SESSION H31L-1670389

Implementing the Ensemble Streamflow PostProcessor (EnsPost) at U.S. National Weather Service River Forecast Centers to account for hydrologic uncertainty

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Introduction

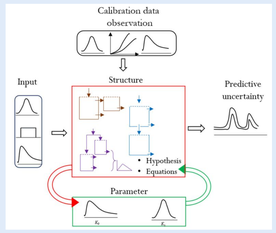


Figure 1: Uncertainty sources (Moges et al., 2021)

- Hydrologic predictions contain numerous sources of uncertainty (Moges et al., 2021).
- The Hydrologic Ensemble Forecast Service (HEFS) was developed to quantify these sources of uncertainty and to correct for biases (Demargne et al., 2014).
- HEFS quantifies meteorological uncertainty with the Meteorological Ensemble Forecast Processor (MEFP) and hydrologic uncertainty with the Ensemble Post-processor (EnsPost, Seo et al. 2006).

EnsPost improves forecast skill at low and moderate flows, but shows mixed performance for the highest flows.

- The primary goal of this work is to determine if EnsPost adds forecast skill at operational headwater streamflow locations and provide recommendations to the NWS River Forecast Centers (RFCs) on which streamflow locations to add EnsPost to operational HEFS forecasts.

EnsPost Implementation Process

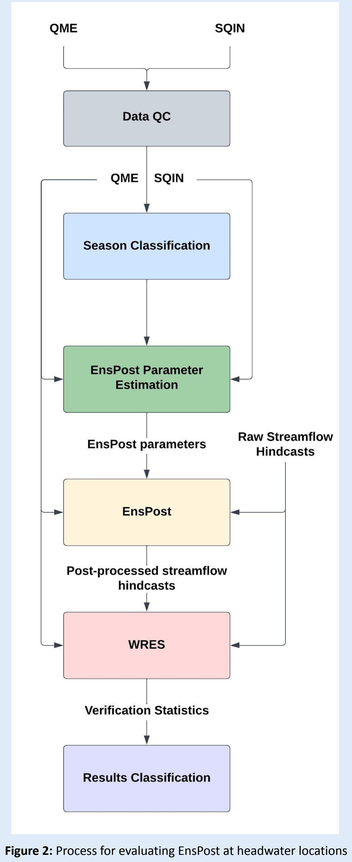


Figure 2: Process for evaluating EnsPost at headwater locations

- EnsPost uses the ARX(1,1) first order autoregressive model with normal-quantile transformed historical simulation and observation data to adjust each MEFP raw ensemble trace.
- Input simulation data (SQIN) is examined against observations (QME) to identify any potential issues (Figure 3).
- For better quantification of hydrologic uncertainty and bias, EnsPost parameters are estimated separately for different seasons (Figure 4).
- Comparisons are made using the Water Resources Evaluation Service (WRES) after EnsPost processing.
- Outputs from WRES include numerous metrics, in particular CRPSS, BSS, and bias fraction, which are used to classify results.
- For locations that are classified as "pass" or "conditional pass", we recommend the RFCs to add EnsPost to their operational HEFS.

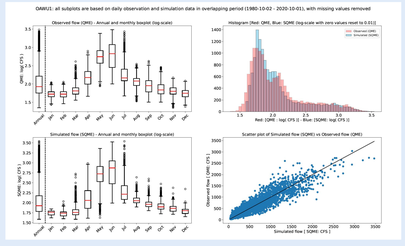


Figure 3: Part of the QC process is to examine seasonal and overall simulation patterns have good correlation with observations.

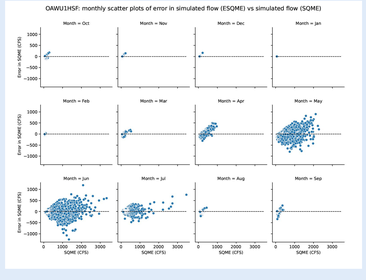


Figure 4: Monthly simulation errors are used to classify seasons, which are used during the parameter estimation.

Metrics
Continuous Ranked Probability Skill Score (CRPSS): Integral square difference between the CDF of the forecast and that of the observation, normalized by the Continuous Ranked Probability Score of the reference forecast, i.e., HEFS without EnsPost (range: -Inf ~ 1.0; perfect score: 1.0).
Brier Skill Score (BSS): mean square error of probabilistic forecasts of dichotomous events, normalized by the Brier Score of the reference forecast, i.e., HEFS without EnsPost (range: -Inf ~ 1.0; perfect score:1.0).
Relative Mean Error (RME) / Bias Fraction: Mean difference between forecast and observation, normalized by mean of observation.

Classification	Interpretation
Pass	skill scores are consistently positive across all thresholds and lead times
Conditional pass	skill scores are mostly positive or non-negative, but can be negative at some thresholds/lead times
Fail	lack of skill (or consistently negative skill) across multiple thresholds (including both high and low flows) and lead times
Fail - high flow	lack of skill (or consistently negative skill) in high flows only; overall positive skill observed in low to medium flows

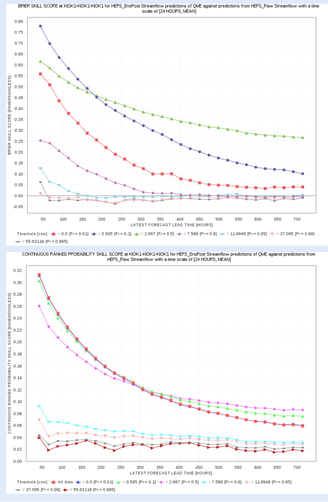
EnsPost Performance by RFC

- OWP's initial evaluation (a separate effort) included 181 basins across all RFCs.
- 140 of 181 basins (77%) were classified as “pass” or “conditional pass”, 41 basins (23%) were classified as “fail – high flow” or “fail”.
- Operational implementation results indicate more basins with unsatisfactory results (67% fail – high flow or fail).
- The EnsPost implementation and collaboration with the RFCs is an on-going effort.

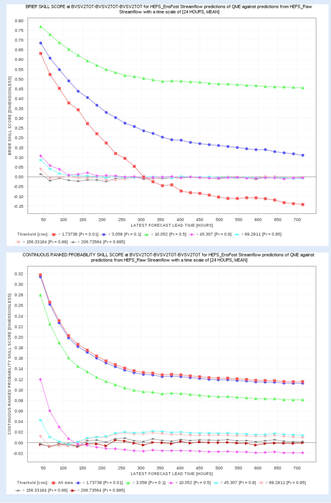
RFC	Total # of basins	Pass	Conditional Pass	Fail-high flow	Fail
Alaska-Pacific (AP)	12	2	5	2	3
West Gulf (WG)	91	16	45	12	15
Arkansas-Red Basin (AB)	19	7	4	5	3
Middle Atlantic (MA)	55	1	3	5	46
Northeast (NE)	71	8	8	44	11
North Central (NC)	84	6	17	51	10
Lower Mississippi* (LM)	42	1	4	33	4
Southeast* (SE)	71	8	8	44	11
All	445	49	94	196	103

* Preliminary results

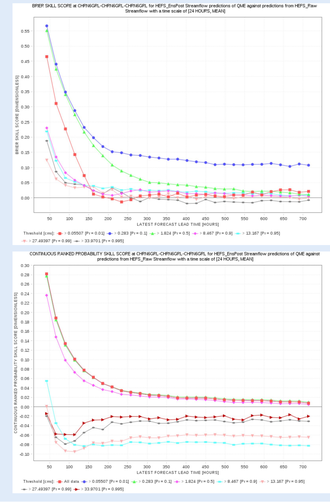
Example of Pass (AB – KIOK1)



Example of Conditional Pass (MA – BVSV2)



Example of Fail High Flows (NE – CHRN6)



Challenges

- In the initial baseline validation, testbed basins were carefully chosen to be representative of operational forecast locations and generally had good data quality/availability.
- For some RFCs and basins, the latest historical simulations (SQIN) are being used to estimate the EnsPost parameters. However, in most cases, archived raw hindcasts are being adjusted by the EnsPost using those same parameters.
- Changes in hydrologic model calibrations between the period when raw hindcast were generated and when SQIN was created could lead to inconsistency.
- For operational implementation, a higher percentage of basins may be affected by regulation influences than in the initial validation.
- The EnsPost may be more sensitive to season definitions than initial results indicated.

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