



An Update on NOAA's National Water Model: Advancing Operational Hydrology Through Continental-Scale Modeling

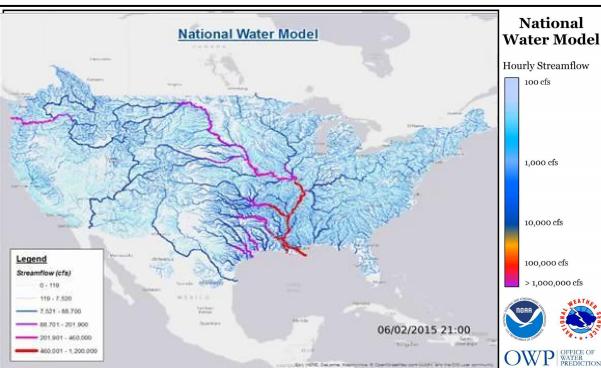
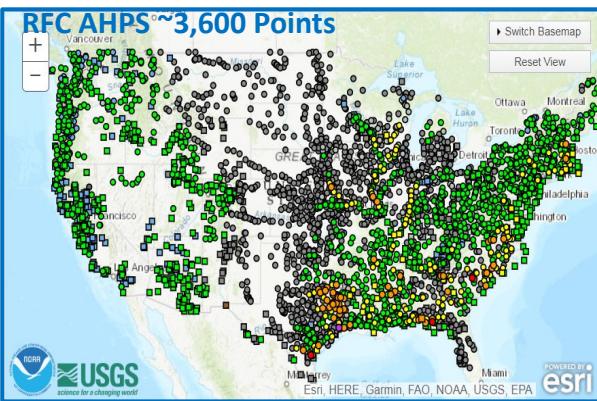


Brian Cosgrove, Ed Clark, Aubrey Dugger, Trey Flowers, David Gochis, Tom Graziano and Fred Ogden

Large Collaborative NOAA/OWP and NCAR Team

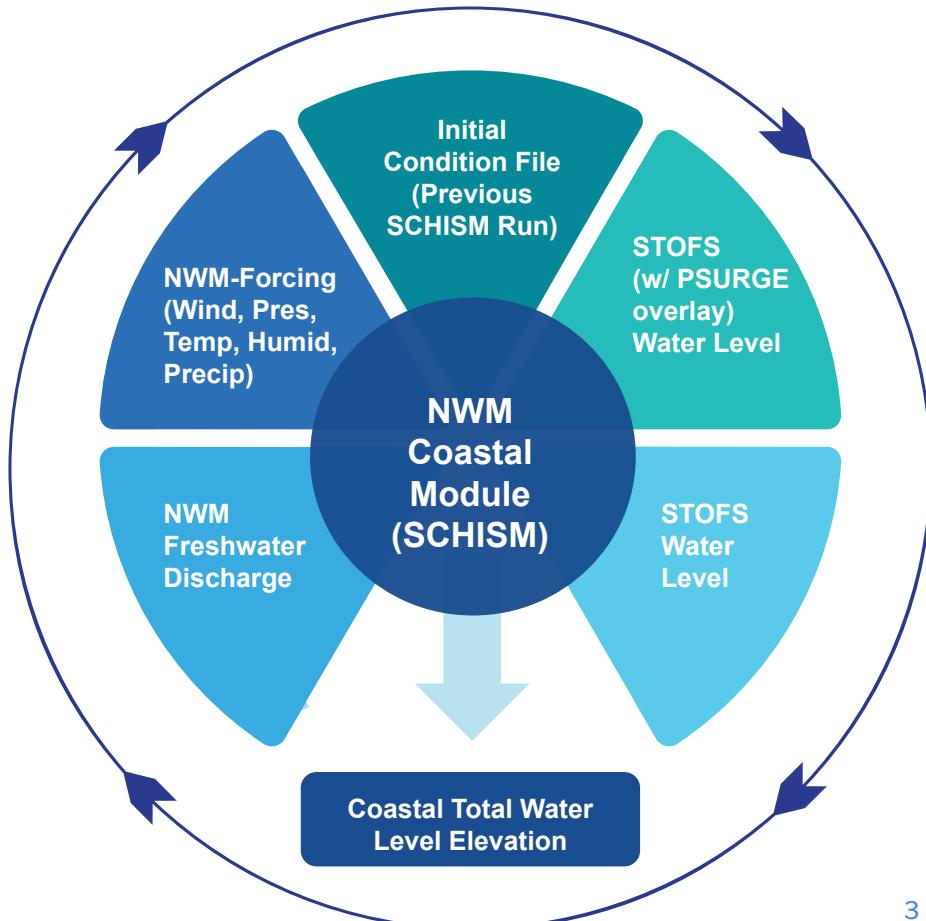
National Water Model Overview

- 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 $\frac{1}{3}$ of the Nation's population



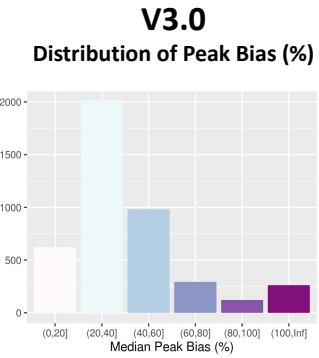
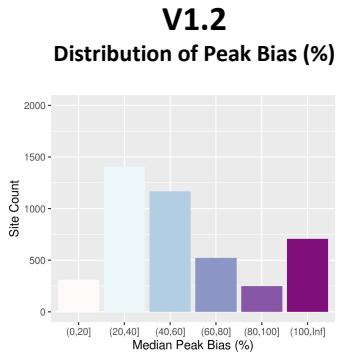
NWM v3.0 Operational Enhancements

- 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

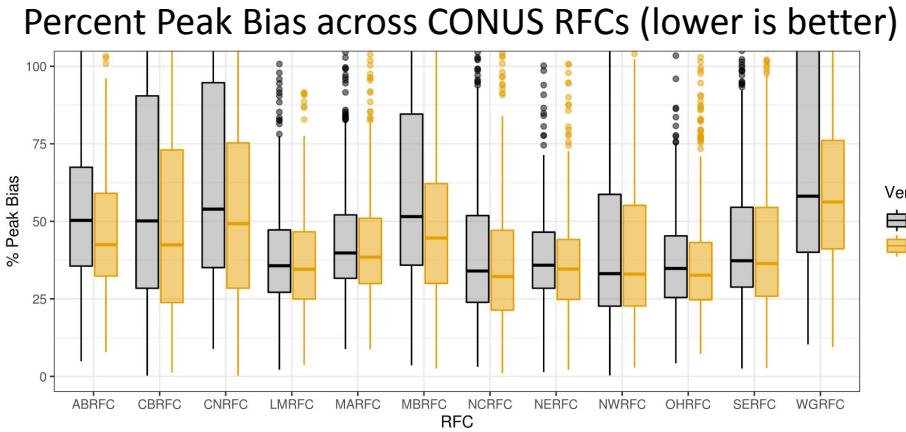


NWM v3.0: Improved CONUS Performance, Region-by-Region

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

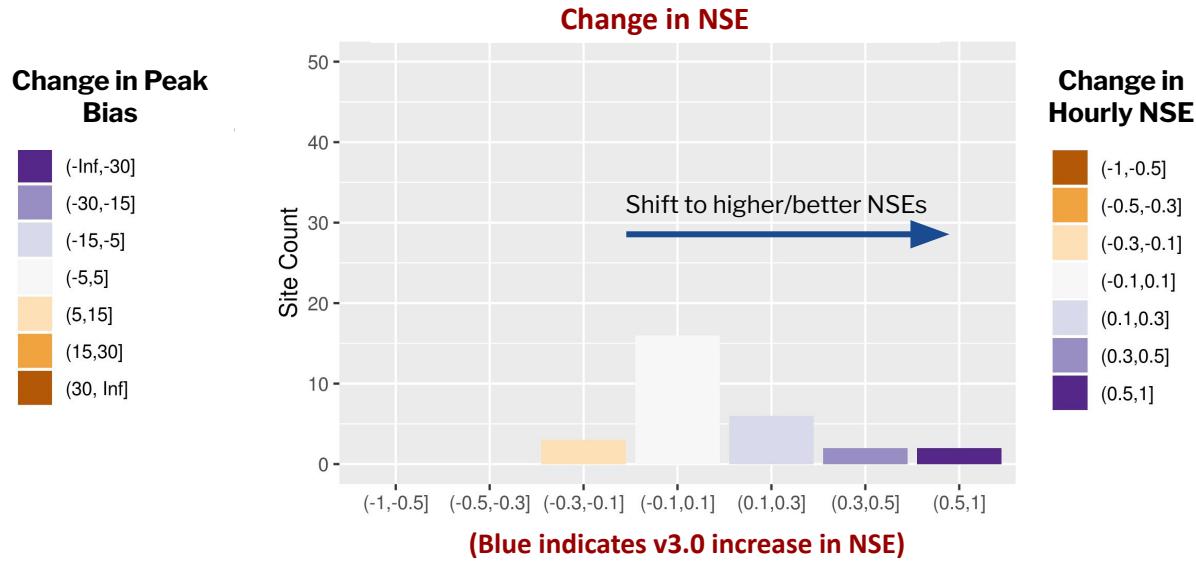
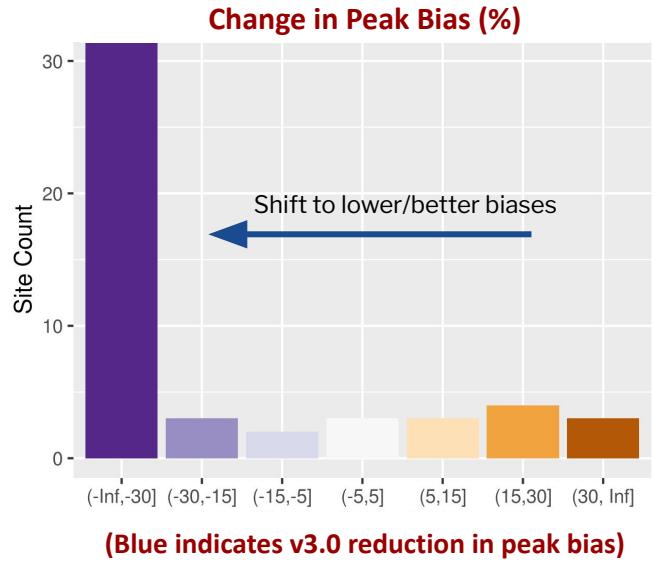


- Streamflow peak bias (%) has improved greatly over the history of the NWM



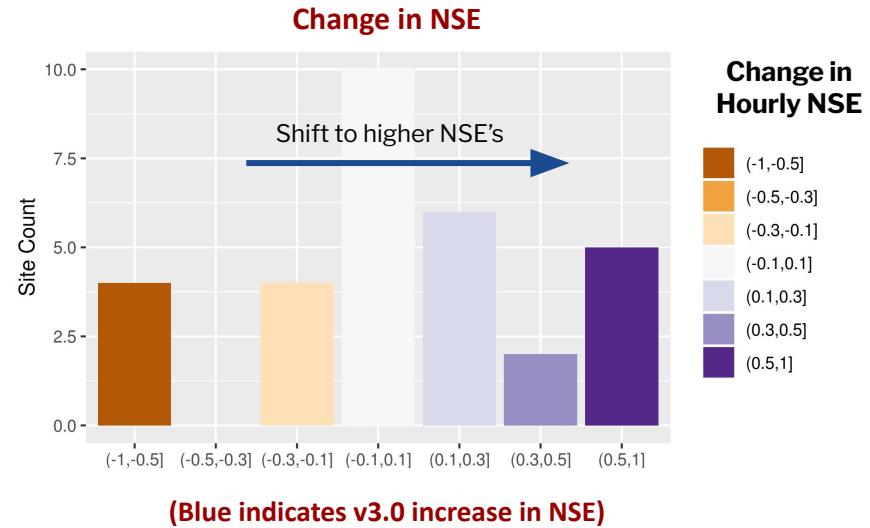
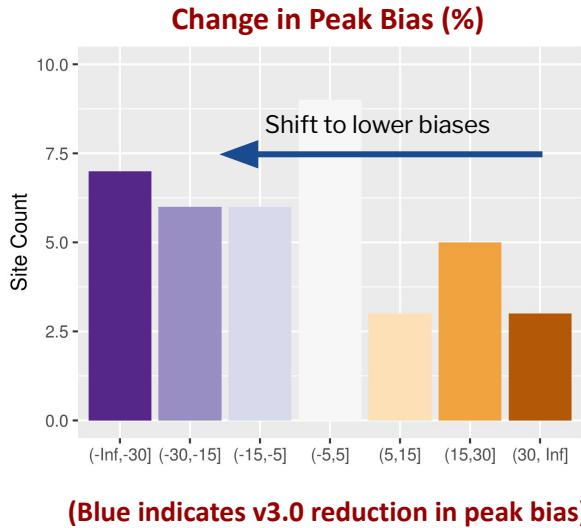
- Median peak bias improves across all River Forecast Center domains in NWM v3.0

NWM v3.0: Improved Performance over Hawaii



- 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

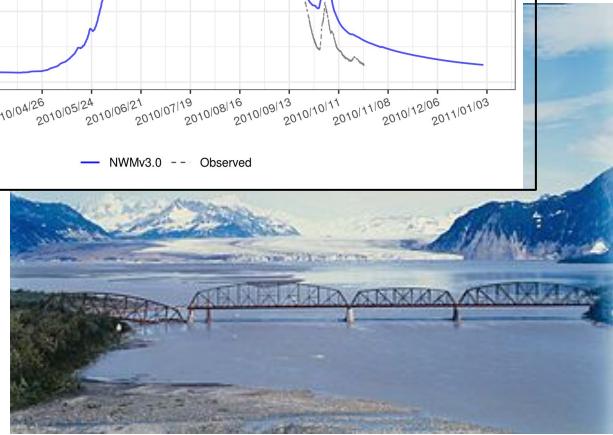
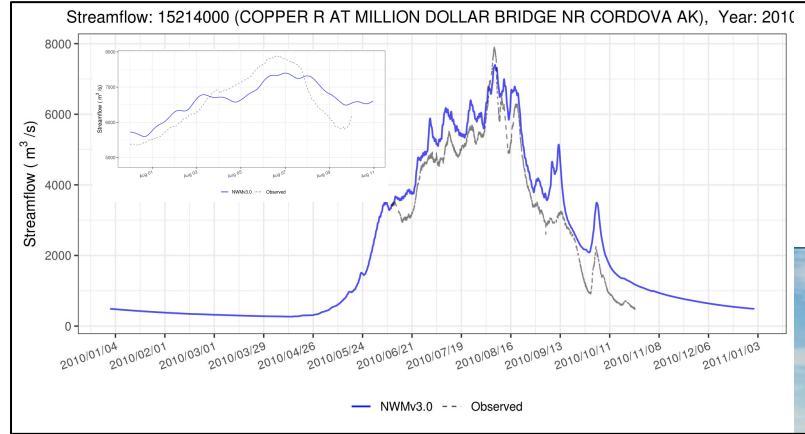
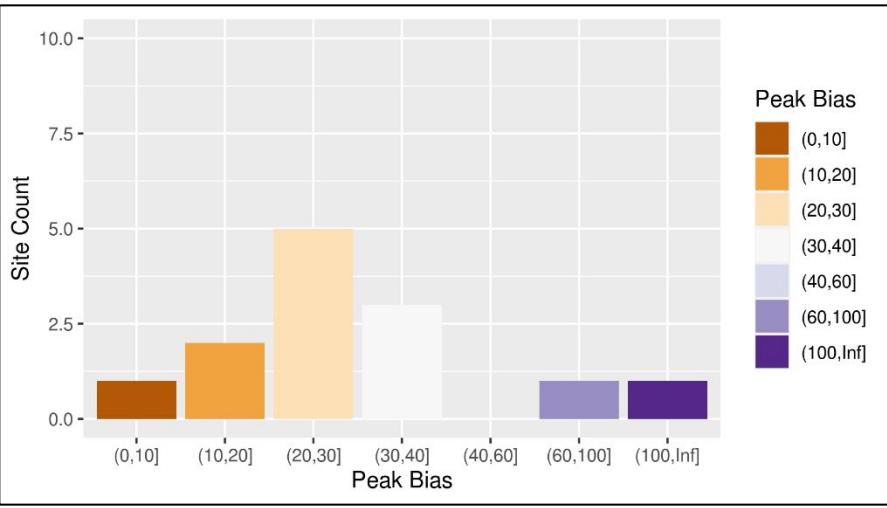


- Assessment is for 2014-2017 validation period, without streamflow DA, using SERFC observed-precipitation
- Improved calibration and model physics have led to improvements in NWM streamflow guidance, as noted in the peak bias and the NSE metrics

Assessing New Capabilities: NWM Alaska Domain

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

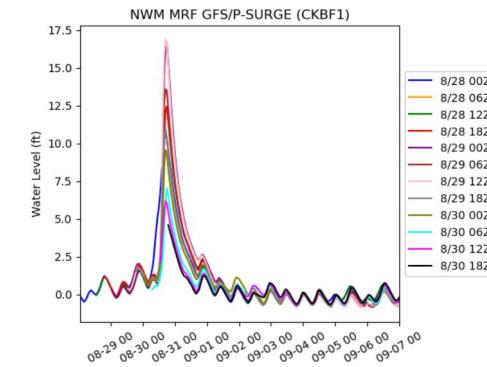
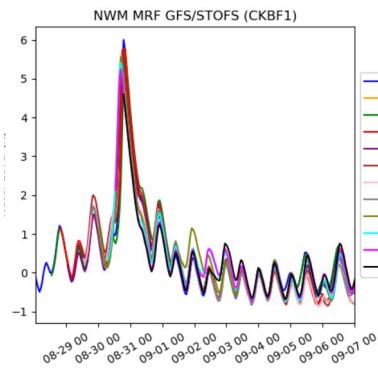
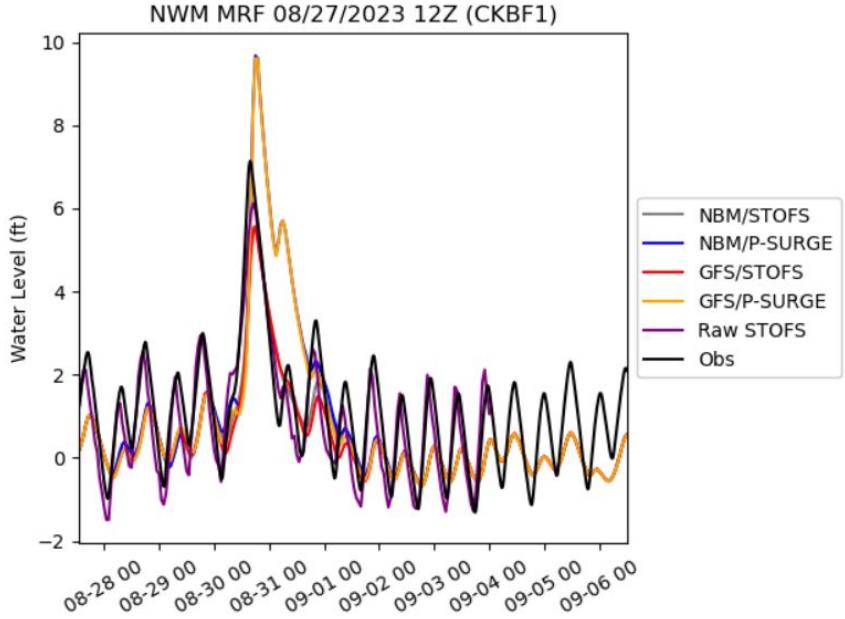
Overall Summary: NWM v3.0 Peak Bias at USGS Reference Gauges (WY 2009-2014, AORC Forcing without assimilation of USGS observations)



- 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)

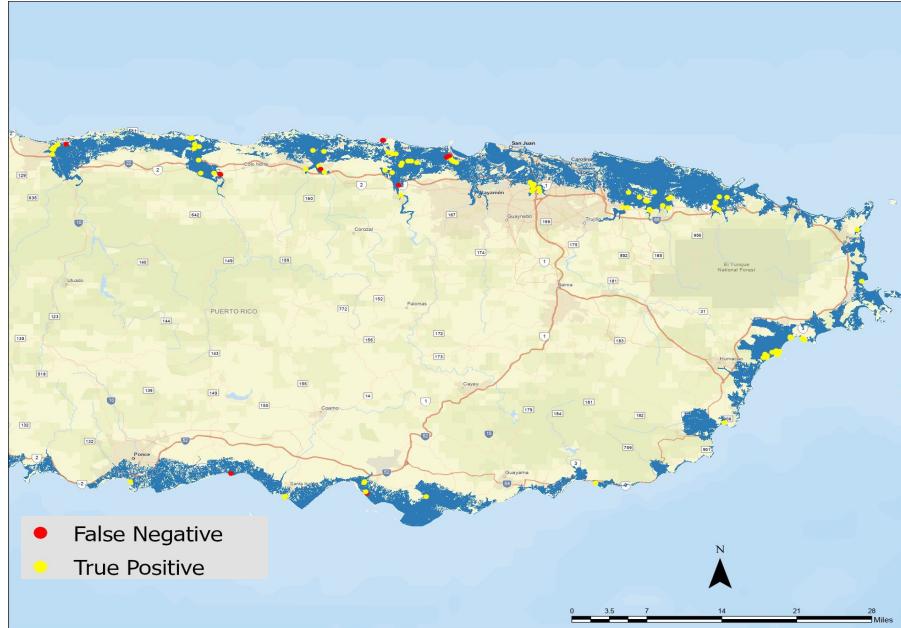
Assessing New Capabilities: TWL for Hurricane Idalia, August 2023

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

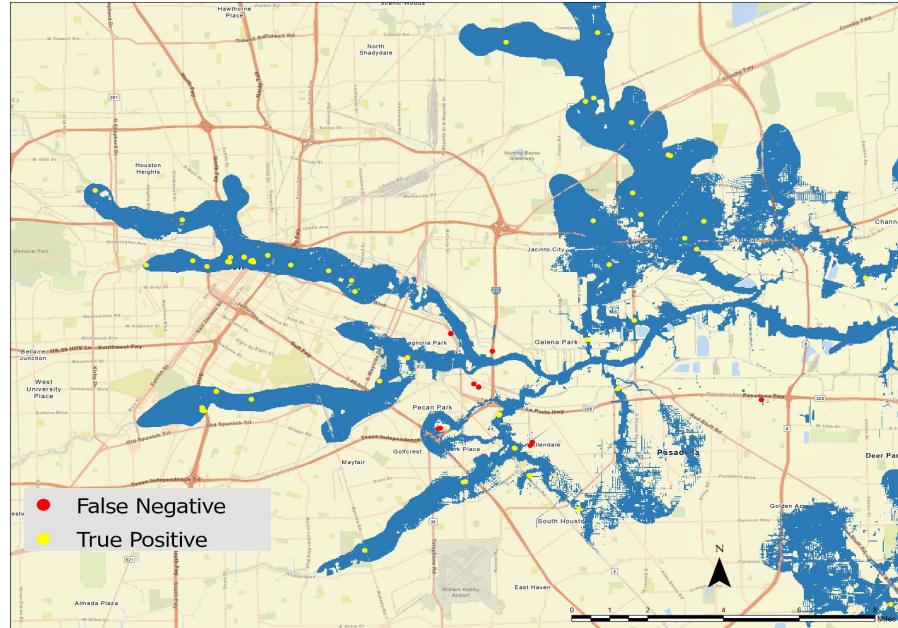


NWM v3.0: Supporting Coast-to-Coast Flood Inundation Mapping

NWM-Driven Maximum FIM, Hurricane Maria (PR)



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



- A critical advance: total water level output from NWM-SCHISM will be joined with NWM inland streamflow forecasts to create national summit-to-sea flood inundation maps



Closing Thoughts

- The implementation of NWM v3.0 continues to rapidly accelerate hydrologic data availability, with Total Water Level and Alaska coverage as key new features
- NWM v3.1 in 2025 will focus on TWL and forcing enhancements, with NextGen-based v4.0 planned for 2026 (*Frazier*)
- Impact of these NWM upgrades is multiplied via parallel upgrades to visualization, forecast products, FIM and assessment tools (*next talk*)
- Upgrades will continue to be enriched by community development via CIROH and other avenues





Thank You!



For More Information:

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<https://water.noaa.gov>



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PREDICTION



National Water Model v3.0 Upgrade Highlights: Providing improved guidance for flood and hydrologic forecasts

- With this version, NWM is supporting congressional direction from the Coordinated Ocean Observations and Research Act of 2020
 - Provides first-time NWM Total Water Level (TWL) guidance for coastal areas of the CONUS, Hawaii and Puerto Rico / USVI
 - Supports nationwide flood inundation mapping
- Other major elements which improve hydrologic guidance
 - Expansion of domain to cover south-central Alaska
 - Addition of National Blend of Models as a forcing source for NWM CONUS medium-range and Alaska forecasts
 - Ingestion of MRMS precipitation forcing over NWM PR/VI domain
 - NWS Field-Driven Enhancements: Field input into calibration/regionalization, inclusion of additional RFC reservoir sites, and design of SHEF-formatted TWL output files

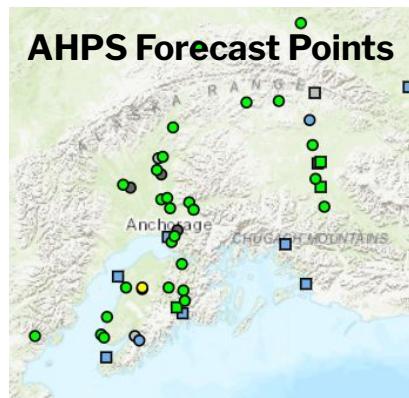
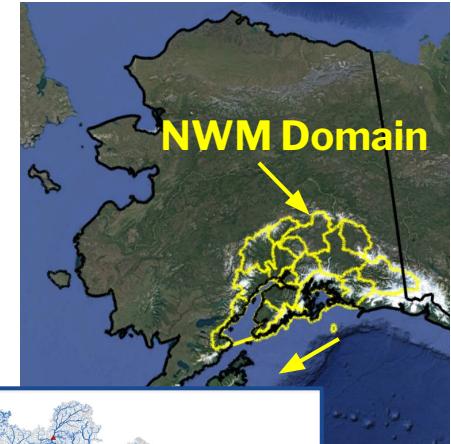


NWM v.3.0 Operations: Expansion to Alaska

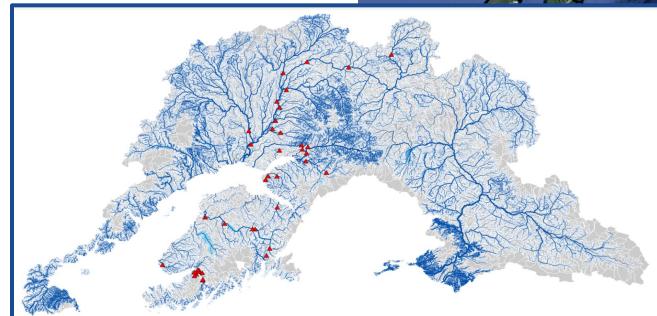
Overarching Goal: Provide complementary and first-time hydrologic guidance for Alaska's Cook Inlet, Copper River Basin and Prince William Sound Regions

NWM Alaska Summary

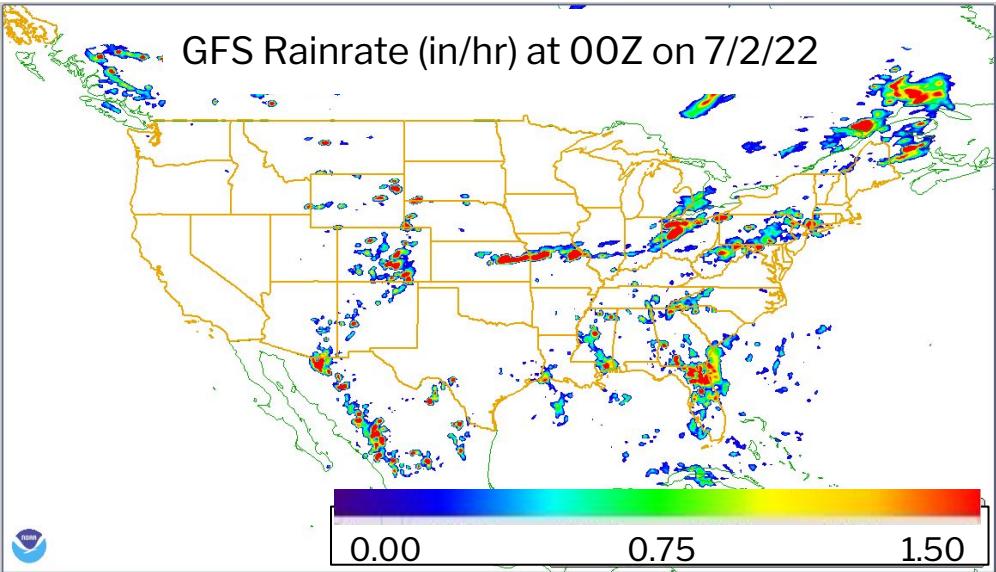
- Close configuration/forcing coordination with Alaska Pacific RFC
- Assimilation of APRFC glacial dam lake (GDL) outflow forecasts
- Customized model and forcing configurations
- Guidance for 390k stream reaches complements RFC AHPS sites
- Total water level guidance for AK coast in Version 4.0 of the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



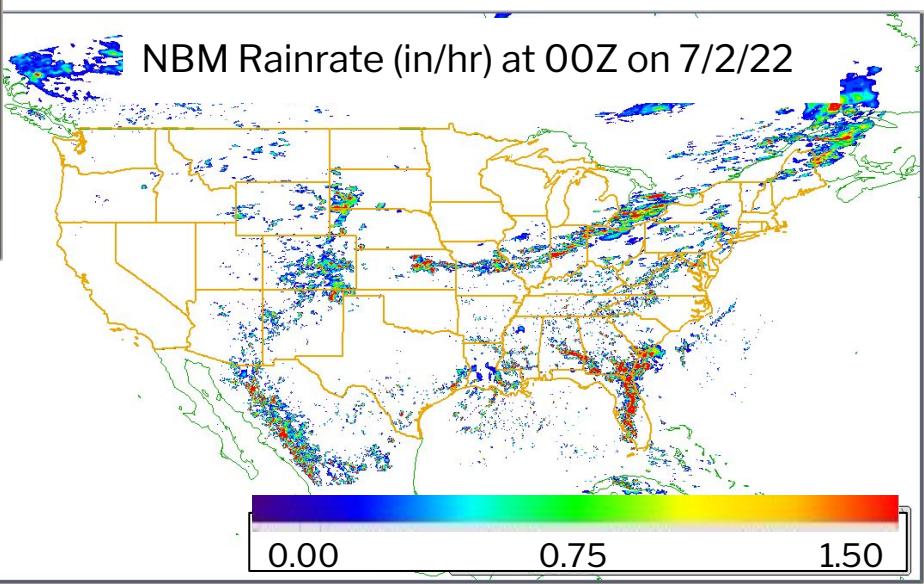
Dense network of NWM
hydrologic guidance



NWM v3.0 Operations: National Blend of Models Forcing



- New 10-day CONUS forecast configuration forced by NBM, complementing existing GFS-forced members
- Use of NBM enhances coordination with NWS Centers and Field offices



- NWM v3.0 features first-time use of the NBM precipitation as forcing
- Implemented for both CONUS and Alaska domains

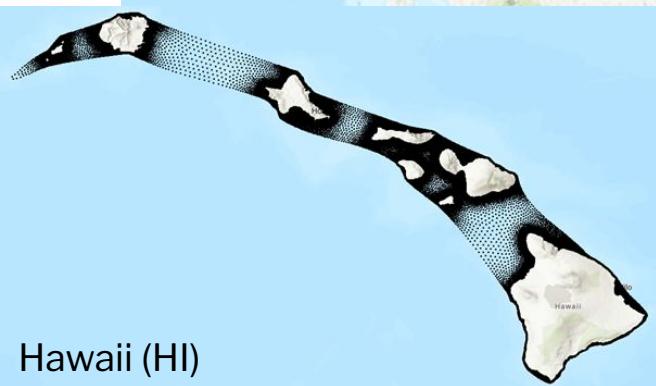


NWM v3.0 Operations: Total Water Level Domain Coverage



Atlantic and Pacific (P) Coasts

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



Average Resolution

Atlantic: 75 m

Pacific: 50 m

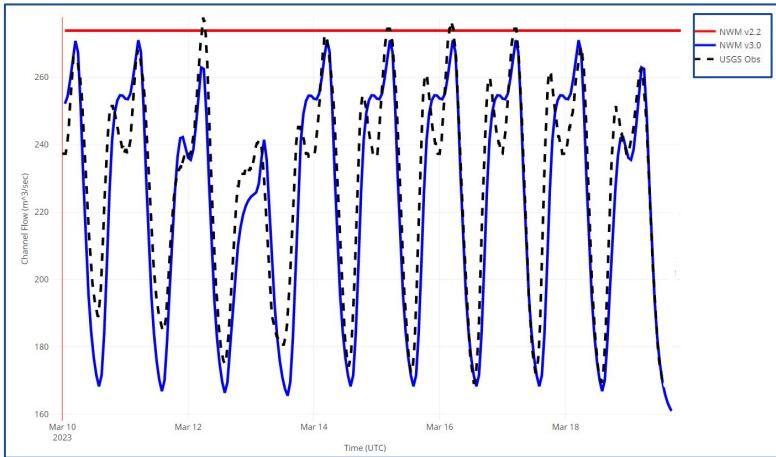
PR-VI and HI: 30 m

Puerto Rico/Virgin Islands (PR/VI)

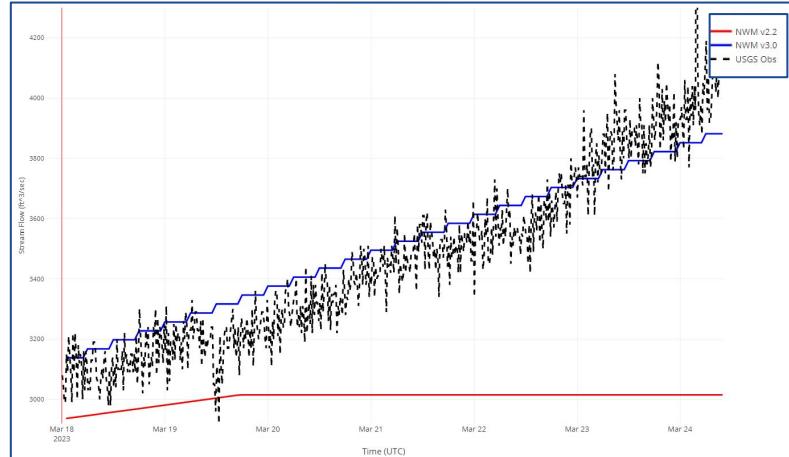


NWM v3.0 Real-time Improvement: Additional RFC Data Ingest

Streamflow Downstream of
Lake Powell Reservoir, Arizona



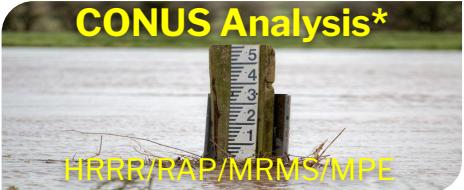
Streamflow Downstream of
Coeur D'Alene Lake, Idaho



- NWM v3.0 assimilates RFC outflow forecasts at additional reservoir locations, improving downstream forecast accuracy, versus persistence or no-DA treatment in NWM v2.2

Putting it All Together: NWM Operational Cycling

CONUS Analysis*



Lookback Range 3-28 hrs

*Including open loop
(non-DA) members*

CONUS Short-Range*



CONUS Med-Range Ens*



CONUS Long-Range Ens



Hawaii* /

Puerto Rico USVI* 3 Hour Lookback 48 Hour Forecast

HiRES ARW/NAM-NEST/MRMS

18 Hour Forecast

~10 Day Ens Forecast

*Including open loop
(non-DA) member*

Alaska

3 Hour Lookback 48/240 Hr Forecasts

HRRR, GFS, NBM, MRMS

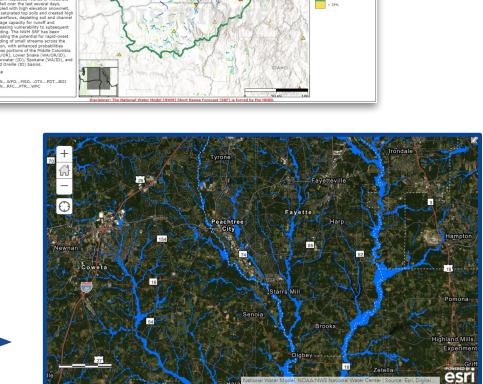
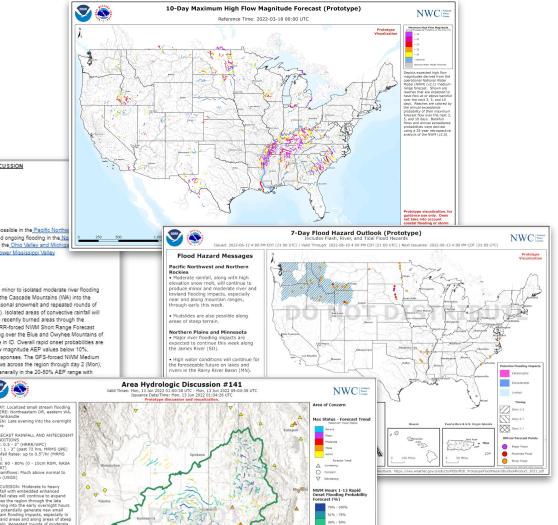
*Coastal Total Water Level

30 Day Ensemble Forecast

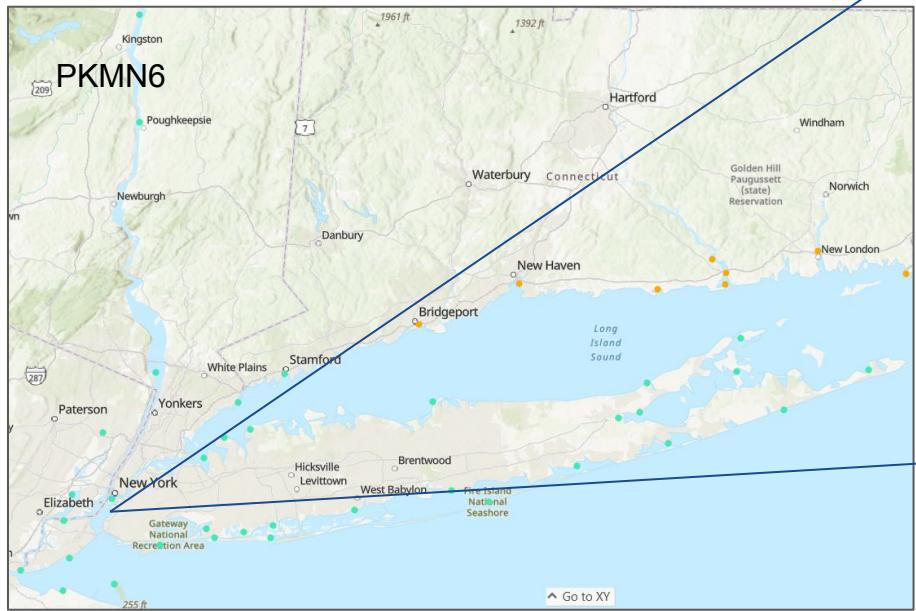
Effective Communication: NWC Experimental Products

<https://www.weather.gov/owp/operations>

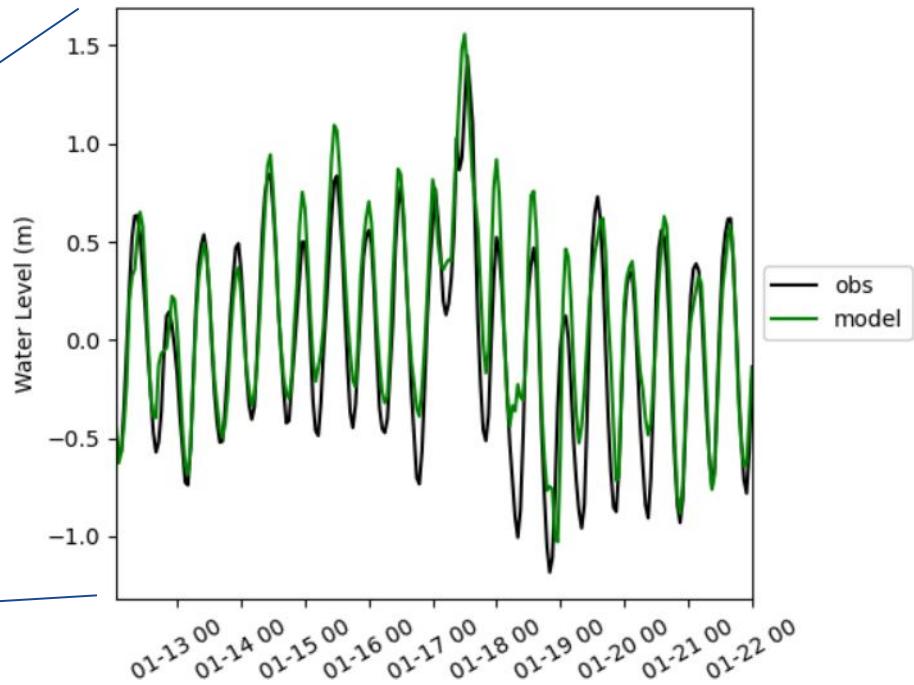
- **NWC Visualization Services**
 - Probability of high flow
 - Arrival time
 - Other value-added products
- **National Hydrologic Discussion (NHD)**
- **Area Hydrologic Discussion (AHD)**
- **Flood Hazard Outlook (FHO)**
- **Note:** Flood Inundation Mapping (FIM) Services are targeted for public release --
(10% of country as of Sept., ~100% by Q4 FY26)



NWM v3.0 Verification: TWL for Strong Nor'easter January, 2022



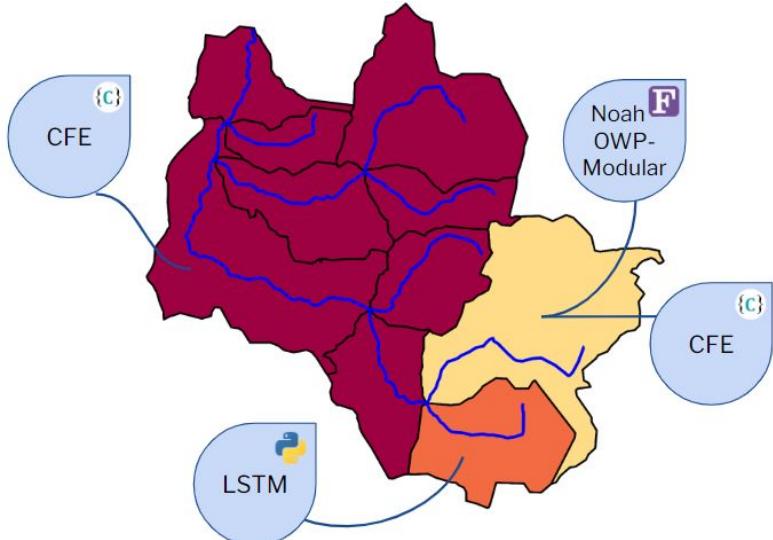
New York Harbor at The Battery (BATN6)



Coastal flooding in New York City

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...

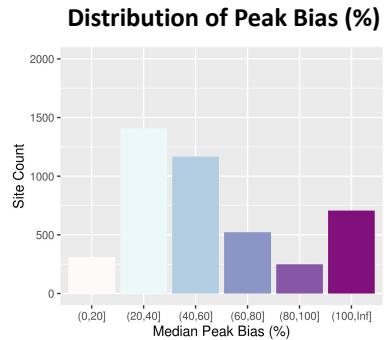


This will lead to key operational improvements

- 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

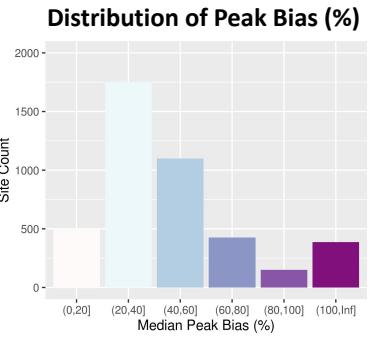
NWM v3.0: Improved Performance over the CONUS

V1.2



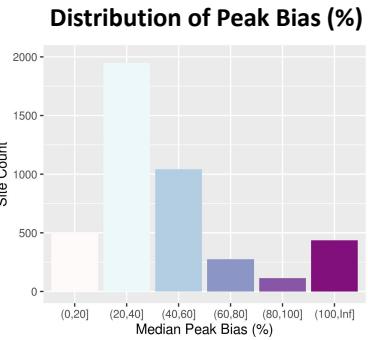
39% have Peak bias < 40%

V2.0



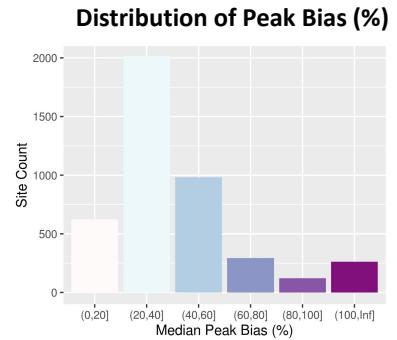
52% have Peak bias < 40%

V2.1



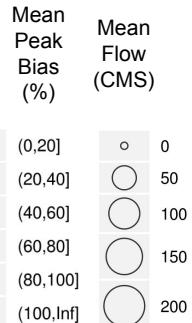
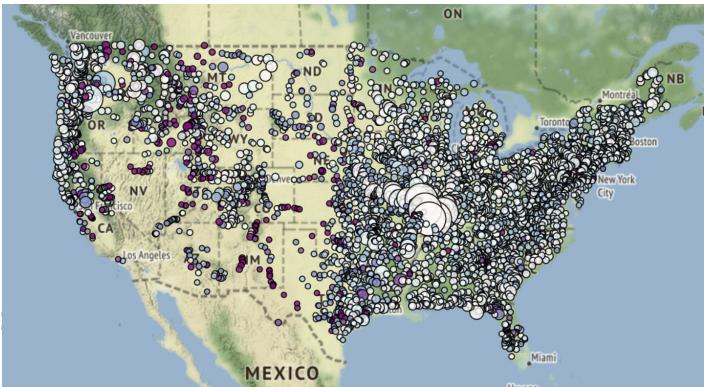
57% have Peak bias < 40%

V3.0



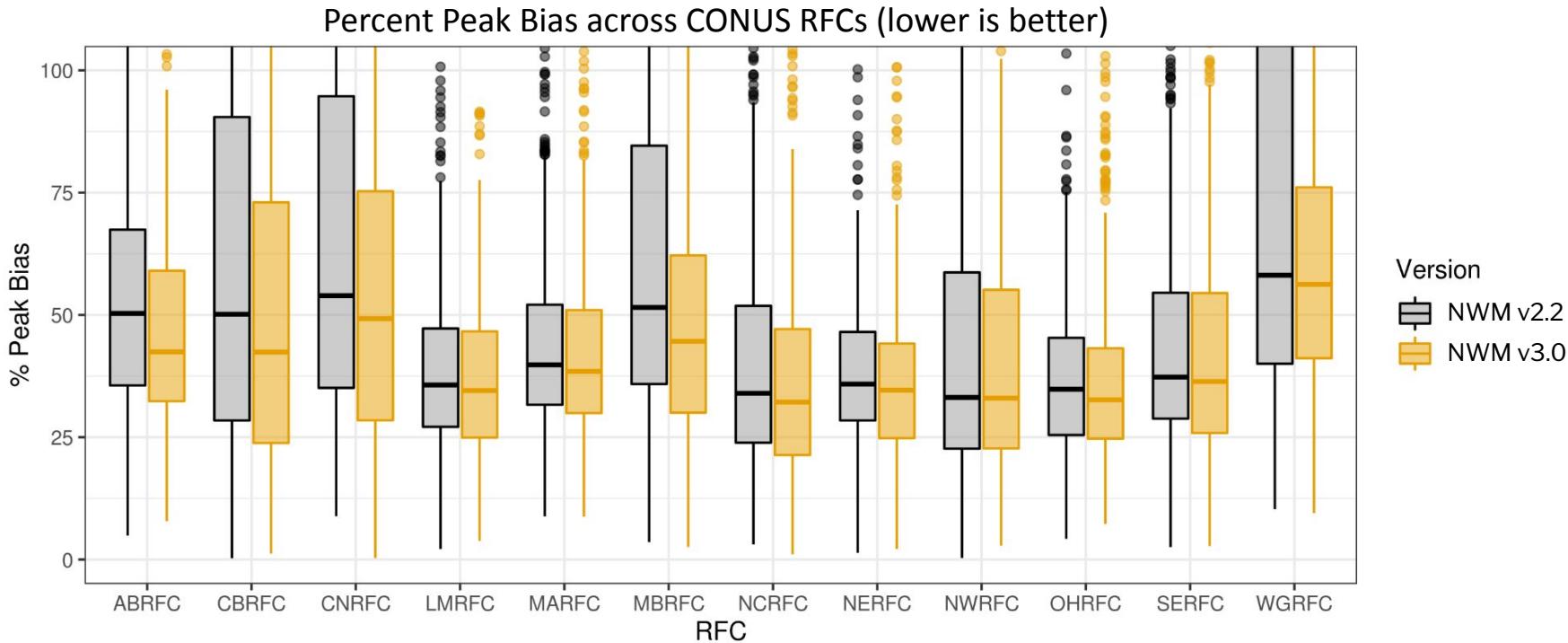
61% have Peak bias < 40%

NWM v3.0 Streamflow Peak Bias (%) at
USGS Gauges (WY 2014-2016, AORC Forcing)



- Streamflow peak bias (%) continues to improve at USGS gauged basins
- Simulation is for WY2014-2016 (validation period) and uses AORC forcing data
- No assimilation of streamflow or reservoir observations

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



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

