The Use of Multi-Model Super-Ensemble Techniques in Hydrology

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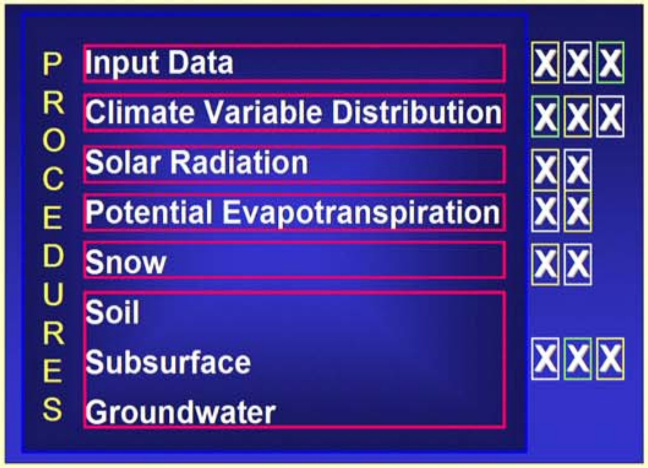
METHOD



Our multi-model super-ensemble technique mixes and matches various methods for modeling hydrologic processes to allow the construction of multiple models, all with different structure. For any given model, the MOCOM-UA automated parameter estimation methodology is used to determine multiple parameter sets that have equivalent skill with respect to three objective functions.

The potential benefits of this approach are:

❖The super-ensemble provides probabilistic information content.

❖The spread of the super-ensemble provides an estimate of forecast uncertainty.

❖It may be possible to combine information from multiple ensembles to provide probabilistic simulations of runoff that have greater accuracy than the raw ensemble.

❖The approach allows automated configuration of hydrological models over multiple river basins with minimal human effort.

❖The multi-model system reduces the commitment of operational agencies to their own model, and thus may allow more rapid transfer of new ideas from the research community to the operational setting.

INITIAL RESULTS

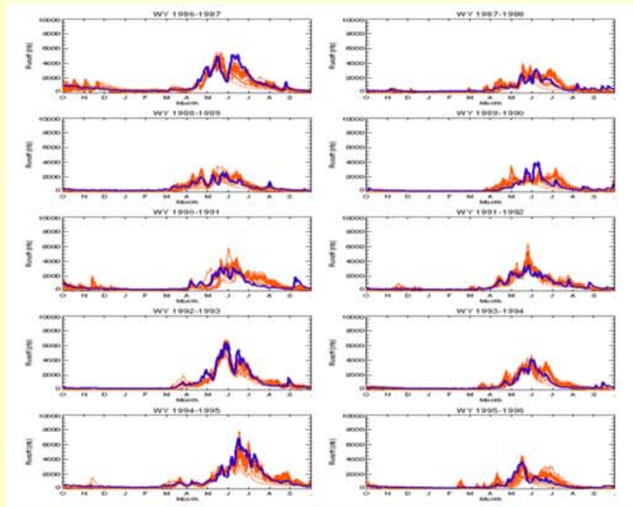


Figure 1. Ensemble simulations of runoff (orange) for the Animas River basin in southwestern Colorado using station data of temperature and precipitation for model input, multiple-linear regression methods to distribute temperature and precipitation, the "Cloud Cover" method to estimate solar radiation, the Jensen-Haise method to estimate E-T, and the PRMS model to estimate snow accumulation and melt as well as soil moisture, surface, sub-surface, and groundwater components of runoff. Observed runoff is in blue.

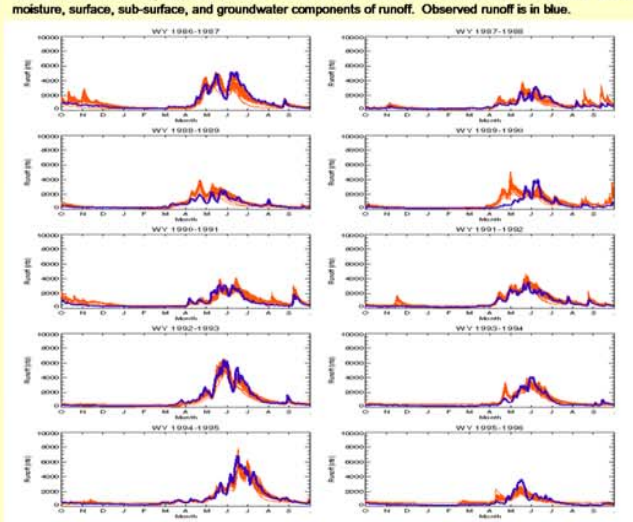


Figure 2. Ensemble simulations of runoff using the model described above, except the degree-day method is used to estimate solar radiation and the Hamon method is used to estimate E-T.

INSIGHTS AND FURTHER WORK

A.Model Uncertainty

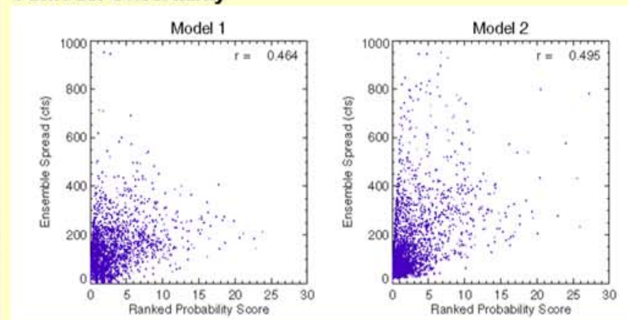


Figure 3. The relationship between ensemble skill (determined from the Ranked Probability Score on each day) and ensemble spread (determined from the difference between the 75th and 25th percentiles on each day) is rather weak for both models. This weak relationship may occur because model uncertainty is not treated explicitly—parameter values are selected based on their performance with respect to multiple objective functions, with no consideration of the uncertainty in the parameters themselves. Cases exist in Figures 1 and 2 where the two (very similar) model structures result in very different simulations of runoff. Once we have more models constructed, further work will examine the extent to which different model structures can be used to estimate model uncertainty.

B.Model Skill

❖ The multi-objective parameter estimation procedure identifies the models that perform best for (i) the rising limb of the hydrograph, (ii) the falling limb of the hydrograph, and (iii) conditions when runoff is dominated by baseflow. With this knowledge, we can improve model skill by identifying the flow regime and giving higher weight to ensemble members that perform well in that regime.

❖ Further work will involve analysis of alternate objective functions (e.g., model skill with respect to daily SNOTEL data on snow water equivalent) to improve the correspondence of model simulations to real-world conditions.

C.Extension to Other Situations

❖ The parameter values, importance of different model structures, estimates of model uncertainty, and model skill are all dependent on (i) the scale of the river basin, (ii) hydro-climate conditions (e.g., rainfall-dominated vs. snowmelt-dominated basins), and (iii) vegetation, topography, etc.

❖ Now this approach is developed, we will set up the super-ensemble system for multiple basins Nationwide.

❖ Further funding for this project has been obtained from the NOAA-OGP GAPP program.