National Water Center (NWC) Requirements

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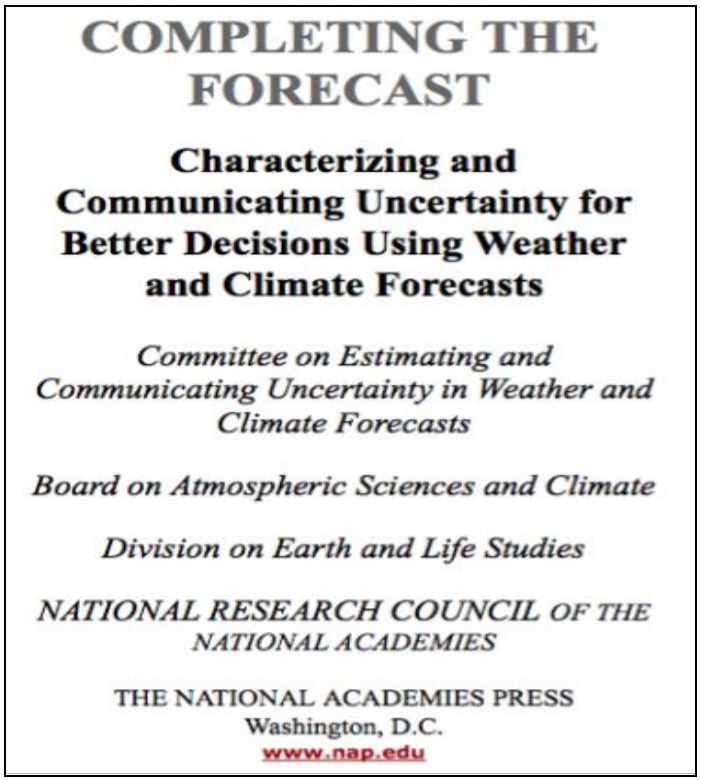
Context and Drivers

- *Inherent uncertainty* in weather, climate and hydrologic forecast needs to be *quantified* and *communicated* to users
- Aids decision-making
  - Forecasters get objective guidance for level of confidence in forecasts
  - End users can decide whether to take action based on risk tolerance
- Objective evaluation framework to baseline performance, prioritize investments, guide forecast operations and decision support


COMPLETING THE FORECAST

Characterizing and Communicating Uncertainty for Better Decisions Using Weather and Climate Forecasts

Committee on Estimating and Communicating Uncertainty in Weather and Climate Forecasts

Board on Atmospheric Sciences and Climate

Division on Earth and Life Studies

NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES

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Weather Services for the Nation: Becoming Second to None

National Academy of Sciences Report 2012

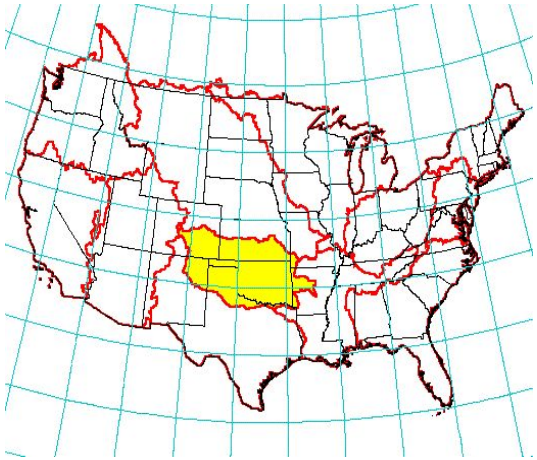
NWC Requirements

Support improved, risk-based, decision making for a variety of water resources applications

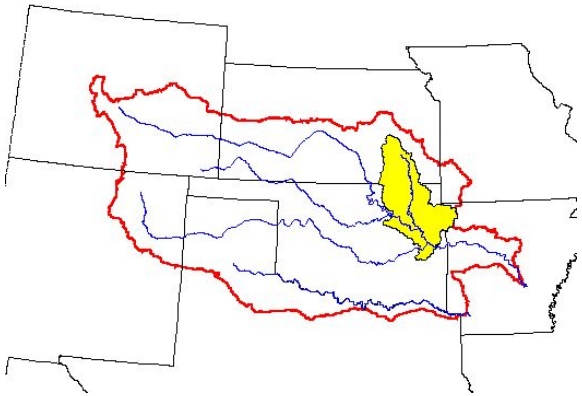
Deliver hydrologic ensemble forecasts that are:

1. Calibrated/unbiased for various aggregation periods
2. Spatially and temporally consistent
3. Seamlessly span lead times from hours to years
4. Consistent with retrospective hindcasts used for verification and decision support
5. Properly validated for a range of conditions and decision support applications

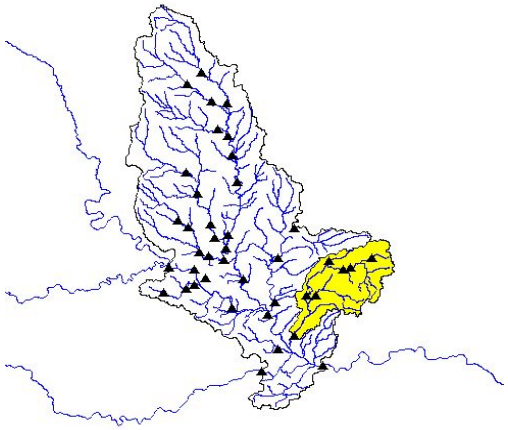
Spatial scale/resolution



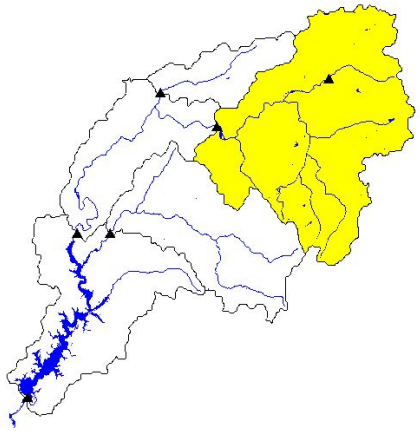
National



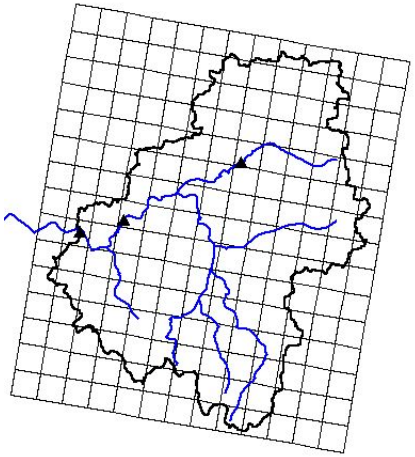
Major River System



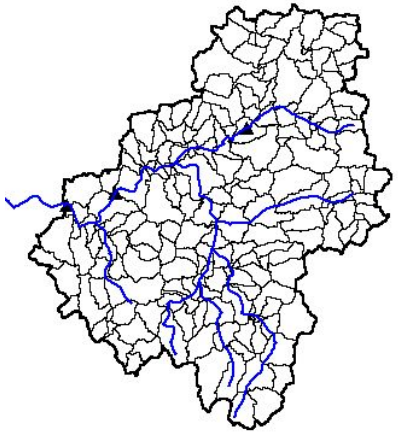
River Basin with River Forecast Points



Forecast Group

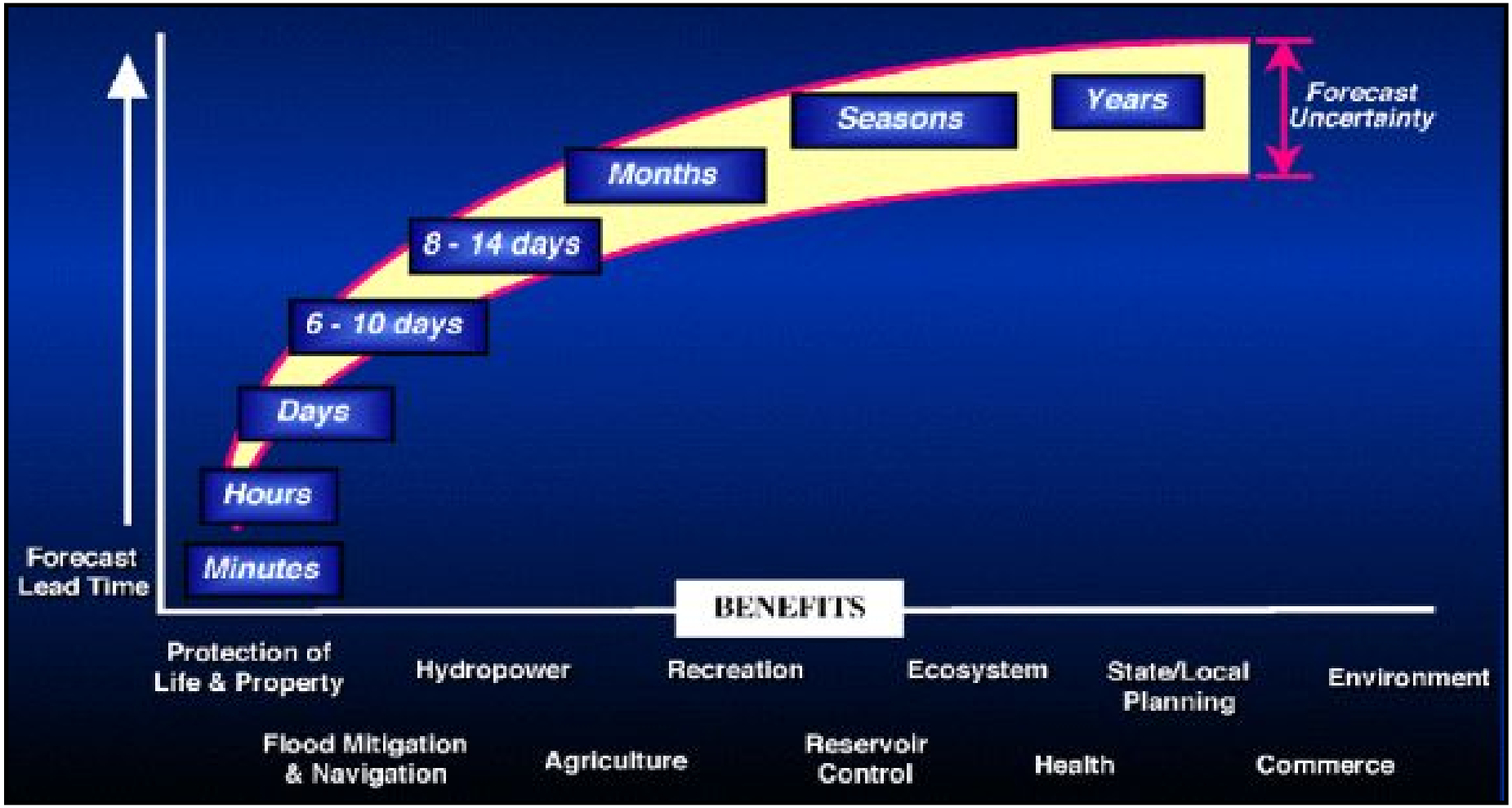


Headwater Basin and Radar Rainfall Grid



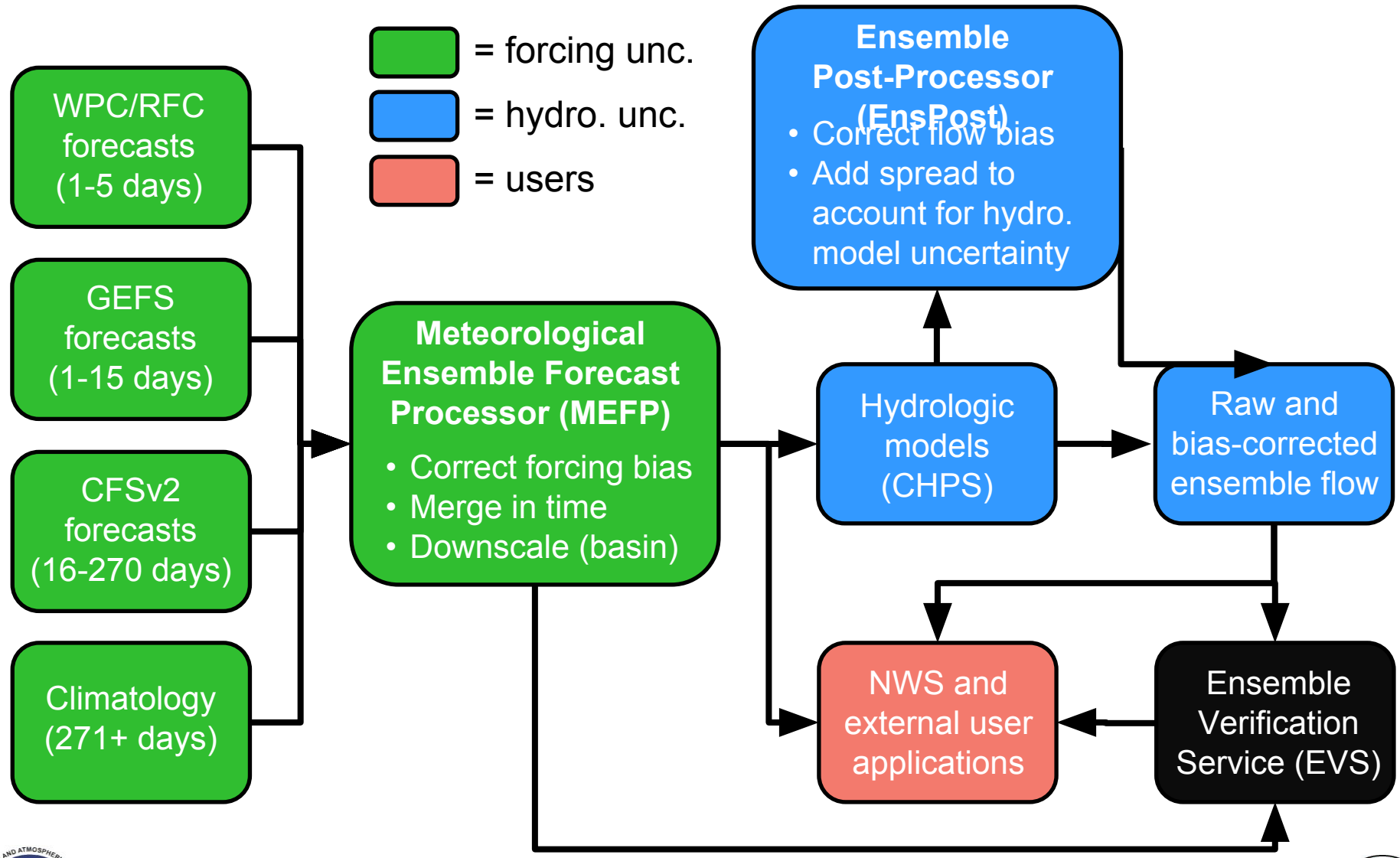
High Resolution Flash Flood Basins

Temporal scale/resolution



Applications depend on lead time and time-aggregation

Hydrologic Ensemble Forecast Service (HEFS)



HEFS reforecast requirements

Sensitivity Analysis

- Calibration of MEFP in keeping w/ White Paper
- Validation and decision support require more data
- Current GEFSv10 reforecast is broadly adequate

Overall minimum requirements

1. At least 25-30 years of reforecasts
2. At least one cycle per day (0Z)
3. Could reduce ensemble members from 11 to 5
4. Strategy for transition between model versions

WRF-Hydro Reforecasting Needs

- Reforecast Uses
  - Post-Processing Forcings
  - Comprehensive Validation
  - Optimization of Decision Support applications
- Factors to consider
  - A broad range of hydrologic events are involved
    - Different combinations of reforecast length and cycling requirements
    - Short, rare, extreme events (flash floods)
    - Larger spatial and temporal scale events (snow pack and reservoir studies)
  - Future reforecasting needs span multiple models (HRRR, RAP, GFS, CFS are current data sources)

Looking forward

Questions/Opportunities to Explore

- Can NCEP produce the ensemble forcings required for NWC modeling? Or reduce NWC post-processing?
- “Smartly thin” the re-forecast dataset while still providing the critical samples of large/extreme events
- New techniques to perform hydrologic validation/decision support optimization with fewer reforecasts (i.e., pool hindcasts across multiple forecast locations to "trade space for time”)
- Potential non-WCOSS resources to produce re-forecasts
- Effects on reforecast quality due to inconsistencies between “analysis” and “reanalysis”

Looking forward

Questions/Opportunities to Explore

- When do model changes necessitate full reforecast production?
- More studies to better understand decision support implications of reduced reforecast dataset (challenge users also)
- More objective and transparent process to determine priorities / tradeoffs for modeling and compute requirements

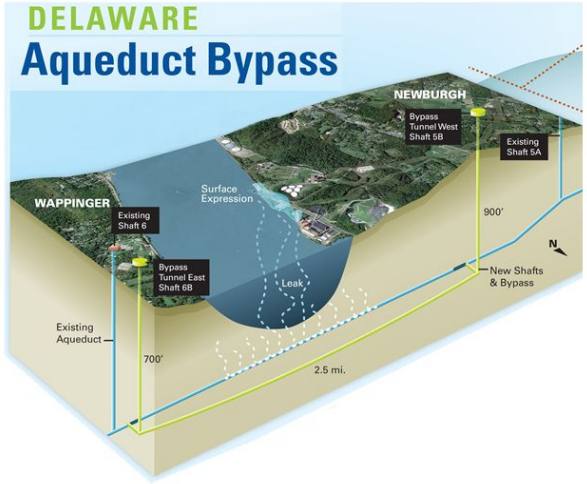
Extra slides

Example application of HEFS

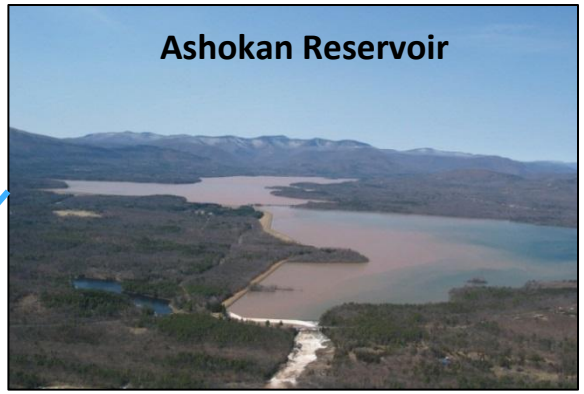
Managing NYC water supply

- 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**

Example application of HEFS

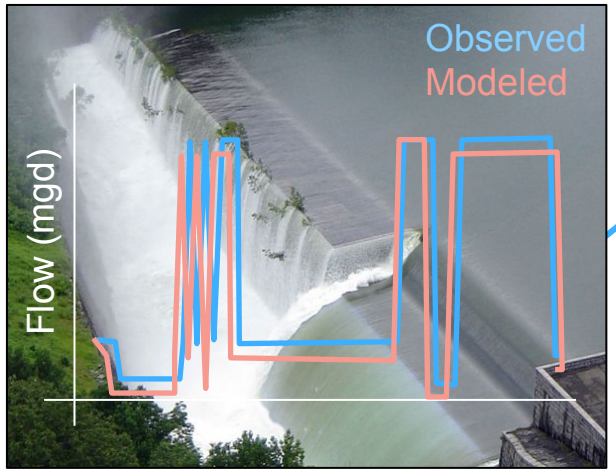


"Mission critical decision to manage shutdown of RBWT Tunnel based on HEFS forecasts"



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

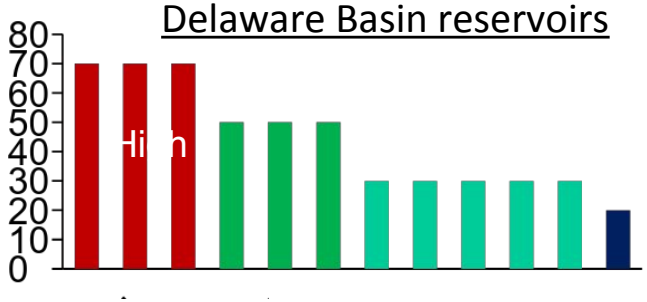
HEFS streamflow forecasts are used to optimize and validate the NYC OST for million/billion dollar applications



(Cannonsville Reservoir Spillway)

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

<u>Risk to water availability from Delaware Basin reservoirs</u>



"HEFS forecasts used to determine risks to conservation releases"

Evaluation - *Strengths*

- Provides a common framework for ensemble forecasting
- The HEFS broadly performs as anticipated
  - Captures skill in inputs (weather and climate forecasts)
  - Produces unbiased outputs (accurate mean, reliable spread)
  - Quantifies the total uncertainty, <u>including hydrologic uncertainty</u>
  - Integrates met inputs spanning short to long lead times
  - Produces spatially and temporally consistent forecast ensembles
  - <u>But</u>, only considered small set of locations and scenarios
- For medium-range forecasting, the **GEFS adds meaningful extra lead time** for all forecast variables compared to the frozen GFS
  - 1-2 days for streamflow and precipitation and 2-4 days for temperature

Reforecasts used by HEFS

GEFSv10 reforecasts (second generation)

CFSv2 reforecasts

Looking forward

Opportunities

- Unsophisticated thinning (N, M) will impact HEFS
- Many possibilities for sophisticated thinning
- E.g. reduced interval during second week
- E.g. augmented runs of extremes

Risks

- Consistency of reforecasts and operations
- Real-time reforecasting (incremental production)
- Transitional arrangements (timelines etc.)