



An Overview of NOAA's National Water Model



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Large integrated OWP and NCAR team

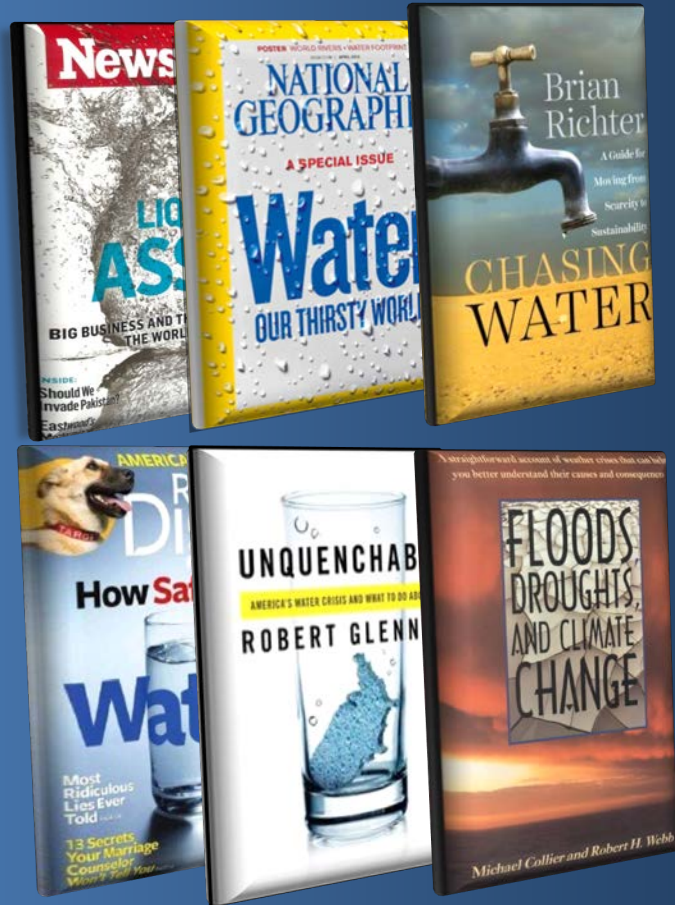


Presentation Outline

- **History of the National Water Model (NWM)**
- **NWM Overview**
- **Data Visualization**
- **Future Development Plans**
- **Summary**



Setting the Stage for the NWM



Growing Water Threats

- Population growth and economic development are stressing water supplies and increasing vulnerability
- An aging water infrastructure is forcing critical, expensive decisions
- Socio-economic risks of floods and droughts are escalating
- A changing climate is impacting water availability and quality, increasing uncertainty

Focusing Requirements: Stakeholder Input



Flooding



**Water
Quality**



**Water
Availability**



Drought



**Climate
Change**

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

- ◆ Provide consistent, high resolution (“street level”), integrated water analyses, predictions and data to address critical unmet information and service gaps
- ◆ Transform information into intelligence by linking hydrologic, infrastructural, economic, demographic, environmental, and political data
- ◆ Integrate Social Science to create *Actionable Water Intelligence*
- ◆ Also: Major National Academy of Sciences report highlighting capability gaps

Digging Deeper: Challenges and Limits to Improving our Prediction Capability and Services

- Observations, Data, and Forcings
- Physical Process Understanding
- Model Enhancement, Complexity, Integration, and Community Development
- Accounting for Anthropogenic Processes
- Lack of Data Integration and Decision Support Tools
- Computational Resources
- Data Visualization and Communication



National Water Model

Key Supporting Partnerships

- Federal Agencies including Integrated Water Resources Science & Services (IWRSS)



Water Information and Science



US Army Corps
of Engineers

Water Management



Water Prediction



FEMA

Response and Mitigation

- Academia/Research including National Academy of Sciences, National Science Foundation, CUAHSI, UCAR, NCAR



- Water Resources Managers, Emergency Managers, and other Enterprise Stakeholders

Key Supporting Facility: National Water Center

Initial Operating Capacity: May 26, 2015



- 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



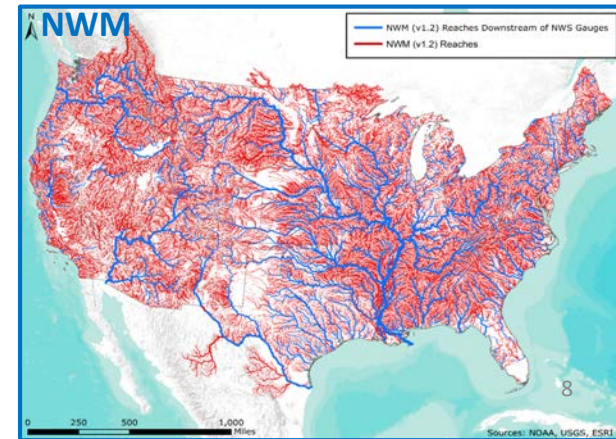
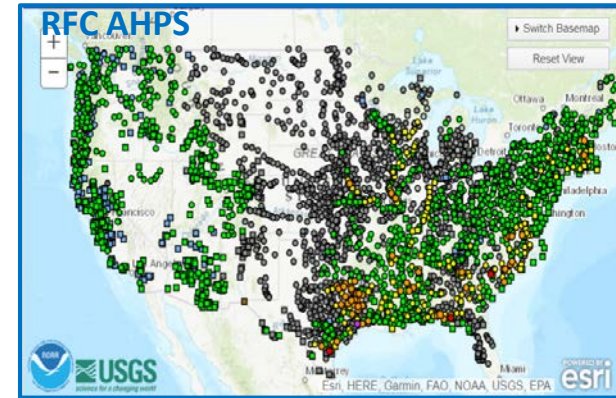
March 21, 2019

NWC has hosted more than 80 scientific meetings with over 3000 participants

National Water Model (NWM) Overview

- Full spectrum hydrologic model, providing complementary NWS hydrologic guidance
- NWM was upgraded to V2.0 in June 2019 by OWP, NCEP and NCAR

River Forecast Centers: Authoritative forecasts at ~3,600 RFC Points
NWM: Guidance at 2.7 million NHDPlus river segments, filling in coverage



V1.0 2016



V2.0 2019



V3.0 2022

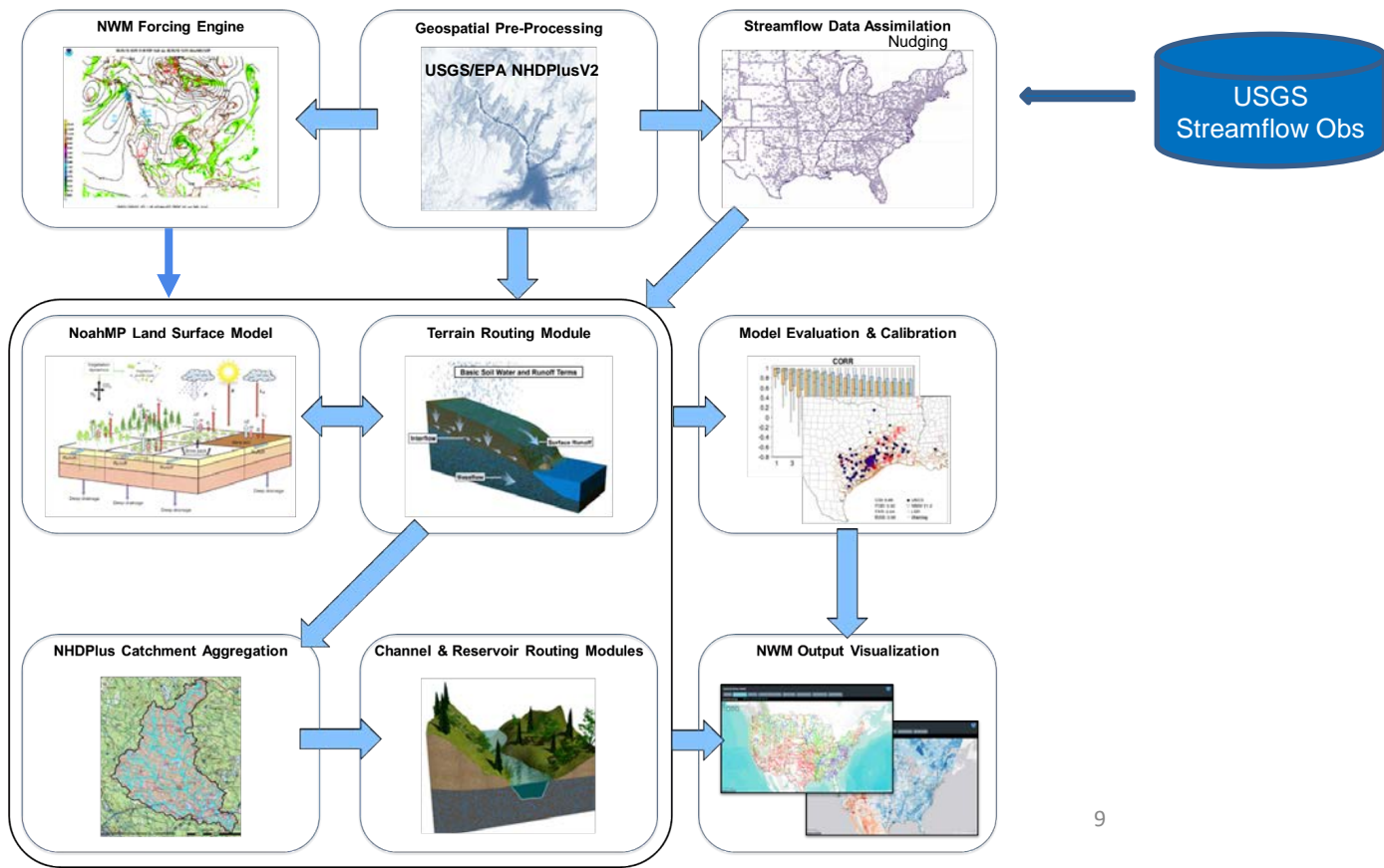


Next Gen

National Water Model System Structure

Fusion of column structure of land surface models, distributed structure of hydrologic models and national USGS/EPA NHDPlusV2 stream network within WRF-Hydro framework. Supported by verification and visualization.

NWM Hydrography
*Medium Resolution
NHDPlusV2*



NWM Operational Computing Environment

- The NWM runs on the NOAA Weather and Climate Operational Supercomputing System (WCOSS)
 - The model runs in a fully automated fashion with no interactive user modifications allowed between upgrades
 - Main data ingest sources should be operational themselves
- NWM Compute and disk usage
 - NWM V2.0 uses 32 nodes per model run (768 cores), and reaches a high water mark of 360 nodes (8,640 cores) due to overlapping jobs
 - V2.1 will use ~392 nodes
- NWM annual upgrade cycle can vary with internal/external factors

National Water Model V2.0: Cycling Overview

Analysis

HRRR/RAP/MRMS/IMPE

Lookback Range 3-28 hrs

*New for V2.1...open loop
(non-DA) member*

Short-Range

HRRR/RAP

Medium-Range Ens

GFS

Long-Range Ens

CFS

18 Hour Forecast

~10 Day Ensemble Forecast

30 Day Ensemble Forecast

Hawaii
3 Hour Lookback
60 Hour Forecast

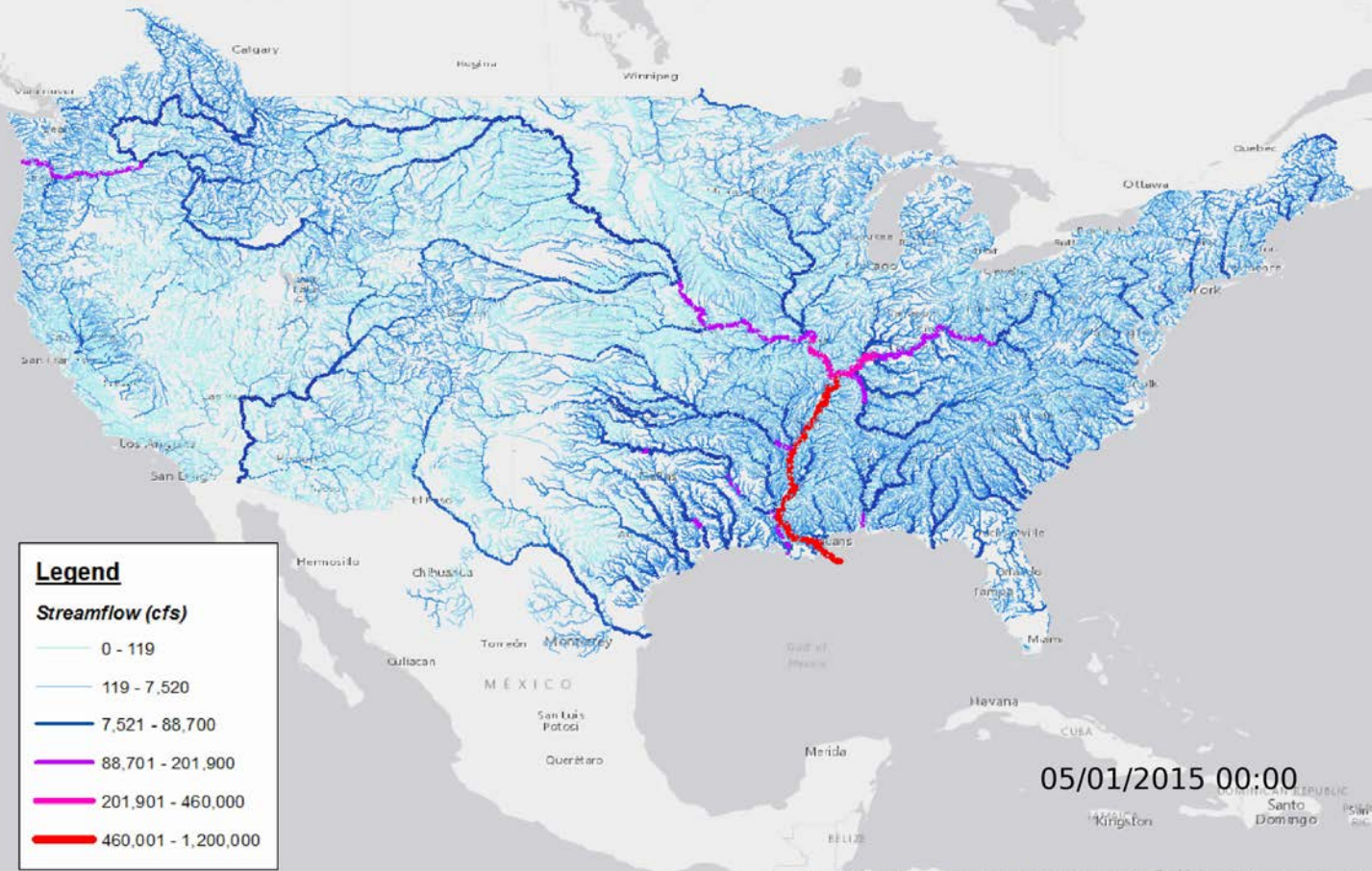
NAM-NEST

*New for V2.1...Hawaii
MRMS+ Puerto Rico*

Compute Footprint:
392 Nodes
(9408 cores)

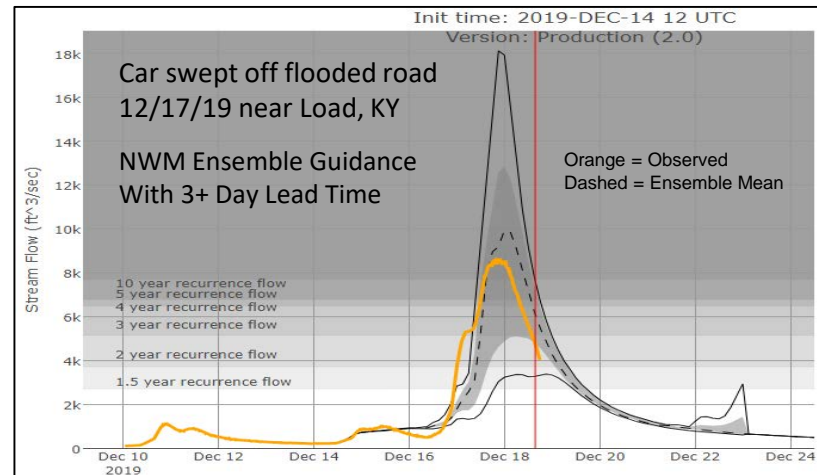
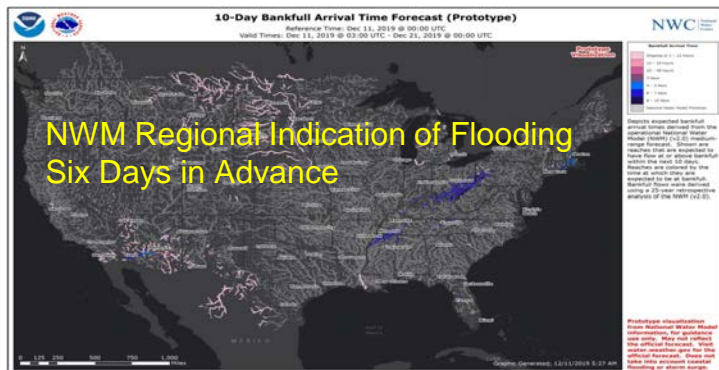
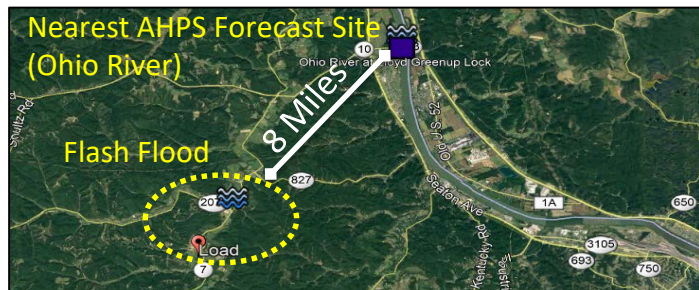


National Water Model



Current Core Capability: Complementary Guidance

- No traditional NWS RFC river forecasts are available for many smaller streams
- Regional NWM signals over underserved areas can be leveraged days in advance
- Closer to event, ensemble guidance valuable for specific rivers



- Daily NWS briefings
- National Water Center operations
- WPC mesoscale precip discussions
- FEMA disaster response support

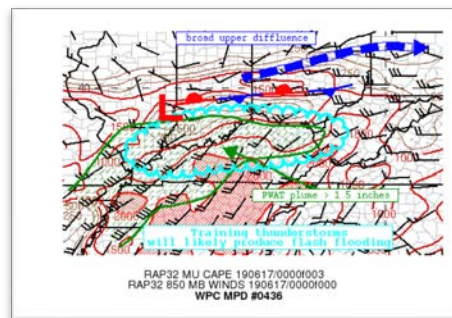
Current Core Capability: Complementary Guidance

- NWM guidance is used by NWS forecasters, Water Prediction Operations staff, as well as partner agencies

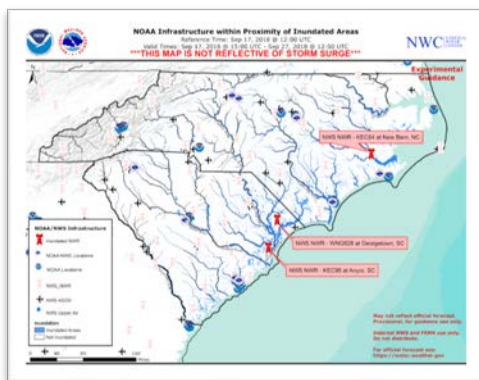
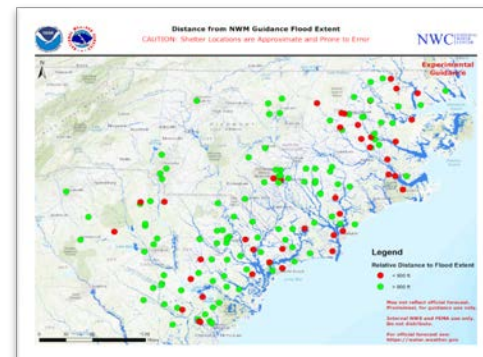
Daily NWS Briefings



WPC Metwatch Desk

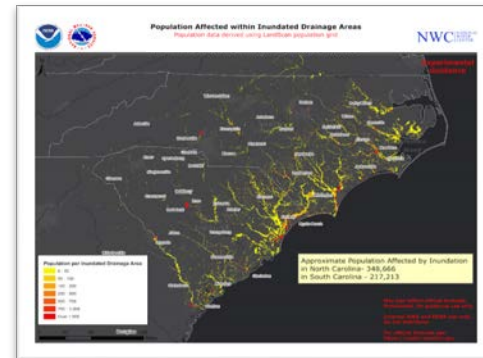


FEMA Disaster Response



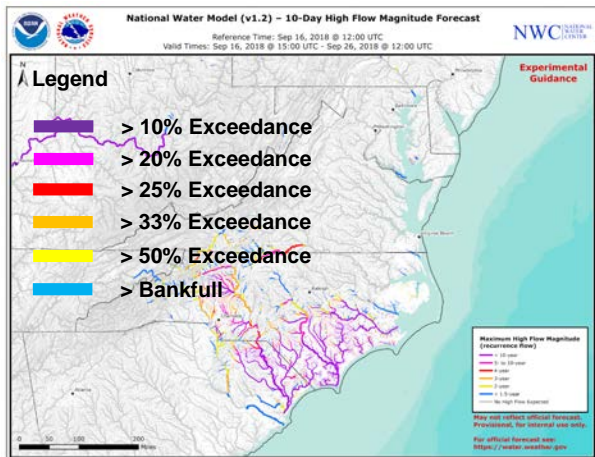
...but the heavy rates into sensitive terrain where NWM 40cm soil moisture is already at least 80% saturated suggests flash flooding will be likely...

....flash flooding noted by 14-day rainfall of 150-300%, and high NWM streamflow anomalies. High-res guidance is in good agreement...

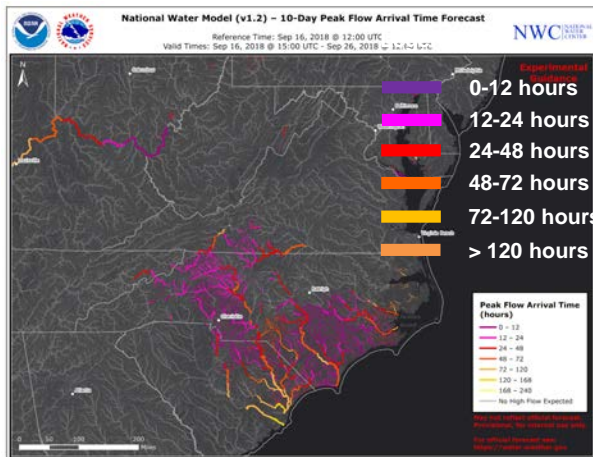


Further Leveraging NWM Model Output: Flow Forecast Mapping

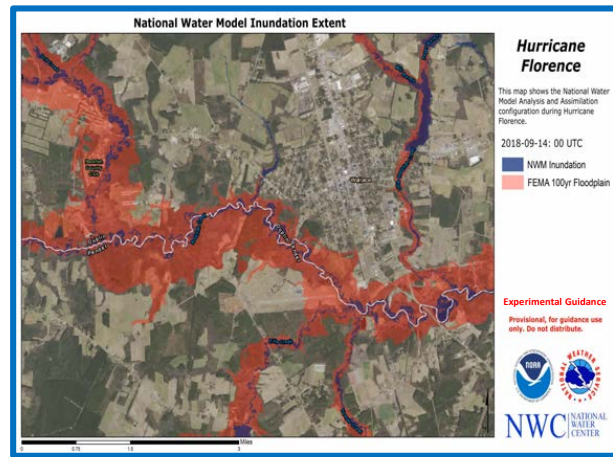
A Look Ahead to Experimental Visualizations



10-Day High Flow
Magnitude
Full Domain



10-Day High Flow Arrival
Time
Full Domain

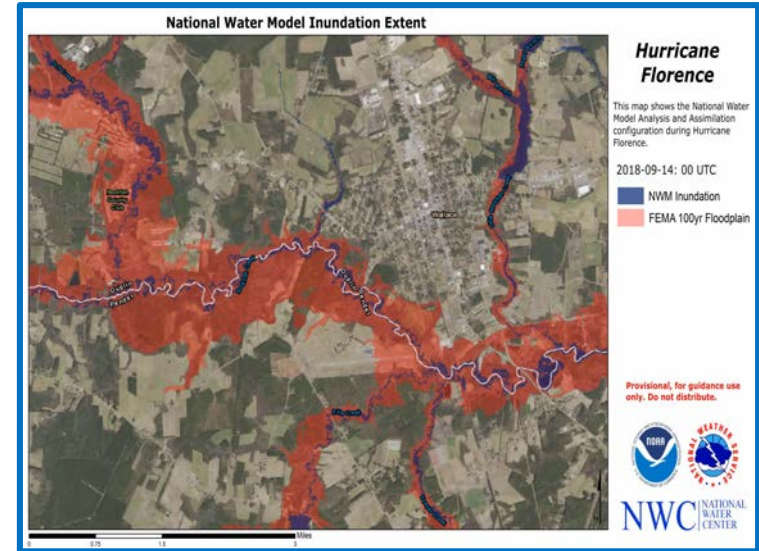


Inundation Extent
Texas now, CONUS by
~ 2021

Where is the event? When will it occur? How likely is it?

NWM Output Visualization: Flood Inundation Mapping

- Goal: Develop Real-time Flood Inundation Mapping Systems
- FY18/19 APG: Two sources of data
 - Official WGRFC Forecasts
 - NWM “Replace and Route”
 - Available below AHPS points
 - NWM Forecasts
 - Operational NWM used as input
 - Available for ~2.7 million reaches
 - Use Height Above Nearest Drainage (HAND) method to translate streamflow to inundation forecasts
- Proposed DOC FY20/21 APG
 - Replace and Route over CONUS domain
 - NWM-based FIM Maps over NERFC



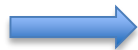
Communication is key: Multiple visualizations being prototyped

Provides actionable information as to the timing and extent of flood waters

Enhancing the NWM: Development Trajectory

v1.0

Foundation: 2016
Water resource model
2.7 million reaches



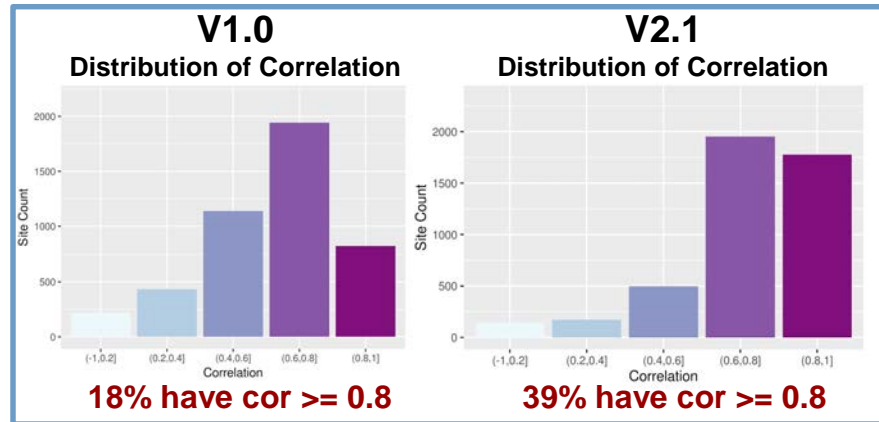
v1.1/1.2/2.0

Upgrades: 2017/2018/2019
Hawaii, medium range ens.,
physics upgrades, improved
modularity, MPE ingest



v2.1

Next Upgrade: Early 2021
Expansion to PR and Great
Lakes, reservoir modules,
forcing upgrades, open-loop,
and improved Hawaii forcing



v3.0

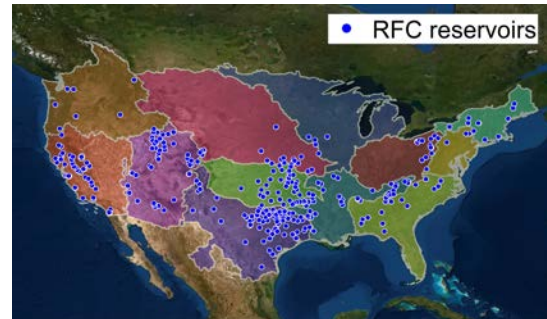
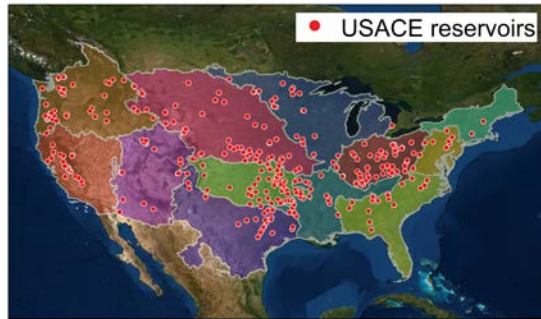
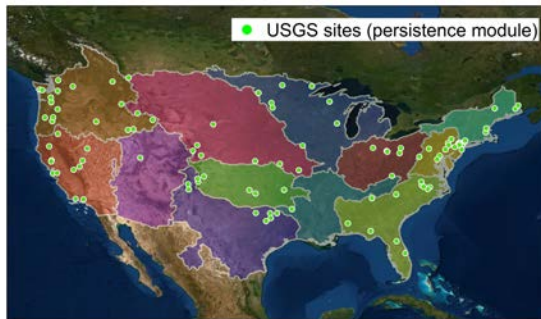


Future Upgrade: 2022
Coastal coupling, expansion to Alaska,
improved groundwater and infiltration,
hydro-fabric upgrades

NWM V2.1 Future Development: Improved Treatment of Reservoir Outflow

- Reservoir outflows are key to overall NWM streamflow accuracy
- Several thousand reservoirs represented in NWM, but in basic fashion
- NWM V2.1 will have two data ingest upgrades to improve outflows
 - Persistence-based data assimilation approach
 - USACE Observations from CWMS RADAR service
 - USGS Observations from existing WCROSS USGS stream gauge feed
 - Use of RFC reservoir discharge time series
 - Forecasts from each RFC transferred to NWM on WCROSS supercomputer

Potential Sites - Refining with Partners



NWM V2.1 Future Development: Domain Expansion to Great Lakes

- NWM V2.1 channel routing domain expanded to include Great Lakes and Lake Champlain drainage basins
- NCAR and Great Lakes Environmental Research Lab (GLERL) collaboration with onboarding by OWP and NCAR



CONUS

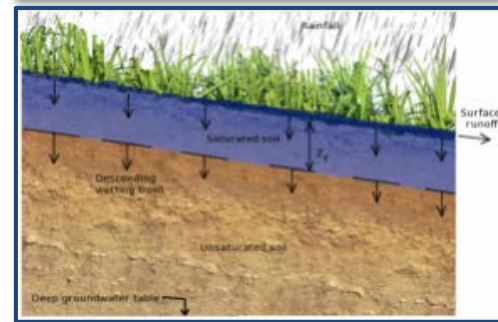
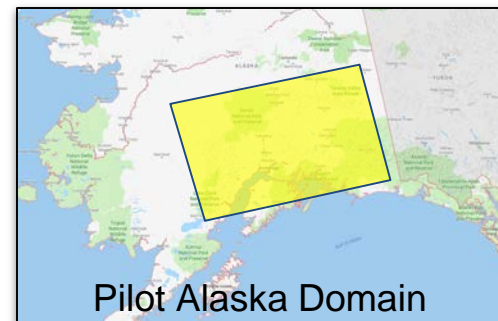
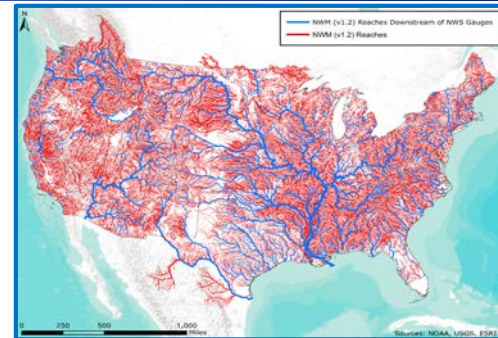
- NWM V2.1 domain expanded to include Puerto Rico / US Virgin Islands
- Designed in partnership with SERFC and Puerto Rico WFO



NWM V3.0 and Beyond (2022+): Expanded Partnerships and Activities

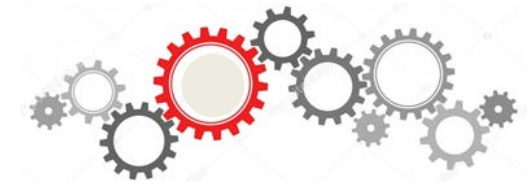
- ★ • Coastal Coupling
 - Freshwater-estuary-ocean model coupling
 - Simulate compound flooding—freshwater/surge/tides
- ★ • Expansion to south-central Alaska (with APRFC)
 - Beginning with Cook Inlet/Copper River Basin
 - Accompanying cold land physics upgrades
- ★ • Inland Hydrologic and Hydraulic Routing
 - Improved routing for backwater and complex channels
 - Accompanying hydrofabric upgrades for routing and FIM
- Improved infiltration scheme for partitioning rainfall
 - ★ – Optimization of existing infiltration options
 - Foundational physics upgrade, evolving Noah-MP
- Improved treatment of groundwater
 - ★ – Enhancement of groundwater approach, calibration
 - Shallow groundwater model with USGS
 - Key to simulating low-flow conditions

★ = V3.0



Accelerating Improvement: Next Gen NWM Framework

- New, purpose-built modular NWM software architecture will aid collaboration and maximize development efficiency, increasing the rate of model improvement
- Design underway with USGS and NCAR, leveraging GSA 18F group
 - Need for re-design informed by the Community Advisory Committee for Water Prediction (CAC-WP)
 - GSA 18F process leverages agile development process; code sprints will be transparent with broader community
 - Will more easily support addition of appropriate models for any surface discretization
 - Capability for TIN/unstructured mesh and heterogenous physics will support coupling and scaling of NWM and will enable linkage to new NWS Unified Forecast System
- Complemented by a new model-as-a-service initiative



Closing Thoughts

- With three upgrades in three years, the NWM is rapidly advancing
- Complements information where already available and provides first-ever guidance at underserved locations
- What exists now is a foundation that will continue to be built upon
 - v2.0 implemented into operations in June: Domain expansion, ensembles
 - v2.1 is anticipated in early 2021: Domain expansion, reservoir upgrades
 - v3.0 is anticipated in 2022: Coastal coupling, AK domain, improved sub-sfc
 - Next Gen NWM planning underway
- Along with upgrades, flood inundation mapping, replace-and-route, model-as-a-service and partnerships with Big Data are key elements moving NWM forward
- The key to advancing the NWM is a rich and vibrant partnership with the research community, along with federal, state and private entities