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Under the project, “Improving operational streamflow forecasts in the Colorado River Basin”, two primary activities undertaken during the period. These were: a) developing a method to quantify model input uncertainty and b) build on the input uncertainty work to develop ensemble data assimilation methods for snow. These are described below.

One of the largest areas of uncertainty for hydrologic forecast models is their precipitation input. Thus quantitative precipitation estimates (QPE) for the period leading up to a forecast are important. We applied a combination of logistic and ordinary least squares regression techniques to be able to synthesize high resolution spatial fields of probabilistic QPE derived from station based data. This was done with a view to the operational setting. Using a cross-validation method, we could estimate errors of the regression, which in turn allowed us to generate cumulative distribution functions (CDFs) of precipitation for each grid box in our desired region. Once the CDFs were obtained, a method was needed to ensure a spatially coherent sampling method. Synthesizing fields of correlated random numbers is the approach. Using a system of nested domains and corresponding distance based correlation functions, random numbers within each sub-domain were constrained via the conditional probabilities of the preceding domain. Ensemble verification methods showed that the resulting precipitation product is reliable in the sense that there is close agreement between the frequency of occurrence of specific precipitation events in different probability categories and the probability that is estimated from the ensemble. The probabilistic estimates also have good discrimination in the sense that the estimated probabilities differ significantly between cases when specific precipitation events occur and when they do not.

Following the model uncertainty theme, we moved on to assessing the uncertainty in model initial conditions. In snow dominated regions, much of the streamflow forecast skill is derived from initial conditions. We implemented the Ensemble Kalman Filter (EnKF) data assimilation scheme within the NWS snow model, SNOW-17. Using data from 53 SNOTEL stations within the Upper Colorado River Basin, we forced the model with an ensemble of driving data (generated using the technique described above). Within the model we assimilated estimates of snow water equivalent (SWE), complete with explicitly derived error values. For the scheme to work correctly, numerous hurdles had to be overcome such as removing data biases and placing the assimilation scheme within “model space”, which allows a pre-calibrated model achieve its optimum performance. Furthermore, due to the heavy autocorrelation found in the timeseries of SWE, simply assimilating observed values via a standard EnKF led to the problem of filter divergence. Divergence occurs because the autocorrelated observational error remains high while model analysis error decreases with each update, thus the model estimate become overly confident and the observations are eventually ignored. Methods to solve this problem were developed as the next research task of this project.

Activities described here led to two publications in the Journal of Hydrometeorology. The research was also presented at the 2004 American Geophysical Union meeting.

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