National Water Model

OWP | OFFICE OF WATER PREDICTION

Hyde County, NC AP Photo

ESRI User Conference – GIS Hydro Meeting

July 7, 2019

Edward P. Clark

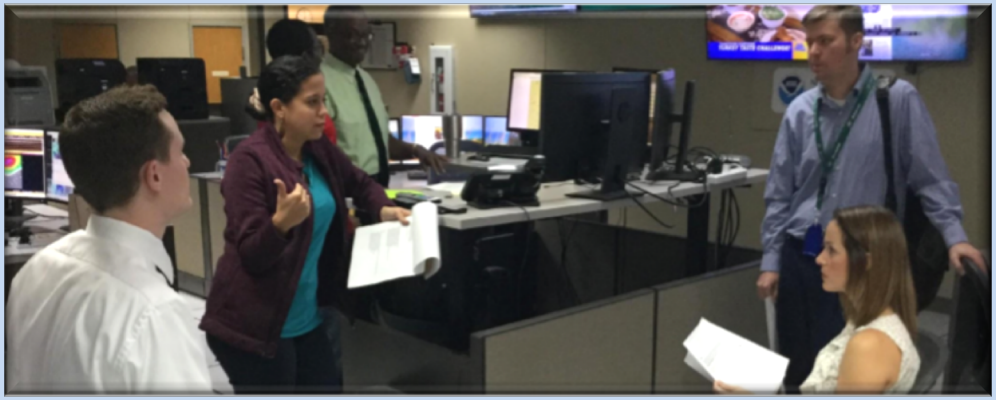
Director, National Water Center (NWC)
National Weather Service (NWS)
National Oceanic and Atmospheric Administration (NOAA)

NOAA NWS Strategic Plan 2019-2022:
Building a Weather-Ready Nation

Released March 26, 2019

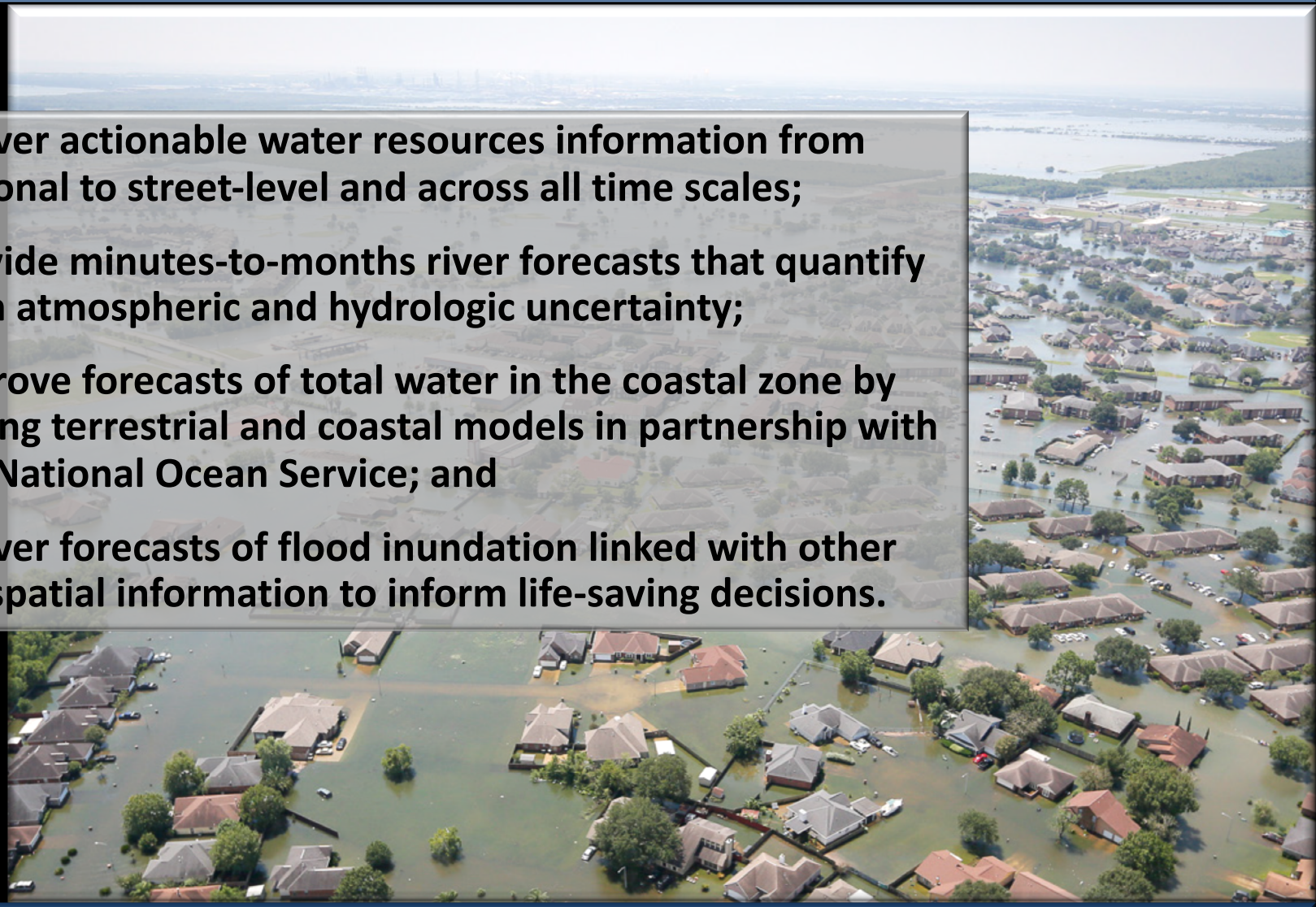
Overarching Goals:

- **Reduce the impacts of weather, water, and climate events by transforming the way people receive, understand, and act on information**
- **Harness cutting-edge science, technology, and engineering to provide the best observations, forecasts, and warnings**
- **Evolve the NWS to excel in the face of change through investment in our people, partnerships, and organizational performance**



https://www.weather.gov/media/wrn/NWS_Weather-Ready-Nation_Strategic_Plan_2019-2022.pdf

NOAA NWS Strategic Plan 2019-2022:
Water-Specific Goals



- Deliver actionable water resources information from national to street-level and across all time scales;
- Provide minutes-to-months river forecasts that quantify both atmospheric and hydrologic uncertainty;
- Improve forecasts of total water in the coastal zone by linking terrestrial and coastal models in partnership with the National Ocean Service; and
- Deliver forecasts of flood inundation linked with other geospatial information to inform life-saving decisions.

https://www.weather.gov/media/wrn/NWS_Weather-Ready-Nation_Strategic_Plan_2019-2022.pdf

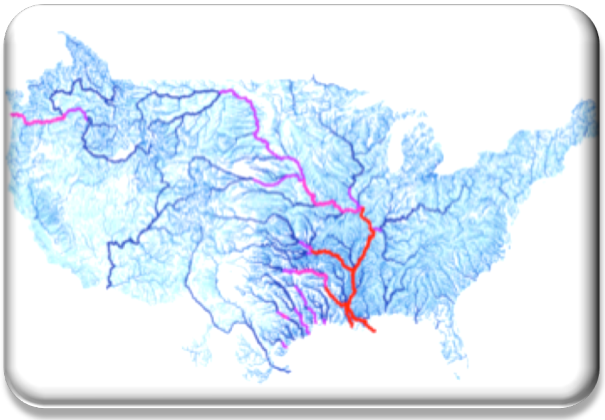
National Water Center

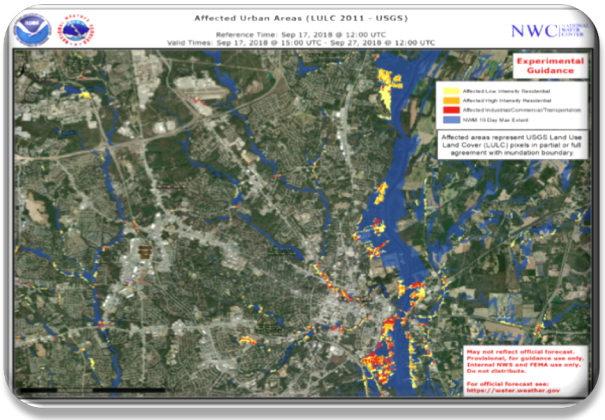
Initial Operating Capacity: Oct 1, 2019

- **Center of excellence for water resources science and prediction**
- **Catalyst to transform water prediction through enterprise collaboration**
- **Operations Center for water resources common operating picture and decision support services on all time scales**

NWC has hosted more than 80 scientific meetings with over 2800 participants

Setting the Stage for Transformation





Centralized Water Forecasting Demo (2015)

- National Water Model (NWM) Development and Demonstration
- Centralized Water Resources Data Services
- Water Resources Test and Evaluation Service

Enhanced Water Prediction Capability (2016)

- Hyper-Resolution Modeling
- Real-Time Flood Forecast Inundation Mapping
- Enhance Impact-Based Water Resources Decision Support Services

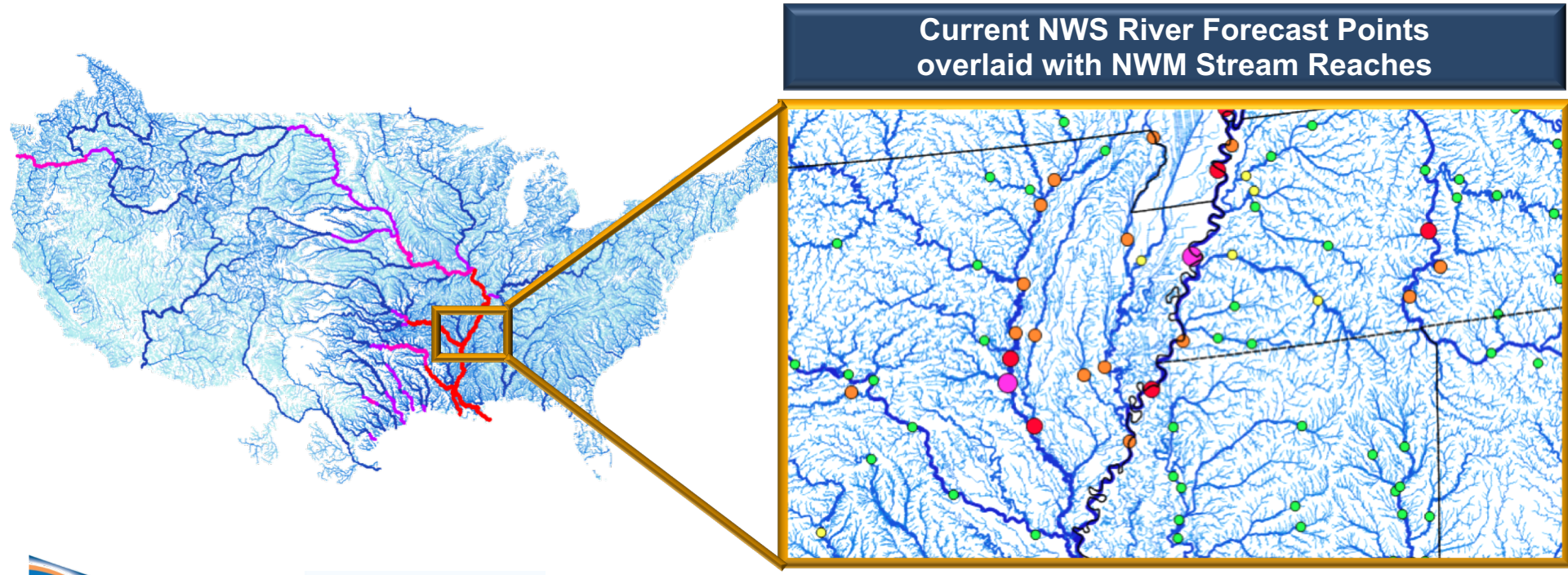
Integrated Water Prediction (2017)

- Stand up the NWC Operations Center
- Increase HPC capacity
- Couple terrestrial freshwater and coastal estuary models for total water prediction

National Water Model

V2.0 Implemented June 19, 2019

- **Continental-scale water resources model providing high resolution, spatially continuous estimates of major water cycle components**
- **Operational forecast streamflow guidance for currently underserved locations: 100,000 River miles → nearly 5,000,000 River miles**



NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

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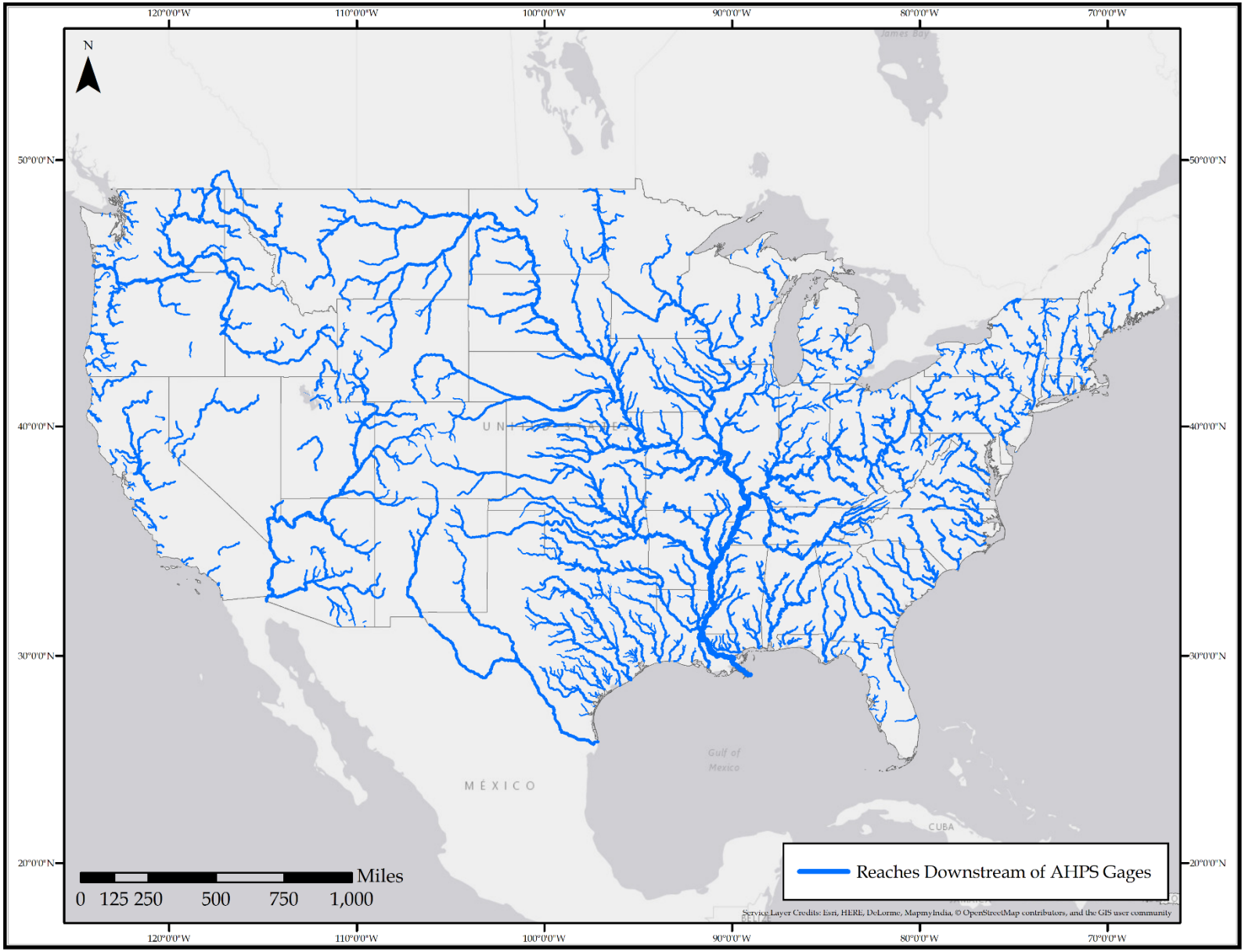
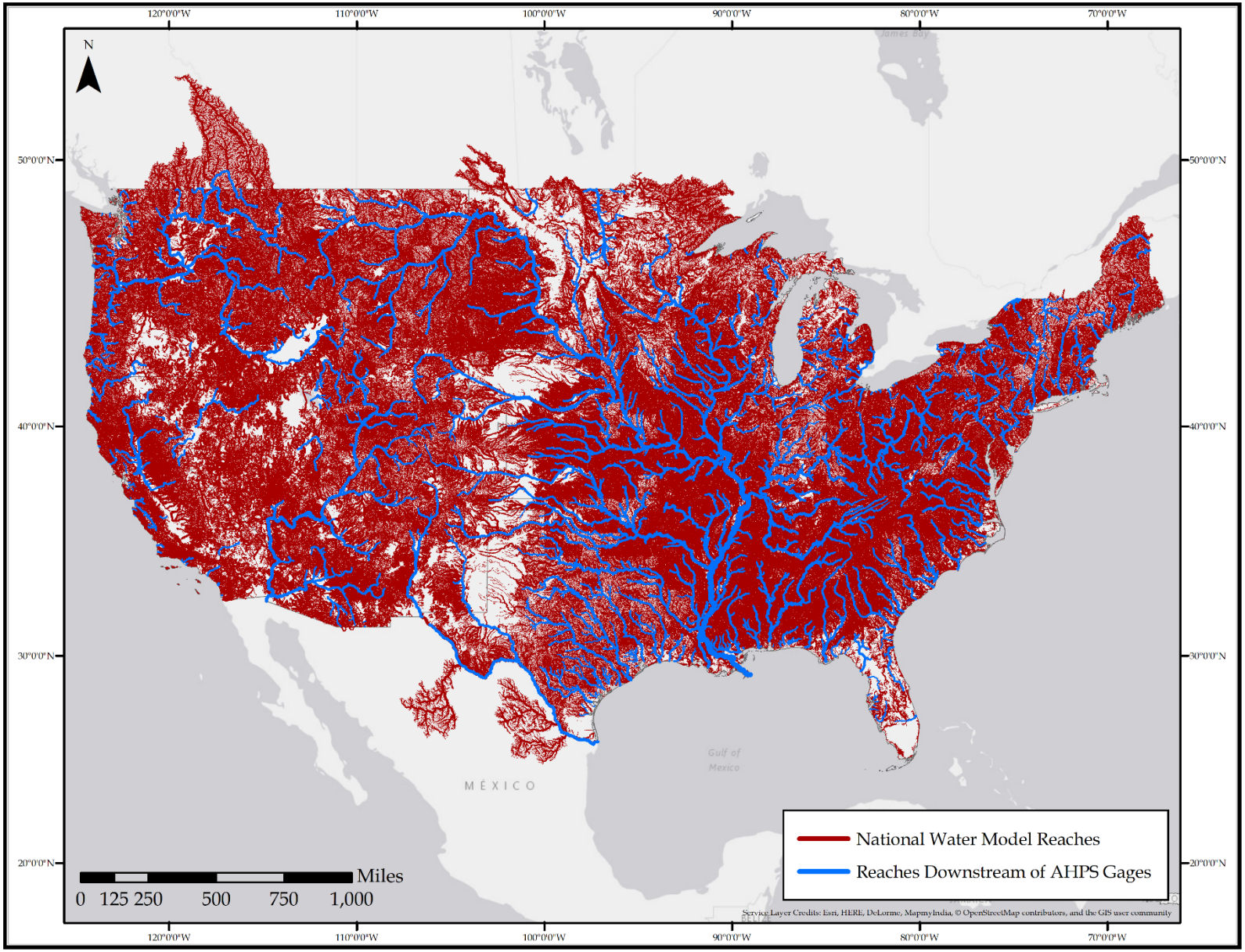
OWP OFFICE OF WATER PREDICTION

National Water Model



National Water Model



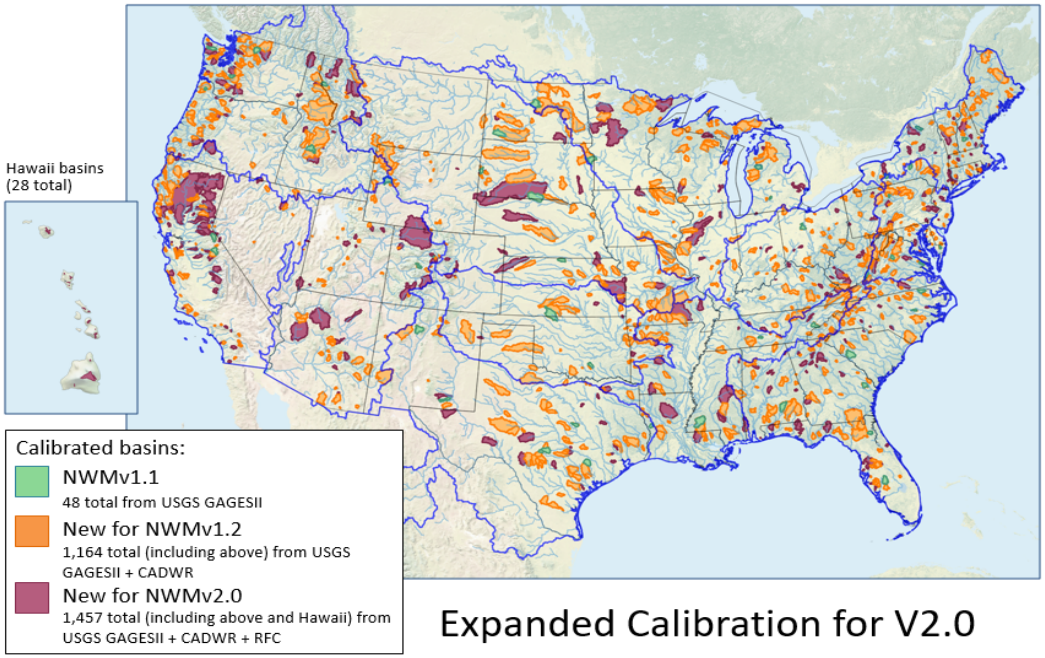
Future Plans: Upgrading to NWM V2.0 and Beyond

v1.0 ⟶ v1.1/1.2 ⟶ v2.0

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

First/Second Upgrade
May 2017/March 2018
Increased cycling freq. and forecast length, improved calibration, soil/snow physics and stream DA

Third Upgrade
June 2019
Expansion to Hawaii, medium range ensembles, compound channel parameterization, increased modularity, improved calibration, longer Analysis w/MPE



Expanded Calibration for V2.0

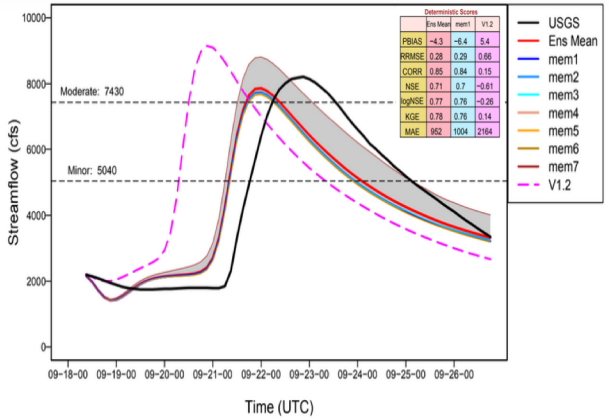
v2.1

Fourth Upgrade
Fall 2020
Expansion to Puerto Rico and Great Lakes, increased modularity, enhanced reservoir module, physics improvements, forcing bias-correction, improved calibration, and improved Hawaii QPE

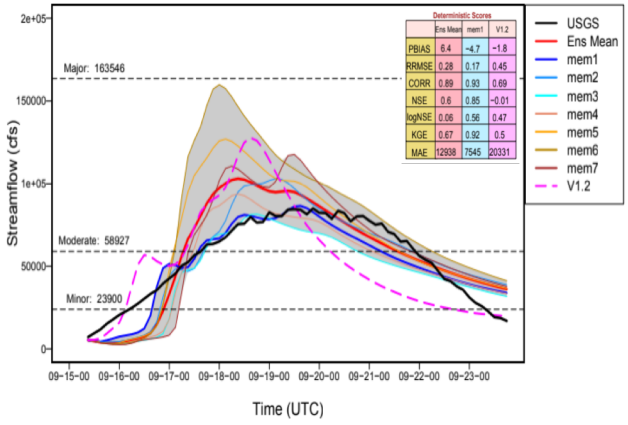
NWM V2.0 Medium-Range Real-time Ensemble Forecast Examples

Hurricane Florence

NWM Medium-Range Forecast (06Z 9/18)
Lynches River at Effingham, SC

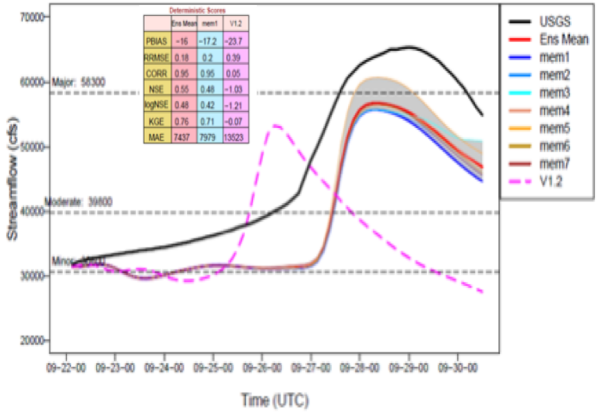


NWM Medium-Range Forecast (06Z 9/15)
Cape Fear River at William O. Huske Lock near Tar Heel, NC

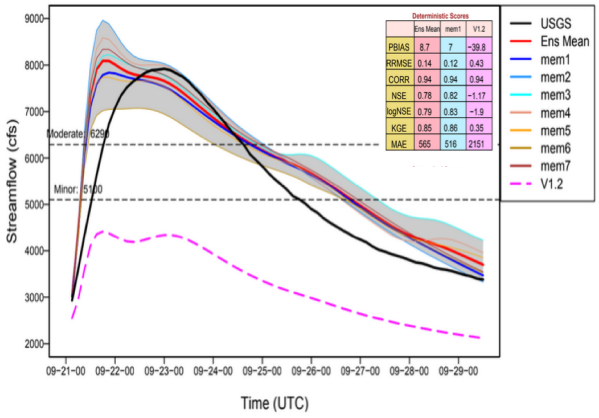


Iowa Flooding

NWM Medium-Range Forecast (00Z 9/22)
Iowa River at Wapello, IA

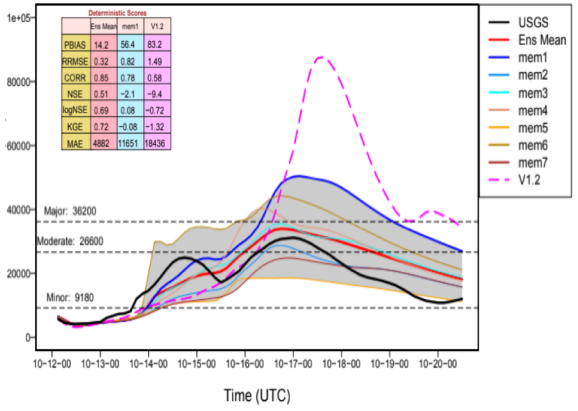


NWM Medium-Range Forecast (00Z 9/21)
East Fork Des Moines River, Near Algona IA

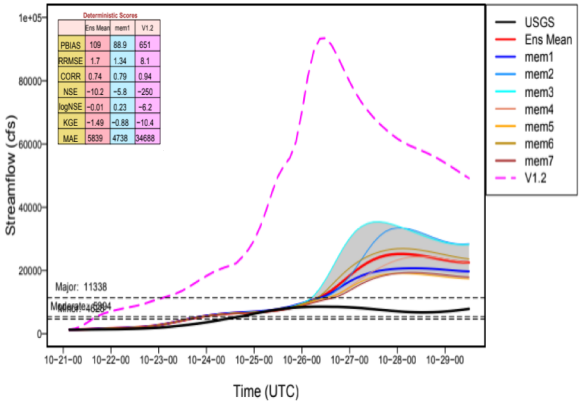


Texas Flooding

NWM Medium-Range Forecast (12Z 10/12)
Trinity River at Dallas, TX



NWM Medium-Range Forecast (00Z 10/21)
Nueces River near Three Rivers, TX



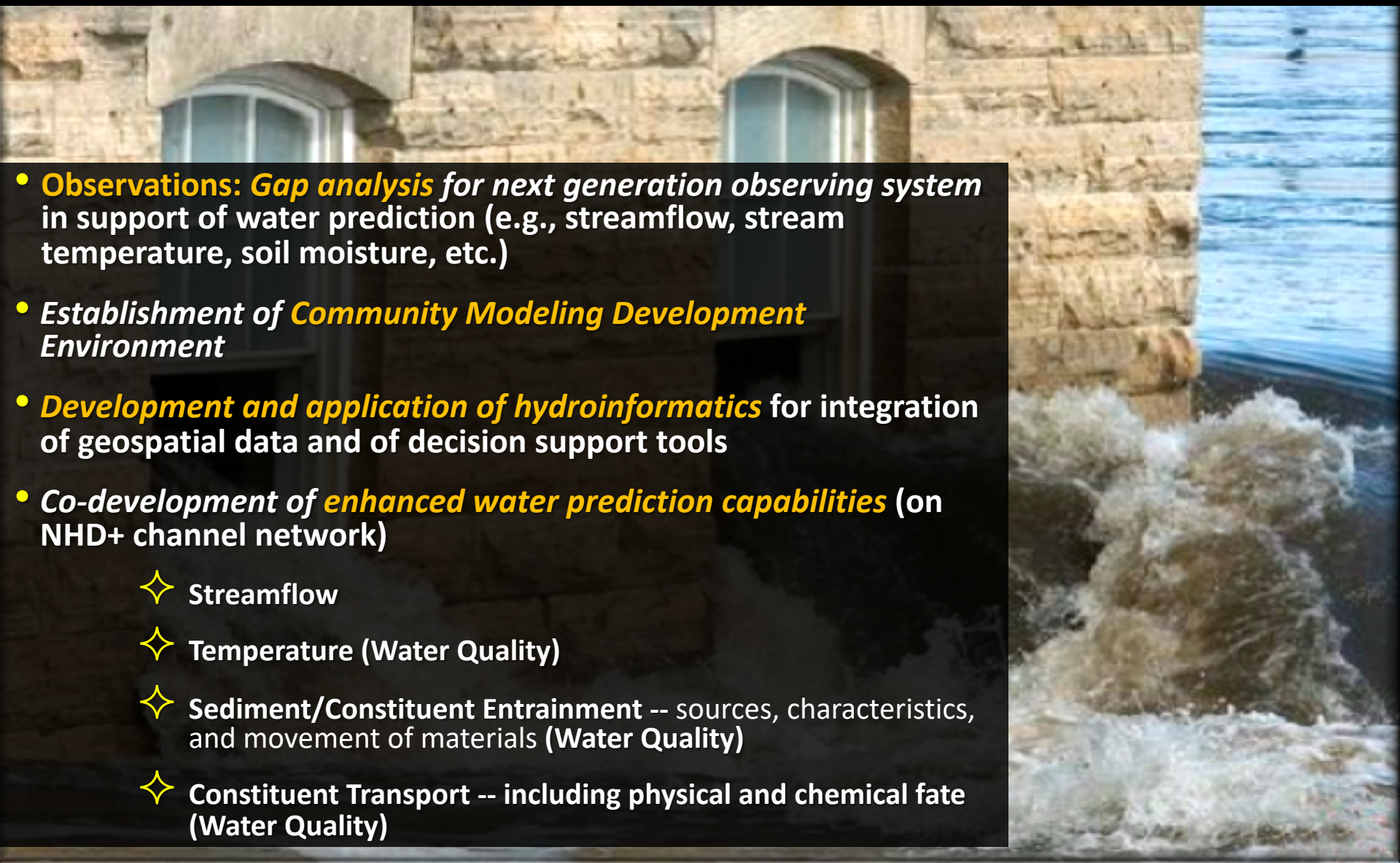
NWM V2.0 displayed good performance for Hurricane Florence flooding, and in Iowa and Texas flood events, new ensemble begins to capture forecast uncertainty

Challenges/Limitations to Improving Water Prediction Capability and Related Services

- Observations, Data, Forcings, Data Assimilation
- Channel Geometry Enhancement
- Model Enhancement, Integration, and Community Development
- Physical Process Understanding
- Accounting for Anthropogenic Processes
- Application of Hydro-informatics for Integration of Geospatial Data and Development of Decision Support Tools
- Communication, including Uncertainty and Risk
- System Interoperability and Data Synchronization
- High Performance Computing Resources

NOAA-USGS National Water Model Collaboration

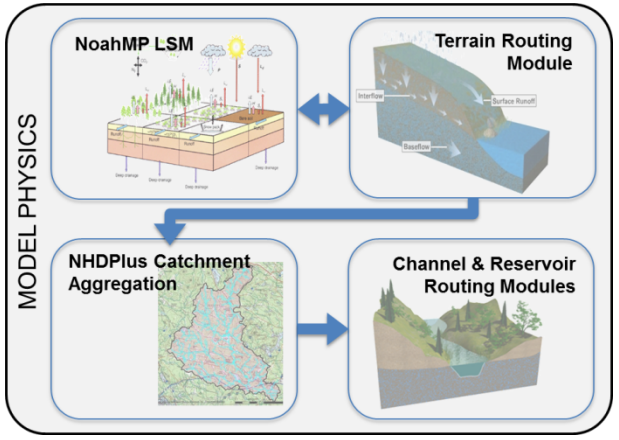
Supported by the USGS Water Prediction Work Program



- **Observations:** ***Gap analysis*** ***for next generation observing system*** **in support of water prediction (e.g., streamflow, stream temperature, soil moisture, etc.)**
- ***Establishment of Community Modeling Development Environment***
- ***Development and application of hydroinformatics*** **for integration of geospatial data and of decision support tools**
- ***Co-development of enhanced water prediction capabilities*** **(on NHD+ channel network)**
  - **Streamflow**
  - **Temperature (Water Quality)**
  - **Sediment/Constituent Entrainment** -- sources, characteristics, and movement of materials **(Water Quality)**
  - **Constituent Transport -- including physical and chemical fate (Water Quality)**

NWM 3.0 Development: Modularity and Community Collaboration

- Community development and collaboration is central to the NWM enterprise effort
- OWP is embarking upon a major, multi-year effort, building on and expanding community
  - Improve on existing modularity of NWM processes using a step-wise, version-over-version approach
  - Spin-up a community code management system
  - Implement a development sandbox with uniform NWM code base and supporting data
- Formulation of this sandbox is ongoing, input will be gathered partners and NOAA EPIC Program
- End Goal: A system which supports community development and funnels innovation into a common platform that can be leveraged for both research and operations across a wide range of scales and applications.

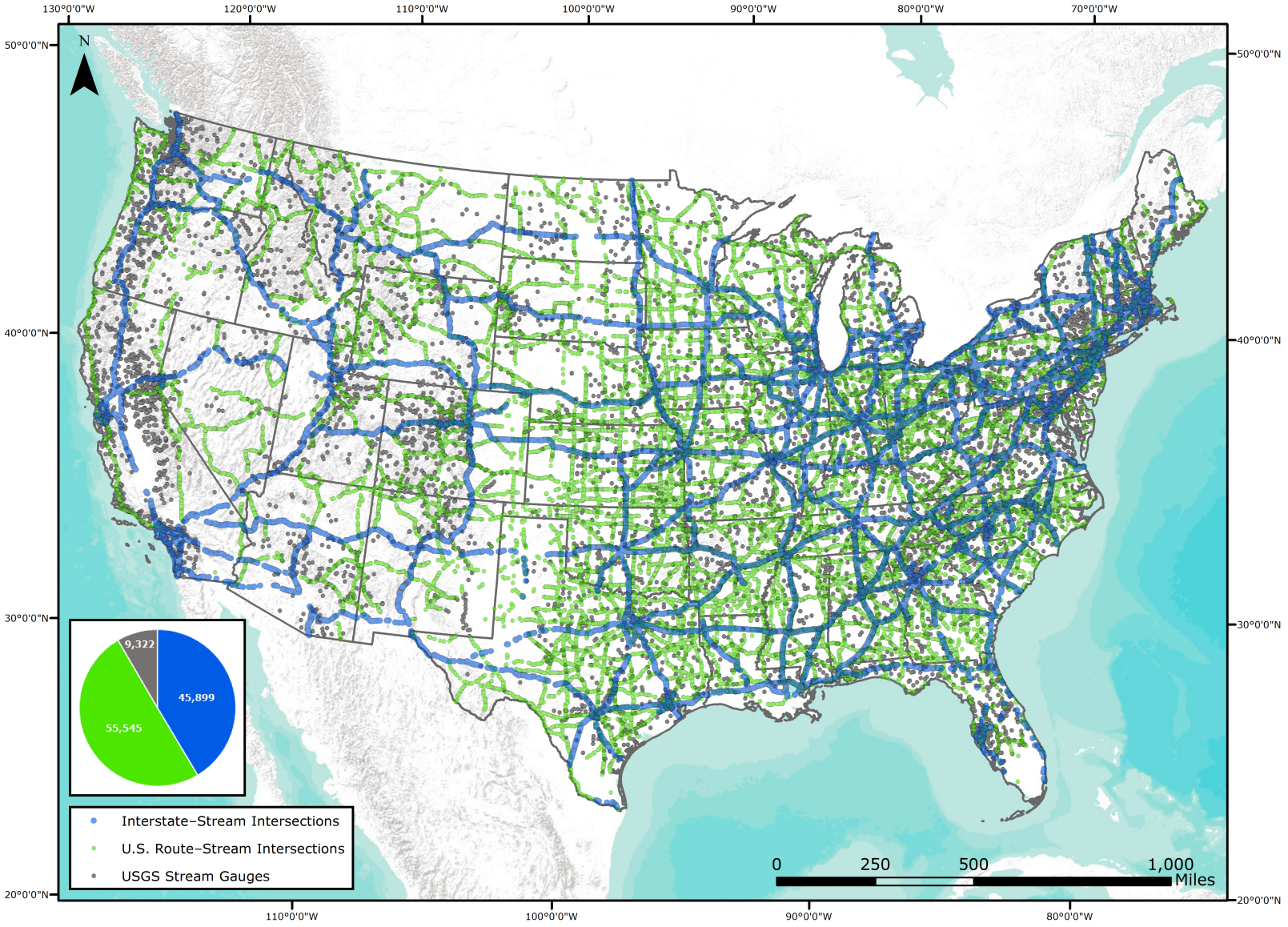


Example of existing modular components within the National Water Model

Backup Slides

National Water Model

Collaboration Opportunity: Intersecting Networks



Water Prediction Operations Division

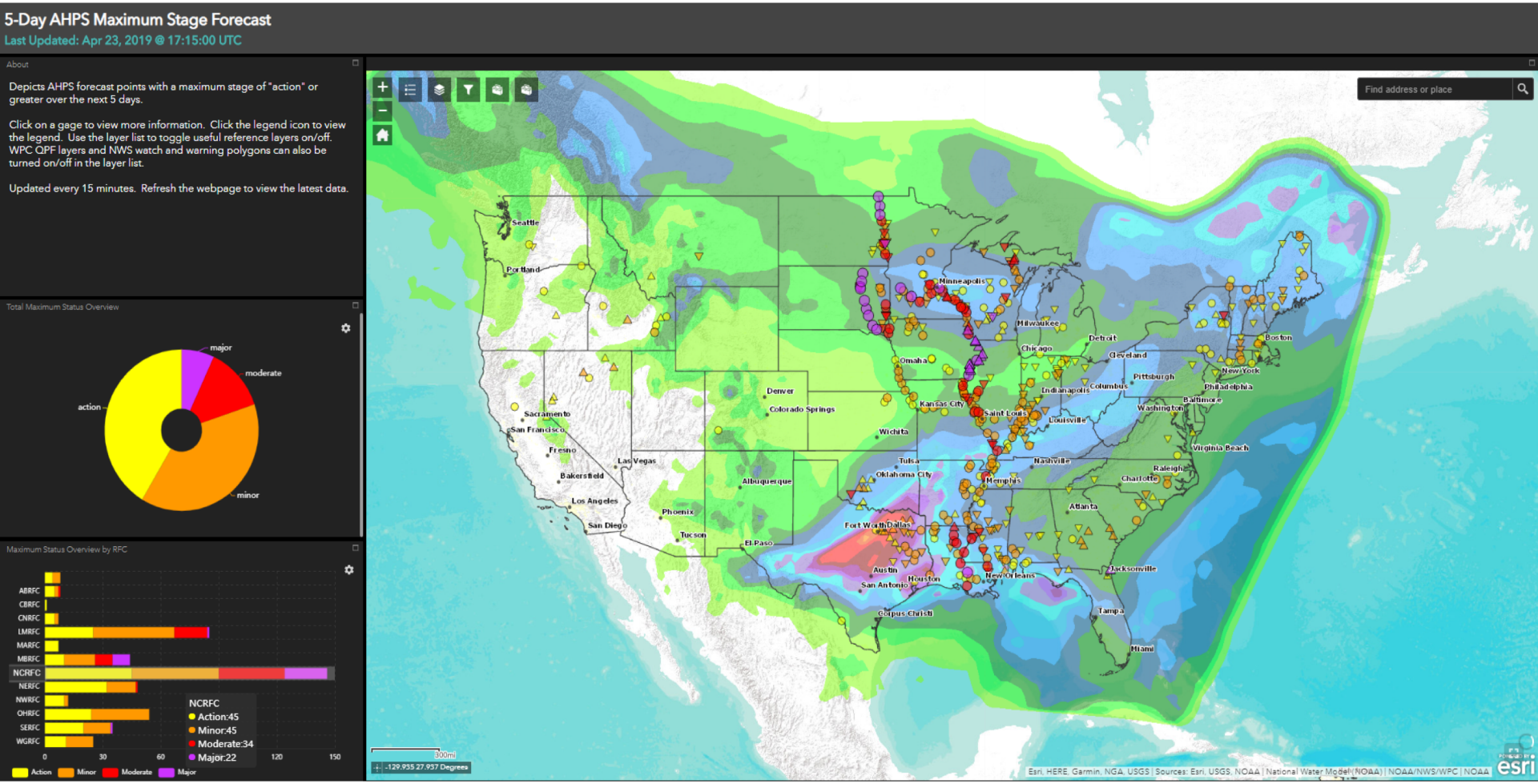
Pre IOC Status (as of today)

- Director
- 9 Staff
- Selected: 2 GS-12
- Hiring in Process: 1 GS-14
- Hours Monday through Friday
- 5AM - 4PM

IOC Status (Oct 1, 2019)

- 13 Total (12 Forecasters,
- 1 System Admin)

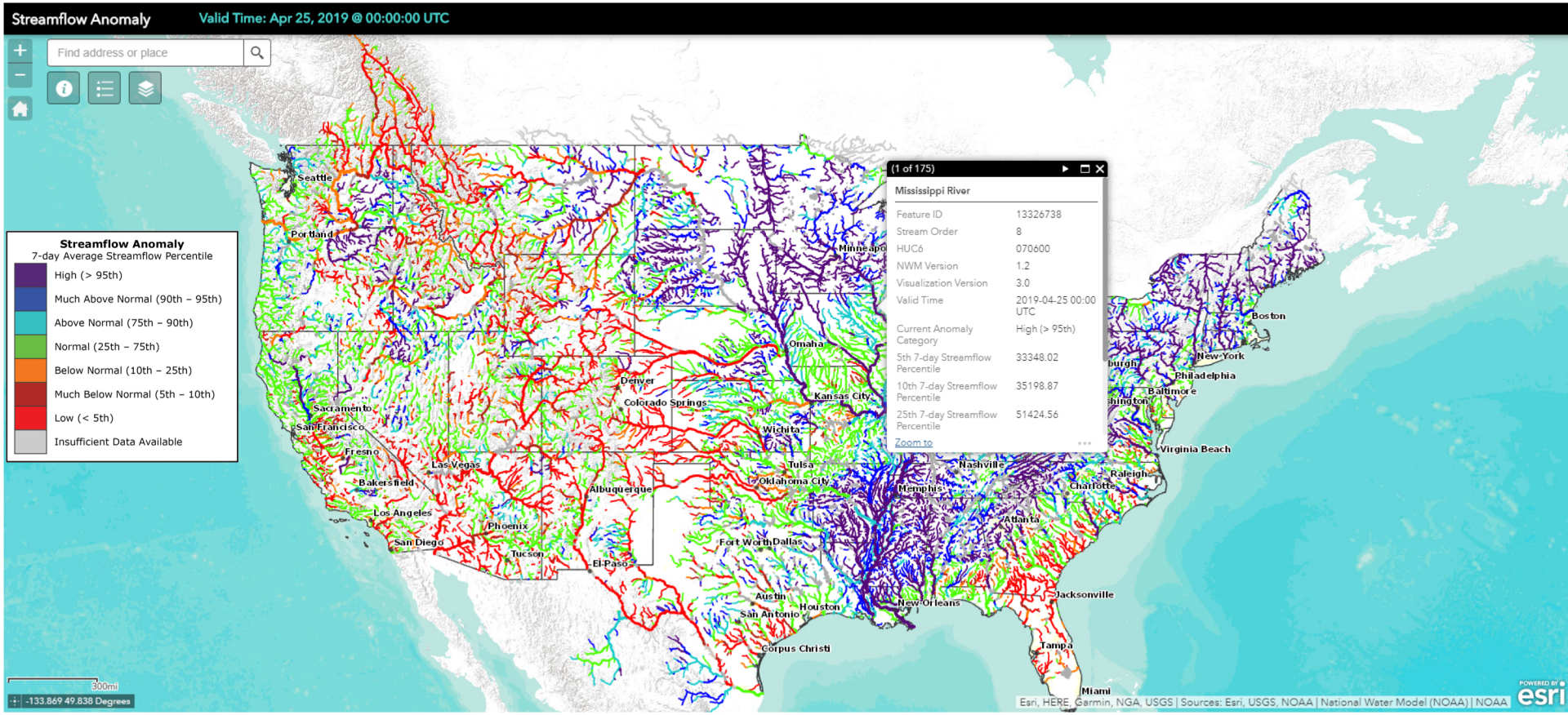
Data Services: AHPS Dash Board



Data Services: National Water Model - Streamflow

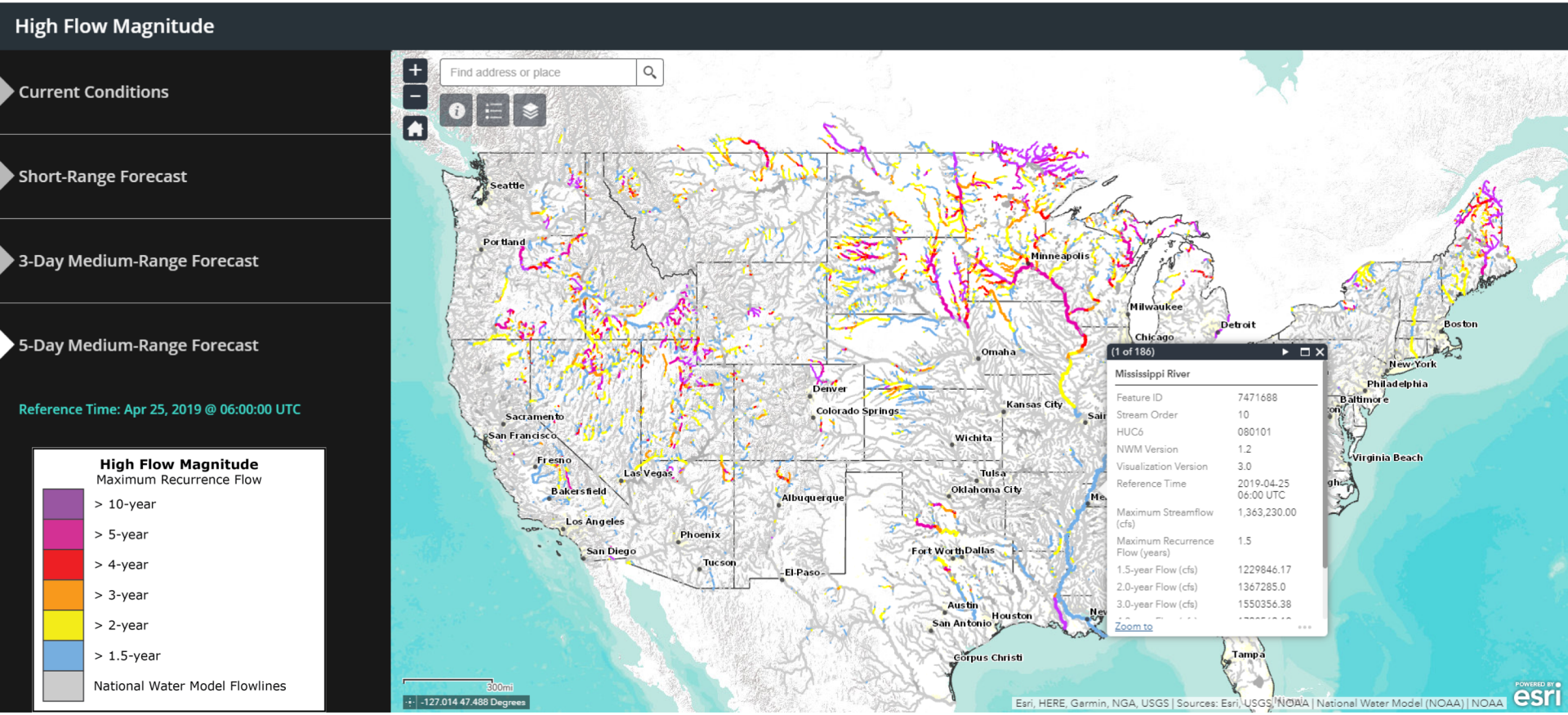
Depicts the latest discharge (cfs) output from the NWM (v1.2), showing current conditions. Updated hourly.

Data Services: National Water Model - Streamflow Anomaly



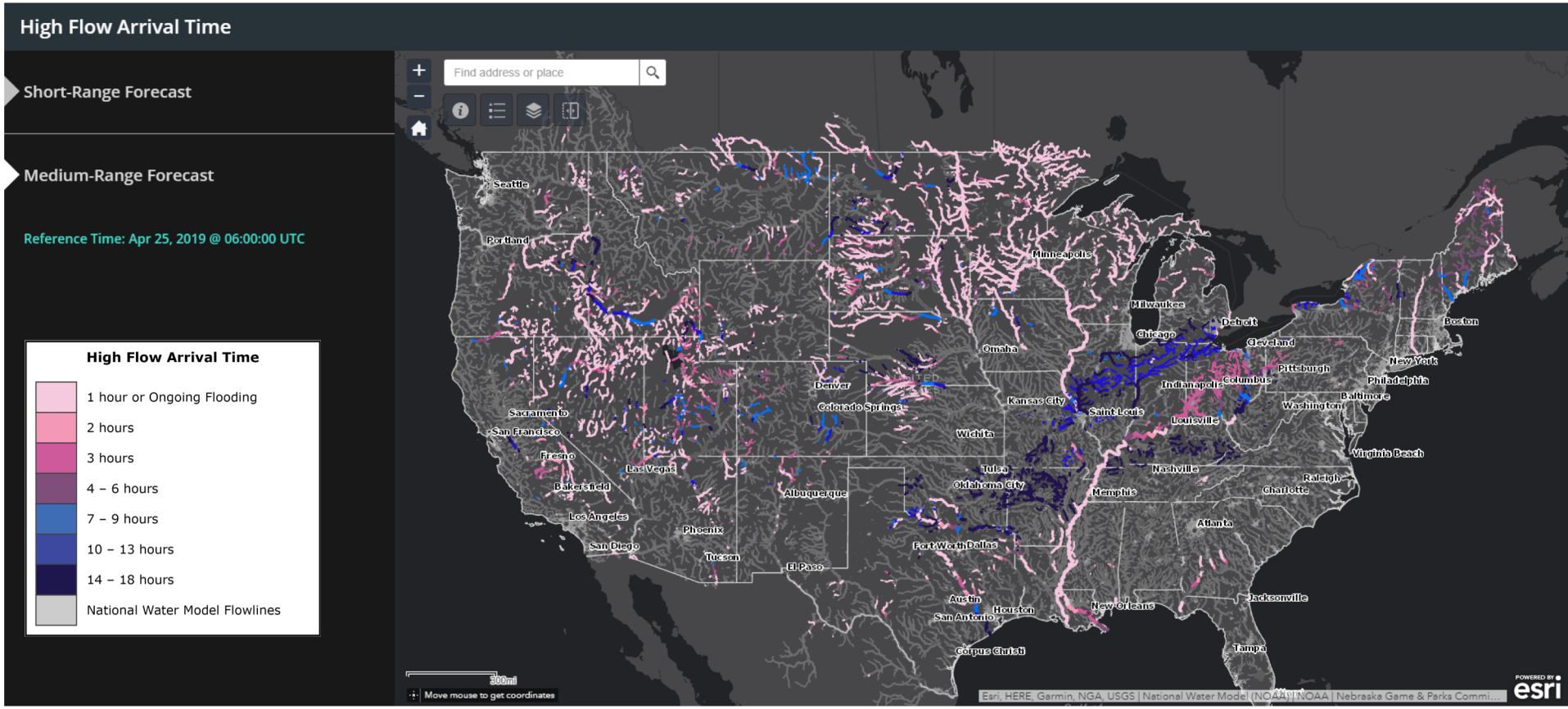
Depicts current seasonal streamflow anomalies derived from the past 7 days of NWM (v1.2) output. Anomalies are based on 7-day average streamflow percentiles for each reach for the current calendar day. Streamflow percentiles were derived from 7-day streamflow averages for each reach for each calendar day using a 23-year retrospective analysis of the NWM (v1.2). Updated daily.

Data Services: National Water Model - High Flow Magnitude



Depicts expected high flow magnitudes derived from the latest NWM (v1.2) current and forecast output. Shown are reaches that are expected to be at or above their 1.5-year recurrence flow. Recurrence flows were derived from annual maxima across a 24-year retrospective analysis of the NWM (v1.2).

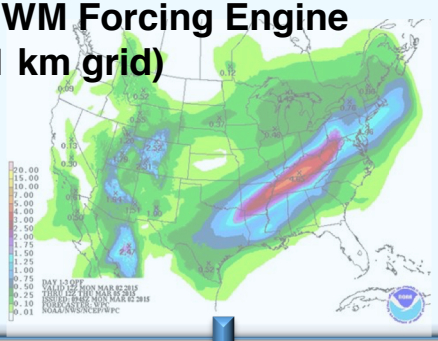
Data Services: National Water Model - High Flow Arrival Time



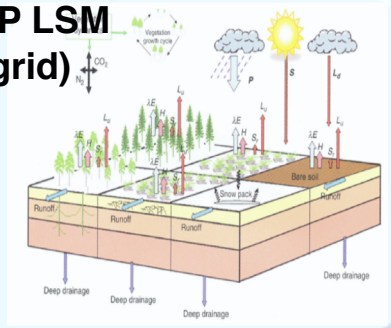
Depicts expected high flow arrival times derived from the latest NWM (v1.2) current and forecast output. Shown are reaches that are expected to be at or above their 1.5-year recurrence flow, and when they are expected to exceed that threshold. Recurrence flows were derived from annual maxima across a 24-year retrospective analysis of the NWM (v1.2).

National Water Model
Initial Operating Capability:
Model Chain

1. NWM Forcing Engine
(1 km grid)

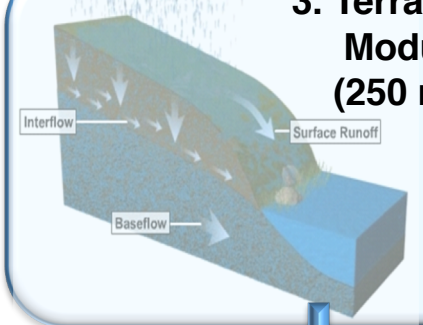


2. NoahMP LSM
(1 km grid)

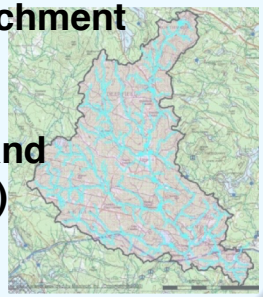


2-way coupling

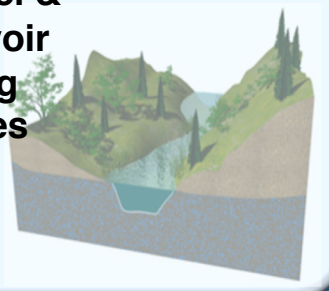
3. Terrain Routing
Module
(250 m grid)



4. NHDPlus Catchment
Aggregation
(2.7M unique
catchments and
river reaches)



5. Channel &
Reservoir
Routing
Modules



NWM uses NCAR supported community WRF-Hydro system

NWM: http://water.noaa.gov/about/nwm

WRF-Hydro: https://www.ral.ucar.edu/projects/wrf_hydro