THE NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM

Todd Hamill

AUTHORS: Hydrometeorologist, National Weather Service/Southeast River Forecast Center, 4 Falcon Dr. Peachtree City, GA 30269
REFERENCES: Proceedings of the 1999 Georgia Water Resources Conference, held March 30-31, 1999, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. The National Weather Service River Forecast System (NWSRFS) comprises techniques and programs for developing river forecasts. NWSRFS contains three major systems which are utilized to set up and use hydrologic and hydraulic models in river forecasting. The three systems include the Calibration System, the Operational Forecast System (OFS), and the Ensemble Streamflow Prediction System (ESP). These systems are evaluated frequently, and changes are made as becomes necessary. New components are added to improve the flexibility and functionality of the NWSRFS. Each system is interrelated and can be used with different models to produce a river forecast. This paper will describe each system and how the National Weather Service Southeast River Forecast Center (SERFC) uses them to produce river forecasts which are disseminated to the public.

CALIBRATION SYSTEM

The first major system of NWSRFS is calibration. Calibration creates the framework which the other two systems will utilize to create forecasts. There are two types of calibration programs in NWSRFS, the Manual Calibration Program (MCP) and the Automatic Parameter Optimizer (OPT). MCP operates by applying hydrologic models with user specified values for all parameters. OPT operates in much the same way, but it includes a procedure to automatically adjust parameter values to improve the streamflow simulation. These methods are designed to be used on one segment of a river system at a given time. The MCP is the program used most extensively while the OPT is less widely utilized at the SERFC.

Before these programs can be utilized, historical streamflow and precipitation data must be obtained. Precipitation measurements are the major input for NWSRFS. Point precipitation data are converted to a mean areal estimate for use in the model. Many different factors influence the estimation of mean areal precipitation including density and arrangement of gage network, methods of areal analysis used, and others. NWSRFS contains various procedures and options which enable the user to obtain reliable historical mean areal precipitation estimates. The first step in creating Mean Areal Precipitation (MAP) is to find historical precipitation data in both 1 hour and 24 hour durations around the basin being calibrated. Getting a dense rain gage network will make the calibration process more accurate, but that is not always possible. Usually, about 10 years of data is best to begin calibration of a segment. Because the SERFC area is not very mountainous, determination of station weights is made more simple. The 1/d^2 (where d equals distance) method is used to determine station weights based on their timing. The Thiessen Polygon method is used to establish station weights based on area. These weights are then applied to averaging techniques to determine MAP for a given area based on the historical rainfall values from the predetermined points used.

Some river forecast centers in other parts of the United States have the need to use Mean Areal Temperatures (MAT) and a snow model for their calculations. The SERFC does not consider these parameters because of the lack of significant snowfall in the area.

After the historical files are set up, the actual calibration process can begin. The Sacramento Soil Moisture Accounting model (SAC-SMA) (Fig. 1) is the model used by the SERFC, but other soil moisture models can be used in NWSRFS. The important issue is that the forecaster have an understanding of how their particular model works and be able to apply it to their calibration process. The SAC-SMA divides the soil mantle into an upper and lower zone. Both zones contain areas that hold or pass water. Each of these parameters in the zones have a value that is assigned to them through calibration. Based on these values, water is retained or passed to other areas based on whether there has been precipitation or been dry. Using the 40 years of historical data, values are adjusted to best match what actually happened during that time. The interactive calibration program (ICP) is a graphical interface that allows a user to more easily monitor changes made to the parameters. Previously, it took a great deal of time to make these changes, rerun the model and examine results. ICP has made calibration more user friendly and decreased the time needed to calibrate a basin.

OPERATIONAL FORECAST SYSTEM

The Operational Forecast System (OFS) is the part of NWSRFS that puts those calibrated segments together to make a forecast. A segment is the group of computations needed to define a specific basin and the accompanying forecast point. This is a continuous river forecasting system which provides the forecaster with predictions of river flow to use in producing flood forecasts and other hydrologic products. The 3 primary components of the OFS are data entry, preprocessor, and the forecast program. These components are so interrelated that all will be mentioned in describing the whole system with an occasional mention of the specific parts when necessary.

Data entry is the automatic and manual entry into a data base of all observed and forecast data needed by the OFS. Data is sent to the SERFC from many different sources. National Weather Service Weather Forecast Offices (WFO), power companies, the Corps of Engineers, and other agencies send data to the SERFC through AFOS (Automation of Field Operations and Services), the main means of data communication in the weather service. All data used must be in Standard Hydrologic Exchange Format (SHEF) in order to be decoded and used by the computers.

After the data is received and decoded, it is put into an Informix database. Two tables have been created to use this data, the value (VL) table and the OFS input (OIN) table. The VL table contains all the data we receive, even if it does not get used by the model. The OIN table only gathers the data that is used in the operational forecast model. This data must go through another decoding program in order to create a batch file that can be used by the forecast operation. The last operation performed, part of the forecast program, is the Mean Areal Precipitation-River Reservoir and Snow (MAP_RRS) program. It is in this process that rainfall point values are converted to areal estimates. Also, 1 to 24 hour duration time series data for the entire users area is created. Now all of the data collected is in a form that can be used by OFS. Forecasters have the capability of monitoring the data as it moves through each of these levels to make sure that reliable data is getting into the model.

The operational forecast program (FCST) contains functions other than the MAP and RRS functions to make realtime forecasting possible. The FMAP function generates 6-hour time series of forecast precipitation from WFO supplied areal values. Another function that will be valuable in the near future is the MAPX which is the Gridded Mean Areal Precipitation function. This computes a 1-hour time series of precipitation for the user's area using gridded estimates of precipitation taken from the modernized National Weather Service radar network.

Quality control of received data is essential in order to make good forecasts. Two programs at the SERFC are used to view data and make changes where bad data exists. They are the DATA program and the XNAV program. The DATA program looks at raw, SHEF decoded data from the VL table. This program is set up to show data values by basin and indicates where the data originated. The XNAV program uses a graphical interface of the SERFC area and sometimes makes finding data errors an easier process.

UNIX workstations are used to run the model and all the data gathering processes mentioned previously. After all the errors have been corrected and programs have been run to put data into the model, a forecast run is made. The Interactive Forecast Programs (IFP) is the means by which the model output is executed and viewed. There are two main applications which make up IFP. The first, IFP_Map, consists of a geographic display of the SERFC area which allows the forecaster to choose the basin and time period for which to run OFS. This display offers many display options to aid the forecaster in making forecast decisions. The second application, ifp_nwsrfs, performs the hydrologic computations of NWSRFS, displays the model results, and allows the user to interactively make model adjustments as needed. Some model adjustments that may be utilized by the forecaster include, changing outflows from reservoirs, adjust computed rainfall runoff, adjust the unit hydrograph, and others.

ENSEMBLE STREAMFLOW PREDICTION

Ensemble Streamflow Prediction (ESP), formerly known as Extended Streamflow Prediction, is the part of NWSRFS which generates extended forecasts which might be weeks or even months into the future. ESP uses the conceptual hydrologic models along with the current watershed and streamflow conditions, and historical meteorological data to make extended probabilistic forecasts for a number of streamflow variables.

ESP uses the same forecast model that is used for the daily forecasts at the SERFC. The difference between OFS and ESP is that ESP is using historical precipitation data. This data was also used in the calibration process. Traces are created using the rainfall data from each year in the historical records. Statistical analysis can be performed on these traces for further use in decision making processes.

The reason for the change of name for ESP is that it may have more information in the statistics than just extended forecasts. It is believed that these statistics also might be valuable in the calibration process. Probabilistic forecasting is another potential use for this data. ESP-ADP (Ensemble

Streamflow Prediction Analysis and Display Program) has recently been developed to make ESP easier to use. The information displayed using the new graphical interface may produce many new benefits for the forecaster.

CONCLUSION

NWSRFS is a system that has been developed so that it is very flexible and can be used by all River Forecast Centers in the National Weather Service. It forms the framework for each RFC to adapt it to their particular circumstances. There are a vast number of programs that can be used and each office incorporates those portions of the system it needs to fulfill their forecasting mission.

LITERATURE CITED

NOAA/NWS/Office of Hydrology, last update: July, 1998, National Weather Service River Forecast System manual.