Towards Improved Verification and Metrics: A Case Study Over the Sevier River Basin at the Colorado Basin River Forecast Center

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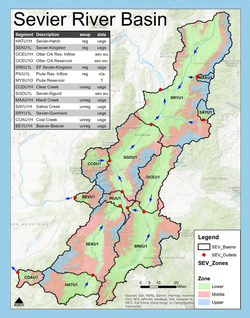
Research Question

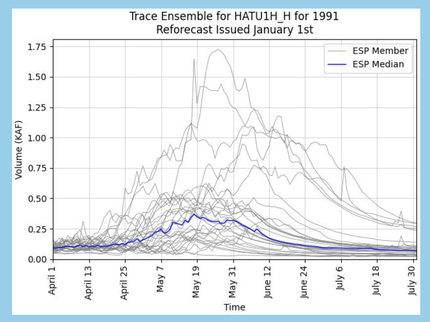
Are regulated or unregulated forecasts more skillful at predicting water supply in the Sevier River basin?

Intuitively, unregulated forecasts should be more skillful because they lessen the need to predict human actions.

Background

The CBRFC's operational territory includes the Colorado River, Great, and Sevier River Basins, which span eight states and supply water to my hometown of Boulder, the CBRFC office in Salt Lake City, agriculture in Southeastern California, and many more users. CBRFC forecasts are issued for near-future flow, annual peak flow, and total, seasonal water supply. This informs decision makers and water managers to appropriately plan for, and respond to, hydrological conditions.





The main model used by the CBRFC is the Sacramento Soil Moisture Accounting (SAC-SMA) Model, which numerically predicts runoff, storage, and streamflows (Burnash, 1973). The model is typically run in an ensemble streamflow prediction (ESP) configuration, with each member fed a different year of historical meteorological data. In regulated mode, this predicts physically observed volume, which includes impacts of human activity. Unregulated mode is based only on natural hydrology.

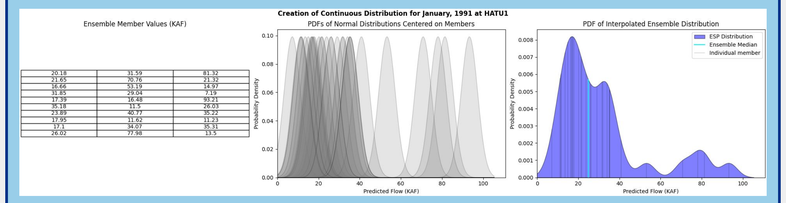
Data

Observations come from US Geological Survey gages and the Sevier River Water Users Association.

Meteorological data from 1991-2020 were used by the CBRFC to create both types of ESP reforecast.

Methods

The 30 individual members of the ESP ensemble were interpolated into a continuous distribution following Brocker and Smith, 2008. This entails using each member's value as the mean of a normal distribution (a kernel) then averaging the PDFs of all kernels to yield one representative distribution.



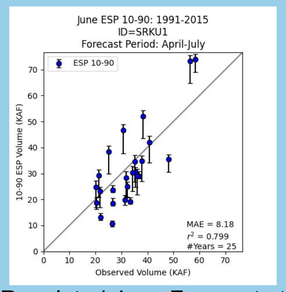
20.18	31.59	81.32
21.65	70.76	21.32
16.66	53.15	14.97
31.65	29.04	7.19
17.39	16.48	93.21
35.18	13.5	26.03
23.89	40.77	35.22
17.95	11.62	11.23
17.1	34.07	35.31
26.02	77.98	13.5

Using this approach, in combination with verification methods based on ensemble quantiles already implemented by the CBRFC, various skill metrics can be computed. One notable statistic which emphasizes correct forecasting of extremes (relevant for drought and flood prediction) is continuous rank probability score. This is found from the ensemble CDF $F(x)$ as

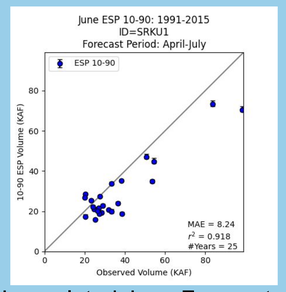
$$CRPS = \int_{-\infty}^{\infty} \left(F(x) - 1_{\{x>obs\}}(x)\right)^2 dx$$

Results

Regulated volumes have dampened extreme wet years, so while standard deviation is similar, regulated 10-90s intersect with observations more frequently. See figures for visualization.



Regulated June Forecast at SRKU1 (Kingston, UT)



Unregulated June Forecast at SRKU1 (Kingston, UT)

Reforecasts for HATU1, SEKU1, and SRKU1 issued in January to May have CRPS of 0.146 and 0.161 for unregulated and regulated reforecasts respectively. Mean absolute relative error (MARE) for the same locations and time period is 0.225 and 0.400 for unregulated and regulated forecasts. Both of these results indicate unregulated forecasts are more skilled.

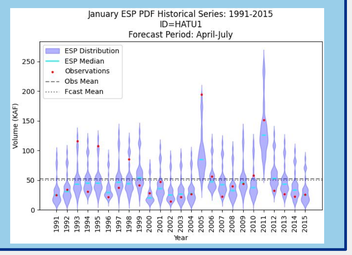
Conclusions

In all, unregulated forecasts are more skillful for key sub-basins along the Sevier River. This result is weakened by the limited number of historical years used (25) and confinement to only 3 locations. By avoiding information loss previously encountered while summarizing the ensemble of 30 members by a select few percentile values, statistical confidence is still maintained. Overall, this investigation recommends that unregulated forecasts are issued by the CBRFC to provide water managers with the best possible information as a basis for their decisions.

Future Work

Since this work was done at the CBRFC, the natural next step is to apply the same experiment to the Colorado River and Great basins.

Another area for future work would be investigating how CBRFC data users interpret verification plots.



Acknowledgements

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References

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Burnash, R. J. (1973). A generalized streamflow simulation system: Conceptual modeling for digital computers. US Department of Commerce, National Weather Service; State of California, Department of Water Resources.

Poster and report available online