MODELLING THE CARBONATIC AQUIFER SYSTEM OF SALENTO (PUGLIA, SOUTHERN ITALY): A SENSITIVITY ANALYSIS

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1. Introduction

Management of groundwater resources requires tools which permit to analyze the water budget and the evolution of the physical system in response to anthropic (e.g., ground water withdrawal) and climatic forcing A first mathematical model of the carbonatic aquifer hosted in cretaceous rocks (Calcare di Altamura) which is the main water resource of the Salento peninsula (Southern Italy) has been developed by Giudici et al. (2012b). The conceptual model was obtained from a GIS-based reconstruction of the 3D geological and hydrostratigraphic model, which permitted to map the geometry of the fractured and karst aquifer and of the overlaying rocks, which are mainly characterized by low permeability rocks and at most local and relatively thin aquifers.

The mathematical model yields a water balance for the carbonatic aquifer at the regional scale; however some parameters are known with some uncertainty and therefore, in this presentation, a sensitivity analysis is conducted in order to quantify the uncertainty and therefore to provide a measure of the reliability of the model forecast.

2. Material and Methods

The mathematical flow model is based on a finite-differences conservative scheme and on the Ghyben-Herzberg's approximation to determine the depth of the salt/fresh water interface and therefore the thickness of the fresh water aquifer. The boundary conditions take into account the aquifer recharge by subsurface flow from North through the border with the Murgia hills, as well as the relationships with sea along the coast, taking into account in different ways the areas where the aquifer is phreatic, i.e. the cretaceous rocks outcrop along the coastal line, or confined, i.e. the sea/aquifer contact occurs off-shore. Pseudo-steady conditions are considered, which simulate the average situation during a typical hydrological year. Groundwater abstraction is taken from published data, whereas aquifer recharge is estimated on the basis of the interpolation of rainfall data and of the hydrostratigraphic architecture, which is used to compute an effective infiltration coefficient, which is similar to the Aquifer Vulnerability Index (AVI) proposed by Van Stempvoort et al. (1993).

The model is based on several parameters, some of which are known with rather large uncertainty and therefore a sensitivity analysis (Hill & Tiedeman, 2008; Saltelli et al 2010) is necessary to quantify the uncertainty on model predictions.

3. Results

The model has been calibrated with respect to hydraulic conductivity by application of an automatic inverse procedure (the comparison model method; see Vassena et al. 2012 for a recent description of the method together with the application to a model of groundwater flow at the scale of an hydrogeological basin), which permits to reproduce the reference piezometric head of the aquifer system at the regional scale within a maximum absolute error of 3 m. Thus a reference set of parameters is available for which local, one-at-a-time sensitivity with respect to different parameters can be easily obtained. However, first-order sensitivity indices, which take into account the non-linear dependence of the model outcome on the model parameters, are computed with a simplified procedure, which was already successfully applied on highly non linear models (Baratelli et al., 2011; Giudici et al. 2012a).

The parameters that are considered for the sensitivity analysis are: the salt water density used in the Ghyben-Herzberg's approximation, the coefficients used to estimate the aquifer recharge, the prescribed water heads assigned as boundary conditions, the conductance used to model fresh water discharge toward the sea along the coastal areas where the aquifer is in phreatic conditions.

4. Conclusions

This presentation shows the application of a sensitivity analysis to quantify the uncertainty of the forecast of a regional groundwater flow model for the cretaceous fractured aquifer of the Salento peninsula. This area is an interesting example of Mediterranean basin, where, on one hand, urbanization, industrial and touristic activities progressively increase the request of fresh water, and, on the other hand, limited precipitation, high evapotranspiration rates and poor surface water bodies make the area prone to the risk of desertification.

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References

Baratelli F., Giudici M. & Vassena C. (2011). *A sensitivity analysis for an evolution model of the Antarctic ice sheet*. Reliability engineering & system safety; DOI:10.1016/j.ress.2011.07.003.

Hill M.C. & Tiedeman C.R. (2006). *Effective groundwater model calibration: with analysis of data, sensitivities, predictions and uncertainty*. J. Wiley & Sons.

Giudici M., Baratelli F., Castellani G. & Vassena C. (2012a). *Modeling the Antarctic ice sheet and ice shelves: assessing the effects of uncertainty on the model parameters by sensitivity analysis*, In Müller J. & Koch L. (Eds.): Ice Sheets: Dynamics, Formation and Environmental Concerns. Nova Science Publishers.

Giudici M., Margiotta S., Mazzone F., Negri S. & Vassena C. (2012b). *Modelling hydrostratigraphy and groundwater flow of a fractured and karst aquifer in a Mediterranean basin (Salento peninsula, southeastern Italy)*; Environmental Earth Sciences; in press.

Saltelli A., Ratto M., Andres T., Campolongo F., Cariboni J., Gatelli D., Saisana M. Tarantola S. (2008). *Global Sensitivity analysis - The Primer*. J. Wiley & Sons.

Van Stempvoort D., Ewert L. & Wassenaar L. (1993). *Aquifer Vulnerability Index: a GIS compatible method for groundwater vulnerability mapping*; Can Water Resour J; 18; 25-37.

Vassena C., Rienzner M., Ponzini G., Giudici M., Gandolfi C., Durante C. & Agostani D. (2012). *Modeling water resources of an highly irrigated alluvial plain: coupling and calibrating soil and ground water models*; Hydrogeology Journal; DOI:10.1007/s10040-011-0822-2.