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3D modelling of soil texture: mapping and incertitude estimation in centre-France

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Soil texture is an important component of all soil physical-chemical processes. The spatial variability of soil texture plays a crucial role in the evaluation and modelling of all distributed processes.

The object of this study is to determine the spatial variation of soil granulometric fractions (i.e. clay, silt, sand) in the region "Centre" of France in relation to the main controlling factors, and to create extended maps of these properties following GlobalSoilMap specifications.

For this purpose we used 2487 soil profiles of the French soil database (IGCS - Inventory Management and Soil Conservation) and continuum depth values of the properties within the soil profiles have been calculated with a quadratic splines methodology optimising the spline parameters in each soil profile. We used environmental covariates to predict soil properties within the region at depth intervals 0-5, 5-15, 15-30, 30-60, 60-100, and 100-200 cm. Concerning environmental covariates, we used SRTM and ASTER DEM with 90m and 30m resolution, respectively, to generate terrain parameters and topographic indexes. Other covariates we used are Gamma Ray maps, Corine land cover, available geological and soil maps of the region at scales 1M, 250k and 50k.

Soil texture is modeled with the application of the compositional data analysis theory namely, alr-transform (Aitchison, 1986) which considers in statistical calculation the complementary dependence between the different granulometric classes (i.e. 100% constraint). The prediction models of the alr-transformed variables have been developed with the use of boosting regression trees (BRT), then, using a LMM – Linear Mixed Model - that separates a fixed effect from a random effect related to the continuous spatially correlated variation of the property. In this case, the LMM is applied to the two co-regionalized properties (clay and sand alr-transforms).

Model uncertainty mapping represents a practical way to describe efficiency and limits of models prediction and can be calculated using different techniques. In this paper our hypothesis is, if a correspondence is supposed and identified between prediction interval (PI) and predictors, a model between them may be used to extrapolate PI to the whole map. This approach is similar to that of Malone et al. (2011), but at pixel level, moreover, the correspondence is validated with an internal leave out cross validation procedure (i.e. 90-10%).

Validation procedures have been adopted both for LMCR fitting the two co-regionalized properties (alr-clay and alr-sand indicators) optimising standardized squared prediction error values, and in analysing the performance of the whole procedure using an external independent dataset of 198 soil profiles from the RMQS (Measurements Network for Soil Quality, Arrouays et al., 2002) soil database.