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SIMPLIFIED SHORT TERM PRECIPITATION ENSEMBLE FORECASTS: APPLICATION

Mary Mullusky[1], Limin Wu[1], Hank Herr[1], Edwin Welles[1], John C. Schaake[1], Joseph Ostrowski[2], and Ned Pryor[2].

1. Hydrology Laboratory, National Weather Service, Silver Spring, MD 20910.
2. Mid-Atlantic River Forecast Center, National Weather Service, State College, PA 16801

1. ABSTRACT

A new method for assessing the uncertainty of precipitation forecasts was described in "Simplified Short Term Precipitation Ensemble Forecasts: Method" paper J1.17 of this conference. This method was tested in collaboration with the forecasters at the Mid-Atlantic River Forecast Center (MARFC) to generate precipitation ensembles within the confines of an operational forecast system. Parameters for the method were computed for two basins, the Raritan in New Jersey and the Juniata in Pennsylvania. Deterministic forecasts for Hurricane Floyd (September 16, 1999) were used with the new method to generate short term precipitation ensembles that were then compared to the observed precipitation. The existing Ensemble Streamflow Prediction (ESP) technique within the National Weather Service River Forecast System (NWSRFS) was used to generate streamflow ensembles from the precipitation ensembles.

2. INTRODUCTION

The difference between actual operational results and the results obtained in the laboratory are always striking and instructive. The operational environment is full of bad data that cause outlier situations, full of unforseen physical constraints and in general a hard test for newly minted procedures. We have found this to be true for the short term ensemble approach developed at the NWS Hydrology Lab to account for uncertainty in the forecast precipitation and temperatures. The theoretical development of this process has been described in paper **J1.17** of this conference. This paper will describe our experience to date with the implementation.

Initial test results on the Raritan for Hurricane Floyd (September 16, 1999) were discouraging but updates to the system calibration and improvements in the algorithm were able to correct the initial results. Once the test case seemed to work well, the system was implemented on the Juniata River in Pennsylvania at the NWS Mid-Atlantic River Forecast Center (MARFC). The MARFC results have been encouraging, though additional lessons have been learned there as well.

Corresponding author address: Edwin Welles, Hydrology Laboratory, National Weather Service, Silver Spring, MD 20912; e-mail: Edwin.Welles@noaa.gov

3. HURRICANE FLOYD

As an initial test case of the algorithm it was applied for a hindcast of the September 16, 1999 precipitation forecasts for hurricane Floyd. Hurricane Floyd generated record flooding on the Raritan river in New Jersey. The six hour Quantitative Precipitation Forecasts (QPF) of about 2" for most of the basins in the Raritan were well below the 4" to 6" areal accumulations and 10" point accumulations that occurred.

Early results for Floyd were alarming. The ensemble maximum did not even reach the QPF let alone the large observed rainfall. Not only had the ensemble process failed to capture the uncertainty correctly, it had made the under forecast of the original QPF worse. This circumstance was energetically investigated and it was found that several factors were contributing to this failure. First, the parameters for these basins indicated an average trend of over forecasting. In the majority of cases the QPF was too high, however most QPF were for small rain events and in the small rain events the over forecast bias was true. However, in the large events, there is an under forecast bias. This required reparameterization and will require a system update to sort between large and small events. Further discussions with the RFC forecasters led to additional possible sorting characteristics such as storm type, season and forecaster confidence.

In order to keep the system from spinning wildly out of control, a limit of 3X the standard deviation

of the observed historical observations for the forecast period on the maximum of the forecast ensemble had been imposed on the forecast ensemble. It was discovered that this limit was too small. The standard deviation of the smoothed climatology that we were using was actually fairly small, less than 0.5". Consequently, the ensembles were severely limited in their ability to pick up extreme events. This limit had to be removed. Rather than relying on an automated process to pick up outlandish ensembles, we now rely on the RFC forecast staff to quality control the ensembles.

With these problems behind us we were able to effectively capture the Hurricane Floyd event.

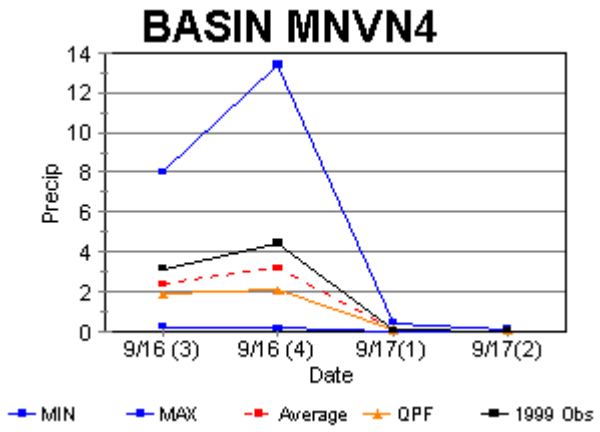

Figure 1. Summary statistics for one watershed in the Raritan basin for Hurricane Floyd.

The simulations look high with almost 14 inches of rain, but this is the very tail of the distribution so not alarming.

3. JUNIATA IMPLEMENTATION

The real test of our new precipitation ensemble system has been in the demonstration project at the MARFC for the Juniata River. There are two levels of testing that occur in these operational demonstrations. The first is a test of the science; can the proposed algorithms produce high quality forecasts? The second level is a test of the systems and implementation process; can the process be implemented efficiently and is the supporting system useable in the operational environment? Unfortunately this second element of testing is often ignored and even belittled. Yet this element is a key to making operational forecasts. It appears to be viewed sometimes as a mere detail which obstructs good science when in fact it is not a mere detail obstructing science, it is a key element that often points out the failings of short sighted scientific development.

The implementation process was considered explicitly in the evaluation of the new short term ensemble demonstration. The ensemble process has been implemented over 10 basins in the MARFC area of responsibility each of which is a forecast point. The MARFC has been generating forecasts from the system since mid-summer. These demonstration forecasts are made available to the public on a daily basis at the MARFC web site http://marfchp1.met.psu.edu/AHPS/juniata_river.htm . These demonstration forecasts are for a 5-day window, in contrast to the current 2 or 3 day deterministic forecasts currently issued in the MARFC area. These 5 day probabilistic forecasts may prove most useful as contingency type forecasts which help address the frequently asked question, " what are other possible river responses that may occur given the current basin conditions and the forecast precipitation?" Graphically displaying the ranges of river levels is an effective method to depict some of the uncertainties associated with runoff events.

To date only qualitative forecast evaluations have been conducted while we collect data and await rain events on the basin. That evaluation by the MARFC forecast staff has found that the ensembles range across an appropriate spectrum of precipitation. In one case the precipitation ensembles on neighboring basins were dramatically different. This circumstance was examined and it was determined that temporal coherence in the precipitation statistics was not sufficient. Spatial coherence is required as well; this requirement will be integrated in to the smoothing procedure. Additionally, methods to address uncertainties associated with temperature forecasting will need to be developed and implemented to properly account for likelihood of rain vs snow and snowmelt.

The implementation was made to be objective so that no forecaster intervention was required. In addition the calibration was designed such that no data beyond the already existing NWS data streams was required. Consequently the calibration was relatively smooth and re-calibration of the statistics when required has been straightforward. This facet of the project has been

a success and will greatly enhance our ability to deploy a short term ensemble process across the nation when the science is sufficiently robust.

4. CONCLUSION

The NWS Hydrology Lab and the MARFC have undertaken to demonstrate the feasability of making short term ensemble forecasts that effectively capture the uncertainty in the meteorological inputs. The system has been put in to operations at the MARFC over a few of the forecast basins and the process appears to be working well. Additional testing and vetting of the science are required however before the process is implemented nationwide.