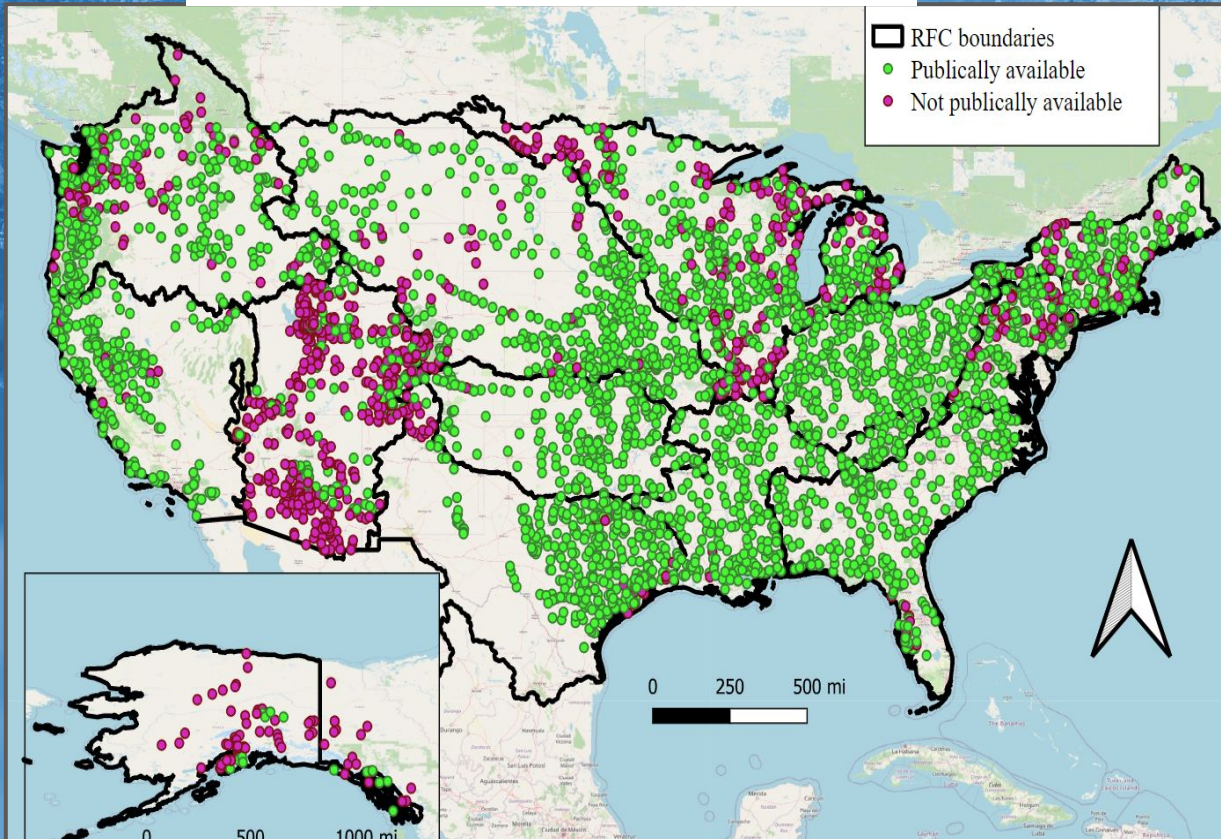OWP | OFFICE OF WATER PREDICTION

The National Weather Service (NWS) Hydrologic Ensemble Forecast Service (HEFS) use of the Global Ensemble Forecast System (GEFS)

Mark A. Fresch, NCEP Ensemble Users Workshop 2023

HEFS coverage

- Collection of daily streamflow (e.g. rivers) forecasts

- Publicly available at ~3000 river locations

- Validated (~30 yrs) to ensure forecasts are 'high quality'

HEFS - Important uses

- Helps NWS move to probabilistic hydro forecasting
  - emergency management (flood forecasts)
  - water supply
  - environmental applications
  - hydroelectric power plant operators
  - risk-based decision making

- Forecasts -> guidance to humans forecasts

- Validation -> ~30 yrs retrospective forecasts
  - Benchmarks
  - Performance informs current forecasts
  - Forecast Informed Reservoir Ops (FIRO, see next slide)

HEFS - 10 Day River Levels Probabilities
Based on Hydrologic Ensemble Forecast Service Model Simulations
Used to Estimate the Range of Possible River Levels

Dec 21 - Dec 31, 2021
**Esopus Creek at Cold Brook, NY (MTRN6)**
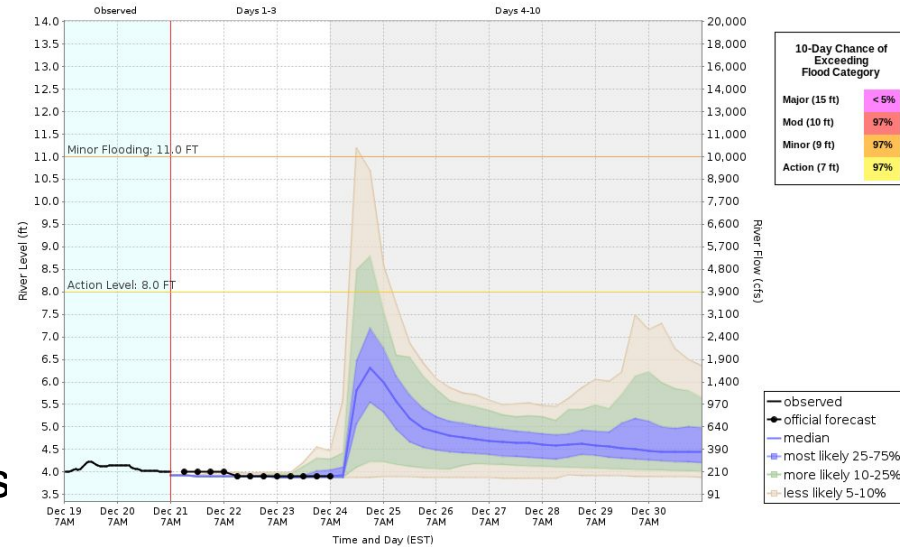
Forecast Informed Reservoir Operations

- Reservoir operations strategy of including forecasts instead of only reacting to current conditions

- HEFS-based FIRO is at several US reservoirs and more are planned

- Multi-agency collaboration: local, state, and federal levels

- Multi-year HEFS hindcasts to train partner decision support tools + real-time forecasts
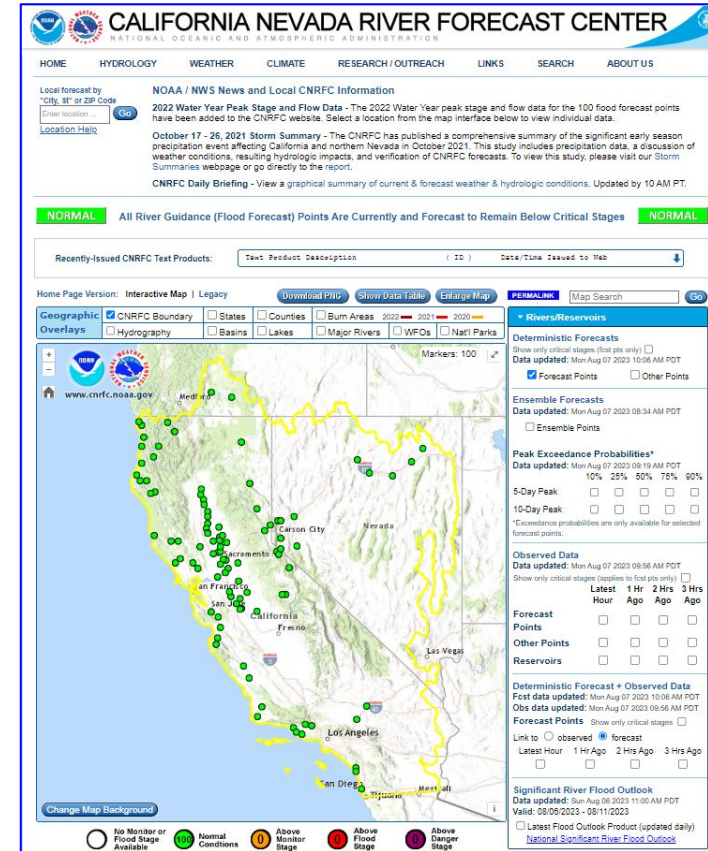
courtesy of CNRFC

Example showing improvement with HEFS-based FIRO
1985-2010 Historical Simulation, Lake Mendocino, CA Storage
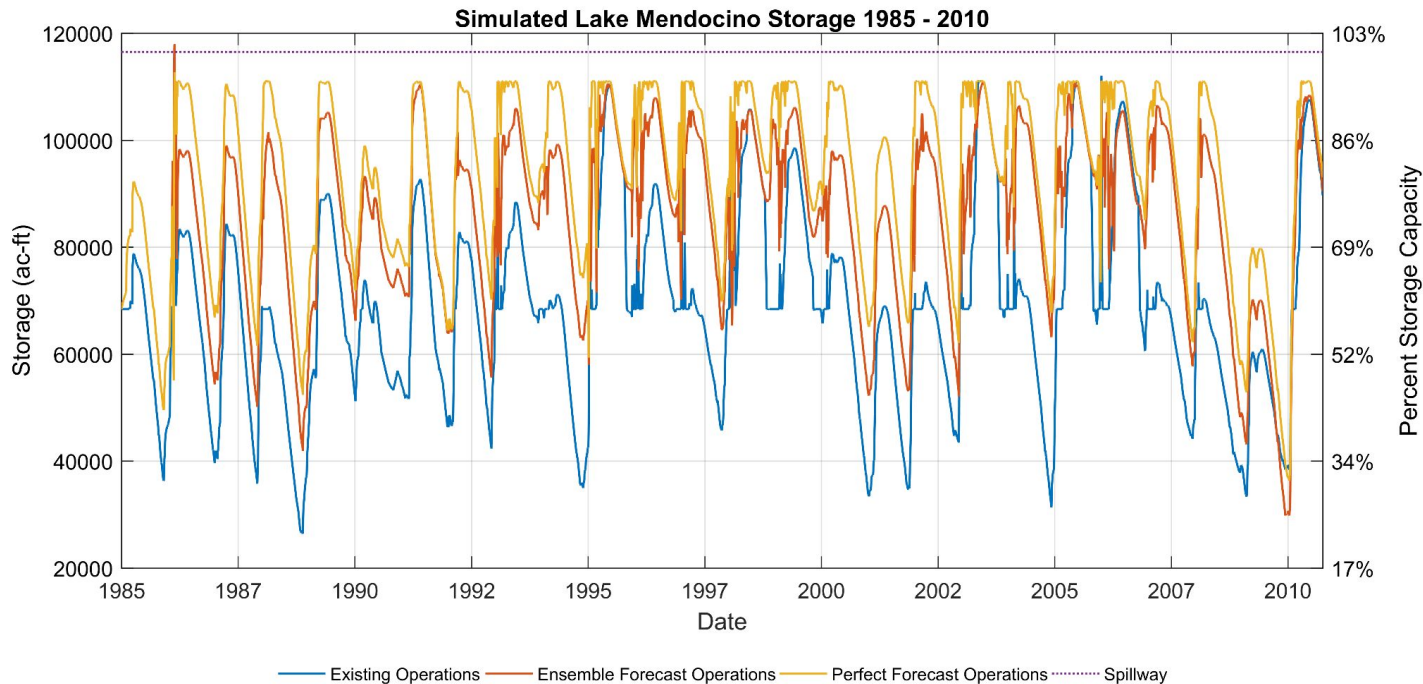
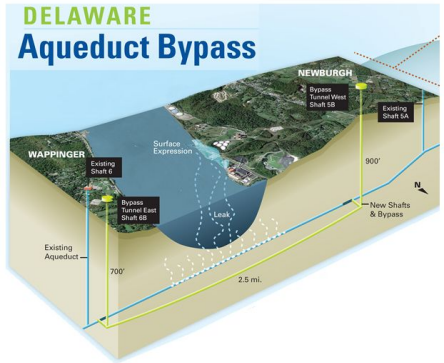Slide courtesy of Chris Delaney, Sonoma Water

5

HEFS for NYC Water Supply

Managing NYC water supply

- Includes 19 reservoirs, 3 lakes; 2000 square miles

- Serves 9 million people

- 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**

New York City's Water Supply System

HEFS at NYC water supply

DELAWARE
Aqueduct Bypass
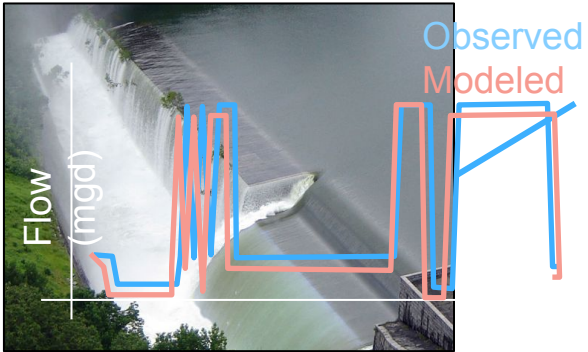

(Cannonsville Reservoir Spillway)

Observed
Modeled

"Mission critical decision to manage shutdown of RBWT Tunnel based on HEFS forecasts"
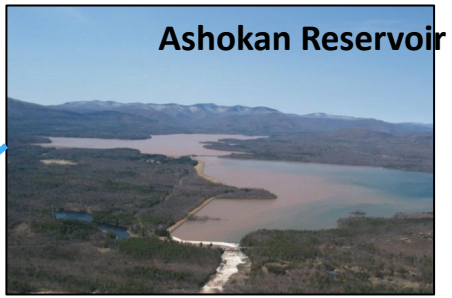
HEFS streamflow forecasts are used to optimize and validate the NYC OST for million/billion dollar applications

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

Ashokan Reservoir

"HEFS forecasts critical to protecting NYC drinking water quality during high turbidity events"
Risk to water availability from Delaware Basin reservoirs
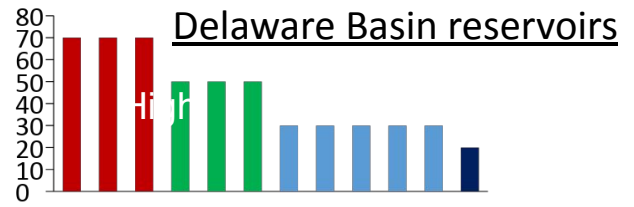
"HEFS forecasts used to determine risks to conservation releases"

HEFS structure

Temp & precip 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)

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

Raw ensemble flow forecasts (flow models)

Bias-corrected ensemble flow forecasts

Ensemble Verification System (EVS)

HEFS use of GEFS

- Real-time daily forecasts -> HEFS operational forecasts
  - Acquired via Satellite Broadcast Network (SBN)

- ~30 yrs daily reforecasts <u>from each major GEFS version</u>
  - Validation (hindcasts) and calibration of HEFS
  - Benchmark HEFS forecast quality for future improvements
  - Guidance to forecasters - How well does HEFS work at this location and situation?
  - HEFS hindcasts -> train FIRO decision support tools

Future improvements

- Short-term (<3yrs) small changes, within the existing HEFS components
  - Add snow-level (better) or freezing level for better snow/rain forecast and uncertainty
  - Improve forecasts during high precipitation
  - Improve services:
    - Data, not just images
    - Customizable graphics

- Long-term (3-5 yrs)
  - Explore ensemble alternatives, inc. AI/Machine Learning, in order to improve forecasts during high precip.
  - Consider centralized processing

Thank You!

For more information: Mark Fresch

✉ mark.a.fresch@noaa.gov

🌐 https://water.noaa.gov