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Estimation of soil textural properties at the field scale from airborne and satellite hyperspectral remote sensing

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The availability of detailed information on soil properties at the field scale currently constitutes a limiting factor for the application of precision agriculture, given the excessive cost of spatially dense soil sampling and analysis. Consequently, there is great interest in the development of low cost soil mapping methods such as satellite or airborne remote sensing.

Imaging spectroscopy of bare soils has been shown to have considerable potential for the estimation of properties such as soil texture, determined by clay, silt and sand fractions.

In the present study, images were acquired by airborne MIVIS (430 – 1270 nm; spatial resolution: 4.8 m) and space-borne CHRIS-PROBA (415 – 1050 nm; spatial resolution: 17 m) hyperspectral sensors, over bare soil fields in Maccarese, Central Italy, at different dates in 2010 and 2011. Concurrently, extensive soil sampling was carried out for lab determination of soil particle size fractions. Soil texture was related to the spectral signature of corresponding CHRIS or MIVIS pixels. Furthermore, the spectral behavior of the soil samples was studied in the lab, by using an spectroradiometer with 350-2500 nm range. Spectra, corrected and pre-treated, were used to calibrate prediction models for the estimation of clay, silt and sand, through partial least-square regression (PLSR). Datasets were used to study the impact of several factors on the accuracy of estimation of soil texture, such as spectral range and resolution, the effect of varying soil moisture and the use of measured or kriged ground data for the calibration of the PLSR models. The modality of setting up the calibration and validation data sets was also investigated, by employing either randomly selected or spatially separated datasets, the latter acquired over an adjacent field.

Accuracy of predictions was assessed from several statistics, such as bias, root mean square error of prediction (RMSEP) and ratio of performance to deviation (RPD).

The results highlight the importance of SWIR bands to estimate clay, silt and sand fractions in the spectroradiometer tests. The tests with satellite data show a sufficient accuracy of prediction (RPD>1.4) only for CHRIS-PROBA datasets, while the tests with MIVIS data, despite the presence of SWIR bands and a higher spatial resolution, show a poor accuracy of prediction. These results highlight the importance of the conditions in which the images were acquired, such as the pattern of soil moisture in the field, as well as the quality of the spectral data.