Simulation of Streamflow in the McTier Creek Watershed, South Carolina, Using TOPMODEL and GBMM

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Introduction

In South Carolina, levels of mercury (Hg) concentrations in fish tissue that may be harmful have resulted in consumption advisories for several river basins within the Coastal Plain physiographic province, including the Edisto River basin (South Carolina Department of Health and Environmental Control, 2006). As part of a larger scientific investigation to expand understanding of relationships among hydrologic, geochemical, and ecological processes that affect fish-tissue mercury (Hg) concentrations within the Edisto River basin, two watershed hydrology models were applied to the McTier Creek watershed (Feaster et al., 2010, fig. 1). The two models are the topography-based hydrological model (TOPMODEL) and the grid-based mercury model (GBMM). This investigation was part of the U.S. Geological Survey National Water-quality Assessment (NAWQA) Program.

Study Area

McTier Creek is a small headwater watershed that is a tributary to the South Fork Edisto River, which is one of the main tributaries to the Edisto River. The study area lies within theintent part of the Coastal Plain physiographic province known as the Sandhills and encompasses about 3.4 square miles of the McTier Creek watershed. Two USGS streamflow-gaging stations were available for comparison of observed daily mean flow with simulated daily mean flow—station 0172300, McTier Creek near Monetta, SC, and station 0172326, McTier Creek near New Holland, SC (fig. 1).

Overview of TOPMODEL and GBMM

TOPMODEL, a topography-based hydrological model, is a physically based watershed model that simulates streamflow based on a variable-surface-area concept of streamflow generation. TOPMODEL systematically accounts for water as it enters the watershed as precipitation until it leaves the watershed through evapotranspiration, by direct withdrawal, or as streamflow.

GBMM computes daily mass balances for hydrology, sediment, and mercury within each geographic information system (GIS) raster grid cell for the watershed.

The runoff generation occurs by overland flow and base flow (groundwater flow).

Gabriel is computed using a modified Natural Resources Conservation Service curve number approach for each grid cell.

Watershed Model Uses

The purpose of using TOPMODEL and GBMM was to provide a framework for a better understanding of the spatial and temporal variability of the relation between hydrology and mercury in the McTier Creek watershed. Along with simulating the hydrology, GBMM also can be used to estimate daily mass balances of sediment and Hg. In addition, GBMM can be used to estimate the amount of Hg derived from each land-cover type in a watershed.

Examples for TOPMODEL uses include:

- Mapping saturated areas in the watershed
- Modeling hydrology in the subwatersheds
- Using the flow components to assess constituent loadings in the system

In the water balance, rain on a given day is used first to satisfy the potential evapotranspiration for the day. The remainder moves overland to a stream if the rain falls on impermeable surfaces that is connected to a stream (imp), soil that is already saturated (spf), or soil through which the water cannot infiltrate rapidly enough (spf) (fig. 2). Precipitation that falls on a surface-water body is added to the streamflow (con). The remaining water infiltrates into the upper soil zone. Any water stored in the saturated subsurface zone is assumed to move downslope toward the stream channel and enter the stream as return flow (cred) in saturated areas and (pr) subsurface flow (p) at the stream banks. The portion of the subsurface water that drains into the stream depends on the volume in storage and the values of the TOPMODEL input parameters.

Calibration Results


References