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Spatialization of physical variables in soils by geophysical, geotechnical and geostatistic methods: the Bayesian maximum entropy data fusion approach

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The soil is considered as a biological reactor or an outlet for treated domestic wastewater, respectively to reduce pollutant concentrations in the flows or because the surface hydraulic medium is too remote. In these cases, the saturated hydraulic conductivity of the soil is a key is a quantitative measure to assess whether the necessary infiltration capacity is available. To our knowledge, there is no satisfactory technique for evaluating the saturated hydraulic conductivity Ks of a heterogeneous soil (and its variability) at the scale of a parcel of soil. The aim of this study is to introduce a methodology that associates geophysical measurements and geotechnical in order to better described the near-surface saturated hydraulic conductivity Ks. Here we demonstrate here the interest of using a geostatistical approach, the BME "Bayesian Maximum Entropy", to obtain a 2D spatialization of Ks in heterogeneous soils. This tool opens up prospects for optimizing the sizing infiltration structures that receive treated wastewater. In our case, we have Electrical Resistivity Tomography (ERT) data (dense but with high uncertainty) and infiltration test data (reliable but sparse). The BME approach provides a flexible methodological framework to process these data. The advantage of BME is that it reduces to kriging as its linear limiting cases when only Gaussian data is used, but can also integrate data of other types as might be considered in future works. Here we use hard and Gaussian soft data to rigorously integrate the different data at hand (ERT, and Ks measurement) and their associated uncertainties. Based on statistical analysis, we compared the estimation performances of 3 methods: kriging interpolation of infiltration test data, the transformation of ERT data, and BME data fusion of geotechnical and geophysical data. We evaluated the 3 methods of estimation on simulated datasets and we then do a validation analysis using real field data. We find that BME data fusion of geotechnical and geophysical data provides better estimates of hydraulic conductivity than using geotechnical or geophysical data alone.