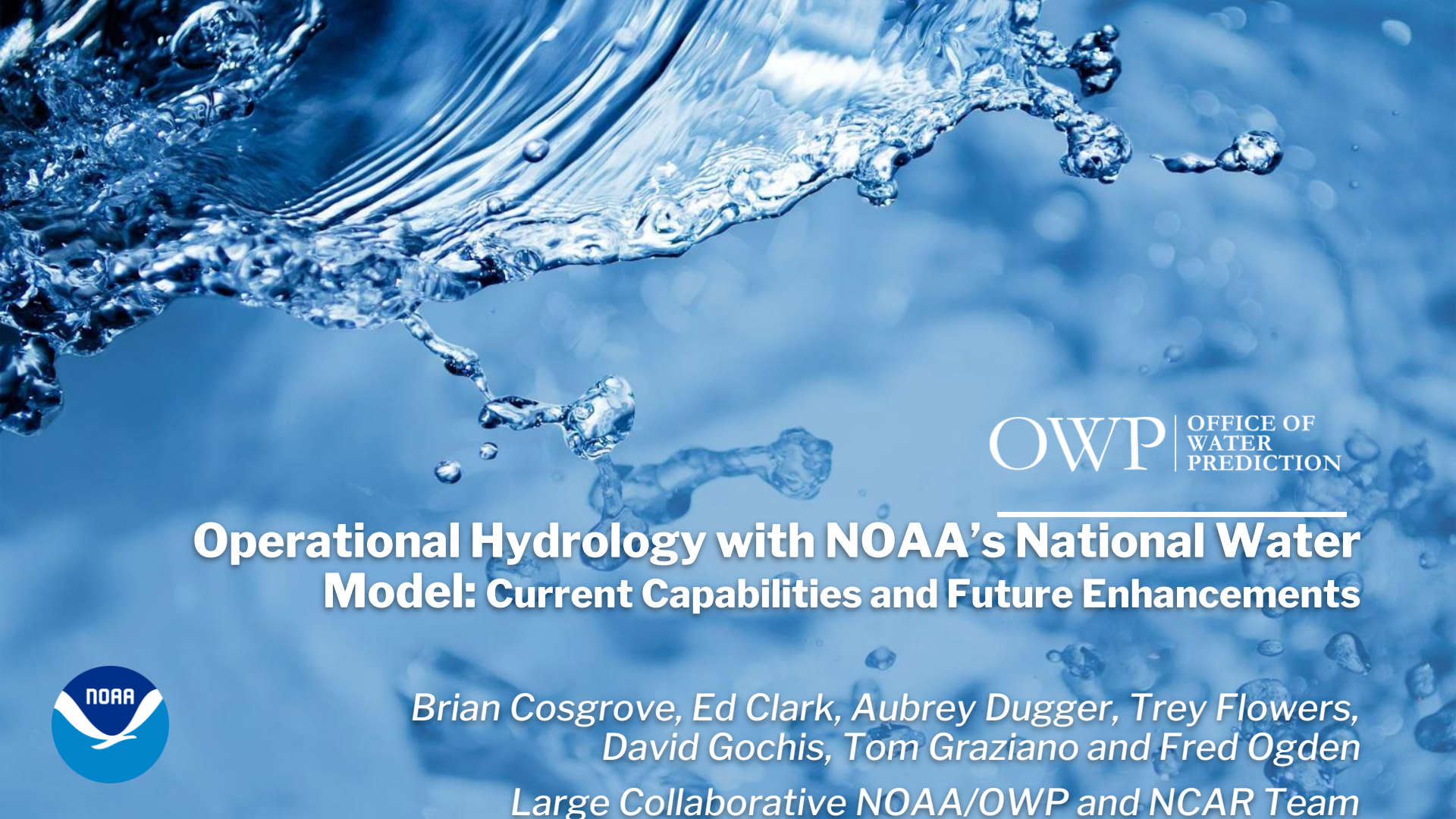

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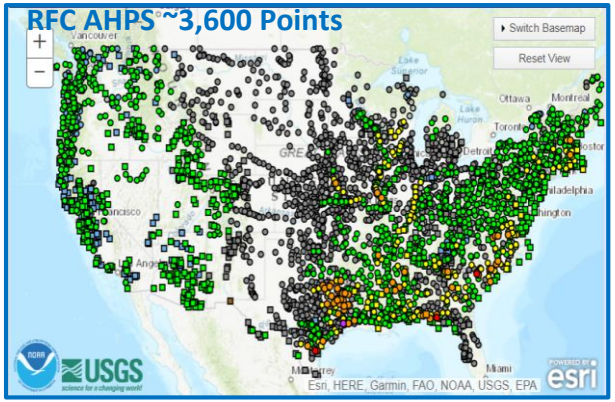
Operational Hydrology with NOAA's National Water Model: Current Capabilities and Future Enhancements

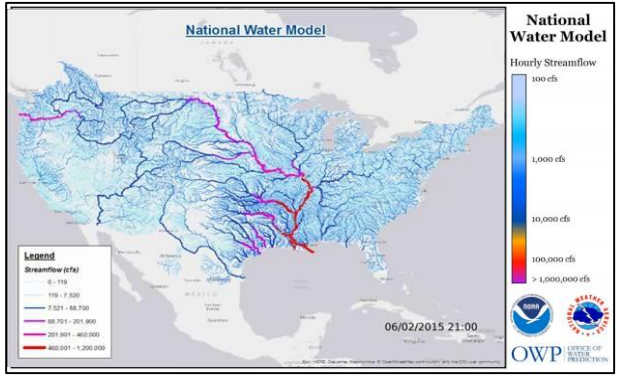
Brian Cosgrove, Ed Clark, Aubrey Dugger, Trey Flowers, David Gochis, Tom Graziano and Fred Ogden

Large Collaborative NOAA/OWP and NCAR Team

National Water Model Overview

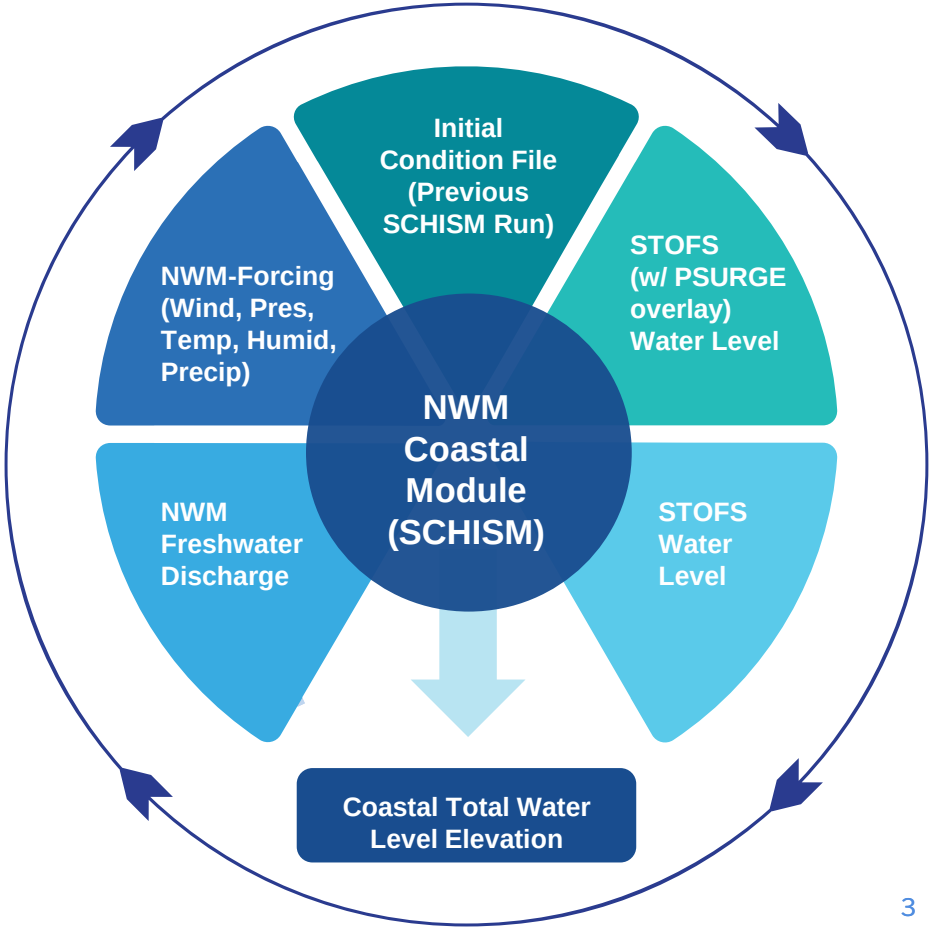
- The NWM provides both complementary and first-time hydrologic guidance to a broad range of users
- With v3.0, the NWM continues to advance water prediction at an accelerated pace, addressing the nationwide coastal total water level prediction challenge with improved services for ⅓ of the Nation's population





NWM v3.0 Operational Enhancements

- With version 3.0, NWM TWL guidance complements existing regional forecasts over *CONUS, Hawaii, and PR/VI domains*
- This new freshwater-estuary-ocean coupling leverages the NWM, SCHISM, STOFS & P-Surge, executes in both Analysis and Forecast modes.
- Other enhancements in v3.0 include
  - First-time Alaska coverage
  - Use of National Blend of Models (CONUS/AK) and MRMS QPE (PR/VI)
  - Improved runoff physics, calibration and regionalization



NWM v3.0 Enhancements: Total Water Level Domain Coverage

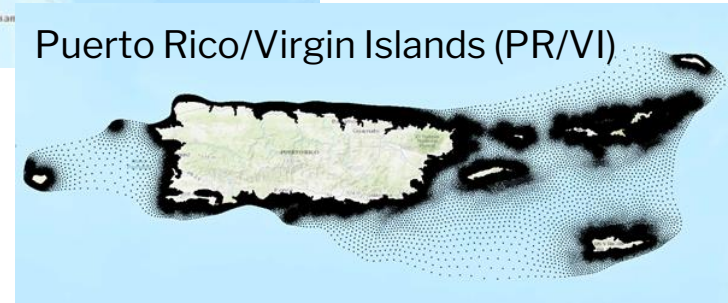
TWL output is masked to a 5 meter bathymetric depth offshore, and extends to 10 meter topographic height inland

<u>Average Resolution</u>

Atlantic: 75 m

Pacific: 50 m

PR-VI and HI: 30 m

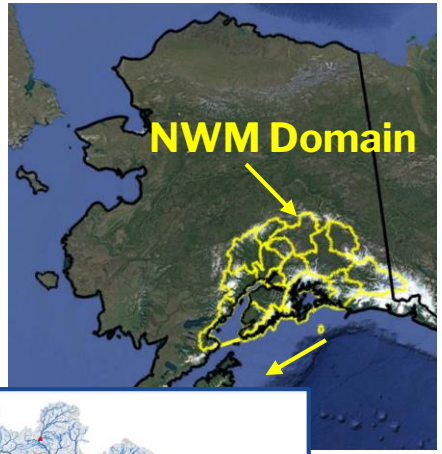


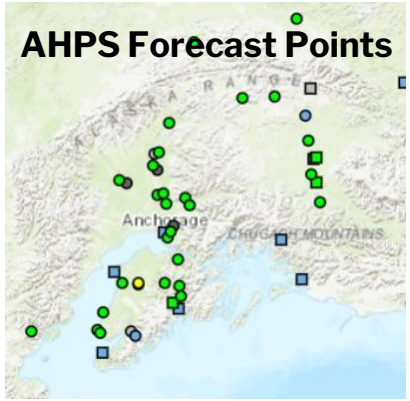
NWM v3.0 Enhancements: Expansion to Alaska

Overarching Goal: Provide complementary and first-time hydrologic guidance for Alaska's Cook Inlet, Copper River Basin and Prince William Sound Regions

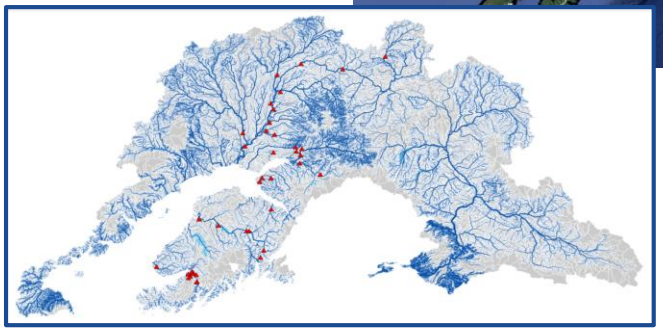
NWM Alaska Summary

- Close configuration/forcing coordination with Alaska Pacific RFC
- Assimilation of APRFC glacial dam lake (GDL) outflow forecasts
- Customized model and forcing configurations
- Guidance for 390k stream reaches complements RFC AHPS sites
- Total water level guidance for AK coast in Version 4.0 of the model





Dense network of NWM hydrologic guidance

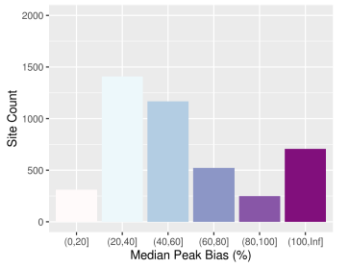


NWM v3.0: Improved CONUS Performance, Region-by-Region

- NWM is assessed with each upgrade to a new version
- Simulation is from WY2014-2016, forced with AORC and with no data assimilation

V1.2

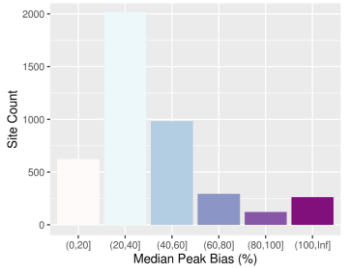
Distribution of Absolute Peak Bias (%)



39% have Peak bias < 40%

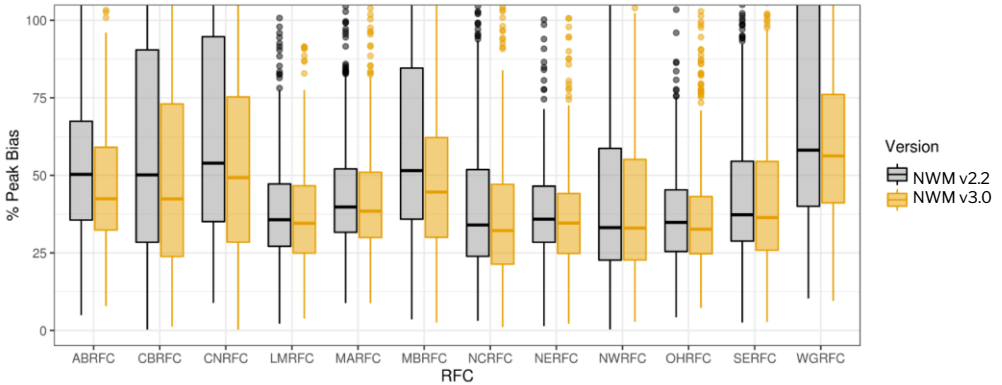
V3.0

Distribution of Absolute Peak Bias (%)



61% have Peak bias < 40%

Percent Absolute Peak Bias across CONUS RFCs (lower is better)

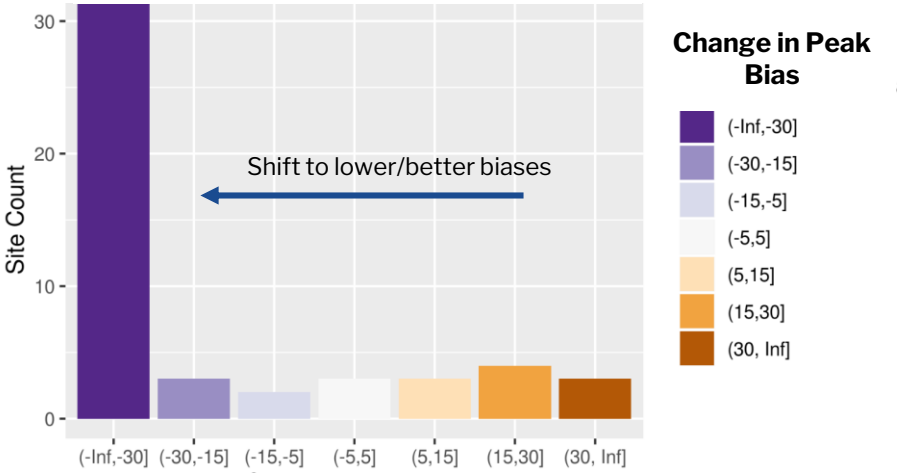


- **Streamflow peak bias (%) has improved greatly over the history of the NWM**

- **Median peak bias improves across all River Forecast Center domains in NWM v3.0**

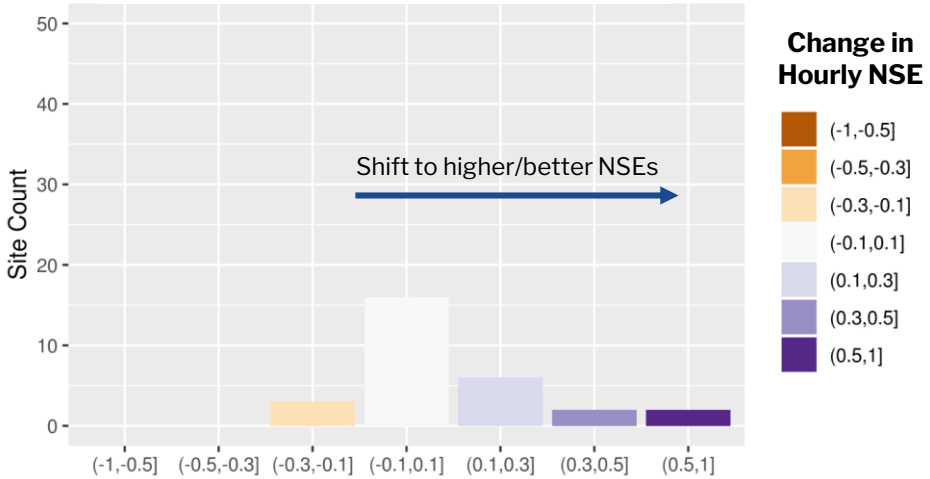
NWM v3.0: Improved Performance over Hawaii

Change in Peak Bias (%)



(Blue indicates v3.0 reduction in peak bias)

Change in NSE



(Blue indicates v3.0 increase in NSE)

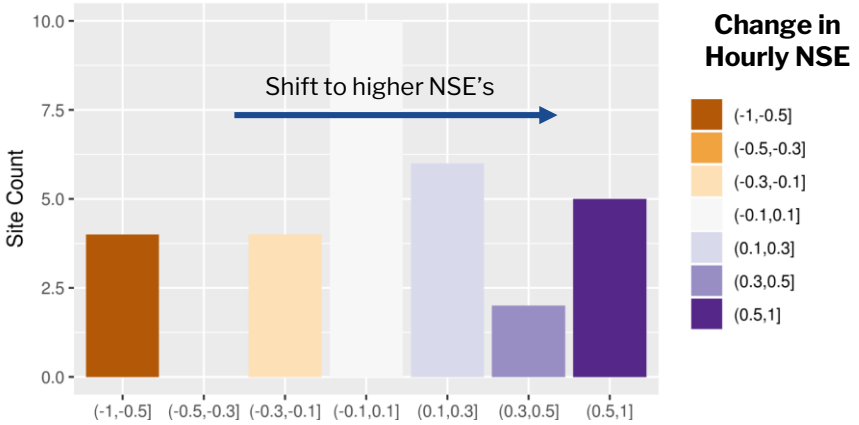
- **Assessment is for 2010-2013 validation period, without streamflow DA, using APRFC observed-precipitation**
- **Improved model physics and parameters from collaborative calibration with APRFC have led to improvements in NWM streamflow guidance, as noted in the peak bias and the NSE metrics**

NWM v3.0: Improved Performance over Puerto Rico

Change in Peak Bias (%)

(Blue indicates v3.0 reduction in peak bias)

Change in NSE



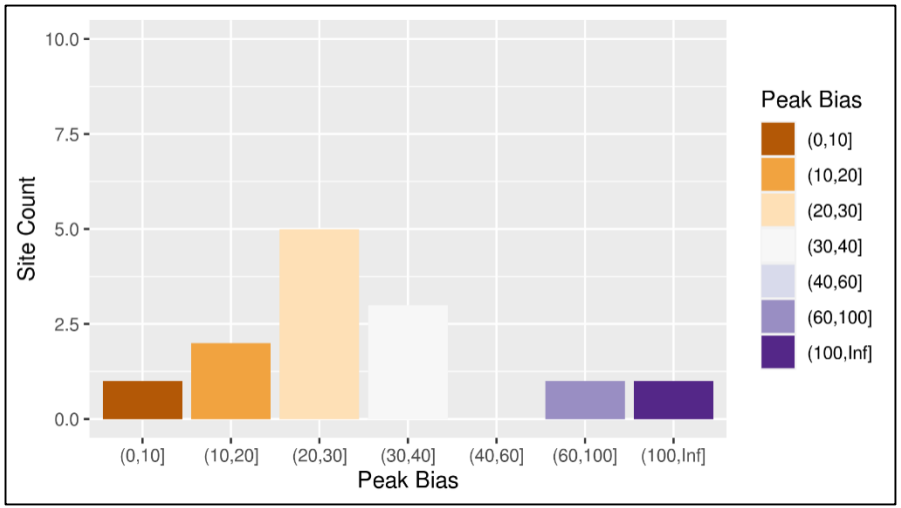
(Blue indicates v3.0 increase in NSE)

- **Assessment is for 2014-2017 validation period, without streamflow DA, using SERFC observed-precipitation**
- **Improved calibration and model physics have led to improvements in NWM streamflow guidance, as noted in the peak bias and the NSE metrics**

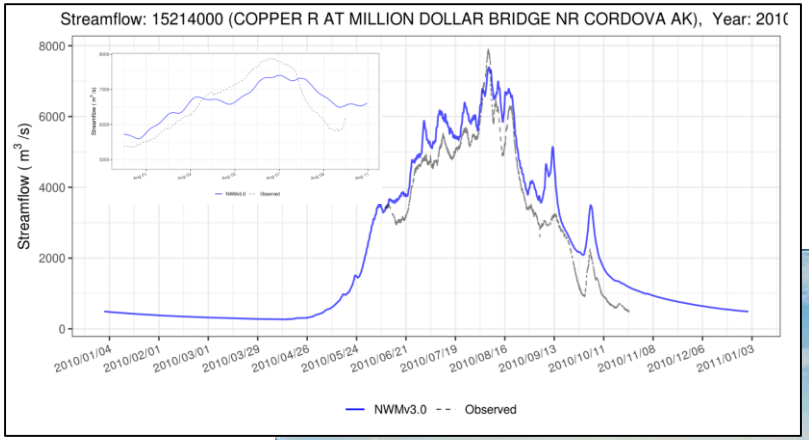
Assessing New Capabilities: NWM Alaska Domain

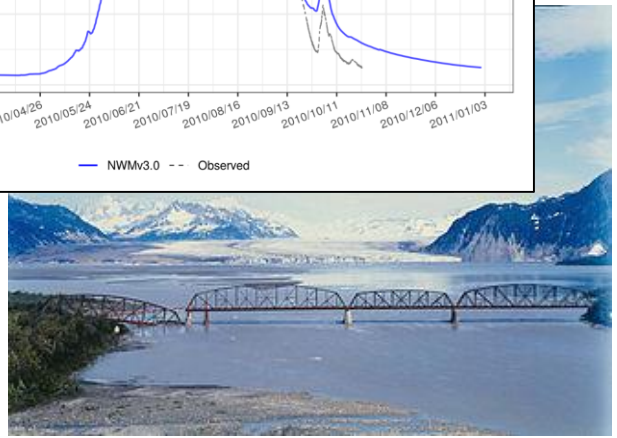
- **Critical expansion to Alaska with complementary forecast guidance for RFC/WFO**

Overall Summary: NWM v3.0 Absolute Peak Bias at USGS Reference Gauges (WY 2009-2014, AORC Forcing without assimilation of USGS observations)



61% have absolute peak bias < 30%

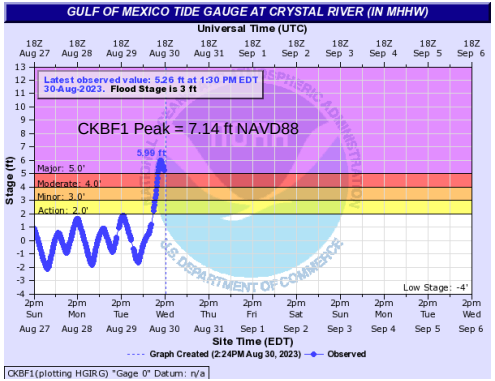


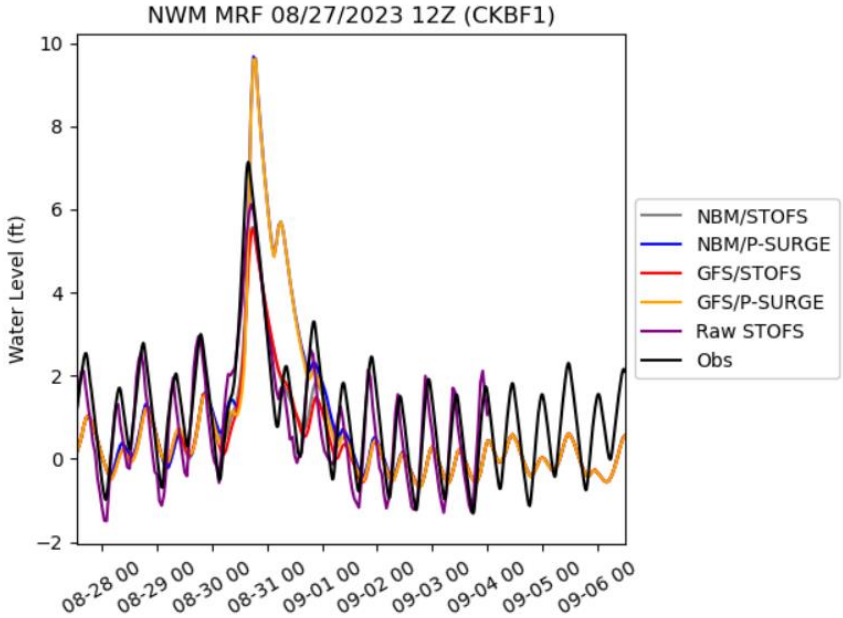


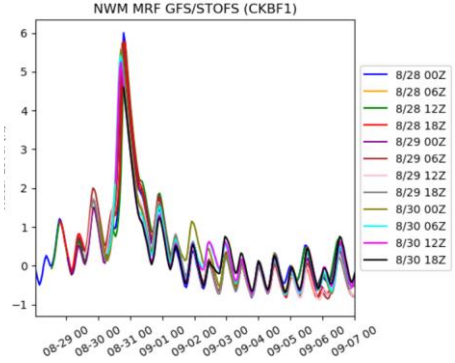
- **Peak streamflow bias clustered towards left half of distribution, reasonable results for first implementation of new Alaska domain (left)**
- **Good agreement with seasonal streamflow observations during warm season (right)**

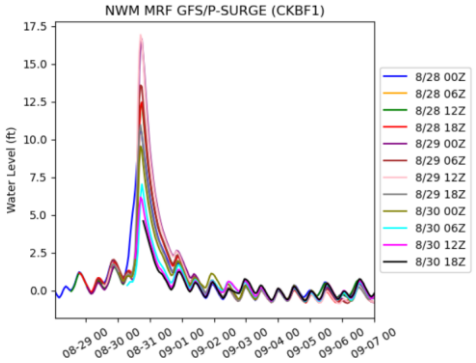
Assessing New Capabilities: TWL for Hurricane Idalia, August 2023

- NWM TWL forecasts bracket observed crest showing importance of dual ocean forcing
- Cycle-to-cycle variability depends on forcing
- Minor freshwater contribution





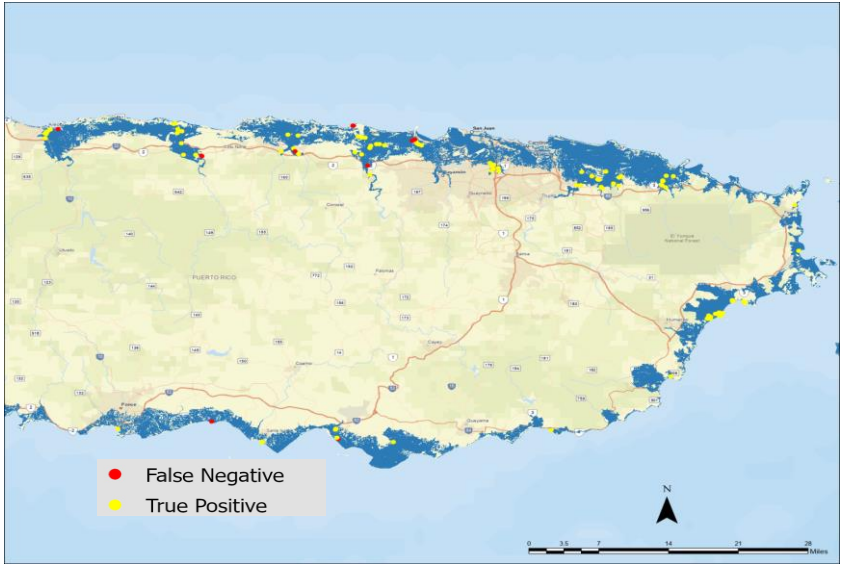




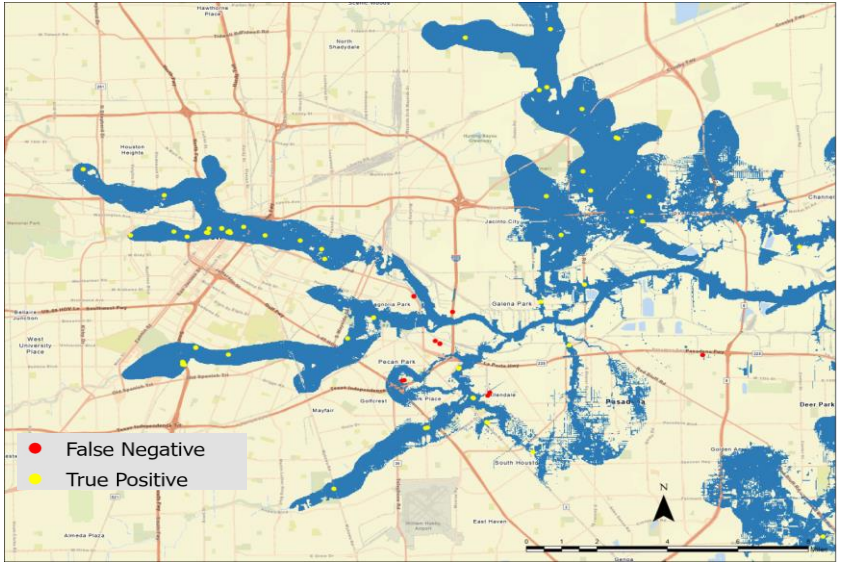
NWM v3.0: Supporting Flood Inundation Mapping

Examples of Coastal FIM derived from NWM v3.0 SCHISM output

NWM-Driven Maximum FIM, Hurricane Maria (PR)



NWM-Driven Maximum FIM, Hurricane Harvey (Houston, TX)



- **Internal real-time FIM TWL testing will transition to public experimental phase with 60% CONUS coverage**
- **This will make possible summit-to-sea inundation maps, with impacts of inland freshwater and coastal TWL**

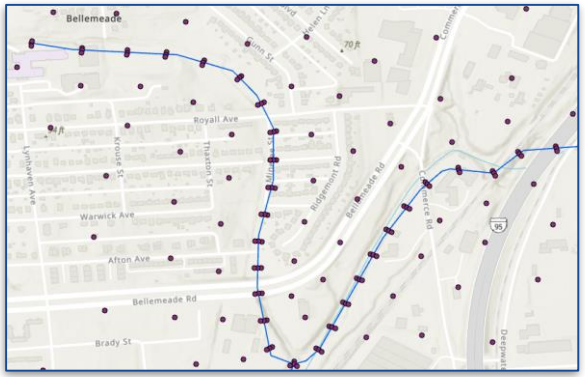
NWM v3.1 (2025): Enhancing Total Water Level Capabilities

- **Focus:** Improving initial v3.0 TWL forecast capability
- Total Water Level Enhancements
  - Reduction in product latency - workflow, inland boundary and forcing optimization
  - Increase in TWL accuracy - mesh optimization, improvements in DEM, inclusion of levees
- Forcing Enhancements
  - Use of hourly NBM data through day 10
  - Use of precipitation type data
- Product Dissemination
  - Inclusion of additional TWL SHEF sites
  - First-time dissemination of streamflow via SHEF

Area Near Richmond, VA

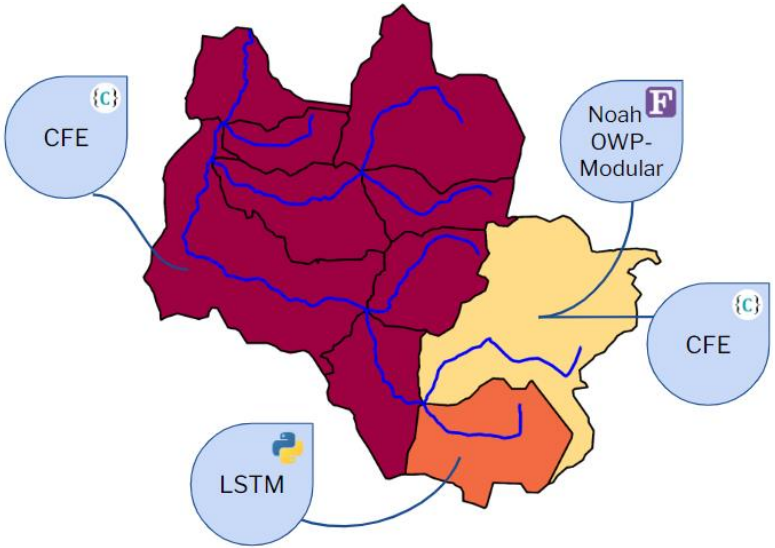
Old Mesh - Goode Creek not resolved

New Mesh - Goode Creek resolved



NWM v4.0 (2026): Advancing Operations with NextGen Framework

- The NWM software architecture is being rewritten from the ground up - Next Generation Water Resources Modeling Framework (NextGen)
- A core feature of the community-oriented Nextgen framework is the ability to vary model components by hydrologic catchment…



Multiple catchments - Multiple formulations

This will lead to key operational improvements

Forecast Accuracy	**Module selection tailored to each catchment's hydrologic characteristics (soil, snow, other)**
Computational Efficiency	**Lighter-weight formulations can be used when appropriate (i.e., turn off snow)**
Model Capability	**Framework flexibility (CFE, Topmodel, LSTM, Noah OWP-Modular, etc.) enables ensembles**

Closing Thoughts

- The implementation of NWM v3.0 continues to rapidly accelerate hydrologic data availability
  - Total Water Level and Alaska coverage key features
  - 44-year v3.0 retrospective simulation now available
- NWM v3.1 in 2025 will focus on TWL and forcing enhancements, with NextGen-based v4.0 planned for 2026 (*now - Transitioning Next Generation Water Resources Models to Operations I, room 320*)
- Impact of these NWM upgrades is multiplied via parallel upgrades to visualization, forecast products, FIM and assessment tools *(next talk)*
- Upgrades will continued to be enriched by community development via CIROH and other avenues

NWM Overview Article Published:
"NOAA's National Water Model: Advancing Operational Hydrology Through Continental-scale Modeling." (2024) JAWRA https://doi.org/10.1111/1752-1688.13184

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Thank You!

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