Soil texture predictions through Machine Learning from airborne radiometric data

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In this work we study the performances of an innovative non-linear analysis based on a Machine Learning (ML) algorithm for the correlation of soil texture, crucial information for precision agriculture, and Airborne Gamma Ray Spectroscopy (AGRS) data.

A total of 1469 geolocalized gamma spectra were collected in the Mezzano Valley (Ferrara, Italy) in a grid-like path of ~500 m spacing by means of an AGRS system mounted on a specifically designed aircraft. The pixels of the K and Th abundance maps derived from an Ordinary Kriging spatial interpolation of gamma data were split into 80% and 20% shares to be utilized as training and testing datasets for the Non-Linear ML (NLML) algorithm, which takes K and Th abundance data as inputs and outputs predictions for the clay and sand soil contents, utilizing data from a public soil texture map as ground truth. The linear and multilinear analyses utilized the same datasets as the NLML algorithm to compare performances.

The NLML results confirm the positive correlations between clay and both K and Th abundances also found from linear and multilinear analyses, attesting the high cation exchange capacity of clay minerals. Moreover, the NLML approach shows the best coefficient of determination R^2 values for the relations “Predicted fraction [%] = m · Ground truth fraction [%]”, where m = 0.94 for the clay soil fraction (R^2 = 0.52) and m = 0.92 for the sand soil fraction (R^2 = 0.49). Additionally, the NLML analysis predicts soil texture values in the USDA soil textural triangle more closely following ground truth data (as can be seen in the below figure), being more easily generalizable to very different soil types.