RECLAMATION
Managing Water in the West
U.S. Department of the Interior
Bureau of Reclamation

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 26
May 2009

HydroGeoSphere: A Robust Hydrologic Modeling Tool

Simulates 2- and 3-dimensional flow in conjunctive surface/subsurface water systems at multiple scales

What Is The Problem?

Managing water and associated resources often requires a good understanding of a region's hydrologic system and the ability to evaluate how the system behaves (water flow and solute/heat transport) under certain conditions. In the past, separate numerical models have typically been used to simulate surface and subsurface water systems. Most existing combined surface and subsurface (conjunctive) water-system modeling methods are known as either linked or iterative simulators (models). Linked simulators solve either surface or subsurface flow/transport separately with the results being used as boundary conditions for the other model, and iterative simulators solve the governing equations iteratively to achieve a successive convergence between the results of the two models. The linked simulators may generate results that are physically reasonable, but only if a proper time-step is applied. Iterative simulators may provide reasonable results, but only if convergence is achieved. Given these limitations with linked and iterative models, there is a need for numerical models that accurately simulate surface and subsurface processes in a fully-integrated manner.

What Is The Solution?

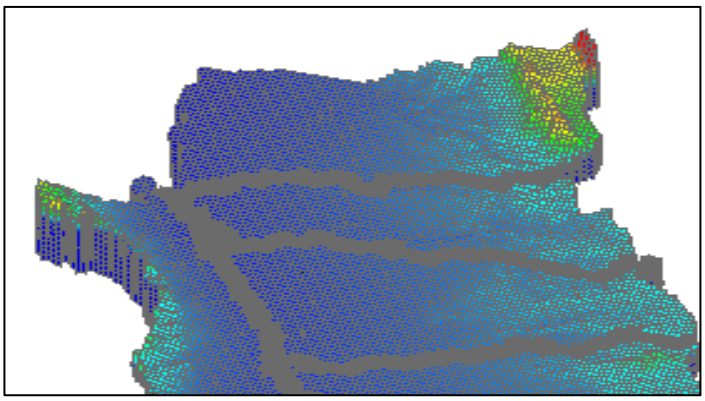
The University of Waterloo, Laval University, HydroGeoLogic Inc. and Reclamation have collaboratively developed a robust conjunctive numerical flow and transport model called HydroGeoSphere (HGS). It is a fully-integrated model that is based on simultaneous solution of the governing surface and subsurface equations, with coupling of the associated interactive relationships. It yields distribution of water depths over 2D surface areas and hydraulic head (water pressure) in 3D variably-saturated subsurface volumes. It also conjunctively models solute and heat transport. In addition to being fully integrated, HGS is based on a rigorous conceptualization of surface and subsurface flow systems with interactions at the interface of the surface and subsurface systems. It is designed to take into account various boundary conditions being applied to the combined system, including rainfall, complex evapotranspiration, interception storage, land use, irrigation, point sources and point sinks.

What Are The Benefits Of This Solution?

HGS can be used in evaluations of efficient water resources utilization, water quality and ecosystem health. It can be applied to evaluate short-term impacts and long-term phenomenon such as climate change. Potential applications include river restoration projects, natural resources and ecosystem related planning, and reservoir systems operations planning.

Where Have We Applied This Solution?

Reclamation's Mid-Pacific Region is currently applying the model on the following projects: evaluation of water storage in a proposed off-stream reservoir for water resource management; interaction of surface and subsurface water systems in Sacramento Valley due to the impact of groundwater pumping; capability of a re-use drainage-water system to control drainage water and salinity below a field site located in the San Joaquin Valley; and the impact of groundwater pumping on land subsidence on the west side of the San Joaquin Valley.



HydroGeoSphere Modeling Grid Schematic

Future Development Plans

Ongoing development work includes construction of future meteorological data for California's Central Valley, linkage of HGS and CalSim (a river system model), integration of HGS and Groundwater Modeling System (a pre- and post-processor tool), and incorporation of sub-timing and sub-gridding algorithms into HGS. The latter will allow fine grid resolution and small time steps to be applied only where needed and further increase computational efficiency and accuracy. Other future development plans include incorporation of the following processes into the model: snowmelt, sedimentation, 3D surface water, hydraulic structures, and land surface features.

More Information

Manuscripts from recent presentations on HGS applications and future developments are available at:
http://www.usbr.gov/research/science-and-tech/research/results/HGS.pdf

Contact Information

George Matanga, Mid-Pacific Region Planning Division
916-978-5084, gmatanga@usbr.gov

Collaborators

Reclamation's Science and Technology Program and Mid-Pacific Regional Office, University of Waterloo, Laval University and HydroGeoLogic Inc.