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Topsoil organic carbon content of Europe, a new map based on a generalised additive model

Delphine de Brogniez (1,2), Cristiano Ballabio (1), Antoine Stevens (2), Robert J.A. Jones (3), Luca Montanarella (1), and Bas van Wesemael (2)

(1) Joint Research Centre of the European Commission, Institute for Environment and Sustainability, Ispra (VA), Italy (delphine.de-brogniez@jrc.ec.europa.eu), (2) Georges Lemaître Centre for Earth and Climate Research, Earth and Life Institute, Faculty of Sciences, Université catholique de Louvain, Louvain-la-Neuve, Belgium, (3) National Soil Resource Institute (NSRI), Department of Natural Resources, School of Applied Sciences, Cranfield University, Bedford, UK

There is an increasing demand for up-to-date spatially continuous organic carbon (OC) data for global environment and climatic modeling. Whilst the current map of topsoil organic carbon content for Europe (Jones et al., 2005) was produced by applying expert-knowledge based pedo-transfer rules on large soil mapping units, the aim of this study was to replace it by applying digital soil mapping techniques on the first European harmonised geo-referenced topsoil (0-20 cm) database, which arises from the LUCAS (land use/cover area frame statistical survey) survey. A generalized additive model (GAM) was calibrated on 85% of the dataset (ca. 17 000 soil samples) and a backward stepwise approach selected slope, land cover, temperature, net primary productivity, latitude and longitude as environmental covariates (500 m resolution). The validation of the model (applied on 15% of the dataset), gave an R2 of 0.27. We observed that most organic soils were under-predicted by the model and that soils of Scandinavia were also poorly predicted. The model showed an RMSE of 42 g kg-1 for mineral soils and of 287 g kg-1 for organic soils. The map of predicted OC content showed the lowest values in Mediterranean countries and in croplands across Europe, whereas highest OC content were predicted in wetlands, woodlands and in mountainous areas. The map of standard error of the OC model predictions showed high values in northern latitudes, wetlands, moors and heathlands, whereas low uncertainty was mostly found in croplands. A comparison of our results with the map of Jones et al. (2005) showed a general agreement on the prediction of mineral soils' OC content, most probably because the models use some common covariates, namely land cover and temperature. Our model however failed to predict values of OC content greater than 200 g kg-1, which we explain by the imposed unimodal distribution of our model, whose mean is tilted towards the majority of soils, which are mineral. Finally, average OC content predictions for each land cover class compared well between models, with our model always showing smaller standard deviations. We concluded that the chosen model and covariates are appropriate for the prediction of OC content in European mineral soils. We presented in this work the first map of topsoil OC content at European scale based on a harmonised soil dataset. The associated uncertainty map shall support the end-users in a careful use of the predictions.