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Multivariate 3D modelling of Scottish soil properties

Laura Poggio and Alessandro Gimona
The James Hutton Institute, Aberdeen, United Kingdom (laura.poggio@hutton.ac.uk)

Information regarding soil properties across landscapes at national or continental scales is critical for better soil and environmental management and for climate regulation and adaptation policy. The prediction of soil properties variation in space and time and their uncertainty is an important part of environmental modelling. Soil properties, and in particular the 3 fractions of soil texture, exhibit strong co-variation among themselves and therefore taking into account this correlation leads to spatially more accurate results.

In this study the continuous vertical and lateral distributions of relevant soil properties in Scottish soils were modelled with a multivariate 3D-GAM+GS approach. The approach used involves 1) modelling the multivariate trend with full 3D spatial correlation, i.e. exploiting the values of the neighbouring pixels in 3D-space, and 2) 3D kriging to interpolate the residuals. The values at each cell for each of the considered depth layers were defined using a hybrid GAM-geostatistical 3D model, combining the fitting of a GAM (generalised Additive Models) to estimate multivariate trend of the variables, using a 3D smoother with related covariates. Gaussian simulations of the model residuals were used as spatial component to account for local details.

A dataset of about 26,000 horizons (7,800 profiles) was used for this study. A validation set was randomly selected as 25% of the full dataset. Numerous covariates derived from globally available data, such as MODIS and SRTM, are considered.

The results of the 3D-GAM+kriging showed low RMSE values, good R squared and an accurate reproduction of the spatial structure of the data for a range of soil properties. The results have an out-of-sample RMSE between 10 to 15% of the observed range when taking into account the whole profile. The approach followed allows the assessment of the uncertainty of both the trend and the residuals.