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Science Challenges to Produce Skillful and Reliable Hydrologic Ensemble Predictions

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Ensemble forecast techniques are beginning to be used for hydrological prediction by operational hydrological services throughout the world. These techniques are attractive because they allow effects of a wide range of sources of uncertainty on hydrological forecasts to be accounted for. Not only does ensemble prediction in hydrology offer a general approach to probabilistic prediction; it offers a significant new approach to improve hydrological forecast accuracy as well. But, there are many scientific challenges that must be overcome to provide users with high quality hydrologic ensemble forecasts.

One of these challenges is to re-scale and downscale atmospheric forecasts to produce appropriate ensemble forcing for hydrologic ensemble Streamflow prediction. One criterion for such forcing is that the long term climatology of the forcing ensemble members (over many forecasts) must be same as the climatology of the forcing used to calibrate the hydrologic forecast model. Another criterion is that the ensemble forcing should preserve both the space-time scale dependent variability of the forcing and the space-time scale dependent uncertainty in this forcing. This is important for at least two main reasons. First, hydrologic processes integrate input forcing over a wide range of space and time scales, depending on the drainage areas above river forecast points. Second, atmospheric forecasts are more skillful at larger space and time scales.

Another challenge is that hydrologic ensemble forecasts tend to underestimate ensemble spread and are affected by systematic hydrologic model biases. A major cause of spread underestimation, especially in short range forecasts, is caused by neglecting uncertainty in initial conditions and neglecting uncertainty in model predictability. Short term forecast errors also may partly be caused by not adjusting model variables to account for recent differences between observed and modeled streamflow. Some of these effects may possibly be reduced by explicitly considering some of their causes as part of the hydrologic ensemble modeling process. But some form of post-processing will likely remain an essential step to produce reliable, unbiased hydrologic forecasts.