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Clay content mapping through integration of geophysical proximal and remote sensing data

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Soil sustainable exploitation planning and land resource evaluation require up-to-date and accurate maps of soil properties. In that respect, geophysical techniques present particular interests given their non-invasiveness and their fast data acquisition capacity, which permit to characterize large areas with fine spatial and/or temporal resolutions. We investigated the relevancy of combining data from airborne hyperspectral (Hs), electromagnetic induction (EMI) and far-field ground-penetrating radar (GPR) for mapping soil properties, in particular soil clay content, at the field scale. Data from the three techniques were acquired at a test site in Mugello (Italy) characterized by relatively strong spatial variations of soil texture. Soil samples were collected for determining actual clay contents. For the frequencies used in this study (200-2000 MHz), the GPR surface reflection is mainly determined by soil dielectric permittivity, itself primarily influenced by soil moisture. In contrast, EMI is mostly sensitive to soil electrical conductivity, which integrates several soil properties including in particular soil moisture and clay content. Taking advantage of the complementary information provided by the two instruments, the GPR and EMI data were combined and correlated to local ground-truth measurements of clay content to provide high-resolution clay content maps over the entire field area. Besides, a relationship was also observed between Hs data and clay content measurements, which permitted to produce a Hs-derived clay content map. EMI-GPR and Hs maps showed close spatial patterns and a relatively high correlation was observed between both clay content estimates, as well as between clay content estimates and ground-truth clay content measurements. Future analyses will entail more advanced Bayesian data fusion techniques for combining EMI-GPR and Hs information. These results demonstrated great promise for integrated, digital soil mapping applications.