American Water Resources Association
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GIS & Water Resources VI
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Monday, March 29
1:30 PM – 3:00 PM
SESSION 3: Groundwater I

GIS-Enabled Multiscale Modeling of a Complex Groundwater Remediation Site in Michigan - Huasheng Liao, Michigan State University, East Lansing, MI (co-author: Shu-Guang Li)

In this paper, we present a hierarchical modeling system for a large groundwater remediation site in Michigan, integrating GIS data (e.g., detailed 10 m DEM) and onsite measurements. The GIS-based groundwater model enables simulating complex flow across multiple scales in response to both ambient and local remediation stresses. The hierarchical modeling system was calibrated to water level measurements from more than 120 monitoring wells. Systematic hierarchical simulations, including forward and reverse particle tracking, as well as, integrated water budget analyses allowed highly detailed evaluation of remediation performance and provided critical information for design optimization at the site.

GIS Enabled Stochastic Modeling of Groundwater Systems and Its Application to Real Problems - Dipa Dey, Michigan State University, East Lansing, MI (co-authors: Hua-Sheng Liao, Shu-Guang Li)

Issues of data limitation and requirement of large computational effort limit the practical applications of stochastic modeling in complex groundwater systems. Traditional data are often too limited to estimate the geostatistical parameters required for stochastic modeling. The Michigan Department of Environmental Quality (MDEQ) recently made a significant investment digitizing the well logs throughout Michigan and created a statewide groundwater GIS database. These data are free and available in almost any geographic area in Michigan at resolution orders of magnitude higher than that of traditional data. In this paper, we demonstrate the usefulness of this GIS database to model complex groundwater systems in a stochastic framework using a fully integrated, interactive groundwater (IGW) modeling environment. IGW allows zooming into virtually anywhere in Michigan to analyze groundwater data geostatistically, characterizing the spatial structure of heterogeneity, and modeling the groundwater systems stochastically. IGW employs parallel Monte Carlo Simulation (MCS) to simulate complex systems without making the commonly-used, highly restrictive assumptions of gaussianity, stationarity, and small perturbation. The usefulness of GIS data for stochastic modeling is illustrated by two classes of real-world examples. The first class of examples involves modeling probabilistically capture zones of community drinking water wells in risk-based source water protection. The second demonstrates application of stochastic modeling to help prioritize decision making for groundwater remedial actions.

Analyzing the Impacts of Climate Change on Groundwater Monitoring Network Design Using GIS - Abdelhaleem Khader, Utah State University, Logan, UT (co-author: Mac McKee)

The global climate is expected to change due to the increase in greenhouse gas concentrations since 1750. According to the IPCC fourth assessment report, global warming is certain and clear. Expected changes in climate include widespread changes in precipitation amounts and aspects of extreme weather including droughts, heavy precipitation, heat waves and intensity of hurricanes. Palestine is among the regions in which drier climates have been observed and are expected to increase. As a result, the need for more intensive water resources management has become more urgent. To be effective, this management requires an efficient and reliable information system to provide data about the water system being managed. This study investigates the impacts of climate change on the Eocene Aquifer, Palestine by utilizing different tools including global climate modeling, groundwater flow modeling, fate and transport modeling, and statistical learning machines. The first step is to predict the future temperature and precipitation based on the different climate change scenarios. Then, these temperature and precipitation values will be used as inputs to the groundwater flow model along with other inputs including soil type, topography, hydrogeology, and land use. After that, the fate and transport of pollutants will be simulated using groundwater flow models and pollutant loading data. Finally, all these models will provide the necessary information for monitoring network design using state of the art, statistical learning machines. The role of geographical information systems (GIS) in this study is vital due to the spatial nature of the problem. First, GIS is used in processing climate change data and preparing them to be used in groundwater flow modeling along with the other data. Then it is used to analyze the results of the groundwater flow model and to prepare them to be used in the fate and transport model along with pollutant loading data. After that, GIS is used in the spatial representation of monitoring network design.

Supporting Fully-Coupled Surface Water-Groundwater Flow Simulations with ArcHydro - Chin Man Mok, AMEC Geomatrix, Oakland, CA (co-authors: Raghavendra Suribhatla, Miao Zhang)

Conjunctive management of water resources requires good understanding of interactions between surface and subsurface flow regimes. Physically-based computer models that dynamically couple surface flow and subsurface flow, such as HydroGeoSphere, are gaining popularity. Application of these models requires surface flow features such as streams to be numerically represented using high-resolution geospatial data. To this end, GIS-based tools provide a powerful means to pre-process topographical and hydrological data for model development. We present a case study in which ArcHydro's terrain pre-processing tools are used to develop a finite-element mesh for a HydroGeoSphere model. The finite-element mesh for simulating overland flow is generated based on an iterative procedure of identifying stream networks from a raw digital elevation model (DEM), generating a mesh, and refining profiles of streams in the finite-element mesh to achieve consistency with orthoimagery and hydrography data. We demonstrate the impact of this iterative procedure on numerical stability of the fully-coupled flow simulations as well as identification of potential regions of high surface-subsurface interactions.