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Potential of combined Sentinel 1/ Sentinel 2 images for mapping topsoil organic carbon content over cropland taking into account soil roughness

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Soil fertility management and climate change mitigation require the monitoring of soil organic carbon content. This study aimed at assessing the potential of combining Sentinel-1/Sentinel-2 images for topsoil organic carbon content (SOC) prediction over croplands, taking into account the soil surface roughness shaped by cultural operations. It focused on the Versailles plain, a peri-urban region of 221 Km^2 located in the Ile-de-France region. Non-agricultural areas were masked using a vector layer derived from the graphical plot reference frame (RPG). Multispectral optical data were acquired from the European Space Agency (ESA) Sentinel-2 mission at four different dates in March-April 2017. For predicting SOC values, 129 plots sampled between 2010 and 2017, which were bare at the time of acquisitions, were used to construct Partial least squares regression (PLSR) models from the reflectance spectra of each Sentinel-2 image. In addition, a set of 13 Sentinel-1 radar images acquired in VH cross polarization and VV copolarization in dry condition during the same period were radiometrically calibrated, orthorectified and filtered by box filtering; they were then used to predict soil roughness from regression models based on soil roughness measurements (standard deviation of the surface height (Hrms)) at 40 plots sampled 3-4 times during a synchronous field campaign in March-April 2017. PLSR models of SOC prediction were constructed by separating plots according to their roughness level, being either smooth (Hrms < 2 cm) or rough (≥ 2 cm).
The best prediction of soil roughness was obtained by inverting logarithmic regression obtained from radar backscattering on VH polarization and Hrms (Residual Prediction Deviation (RPD) of external validation 1.88; R^2 of external validation 0.71). Separation of optical data according to their roughness level, resulted in a better predictive ability of SOC for smooth soils (R^2 of Leave one-out cross validation (R^2CV) 0.54, cross-validation RPD (RPDCV) 1.44) compared to rough (R^2CV 0.39, RPDCV 1.3). At the four optical data acquisition dates, different performances were obtained (R^2CV varying between 0.38 and 0.59). The best performance was for 9 April, when the seedbed was prepared for most plots (RMSECV = 1.2 g/Kg ; RPDCV 1.59). Effects of soil moisture, crop residues and emergent vegetation are here discussed, paving the way for a multidate approach for optimizing soil organic carbon content prediction over croplands.
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