Transforming NOAA Water Prediction For A Water Prepared Nation

NWS Partners Meeting

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National Water Center
Tuscaloosa, AL

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National Weather Service, NOAA

Outline

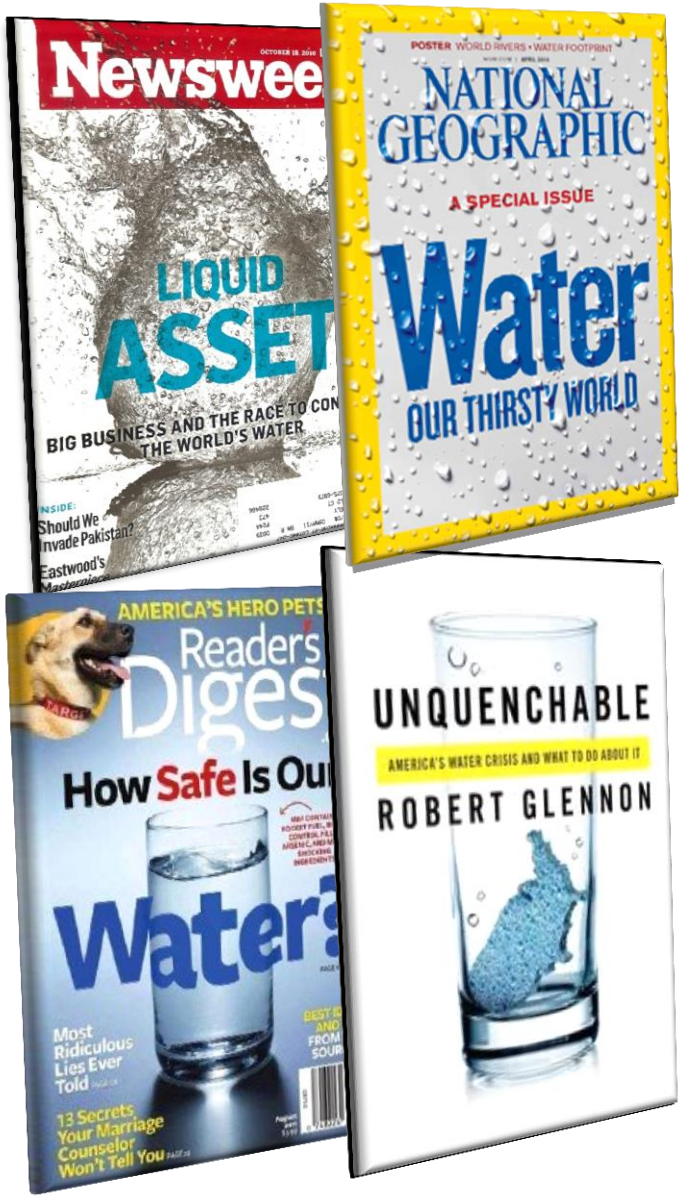
- Impetus for Change
- NWC Status and Plans
- Partnerships
- Services Overview
- Summary

TOO MUCH

TOO LITTLE

POOR QUALITY

Impetus for Change
Growing Water Challenges



Multiple Threats

- 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
- Socio-economic risks of floods and droughts are escalating

National Academy of Sciences Report:

Weather Services for the Nation: Becoming Second to None

Findings	Recommendations
NWS Modernization and Restructuring (MAR) did not directly address hydrologic prediction services	Prioritize core capabilities - a MAR-like effort is needed to address long-standing and deep-seated issues in hydrology
A significant gap exists between the state of hydrologic science today and current NWS hydrologic operations The level of sophistication, representation of processes, and characterization of uncertainties in external research and operational communities outpace those used in NWS hydrology operations	Improve pathways for collaboration & accelerate R2O Establish a hydrologic prediction testbed as part of the National Water Center Implement a consistent framework for hydrologic prediction skill assessment
NWS Hydrologic Forecasters are extensively *"in the forecast loop"*	Transition RFC forecasters to "over the loop" enabling a shift in focus to model and product development, forecast interpretation, and decision support
Qualifications for hydrologist positions were not updated in the MAR to require degreed hydrologists Lack of skill in modern computational programming, construction and use of new Earth System Models, current hydrologic data assimilation methodologies, and preparation and interpretation of meaningful ensemble predictions	Hydrologist staff require re-education and continual retraining to enable adoption of state-of-the-art prediction methodologies Instill evolutionary culture Add value to hydrologic forecasts through the use of more advanced models, data assimilation and employment of more sophisticated ensemble techniques

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

Collaborative Science-Based Solutions to Address Service Needs

USGS science for a changing world

Water 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 will expand over time

CUAHSI

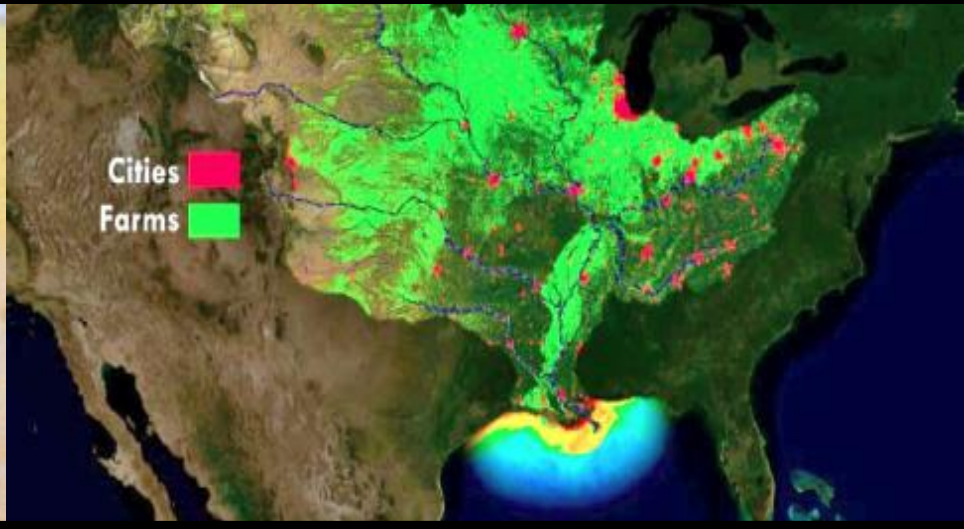
U.S. Department of the Interior Bureau of Reclamation

NRCS

WATER EXTREMES

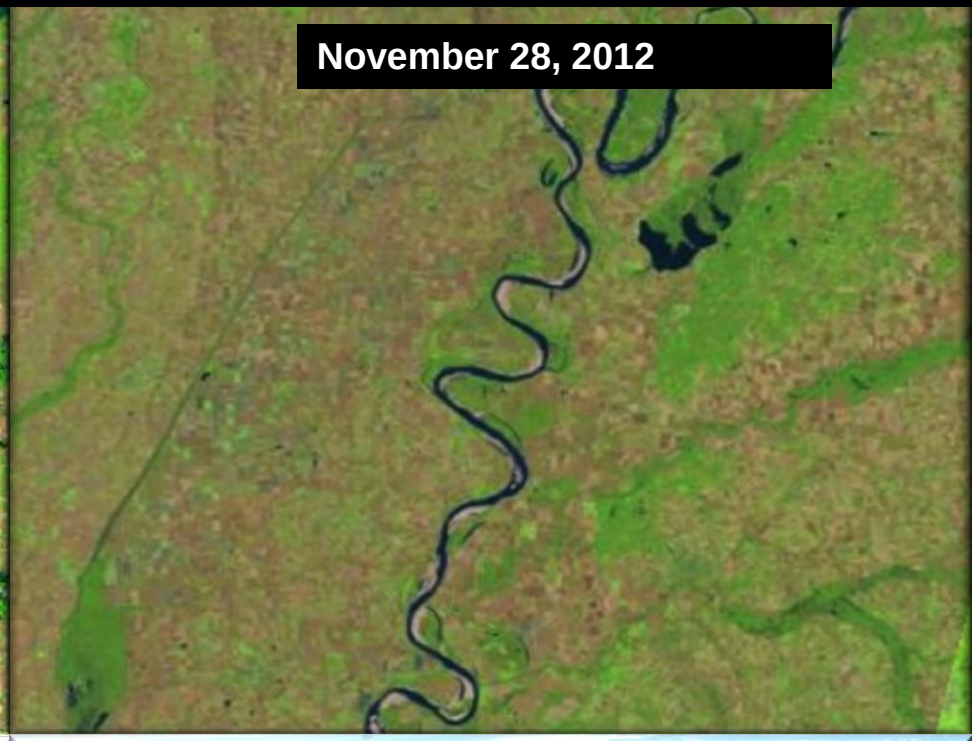
WATER SECURITY

WATER QUALITY

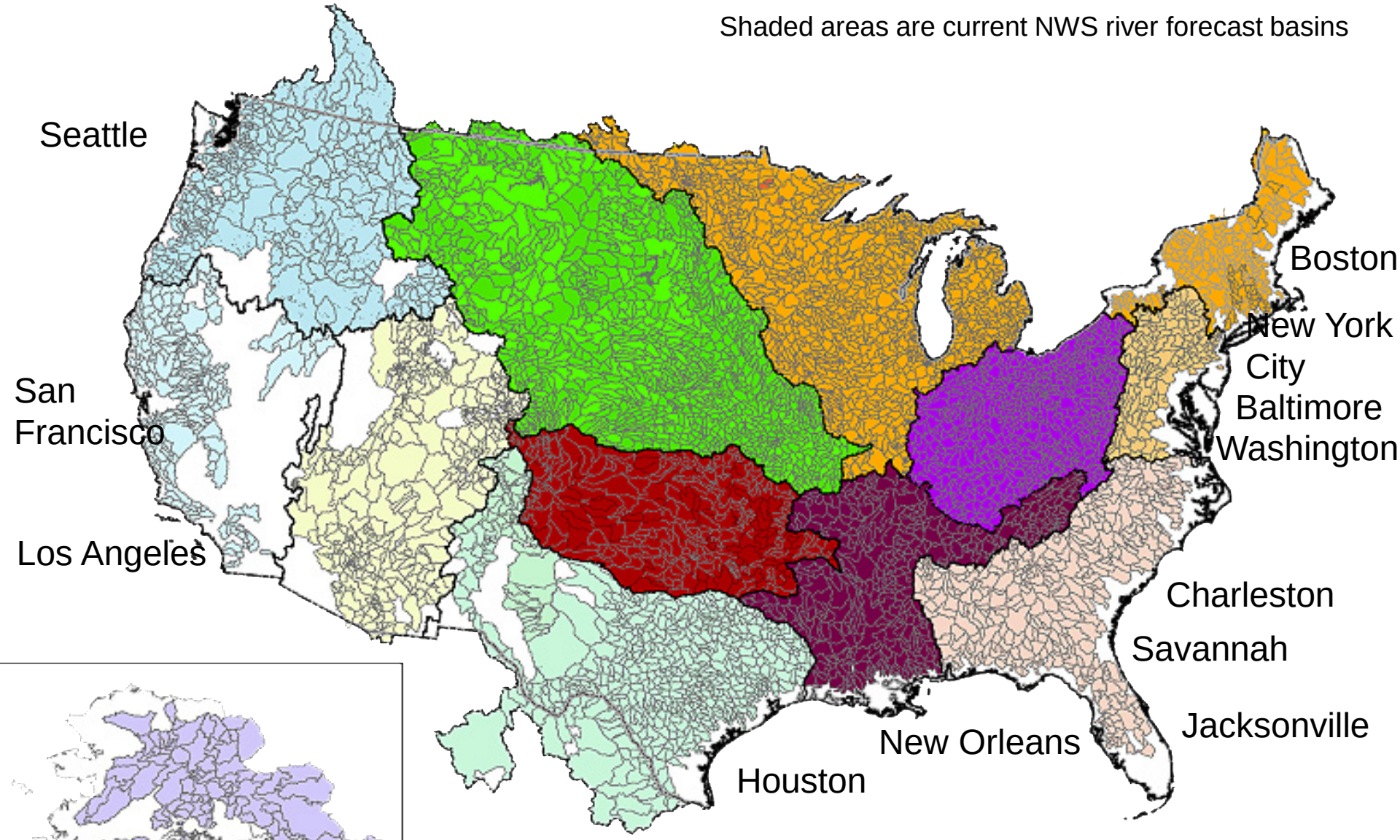


Interrelated Grand Challenges

Grand Challenge examples:
Mississippi River Above Memphis, TN



NWS River Forecast Centers



Over 100 million people live in the white space near the coast that don't get a water forecast today

Initial Stakeholder Priorities

Flooding

Water Quality

Water Availability

Drought

Climate Change

Need integrated understanding of near- and long-term outlook and risks

Actionable Water Intelligence

High Resolution, Integrated Water Analyses, Predictions and Data

Transform information into intelligence by linking hydrologic, infrastructural, economic, demographic, environmental, and political data

Regional Water Conversations
What did we hear?

- River Forecast Centers (RFCs) valued highly
- Account for anthropogenic processes across all prediction platforms
- Verify and validate
- Provide uncertainty information for forecast guidance on all time scales
- Extend the forecast range of the National Water Model (NWM)
- Provide more high performance computing capacity for the NWM
- Continue the implementation of the Hydrologic Ensemble Forecast Service (HEFS)
- Sustain engagement (End-to-end leveraging social science best practices)
- Improve quantitative precipitation forecasts on all time scales
- More stream gages
- For water resources, impact based decision support includes both event-driven, high-impact events and routine, high-value decision making

Integrated Water Prediction

Setting the Stage for Transformation

Centralized Water Forecasting Demonstration (2015)	Enhanced Water Prediction Capability (2016)	Integrated Water Prediction (2017 Proposed)
• 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 • Couple terrestrial freshwater and coastal estuary models for total water predictions in the coastal zone • New service delivery model for coastal and inland communities

National Water Center

Initial Operating Capacity: May 26, 2015

A catalyst to transform NOAA's water prediction program

Mission: Nationally Integrated Water Prediction

- Earth system modeling and geo-intelligence
- Operations Center for water resources common operating picture
- Decision support services for spectrum of water stakeholders
- Proving ground to accelerate research to operations
- Interagency and Academia Collaboration
- Center of excellence for water resources science and prediction

National Water Center Innovators Program

- Partnership between **NWS and the academic community** (Interagency Agreement between NSF and NOAA) with two fundamental goals:
  - Provide a Framework for Collaboration
  - Target Emerging Technologies
- **Year one** included a **Summer Institute** for 44 graduate students from 19 Universities at the National Water Center, June 1 to July 17, 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
  - A more elaborate version of this prototype is currently scheduled to become operational as the **National Water Model**

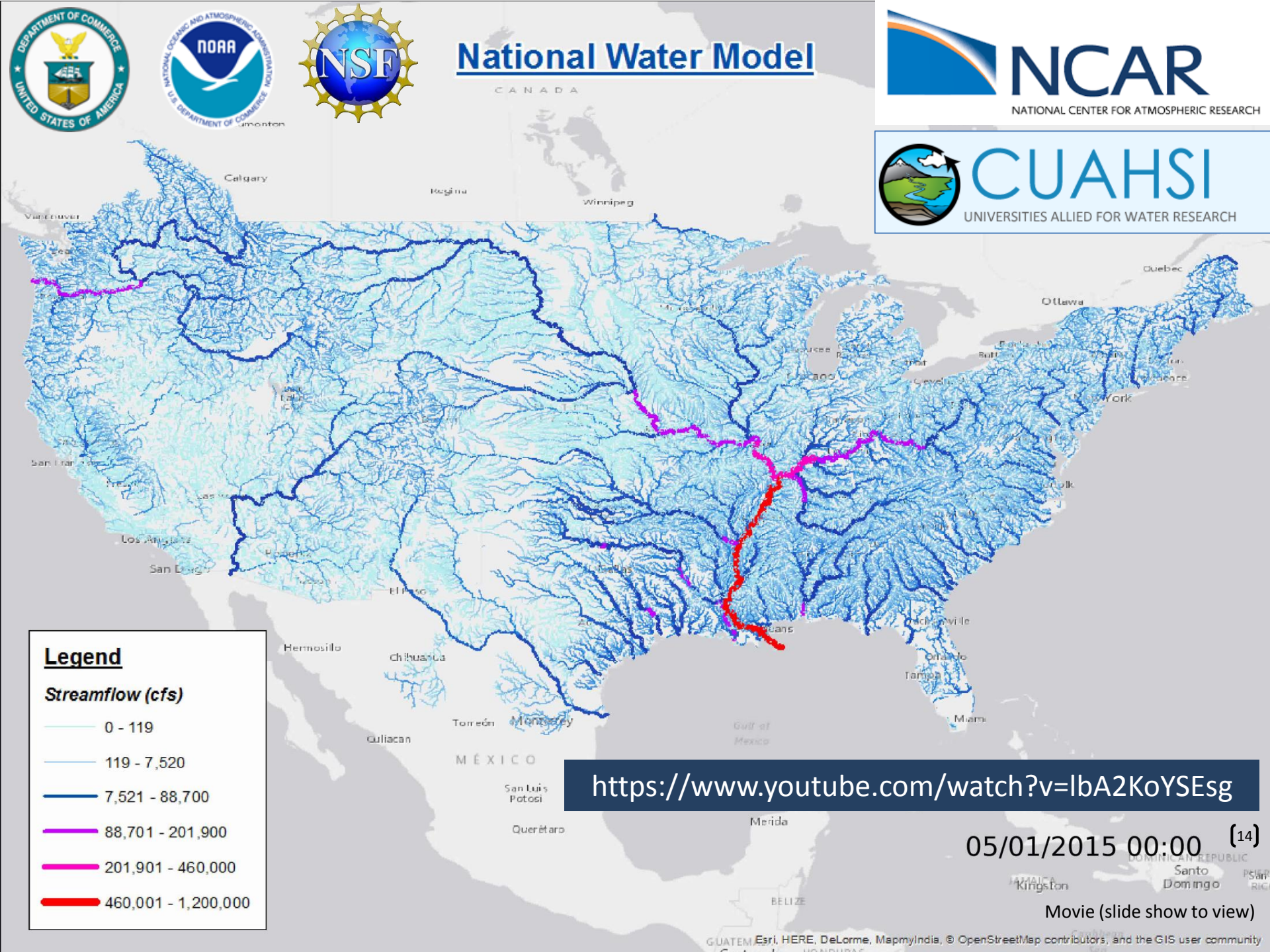
CUAHSI
UNIVERSITIES ALLIED FOR WATER RESEARCH

NSF

DEPARTMENT OF COMMERCE · UNITED STATES OF AMERICA

NOAA · NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION · U.S. DEPARTMENT OF COMMERCE

National Water Model



https://www.youtube.com/watch?v=lbA2KoYSEsg

05/01/2015 00:00

Movie (slide show to view)

National Water Model Version 1.0

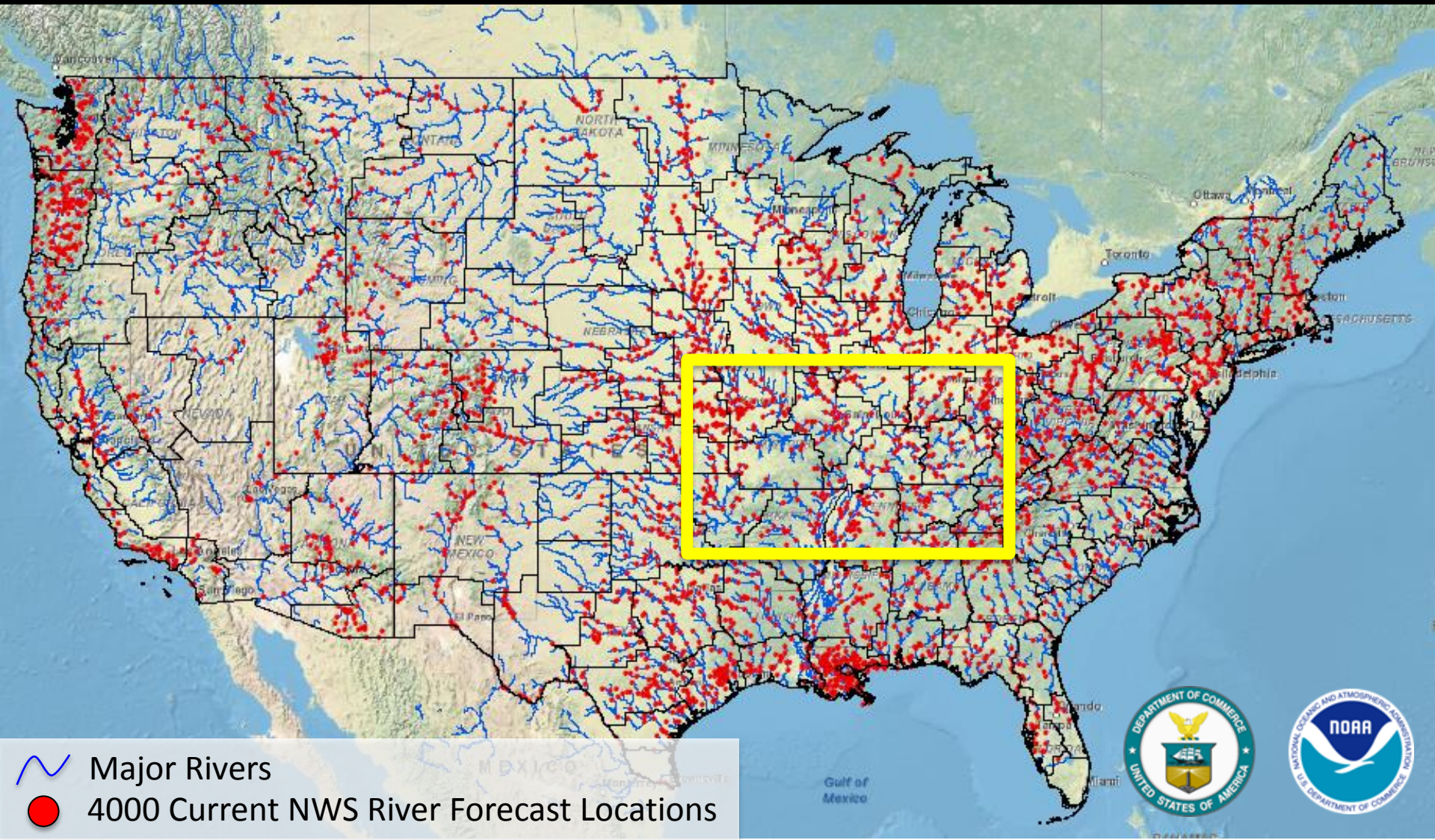
- **WCOSS Implementation and guidance product availability in FY16 Q4**
  - Office of Water Prediction/National Center for Atmospheric Research/National Centers for Environmental Modeling partnership
  - 30-day stability test/evaluation ends August 5th, implementation August 16th
- **Foundation for sustained growth in nationally consistent operational hydrologic forecasting capability**
- **Goals for NWM V1.0**
  - Provide forecast streamflow guidance for underserved locations
  - Produce spatially continuous national estimates of hydrologic states (soil moisture, snow pack, etc.)
  - Implement a modeling architecture that permits rapid infusion of new data and science, and allows for geointelligence linkages

Transforming NOAA Water Prediction

TODAY	THE FUTURE
Approximately 4000 forecast locations at points	Approximately 2,700,000 forecast stream reaches
Forecast river flow/stage, from summit to coastal zone	Forecast all hydrologic parameters which define the water budget, from summit-to-sea
Driven by large catchment "lumped" modeling	Driven by high resolution Earth System modeling
Forecaster "*in the loop*" – serial, basin to basin, modeling of flow through the river network	Forecaster "*over the loop*" – simultaneous modeling of the nation's entire river network (will no longer need to be "in the loop")
Average basin size greater than 420 square miles	Average basin size ~1 square mile
13 River Forecast Centers developing separate versions of the same regional model	NOAA, academia, and federal partners developing/evolving same national, community-based model
Impact-based forecasts at selected points	Predictions linked with detailed local infrastructure data to communicate street level impacts

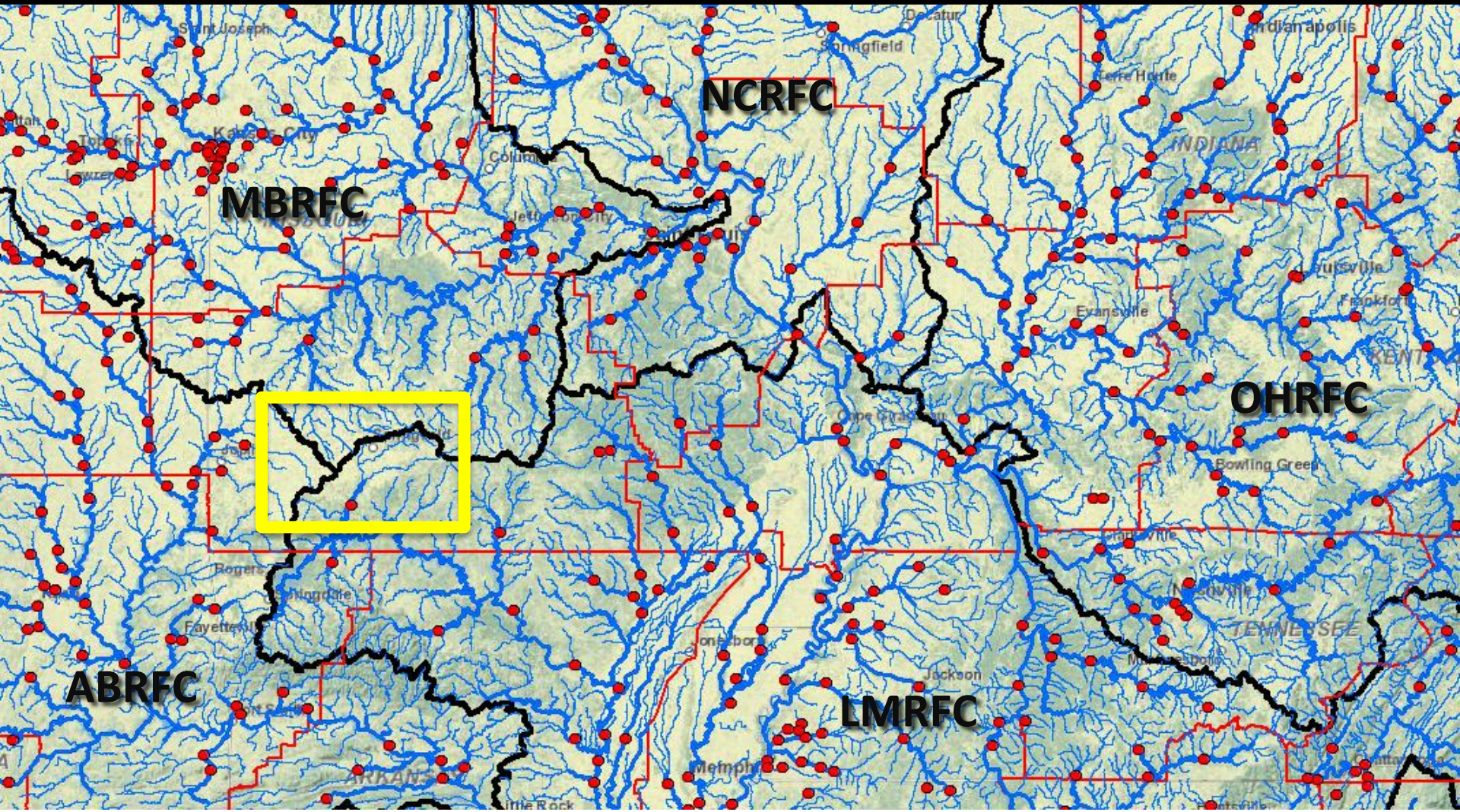
For the hydrology community, the implementation of the NWM and the leap ahead capability it provides parallels the implementation of mesoscale atmospheric models in the 1970s (i.e., model resolution substantially greater than available observational network)

Major Rivers and NWS Hydrologic Forecast Locations (Today)



River Forecast Centers, Major Rivers, and NWS Hydrologic Forecast Locations (Today)

Middle Mississippi River



Full Resolution National Hydrography Dataset NHD+
Forecasts for every stream reach
(2.7 million across U.S.)
Water Prediction + National Infrastructure = Water Intelligence

Springfield, Missouri
(Population: 165,000)

Every stream segment ("reach") gets a forecast

Current NWS Hydro Forecast Location
James River at Galena, MO
(40 miles downstream)

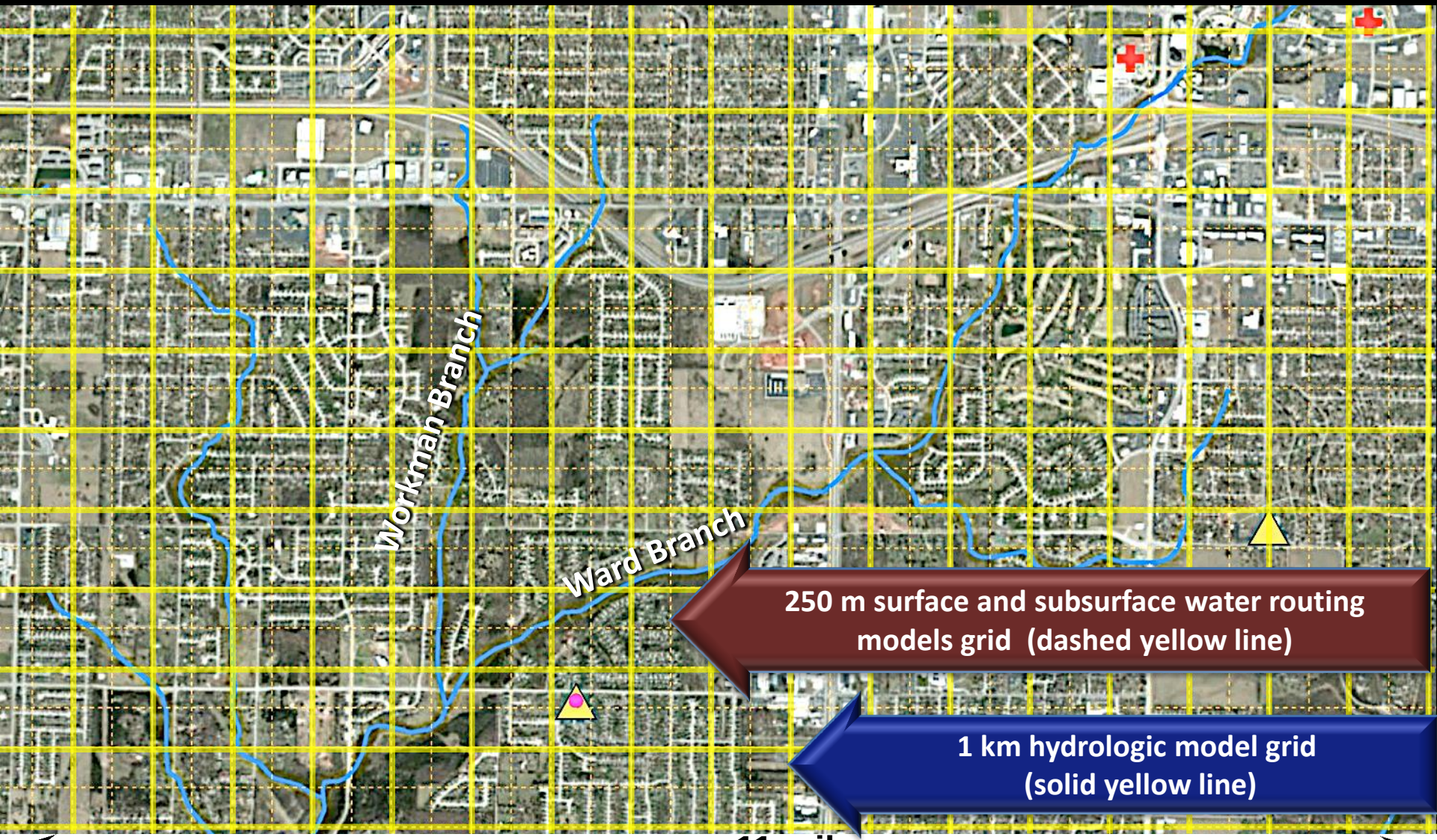
150 km

Hospitals EMS Fire

Infrastructure Data from National Geospatial Intelligence Agency

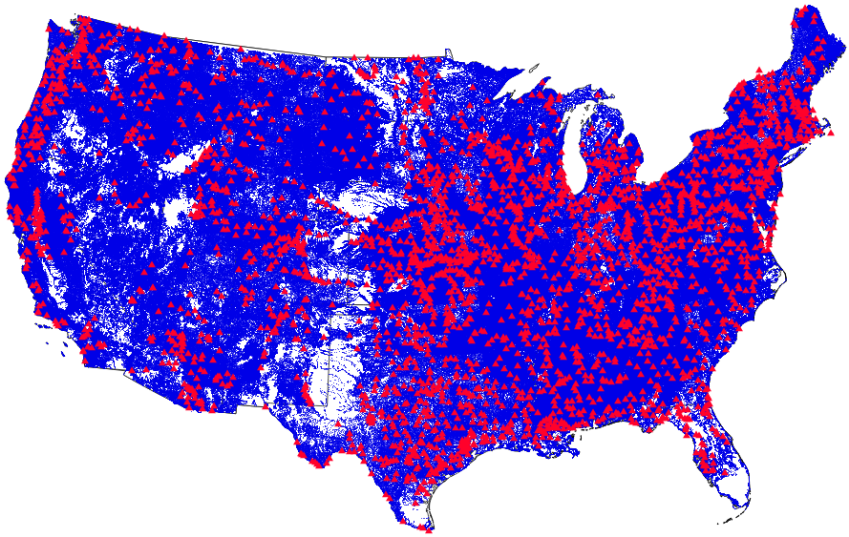
Water Prediction + National Infrastructure

Hospitals, EMS & Fire Stations

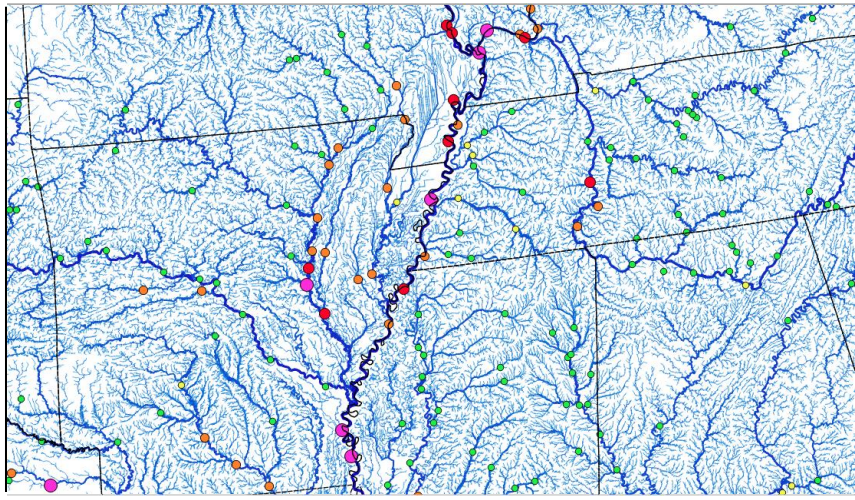


NWM V1.0 Model Guidance Output

- **Hydrologic Output**
  - River channel discharge and velocity at 2.7 million river reaches
  - Ponded water depth and depth to saturation (250 m CONUS+ grid)
- **Land Surface Output**
  - Soil moisture on 1km CONUS+ grid
- **Data Services**
  - Public-facing NWC website (animation, zoom, point and click hydrographs)
  - Data feed to River Forecast Centers
  - NOMADS data service (NOAA National Operational Model Archive & Distribution System)



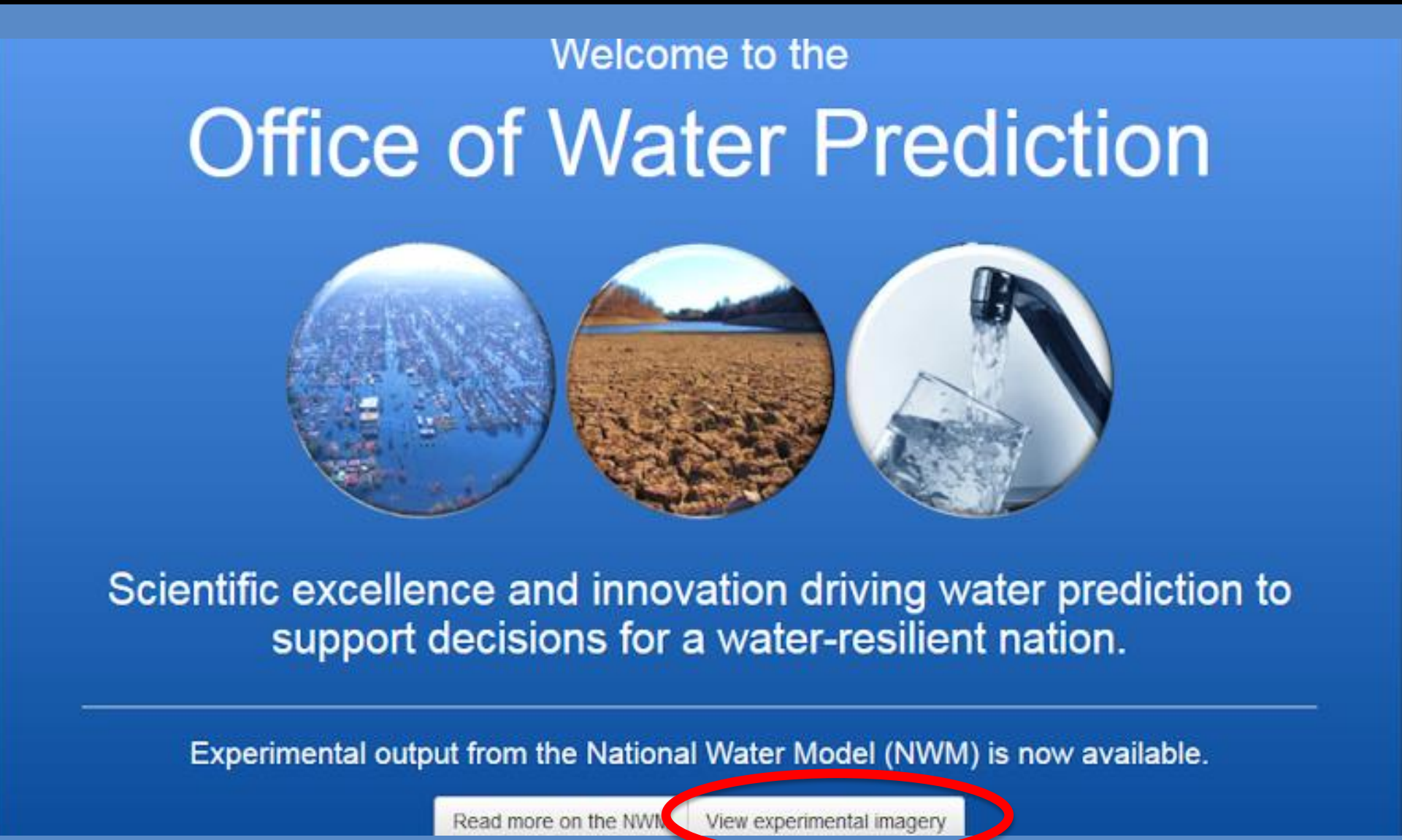
Current NWS AHPS points (red)
NWM output points (blue)



Current NWS River Forecast Points (circles)
Overlaid with NWM Stream Reaches

National Water Model (NWM)

Accessing Model Guidance Output (FY16 Q4)



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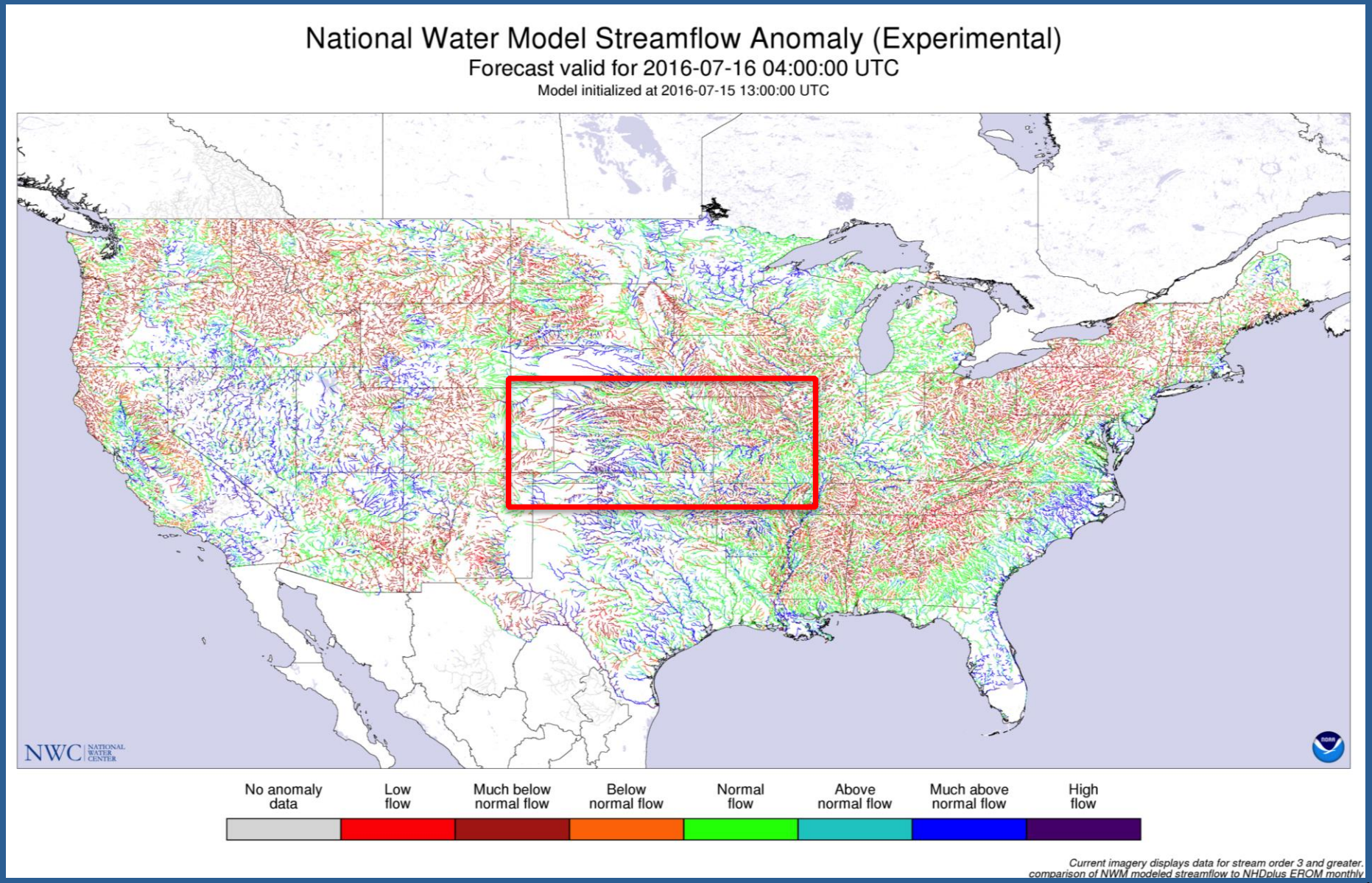

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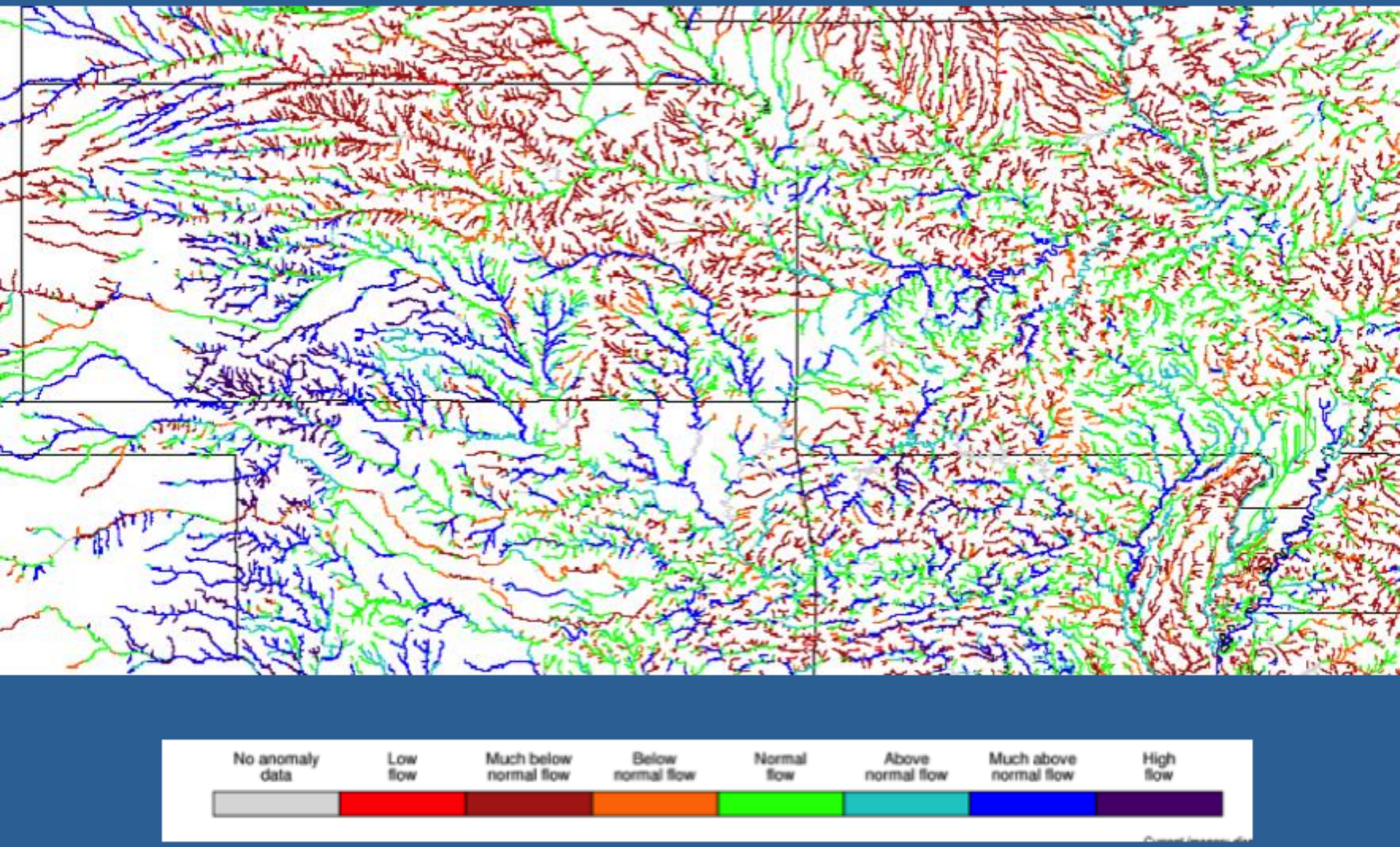

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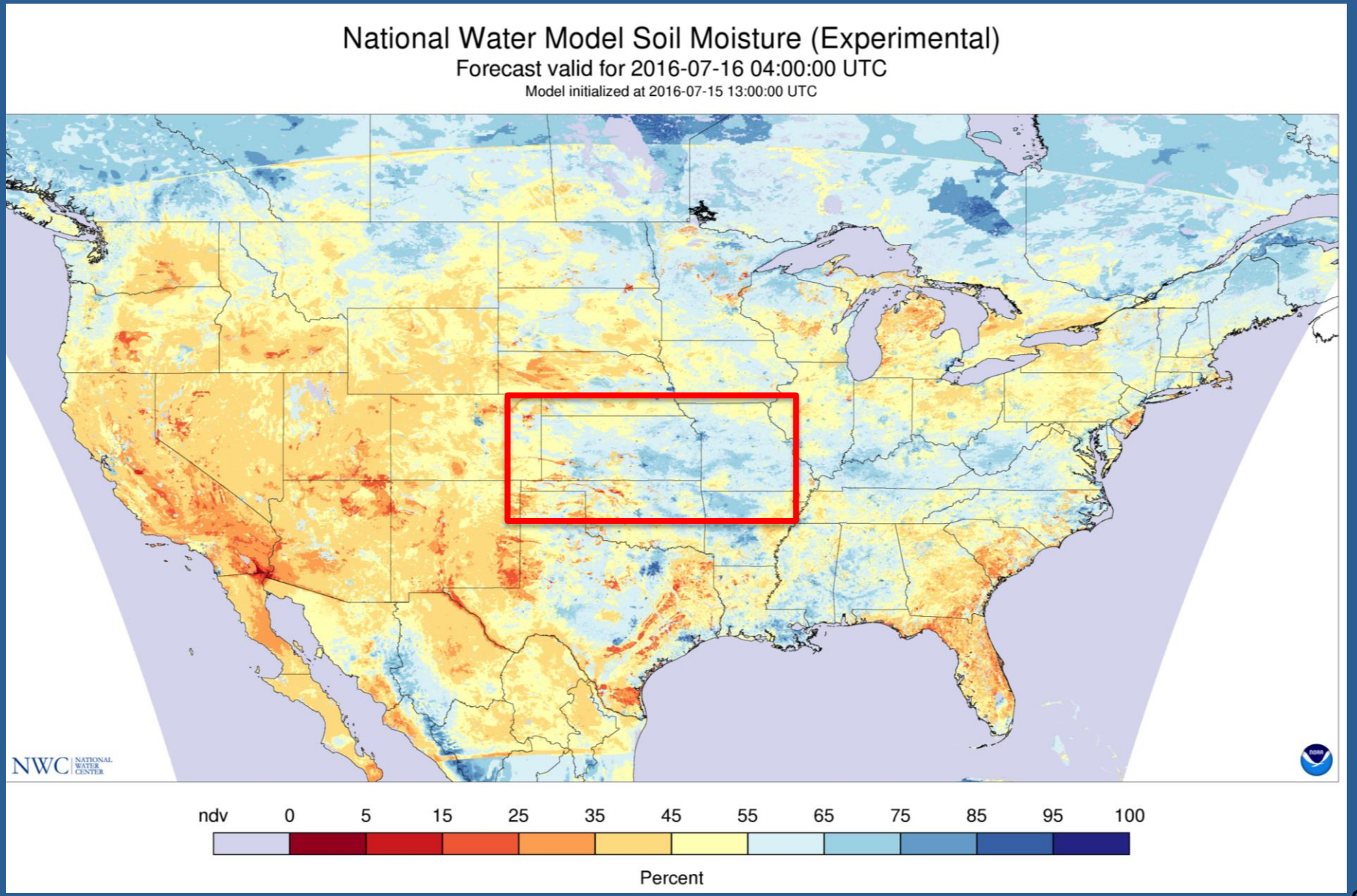

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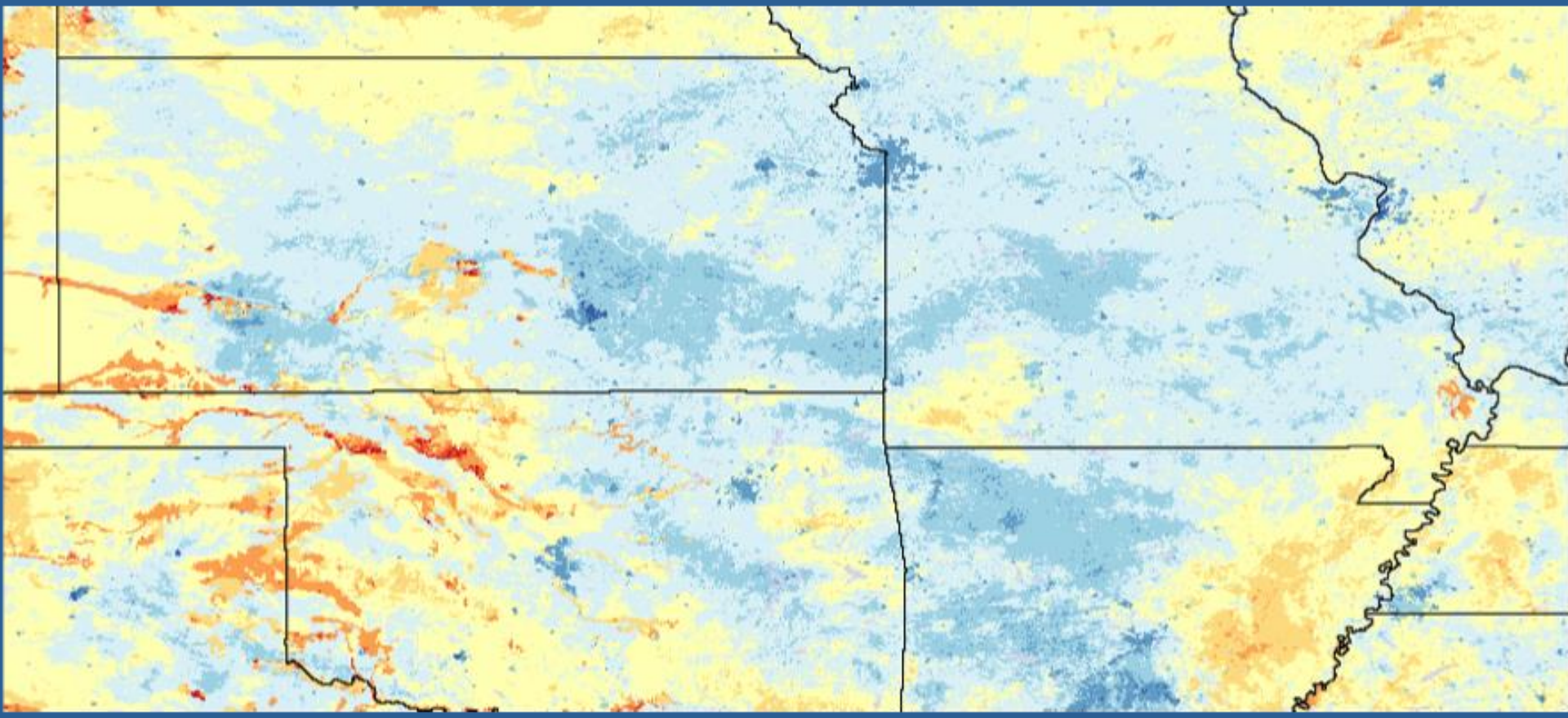
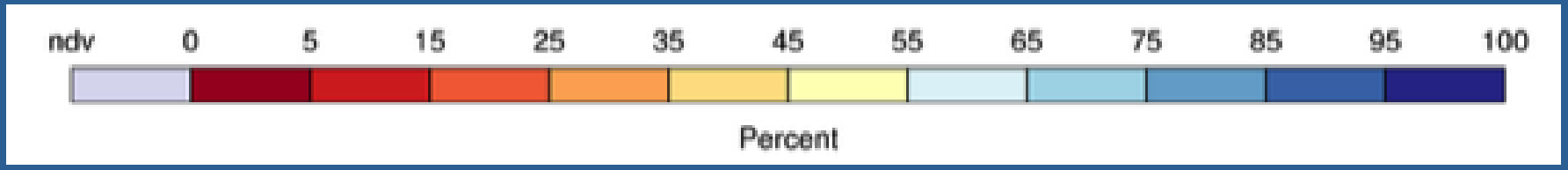
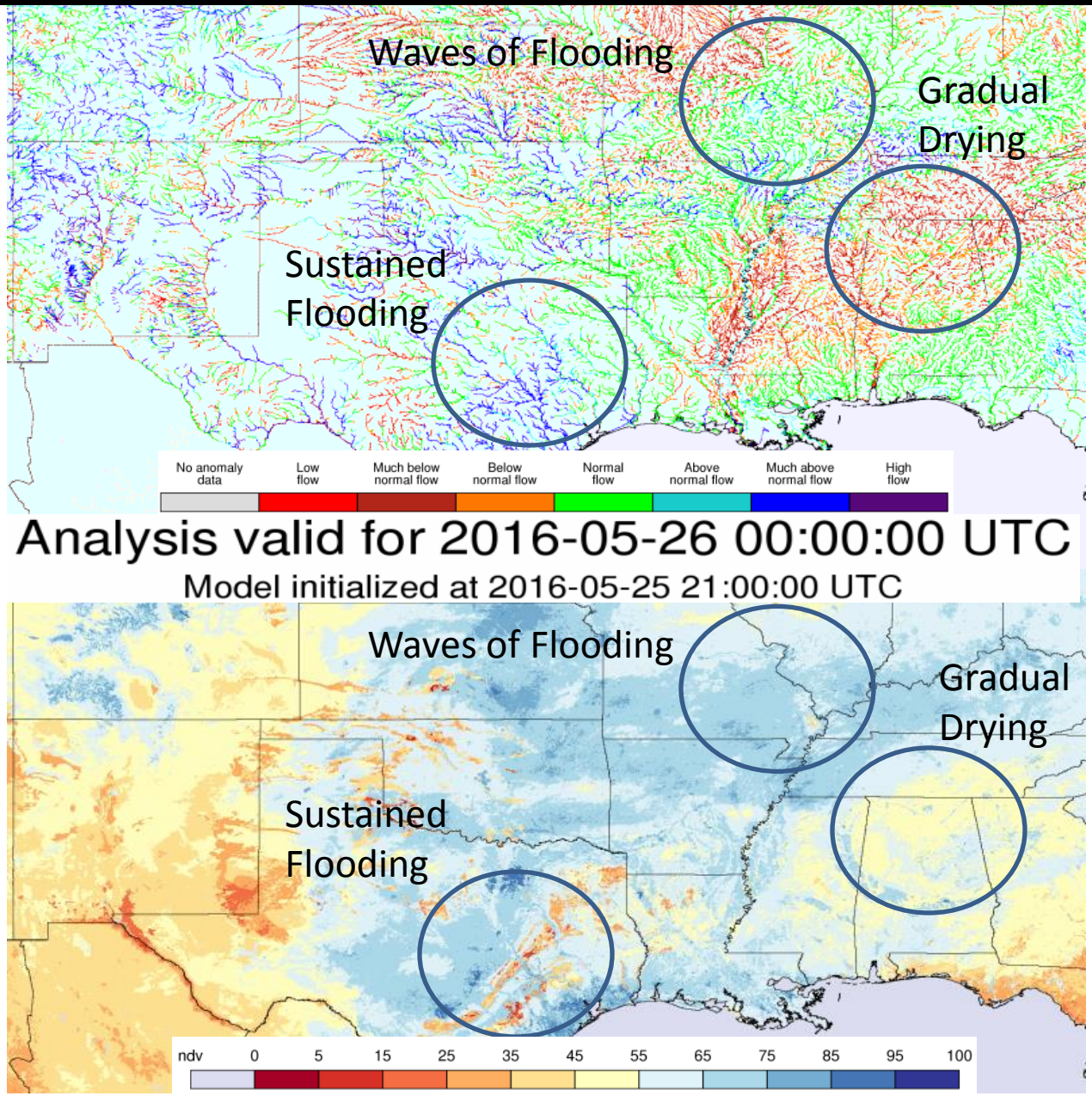




NWM V1.0 Experimental Output Visualization

- Web-hosted real-time images of streamflow, streamflow anomaly and soil moisture
- Will be replaced by dynamic web-based geoserver, allowing for dynamic full-resolution zooming



Value in joint examination of soil moisture saturation (bottom) and streamflow anomaly (top)

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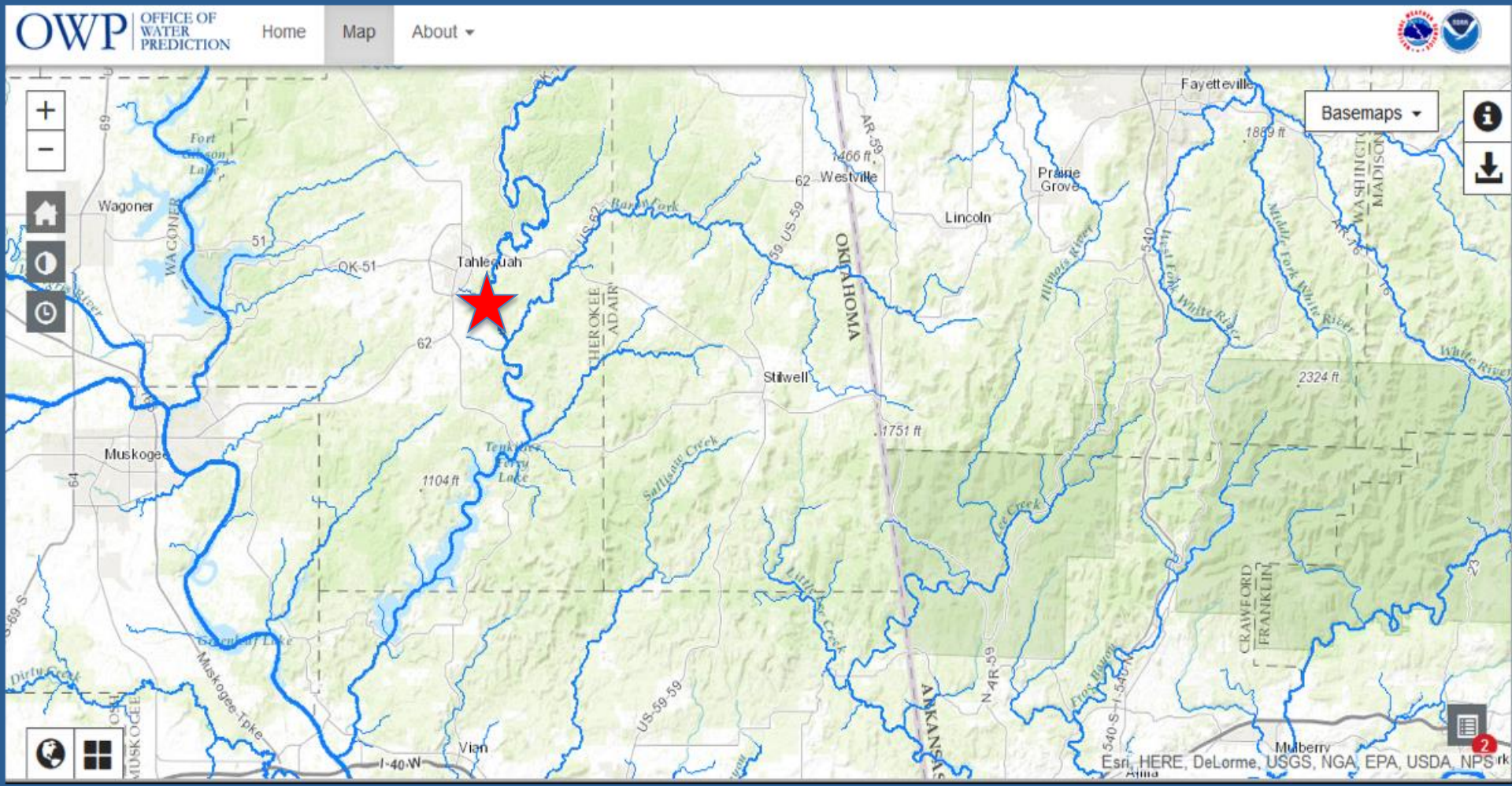

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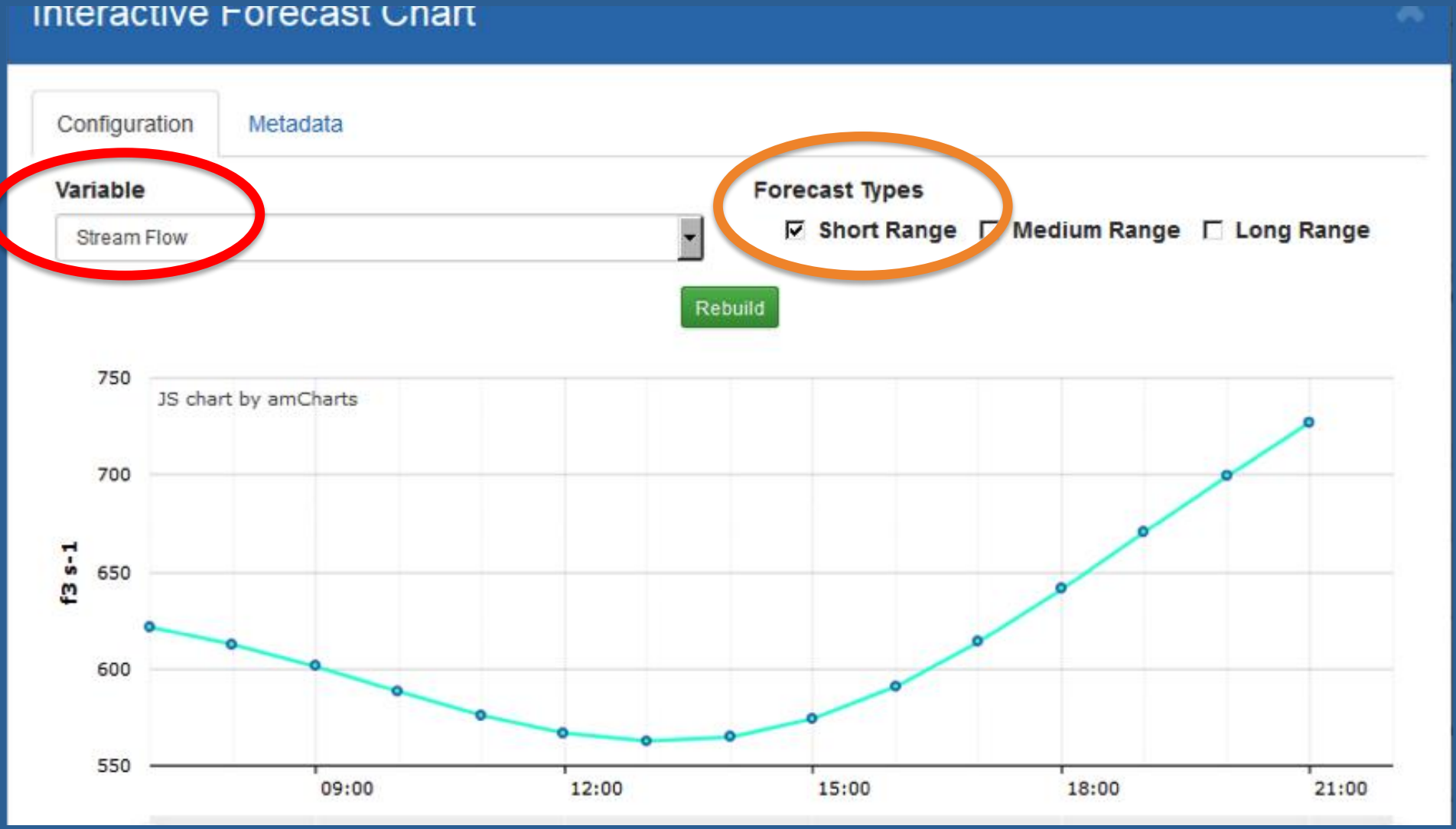
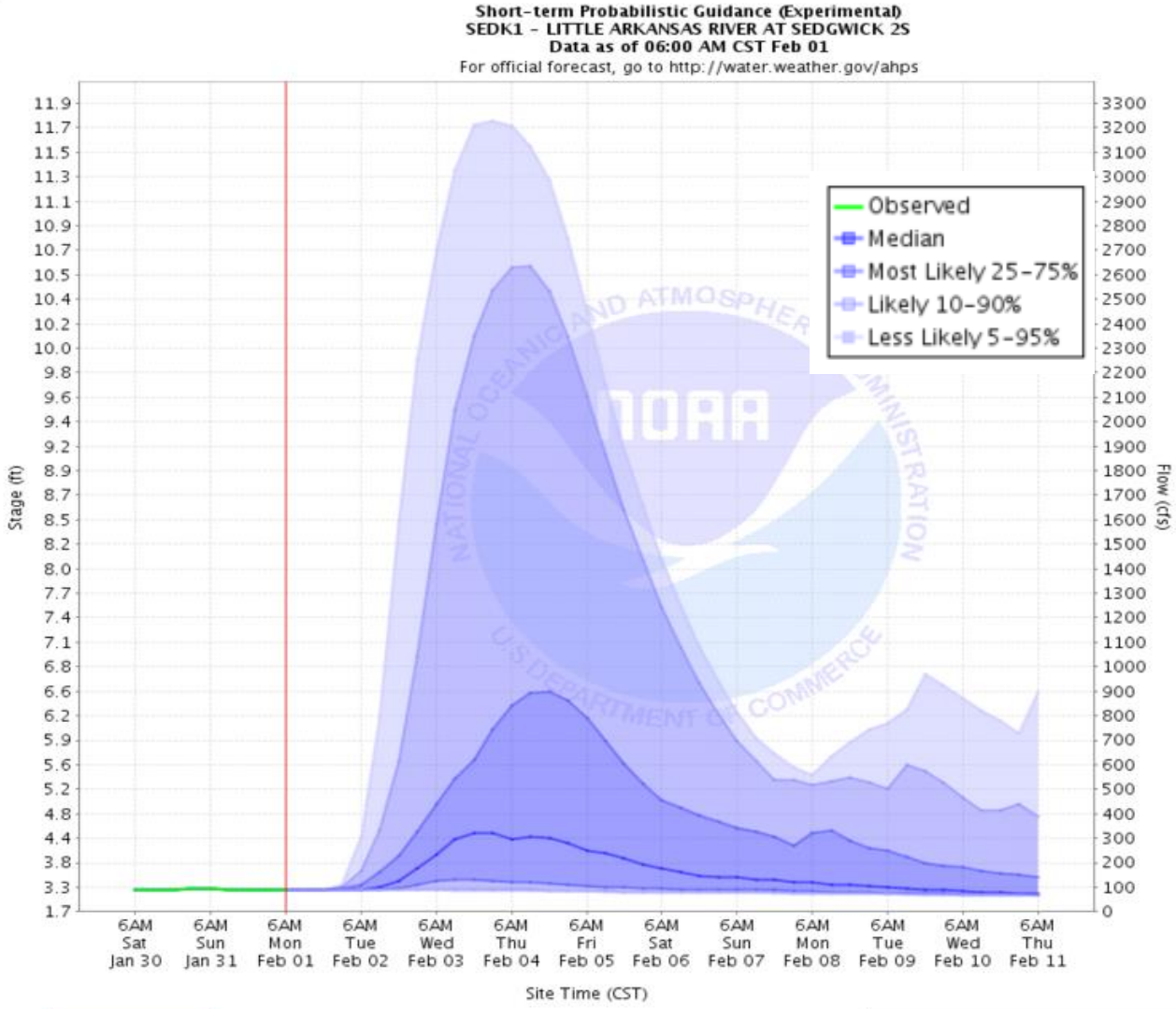


Enhancing Current Forecasting System

Hydrologic Ensemble Forecast System (HEFS)

Probabilistic information to support risk-based decisions

- Incorporates both atmospheric and hydrologic uncertainties
- 130 locations have experimental product for short-range river forecasts
- Testing and evaluation ongoing; collecting feedback via web
- New river service locations will continue to expand



Summary

- **NOAA's Water Services are Evolving**
  - We are building a foundation for change – but have a long way to go
  - Stakeholder input will inform future development activities, and the delivery and evolution of new services
  - Deliver comprehensive, integrated actionable water intelligence

- **Implementing State-of-the-Art Technical Approach**
  - Water prediction through state-of-the-science earth system modeling
  - Impact-based decision support services underpinned by geo-intelligence

- **Scale Change: Orders of Magnitude More Data**
  - Reach-based "Street Level" prediction
  - High Performance Computing

- **New Organization, Cornerstone Facility and Philosophy**
  - Office of Water Prediction/National Water Center
  - Collaborative, cross-NOAA, interagency, academic partnerships