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Digital mapping of topsoil organic carbon in Grand-Duchy of Luxembourg using a compilation of legacy soil data

Antoine Stevens (1), Simone Marx (2), and Bas van Wesemael (1)

(1) UCLouvain, Earth & Life Institute, TECLIM, Louvain La Neuve, Belgium (antoine.stevens@uclouvain.be), (2) Administration des Services techniques de l'Agriculture, Service de pédologie (simone.marx@asta.etat.lu)

Providing localized predictions (with uncertainties) of soil properties is needed to assist soil surveyors and land managers, and inform/assist the political debate with quantified estimates of the status and change of the soil resource. Such maps can be produced with data originating either from purpose-built soil monitoring networks (SMN) or from previous soil measurements exercises such as soil testing for farmers by commercial/institutional soil laboratories. Although SMN's are likely to provide better and less biased estimates of soil attributes because of their optimal sampling strategy, SMN's are costly to establish, maintain and re-visit. Data gathered from other sources, on the other hand, are often more numerous which might favor greater accuracy in a geostatistical context. Another advantage is that these data are often acquired continuously so that derived-maps can be rapidly and easily improved or updated with upcoming data. In this study, we produce a map of the topsoil Organic Carbon (OC) content of croplands, grasslands, vineyards and forest land of the Grand-Duchy of Luxembourg using more than 2000 samples analyzed for OC (by dry combustion) in 2012-2013 by an accredited soil laboratory in Luxembourg. To model OC content, this study relies on a set of spatial covariates with a resolution of 90 m, including elevation and its derivatives, land cover, soil texture, climate and livestock intensity. To avoid problems related to co-linearity in the independent variables, the covariates were transformed using Principal Component (PC) analysis, retaining PC components explaining more than 99% of the variation. Different prediction models were developed for each of the four land cover classes using either Generalized Additive Models (GAM) or Random Forest Kriging. For cropland soils, the model is characterized by a R^2 = 0.75 and RMSE = 4 g C kg^{-1} and the variables used in the model are geographical coordinates and PC components related to elevation and aspect. Models developed for the other land covers were less successful (R^2 < 0.3) with a large part of OC variation occurring at small scales. Maps show overall a clear south-north gradient in OC in Luxembourg.