REGION GROWING BASED SEGMENTATION FOR THE ESTIMATION OF TRANSMISSIVITY ZONE STRUCTURE

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It is well known that the inverse problem is an ill-posed problem: from few erroneous observations of heads we aim to estimate a transmissivity map which is a complex two dimensional continuous function. This leads to multiple solutions, hence prior information is often exploited to limit the solution space. Assumptions are made regarding the structure of the unknown parameters, (e.g. smoothness of variations, zone structures, etc.). Here we focus on cases where transmissivity can be represented by a zone structure and the inverse methods aims to determine not only the values of parameters but also the zone geometry. Several approaches have been presented in the literature for estimating the zone structure of a groundwater flow system. Some methods use clustering methodologies and combine them with genetic algorithms in order to estimate the optimal zone structure minimizing the error between the field measurements and the ones estimated by the groundwater model.

In this paper a recursive methodology for estimating the zone structure of transmissivity is introduced requiring direct discrete samples of piezometric head measurements. The proposed methodology uses concepts from digital image segmentation methods, based on a region growing approach to estimate zone structure and transmissivity values in heterogeneous aquifers. The method examines neighboring cells (i.e., blocks of the finite difference grid) and determines whether they should be added to a region depending on specific features. An estimate of the gradient of hydraulic heads based on head measurements is used as a similarity criterion. A hydraulic head map is obtained by interpolation of the discrete piezometric measurements and the region growing method is utilized to obtain an initial approximation of the aquifer zone structure. Using this zone structure as a prior estimate, we estimate the spatial distribution of transmissivity more effectively. Next, the initial zone structure is updated using a split and merge procedure and the recursive process is repeated until no changes in zone structure segmentation are observed. At each iteration of the algorithm, new zone structures are obtained as segments merge or split. Segments merge based on head estimates obtained by the forward model and the estimated transmissivity values form previous iteration. On the other hand, segments spilt considering the error between field head measurements and the values estimated by the model.

Several numerical examples with aquifers of different zone structure are used to investigate the efficiency of the method. A sensitivity analysis is also performed regarding two key parameters of the region growing method: the location of the initial seed and the threshold value, according to which an individual cell is marked as part of a region. The region growing method proved to be quite sensitive to the threshold value and an automatic threshold algorithm is introduced to address this problem. The proposed iterative scheme provides after few iterations satisfactory approximations of transmissivity field zones and corresponding transmissivity estimates.