American Water Resources Association
2009 SPRING SPECIALTY CONFERENCE
Managing Water Resources Development in a Changing Climate
May 4-6, 2009
Anchorage, AK

Tuesday, May 5
8:30 AM – 10:00 AM
Session 10: Addressing Uncertainty with Models I

1. Incorporating the Uncertainty of Climate Change Predictions into a Watershed Modeling - Suresh Hettiarachchi, HDR Engineering, Minneapolis, MN (co-authors: Ted Shannon, Jeff Christopherson, Scott Zilka, Matt Redington)

Distribution of water resources on the planet is one of the more important topics within the climate change discussion for which a high degree of uncertainty yet prevails. This distribution affects and shapes lifestyles, geography, economy, and ecology. Engineers, Planners, and Scientists rely on predictive models to design and plan future infrastructure and management policies for our water resources. This presentation contributes to the body of research in estimating the uncertainty of these predictive models for surface water management to which the impacts of climate change has brought about a further degree of uncertainty. This case study focuses on a 25 square mile watershed within the South Washington Watershed District. The District encompasses parts or all of five separate communities in a rapidly urbanizing area located in central Minnesota. A detailed hydrologic and hydraulic XP-SWMM model has been created for the 25 square mile watershed. During calibration of the model it was determined that conditions such as soil moisture, initial depth in lakes and ponds, and rainfall depths were the most sensitive parameters related to the variability of the modeling results. A Monte Carlo method is used to determine the variability and spread of the ending lake levels generated by the model. A normal probability distribution is used to weight the parameters for the Monte Carlo Simulation. To reduce the model run-time needed to perform a Monte Carlo Simulation (MCS), methods including dimensionless analysis, regression, and artificial neural networks are developed. The impacts of climate change are then incorporated by adjusting the variability and spread of the input parameters based on current prediction on how each of these parameters might change in the future. An MCS is then run with the new distributions for the input parameters to generate the mean lake levels and spread of projected future conditions. The results are compared to the base or present day conditions to evaluate the impacts of added uncertainty due to impacts of climate change. The model results will contribute to future policy making and infrastructure planning within the District to reduce flood damages.

2. The Value of Uncertain Irrigation Water Deliveries - Mohamed Said Gheblawi, United Arab Emirates University, Al-Ain, United Arab Emirates

This presentation provides a methodology for estimating the expected value of uncertain irrigation water deliveries under trading water rights conditions that may introduce irrigation water shortages. Thus, farmers are faced with added uncertainty in conjunction with other risk sources manifested in output price, spring soil moisture, and precipitation. Risk components of the demand for irrigation water must be identified in order to estimate the water values. A discrete sequential stochastic programming model is developed and the flow of information is assumed to follow a complete knowledge of the past and present structure. Estimates of the value of stochastic water deliveries resulting from water transfers are obtained through subtracting the values of risk penalties from the deterministic value of water. A sample of twelve farms representing the production-farming units located at the Eastern Irrigation District in southern Alberta is fitted to the empirical models. The values of risk penalties, for five scenarios of irrigation water availability ranging from zero to 100 percent, ranged from $41/ha-cm ($503/ac-ft) for the first 5 to 25 percent of irrigation water deliveries to $11/ha-cm ($133/ac-ft) for the remaining 30 to 95 percent of irrigation water deliveries. The estimates of the marginal value of stochastic irrigation water deliveries reach $128 per ha-cm ($1579/ac-ft) when irrigation water is scarce, compared to $38 per ha-cm ($467/ac-ft) when water is abundantly available.

3. Digital Elevation Data for Hydrologic Applications: Computational Efficiency in Two-Dimensional Modeling - David Judi, Los Alamos National Laboratory, Los Alamos, NM (co-authors: Timothy McPherson, Steven Burian)

Digital elevation models (DEM) have long been an important dataset for many water resource applications. One application that relies heavily on the availability and accuracy of this data is two-dimensional overland flow modeling. These models should benefit from the increasing availability of higher resolution data, especially for regions where flow is dominated by small-scale topographic features (urban areas). The difficulty in utilizing the higher resolution data is that model computation time is increased drastically and becomes, in the case of wide-area (regional) analyses, infeasible to use. The tendency for modelers, therefore, is to use lower resolution data for these model applications. It is clear that when using the lower resolution data that topographic features are not represented as well, but it is not as clear what impact this has on two-dimensional modeling. Additionally, there is no rule-of-thumb as to which resolution should be used. This paper presents a two-dimensional model that has been recently developed using the full shallow water equations. The model has been designed to take advantage of readily available DEM data downloadable from the United States Geological Survey (USGS). In addition, the model has been designed to increase the computational efficiency such that available high resolution DEM data may be used more effectively. This is accomplished through the use of efficient numerical algorithms, as well as utilizing recent technological advancements making parallel computing possible on prevalent multi-core, multi-processor computers. This model is presented, as well as the results from a study to determine the impacts of DEM resolution on flood inundation studies.

4. Global Sensitivity and Uncertainty Analysis of Hydrologic, Spatially Distributed Watershed Models – Application to the Regional Simulation Model. - Zuzanna Zajac, University of Florida, Gainesville, FL (co-author: Rafael Munoz-Carpena)

Computer-modeled simulations are used widely in the investigation of complex physical systems. Often, important management decisions are based on those simulations results. This study aims to explore the global sensitivity and uncertainty techniques suitable for complex, spatially distributed hydrological models. The techniques are applied to the Regional Simulation Model (RSM), which is a regional, management oriented spatially distributed hydrologic model developed for application in South Florida. Sensitivity analysis (SA) studies how the uncertainty in the output can be apportioned to different sources of uncertainty from the model input factors. Uncertainty analysis (UA) involves quantification of the uncertainties in the model input factors and their propagation through to model predictions. Local and global types of SA can be distinguished. Local, one-at-a-time (OAT) methods are only effective for the purpose of assessing the relative importance of input factors if the model is linear and additive. In contrast, global techniques enable exploration of the entire interval of definition for each input factor and do not require any assumptions on the model nature (such as linearity or additivity). A two-step statistical model evaluation framework using global techniques is presented. In the first step, a computationally efficient global method of Morris, a suitable screening technique for complex models, is applied. In the second step, the method of Sobol, which is a variance-based technique, is applied for quantitative global sensitivity and uncertainty analysis. Probability distributions of uncertain input factors, required for the analysis, are obtained from the available databases and literature specific to the South Florida region. Alternative spatial realizations (maps) of spatially distributed parameters are obtained by geostatistical techniques, like sequential simulation. The formal evaluation of RSM can contribute to the successful adoption of the model as a tool for water resources management in South Florida.