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

River Forecast Centers: Authoritative forecasts at ~3,600 RFC Points

NWM: Guidance at 2.7 million NHDPlus river segments, filling in coverage gaps and enriching existing points
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.
National Water Model V2.0: Cycling Overview

Analysis
HRPR/RAP/MRMS/MPE

Short-Range
HRRR/RAP

Medium-Range Ens
GFS

Long-Range Ens
CFS

Lookback Range 3-28 hrs

18 Hour Forecast

~10 Day Ensemble Forecast

New For V2.0

30 Day Ensemble Forecast

Hawaii
3 Hour Lookback
60 Hour Forecast

NAM-NEST

HRRR/RAP/MRMS/MPE

GFS

CFS
NWM Provides Multi-Scale Hydrologic Forecast Guidance
Large River at Traditional RFC Forecast Location

• Leveraging accurate precipitation NWM correctly forecasts minor flooding two days in advance
• Inter-cycle variability/biases highlight need for improved precip forecasts, NWM development

Small Ungauged Stream Away from Traditional Forecast Point

• Successive NWM forecasts indicate correct timing for dangerous flow
• Run-to-run variability indicates need for continued precipitation improvement
Use Case: Tropical Depression Imelda (September 2019)

- 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?
Tropical Depression Imelda: NWM Complementary Guidance

- 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
Tropical Depression Imelda: NWM Complementary Guidance

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

- NWM guidance covers underserved areas (ex. low water crossings)
  - Vital flow timing information
  - Depth, if flow-depth rating curve available
Further Leveraging NWM Model Output: Flow Forecast Mapping

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?
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

**v3.0**

**Future Upgrade:** 2022

Coastal coupling, expansion to Alaska, shallow groundwater, infiltration physics and hydro-fabric upgrades
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
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.

Closing Thoughts
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