Geophysical Research Abstracts
Vol. 15, EGU2013-10325, 2013
EGU General Assembly 2013

Transmissivity Zone Structure Estimation based on Region Growing and Edge Detection Segmentation Methods

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A zonation approach is proposed to parameterize the aquifer and the objectives of the inverse method are identification of zone geometry as well as estimation of the values of the parameters. The potential of image processing tools in the estimation of the transimissivity field in highly heterogeneous aquifers is explored. The proposed method is based on the notion of the fluid flow refraction, due to an abrupt change in the medium transmissivity, for example in cases where geological facies of distinct features are in contact. Concepts from digital image segmentation methods and specifically edge detection and region growing are utilized to reconstruct transmissivity field, using piezometric head measurements. Based on few hydraulic head measurements, the hydraulic head field is calculated for the entire area using interpolation methods (e.g. kriging). The cells of the finite difference grid are treated as pixels. Next, the hydraulic gradient is evaluated and the segments/zones are obtained by a segmentation methodology. In this approach, adjacent cells are examined to determine if they should be included in particular segments/zones depending on the hydraulic gradient, which is used as the region membership criterion. The hydraulic gradient is also used to extract edges providing an initial indication of the zone boundaries. The process terminates when all cells are examined and classified in a certain zone. Next, based on the resultant aquifer structure, an optimization scheme is utilized to calculate transmissivity values for each zone. The above methodology is applied iteratively in order to provide a more effective estimation of transmissivity spatial distribution. In each step, the zone structure is modified using a split and merge procedure. Segments merge based on transmissivity values calculated in previous step, while they split if the discrepancy between measured and calculated hydraulic heads is significant.

The method is applied to simplified aquifer geometries in order to examine its efficiency. The region growing method proved to be sensitive to a threshold value of the membership criterion and requires using an adaptive thresholding scheme. A sensitivity analysis is also performed regarding the number of the observation points and the quality of measurements. Preliminary results concerning determination of aquifer structure and transmissivity values are considered satisfactory.