Methodological and practical aspects of geostatistical bootstrap for quantifying global and local soil contamination uncertainty

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Soil contamination studies often require to estimate mean contaminant grades or in place contaminant masses over estimation zones, and to quantify associated estimation uncertainties. Such estimation problems involve non linear geostatistics and change of support aspects.

Stochastic (e.g. sequential) geostatistical simulation methods are generally recommended and used to generate “equiprobable” soil contamination models, which can then be post-processed to perform change of support and advanced statistical calculations. Such an approach requires, however, good expertise in geostatistics and can be time consuming when several contaminants and rock properties (e.g. bulk density) have to be modeled independently or jointly.

As an alternative to stochastic simulation, or as a fast approach at an early stage of a study before deciding to proceed with geostatistical modeling, bootstrap techniques can be used, together with spatial declustering methods, to quantify spatial uncertainty from properly weighted soil contamination data. The idea is to account for spatial data redundancy by computing estimation zone-dependent declustering weights, then to carry out bootstrapping on weighted data. Different declustering methods can be used that must all have the capability to take into account the geometry of the estimation zone. If one declustering method is more efficient than another, it is at the price of additional statistical analysis effort. More advanced and time consuming declustering methods can therefore be used after simpler methods have been applied to confirm that the uncertainty issue is potentially consequential for decision making.

The advantages of the proposed approach are many beyond the fast implementation: little expertise needed in statistics or geostatistics, no need for normal score or other data transformation, which may be particularly complex when applying to contamination grade data involving outliers and censored data, no need to model multivariate relationships to estimate the joint effect of several contaminants and rock properties on the level of contamination of soils.

The paper will present the approach and demonstrate its efficiency on actual case studies. Comparisons will be made between different declustering methods (geometrically constrained Voronoi, cell and kriging-based declustering methods) and with reference sequential Gaussian simulation results.