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# Modelling large-scale spatial variability of soil properties with sequential stochastic simulation conditioned by universal kriging in a Hungarian study site

Gábor Szatmári (1), Károly Barta (1), and László Pásztor (2)

(1) University of Szeged, Faculty of Science and Informatics, Department of Physical Geography and Geoinformatics, Szeged, Hungary (szatmari.gabor.88@gmail.com), (2) Institute for Soil Science and Agricultural Chemistry, Centre for Agricultural Research, Hungarian Academy of Sciences, Department of Environmental Informatics, Budapest, Hungary (pasztor@rissac.hu)

Modelling of large-scale spatial variability of soil properties is a promising subject in soil science, as well as in general environmental research, since the resulted model(s) can be applied to solve various problems. In addition to “purely” map an environmental element, the spatial uncertainty of the map product can deduced, specific areas could be identified and/or delineated (contaminated or endangered regions, plots for fertilization, etc.). Geostatistics, which can be regarded as a subset of statistics specialized in analysis and interpretation of geographically referenced data, offer a huge amount of tools to solve these tasks.
Numerous spatial modeling methods have been developed in the past decades based on the regionalized variable theory. One of these techniques is sequential stochastic simulation, which can be conditioned with universal kriging (also referred to as regression kriging). As opposed to universal kriging (UK), sequential simulation conditioned with universal kriging (SSUK) provides not just one but several alternative and equally probable “maps”, i.e. realizations. The realizations reproduce the global statistics (e.g. sample histogram, variogram), i.e. they reflect/model the reality in a certain global (and not local!) sense.
In this paper we present and test SSUK developed in R-code and its utilizations in a water erosion affected study area. Furthermore, we compare the results from UK and SSUK. For this purpose, two soil variables were selected: soil organic matter (SOM) content and rooting depth (RD).
SSUK approach is illustrated with a legacy soil dataset from a study area endangered by water erosion in Central Hungary. Legacy soil data was collected in the end of the 1980s in the framework of the National Land Evaluation Programme. Spatially exhaustive covariates were derived from a digital elevation model and from the land-use-map of the study area. SSUK was built upon a UK prediction system for both variables and 200 realizations were generated, respectively. The set of 200 realizations provides a set of 200 simulated values for each grid node, which can be used to model the cumulative distribution function (CDF) for each grid node and provides statistical inferences for the consideration of the spatial uncertainty. The expected value and the corresponding confidence interval for each grid node were mapped, where latter offers an opportunity for estimating the spatial uncertainty.
CDFs can also be used to map specific conditions of the modelled property, e.g. the distribution of probability if RD is less than or equal to 30 centimeters. Utilizing this opportunity, functional “soil maps” were generated for the study area, which were used to delineate (with a predefined confidence level) the highly, moderately and weakly erosion affected areas, as well as the accumulation zones. In the last step, the results of SSUK and UK were compared, which showed that, SSUK gave a similar model of regional tendencies as UK for both variables. However, SSUK did not smooth out the local heterogeneities, which is crucial in large-scale digital soil mapping.
In conclusion, SSUK proved to be an appropriate technique to model the large-scale spatial distribution and uncertainty of soil variables.

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