Quality Assurance of Probabilistic River Forecasts at the North Central River Forecast Center: A Case Study for the Minnesota River at Montevideo

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Once a month probabilistic river forecasts are issued by the North Central River Forecast Center (NCRFC). These forecasts provide the chance of possible flood or drought conditions that might occur in the next three months. For further description on all of the individual probabilistic products, visit here.

Probabilistic forecasting over extended periods creates a number of challenges for river forecasters. Some are due to the extended nature of these forecasts, while others are due to the unique capabilities of the Ensemble Streamflow Prediction (ESP) model, a component of the National Weather Service River Forecast System (NWSRFS). This model combines current basin conditions with past historical climate data to create future potential outcomes. NCRFC forecasters continually conduct quality assurance measures on these forecasts to ensure we are providing the best possible service to our users. This paper will present a case study of a recent forecast scenario, and specific measures undertaken to ensure the quality of the forecast.

The December 2005 probabilistic 90 day forecast indicated a 2% chance for a major flood on the Minnesota River at Montevideo (Fig 1.1). The magnitude of this flood discharge would be approximately equal to the 4th highest flood on record. The 4% probability value, which is the next closest value on the distribution, indicates only about one third as much flow. The fact that the 2% value is such a large outlier provides a signal to forecasters that it requires further investigation before public issuance.

The first question that must be addressed in this case was what specific year of the historical climate record was responsible for producing the outlier. This is easily achieved by use of the ESP Analysis and Display Program (ESPADP). By interactively using the ESPADP model, hydrograph trace analysis revealed that 1977 was associated with the 2% probability level. Exploring the observed monthly precipitation data from 1948 through 2004, 1977 revealed that this was actually a very wet spring period (Fig. 1.2). In fact, the January to March total precipitation ranked as the highest in the entire 56 year period of record. This ruled out bad data as a source of error in the model. An exhaustive analysis of the upstream reservoir model and possible calibration bias also eliminated these two possibilities as a source of error in the exceptionally high simulation that year. Examination of upstream tributaries also indicated the same type of response in flows during 1977, so we also know that this wasn't just an anomaly happening at Montevideo.

Given that no potential model error was identified, the high simulated flows seemed reasonable as a result of the extremely wet spring in 1977. However, a review of the USGS historical record determined there were no high river levels recorded that year at this location. So why was the model simulation indicating such high flow potential?

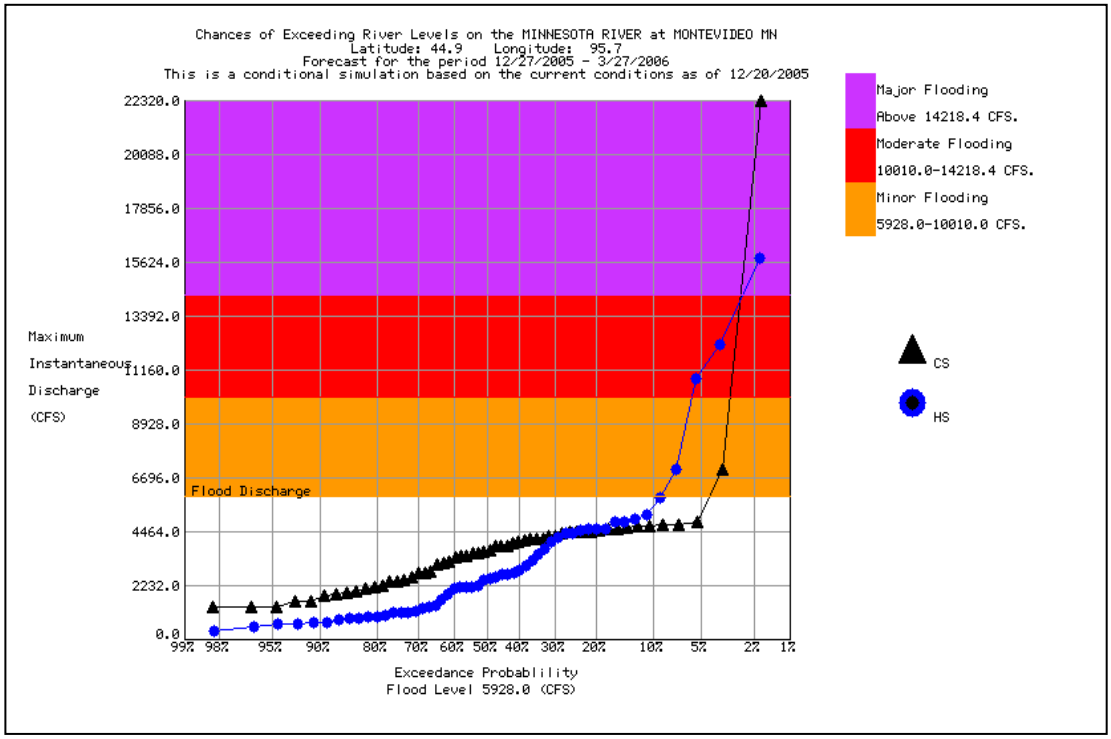

Figure 1.1 Exceedence Probability - Maximum Flows at the Minnesota River at Montevideo, MN.

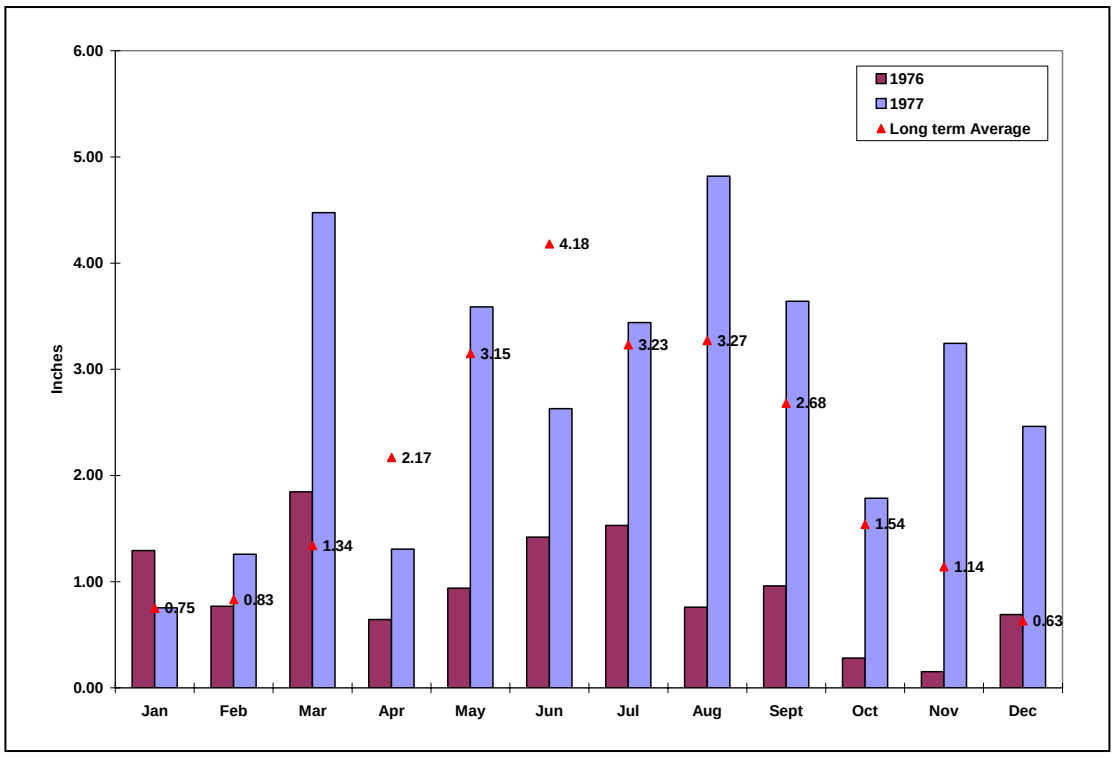

Figure 1.2 1976 and 1977 Monthly Precipitation Levels at Montevideo, MN.

To answer this question, we had to examine further the climate record. Looking at the year preceding our high flows revealed that monthly precipitation was substantially lower in 1976 than in 1977. Dry conditions prevailed starting in April 1976 and continued through January 1977. This trend was quickly reversed in March 1977 as monthly precipitation amounts exceeded the long-term average by more than 200%. Comparing total precipitation for the January to March period of 1976 to 1977, we found that 1976 ranked as the lowest year on record. So we now know that the precipitation trend underwent a dramatic reversal over the winter of 1976 to 1977, rising from the lowest 90 day precipitation total on record to the highest on record by the following March! This wet trend continued for the remainder of 1977 as monthly totals were above the 56 year average for 10 of the next 11 months.

This scenario is an excellent example of how probabilistic forecasts based on a conditional simulation add value to purely statistical analyses. By combining the current basin conditions with future scenarios from the climate record, we can see what the relative flood threats are for any location at any given time. Based on the preceding precipitation data, one can arrive at the conclusion that if there hadn't been drought conditions in 1976, there probably would have been a large flood event in the Minnesota River in the spring of 1977 (Fig 1.3). What does this mean for 2006? At this time we know that the basin conditions are much wetter than they were in 1976. If we continue to receive spring precipitation amounts similar to 1977, it will result in major flooding in the Minnesota River Basin.

Probabilistic river forecast products based on conditional simulations should be used as guidelines for possible scenarios that could occur during the forecast period. Subsequent forecasts in the following months will refine this forecast based on updated seasonal conditions and give us further information.

Final thought: Based on the December simulation, there is an approximate 2% chance of a very large flood in the Minnesota River Basin this spring, if spring conditions continue to develop like those in 1977. Stay tuned!

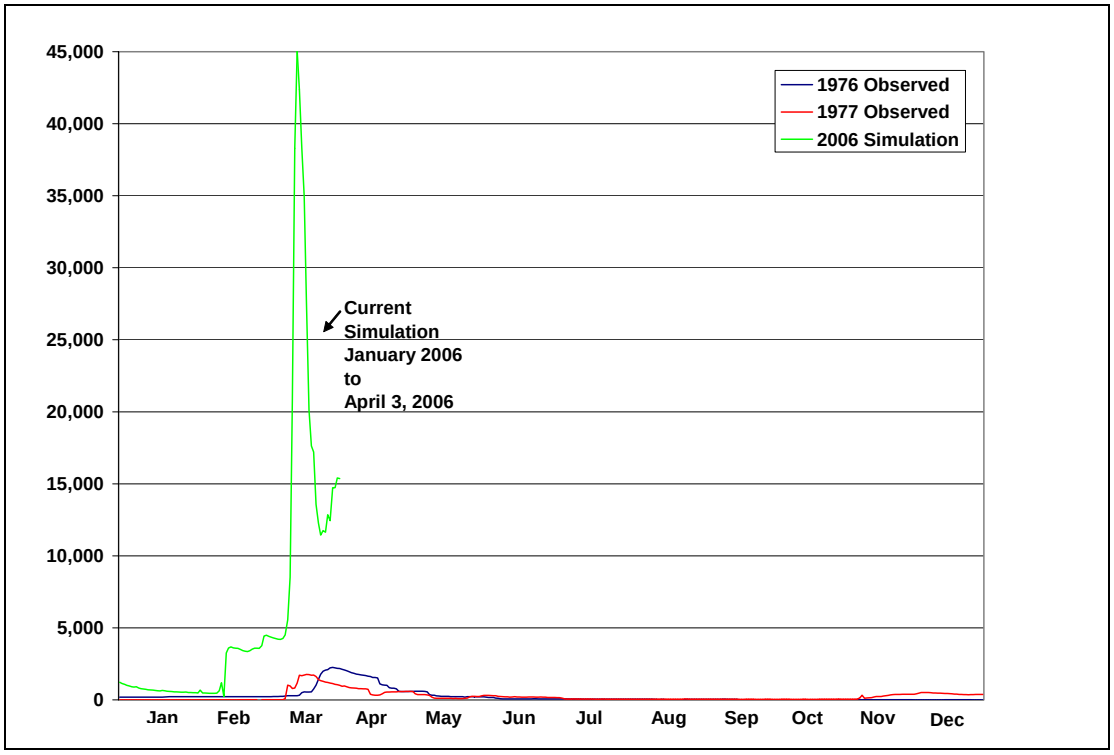

Figure 1.3 1976 and 1977 Average Daily Flows at the Minnesota River at Montevideo, MN, along with the 2006 Flow Simulation.