Synopsis: Arc Hydro Groundwater Applications
GIS in Water Resources, Fall 2012

The Arc Hydro Groundwater (AHGW) Data Model is a geodatabase design for managing groundwater data in ArcGIS. The Data Model is the basis for a suite of tools called *Arc Hydro Groundwater Tools*, developed to help users implement the data model, organize their groundwater-related data, and visualize the data through GIS products such as maps and 3D scenes. The AHGW Tools consist of three components: Groundwater Analyst, Subsurface Analyst, and MODFLOW Analyst.

Groundwater Analyst. Groundwater Analysts is a basic set of GIS-based tools for managing groundwater data and for creating basic GIS products such as water-level, water-quality, and flow direction maps. The tools can be used to import data, assign attributes of related features to establish relationships between features, and create summary statistics of time series to support creation of maps such as water quality and water level maps.

Subsurface Analyst. Subsurface Analyst is a set of GIS-based tools that support visualization, creation, and editing of 2D and 3D subsurface models. The tools support the creation of workflows starting with visualization and classification of borehole stratigraphy, generation of cross sections, and construction of fence diagrams and volume models.

MODFLOW Analyst. One of the primary components of the Arc Hydro Groundwater data model is the Simulation feature dataset. This dataset is used to represent groundwater simulation models in a geodatabase. MODFLOW Analyst (MA) includes a suite of tools for managing data in the MODFLOW data model. The tools are organized into four primary categories: import tools, visualization tools, data building tools, and export tools.

Most of the AHGW Tools are implemented as geoprocessing tools. A geoprocessing tool is a stand-alone utility within ArcGIS that can be launched interactively from the Arc Toolbox, from a command line, within Python scripts, or as functions within any program language (C++, C#, VB, FORTRAN, etc.) using a COM interface. Furthermore, geoprocessing tools can be pulled into the ArcGIS Model Builder where each geoprocessing tool is shown in graphical form with a symbol for the tool and ovals illustrating the inputs and the outputs. A set of geoprocessing tools can then be connected into a sequence where the outputs from one tool become the inputs to the next tool in the sequence. This makes it possible to use low-level tools as building blocks for more sophisticated custom workflows. These workflows can form the basis for a variety of powerful groundwater-related applications.

Cloud-Based MODFLOW Simulations

A framework to publish simplified MODFLOW groundwater modeling capabilities to a web interface for use by water managers and stakeholders was recently developed for the Utah Division of Water Rights using the AHGW Tools. Numerical modeling simulations can assist aquifer management decisions, but the amount of time and professional expertise required to wield modern groundwater models often exceeds the resources of regulating agencies – even for simple modeling tasks that are repetitive in nature. The framework is capable of automating such modeling tasks, accepting user input, executing MODFLOW, and generating specialized results including maps and modeling reports. This framework was used to build a pilot system for an aquifer in central Utah, allowing a user to simulate the effects of proposed well diversions. This prototype system allows a user to input properties for any number of candidate wells, execute an associated MOFLOW model, and view drawdown contours and regions of decreased spring flow on a web map interface. The modeling analysis is cast into a geoprocessing workflow using ArcGIS and AHGW tools, and then made accessible from a server. Such automated and accessible modeling systems have promising potential to facilitate efficient groundwater resources management and reduce modeling errors. A prototype of the system can be found here: http://utahdwr.groups.et.byu.net/app3/.

Cloud-Based Water Level Mapping

Another recent application of the AHGW Tools involved the development of a cloud-based water level simulator for the state of Texas. In 2011-2012, the state of Texas saw the worst one-year drought on record. Fluctuations in gravity measured by GRACE satellites indicate that as much as 100 cubic kilometers of water was lost during this period. Much of this came from reservoirs and shallow soil moisture, but a significant amount came from aquifers. In response to this crisis, a Texas Drought Technology Steering Committee (TDTSC) consisting of academics and water managers was formed to develop new tools and strategies to assist the state in monitoring, predicting, and responding to drought events.

When analyzing the impact of drought on groundwater levels, it is fairly common to examine time series data at selected monitoring wells. However, accurately assessing impacts and trends requires both spatial and temporal analysis involving the development of detailed water level maps at various scales. Creating such maps in a flexible and rapid fashion is critical for effective drought analysis, but can be challenging due to the massive amounts of data involved and the processing required to generate such maps. Furthermore, wells are typically not sampled at the same points in time, and so developing a water table map for a particular date requires both spatial and temporal interpolation of water elevations.

To address this challenge, a Cloud-based water level mapping system was developed for the state of Texas. The system is based on the Texas Water Development Board (TWDB) groundwater database, but can be adapted to use other databases as well. The system involves a set of ArcGIS workflows running on a server with a web-based front end and a Google Earth plug-in. A temporal interpolation geoprocessing tool was developed to estimate the piezometric heads for all wells in a given region at a specific date using a regression analysis. This interpolation tool is coupled with other geoprocessing tools to filter data and interpolate point elevations spatially to produce water level, drawdown, and depth to groundwater maps. The web interface allows for users to generate these maps at locations and times of interest. A sequence of maps can be generated over a period of time and animated to visualize how water levels are changing. The time series regression analysis can also be used to do short-term predictions of future water levels.

A prototype of the water level app can be found here:

http://ci-water.groups.et.byu.net/groundwater/index.htm