Report as of FY2006 for 2004IL49G: "Estimating shallow recharge and discharge in northeastern Illinois using GIS and pattern recognition procedure"

Publications

Project 2004IL49G has resulted in no reported publications as of FY2006.

Report Follows

Problem and Research Objectives

Evaluations of water availability and the management of water resources requires quantifying the interaction between components of the hydrologic cycle, including the rates and variability of the recharge and discharge (R/D) to aquifers. These R/D rates define the relationships among groundwater, precipitation, and surface water, and thus can restrict management options for water supply. The management of water resources in northeastern Illinois is complicated by interstate agreements, hydraulically coupled aquifer systems, natural and anthropogenic contamination, groundwater / surface water interaction, and conjunctive use of multiple resources. This research is developing an automated computer software system implementing several methods of estimating and mapping R/D, and will apply the resulting software to improve the understanding of spatial variability of shallow R/D in northeastern Illinois, thereby addressing a research priority of national importance and of broad interest.

Methodology

The first task to be addressed is the development of a Pattern Recognition Utility (PRU) to identify recharge zones within noisy spatial data and estimate R/D rates for each zone. The PRU will be a graphical user interface (GUI) tool and compatible with ArcGIS 9 that implements several advanced image processing methods and couples these to the R/D estimation codes of Stoertz and Bradbury (1989), Bradbury et al. (2000), and Lin (2002). The software will be tested on a USGS internal project (Krohelski et al., 2003) in Wisconsin to determine trends (spatial and temporal) in recharge rates and investigate dominant recharge processes occurring in selected undeveloped, agricultural, and urban watersheds.

This approach will be used to assist in the estimation and mapping of R/D for the groundwater models that are part of a water resources assessment for northeastern Illinois (Meyer et al., 2002). Previous studies for regional R/D in this region are limited and the software will be applied to estimate the R/D to the shallow aquifers within a much shorter preparation time than current methods.

Principal Findings and Significance

The software has been upgraded in Visual Basic in order to be compatible with the latest version of ArcGIS 9.2. In addition to the integration of ArcGIS building functions (e.g., moving average, color ramp, rate options) and our adapted algorithm from recently developed image-processing, ($TV+L^1$), we have also added an algorithm based on normalization to enhance the efficiency of recognition for the R/D rates in various scales such as dry and wet seasons.

We have also developed an additional GIS tool to estimate grid R/D rates based on the water balance method (Stoertz and Bradbury, 1989). This additional utility will serve as a default R/D estimator to provide a convenient option prior to the R/D pattern recognition process.

We are currently in the final refinement stage of the software development in order to make the PRU robust. We have been testing and refining the PRU using the example sites in Wisconsin. In addition, Dr. Hunt is also testing the PRU with an alternative recharge estimation method (Dripps, 2003). At the same time, we have also been estimating the R/D patterns and rates in

Illinois using this software.

Budget

This project is progressing as scheduled in our latest progress report. Our work has been presented at several conferences and, as a result, many scientists have shown an interest in our research and have volunteered to be software testers. We now have volunteer testers from a variety of universities, national laboratories, and federal and state agencies ranging across the US and extending to Asia.

Therefore, the PI recently requested a further no-cost extension to December 31, 2007 in order to demonstrate our final results at two major conferences and publications. The two conferences are the Geological Society of America Annual Meeting in Denver, Colorado and the American Geophysical Union Fall Meeting in San Francisco, California. These promise to be excellent opportunities to promote and share our work with the domestic and international science community. However, some budget re-allocations (the net total budget change is $0) were necessary and requested on May 9, 2007 as the following:

Budget Item	Current Budget	Re-allocation	Proposing Budget
Equipment	6,695	- 400	6,295
Travel	5,941	+ 2,155	8,096
Contractual	6,730	- 900	5,830
Telecommunications	855	- 855	0

The preparation of final report is already in progress. The report is scheduled to be completed at the end of this year so we can include the comments from the conference presentations mentioned above.

Related and Seed Projects

A new research project, "The development of point-to-zone pattern learning (P2Z) for groundwater recharge," based on the development of the PRU has been funded by National Center for Supercomputing Applications (NCSA) and started in September 2006. The NCSA project has been collaborating with this NIWR/USGS project successfully by developing innovative R/D pattern learning algorithms with not only image processing methods, but also machine learning approach to help users classify their conceptual recharge maps. A new proposal based on the achievements of both projects was recently submitted to the National Science Foundation. This new proposed research will develop algorithms and procedures that will enable scientists to improve conceptual models and understand the impact of conceptual model uncertainties arising from field measurements and ancillary data. This sequential research development has demonstrated the scientific merit and superior quality of this NIWR/USGS project.

Literature Citations/References

Bradbury, K.R., Dripps,W., Hankley, C., Anderson, M.P., and Potter, K.W., 2000, Refinement of two methods for estimation of groundwater recharge rates, Final project report to the

Wisconsin Department of Natural Resources, 84 pp.
Doherty, J., 2005, Manual for version 10 of PEST. Watermark Numerical Computing, Brisbane, Australia.
Dripps, W.R. 2003, The spatial and temporal variability of groundwater recharge within the Trout Lake Basin of northern Wisconsin, Ph.D. Dissertation, University of Wisconsin-Madison Department of Geology and Geophysics. 231 p.
Environmental Systems Research Institute (ESRI), 2001. ArcGIS User Guides – Bundle, Redlands, California: Environmental Systems Research Institute.
Krohelski, J.T., Hunt, R.J., and Gebert, W., 2003, Spatial and Temporal Shallow Recharge Rates in Wisconsin, U.S. Geological Survey internal project number: 2491-9KH38, US Geological Survey - WRD, Middleton, Wisconsin.
Lin Y-F., 2002, Development of a Digital Method for Estimating Groundwater Recharge and Discharge, Ph.D. Dissertation, University of Wisconsin - Madison, 106 p. (plus one CD-ROM).
Meyer, S.C., Walker, D.D., McConkey, S.M., Dey, W.S., B. Brandon, C., Abert, C.C., and Mehnert E., 2002, Water-Resources Investigations for Kane County, Illinois, Proposal to Kane County Development Department, Geneva, Illinois, Illinois State Water Survey and Illinois State Geological Survey, Champaign, Illinois, 55 pp.
Poeter, E.P., and Hill, M.C., 1998, Documentation of UCODE, A computer code for universal inverse modeling. United States Geological Survey, Water-Resources Investigations Report 98-4080.
Stoertz, M.W., and Bradbury K.R., 1989, Mapping recharge areas using a groundwater flow model – a case study, Ground Water 27 (2), p. 220-228.