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Stochastic regularization operators on unstructured meshes

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Most geophysical inverse problems require the solution of underdetermined systems of equations. In order to solve such inverse problems, appropriate regularization is required. Ideally, this regularization includes information on the expected model variability and spatial correlation. Based on geostatistical covariance functions, which can be adapted to the specific situation, stochastic regularization can be used to add auxiliary constraints to the given inverse problem.

Stochastic regularization operators have been successfully applied to geophysical inverse problems formulated on regular grids. Here, we demonstrate the calculation of stochastic regularization operators for unstructured meshes. Unstructured meshes are advantageous with regards to incorporating arbitrary topography, undulating geological interfaces and complex acquisition geometries into the inversion. However, compared to regular grids, unstructured meshes have variable cell sizes, complicating the calculation of stochastic operators. The stochastic operators proposed here are based on a 2D exponential correlation function, allowing to predefine spatial correlation lengths. The regularization thus acts over an imposed correlation length rather than only taking into account neighbouring cells as in regular smoothing constraints. Correlation over a spatial length partly removes the effects of variable cell sizes of unstructured meshes on the regularization.

Synthetic models having large-scale interfaces as well as small-scale stochastic variations are used to analyse the performance and behaviour of the stochastic regularization operators. The resulting inverted models obtained with stochastic regularization are compare against the results of standard regularization approaches (damping and smoothing). Besides using stochastic operators for regularization, we plan to incorporate the footprint of the stochastic operator in further applications such as the calculation of the cross-gradient functions for geophysical joint inversion.