

## ABSTRACT

Kang, Kwangmin. Ph.D., Purdue University, May 2011. Object-oriented Hydrologic Modeling with GIS. Major Professor: Venkatesh Merwade.

A prototype geographic information system (GIS) based tightly coupled object oriented framework called GIS and Hydrologic Information System Modeling Object (GHISMO) is presented in this thesis. The proposed GHISMO framework is developed within ArcGIS environment such that geographic datasets can be treated as hydrologic objects that have properties and methods to simulate a hydrologic system. The overall GHISMO framework consists of HydroShed as a super class which is composed of six sub classes, namely, HydroGrid (for grid based data such as digital elevation model), ParameterGrid (for grid based parameters such as land use type), HydroArea (for polygon features such as lakes and reservoirs), HydroCatchment (for polygon features representing catchments and watersheds), HydroLine (for polyline features such as rivers) and HydroTable (for input and output tabular data). The GHISMO framework is applied to develop a modular hydrologic modeling system called the Storage Released based Distributed Hydrologic Model (STORE DHM). The storage-release concept uses a travel time within each cell to compute how much water is stored or discharged to the watershed outlet at each time step. The STORE DHM is tested by using it to simulate multiple hydrologic events in three watersheds in Indiana. In addition, the GHISMO framework is tested for its flexibility to adopt additional modules by implementing three rainfall bias correction methods to provide accurate input for the STORE DHM.

This research investigates (1) robustness of the developed modular hydrologic system and (2) flexibility of the linking additional rainfall bias correction modules. In the testing of the developed hydrologic modeling module, simulation results show that the STORE DHM is able to predict runoff hydrographs for different types of events in terms of storm duration, peak flow magnitude and time-to-peak. In addition, the STORE DHM output is compared with outputs

from two hydrologic models including Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) and time variant Spatially Distributed Direct Hydrograph travel time method (SDDH). Results from these comparisons show that the STORE DHM outperforms both HEC-HMS and SDDH in terms of overall hydrograph shape and flow magnitude. In a following investigation, evaluating prediction accuracy of spatio-temporal rainfall bias corrected rainfall and its effect on sensitivity of the STORE DHM simulations are presented by implementing additional rainfall bias correction modules. In correcting rainfall bias modules, data assimilation technique is performed by considering radar and available rain gauges which can be used to assimilate spatially uniform (same as Multisensor Precipitation Estimator scheme) and non-uniform (based on rainfall interpolation and bias interpolation) radar bias estimations during a storm event by Kalman filtering. Analysis of correcting radar bias rainfall with three different bias correction schemes is tested and compared in this research. The prediction accuracy of the STORE DHM simulations is also evaluated by using three different radar bias corrected rainfall inputs. The results suggest that spatially non-uniform rainfall bias correction schemes in large radar rainfall variation area are a higher improvement of rainfall bias correction over small radar rainfall variation area. Similarly, the GHISMO can be integrated with other hydrologic modules and platforms without changing its main framework because it allows flexibility and extensibility for future hydrologic issues through object-oriented approach.