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Downscaling parameters from groundwater model scale to properties of the constituting litho classes

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Like other numerical models, groundwater models are created using the best knowledge available. Still, these models usually suffer from data uncertainty and model misconceptions. Calibration of such a model may yield parameter values with which the model produces output more closely to the observed values of the dependent variables than the uncalibrated model does. In groundwater models, the model parameters are often an aggregation of two or more observed properties. For example, the transmissivity is defined as the product of the layer thickness and the conductivity of the deposits, and the vertical resistance as the quotient of the layer thickness and the conductivity. Moreover, the parameters used in groundwater models are often constructed by vertical upscaling and horizontally interpolation of small geological units (litho-layers). When calibrating the groundwater model parameters, a better fit to the groundwater head data is achieved, but it is not clear to what extent the thickness or the conductivity of the individual litho-layers should be modified. This may yield parameter values at the litho-layer scale which are not very likely from geological point of view. The question is how can we downscale the calibrated model parameters to arrive at the most likely set of conductivities and thicknesses of the individual litho-layers, respecting the prior uncertainty from geological point of view.
Here, we present a method to find the most likely values of parameters of constituting litho-layers of an aquitard, based on the parameter values of a calibrated groundwater model. The objective of this method is twofold. On one hand, finding the most likely parameter values for the thicknesses and the hydraulic conductivities of each individual litho layer. On the other hand, the most likely parameter values of the litho-layers may be very unlikely from geological perspective and, herewith, indicate connectional model errors.
The properties of each litho-class at the borehole scale are upscaled and interpolated to the grid cell scale of the groundwater model, using the complete probability density function (PDF) of the parameter values. Herewith, the joint PDF of all litho-classes at every grid cell is available. Assuming the calibrated parameter value being the truth, the maximum likelihood values of the conductivity and layer thickness of each litho-class at each grid cell can be determined. All random variables are described by piecewise linear PDFs, which makes the use of a wide variety of PDFs possible and the calculations feasible.
The method is illustrated with an example derived from a real world groundwater model.