INITIAL EVALUATION OF NATIONAL WEATHER SERVICE ENSEMBLE POST ADUSTMENT PROCEDURE ON MONTHLY FLOW FORECASTS AT THREE FORECAST POINTS IN THE WESTERN U.S.

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ABSTRACT

The National Weather Service Ensemble Streamflow Prediction (ESP) system is a modeling component of the Community Hydrologic Prediction System used by NWS River Forecast Centers. ESP produces long range probabilistic forecasts utilizing a physically based system to simulate snow and soil moisture states, runoff, and streamflow. ESP is forced with historical time series of precipitation and temperature to create equally likely forecast ensembles. The National Weather Service Office of Hydrologic Development has developed a statistical post-adjustment method to improve ESP forecasts. The goal of the method is to remove model bias and produce more statistically reliable ensemble members. In this study the ensemble post–adjustment method is applied to three probabilistic water supply forecast points. Ensemble forecasts are evaluated from both the ESP only forecasts and ESP forecasts that were post-adjusted. Mean continues ranked probability scores were compared showing the post-adjustment does improve ensemble forecasts to various degrees. Preliminary analysis also provides insight into which forecast points may be more susceptive to significant improvement using post-adjustment method than others based on historical simulation bias evaluation. (KEYWORDS: probabilistic streamflow ensemble forecasts post-adjustment)

INTRODUCTION

The National Weather Service utilizes a physically based hydrologic model to simulate soil moisture, snowpack and runoff. The ensemble stream flow prediction (ESP) system is a modeling component primarily used to generate long range probabilistic forecasts. ESP uses current modeled hydrologic states along with historical time series of precipitation and temperature to create future hydrologic conditions or ensembles. Statistical analysis is then done on these ensembles to generate probabilistic forecasts for water supply or other uses. The forecast horizon can be from one week to one year and the forecast durations are usually weekly or monthly.

A statistical method to try and improve the ESP forecasts was developed by National Weather Service Office of Hydrology. The method utilizes the relationship between historical ESP simulations of streamflow and observed streamflow to post process current ESP forecasts. Wood and Schaake (2008) showed a need and demonstrated positive results by essentially calibrating forecast means with observations to improve future ESP forecasts. A recent approach developed by Dr John Schaake at the National Weather Office of hydrology adapting his previous work on transforming distributions (Clark et al, 2004) develops a correlation parameter between simulated discharge from ESP distributions and observed flows. The post-adjustment method then transforms the current or real-time ESP simulation using the derived correlation parameter. The goal of the post processor is to reduce model bias and produce more statistically reliable ensemble members. The motivation of this paper is to evaluate the ensemble post processor at three forecast points which have historical simulations and provide a basis for how the method may perform at other forecast point in Alaska.

APPROACH AND RESULTS

ESP re-forecasts were obtained for the Smith River in northern California, St Joe River in northern Idaho and the Gunnison River in Colorado. The re-forecasts represent 25+ years of historical simulations with a forecast horizon of several months. The re-forecasts were then post-adjusted using the Schaake aforementioned post adjustment procedure and the results from the post-adjustment and raw ESP forecasts were compared to observed using a mean continuous ranked probability as the primary evaluation statistic.

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In order to provide an assessment of the raw ESP performance prior to post adjustment, historical monthly simulations were plotted for the Smith and Gunnision Rivers. These locations were chosen specifically because the bias characteristics of the historical simulations versus observed were significantly different with Smith River having much more spread in simulation bias versus the Gunnison. The historical simulations are shown in Figure 1.

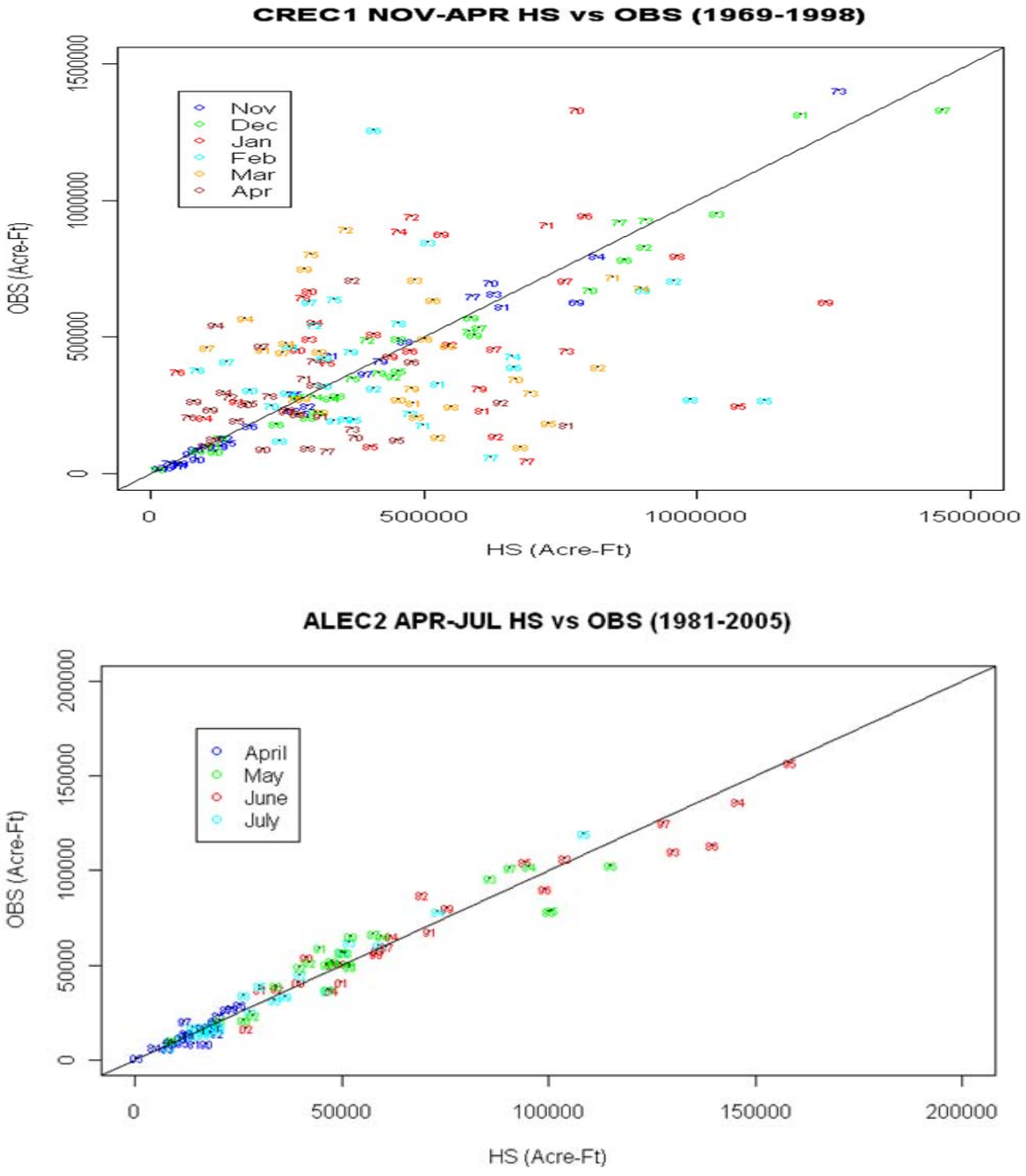

Figure 1. Smith River (CREC1) and Gunnison River ALEC2 observed monthly flow vs ESP simulated flow (HS) for 1969-1998

The third forecast point evaluated was the St Joe River and its historical simulation versus observed plot was roughly similar to the Smith River and was not plotted. Since the ESP post-adjustment method develops a correlation parameter between the historical simulations and observed to adjust future ESP forecasts, the Smith and Gunnison rivers should provide a good indicator of post-adjustment method sensitivity at other NWS water supply points; as the spread in bias represent good upper and lower bounds of raw ESP simulation bias characteristic for other forecast points.

To evaluate the post-adjustment method ESP forecasts were post adjusted and the mean continuous ranked probability scores (MCRPS) for the post adjusted ensemble forecasts and raw ESP forecasts were derived. In Figure 2 MCRPS box plots of the 37 years of historical January post adjusted forecasts and raw ESP forecasts are compared for the Smith River. In addition a Student's t-test is derived for the raw and post-adjusted distributions to determine whether the monthly MCRPS are significantly different. Results from post-adjusting the Smith River ESP forecasts shows the method improves forecasts indicated by the reduction in MCRPS and for most of the forecast months the raw ESP versus post adjusted distributions are statistically different as indicated by the P-value derived from the t-test.

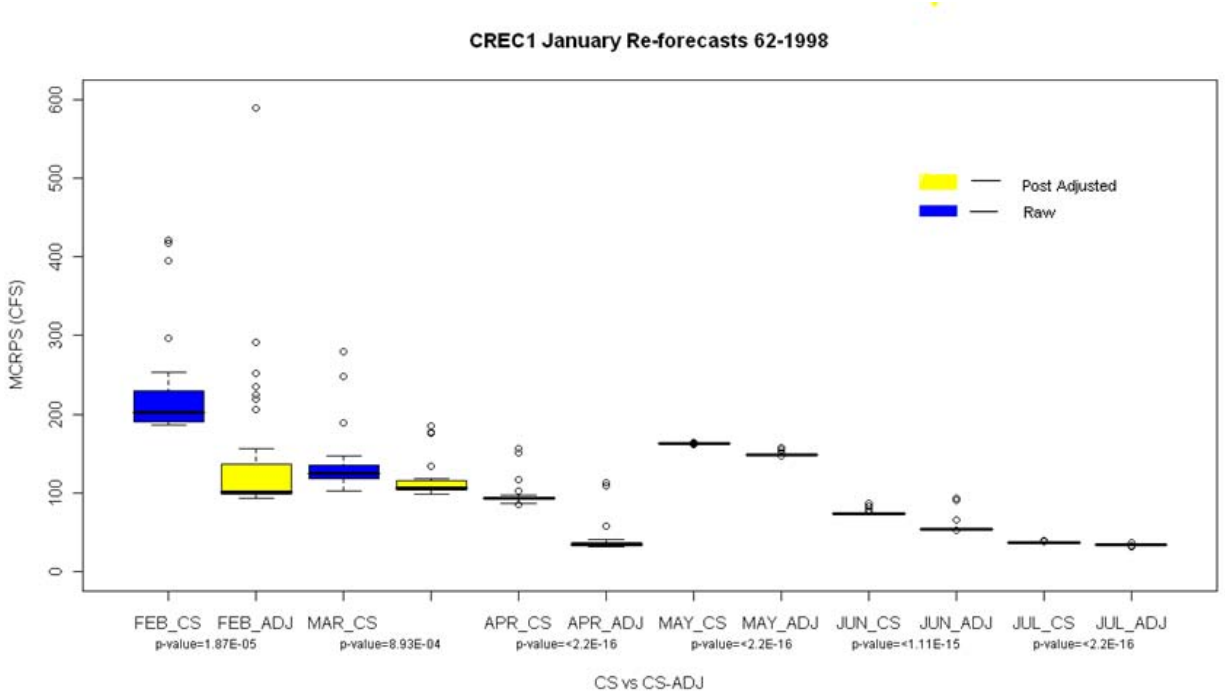

Figure 2. Smith River (CREC1) mean continuous ranked probability score box plots for 37 years of January 1 forecasts for February through July. Post adjusted MCRPS are lower indicating post-adjustment reduces simulation bias and p-values indicate post-adjusted and raw distribution are statistically different.

In Figure 3 MCRPS were derived for the Gunnison River post-adjusted forecasts and raw ESP forecasts. The results show very little improvement which likely could be predicted by the very small spread shown between the historical raw simulations versus observed flow as shown in Figure 1 for the Gunnison. In addition there is little adverse effect by the post-adjustment method on the forecasts. This result provides some initial guidance the method could be applied at numerous National Weather Service water supply forecast points without detrimental effect. The results also show that examination of historical ESP simulations versus observed may provide a good indicator as to which National Weather Service forecast points may be most sensitive to post-adjustment procedure.

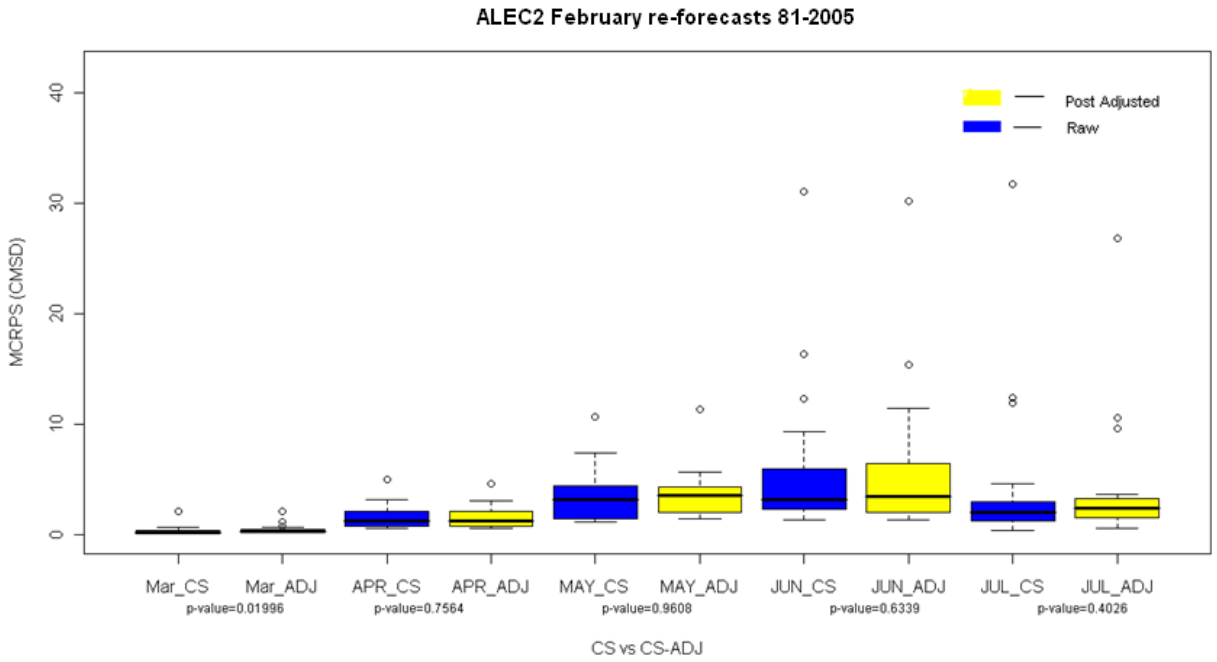

Figure 3. Gunnison River (ALEC2) mean continuous ranked probability score box plots of 25 years of February 1 forecasts for March through July. Post adjusted and raw ESP MCRPS are very similar indicating no significant improvement of post adjustment.

SUMMARY

An ensemble post-adjustment method was applied to three locations that historical National Weather Service ESP reforecasts were available. Two of the forecast points the Smith River and Gunnison River were focused on because they had distinctive different historical simulation bias characteristics. The Smith River had a large amount of historical ESP monthly bias spread from year to year while the Gunnison River had very little. Based on the post-adjustment methodology and verified by these results historical simulation spread is a good indicator of how the post adjustment method may perform. Mean continuous ranked probability scores were derived for the monthly post-adjusted and raw ESP historical forecast distributions. The post adjustment improved simulations for the Smith River as seen by the reduction in MCRPS and had very little effect on the Gunnison River. More locations need to be evaluated to make further conclusions.

REFERENCES

Clark, M., S. Gangopdhyay, L. Hay, B. Rajagopalan, and R. Wilby. 2005. The Schaake Shuffle: A method for reconstructing space-time variability in forecasted precipitation and temperature fields. Journal of Hydrometeorology5(1): 243-262.

Wood, Andrew W. and John C. Schaake. 2008. Correcting Errors in Streamflow Forecast Ensemble Mean and Spread. Journal of Hydrometeorology9(1):132-148.