NOAA's National Water Model
Background, Capabilities and Future Plans

Brian Cosgrove (NOAA/NWS Office of Water Prediction)
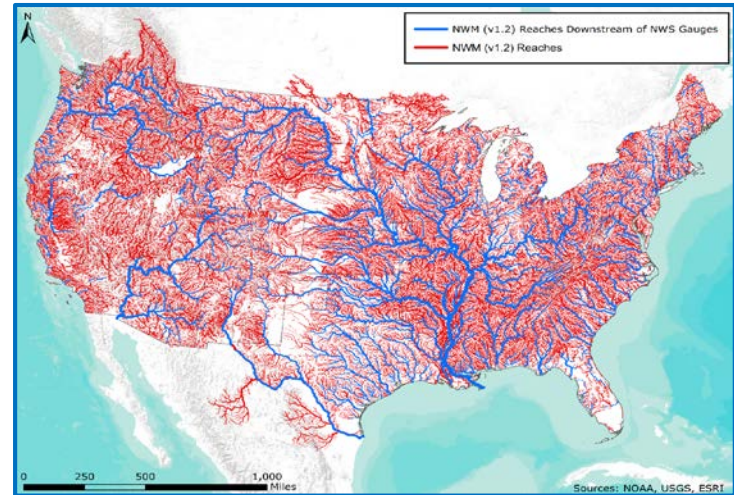Large OWP and NCAR Development Team

National Water Model (NWM)

- Full spectrum hydrologic model, providing complementary hydrologic guidance
- NWM was upgraded to V2.0 in June 2019 by OWP, NCEP and NCAR
- Hydrologic core is WRF-Hydro, a community-based hydrologic modeling framework

**RFC AHPS**
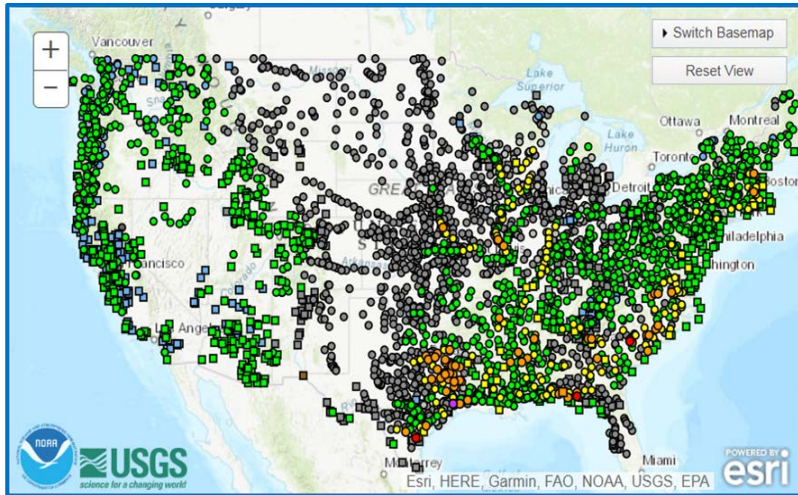
NWM

River Forecast Centers: <u>Authoritative forecasts</u> at ~3,600 RFC Points
NWM: <u>Guidance</u> at 2.7 million NHDPlus river segments, filling in coverage gaps and enriching existing points

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. Supported by verification and visualization elements.

NWM Hydrography
Medium Resolution NHDPlusV2
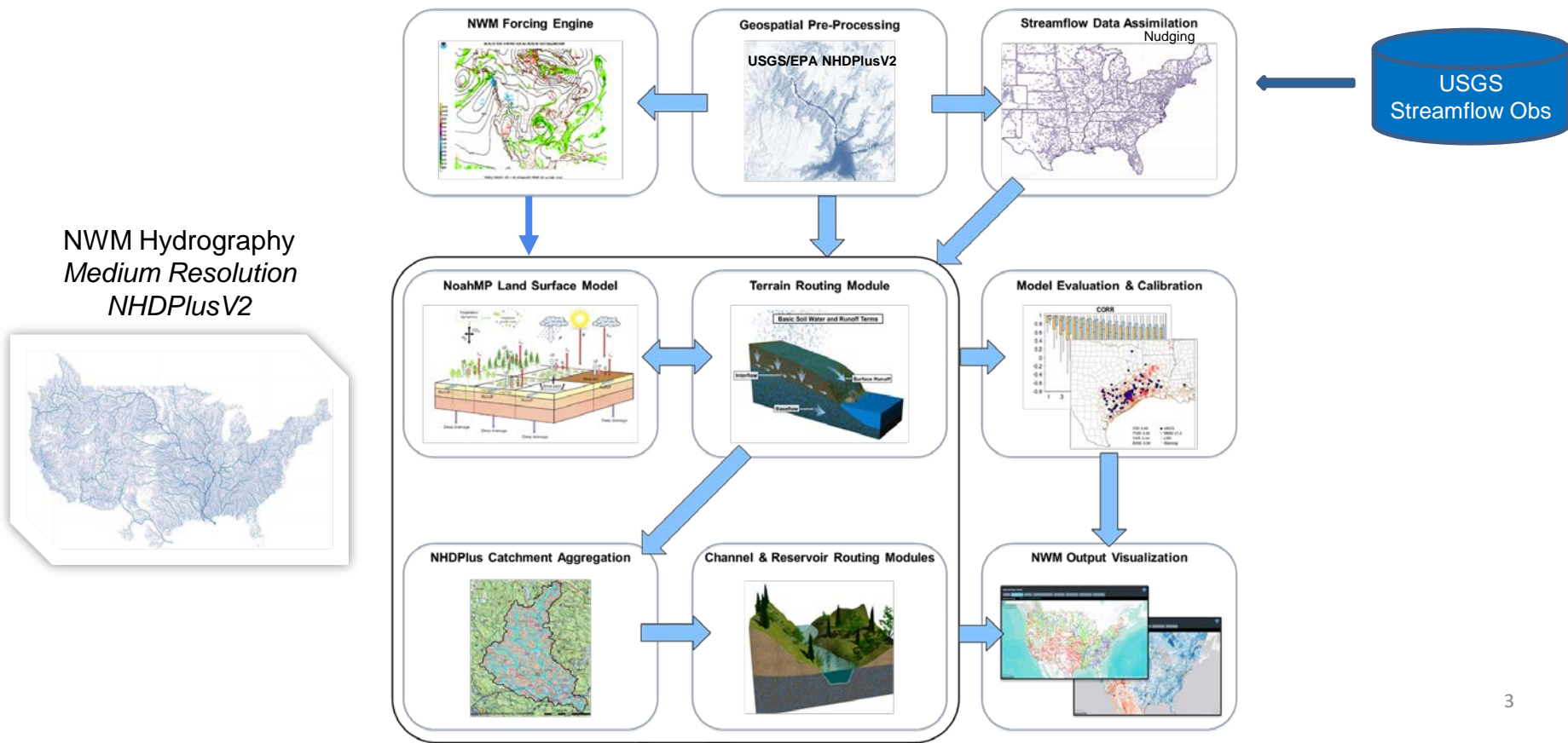
National Water Model V2.0: Cycling Overview

Analysis

HRRR/RAP/MRMS/MPE

Lookback Range 3-28 hrs →

Short-Range

HRRR/RAP

18 Hour Forecast →

Medium-Range Ens

GFS

~10 Day Ensemble Forecast →

Long-Range Ens

CFS

30 Day Ensemble Forecast →

Hawaii
3 Hour Lookback
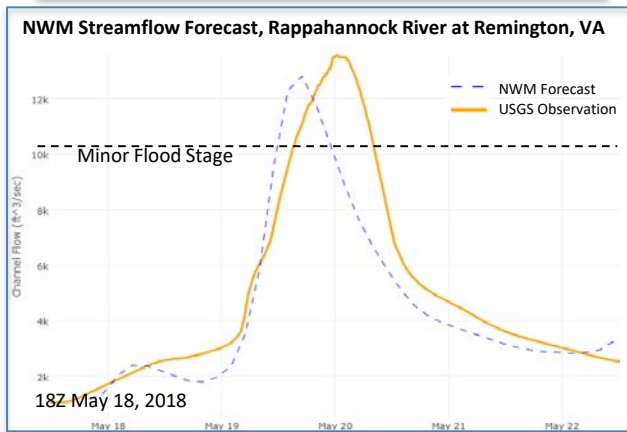**60 Hour Forecast**

NAM-NEST

New For V2.0

NWM Provides Multi-Scale Hydrologic Forecast Guidance
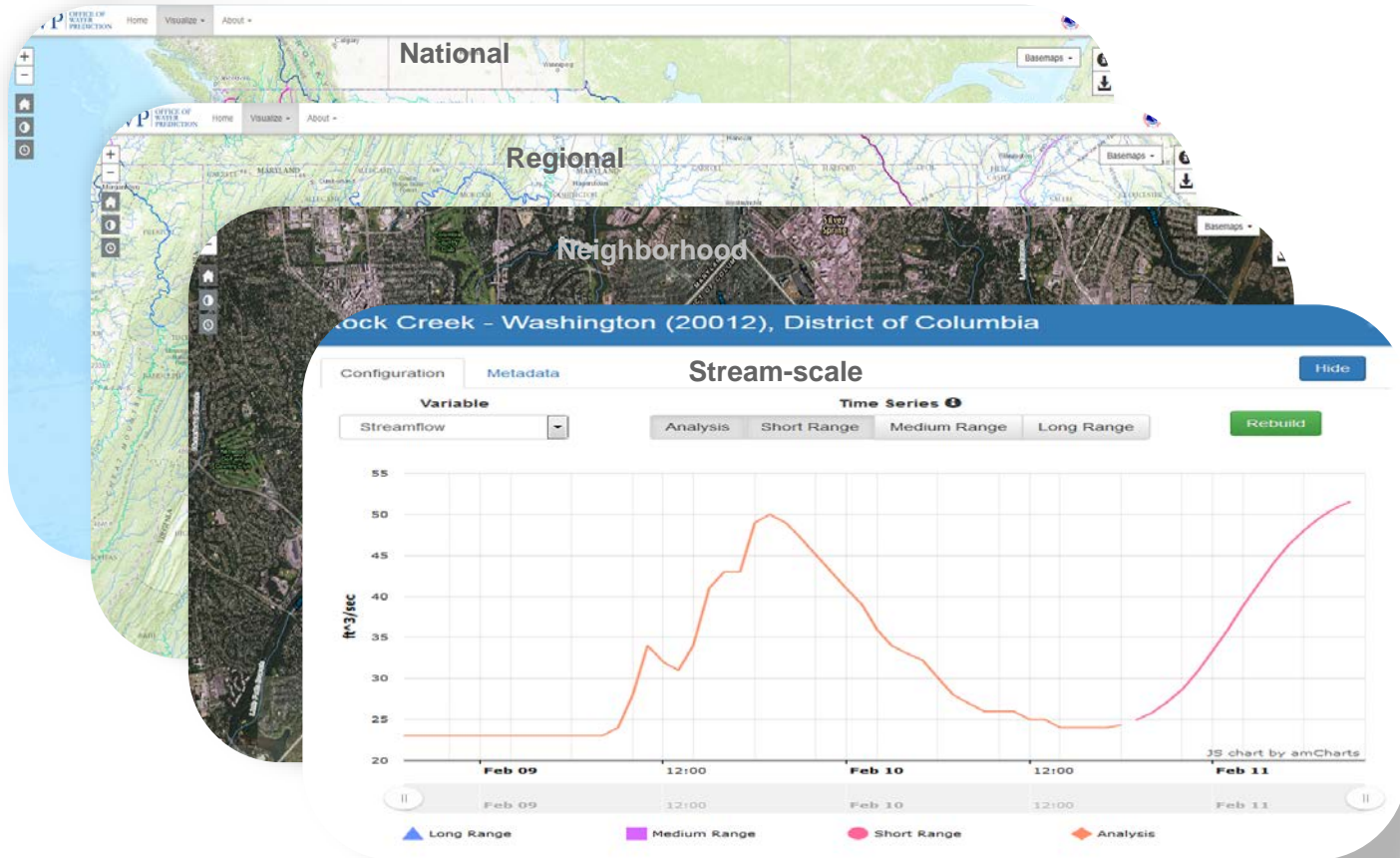
NWM Output: Complementary Guidance for Forecasters

Large River at Traditional RFC Forecast Location

NWM Streamflow Forecast, Rappahannock River at Remington, VA

Small Ungauged Stream Away from Traditional Forecast Point

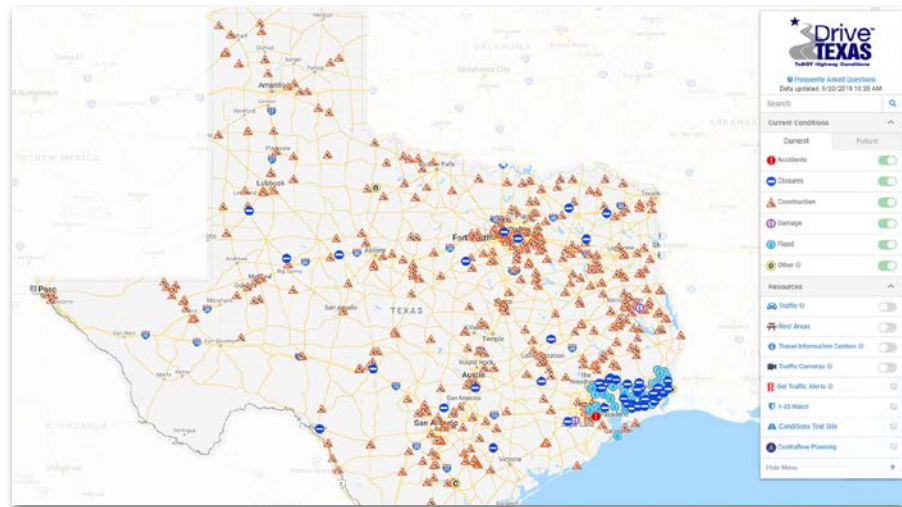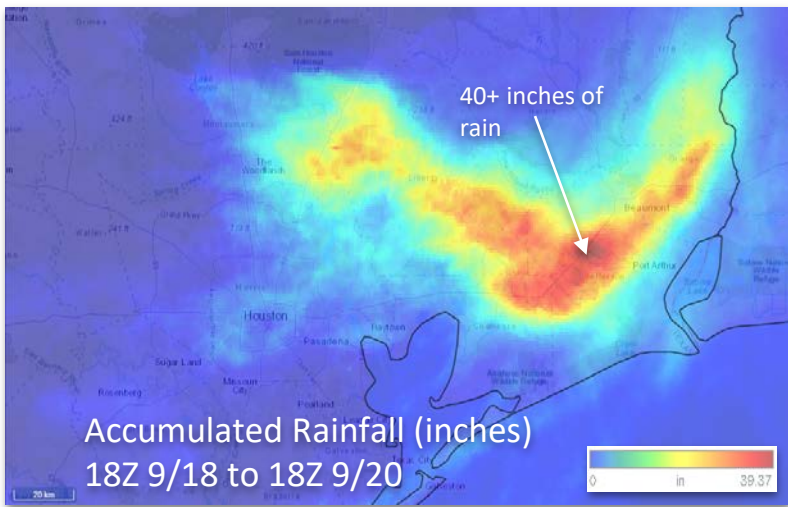NWM Streamflow Forecasts for Hawlings River, Maryland

- Leveraging accurate precipitation NWM correctly forecasts minor flooding two days in advance
- Inter-cycle variability/biases highlight need for improved precip forecasts, NWM development
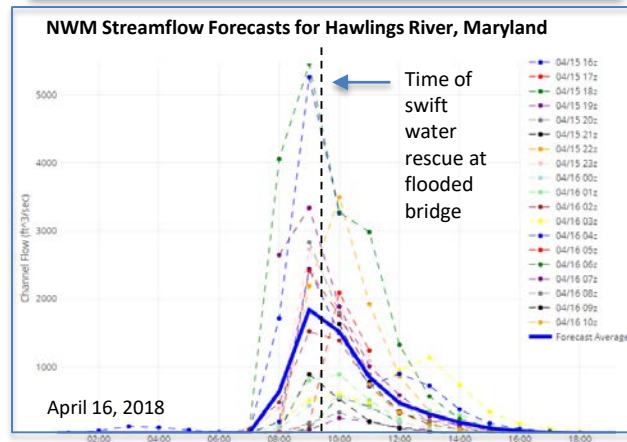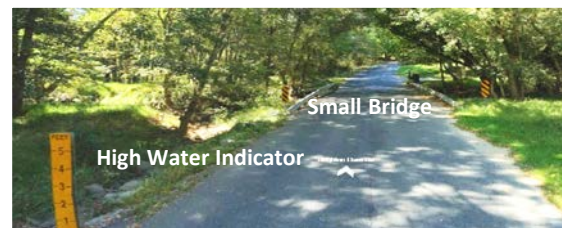
- Successive NWM forecasts indicate correct timing for dangerous flow
- Run-to-run variability indicates need for continued precipitation improvement
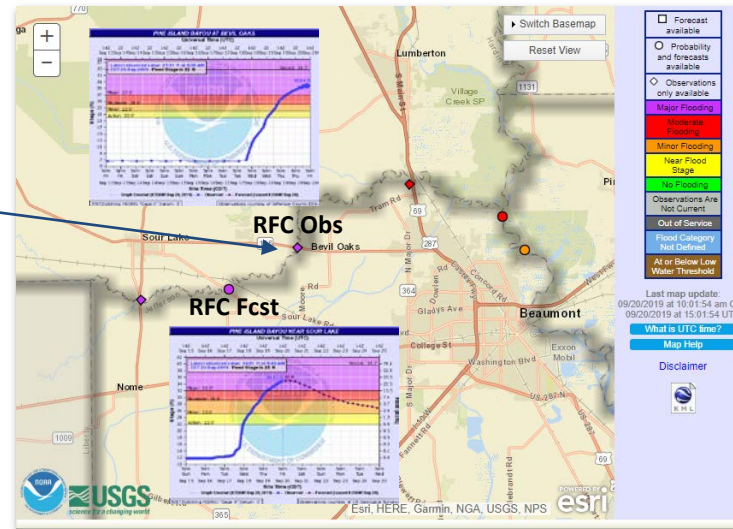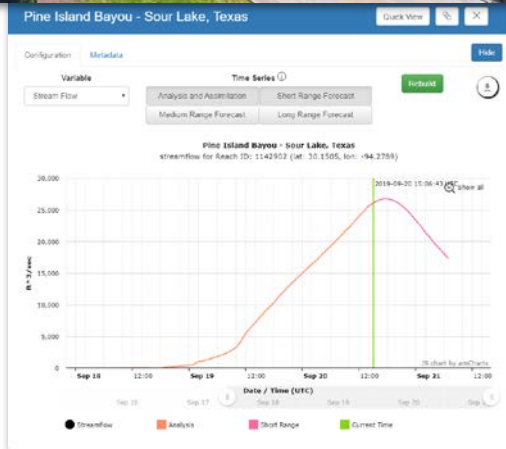
40+ inches of rain

Accumulated Rainfall (inches)
18Z 9/18 to 18Z 9/20

- Heavy rain from tropical depression Imelda led to widespread flooding
- Texas Department of Transportation mapped many road closures
- Critical to know both start and end times of flooding
    - When should roads be closed?
    - What segments need to be closed?
    - When can they reopen?

- Some RFC observation or forecast points located near transportation infrastructure
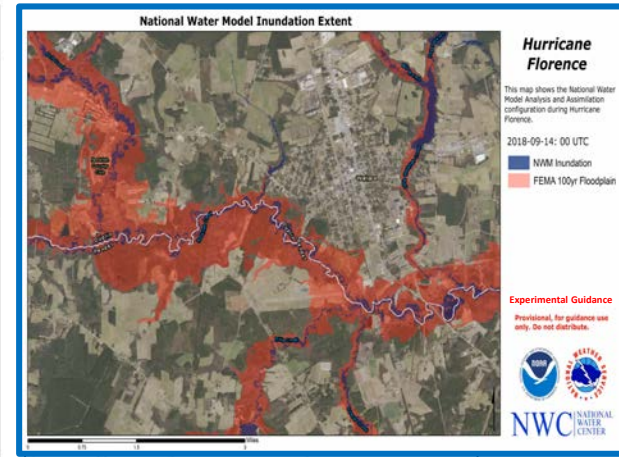- Here, NWM guidance can provide complementary information
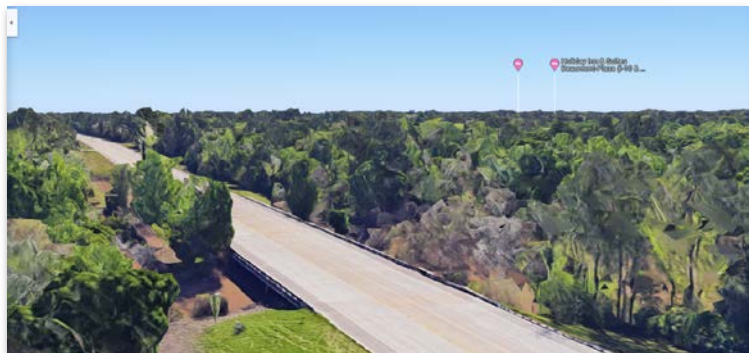
- NWM streamflow guidance for river crossing
- Rapid updates, long forecast horizon

- No traditional NWS RFC river forecasts are available for many smaller streams

Texas DOT 9/20
Flood closure for low water crossings

Low Water Crossing

- NWM guidance covers underserved areas (ex. low water crossings)
  - Vital flow timing information
  - Depth, if flow-depth rating curve available

NWM Stream Reach

Nearest RFC point

NWM Guidance

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A Look Ahead to Potential Visualizations
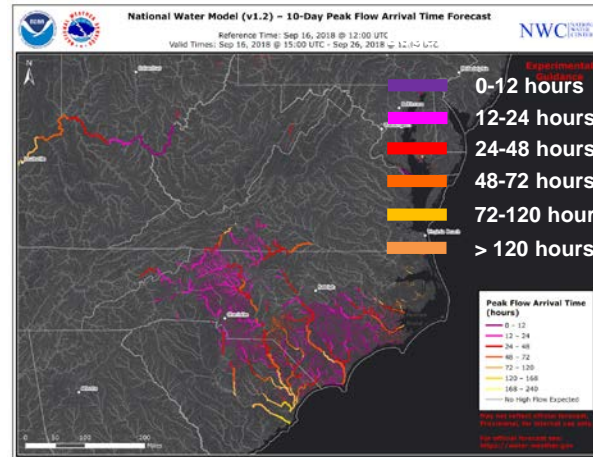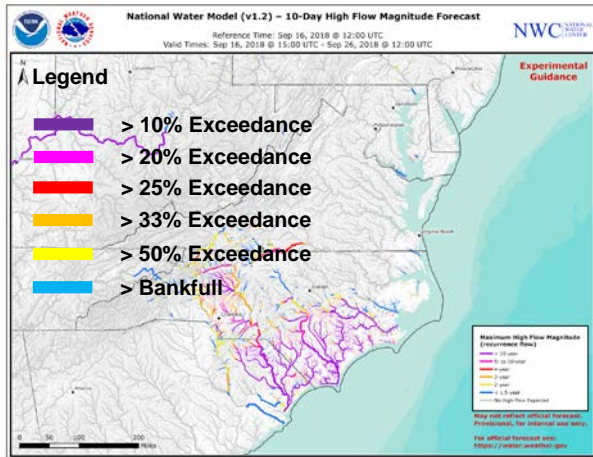
10-Day High Flow Magnitude Full Domain

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?

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v1.0 → v1.1/1.2/2.0 → v2.1

Foundation: 2016
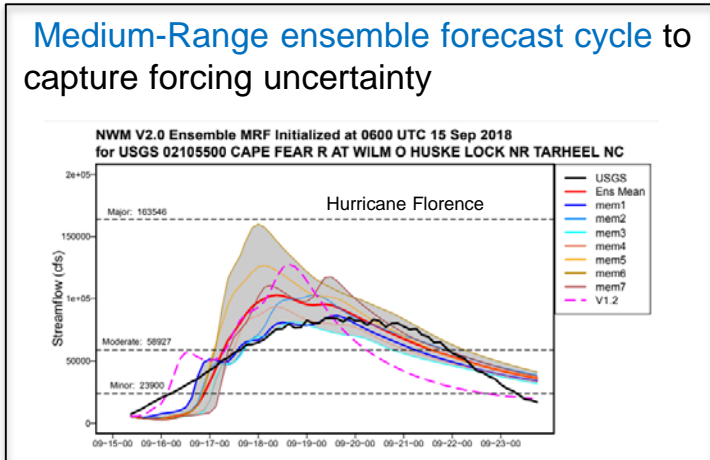Water resource model
2.7 million reaches

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

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

Medium-Range ensemble forecast cycle to capture forcing uncertainty

NWM V2.0 Ensemble MRF Initialized at 0600 UTC 15 Sep 2018
for USGS 02105500 CAPE FEAR R AT WILM O HUSKE LOCK NR TARHEEL NC

Hurricane Florence

USGS
Ens Mean
mem1
mem2
mem3
mem4
mem5
mem6
mem7
V1.2

Major: 163546
Moderate: 58927
Minor: 23900

Streamflow (cfs)

2e+05
150000
1e+05
50000
0

09-15-00 09-16-00 09-17-00 09-18-00 09-19-00 09-20-00 09-21-00 09-22-00 09-23-00

v3.0

Future Upgrade: 2022
Coastal coupling, expansion to Alaska, shallow groundwater, infiltration physics and hydro-fabric upgrades
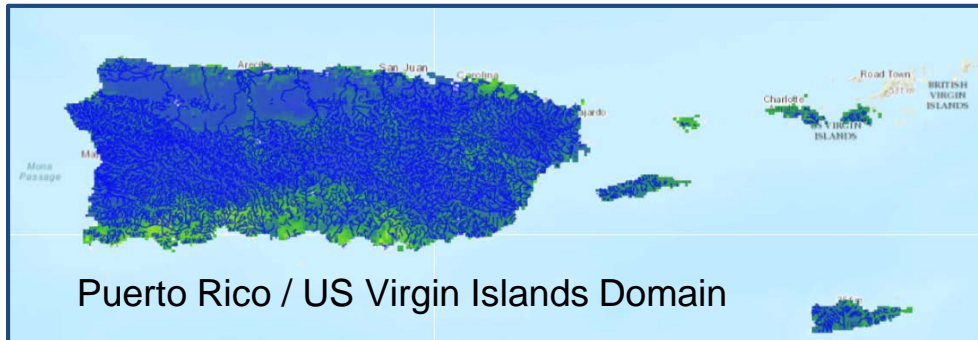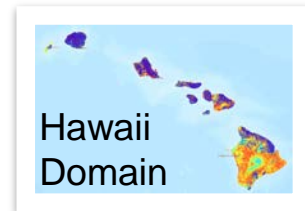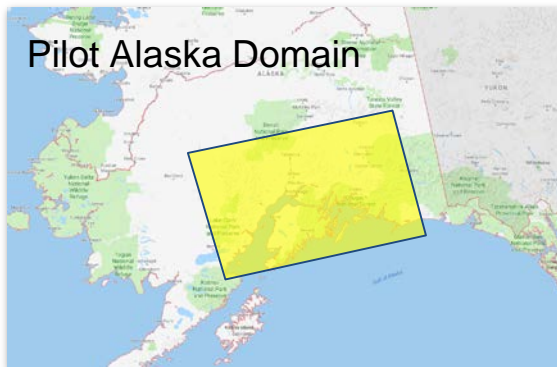
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- Reservoir outflows are key to overall NWM streamflow accuracy
- NWM V2.1 will have two data ingest upgrades to improve outflows
  - Persistence-based data assimilation approach
    - ACE Observations from CWMS RADAR service
    - USGS Observations from existing WCOSS USGS stream gauge feed
  - Use of RFC reservoir discharge time series
    - Forecasts from each RFC transferred to NWM on WCOSS supercomputer

Potential Sites - Refining with Partners
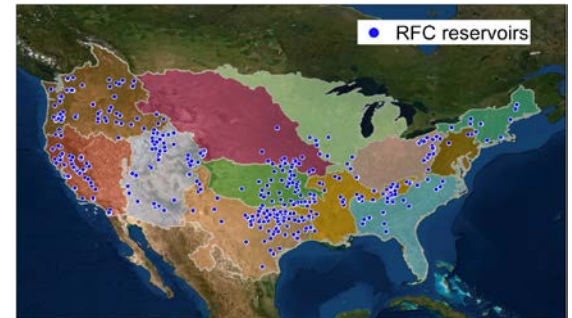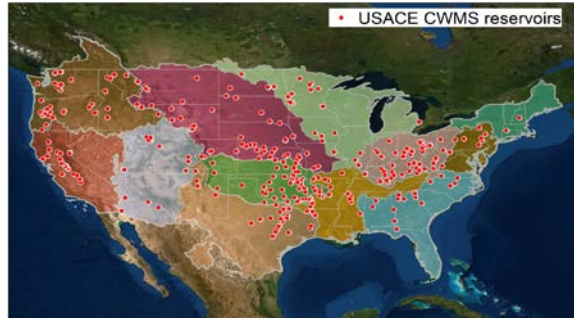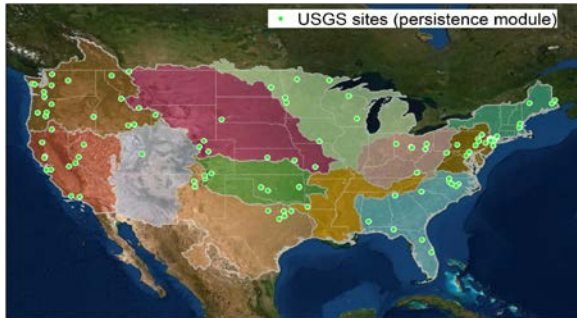
# NWM Version-Over-Version Domain Expansion

- NWM V2.0 - Hawaii
- NWM V2.1
  - Great Lakes and Lake Champlain (GLERL)
  - Puerto Rico and US Virgin Islands (SERFC and Puerto Rico WFO)
- NWM V3.0 - Alaska

Pilot Alaska Domain

Hawaii Domain

Image Credit: Environment Canada

Great Lakes Expansion

Puerto Rico / US Virgin Islands Domain

Closing Thoughts

- The NWM is running operationally 24x7, producing nationwide water resource analyses and forecast guidance
- Complements existing information and provides first-ever operational hydrologic guidance at underserved locations, supporting range of DSS applications
- What exists now is a foundation that will be rapidly upgraded
  - v2.0 was just implemented into operations in June
    - Hawaii domain, new Analysis cycles, medium range ensemble, calibration
  - v2.1 is anticipated in late 2020 / early 2021
    - Inclusion of PR & Great Lakes basin and improved reservoir forecasts
  - v3.0 is anticipated in 2022
    - Improved subsurface flow and channel routing, forecast coastal coupling, AK domain expansion, advanced hydrofabric, updated parameters
  - Next-gen design is underway
- Effective visualization and data delivery are key ongoing efforts
- Expanding partnerships will enable accelerated and expanded enhancements

Additional
Background Material
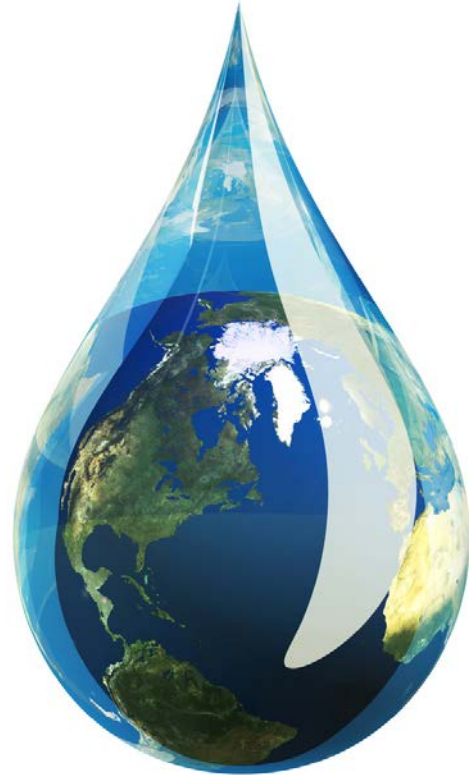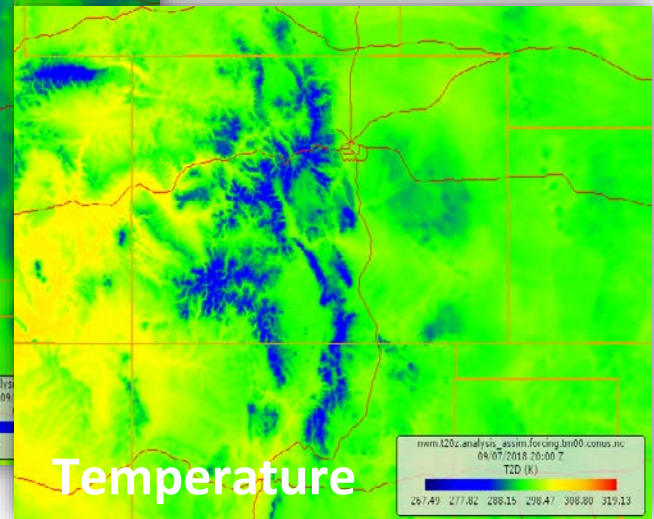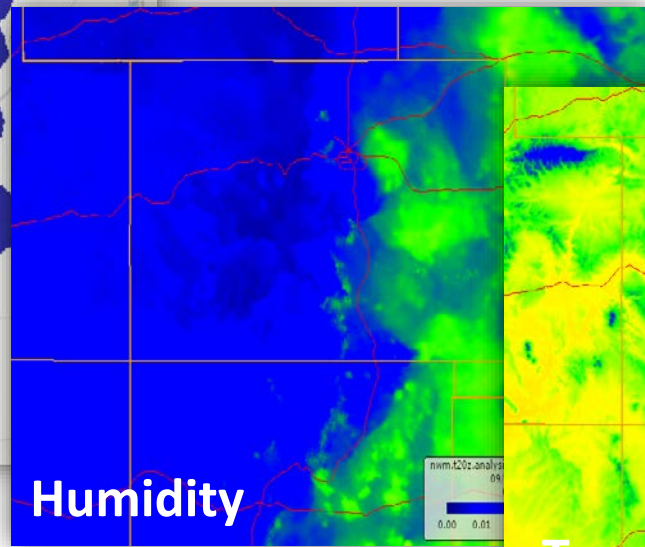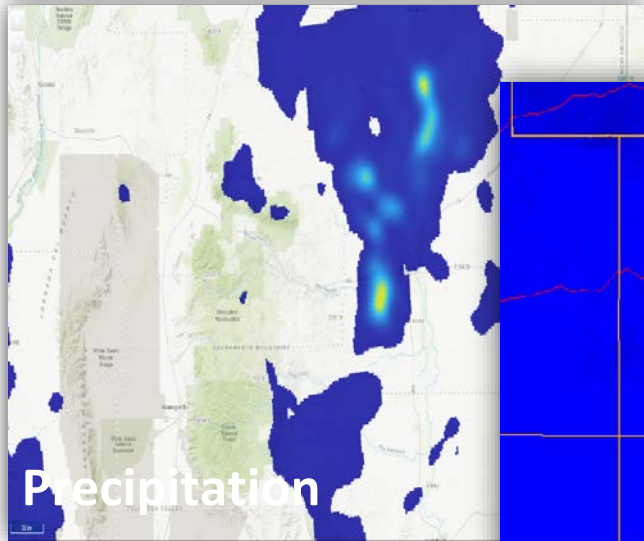
- The NWM ingests weather forcing as drivers of the water and energy cycles
- Eight forcing fields: Temp, Humidity, U/V Wind Speed, Pressure, Shortwave, Longwave, Precip
- The fields are downscaled from several external sources: the HRRR, RAP, GFS, CFS and NAM-Nest models and from MRMS and MPE precipitation observations

- **The National Water Model outputs massive amounts of data**
  - Real-time Operations: ~400 GB/Day
  - Dual 26-Year Retrospective Simulations (Jan 1993 - Dec 2018)
    - Full Physics (matches AnA, SR, MR): ~35 TB for model output
    - Long-Range Physics (matches LR): ~30 TB for model output
- **NWS NCEP Central Operations handles distribution of real-time operational data via NOMADS distribution service (rolling window)**
- **NOAA's partnership with Big Data is being leveraged to transfer additional NWM data to Big Data partners and from there to end users**

NWM ➡ Big Data Services