



## Two new algorithms to combine kriging with stochastic modelling

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Two main groups of statistical methods used in the Earth sciences are geostatistics and stochastic modelling. Geostatistical methods, such as various kriging algorithms, aim at estimating the mean value for every point as well as possible. In case of sparse measurements, such fields have less variability at small scales and a narrower distribution as the true field. This can lead to biases if a nonlinear process is simulated driven by such a kriged field. Stochastic modelling aims at reproducing the statistical structure of the data in space and time. One of the stochastic modelling methods, the so-called surrogate data approach, replicates the value distribution and power spectrum of a certain data set. While stochastic methods reproduce the statistical properties of the data, the location of the measurement is not considered. This requires the use of so-called constrained stochastic models.

Because radiative transfer through clouds is a highly nonlinear process, it is essential to model the distribution (e.g. of optical depth, extinction, liquid water content or liquid water path) accurately. In addition, the correlations within the cloud field are important, especially because of horizontal photon transport. This explains the success of surrogate cloud fields for use in 3D radiative transfer studies. Up to now, however, we could only achieve good results for the radiative properties averaged over the field, but not for a radiation measurement located at a certain position. Therefore we have developed a new algorithm that combines the accuracy of stochastic (surrogate) modelling with the positioning capabilities of kriging. In this way, we can automatically profit from the large geostatistical literature and software. This algorithm is similar to the standard iterative amplitude adjusted Fourier transform (IAAFT) algorithm, but has an additional iterative step in which the surrogate field is nudged towards the kriged field. The nudging strength is gradually reduced to zero during successive iterations.

A second algorithm, which we call step-wise kriging, pursues the same aim. Each time the kriging algorithm estimates a value, noise is added to it, after which this new point is accounted for in the estimation of all the later points. In this way, the autocorrelation of the step-kriged field is close to that found in the pseudo measurements. The amount of noise is determined by the kriging uncertainty.

The algorithms are tested on cloud fields from large eddy simulations (LES). On these clouds, a measurement is simulated. From these pseudo-measurements, we estimated the power spectrum for the surrogates, the semi-variogram for the (stepwise) kriging and the distribution. Furthermore, the pseudo-measurement is kriged.

Because we work with LES clouds and the truth is known, we can validate the algorithm by performing 3D radiative transfer calculations on the original LES clouds and on the two new types of stochastic clouds. For comparison, also the radiative properties of the kriged fields and standard surrogate fields are computed. Preliminary results show that both algorithms reproduce the structure of the original clouds well, and the minima and maxima are located where the pseudo-measurements see them. The main problem for the quality of the structure and the root mean square error is the amount of data, which is especially very limited in case of just one zenith pointing measurement.