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# Topsoil properties retrieval using hyperspectral data in view of the forthcoming hyperspectral satellite missions: Italy case study

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Tillage operations in agricultural fields make topsoil properties, such as texture and soil organic content (SOC), uniform over the first 30 cm of soil layer. Hyperspectral remote sensing in the 0.4-2.5 $\mu$m has shown the capability to retrieve topsoil properties, so reducing the costs of collecting and interpreting soil samples, with great application potential, especially in the context of precision agriculture. In particular, VNIR-SWIR reflectance spectra of agricultural topsoil show characteristic spectral features connected to different chemical and/or mineralogical compositions or molecular groups with specific absorption bands. Variations in the reflectance intensity and shape of topsoil spectral curves could be due to differences in soil texture. The capability of accurately characterizing SOC and soil texture by hyperspectral data depends mainly on sensor's spectral and spatial resolutions: position and signal characteristics in relation to chemical absorption features (e.g., overtones of hydroxyl group, etc.) and to other characteristics not directly connected to chromophores.

The present study, carried out in the context of an ESA supported study for CHIME Mission Requirements Consolidation, explores the sensitivity of the topsoil properties estimation accuracy to spectral and spatial resolution. To this aim, AVIRIS-NG airborne data were acquired, in the spectral range 0.38 $\mu$m to 2.51 $\mu$m with 5 nm bandwidth and a pixel size of 3.7 m, in the framework of a field campaign carried out in the summer of 2018 near Grosseto (Italy). AVIRIS images were acquired over agricultural bare soil fields and soil samples were collected and then analyzed in the lab. The spatial structure of the soil properties was analyzed by means of semivariogram analysis of ground-collected data and ordinary kriging was used to set up top soil properties maps. Two different multivariate methods were then used for the calibration and validation of clay and SOC data estimation models: partial least square regression (PLSR) and random forest (RF). After that, PLSR and RF were applied to AVIRIS-NG reflectance imagery, as well as to data resampled to lower spatially and spectrally resolutions in order to verify the potential of the forthcoming hyperspectral missions in mapping topsoil properties. The results show the advantages of the high spectral resolution, noise equivalent spectral radiance (NESR) and signal-to-noise ratio (SNR), which will be available with the next generation of hyperspectral satellite sensors.

The advent of the hyperspectral satellite missions with 30 m of GSD, such as PRISMA (ASI, Italy), EnMAP (DLR-GFZ, Germany) and ESA Copernicus CHIME candidate missions, will certainly allow an improvement of the current agricultural topsoil properties retrieval in the near future.