An Innovative Ensemble Modeling System for Improved Water Supply Forecasts in the Sacramento-San Joaquin Delta

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Outline

- Introduction (slide 3)
- Method (slides 4-6)
- Results (slides 7-12)
- Summary (slides 13-14)

Introduction

❖ Why water supply forecasting matters to the Delta?

- ❑ Delta ecosystem (water quantity/quality objectives)
  - → water supplied by upstream reservoirs

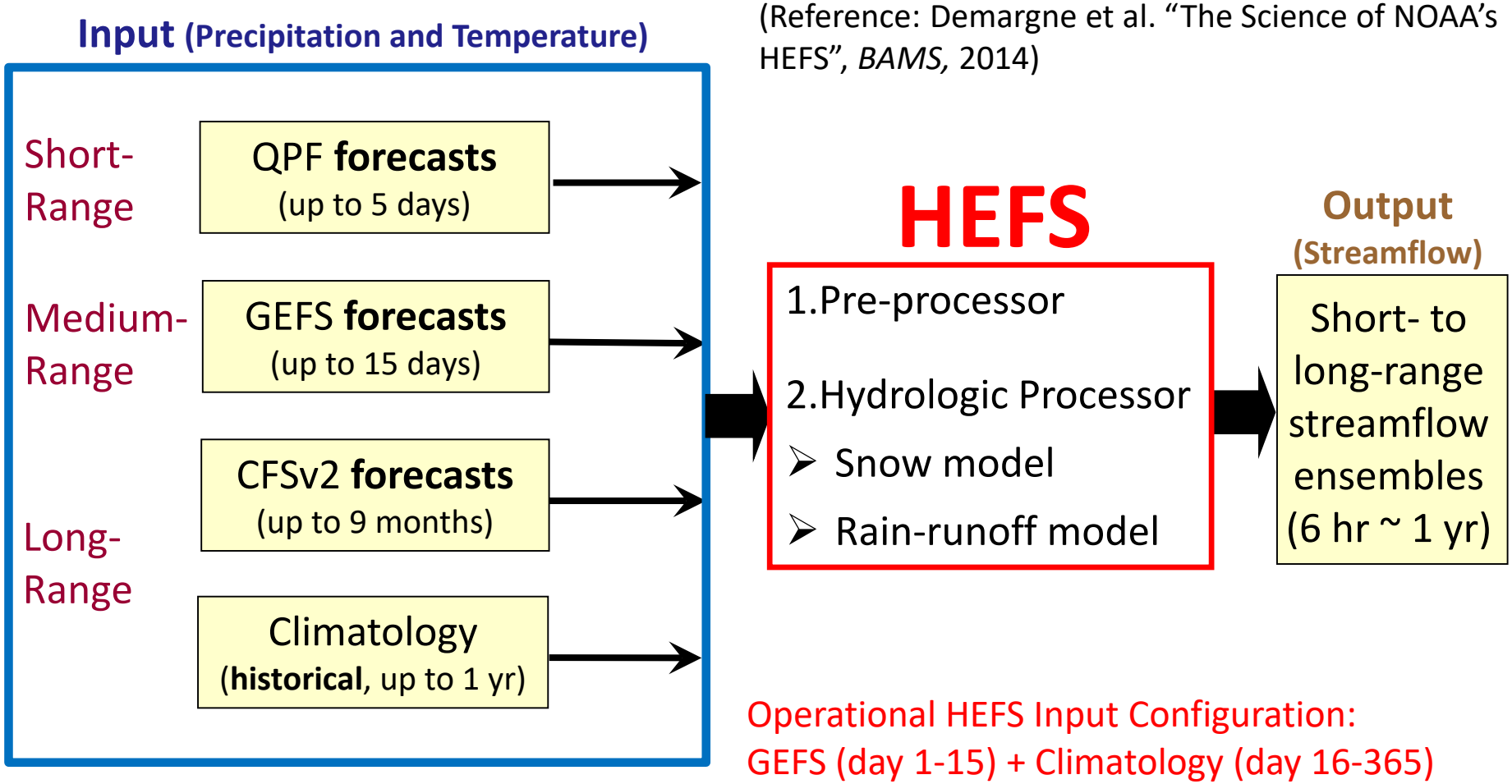
❖ What is the current forecasting practice?

- ❑ Regression equation: Runoff (Apr.-July) = function(snow, runoff, precipitation)
- ❑ Issued weekly from February to June

❖ What will this presentation cover?

- ❑ Introduce the innovative Hydrologic Ensemble Forecast Service (HEFS)
  - → Ingests short-to-long term forecast information
  - → Runs daily
  - → Starts from Oct.1
- ❑ Verify the skill and reliability of HEFS forecasts

HEFS Overview



(Reference: Demargne et al. "The Science of NOAA's HEFS", *BAMS,* 2014)

Operational HEFS Input Configuration:
GEFS (day 1-15) + Climatology (day 16-365)

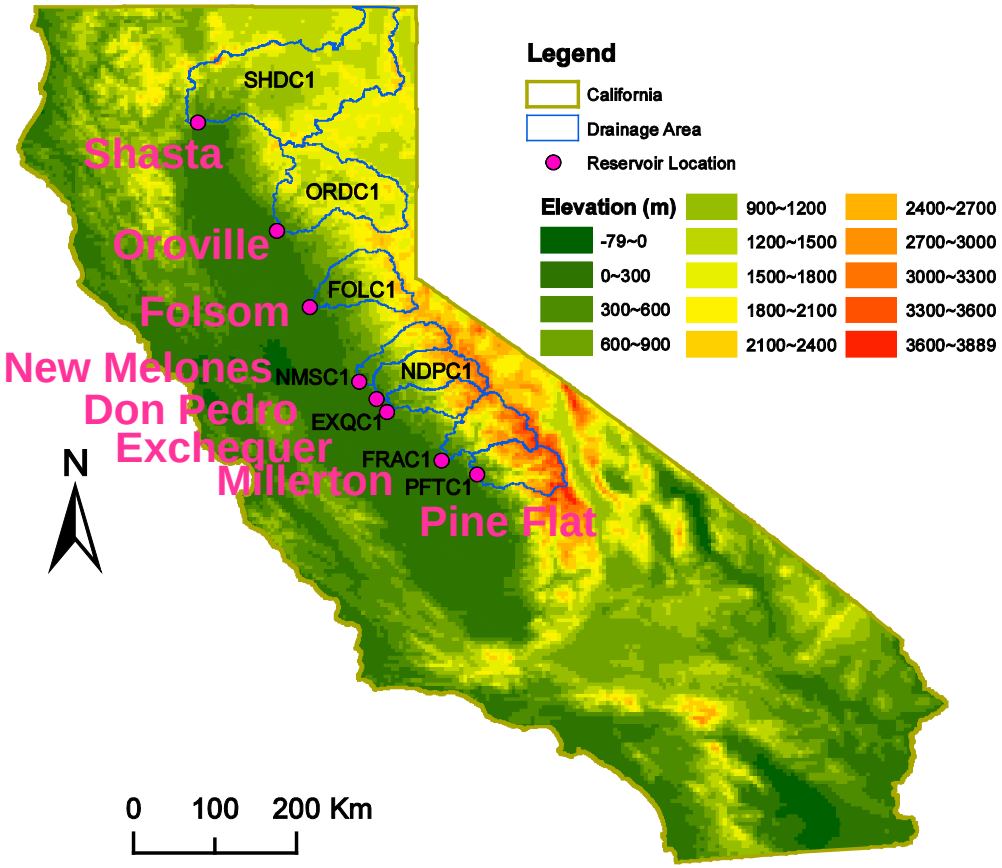
Acronyms:

QPF: Quantitative Precipitation
GEFS: Global Ensemble Forecast System
} Numerical Weather Model

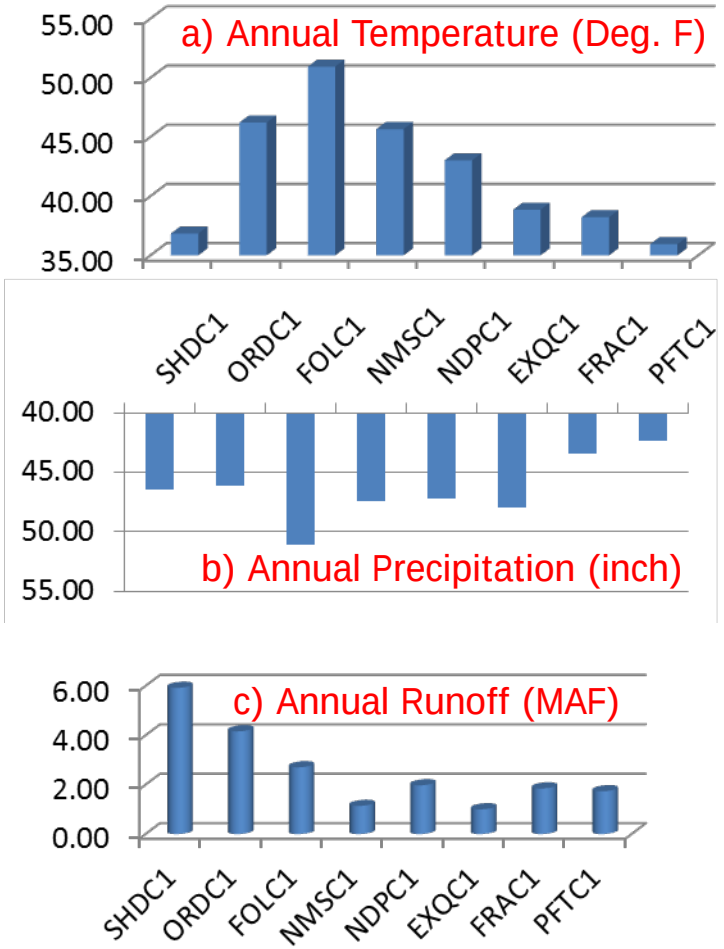
CFSv2: Climate Forecast System version 2 → Numerical Climate Model

Study Areas

Location Map



Hydro-climatic Characteristics



Accumulated Reservoir Capacity: 16 MAF (42% of the total capacity of 154 major reservoirs statewide)

Study Scope and Metrics

❖ Study Scope

1. Skill and reliability: fcsts of current/operational HEFS input configuration
2. Impact of different input sources, ensemble/sample sizes: four scenarios

   S1: GEFS (day 1-15)+Climatology (16-365): *26 years (1985-2010), 60 members*

   S2: Climatology (1-365): *26 years, 60 ens. members* [Input]

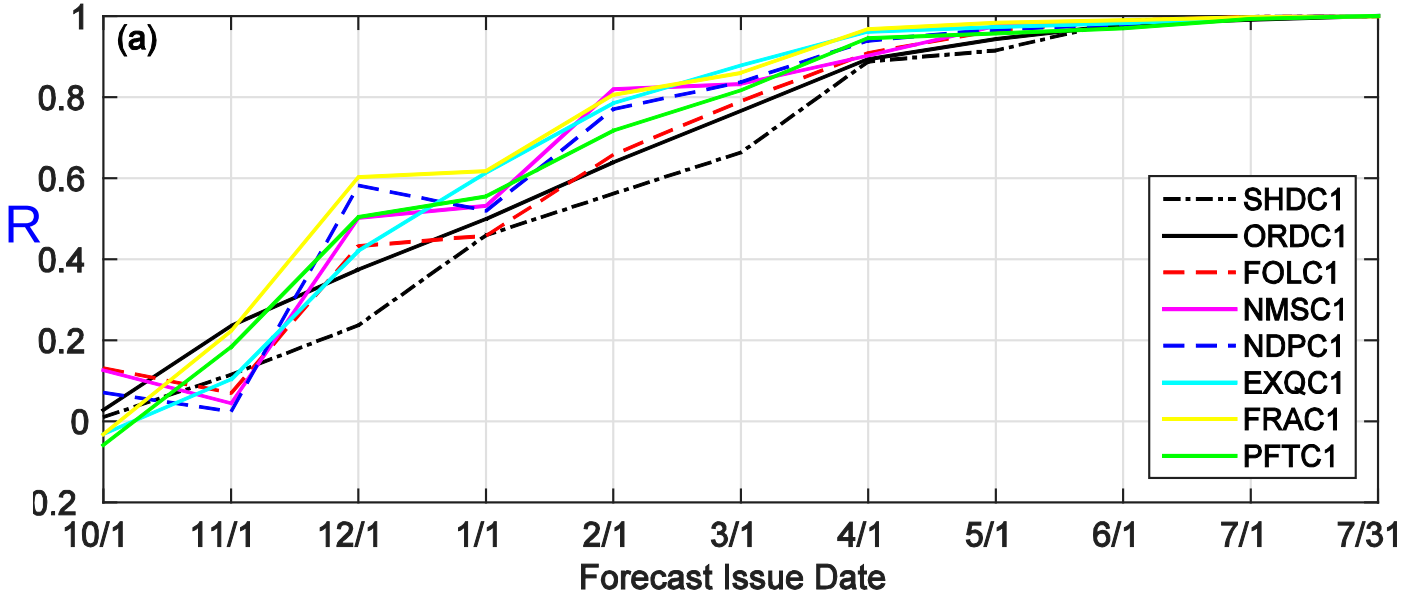
   S3: GEFS (day 1-15) + Climatology (16-365): *26 yrs, 25 ens. members* [Ensemble size]

   S4: Climatology (day 1-365): *61 yrs (1950-2010), 60 ens. members* [Input/Sample size]

❖ Study Metrics

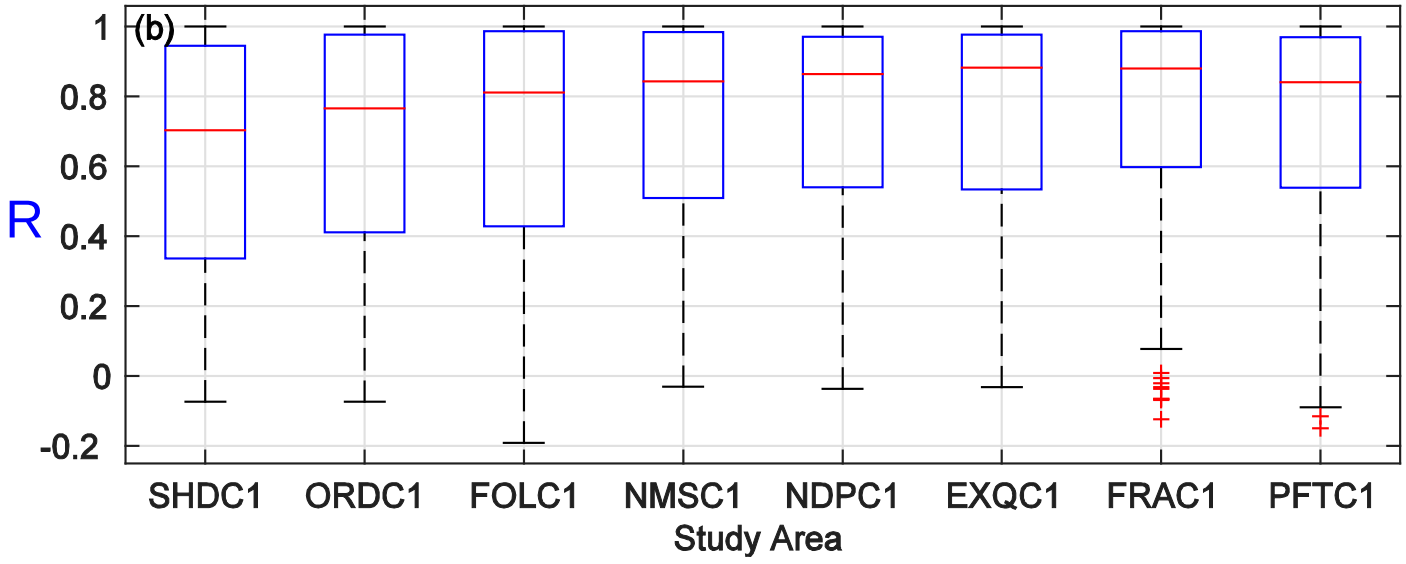
- ❑ Skill (applied to the median forecast, aka most probable forecast):
  - ➢ Rank correlation (R) ([-1 1]: 1, perfect; 0, no correlation)
  - ➢ Nash-Sutcliffe Efficiency (NSE) (<=1: 1, perfect; <=0, no skill)
- ❑ Reliability (applied to different forecast percentiles):
  - ➢ Containing Ratio (CR) ([0 1]: 1, perfect; 0, not reliable)

Correlation of Median Fcst



(a) Monthly R

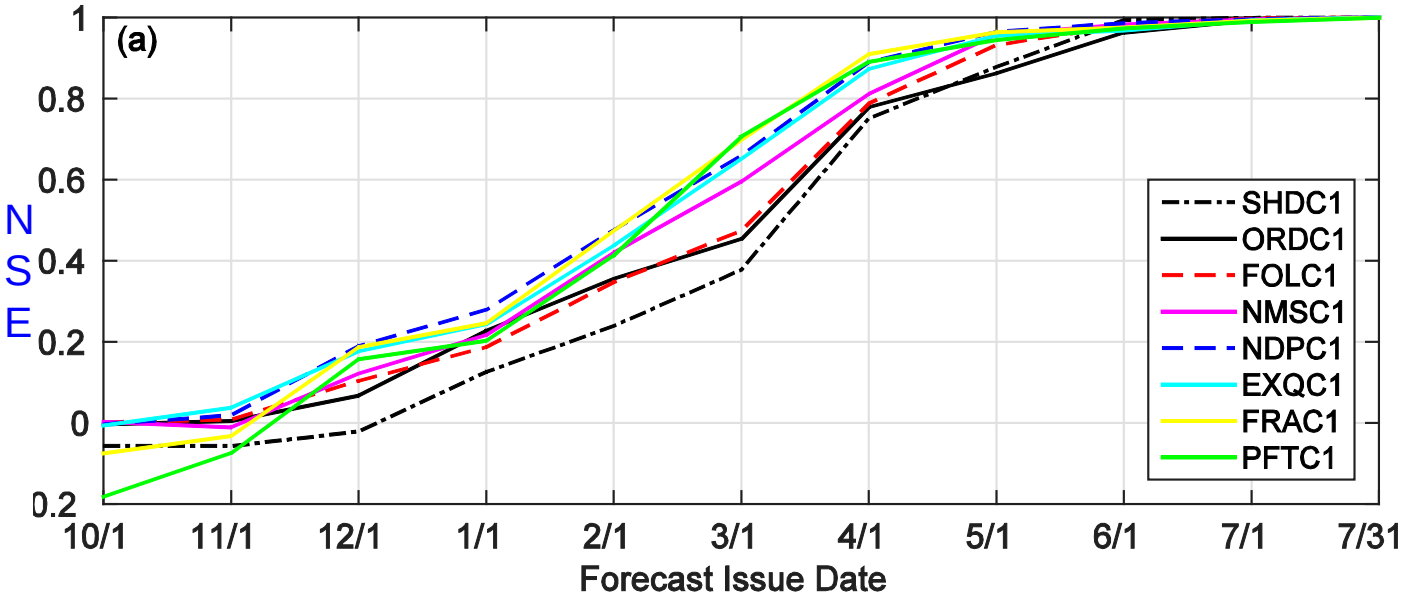
- Increasing
- Shasta lowest
- Millerton highest
- Southern areas higher



(b) Daily R (10/1~7/31)

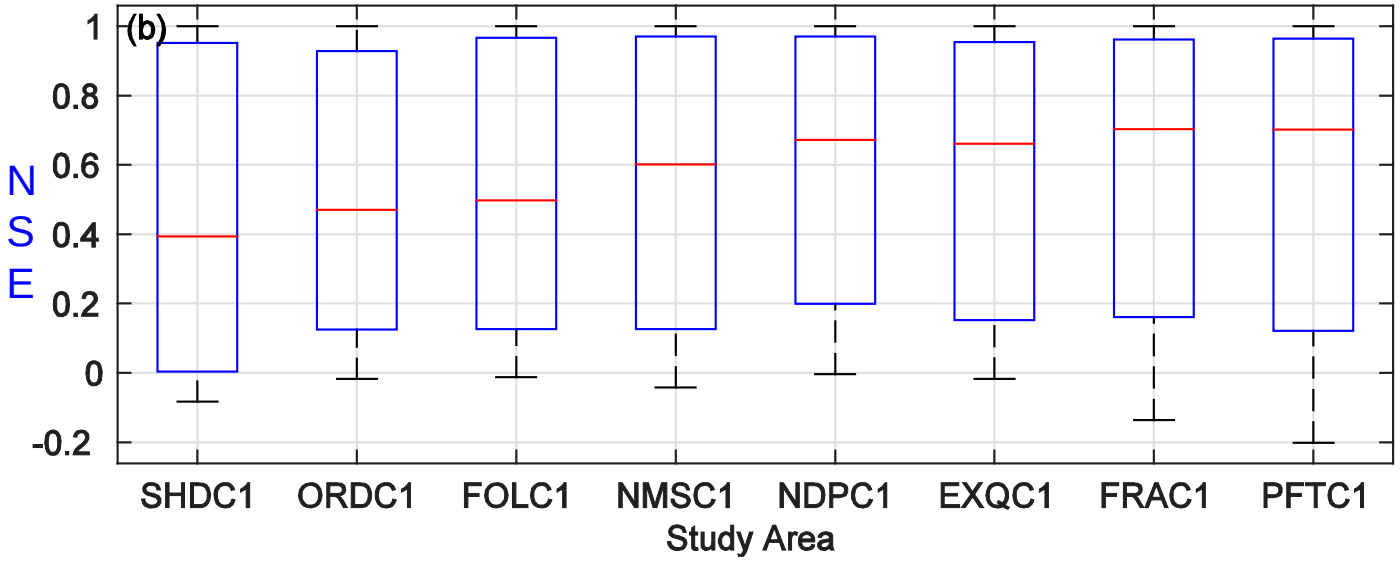
- Large variations
- Median R (red line) increases from North to South

NSE of Median Fcst



(a) Monthly NSE

- Increasing
- Shasta lowest
- Southern areas higher

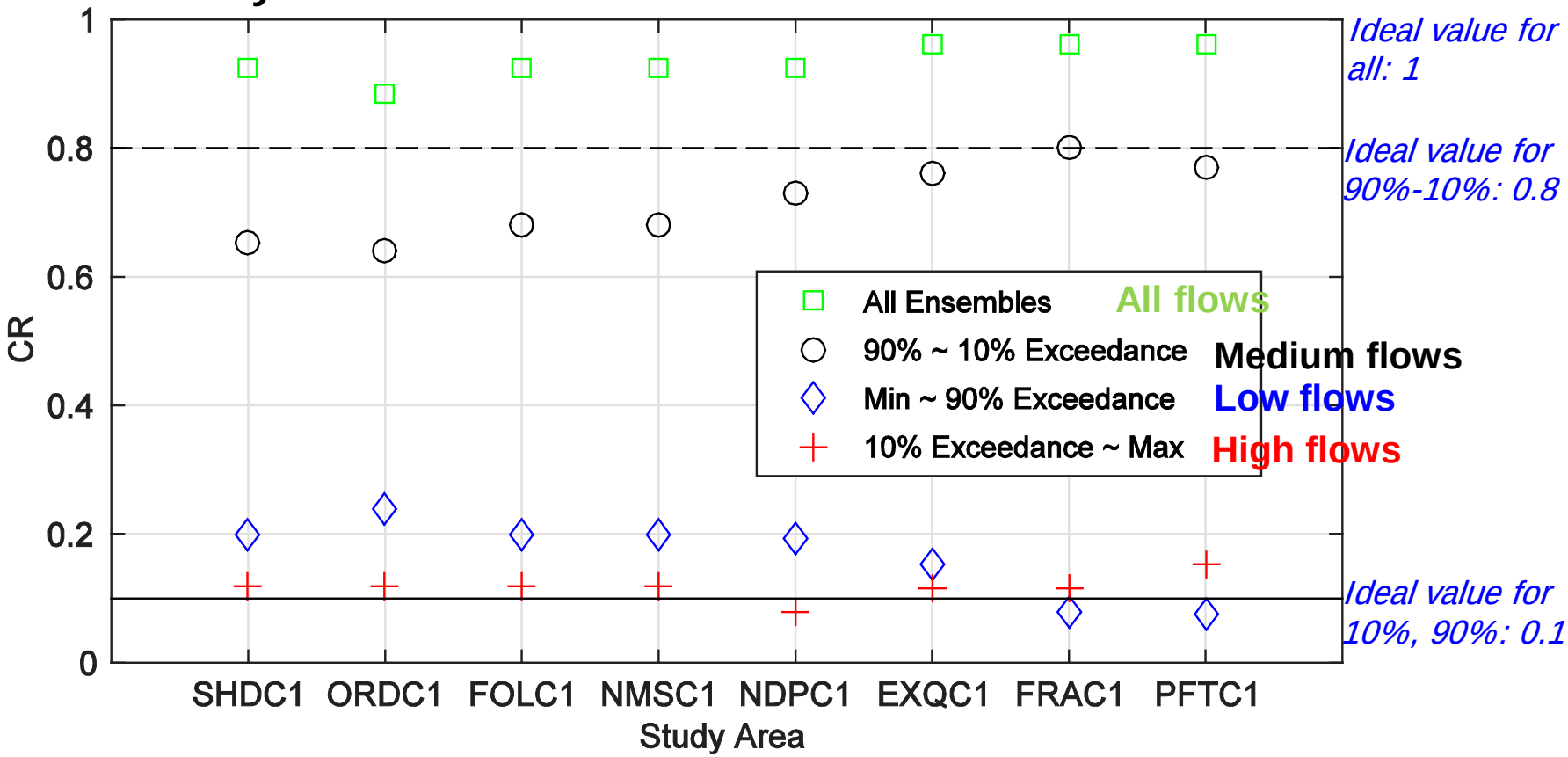


(b) Daily NSE (10/1~7/31)

- Large variations
- Median R (red line) increases from North to South

Containing Ratio (CR)

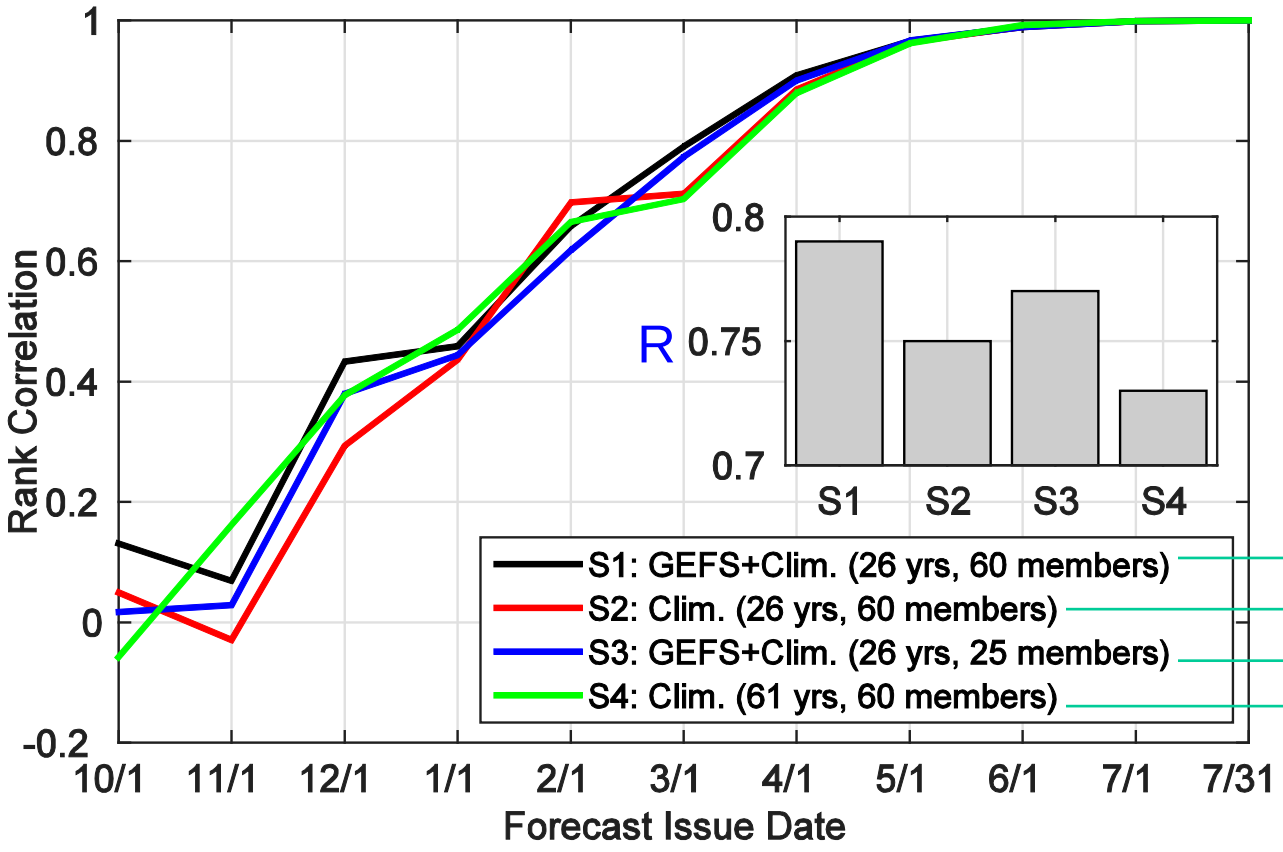
❖ Median daily CR of ensemble fcsts



- ❑ Forecast on high flows (10% exceedance ~ Max) very reliable
- ❑ Forecast frequency on low flows (Min~90%) too high (except FRAC1/PFTC1)
- ❑ Forecast frequency on medium flow (90%-10%) too low (except for FRAC1)
- ❑ Overall forecast frequency (all flows) slightly lower than observed frequency

Sensitivity Analysis

❖ Monthly correlation (R) of median fcst with obs. for Folsom



- Current configuration
- Current but diff. input (D1-15)
- Current but diff. ensemb. size
- Current but diff. inp. smp. size

❑ Overall S1 has higher R (with a few exceptions- 11/1 & 1/1: S4; 2/1: S2)

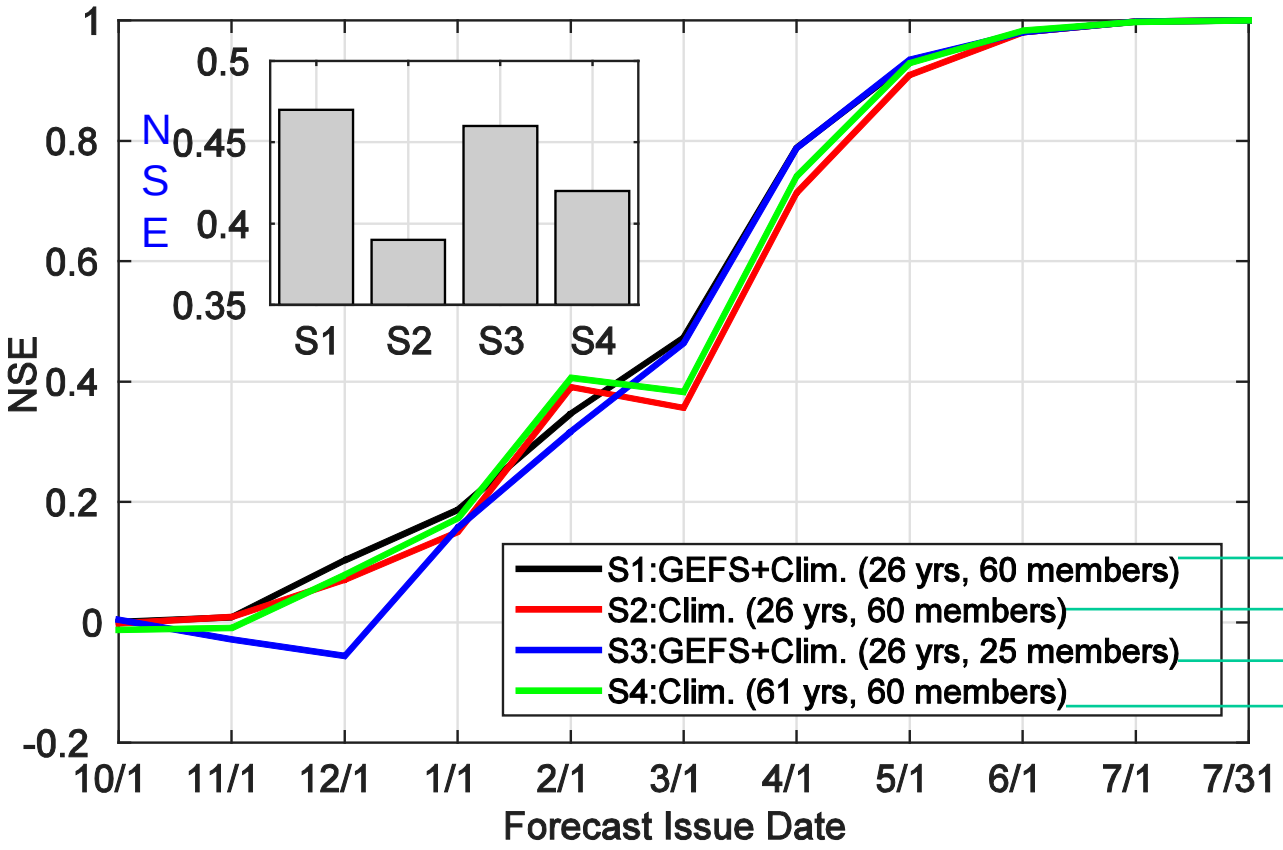
Insert Diagram:

❖ Median daily correlation (10/1-7/31) of median fcst

❑ S1 >S3 >S2 >S4

Sensitivity Analysis

❖ Monthly NSE of median fcst for Folsom (FOLC1)



- Current configuration
- Current but diff. input (D1-15)
- Current but diff. ensemb. size
- Current but diff. inp. smp. size

❑ Overall S1 has higher NSE (with a few exceptions- 2/1: S2, S4)

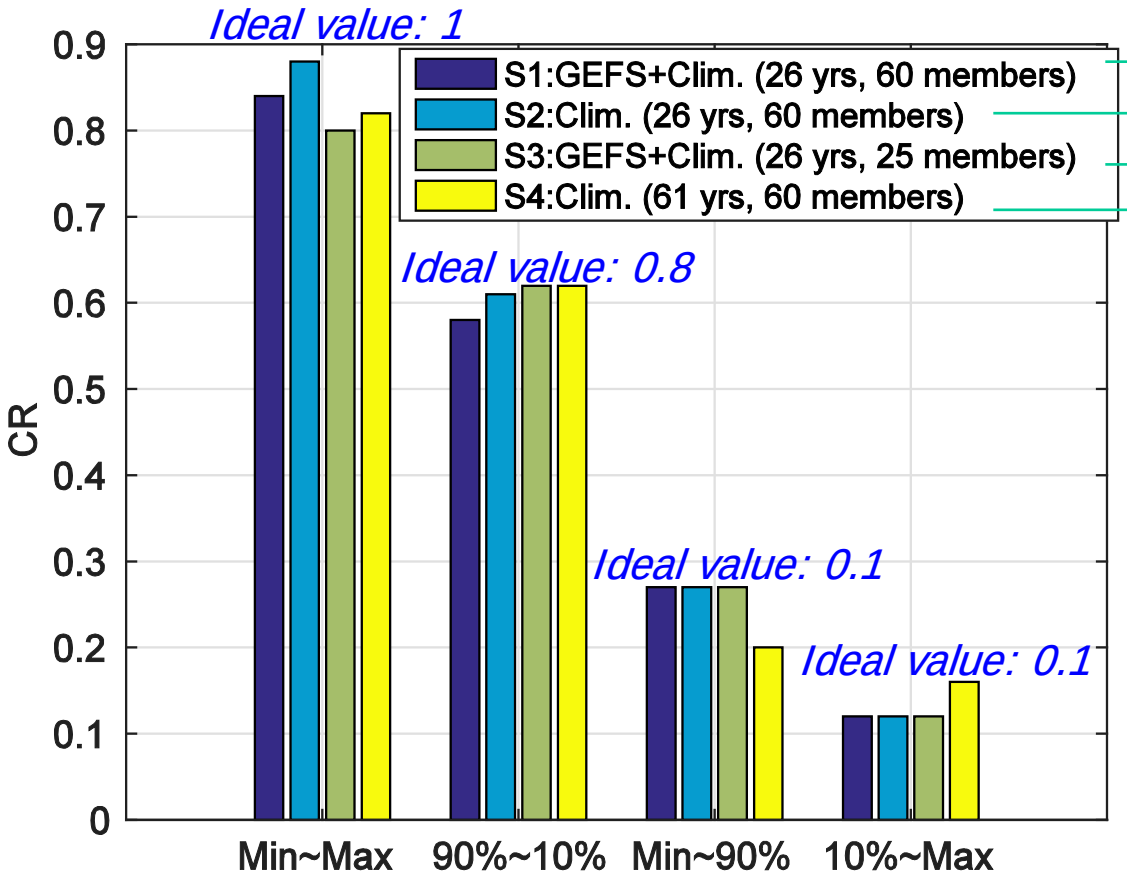
Insert Diagram:

❖ Median daily NSE (10/1-7/31) of median fcst

❑ S1 >S3 >S4 >S2

Sensitivity Analysis

❖ Median daily CR of fcsts on four different categories of flows for Folsom (FOLC1)



→ Current configuration
→ Current but diff. input (D1-15)
→ Current but diff. ensemb. size
→ Current but diff. inp. smp. size

- ❑ For all flows, S2 (/S3) has highest (/lowest) CR
- ❑ For medium flows (90%-10%), S1 has the lowest CR
- ❑ For low flows (<90%), S4 has the lowest CR
- ❑ For high flows (>10%), S4 has the highest CR

Summary

❖ Forecast Skill / Reliability

- Limited in early forecast dates; increases throughout the forecast period
- Increases from North to South (more snow-dominated)
- Forecasts in wet years (with high flows) more reliable

❖ Impact of Input Sources / Ensemble Size / Sample Size

- Alternative scenarios: no significant added value

❖ Implication / Value of This Work

- HEFS (with current configuration) water supply fcsts: skillful/reliable
- Guide efforts in improving water supply reliability for the Delta:
  - ➢ Invest more on (Northern) basins with lower predictability
  - ➢ Focus more HEFS enhancements for fcsts in dry/average years

Thank You!

Questions?

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Reference:

He et al. (2016), Verification of Ensemble Water Supply Forecasts for Sierra Nevada Watersheds, *Hydrology,* 3(4), 35; doi:10.3390/hydrology3040035