INVERSE MODELLING OF GROUNDWATER FLOW AND GROUNDWATER MASS TRANSPORT

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Summary

Groundwater flow and groundwater mass transport models try to predict the behavior of groundwater and groundwater contaminants as good as possible. Unfortunately, model predictions and especially predictions of contamination, are not very reliable in many cases. One of the reasons of the erroneous predictions is the heterogeneity of the subsurface. The heterogeneity of the subsurface is in most cases not well known. Direct measurements of the soil properties at such a small scale that they describe the heterogeneity good enough demands and enormous amount of measurements and consequently, it is very expensive.

In this research, another method to obtain information about the heterogeneity of the subsurface (inverse modeling) has been applied. Inverse models use measurements of variables that are related to the properties that are to be estimated. In this case, groundwater head and concentration measurements are used to obtain better estimates of soil properties, such as hydraulic conductivities, sorption coefficients, dispersivities, etc.

In this research, a Bayesian approach has been used, in which an objective function will be minimized. This objective function punishes both residuals between measurements and model predictions and deviations from the a priori guess of the model parameters (hydraulic conductivities, etc.) quadratically. The measurement residuals are weighted by the inverse of the covariance of the measurement errors, whereas the parameter deviations are weighted by the inverse of the priori covariance function (Tarantola 1984).

The minimization of the objective function is very computer time consuming for large-scale real world problems as the number of unknown parameters becomes very large. In this research, it has been proved that the number of unknown parameters can be reduced to the number of measurements that are available using an optimal parameterization technique (Valstar 2000).
This method has been applied on both a synthetic example and the real world case (Valstar 2000), which is the bromide tracer test at Columbus Air Base,

Mississippi (Boggs et al. 1992). In the synthetic example, a heterogeneous conductivity field has been generated after which the transport of a contaminant has been simulated. Groundwater flow was driven by infiltration of the top of the aquifer and a constant flux on the model boundary on the right hand side. The left boundary is a constant head boundary, whereas the lower boundary is a no flux boundary. Th initial plume started at the top of the aquifer in the right hand part of the model domain. Contaminant transport had been simulated for 400 days.

From this data set, 4 head and 45 concentration measurements have been sampled, which have been used in the inverse model. In Fig. 1, the concentration of the contaminant after 400 days will be shown in case the a priori guess of the model parameters has been used. The solid lines denote the real contour lines of the concentrations. The concentration calculated with the updated parameters estimates are shown in Fig. 2. It is clear that the model predictions have become significantly better.

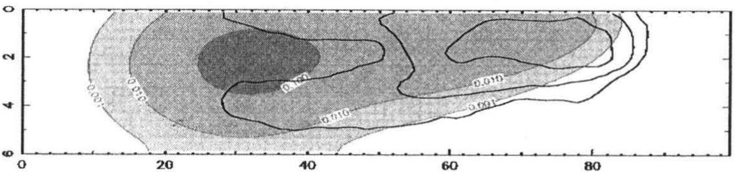

Fig. 1. Prior (grey scale areas) and real (solid line) concentration after 400 days

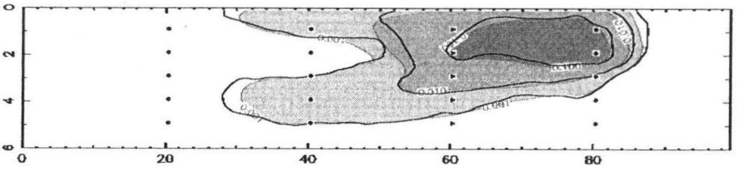

Fig. 2. Posterior (grey scale areas) and real (solid line) concentration after 400 days, the asterisks denote the locations of the concentration measurements that were sampled after 400 days

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