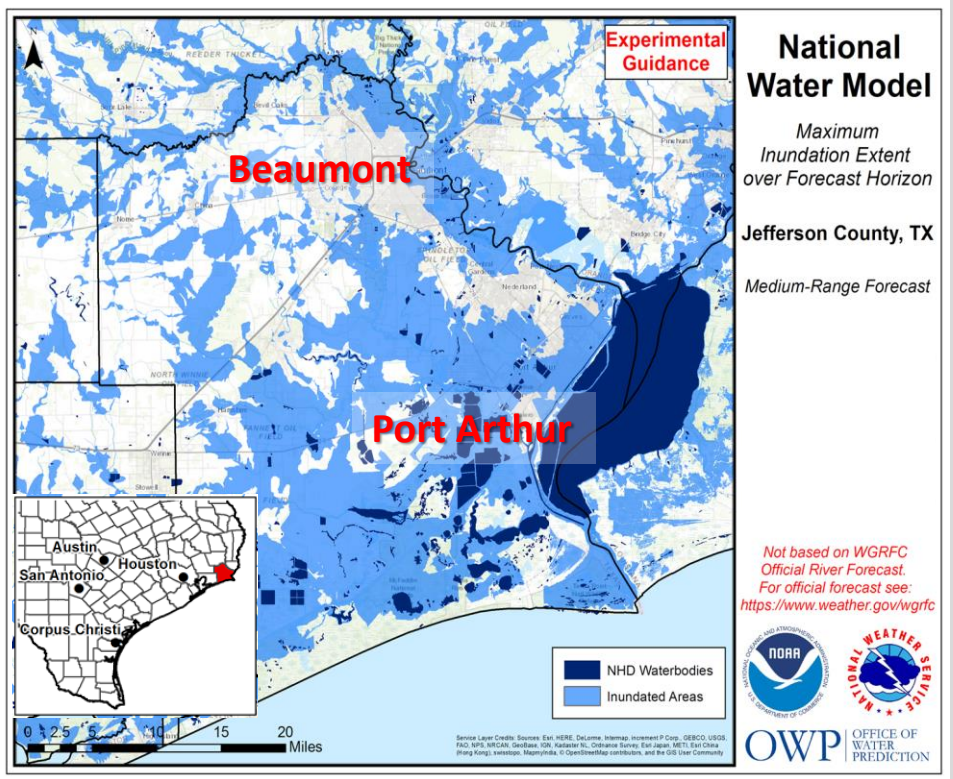


- **Provided TDEM forecasts of streamflow, streamflow anomaly, time to bankfull (i.e., full river channel), peak streamflow, time to peak streamflow, and time to recession (to bankfull).**
- **Routine coordination calls between OWP, NWC, WGRFC, SR ROC, WPC, and USACE**

Experimental NWM-based Guidance for Hurricane Harvey

Flood Inundation Maps based upon the NWM Analysis and 5-Day Forecast





- **Maps supported emergency management efforts to stage supplies in non-flooded areas and to target relief efforts**
- **TDEM needed information on exisiting and maximum possible flood extent**

Future Challenges to Improving Water Prediction

- Expanded set of water variable observations, data, forcings, and assimilation strategies
- Physical Process Understanding
- Model Enhancement and Community Development
- Accounting for Anthropogenic Processes
- Application of Hydro-informatics for Integration of Geospatial Data and Development of Decision Support Tools
- Model component and forecast evaluation
- Quantification and Communication of Uncertainty and Risk
- System Interoperability and Data Synchronization
- High Performance Computing Resources

Summary

- **NOAA's Water Services are Evolving**
  - We are building a foundation for change
  - Continental scale modeling approach producing consistent, "street-level" information to address growing stakeholder needs
  - Stakeholder input will continue to inform future science/service development activities
  - Deliver comprehensive, integrated actionable water predictions/intelligence
  - More than streamflow -- spatially-continuous forecasts of soil moisture, evapotranspiration, runoff, snow water equivalent and other parameters
- **Implementing State-of-the-Art Technical Approach**
  - Water resources prediction through state-of-the-science earth system modeling in a high performance computing environment
  - Impact-based decision support services underpinned by geo-intelligence
- **New Organization, Cornerstone Facility and Philosophy**
  - Office of Water Prediction/National Water Center
  - Collaboration across NOAA and with Federal Partners, Academia, and the broader Water Resources Enterprise is critical to success

Vision without action is merely a dream. Action without vision just passes the time.
Vision with action can change the world.

Joel A. Barker