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SITE SPECIFIC MODELING FOR NATIONAL WEATHER SERVICE WEATHER FORECAST OFFICES

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1. INTRODUCTION

National Weather Service (NWS) Weather Forecast Offices (WFO's) receive hydrologic guidance from NWS River Forecast Centers (RFC's). WFO's use these hydrologic products to issue stage forecasts, watches, and warnings to the general public. In certain circumstances, the WFO may need hydrologic information in addition to that information received from the RFC. In order to meet this need the WFO's will be provided with a simple, easy-to-operate hydrologic modeling system.

There are two particular circumstances in which the WFO may need their own hydrologic modeling system : 1) when the RFC is not staffed and 2) to model basins that the RFC does not model. The size of a typical RFC forecast basin tends to be rather large, on the scale of hundreds of square miles and the forecast model time step is usually 6 hours (though in some cases, 1 hour time steps are used). These time and space scales are too coarse to capture many fast rising or "flash flood" events. The WFO's need a hydrologic modeling system that will allow them to update forecasts in quick response headwater basins because a fast-rising water course may flood before an RFC could provide guidance to a WFO.

2.EXISTING SYSTEMS

There are currently a variety of different modelling packages used by WFO's to forecast these fast-rising hydrographs. The existing systems have various database and user interface types and are not integrated into any other software that WFO's use. One project the NWS Office of Hydrology (OH) has undertaken is to develop a WFO Hydrologic Forecast System (WHFS) (Roe, 1998). The WHFS includes the ability to manage hydrologic reference data sets, review and display operational data sets, and generate hydrologic products for public release. A future release of the WHFS will include a Site Specific Modeling System (Glaudemans, 1996). Rather than simply promoting existing techniques forward into the WHFS, several significant concerns surfaced as OH moved toward a single nationally supported system for WFO hydrologic applications.

3. MODELING ISSUES

In general, the existing WFO-based systems use Antecedent Precipitation Index (API) models that are initialized with Flash Flood Guidance (FFG) (Sweeney, 1992) values. Flash Flood Guidance is an areal average value that describes the number of inches of rain necessary to bring the streams in that area to bankfull. Initial states for the API models are back computed from the FFG values. Once the initial states are computed, the current and forecast precipitation are run through the model and a hydrograph is computed.

As a part of the NWS modernization the RFC's are adopting the Sacramento Soil Moisture Accounting model (SAC-SMA) (Burnash, 1972) as their primary means of computing rainfall excess. Because there are many more parameters in the SAC-SMA model than there are in API models, it is not obvious how to back compute the initial states of the SAC-SMA model from FFG values. Therefore, rather than transferring the initial

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states as a single FFG value, the parameters and the states of the SAC-SMA model being used at the RFC will be passed to the WFO directly.

Unfortunately, when the model states and parameters are used directly, the fact that SAC-SMA parameters are calibrated for a particular time scale becomes an issue. The RFC's have generally calibrated their models to run at six-hour time steps. A six-hour time step will be too long in many cases when the goal is modelling fast rising streams. Many streams will reach flood stage in less than 12 hours and six-hour time steps will not be adequate for these short-fused flood events.

It is not possible to require that the RFC's recalibrate their models to operate at shorter time steps. There is not sufficient data to create 1-hour (or shorter) Mean Areal Precipitation (MAP) time series of a suitable length for calibration. In addition, the time consuming nature of the calibration process precludes a wholesale recalibration of the SAC-SMA model to meet the needs of the Site Specific System.

Several solutions were examined and two, which will be described below, were selected. The purpose of the Site Specific System is to produce a sufficiently accurate hydrograph that a forecaster can determine if a Flash Flood Watch or Warning is necessary. The needed information is almost as simple as a categorical forecast, flood or no flood. With this purpose in mind, the first selected solution was to simply apply the six-hour calibrated parameters at the desired shorter time steps. A simple study was done in which the Total Channel Inflow (TCI) produced at six-hour and one hour time steps was compared. When the hydrographs were compared it was found, as expected, that the one-hour TCI hydrograph produced higher peaks than the six- hour TCI hydrograph. Figure 1 shows the hydrographs. The percent difference was computed and plotted as a function of the six hour TCI. Figure 2 shows this plot. In the context of the Site Specific System the differences are within a reasonable range.

Clearly the differences will depend upon the type of watershed and the particular parameters selected to model a basin. Those areas in which the surface runoff generating mechanisms create much of the rainfall

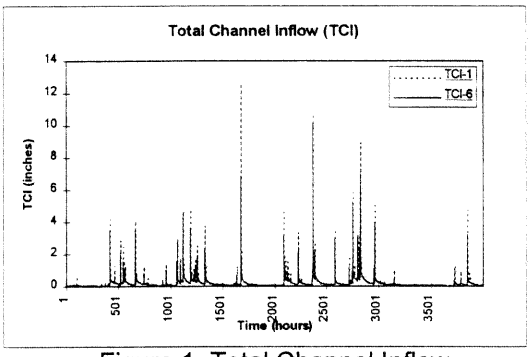

Figure 1. Total Channel Inflow

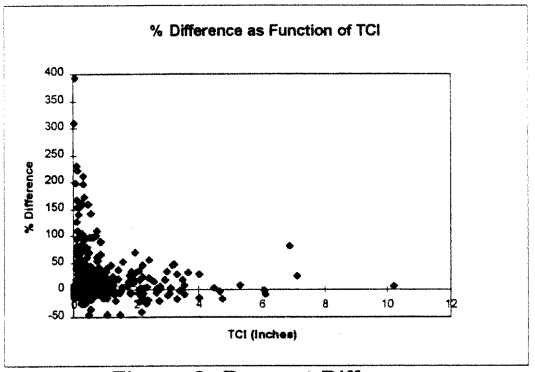

Figure 2. Percent Difference

excess, as opposed to those areas in which interflow dominates, will have larger differences between the 1 and 6-hour time step hydrographs. Basins in the arid and mountainous southwest should show larger differences than those basins in the rolling hills of Pennsylvania.

The six-hour parameters are a reasonable starting point for the Site Specific application of the SAC-SMA model. The RFC's and the WFO's will have to work together to identify those basins in which the calibrations need to be adjusted. But, again, for the purpose of the Site Specific application, a high degree of accuracy is not needed and the original 6 hour parameters may not require adjustment.

The SAC-SMA is not availble for use everywhere because the RFC's do not forecast and calibrate all the same basins that the WFO's need. In these cases it is not possible to apply RFC calibrated parameters to the WFO forecast model because no RFC parameters exist. Because of the difficulites in

parameterizing the models at 1-hour time steps, it is not possilbe to expect that the RFC's will be able to provide calibrations to the WFO's for all the basins at which they want to forecast. Another solution has to be provided for these non-RFC forecast points.

Any alternative model will have to be simple to calibrate or, more desirably, calibrated from a priori information that can be gleaned from a Geographic Information System (GIS) coverage. It must respond well to high intensity rainfall and it must be simple to initialize. Several infiltration equations were considered, but were rejected because of the difficulty in finding parameters for the equations. The Soil Conservation Service (SCS) curve number method was finally selected because of the ease with which this model can be parameterized. In addition, the SCS curve number method does model the high intensity events which the Site Specific system is designed to model.

Another significant modeling issue is the source of the Unit Hydrographs. Where the basin the WFO is modeling matches the basin that the RFC is modeling, the 6-hour unit hydrograph can be transformed using standard techniques into a 1-hour Unit Hydrograph (UHG). However, the resulting hydrographs often tend to be somewhat unsatisfactory because there is simply not enough information in the 6-hour UHG to define a 1-hour UHG.

Additional concerns have arisen pertaining to the use of unit hydrographs that have been calibrated for use with the SAC-SMA. These unit hydrographs tend to have distorted shapes due to the various channel inflow components and built-in timing of the SAC-SMA. It will be recommended that unit hydrographs calibrated for use with the SAC-SMA model, NOT be used with the alternative methods of estimating excess precipitation (i.e., the SCS curve number).

It is planned that several methods of deriving synthetic unit hydrographs will be provided along with the WHFS software to assist RFC's in developing the necessary inputs for the Site Specific System.

4. SYSTEM ISSUES

In order for this tool to be useful for a WFO forecaster, this tool must be very easy to use. When there is extreme weather and flooding in an area the WFO's become very busy and all forecasting tools must work without difficulty or they become a burden.

By integrating the Site Specific System into the WHFS, the WFO forecaster will have only one software system to use in order to review and produce hydrologic forecasts. The Site Specific model will be accessible from the screen on which the data review is done.

Another important requirement is to minimize the amount of forecaster interaction with the Graphical User Interface (GUI). Therefore, the Site Specific model will be invoked with a simple forecast point selection and then single mouse click initiation. The forecaster will then be queried to verify the precipitation input and the intitial conditions. Once these two inputs have been accepted, the models will run and hydrographs will be displayed. Parameters and initial states will be automatically transferred from the RFC to the WFO on a daily basis. The RFC's use the National Weather Service River Forecast System (NWSRFS) (Page 1996) to update the states of the models on a daily basis.

One important function of the Site Specific System is the ability to do *'what if'* scenarios. These will consist of varying precipitation and intitial wetness to evaluate the likelihood of flooding via an ensemble approach. This is useful so that the uncertainty in the forecast precipitation can be evaluated for the ultimate effect on runoff predictions.

5. CONCLUSION

In an effort to better serve the public, the National Weather Service is developing a means of providing flood watches and warnings in a more timely and accurate manner. Weather Forecast Offices will be able to provide additional and ultimately more public information regarding fast rising storm events, particularly during those times when River Forecast Centers are not staffed or when interaction with RFC's is at a minimum.

6. REFERNCES

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