EGU22-361
https://doi.org/10.5194/egusphere-egu22-361
EGU General Assembly 2022

Mapping soil texture with airborne gamma ray spectroscopy

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Soil texture is a key information in precision agriculture for improving soil knowledge and crop performances. A precise mapping of its variability is thereby imperative for rationally planning cultivations and targeting interventions. Unlike direct soil texture measurements that are punctual, destructive, and time-consuming, remote sensing surveys can give widespread, non-invasive, and fast indirect evidence of clay, silt, and sand content. In this study we investigate the performance of Airborne Gamma Ray Spectroscopy (AGRS) for discriminating different texture classes in the ternary diagram of soil texture.

The Mezzano valley (Ferrara, Italy), a 180 km^2 rural area reclaimed in the last century, represents an extraordinary benchmark for validating our method. This area, for which a public soil texture map at 1:50000 scale and a spatial resolution of 500 m is available, was scanned by an AGRS system mounted on a dedicated aircraft. The aircraft flew over the study area in a grid-like path of ~500 m spacing, collecting 1469 geolocalized spectra. The K and Th punctual measurements were spatially interpolated by Ordinary Kriging to elaborate K and Th maps with the identical spatial resolution of the soil texture map. Simple and multiple linear correlations, as well as a non□linear Machine Learning algorithm, were then performed between gamma and soil texture data.

The obtained results by a simple linear regression analysis highlight a moderate positive (negative) correlation between clay (sand) content and K and Th abundances. Multiple linear regressions show a similar trend, with the limitation that the calculated clay, silt, and sand values populate the soil texture ternary diagram in a straight line. Finally, we demonstrate that the most accurate reconstruction of soil texture values is obtained by a non-linear fitting based on the Machine Learning algorithm.