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Stochastic Groundwater Modelling with Artificial Neural Networks

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Abstract

Groundwater beneath the cities is becoming an important and valuable resource. Conjunctive use of surface and groundwater is likely to become increasingly more common as urban population grows by time. Therefore, one important requirement for urban water management planning is forecasting the groundwater level fluctuations. Less experience and information is available to evaluate the fluctuations of groundwater level in urban environment compare to the natural systems, also different processes (sources) are involved in an urban water cycle, which all together make it more complicated to study.

Conclusion: This study has demonstrated the potential applicability of ANN models in selecting optimal pumping strategy for contaminated aquifer cleanup. In very short time (17 times faster than the physically based model in average), the ANN model was able to give reasonably good solution. The validation result shows that the trained ANNs predicted the model output (both cleanup time and cleanup cost) to reasonable accuracy. This is true especially in the lower range of these values where the accurate approximation of the models is very important for the optimization purpose. The simplicity of the ANN model, both for its use and for coupling with GO tool, is another advantage of the ANN model. However, it is clear that the ANN must be trained with data.

Opinion

Intensive use of groundwater is becoming a common situation in many areas of the world, especially in semiarid and arid areas, and in small islands and coastal zones. When studying groundwater it is necessary to consider that it is not only an important mineral resource (in recent years geologists often call groundwater the 'number one mineral resource') but a component of the total water resources and water balance and is one of the main components of the environment Zektser et al. 2004 Groundwater level is an indicator of groundwater availability, groundwater flow, and the physical characteristics of an aquifer or groundwater system. A choice of a method for prediction depends on the complexity of hydro geological conditions, volume of information, water demand, purpose of calculations made and experience in exploitation of operating well fields. In recent years, Artificial Neural Network (ANN) has shown a great ability in forecasting nonlinear and nonstationary time series in hydrology due to the highly flexible function estimator that has self-learning and self-adaptive feature; therefore it has been widely applied in the hydrology and water resource engineering.

Urban groundwater in recent years has emerged as a specialized area of study within hydrogeology. While the basics of groundwater as a science are well established, the specific aspects of groundwater in urban environments have only recently been recognized [1-3]. These events have been motivated by the strong interaction between city growth and groundwater impacts. Because of lack of proper data and planning, quantification of groundwater fluxes and modeling in an urban area are difficult tasks and usually includes expensive, imprecise and difficult to understand methods which require site specific validation. Although conceptual and physically based models are the main tool for depicting hydrological variables and understanding the physical processes taking place in a system, they do have practical limitations.

When data is not sufficient and getting accurate predictions is more important than conceiving the actual physics, empirical models remain a good alternative method, and can provide useful results without a costly calibration time N Daliakopoulos et al. 2004 A significant advantage of the ANN approach in system modeling is that one need not have a well-defined physical relationship for systematically converting an input to an output Nayak et al. 2004. Artificial Neural Networks (ANNs) has been increasingly applied in various aspects of science and engineering because of its ability to model both linear and non-linear systems without the need to make assumption as are implicit in most traditional statistical approaches. Neural networks are one computational methodology for hydrological forecasting. Although widely used in other research and application fields they are employed less by hydrologists.

Several researchers have applied ANNs to groundwater problems, such as Daliakopoulos et al. 2004, who examined the performance of different neural networks in a groundwater level forecasting in order to identify an optimal ANN architecture that can simulate the decreasing trend of the groundwater level and provide acceptable predictions up to 18 months ahead. Coulibaly et al. 2001 calibrated three types of functionally different artificial neural network (ANN) models using a relatively short length of groundwater level records and related hydrometeorlogical data to simulate water table fluctuations in the Gondo aquifer, Burkina Faso. Nayak et al. 2006 used ANN to forecast groundwater level in a shallow aquifer and so many researches predicted the groundwater contaminates like Yesilnacar et al. 2007 who predicted nitrate in groundwater. The purpose of this paper is to identify the need of ANN models that can capture the complex dynamics of urban groundwater table fluctuations. This paper examines and compares the capability of an artificial neural network (ANN) with different sets of inputs for predicting urban groundwater level in urban area, with it's complicated conditions, and determine [4-5].

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