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Combining geostatistics and physically-based simulations to characterize contaminated soils

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Characterization of contamination in soils resulting from nuclear or industrial activities is a crucial issue for site remediation. A classical approach consists in delineating the contaminated zones based on a geostatistical estimation calibrated from measured activities, but it results in high uncertainties when the number of measurements is low and/or the spatial variability of the studied variable is governed by complex processes. In order to reduce these uncertainties, a novel approach, called Kriging with Numerical Variogram (KNV), is developed: the variogram is computed from a set of physically-based flow-and-transport simulations rather than from the measurements.

The KNV approach is assessed on a two-dimensional synthetic reference test case reproducing the migration of a tritium plume within an unsaturated soil with hydraulic properties highly variable in space. The results show that the mean absolute error in estimated activities is 50% to 75% lower with KNV compared to classical geostatistical approaches, depending on the sampling scenario. Moreover, KNV leads to a significant reduction of the empirical error standard deviation, which reflects uncertainties on the estimated activities. The performance of KNV regarding the classification into contaminated or not-contaminated zones is yet sensitive to the contamination threshold.

The KNV approach could thus help to better estimate volumes of soils to be decontaminated in the context of remediation of nuclear or industrial sites. This approach can be transposed to other scales of heterogeneities, such as systems with several geological units, or other pollutants with a more complex chemical behavior, as soon as a numerical code that simulates the phenomenon under study is available.

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