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Combining time-series of Sentinel-1 and Sentinel-2 for soil organic carbon estimation and mapping. Application to agricultural soils of a catchment area in Brittany, France

The degradation of agricultural soils, in the context of climate change and a growing world population, requires the urgent implementation of sustainable management of soils to improve their health. Therefore, it is important to produce maps that provide accurate information on the current state of soils and allow monitoring of soil properties changes over space and time. This is particularly true in the context of the 4 per 1000 initiative (Arrouays et al., 2019), which requires quantifying soil organic carbon storage in order to assess the relevance of changes in agricultural practices.

This study is carried out in the framework of the STEROPES project of the European Joint H2020 Program SOIL1 (Vaudour et al., 2022) and POLYPHEME project through the TOSCA program of the CNES (French Space Agency). Both projects aim to update SOC maps based on the use of Sentinel satellite time-series. Our main purpose is to evaluate the accuracy of SOC content estimates predicted using Deep Neural Network (DNN) algorithm and combined time-series of Sentinel-2 (S-2) images and soil moisture derived from Sentinel-1 (S-1) radar images.

Our approach was implemented to map SOC content of 12 agricultural fields over the Naizin catchment area (12 km²) in Brittany, western France. In October 2020, 55 composite soil samples were collected from the top 5 cm within these fields and Sentinel time-series were constituted using images acquired between September 2020 and August 2021. Setting the cloud cover threshold to 5% resulted in 24 usable S-2 images. After testing different combinations for the DNN input data, the best results in estimating SOC contents were achieved with time-series combining S-2 images with several spectral indices derived from S-2 bands and soil moisture derived from S-1 images. Finally, our results showed that the implemented approach resulted in a relatively accurate SOC content map.

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Prediction of Soil Organic Carbon based on Sentinel-2 NDVI data in Sardinia, Italy

Major drivers of gains or losses in soil organic carbon (SOC) include land management, land use change, and climate change (Beillouin at al., 2022). Environmental variables are widely used in SOC prediction. However, it is still difficult to determine which methods and variables are effective for SOC mapping (Chen at al., 2022). While knowledge of the spatial distribution of soil SOC content and its mapping is closely linked to its conservation (Zeraatpisheh at al., 2021), a spatially explicit map of it on the Sardinian Island is non-existent. The peculiarity of the latter is a great variety of landscapes owing to the different parent material, climatic conditions, topography, vegetation, and geomorphology. The interaction of these features has produced many soil types, such as Leptosols, Regosols, Luvisols, Cambisols and Umbrisols, with large differences in SOC content. Therefore, the aim of this study was to quantify the spatial distribution of SOC stocks and associated uncertainties to a target depth of 0–30 cm based on a multiple linear regressions (MLR) approach for Pedological Units to fill this knowledge gap. Data for 4032 georeferenced topsoils, extracted from Sardinian Soils Database (DBSS), were divided into calibration (n=3000) and validation (n=1032) dataset. Environmental variables including temperature, precipitation, elevation, slope, distance from the coast and Normalized Difference Vegetation Index (NDVI) data have been explored and included as independent variables to establish the model and estimate the SOC stock. We selected all S-2 cloud-free images covering the Sardinian Island (by averaging the monthly values of the most recent images) obtaining an average annual NDVI value. This study presente an effective method to overcome the selection of auxiliary variables for digital soil mapping in Sardinian Island and indicate that NDVI was conducive for predicting SOC. The results and the method will show exhaustively in the Poster.

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DBSS, Sardinian Soils Database included in http://www.sardegnaportalesuolo.it/.

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