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Statistical Downscaling Based on Spartan Spatial Random Fields

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Abstract

Stochastic methods of space-time interpolation and conditional simulation have been used in statistical downscaling approaches to increase the resolution of measured fields. One of the popular interpolation methods in geostatistics is kriging, also known as optimal interpolation in data assimilation. Kriging is a stochastic, linear interpolator which incorporates time/space variability by means of the variogram function. However, estimation of the variogram from data involves various assumptions and simplifications. At the same time, the high numerical complexity of kriging makes it difficult to use for very large data sets. We present a different approach based on the so-called Spartan Spatial Random Fields (SSRFs). SSRFs were motivated from classical field theories of statistical physics [1]. The SSRFs provide a different approach of parametrizing spatial dependence based on "effective interactions," which can be formulated based on general statistical principles or even incorporate physical constraints. This framework leads to a broad family of covariance functions [2], and it provides new perspectives in covariance parameter estimation and interpolation [3]. A significant advantage offered by SSRFs is reduced numerical complexity, which can lead to much faster codes for spatial interpolation and conditional simulation. In addition, on grids composed of rectangular cells, the SSRF representation leads to an explicit expression for the precision matrix (the inverse covariance). Therefore SSRFs could provide useful models of error covariance for data assimilation methods. We use simulated and real data to demonstrate SSRF properties and downscaled fields.

keywords: interpolation, conditional simulation, precision matrix

References

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