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Sentinel-2 exposed soil composite for soil organic carbon prediction: the 'greening-up' method for detecting suitable images

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Pilot studies have demonstrated the potential for remote sensing techniques for soil organic carbon (SOC) mapping in exposed croplands. However, the use of remote sensing for SOC prediction is often hindered by disturbing factors at the soil surface such as photosynthetic active and nonphotosynthetic active vegetation, variation in soil moisture or surface roughness. With the increasing amount of freely available satellite data, many studies have focused on stabilizing the soil reflectance by building image composites that are generated using a set of criteria. These composites tend to minimize and cancel out the disturbing effects. Here we aim to develop a robust method that allows selecting Sentinel-2 (S-2) pixels that are not affected by the following disturbing factors: crop residues, surface roughness and soil moisture. We selected all S-2 cloud-free images covering the Loam Belt of Belgium from January 2019 to December 2020 (in total 38 images). We then built four exposed soil composites based on four sets of criteria: (1) NDVI < 0.25, (2) NDVI < 0.25 & Normalized Burn Ratio (NBR2) < 0.07, (3) the 'greening-up' period of a crop and (4) the 'greening-up' period of a crop & NBR2 < 0.07. The 'greening-up' period was selected based on the NDVI timeline, where 'greening-up' is considered as the last date of acquisition where the soil is bare (NDVI < 0.25) before the crop develops (NDVI > 0.6).,We then built a partial least square regression (PLSR) model with 10-fold cross-validation to estimate the SOC content based on 137 georeferenced calibration samples on the four above described composites. We obtained a non-satisfactory result for composites (1) to (3): R^2 = 0.22, RMSE = 3.46 g C kg^{-1} and RPD 1.12 for (1), R^2 = 0.19, RMSE = 3.43 g C kg^{-1} and RPD 1.10 for (2) and R^2 = 0.15, RMSE = 2.74 g C kg^{-1} and RPD 1.06 for (3). We, however, obtained a satisfactory result for composite (4): R^2 = 0.54, RMSE = 2.09 g C kg^{-1} and RPD 1.68. Hence, the 'greening-up' method combined with a strict NBR2 threshold allows selecting the purest exposed soil pixels suitable for SOC prediction. The limit of this method might be the surface coverage, which for a two-year period reached 47% of croplands, compared to 89% exposure if only the NDVI threshold is applied.