A hybrid inversion method to estimate hydraulic transmissivity using multiple-point statistics and the comparison model method

Topic: Inverse Modeling

An accurate parameterization of the subsurface is required to properly model fluid flow and transport in porous media. For example, when modelling a 2D confined aquifer, one of the parameters required is the hydraulic transmissivity T, which is rarely accessible for all the nodes of the simulation grid. Inverse modelling provides a number of tools and methods to tackle this problem. Among the others, the Comparison Model Method (CMM) is a direct method of inversion and allows to estimate a T field for a confined aquifer given one reference hydraulic head field (interpolated on the same simulation grid), the corresponding source/sink terms and a tentative initial model for T (comparison model, CM). One of the advantages of the CMM is its computational efficiency as it is based on the solution of a forward problem or the CM. Nevertheless, the CMM suffers from some drawbacks. For example, as the information used in the inversion process mainly come from the hydraulic heads, the fine-scale details of the T field are lost because the hydraulic heads only represent the long-wavelength components of the parameter field.
To cope with this drawback, we propose an hybrid inversion method that allows to inject additional information coming from a prior model of heterogeneity making use of multiple-point statistics (MPS). MPS is a geostatistical simulation technique based on the concept of training image (TI), which is a conceptual model that contains the expected patterns of heterogeneity. In the proposed hybrid inversion method the CMM and MPS are applied iteratively. For the first iteration, the tentative initial T field is extracted from a TI. Then, the T field resulting from each CMM inversion step is used as auxiliary variable to perform an MPS simulation. These auxiliary variables, which contain the information related to the available measurements of hydraulic head, are used in the following iteration steps to improve the MPS simulation of a new tentative initial T field for the CMM. The proposed method is tested on two synthetic datasets. The prior information provided by the TI allows to reduce the loss of short-wavelength components of the T fields which cannot be reproduced by the application of the CMM alone. At the same time, the proposed hybrid inversion method allows to inject information coming from hydraulic head measurements and to improve MPS simulation.