

# **Hydrologic Operations of the Lower Mississippi River Forecast Center**

By: Kai Roth: Hydrologist: Lower Mississippi River Forecast Center

## **Introduction**

The National Weather Service Lower Mississippi River Forecast Center (LMRFC) is a multi-functional public service organization which uses cutting edge technology to prepare flood forecasts for dissemination to the public. The preparations of these forecasts are done daily using a combination of hydrologic experience, historical data, and real-time hydrologic / hydraulic models. The Sacramento Soil Moisture Accounting Model (SAC-SMA) is the soil moisture accounting model used at the LMRFC. The Dynamic Wave Operational Model is used for larger, more complex “mainstem” river forecasts, such as the Mississippi River. For most reaches, the Lag/K hydrologic routing technique is used. The forecast prepared using these models are disseminated to the public through the Weather Forecast Offices and in the form of a user friendly website. This website, along with all the graphics displayed on it are generated and maintained at the LMRFC.

The LMRFC is responsible for preparing forecasts for a service area of approximately 220,000 sq. miles and parts of 12 states (fig. 1). Within this area, a network of 2900 rain and 500 river gages are utilized. These gages transmit information back to the LMRFC for use in the forecast model, which in turn is used to prepare five day forecasts. The data from these gages is used to prepare forecasts for 220 points. These forecasts are disseminated to the public every morning and updated as needed in times of flooding.

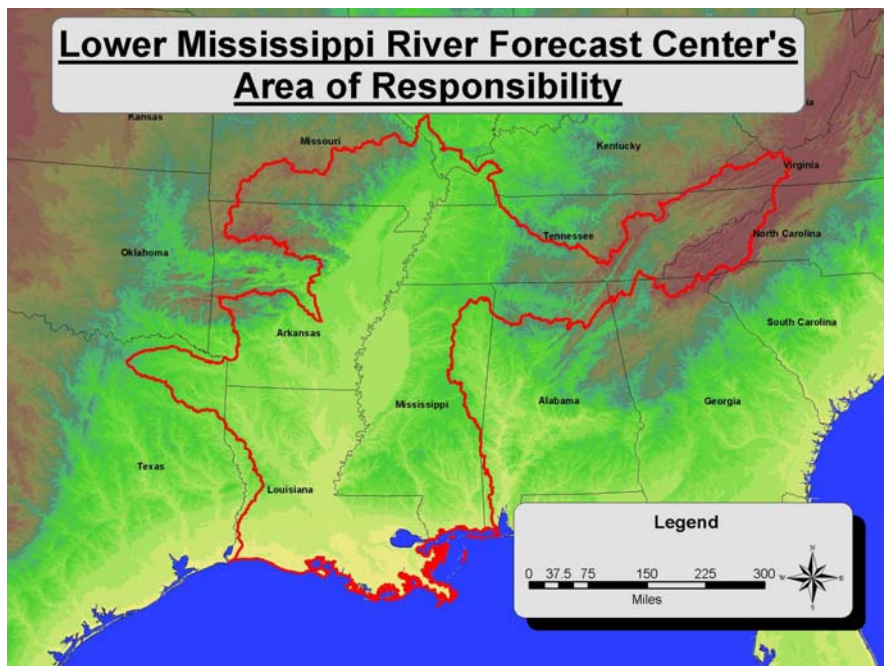


Figure 1: Lower Mississippi River Forecast Center 's area of responsibility.

## **Daily Operations**

Making 5 day forecasts is the primary function of the LMRFC. The LMRFC has a total of 220 forecast points. 189 of these forecast points are forecasted daily while the other 31 are forecasted only in times of flood. The forecasts are generated using a combination of experience, historical hydrographs, and model output and disseminated to the public daily. Rainfall, forecasted rainfall, stage data, and soil moisture conditions are ingested into the Sacramento Soil Moisture Accounting Model and a forecasted hydrograph for the next five days is generated. The model output is then inspected by a hydrologist for accuracy. The forecaster can adjust the forecast up or down to improve its accuracy. This forecasted flow is then routed downstream to the next forecast point using the Lag/K technique where the forecast process is done again. When the forecasts for an entire river system are finished, they are disseminated to the public through a user friendly web site and the Weather Forecast Office. In times of flood these forecasts are updated nightly or as necessary.

## **LMFRC Model Efforts**

Model output is an integral portion of the forecast process. The Sacramento Soil Moisture Accounting Model is used to track soil moisture and estimates runoff. This model is a continuous model as opposed to being “event driven”. The SAC-SMA model is broken down into two soil zones (fig. 2), the upper zone and the lower zone. Each zone has free water and tension water. Tension water is the water that is held so tightly in the pores of the soil that it can only be removed by evaporation. Free water is the water that is free to move about the soil profile and can eventually make its way into the river system or groundwater. This model has a total of 17 parameter. These parameters take into account, but not limited to, the amount of water that can be held in the soil, the amount of impervious area rainwater has to run off of, and vegetation. With precipitation and evapo-transpiration as input, the model simulates tension water and free water and generates surface flow, lateral drainage, and percolation. The SAC-SMA model takes into account areas impervious to infiltration including areas covered with rock, and areas that are covered by streams or marshes that are already linked to the hydrologic system. Losses from evaporation from the soil and transpiration from plants play a vital role. Evapo-transpiration is estimated using wind speed and direction, solar radiation, and humidity which are input into the Penman Equation.

The Sacramento Soil Moisture Accounting model accounts for the amount of water that enters a river system through run off, interflow, and long term base-flow. This water, along with the current flow, flow from upstream, and forecasted rainfall makes up the total amount of water in a river at a given point. To route the water downstream, the LMRFC uses the lag/K routing technique. This technique along with the Sacramento Model outputs a hydrograph the forecaster can use to create a river forecast.

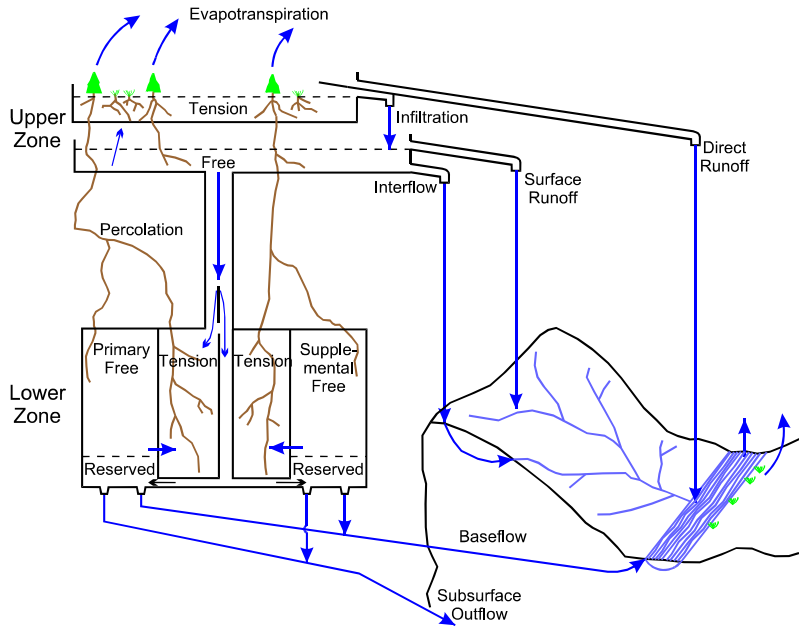


Figure 2: Conceptual Representation of the Sacramento Soil Moisture Accounting Model.

To route water downstream, LMRFC uses the hydrologic technique, Lag/K and the Dynamic Wave, a one-dimensional unsteady flow hydraulic model. DWOPER solves the St. Venant equation of one dimensional unsteady flow. This model can handle the problems associated with larger more complex river systems, such as the Mississippi River and can take into account issues such as backwater, tides, and levee overtopping. All the features associated with this model make it the logical choice for use on the Lower Mississippi and Ohio Rivers.

To route water downstream, DWOPER obtains initial river conditions from either an observed / estimated stage or discharge. Boundary conditions include known stage, discharge hydrograph, tides, or a rating curve. Off channel storage is also a component of DWOPER that is described as an area that does not pass flow to the active channel of the river. This can be an area such as an embayment or a tributary. Flooded woodlands can also serve as an area of storage. In these examples, a flow velocity of zero is used for the areas of storage to more accurately model the river instead of the average velocity of the main channel and the storage area. Channel roughness is modeled with Manning's  $n$ , which is used to describe things such as bends in the river, bank vegetation, or anything that would impede the flow or the river. In addition to the components just mentioned, DWOPER can take into account wind effects on the surface of a river, inflows from any number of tributaries, and changing conditions from lock and dam operation. Taking into consideration these many components of DWOPER, it is a powerful model used for the Lower Ohio and Mississippi Rivers at the LMRFC.

The maintenance of the models used in our forecasting is the responsibility of the LMRFC. Therefore the models need to periodically be calibrated. To do this the model output is compared with historical data. The 17 parameters in the Sacramento model are modified in the Interactive Calibration Program (ICP) through a trial and error process until the model output closely matches both statistically and visually with the historical stage data. Once a model is calibrated, the new Sacramento parameters are input into the operational model and used in the daily forecast.

## **Development Work**

In addition to flood forecasting, the LMRFC is involved in developmental work. Geographic information systems (GIS), scripting, and web design are a few of the developmental projects the LMRFC is involved in. GIS is an integral part of our forecast dissemination process. Over 5000 graphics on the LMRFC's web pages are created daily with a GIS. These graphics are generated daily by scheduling Avenue and VBA scripts to run at certain times. These scripts were generated and are maintained in house at the LMRFC. In addition to updating maps on the web page daily, GIS are also used in the creation of the base maps used to display river conditions on the web page ([www.srh.noaa.gov/lmrfc](http://www.srh.noaa.gov/lmrfc)) and in manipulating data for our calibration activities. Data such as basin delineation, statistics on potential evaporation and long term precipitation, forest type and cover, and soil conditions for 11 of the 17 Sacramento model parameters can be estimated using GIS software.

Many scripts are written at the LMRFC for use on a LINUX platform to do tasks such as pulling data off of websites or move graphics to the web. SQL scripts are also written to pull off data stored on an Informix database and used for various purposes, such as creating historical hydrographs. In addition to these developmental projects, the LMRFC also designs and maintains an informative web site. This website contains all the forecast information and precipitation data the LMRFC uses and produces daily. One of the more useful pages is the quick briefing page (fig. 3). This page contains all the flood forecast data, historical precipitation data, and forecasted precipitation data. This page also contains a graphic which depicts where significant flooding is occurring or forecasted to occur. With one click, the majority of the information the LMRFC provides can be accessed.

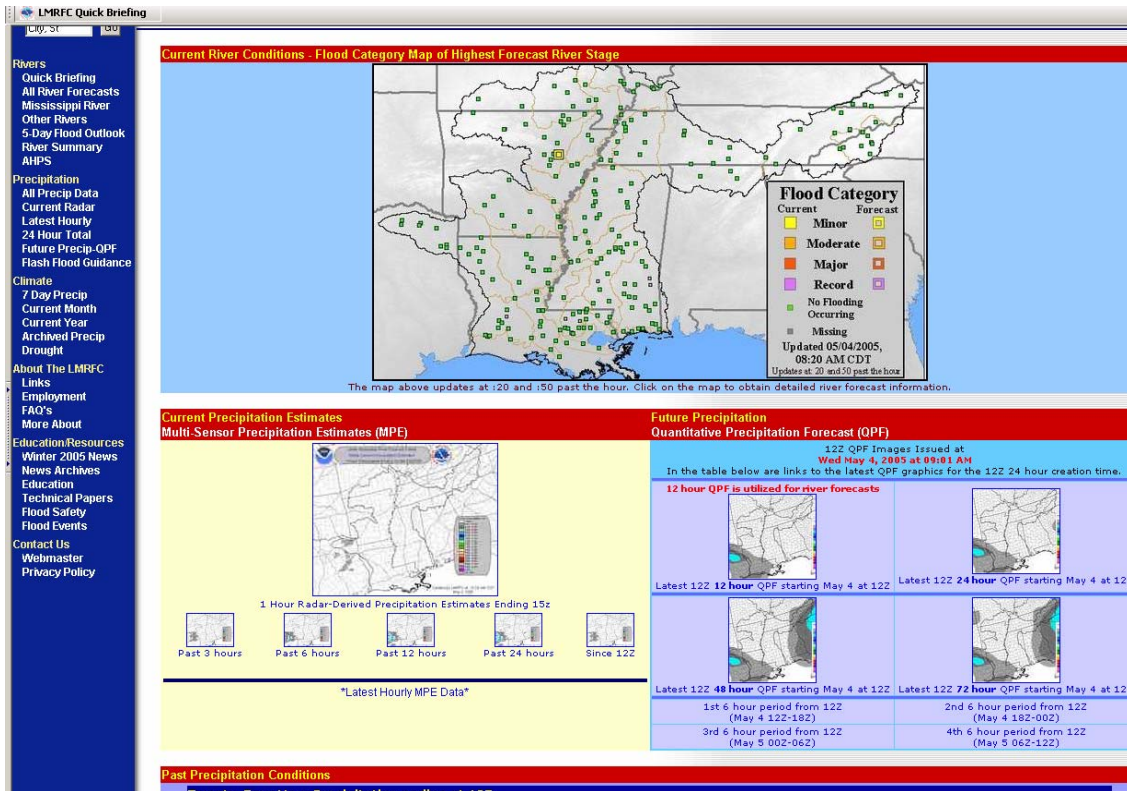


Figure 3: The Lower Mississippi River Forecast Center's quick briefing page.

## Conclusion

The National Weather Service Lower Mississippi River Forecast Center is the government office that is responsible for preparation of the river forecasts for the Lower Ohio and Mississippi River drainages along with all Gulf drainages from the Calcasieu River in southwest Louisiana to the Pascagoula River in southeast Mississippi. They use and maintain two hydrologic / hydraulic models for forecasting. These models are maintained through calibration and by keeping boundary and soil moisture conditions current and accurate in their values. The LMRFC also is a developmental office. Projects such as web design and maintenance, programming, and GIS are just a few of the developmental activities done at the office when forecasting is not being done. The LMRFC is instrumental in saving life and property through their timely and accurate forecasts.