HEFS and National Water Model-based inflow prediction

OK/TX FIRO, Sep 2019

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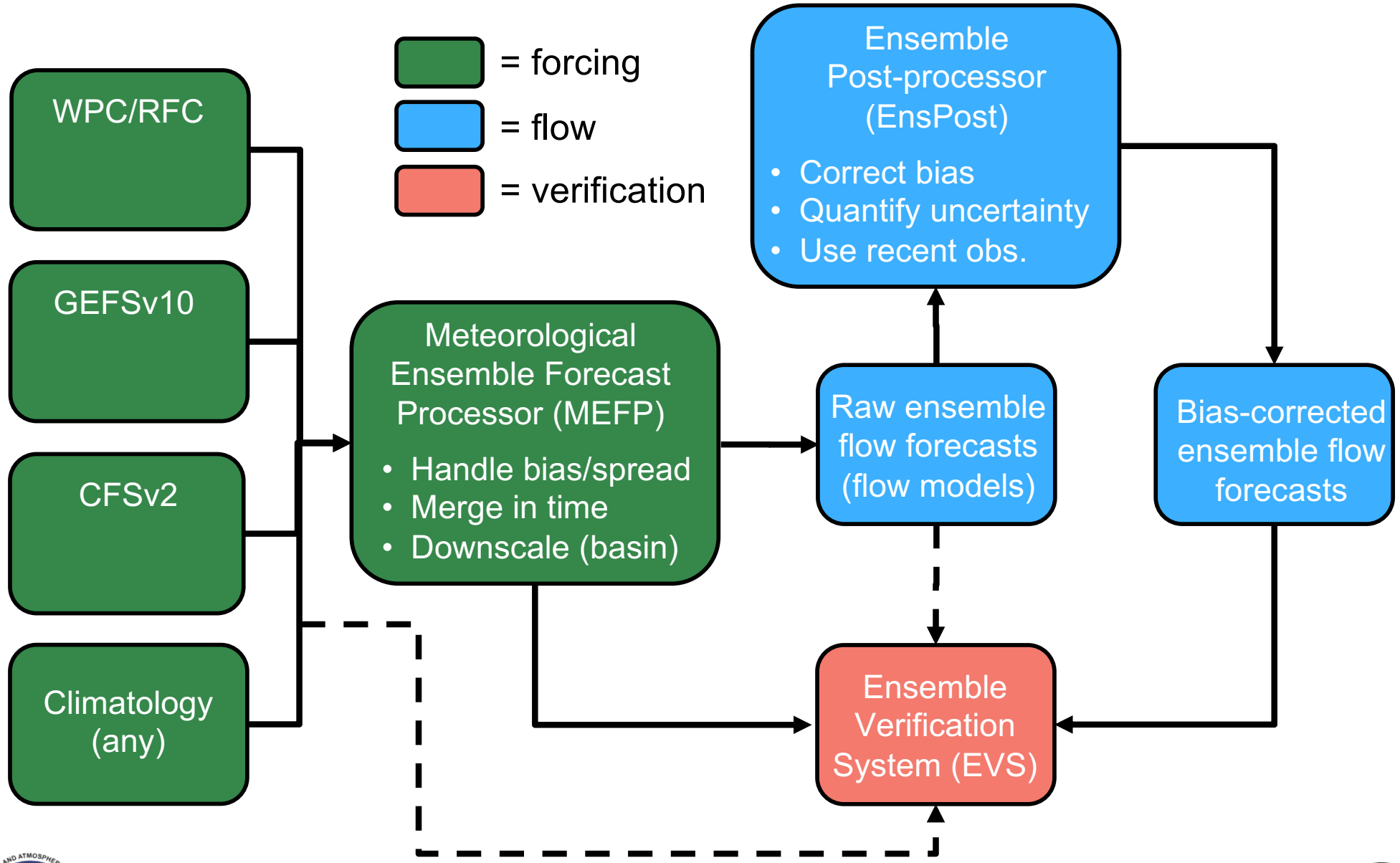
Outline

- HEFS
  - Basic Workflow
  - Baseline Validation & Implementation Status
  - Next steps, Priorities, and Challenges

HEFS basic workflow



Baseline Validation and Implementation

2017-2019: OWP & River Forecast Centers (RFC) “Baseline Validation”

- **To accelerate implementation**
  - To provide targets for the public distribution of HEFS products on AHPS (i.e. forecast locations)
- **To create a performance benchmark**
  - To provide a benchmark for future HEFS versions
  - To clarify our own requirements (e.g. GEFS (re)forecasts)
  - Provides a 30 year HEFS hindcasts to users
- **To develop best practices for evaluation**
  - First objective, large-sample, evaluation of our hydrologic products and services

Methodology for Baseline Validation

- Streamflow forecast for 1-30 days (GEFS for 1-15, then climatology)
  - Maximizes sample size (allows for daily forecast for 30 years)

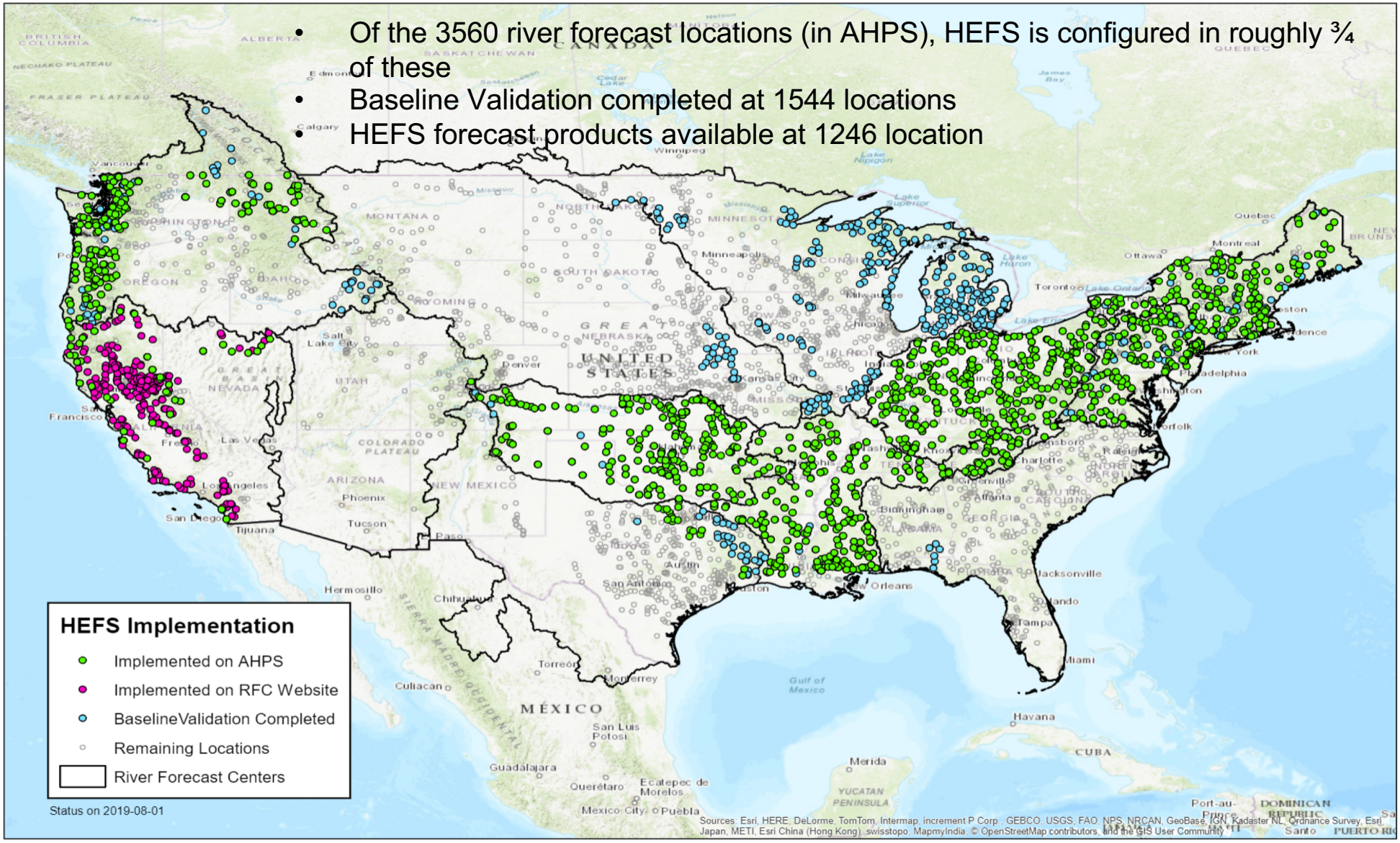
- Legacy climatological ensemble (ESP) as a baseline for skill

- Utilize multiple metrics (CRPSS, BSS, correlation coefficient, etc) to capture multi-dimensional character of forecast quality

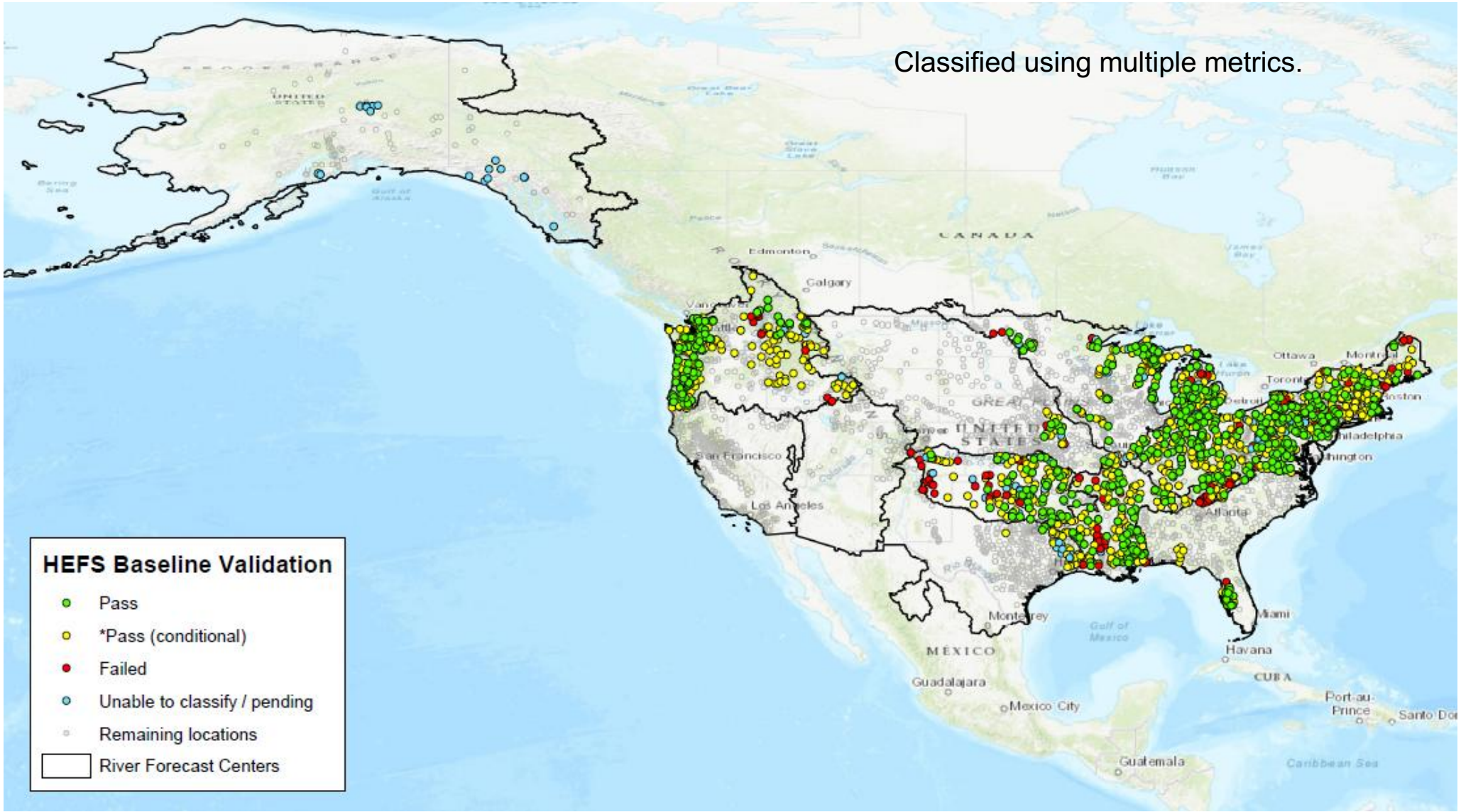
- Precipitation and temperature, only where necessary to troubleshoot problems identified in streamflow validation

HEFS Implementation Status

- Of the 3560 river forecast locations (in AHPS), HEFS is configured in roughly ¾ of these
- Baseline Validation completed at 1544 locations
- HEFS forecast products available at 1246 location



HEFS Baseline Validation Classification



Results

- Failed basins are mainly due to issues with hydrological modeling and/or regulation, & have good MEFP forecasts, especially precipitation
- In some cases, BV has flagged potential optimizations that could be made and/or identified problems with the hydrologic model calibration
- At some locations, especially snow dominated ones, there's very little or no improvement especially early in the forecast horizon, since it takes longer for the forcings to show up in the streamflow
- Better in big synoptic systems, worse in short-term precip/convection
- Earlier verification results show that the EnsPost can add a further 10-80% skill at the earliest forecast lead times and further increase the "break even" point relative to ESP

Early applications of HEFS

Managing NYC water supply

- Croton; Catskill; and Delaware
- Includes 19 reservoirs, 3 lakes; 2000 square miles
- Serves 9 million people (50% of NY State population)
- Delivers 1.1 billion gallons/day
- Operational Support Tool (OST) to optimize infrastructure, and avoid unnecessary (**$10B**+) water filtration costs
- HEFS forecasts are central to OST. The OST program has cost NYC under **$10M**

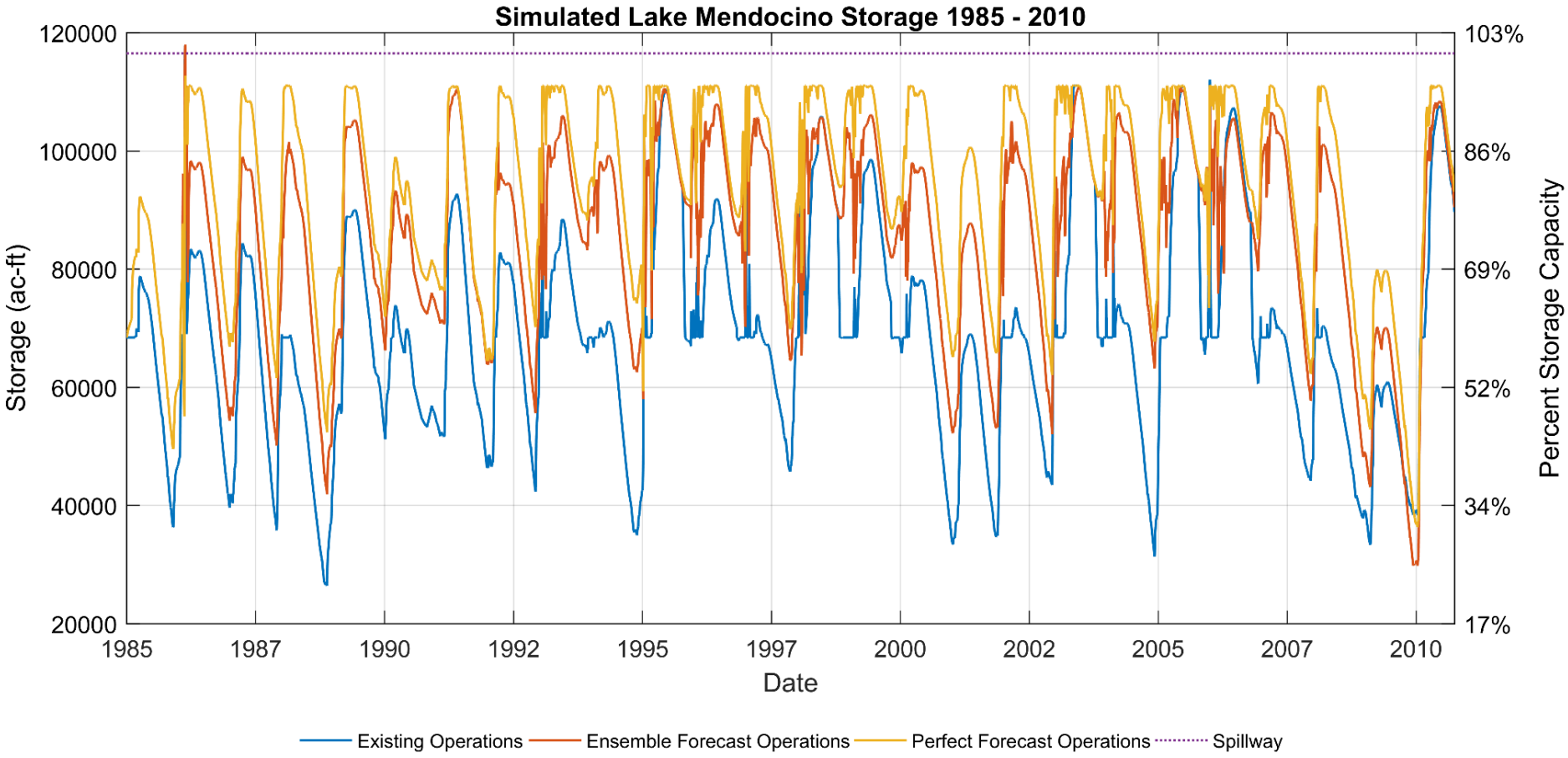
Slide courtesy of NYCDEP

Early applications of HEFS

Forecast Informed Reservoir Operations (FIRO) in Russian River Watershed

- Multi-Agency study on Lake Mendocino
- Can we enhance reservoir operations and use of available storage by using forecasts to inform decisions about releasing or storing water?
- HEFS forecasts are central to optimized forecast-based reservoir operations
- Supports water control manual change request for Lake Mendocino
- Process can be replicated in other watersheds

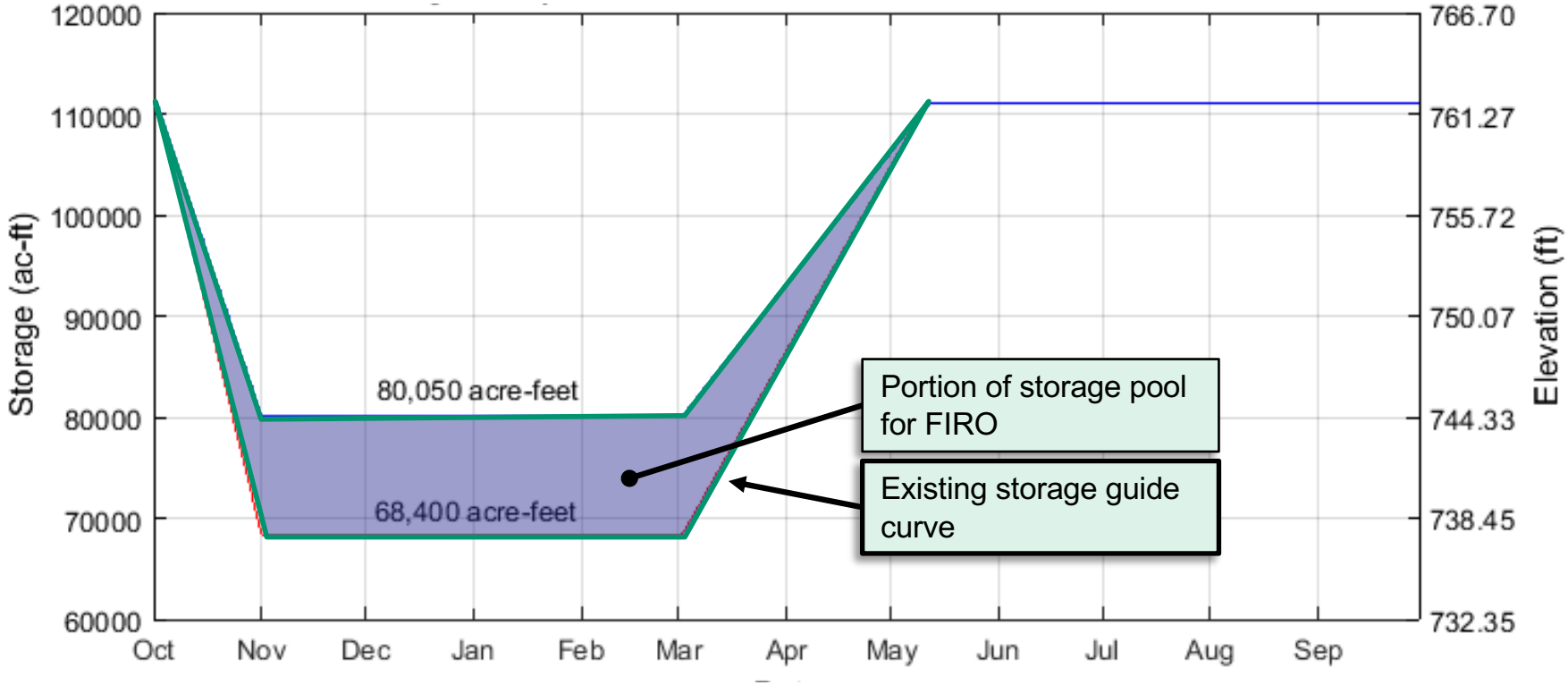
1985-2010 Historical Simulation Lake Mendocino, CA Storage



Slide courtesy of Chris Delaney, Sonoma Water

2019 Major Deviation

- Major Deviation to Water Control Manual
  - Approved by USACE in November 2018 for 2018/2019 winter and spring season



Slide courtesy of Chris Delaney, Sonoma Water

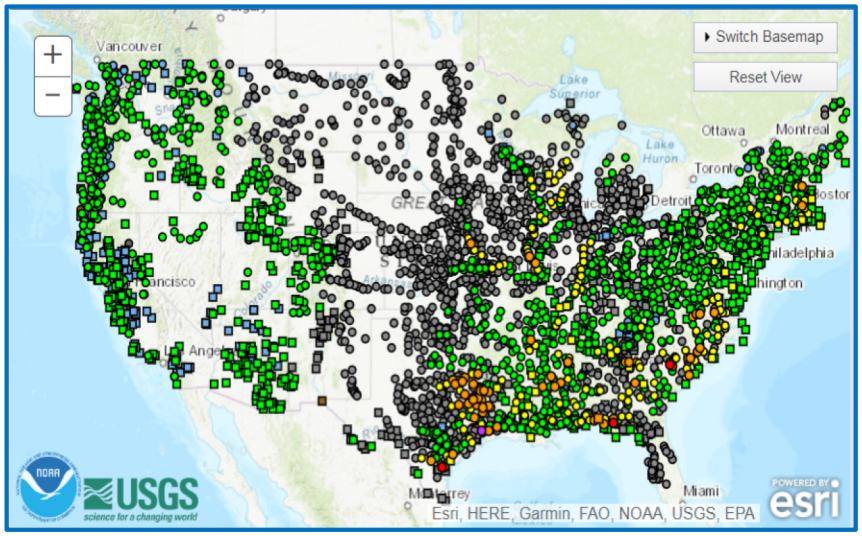
HEFS Next Steps and Priorities

- Implement GEFSv12 forcings into operations (WRES)
- Extend and evaluate implementation of hydrologic post-processor (including regulated locations)
- Expand and formalize Validation Testbed for enhancements
  - Facilitates outside development (UTA, ESRL)
- Address performance in extreme events
- Explore update to temp modeling in MEFP to address limitations in steep terrain, etc
- Complete HEFS implementation at ESP locations

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



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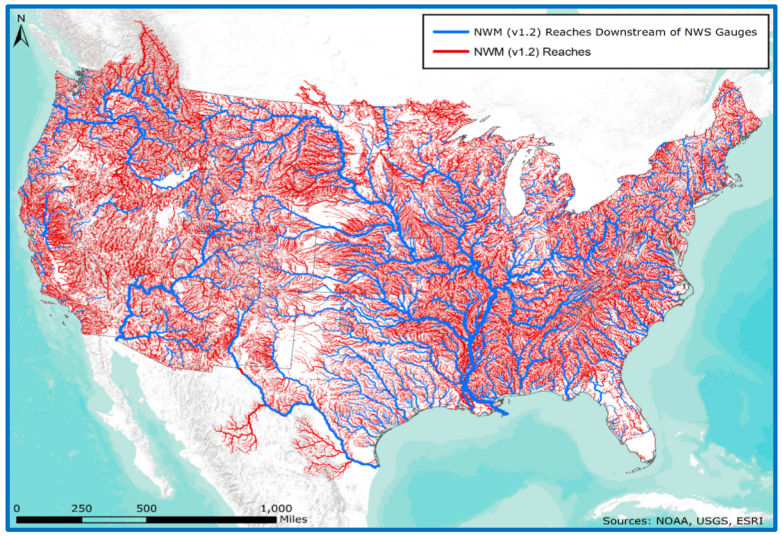
NWM

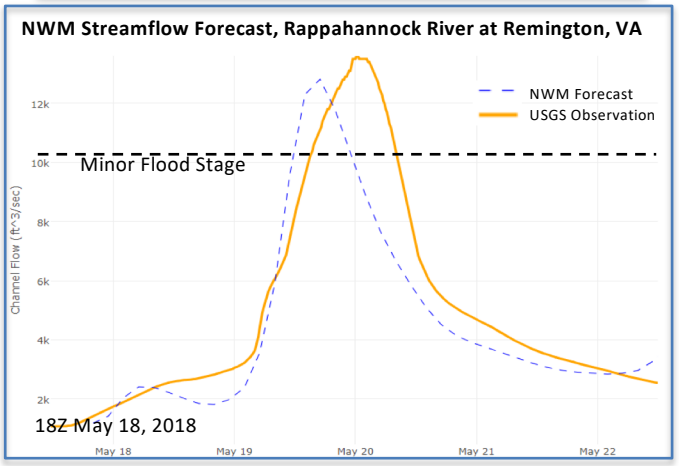


River Forecast Centers: Authoritative forecasts at ~3,600 RFC Points

NWM: Guidance at 2.7 million NHDPlus river segments, filling in coverage gaps and enriching existing points

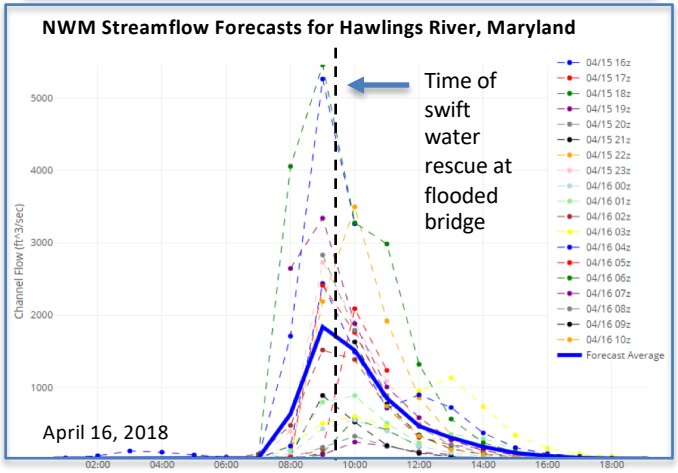
NWM Output: Complementary Guidance for Forecasters

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

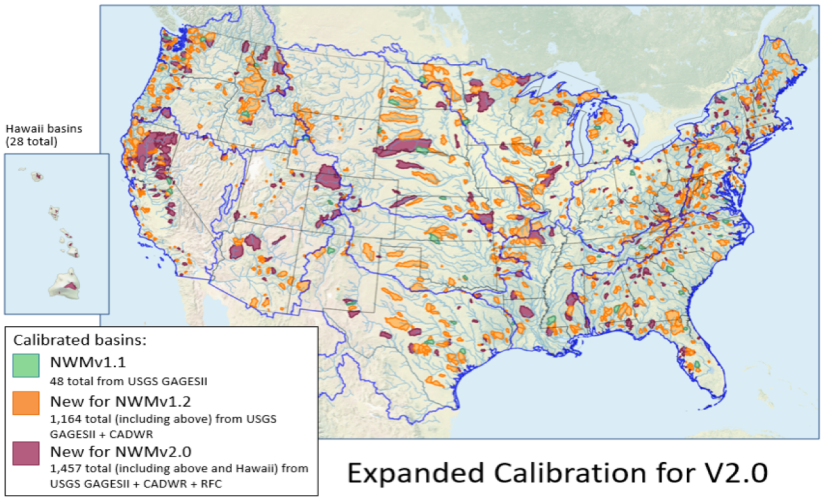
National Water Model: Development Trajectory

v1.0 → v1.1/1.2 → v2.0

Foundation: 2016
Water resource model
2.7 million reaches

Upgrades: 2017/2018
Increased cycling freq. and fcst length, improved calibration, physics, stream DA

Domain Expansion: 2019
Hawaii, medium range ens., compound channels, improved modularity, longer Analysis w/MPE

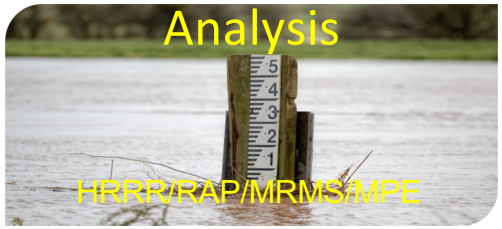


Expanded Calibration for V2.0

v2.1

Future Upgrade: Early 2021
Expansion to PR and Great Lakes, reservoir modules, forcing bias-correction, calibration and improved Hawaii forcing

National Water Model V2.0: Cycling Overview



Lookback Range 3-28 hrs

18 Hour Forecast

~10 Day Ensemble Forecast

30 Day Ensemble Forecast

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Questions/Discussion