OWP | OFFICE OF WATER PREDICTION

The Hydrologic Ensemble Forecast Service - Overview and Future Development

Mark A. Fresch, AMS Annual Meeting 2022
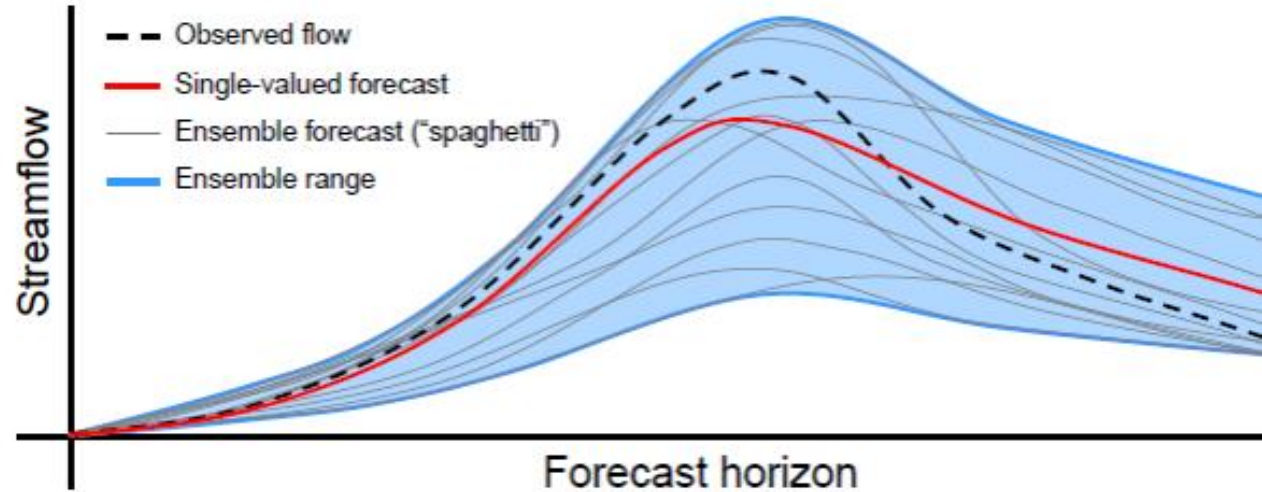*38th Conference on Hydrology*

HEFS Highlights

- Now operational across the US - publicly available forecasts at ~3000 streamflow locations

- Improvements planned to addressed the highest priority 'gaps'

Hydrologic ensemble forecasts

- A collection of streamflow forecasts

- Each forecast (ensemble member or trace) is one possible (equally likely) outcome

- Captures uncertainty

- Drives probabilistic forecasting

Legend:
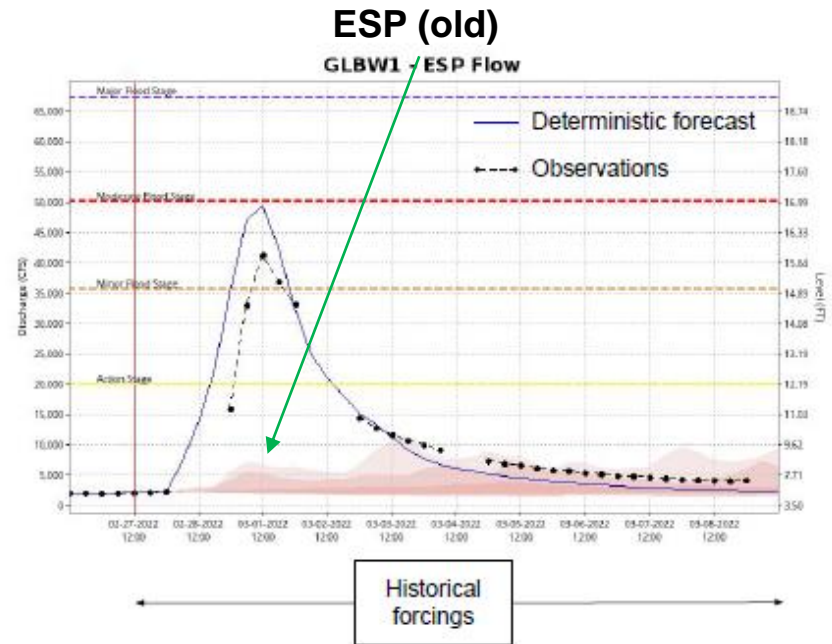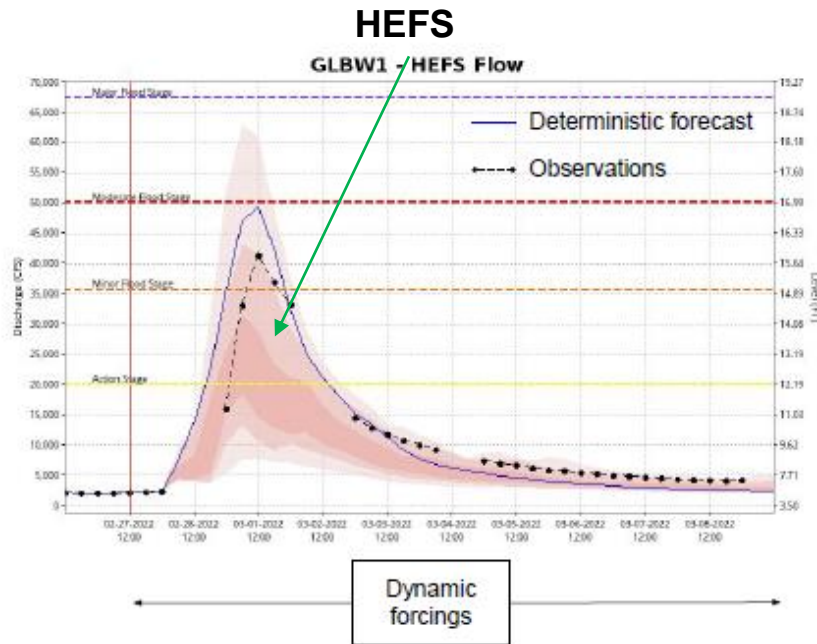- **– –** Observed flow
- **——** Single-valued forecast
- **——** Ensemble forecast ("spaghetti")
- **——** Ensemble range

(x-axis: Forecast horizon; y-axis: Streamflow)

HEFS Introduction

	Ensemble Streamflow Prediction (ESP, old)	HEFS
Forecast horizon	Weeks to seasons	Hours to years and customizable
Input /forecasts	Historical climate data observations	Short-, medium-, sub-season, and long-range weather/climate forecasts
Uncertainty modeling	No accounting for hydrologic uncertainty or bias. Only suitable for long-range forecasting	Captures total uncertainty and corrects for biases at all forecast lead times
Products	Limited graphical products focused on long-range	A wide array of data and user-tailored products are planned, including standard verification

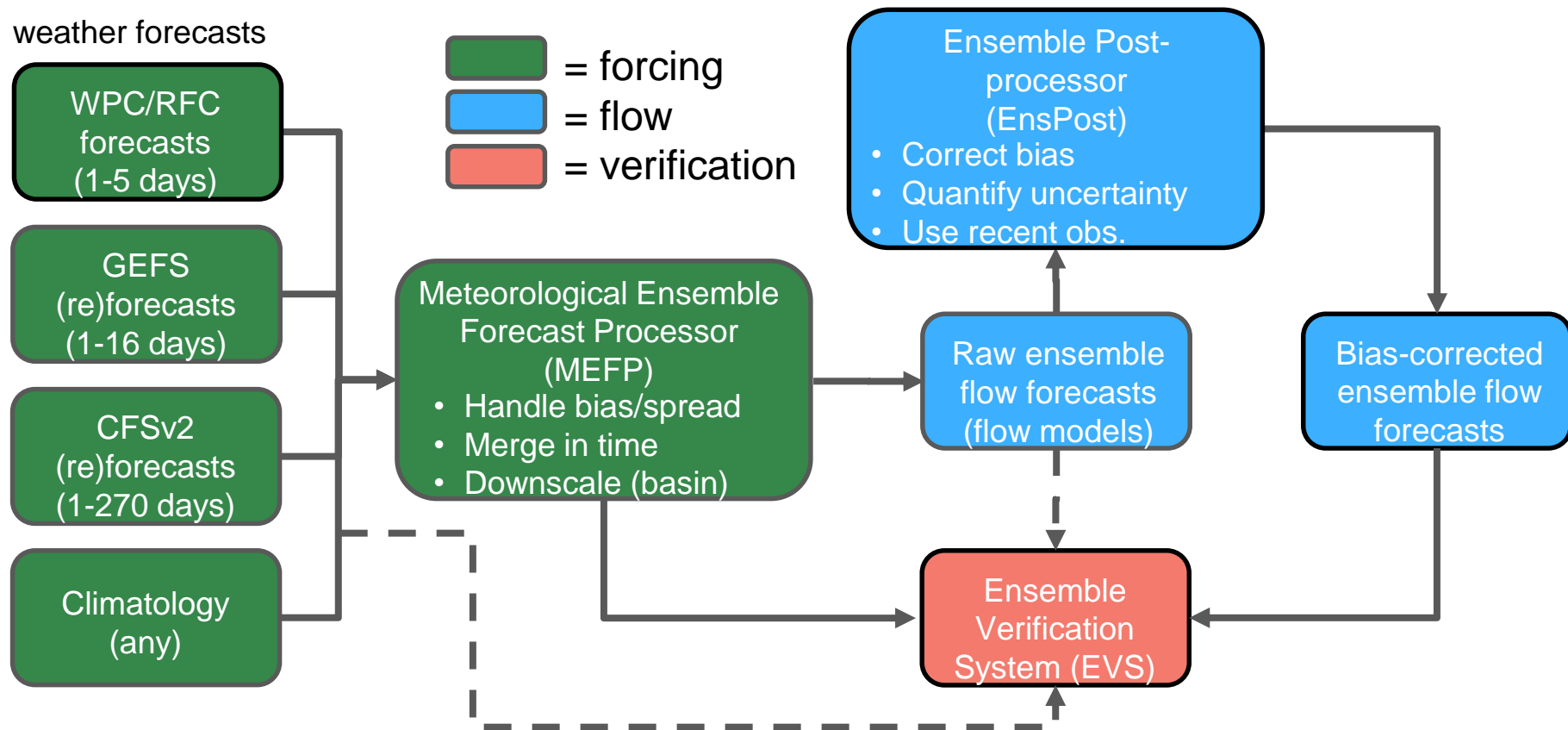NOAA

OWP | OFFICE OF WATER PREDICTION

HEFS Introduction

HEFS provides a large advantage of old ESP forecasts. In the two images below, the ensemble forecasts are in pink shading. HEFS, on the left, is much closer to the observations in the dashed line than the old climatology-only ensemble forecasts.

HEFS structure

weather forecasts

WPC/RFC forecasts (1-5 days)

GEFS (re)forecasts (1-16 days)

CFSv2 (re)forecasts (1-270 days)

Climatology (any)

= forcing

= flow

= verification

Meteorological Ensemble Forecast Processor (MEFP)
- Handle bias/spread
- Merge in time
- Downscale (basin)

Raw ensemble flow forecasts (flow models)

Ensemble Post-processor (EnsPost)
- Correct bias
- Quantify uncertainty
- Use recent obs.

Bias-corrected ensemble flow forecasts

Ensemble Verification System (EVS)

Hydrologic Ensemble Forecast Service (HEFS)

- Operational roll-out completed in 2023

- Validation over ~30 yrs

- Important uses
  - flood forecasts
  - water supply
  - environment
  - hydroelectric
  - guidance for human forecasts
  - Impact-based decision support (IDSS)
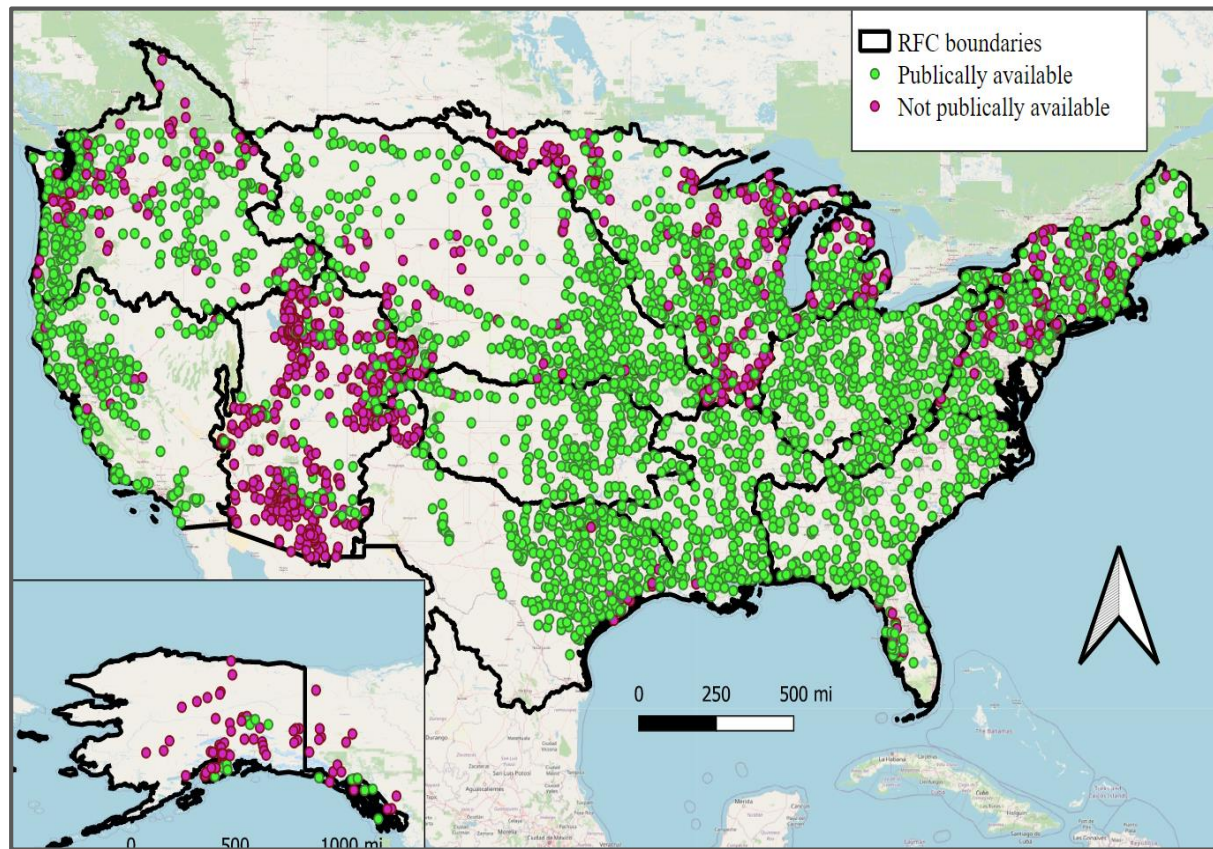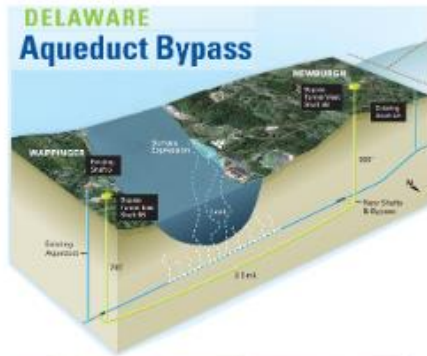

HEFSv1 coverage

New York City Forecast Informed Reservoir Operations (FIRO)

NYC Water Supply

- Croton; Catskill; and Delaware watersheds

- Includes 19 reservoirs, 3 lakes; 2000 square miles

- Serves 9 million people (50% of NY State population)

- Delivers 1.1 billion gallons/day

- **Uses HEFS forecasts in a decision support system, called the Operational Support Tool (OST)**

- Avoids (**$10B+**) water filtration costs
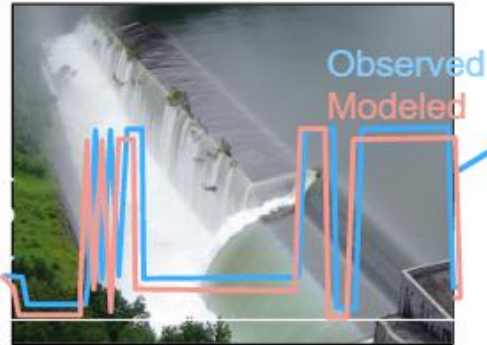
New York City Reservoir Management Decisions

DELAWARE
Aqueduct Bypass

(Cannonsville Reservoir Spillway)

Observed
Modeled

"Mission critical decision to manage shutdown of RBWT Tunnel based on HEFS forecasts"

Ashokan Reservoir

HEFS streamflow forecasts are used to optimize and validate the NYC OST for million/billion dollar applications

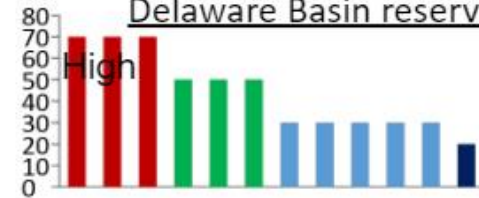"HEFS forecasts critical to protecting NYC drinking water quality during high turbidity events"

"HEFS forecasts help optimize rule curves for seasonal storage objectives in NYC reservoirs"

Risk to water availability from Delaware Basin reservoirs

High

"HEFS forecasts used to determine risks to conservation releases"

Russian River/Lake Mendocino FIRO

Simulated Lake Mendocino Storage 1985 - 2010
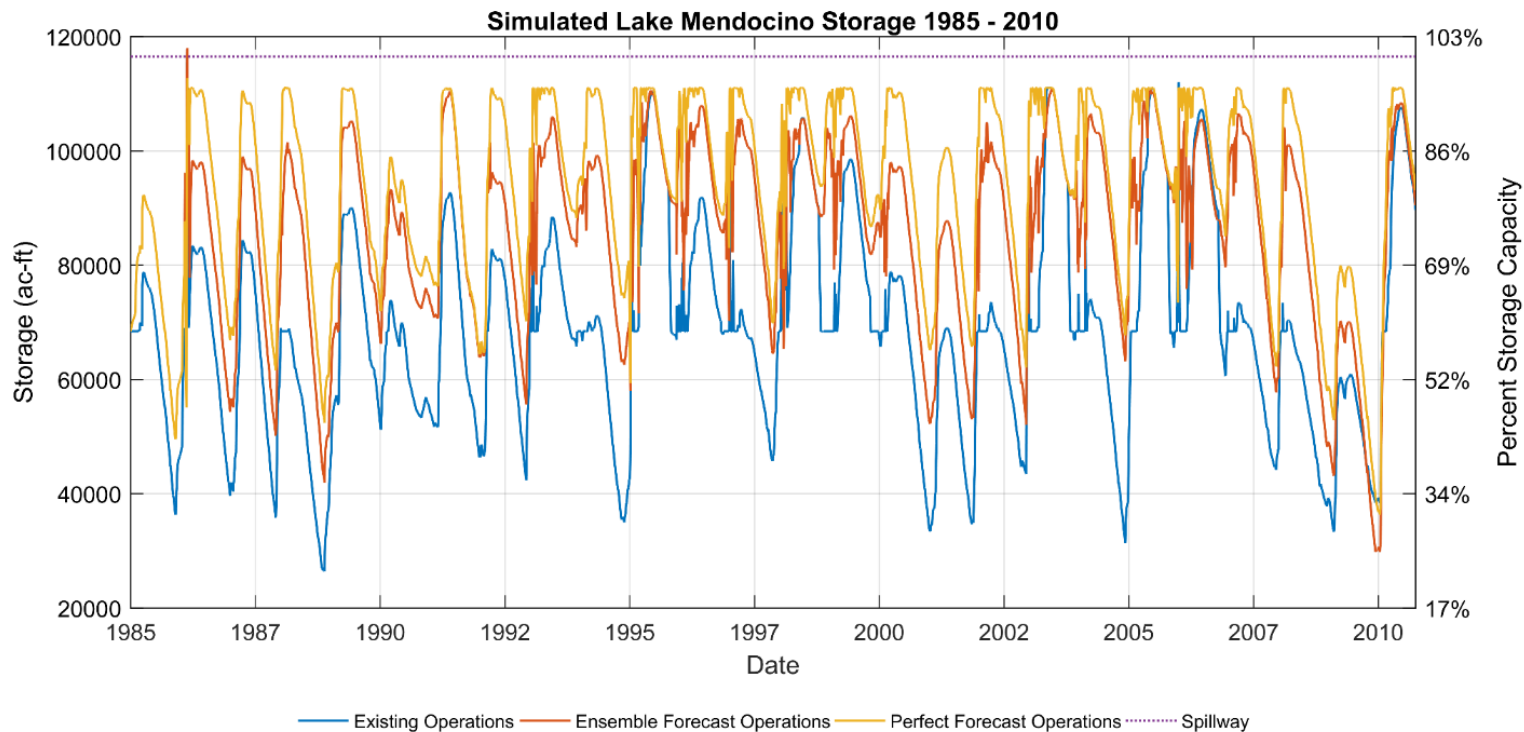
Planned improvements to existing framework

led by OWP and within 3 years

Improvements to HEFSv1 forecasts

Improve large event forecasts w/ Conditional Bias-Penalized Regression (CBPR) - under evaluation

Eliminate forced diurnal temp pattern

Evaluate & implement hydrologic ensemble post-processor (EnsPost) - implementation is underway

Add modeling of freezing level

Improvements to Dissemination and Data Services

Provide data (not just graphics) service - 2024

Customizable graphics - in progress with National Water Prediction Service (NWPS)

Historical data access and viewer

Archive 'mods' and model states

Planned improvements requiring R&D

via the Cooperative Institute for Research to Operations in Hydrology (CIROH)

Better meteorolocial post-processing

- Centralized post-processing
- Alternative post-processing
- Combine information from multiple models
- Use full ensemble information

Better hydrologic post-processing

- Roadmap for source-based accounting of uncertainties
- Alternative and better statistical models

Better seasonal/ sub-seasonal forecasts

- Evaluate/use improved long lead weather models
- Evaluate/add alternative predictors post-processing
- Evaluate alternatives to site-specific seasonal hydrologic forecasts

Thank You!

For more information: Mark Fresch

✉ mark.a.fresch@noaa.gov

🌐 https://water.noaa.gov

NOAA

OWP | OFFICE OF WATER PREDICTION