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Quantifying variogram uncertainty linked to soil moisture at field scale

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The spatial dependence of an environmental variable is commonly estimated by variogram analysis. However, especially for smaller data sets (< 100 sample points) the resulting sample variogram typically includes large uncertainty. This uncertainty is often neglected in further analysis and interpretation of the data. In this study, we used stochastic simulation to estimate the expected variogram uncertainty and used this information for the quantification of spatial dependence of soil water content.
We used a data set of soil water content measured weekly from April to October 2009 in 6 cm depth at 61 locations in a 50 $\times$ 50 m plot of an bare agricultural field in Jülich, Germany. For each variogram, 1000 realizations of the underlying random field were generated using unconditional sequential Gaussian simulation. For each realization we draw 2000 samples within the sampling domain. From these realizations the ergodic and nonergodic sample variogram were calculated. The ergodic variogram is the exhaustive variogram including all 2000 realizations and the nonergodic variogram is the sample variogram including only the 61 actually sampled locations. Variogram uncertainty was calculated from the differences between ergodic and nonergodic variograms. We fitted various variogram models to the underlying sample variogram by iterative weighted least squares using the uncertainty of each variogram lag as weights. We then applied among others the corrected *Akaike Information Criterion* (AIC_c) to select the variogram model that best described the data. Our results indicate that explicit consideration of variogram uncertainty may strongly affect the interpretation of geostatistical data and we propose to apply this approach routinely in geostatistical practice.