Geophysical Research Abstracts
Vol. 16, EGU2014-14038, 2014
EGU General Assembly 2014

Advantages of 3D FEM numerical modeling over 2D, analyzed in a case study of transient thermal-hydraulic groundwater utilization

Martin Fuchsluger and Gregor Götzl
Geologische Bundesanstalt, Wien, Austria, (martin.fuchsluger@geologie.ac.at)

In general most aquifers have a much larger lateral extent than vertical. This fact leads to the application of the Dupuit-Forchheimer assumptions to many groundwater problems, whereas a two dimensional simulation is considered sufficient. By coupling transient fluid flow modeling with heat transport the 2D aquifer approximation is in many cases insufficient as it does not consider effects of the subjacent and overlying aquitards on heat propagation as well as the impact of surface climatic effects on shallow aquifers. A shallow Holocene aquifer in Vienna served as a case study to compare different modeling approaches in two and three dimensions in order to predict the performance and impact of a thermal aquifer utilization for heating (1.3 GWh) and cooling (1.4 GWh) of a communal building. With the assumption of a 6 doublets well field, the comparison was realized in three steps:
At first a two dimensional model for unconfined flow was set up, assuming a varying hydraulic conductivity as well as a varying top and bottom elevation of the aquifer (gross – thickness). The model area was chosen along constant hydraulic head at steady state conditions. A second model was made by mapping solely the aquifer in three dimensions using the same subdomain and boundary conditions as defined in step one. The third model consists of a complete three dimensional geological build-up including the aquifer as well as the overlying and subjacent layers and additionally an annually variable climatic boundary condition at the surface. The latter was calibrated with measured water temperature at a nearby water gauge. For all three models the same annual operating mode of the 6 hydraulic doublets was assumed. Furthermore a limited maximal groundwater temperature at a range between 8 and 18 °C as well as a constrained well flow rate has been given. Finally a descriptive comparison of the three models concerning the extracted thermal power, drawdown, temperature distribution and Darcy flow has been realized. In addition the effects of the basement of the building to the groundwater flow have been analyzed.
The results of the 2D model show an underestimation of more than 10 % of the performance of the groundwater utilization facility and a considerable smaller groundwater table drawdown compared to the 3D simulations. This is due to the possibility of 3D modeling to consider (i) the heat distribution and storage in the adjacent layers, (ii) the climatic surface effect and (iii) vertical groundwater flow.