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Hydrologic Ensemble Hindcasting & Verification in the U.S. National Weather Service

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wyle

Riverside Technology, inc.
Water Resources Engineering and Consulting

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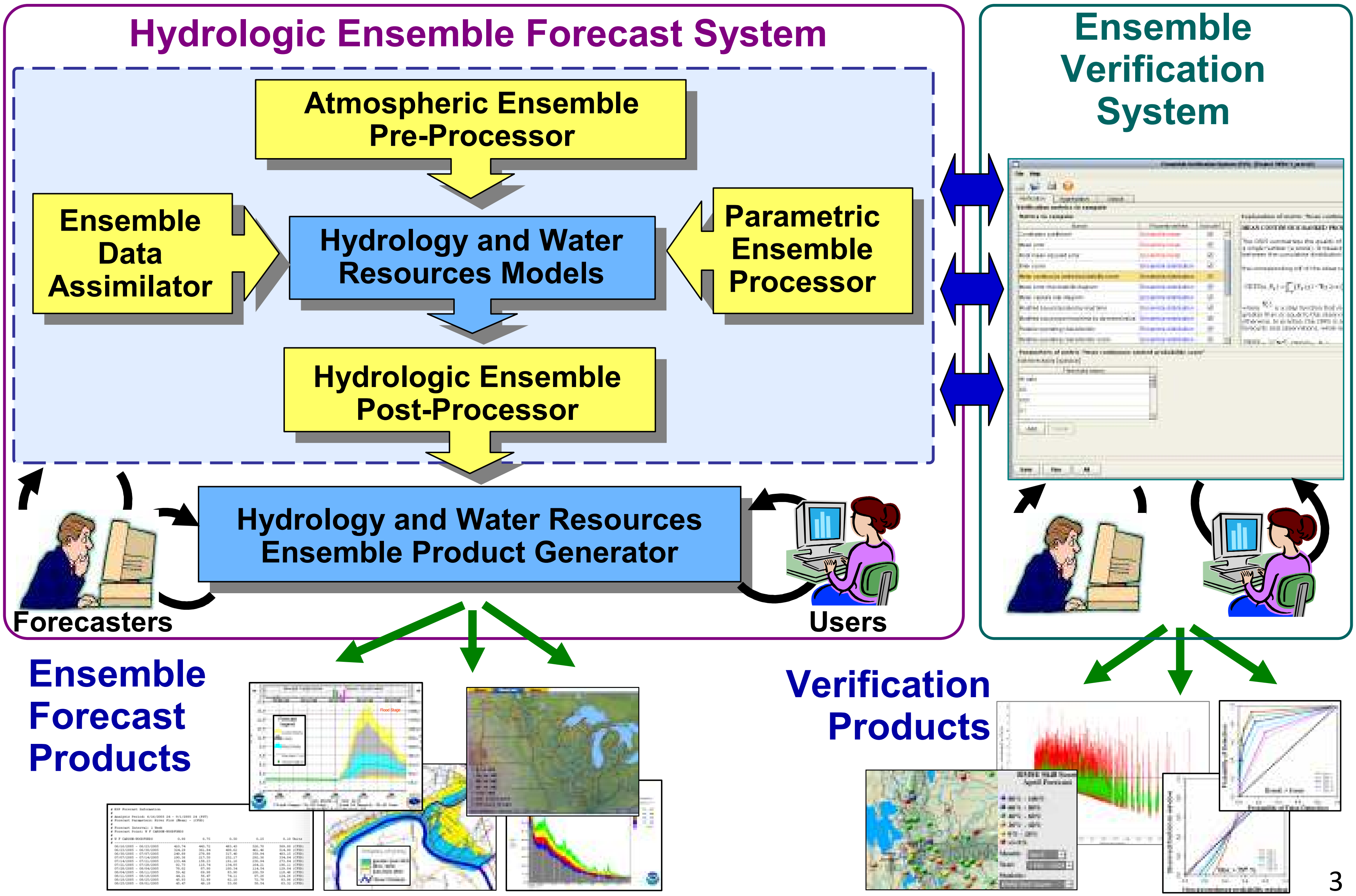
UNESCO-IHE
Institute for Water Education

Need for ensemble forecasting and verification

In 2006, National Research Council recommended that NWS produce uncertainty-quantified products, expand verification and make information easily available to all users in near real time.

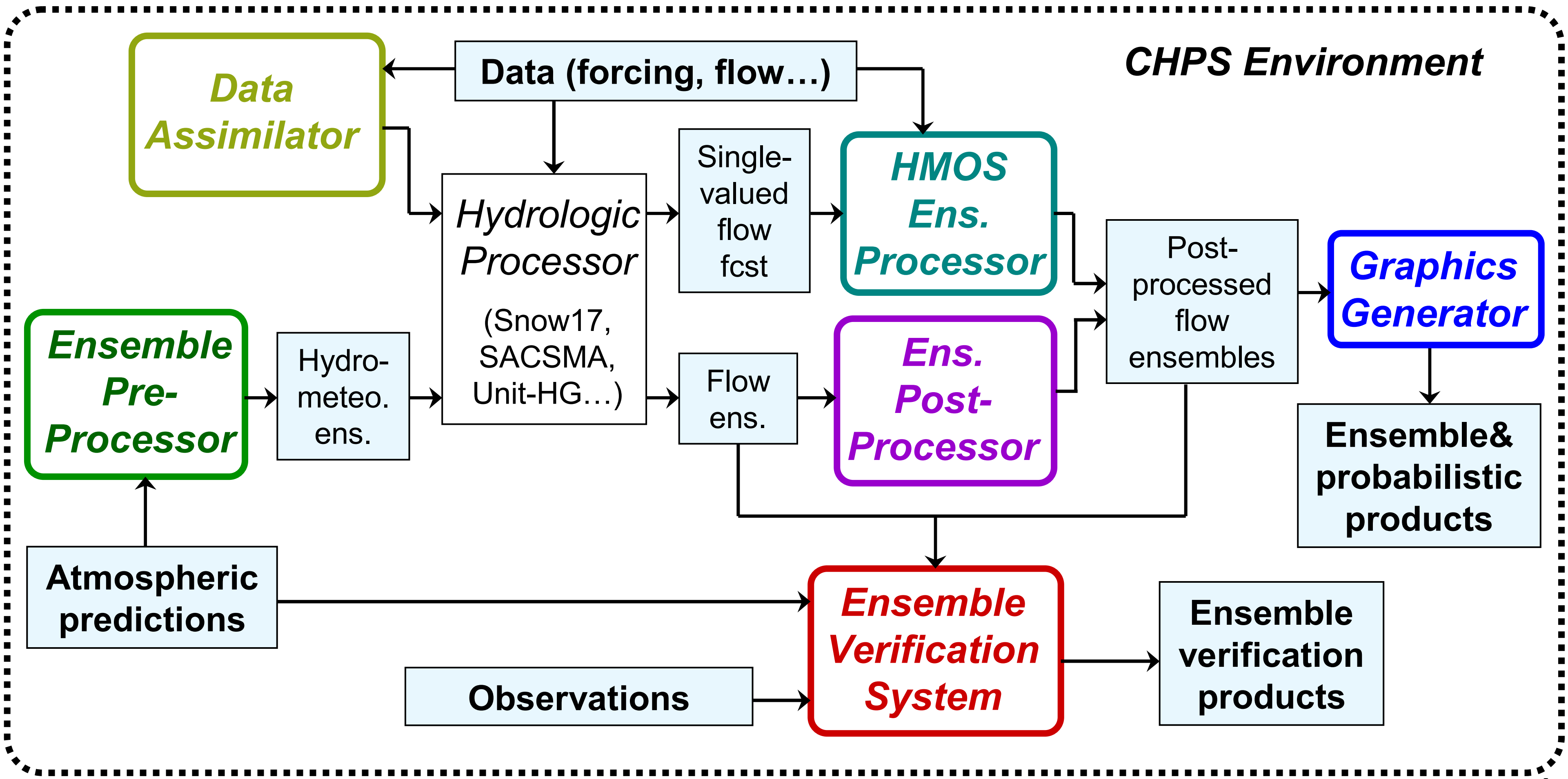
- **Forecasters** get objective guidance for **level of confidence** in forecasts
- **End users** decide whether to take action based on their **risk tolerance**

Hydrologic Ensemble Forecast System (HEFS)

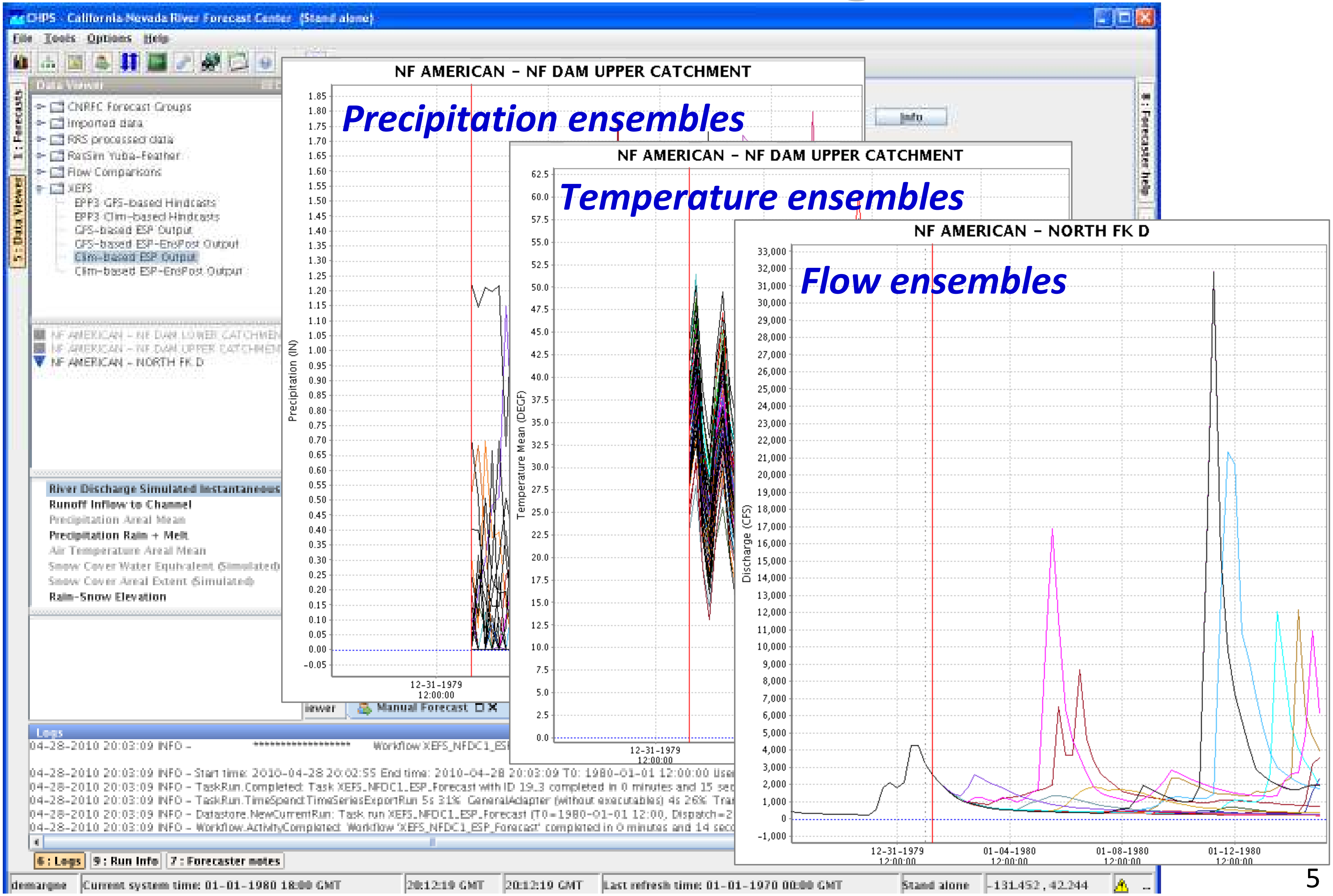


Experimental Ensemble Forecast System (XEFS)

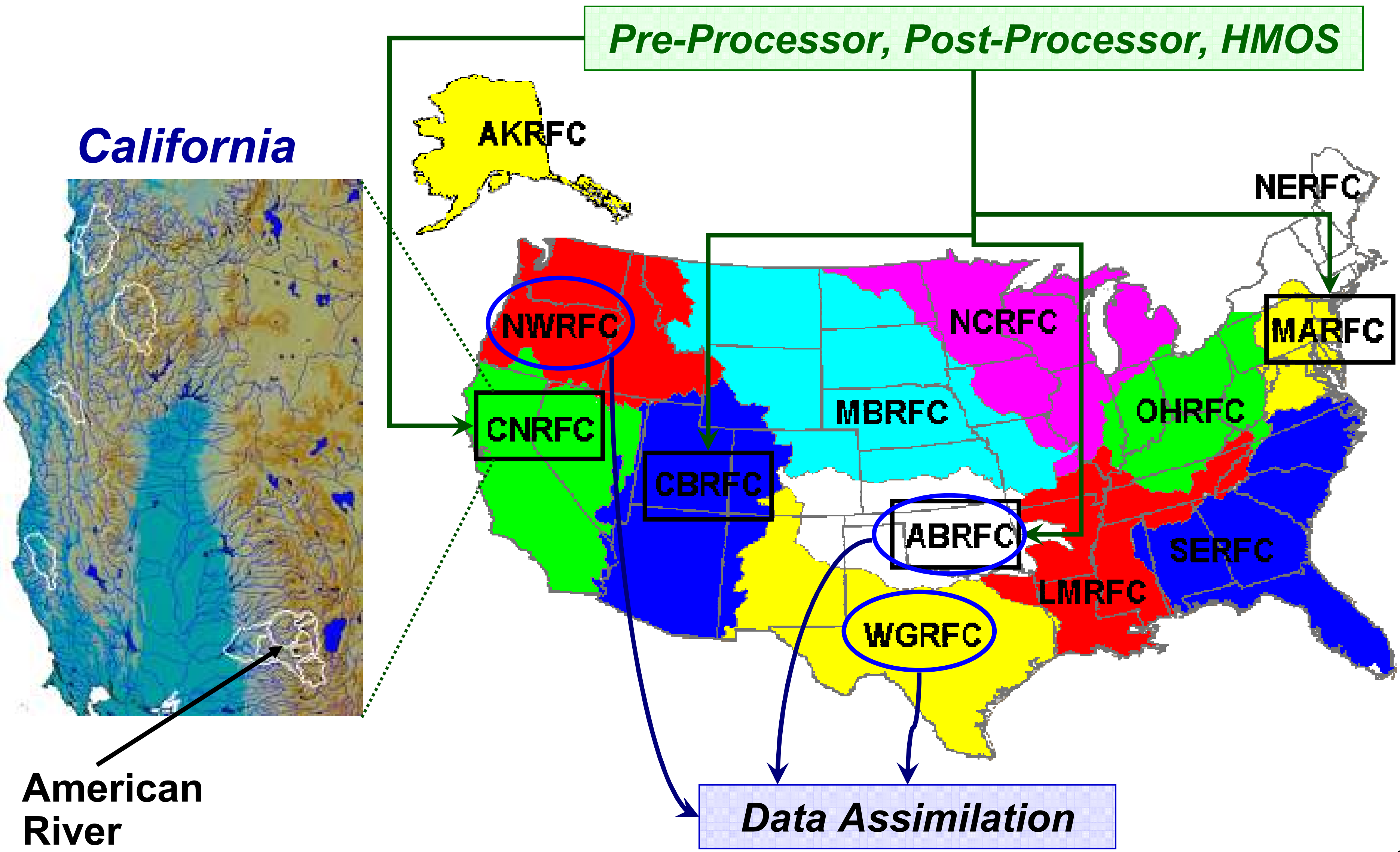
XEFS Components are being integrated into **Community Hydrologic Prediction System (CHPS)** which builds on Flood Early Warning System developed by Deltares



Ensemble Forecasting in CHPS

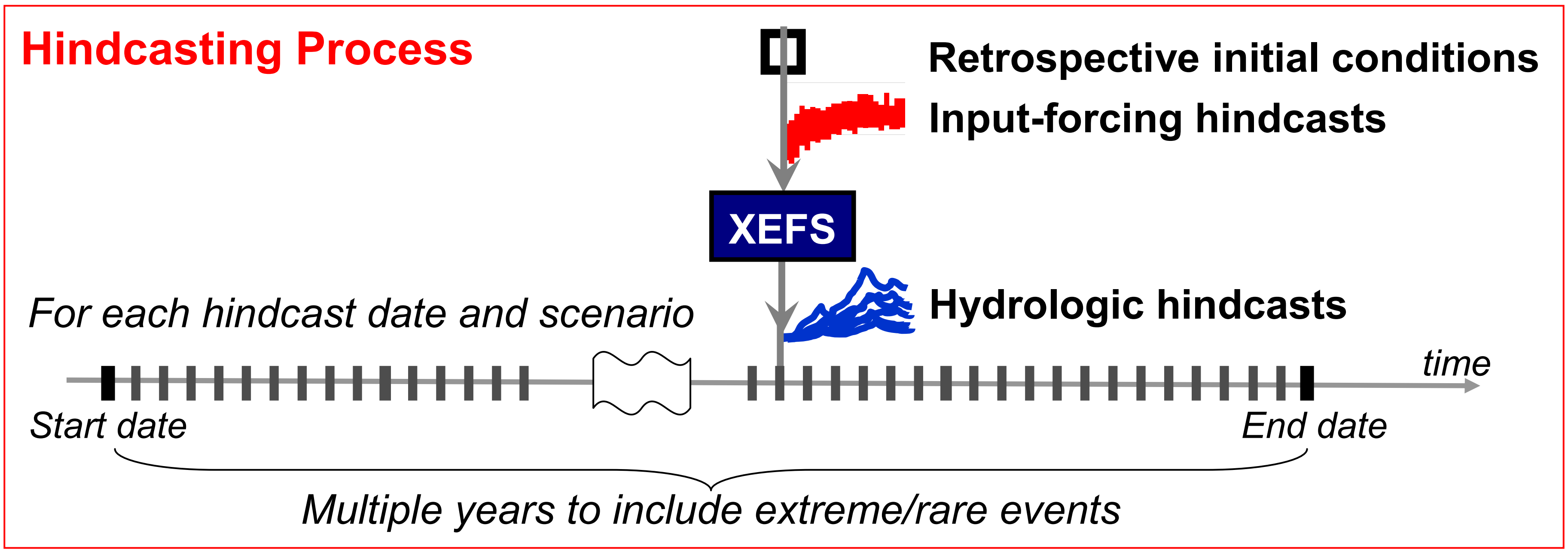


Current XEFS Test Basins at the NWS River Forecast Centers (RFC)



XEFS Hindcasting and Verification

- Systematic hindcasting and verification of all XEFS processes is necessary to
  - evaluate ensemble forecast performance, including that for **extreme events**
  - serve operational need for ensemble forecast system calibration
  - identify and quantify different error sources using various scenarios

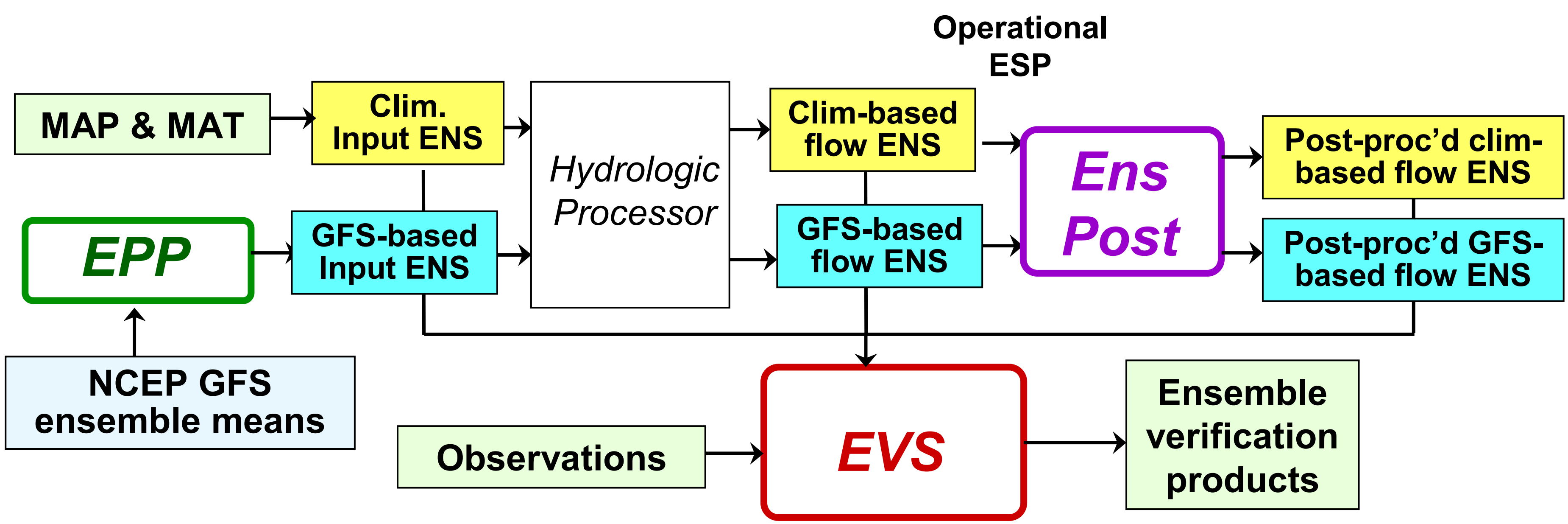


Case Study

- North Fork of the American River (875 km^2) near Sacramento, California
- Daily products, 14 lead days, 45 members, 1979-2005
- GFS-based Ens. Pre-Processor (**EPP**) and Ens. Post-Processor (**EnsPost**) against climatology, evaluated via Ensemble Verification System (**EVS**)

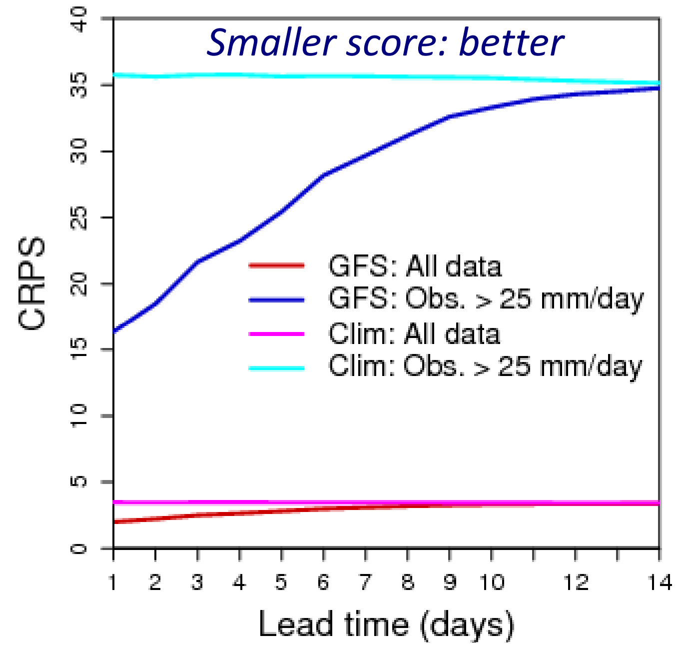
EPP: retain skill in single-valued input fcst & generate unbiased ENS

EnsPost: account for all hydrologic uncertainties

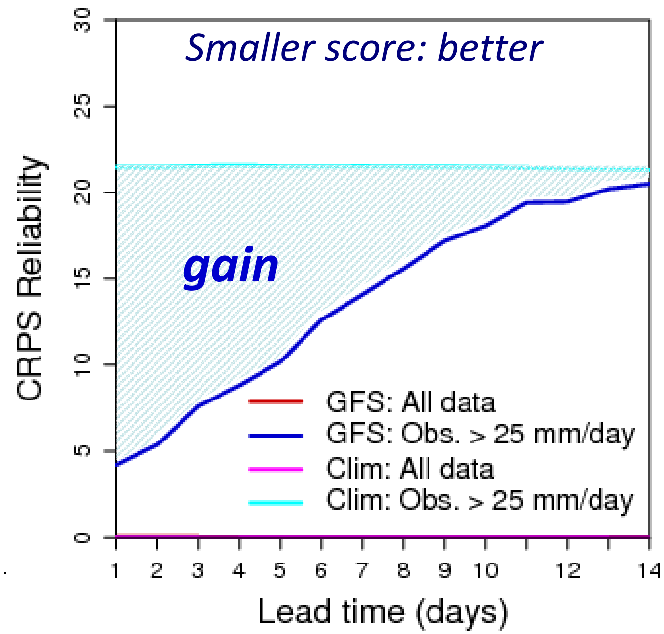


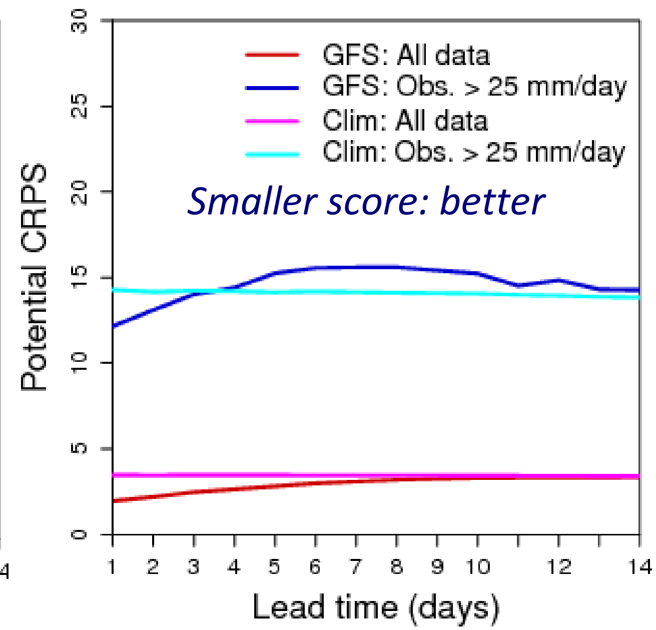
Verification Results: Pre-Processor

- GFS-based 24-hr **precipitation ENS** from EPP vs. Climatology:
  - **Mean Continuous Ranked Probability Score (CRPS)**
  - **Mean CRPS decomposition**



Mean CRPS=
Reliability
+ Potential CRPS

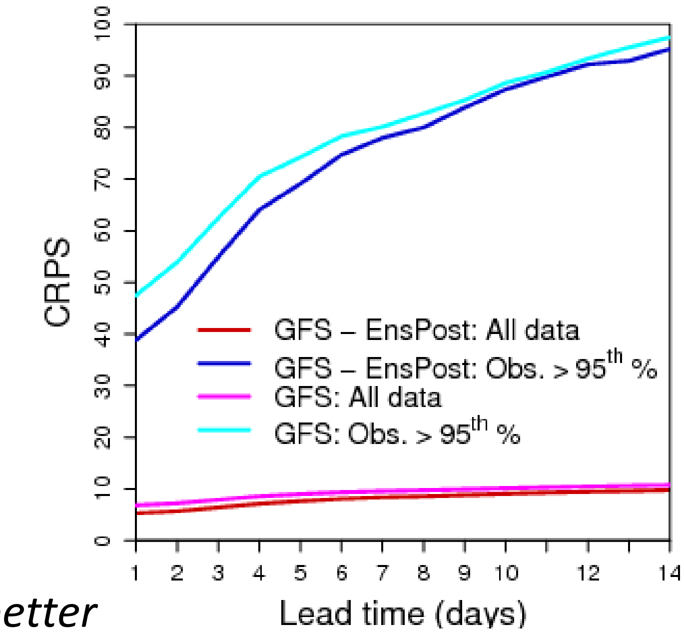




Gain is mostly in reliability

Verification Results: Post-Processor

- 24-hr **flow ENS** from EPP GFS-based forcing w/ vs. w/o EnsPost
  - **Mean CRPS**: improvement from EnsPost is most significant at short lead time, from reducing uncertainty in initial conditions

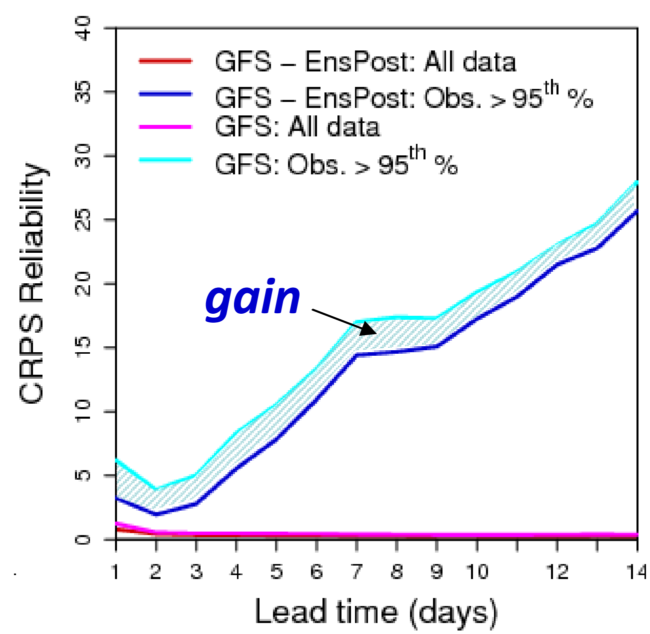


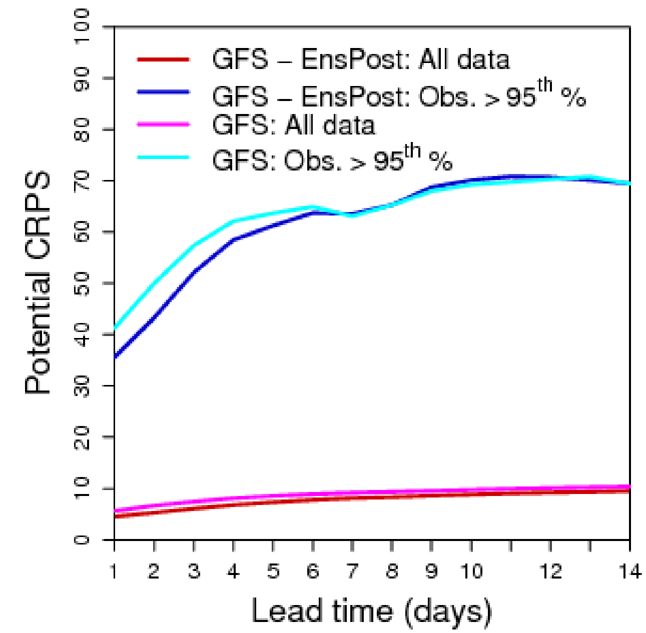
Smaller scores: better

- **Mean CRPS decomposition**

Mean CRPS= Reliability + Potential CRPS

Significant gain in reliability w/ EnsPost at all lead times



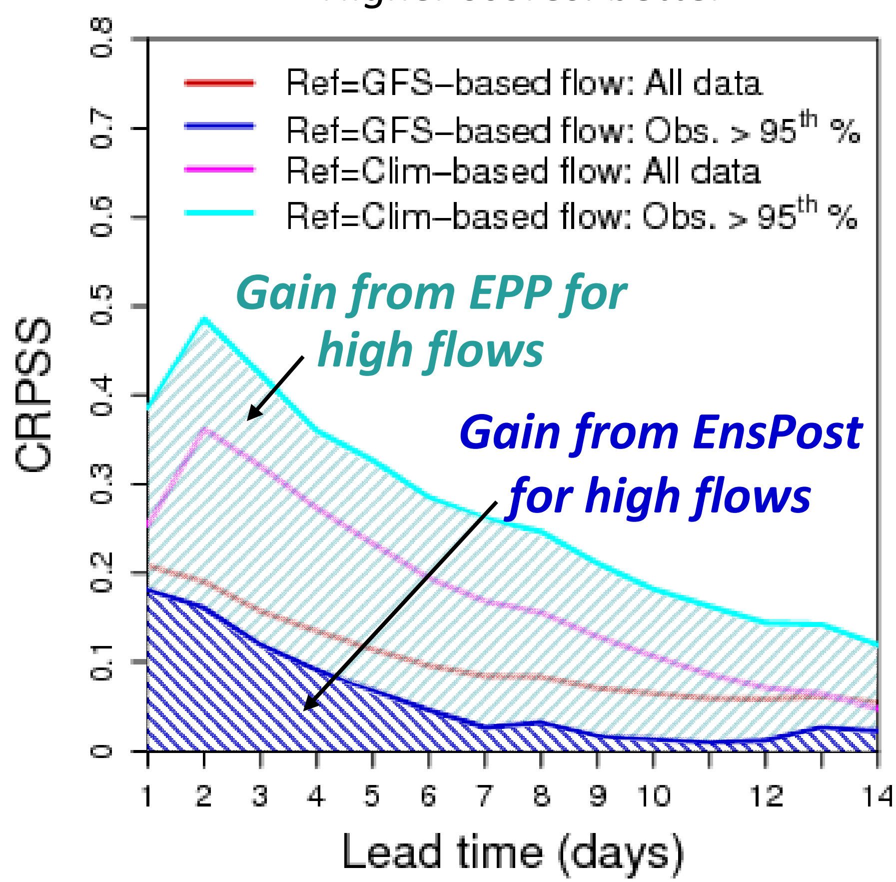


Verification Results: EPP-EnsPost

- EPP-EnsPost flow ENS vs. operational ESP:

  - **Skill Score for Mean CRPS (CRPSS)**: GFS-based flow generated by EPP-EnsPost compared to
    - GFS-based flow (EPP-ESP)
    - climatology-based flows (operational ESP)

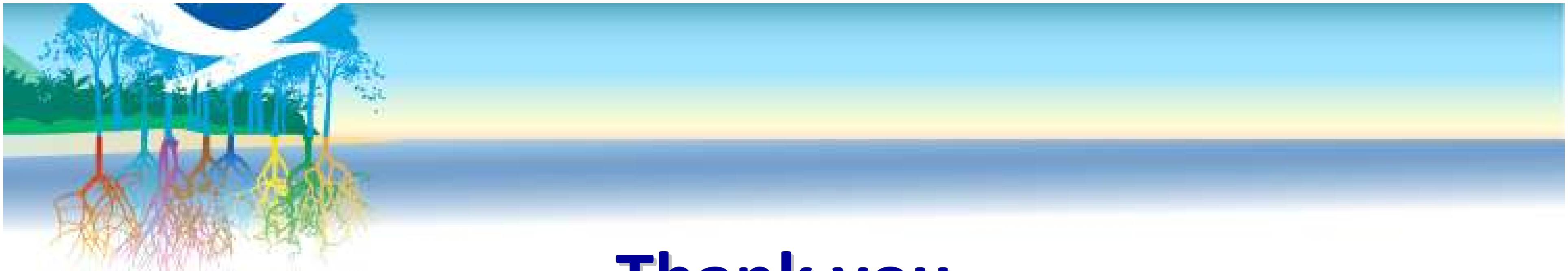
Higher scores: better



Significant gain in skill at all lead times from EPP and EnsPost especially for larger flows

Future Work & Outstanding challenges

- Further evaluate XEFS components (HMOS, DA) & other forcing forecasts (e.g. SREF, CFS)
- Challenges:
  - Closer collaboration between hydrologic and meteorological communities
  - Closer collaboration among scientific, operational and user communities (e.g., THORPEX-Hydro, HEPEX)
  - Sampling uncertainty, observational uncertainty, coherent verification, long-term hindcasting, synergistic product improvement, prediction of extreme events ...



Thank you

Questions?

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References

EPP: Schaake et al, 2007. Precipitation and temperature ensemble forecasts from single-value forecasts. HESSD.

EnsPost: Seo et al, 2006. A statistical post-processor for accounting of hydrologic uncertainty in short-range ensemble streamflow prediction. HESSD.

EVS download: www.nws.noaa.gov/oh/evs.html