Geostatistical A-priori Information in Coupled Hydrogeophysical Inverse Problems

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Abstract

In groundwater inverse modeling the hydraulic conductivity field is often the parameter of interest as it enables to predict the solute transport in the subsurface. However, data to support groundwater models are usually limited even when indirect geophysical data are considered. This leave us with an ill-posed problem which needs to be handled by some form of regularization, that is, introducing some a-priori information about the unknown model.

One way to add regularization is to parametrize the 3D hydraulic conductivity field $\mathbf{k}$, by a few parameters, reducing the dimensionality of the problem. There are multiple approaches that can be generally cast as a linear combination of some **known**, M basis vectors $\mathbf{V} = [\mathbf{v}_1, \ldots, \mathbf{v}_M]$, (where M is usually much smaller than the grid size), setting

$$\mathbf{k} = \sum_{j=1}^{M} \alpha_j \mathbf{v_j} = \mathbf{V}\boldsymbol{\alpha} \tag{1}$$

Using a judicial choice of the basis vectors, $\mathbf{V}$, it can replace the full parameter space of the size of the grid (*Oliver et al.,2011*).

Another approach is to introduce a-priori assumption that the hydraulic conductivity field, $\mathbf{k}$, corresponds to some random field $\mathbf{k}(x, \xi)$ with a mean value $E(\mathbf{k}) = \mu(x)$ and covariance $\mathbf{C}(x, \xi)$. Karhunen-Loeve expansion is commonly used to represent the covariance matrix $\mathbf{C}$ (*Chang et al.,2014*) and $\mathbf{V}$ in (1) is chosen to be the M leading vectors in the expansion. The covariance matri expansion enable us to regularize the problem and obtain geologically feasible solutions. However, this requires a-priori knowledge of the covariance matrix. If the scale lengths or other parameters in the covariance matrix are wrong an unrealistic inversion can yield biased results. Therefore, the question is, can we estimate the scale length parameters directly from the data? In this work we show how to estimate the vectors and the covariance matrix simultaneously from the data.

References

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