

Simultaneous estimation of groundwater recharge rates, associated zone structures, and hydraulic conductivity values using fuzzy c-means clustering and harmony search optimisation algorithm: a case study of the Tahtali watershed

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Abstract The aim of this study is to present a linked simulation–optimisation model to estimate the groundwater recharge rates, their associated zone structures, and hydraulic conductivity values for regional, steady-state groundwater flow models. For the zone structure estimation problem the fuzzy c-means clustering (FCM) method was used. The association of zone structures with the spatial distribution of groundwater recharge rates was then accomplished using an optimisation approach where the heuristic harmony search (HS) algorithm was used. Since the solution was obtained by a heuristic algorithm, the optimisation process was able to use a non-specific initial solution, i.e. an initial solution that does not have to be close to the final solution. The HS-based optimisation model determines the shape of zone structures, their corresponding recharge rates and hydraulic conductivity values by minimizing the root mean square error (\mathcal{R}) between simulated and observed head values at observation wells and springs, respectively. To determine the best recharge zone structure, the identification procedure starts with computation of one zone and systematically increased the zone number until the optimum zone structure is identified. Subsequently, the performance of the proposed simulation–optimisation model was evaluated on the Tahtali watershed (Izmir, Turkey), an urban watershed for which a seasonal steady-state groundwater flow model was developed for a previous study. The results of our study demonstrated that the proposed simulation–optimisation model is an effective way to calibrate the groundwater flow models for the cases where tangible information about the groundwater recharge distribution does not exist.

Key words groundwater recharge; zone structure estimation; optimisation; harmony search