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# A stochastic–geometric model of soil variation in Pleistocene patterned ground

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In this paper we examine the spatial variability of soil in parent material with complex spatial structure which arises from complex non-linear geomorphic processes. We show that this variability can be better-modelled by a stochastic–geometric model than by a standard Gaussian random field. The benefits of the new model are seen in the reproduction of features of the target variable which influence processes like water movement and pollutant dispersal.

Complex non-linear processes in the soil give rise to properties with non-Gaussian distributions. Even under a transformation to approximate marginal normality, such variables may have a more complex spatial structure than the Gaussian random field model of geostatistics can accommodate. In particular the extent to which extreme values of the variable are connected in spatially coherent regions may be misrepresented. As a result, for example, geostatistical simulation generally fails to reproduce the pathways for preferential flow in an environment where coarse infill of former fluvial channels or coarse alluvium of braided streams creates pathways for rapid movement of water. Multiple point geostatistics has been developed to deal with this problem. Multiple point methods proceed by sampling from a set of training images which can be assumed to reproduce the non-Gaussian behaviour of the target variable. The challenge is to identify appropriate sources of such images.

In this paper we consider a mode of soil variation in which the soil varies continuously, exhibiting short-range lateral trends induced by local effects of the factors of soil formation which vary across the region of interest in an unpredictable way. The trends in soil variation are therefore only apparent locally, and the soil variation at regional scale appears random. We propose a stochastic–geometric model for this mode of soil variation called the Continuous Local Trend (CLT) model. We consider a case study of soil formed in relict patterned ground with pronounced lateral textural variations arising from the presence of infilled ice-wedges of Pleistocene origin. We show how knowledge of the pedogenetic processes in this environment, along with some simple descriptive statistics, can be used to select and fit a CLT model for the apparent electrical conductivity ($EC_a$) of the soil. We use the model to simulate realizations of the CLT process, and compare these with realizations of a fitted Gaussian random field. We show how statistics that summarize the spatial coherence of regions with small values of $EC_a$, which are expected to have coarse texture and so larger saturated hydraulic conductivity, are better reproduced by the CLT model than by the Gaussian random field. This suggests that the CLT model could be used to generate an unlimited supply of training images to allow multiple point geostatistical simulation or prediction of this or similar variables.