



Office of Water Prediction



NOAA's National Water Model: Current Operations and Future Plans



**AMS 2021:
Presentation 14A.1**

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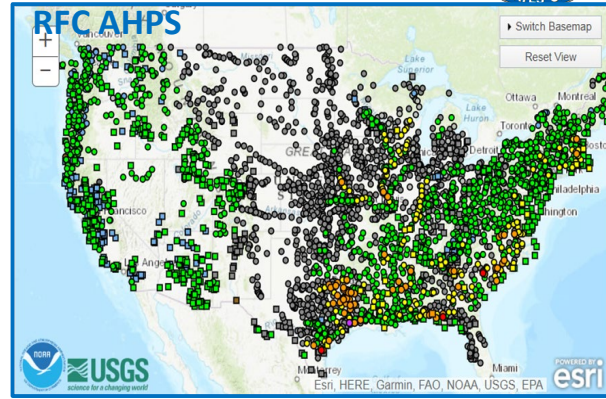
Tom Graziano, Ed Clark and Trey Flowers (Office of Water Prediction)

Large integrated OWP and NCAR team

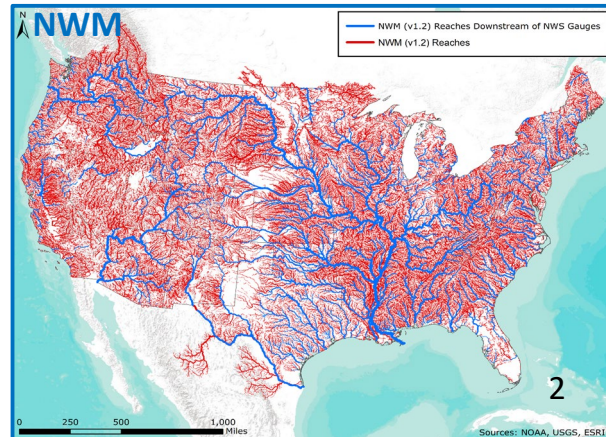
National Water Model Overview

- Full spectrum hydrologic model, providing complementary NWS hydrologic guidance
- NWM will be upgraded to V2.1 in January 2021 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



V2.1 2021



V3.0 2023



Next Gen

Current Capabilities: Operational Forecast Cycling

Analysis

HRRP/RAP/MRMS/IMPE

Lookback Range 3-28 hrs

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

Short-Range

HRRR/RAP

Medium-Range Ens

GFS

Long-Range Ens

CFS

18 Hour Forecast

~10 Day Ensemble Forecast

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

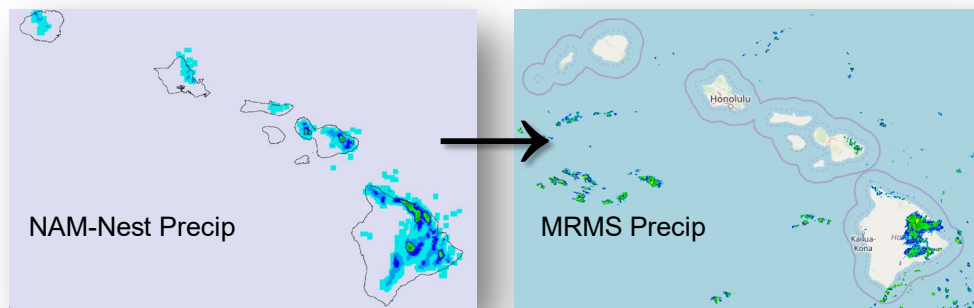
30 Day Ensemble Forecast

Hawaii / Puerto Rico
3 Hour Lookback
48 Hour Forecast

HiRES ARW/NAM-NEST
(MRMS for Hawaii)
(Open Loop Configs)

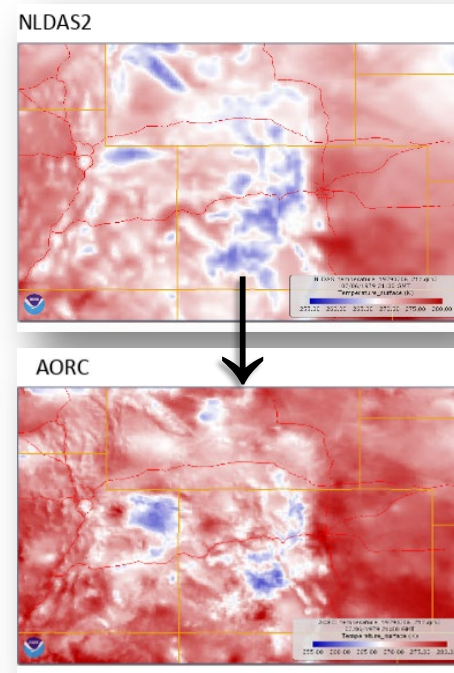
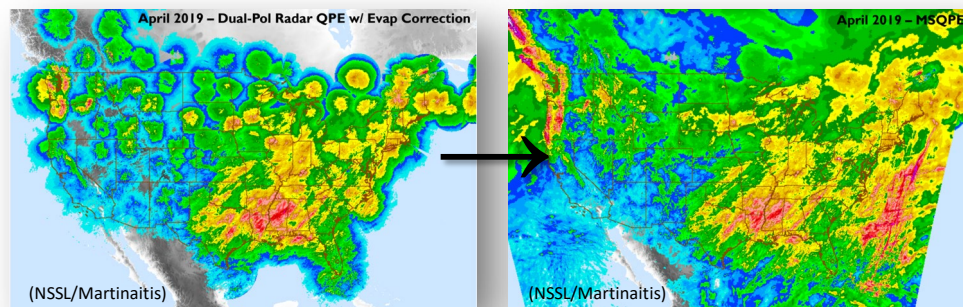
Improved Forcing for NWM V2.1

MRMS V12 Hawaii QPE in real-time operations



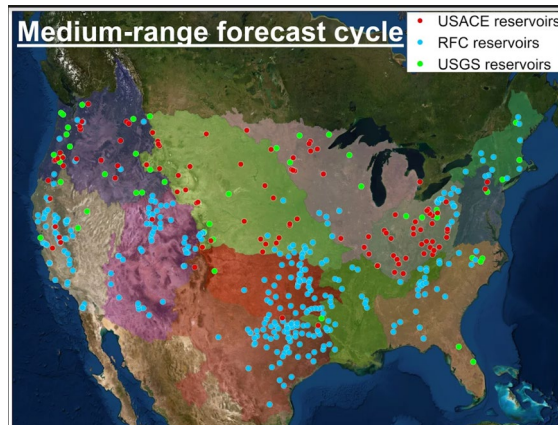
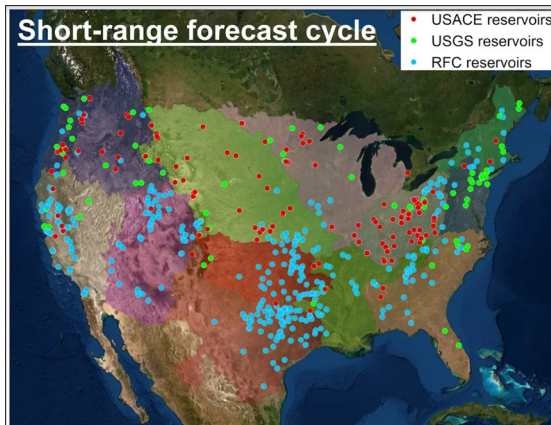
Analysis of Record for Calibration (AORC) in calibration / retrospective runs

MRMS V12 Blended Radar/Gauge/Model QPE product over CONUS in real-time operations



NWM 2.1 Highlights: Reservoirs and Domain Expansion

Key Link to Field and Skill Improvement: Improved treatment of reservoir outflow via ingest of RFC-provided forecasts. Also, application of reservoir persistence approach leveraging USACE and USGS observations. Improved physics.



Short-range forecast cycle:

number of USGS sites: 74

number of USACE sites: 122

number of RFC sites: 316

Total number of sites: 512

Medium-range forecast cycle:

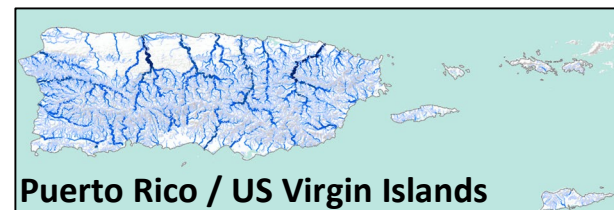
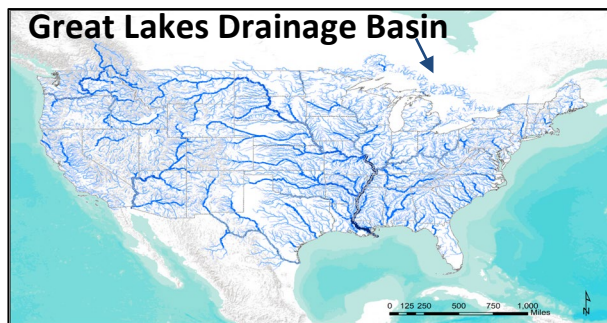
number of USGS sites: 46

number of USACE sites: 106

number of RFC sites: 308

Total number of sites: 460

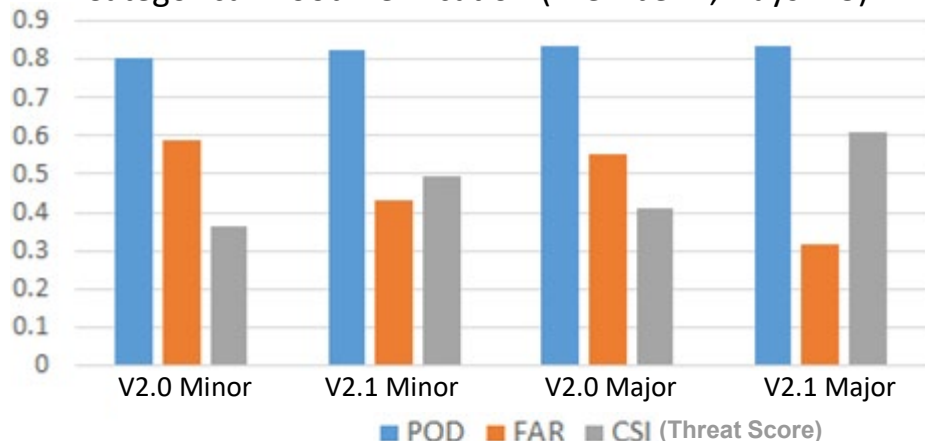
**Domain
Expansion:**



Performance Improvements in NWM V2.1: Overview

CONUS Verification – Medium-Range

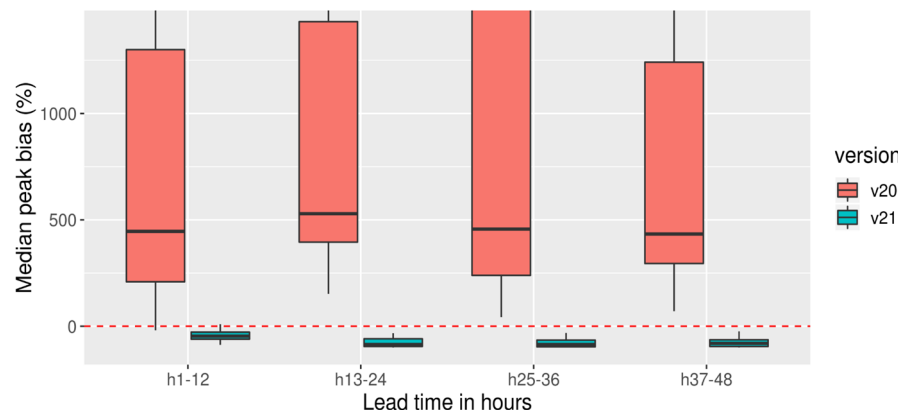
Categorical Flood Verification (Member 1, Days 1-3)



- Categorical flood forecast skill is greatly improved in V2.1. Similar results for days 4-10. Ensembles exhibit higher scores.

Hawaii Verification – Short-Range

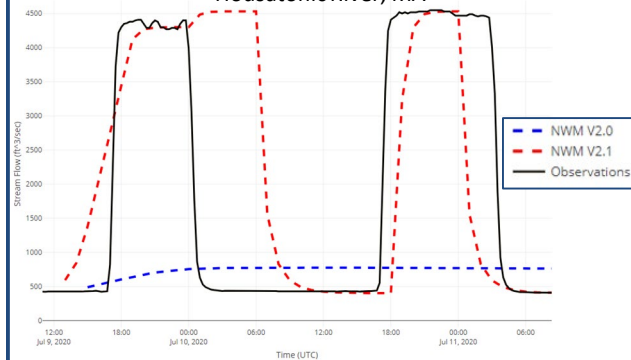
Median Peak Bias (%)



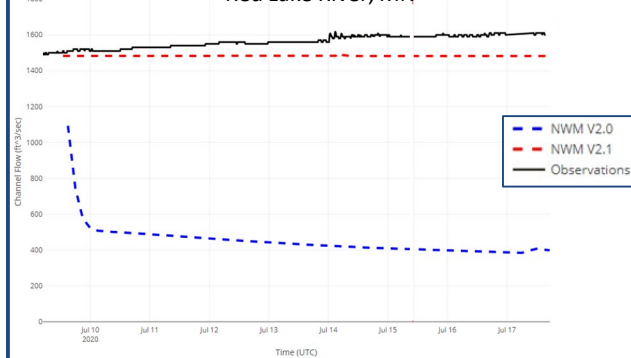
- Large overestimation of peak streamflow discharge in v2.0 is significantly reduced in v2.1 across all lead times

Performance Improvements in NWM V2.1: Reservoir Outflow

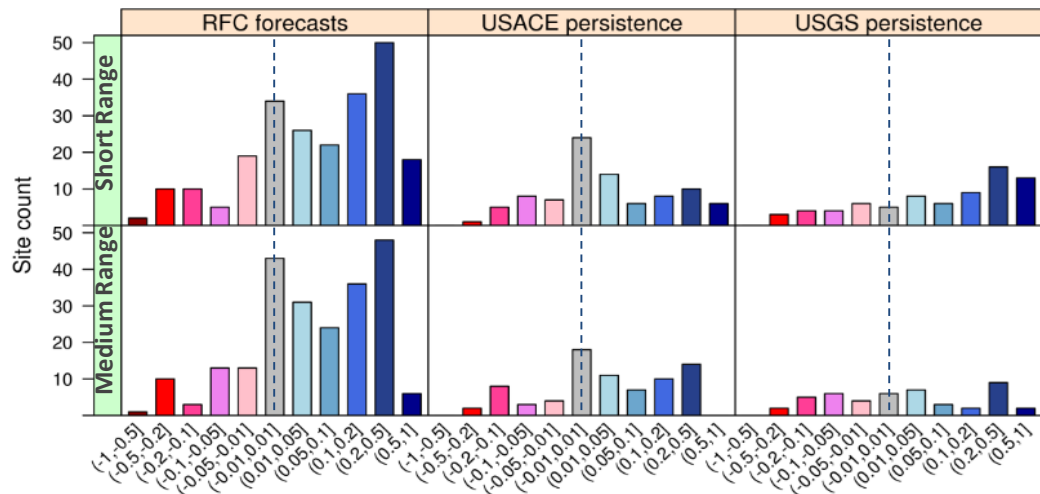
Medium Range Forecast Streamflow (12Z July 9th, 2020)
Housatonic River, MA



Medium Range Forecast Streamflow (12Z July 9th, 2020)
Red Lake River, MN



Distribution of improvement in NNSE in NWM v2.1 relative to v2.0
(all lead times)



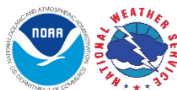
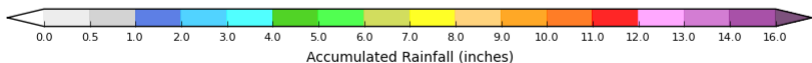
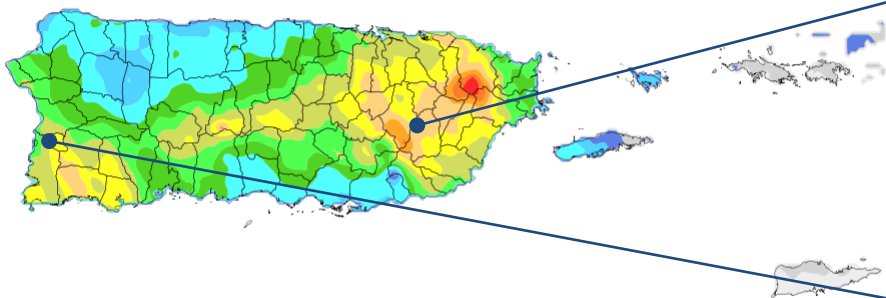
- **Left:** NWM V2.1 ingest of RFC (top), USGS (bottom) and USACE (not shown) data greatly improves streamflow forecast downstream of reservoirs
- **Right:** NWM V2.1 NNSE greatly improves via data ingest

Performance Improvements in NWM V2.1: Hurricane Isaias

Preliminary Rainfall Totals for Puerto Rico and the U.S. Virgin Islands

Data Source: MPE (Radar Estimates & Rain Gages)

Valid from 07/29/2020 12Z to 07/31/2020 12Z



National Weather Service
San Juan, PR
07/31/2020 10:18 GMT

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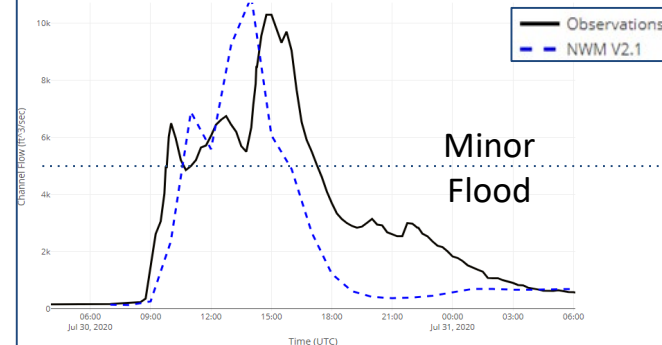


weather.gov/sju

- First implementation of PR/USVI domain performing well
- Good streamflow forecast magnitude and timing during Isaias

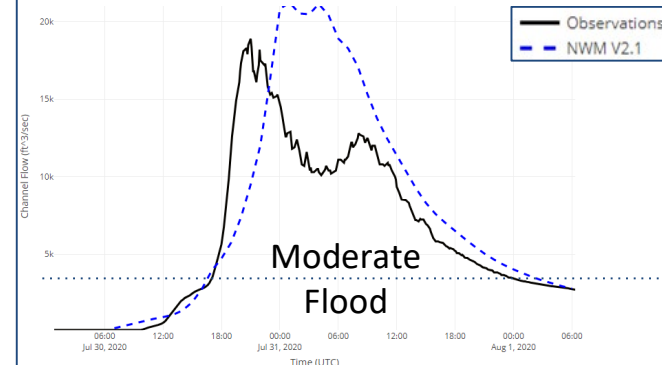
Short Range Streamflow Forecast (06 July 30th, 2020)

Rio Grande De Loiza, Puerto Rico



Short Range Streamflow Forecast (06 July 30th, 2020)

Rio Guanajibo, Puerto Rico

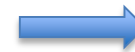


Enhancing the Model: Development Trajectory

v1.0



v1.1/1.2/2.0



v2.1

Foundation: 2016

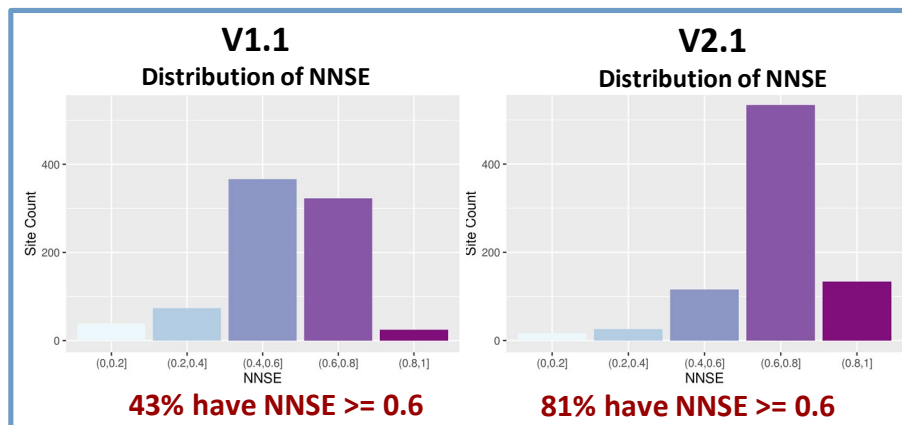
Water resource model
2.7 million reaches

Upgrades: 2017/2018/2019

Hawaii, medium range ens.,
physics upgrades, improved
modularity, MPE ingest

Next Upgrade: Jan 2021

Expansion to PR and Great
Lakes, reservoir modules,
forcing upgrades, open-loop,
and improved Hawaii forcing



v3.0

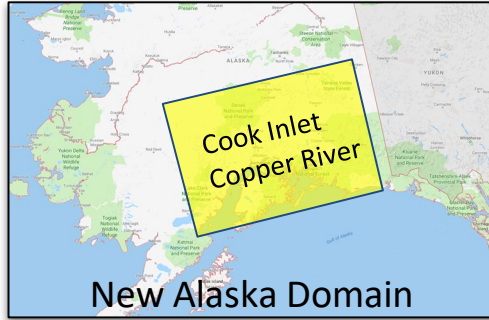


Future Upgrade: 2023

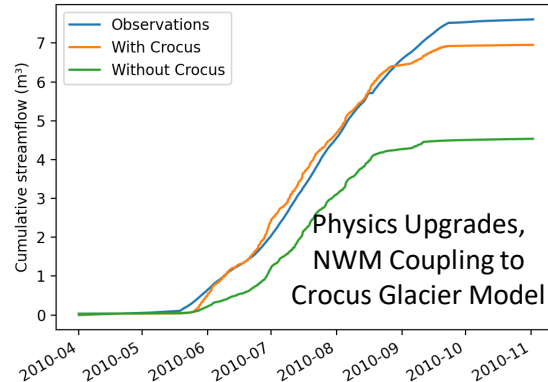
Coastal coupling, expansion to Alaska,
improved runoff module, parameter,
calibration and hydro-fabric upgrades

NWM V3.0: Expanded Partnerships and Activities

Expansion to Alaska with APRFC



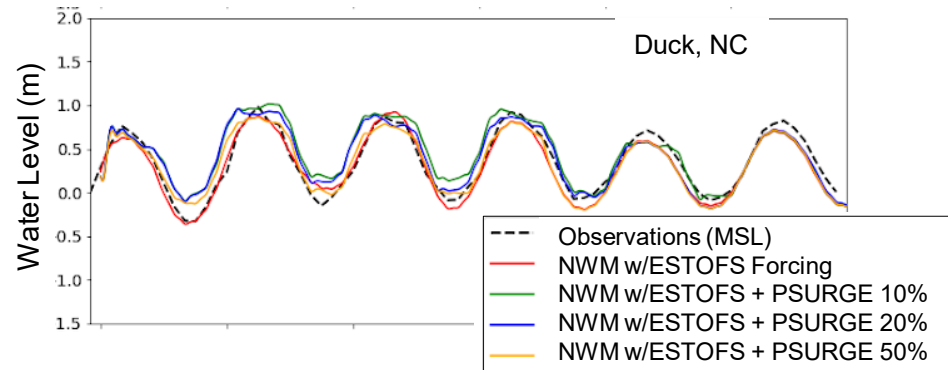
Accumulated Streamflow ($\text{m}^3 \times 10^7$) Gulkana Benchmark Glacier Site



NWM Coastal Coupling

- Total Water Level Forecasts
 - Freshwater-estuary-ocean model coupling, leveraging ESTOFS, PSURGE, SCHISM
 - Goal: Simulate compound flooding— freshwater/surge/tides
 - Complements existing regional total water level forecasts with first ever CONUS-wide, Hawaii and Puerto Rico forecasts.

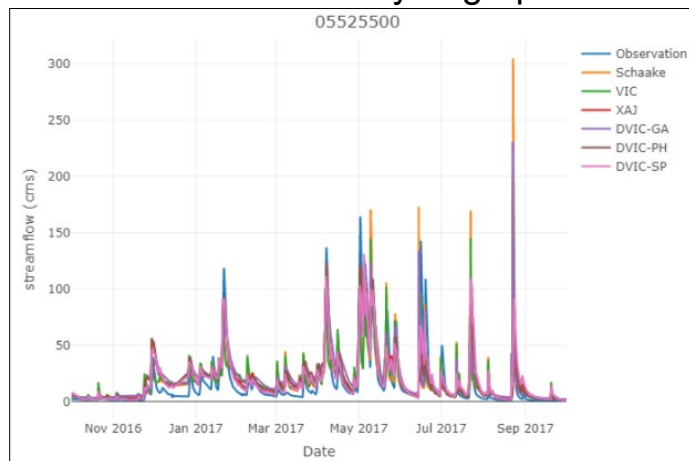
Total Water Level Simulation, Hurricane Florence NWM with SCHISM Estuary Model



NWM V3.0: Expanded Partnerships and Activities

Exploration of Improved Runoff Schemes

Individual Basin Hydrographs



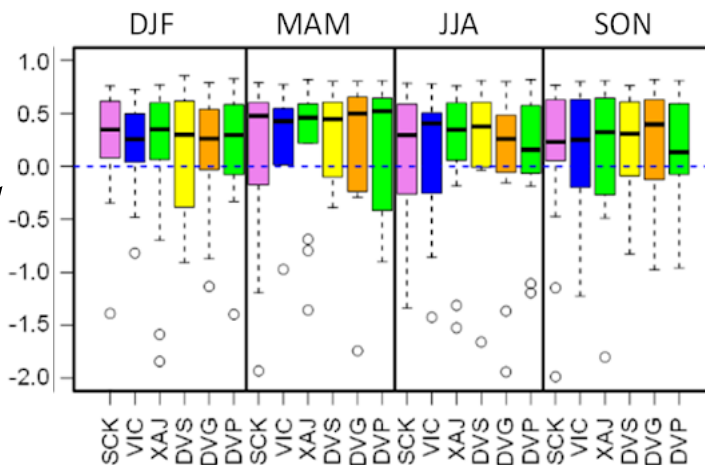
→ Existing runoff scheme (Schaake-SCK) compared against new options: Xinanjiang (XAJ), Variable Infiltration Capacity Module (VIC) and Dynamic VIC options (DVS, DVG, DVP)
→ Assessment ongoing

Domain-Averaged Statistics

Improved Inland Routing

- Replacement of current Muskingum-Cunge Approach
 - Improved routing for backwater and complex channels
 - Diffusive wave base, with dynamic wave when needed
 - Accompanying hydrofabric upgrades for routing and Flood Inundation Mapping

Nash Sutcliffe Efficiency



Closing Thoughts

- With four upgrades in just over four years, the NWM is rapidly advancing
- What exists now is a foundation that will continue to be built upon
 - v2.1 into operations in January 2021: Domain expansion, reservoir upgrades
 - v3.0 is anticipated in early 2023: Coastal coupling, inland routing upgrades, first-ever Alaska domain, improved runoff module
 - Next Gen NWM planning underway
- Along with upgrades, nationwide NWM- and RFC-forecast-based flood inundation mapping, model-as-a-service and partnerships with Big Data are key elements moving NWM forward