Testing the RSM model using the TVDLF method for simulating hydrology in Mendocino and upper Kissimmee watersheds

Wasantha Lal, Lead Engineer, US Army Corps of Engineers, West Palm Beach, FL 33406, email:wasantha.lal@usace.army.mil
Jaime Graulau-Santiagp , Sup. Civil Engineer, US Army Corps of Engineers, IMC, West PalmBeach, FL 33406 email:jaime.A.Graulau-Santiago@usace.army.mil

Abstract

Physical process-based hydraulic models have become the centerpiece of many watershed studies because of the close connection between the actual physical processes, the governing equations, independently measurable physical parameters, and the use of the same state variables between the field and the model. Because of this close connectivity, it has become easier for anyone to translate model predictions into actionable plans on the ground leaving little use for empirical methods and extreme approximations. The Regional Simulation Model (RSM) using the Total Variation Diminishing Lax Friedrichs (TVDLF) method and various other linearized implicit methods developed at the SFWMD is one such model that is designed to be applied to a wide range of complex watersheds. The model is robust because of stable non-oscillatory algorithms, full coupling of all hydrologic components, and better conceptual models that describe the surface and subsurface hydrology of hillslopes, wetlands, and urban landscapes.

The TVDLF version of the RSM model is the end product of the effort to modernize the 1980s version of the South Florida Water Management Model (SFWMM) and the subsequent development of the fully integrated RSM model that is currently in use at the SFWMD. The earlier version of the RSM model suffered from problems of oscillation when simulating steeper landscapes. A deeper look into the problem showed that practically all the existing hydrologic models, including MIKE-SHE/MIKE-11, GSSHA, and RAS-2D have the same problem of not being able to simulate kinematic flow and fully dynamic canal flow with Froude numbers reaching critical levels. The TVDLF version of RSM was developed to solve both parabolic, hyperbolic and hyperbolic-parabolic partial differential equations. These equations represent diffusive, kinematic, and mixed flow types under steep and flat surface and subsurface conditions. The model solutions were tested using field-scale seepage experiments, hydraulic studies, and wetland experiments in south Florida and in Sri Lanka.

We present the RSM model application to the upper Russian River watershed that is currently facing occasional flooding and water shortage problems due to droughts and increased demands. The simulation results from the upper Russian River show detailed flow patterns along the hillslopes of Ukiah, Redwood, and Potter valleys joining the Russian River and adding to the groundwater storage at the bottom of the valley. The model results include the water levels in the river and the lake, along with water levels and discharge vectors throughout the watershed. The discharges at USGS gauge sites and water levels are compared with values simulated by the model.

The results clearly show how the physical processes simulated by the model can successfully explain the observed hydrological behaviors in the field. They show that withdrawals from the groundwater aquifer and lake Mendocino for agricultural and urban water use can influence the groundwater table and the flood peaks. The study illustrates the benefits of using a single model to capture the necessary physical processes in a watershed regardless of whether the application is in California, south Florida, or Sri Lanka.