Geophysical Research Abstracts
Vol. 16, EGU2014-4894, 2014
EGU General Assembly 2014

Integrating a Gravity Simulation and Groundwater Modeling on the Calibration of Specific Yield for Choshui Alluvial Fan

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For sustainable management, accurate estimation of recharge can provide critical information. The accuracy of estimation is highly related to uncertainty of specific yield (Sy). Because Sy value is traditionally obtained by a multi-well pumping test, the available Sy values are usually limited due to high installation cost. Therefore, this information insufficiency of Sy may cause high uncertainty for recharge estimation.

Because gravity is a function of a material mass and the inverse square of the distance, gravity measurement can assist to obtain the mass variation of a shallow groundwater system. Thus, the groundwater level observation data and gravity measurements are used for the calibration of Sy for a groundwater model. The calibration procedure includes four steps. First, gravity variations of three groundwater-monitoring wells, Si-jhou, Tu-ku and Ke-cuo, are observed in May, August and November 2012. To obtain the gravity caused by groundwater variation, this study filters the noises from other sources, such as ocean tide and land subsidence, in the collected data The refined data, which are data without noises, are named gravity residual. Second, this study develops a groundwater model using MODFLOW 2005 to simulate the water mass variation of the groundwater system. Third, we use Newton gravity integral to simulate the gravity variation caused by the simulated water mass variation during each of the observation periods. Fourth, comparing the ratio of the gravity variation between the two data sets, which are observed gravity residuals and simulated gravities. The values of Sy is continuously modified until the gravity variation ratios of the two data sets are the same.

The Sy value of Si-jhou is 0.216, which is obtained by the multi-well pumping test. This Sy value is assigned to the simulation model. The simulation results show that the simulated gravity can well fit the observed gravity residual without parameter calibration. This result indicates that the proposed approach is correct and reasonable. In Tu-ku and Ke-cuo, the ratios of the gravity variation between observed gravity residuals and simulated gravities are approximate 1.8 and 50, respectively. The Sy values of these two stations are modified 1.8 and 50 times the original values. These modified Sy values are assigned to the groundwater morel. After the parameter re-assignment, the simulated gravities meet the gravity residuals in these two stations.

In conclusion, the study results show that the proposed approach has the potential to identify Sy without installing wells. Therefore, the proposed approach can be used to increase the spatial density of Sy and can conduct the recharge estimation with low uncertainty.