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Mineral classification and quantitative chemical analysis of Israeli soils using hyperspectral longwave infrared (LWIR) ground-based data

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Soil is a complex material that is extremely variable in its physical and chemical properties.
Soil quantitative analysis using the reflected solar radiation region is well known and covered in the literature, proving to be a powerful tool, from laboratory to field and airborne domains. As the hyperspectral technology in the emitted radiation in the LWIR region is entering into the field of terrestrial mapping, it is important to study the potential of this technology for soil mapping. Analyzing soil mineralogy and chemical attributes from the emitted radiation in the LWIR region (8.0–13 μm) is thus the purpose of this study. In general, soil mineralogy is an important factor to understand soils' behavior, quality and growth potential. Most common minerals in soils—quartz, clay minerals and carbonates—present fundamental spectral features in the thermal infrared region (mainly in the LWIR). Whereas quartz is featureless in the optical region but very active in the LWIR region, the new technology can provide new information about one of the most abundant minerals in the Earth's crust. Applying a chemometric analysis to ground- and air- based LWIR data is an important issue that have not been considered yet. A set of ninety soil samples from the Israeli Legacy Soil Spectral Library were selected to examine the potential of the LWIR region for soil analysis under pseud field condition. The soils underwent a comprehensive chemical determination of more than seventy soil attributes based on common methods in soil science. In addition, a complete soil mineralogy determination using semi quantitative XRD was executed. Ground-based hyperspectral LWIR images were acquired with the hyperspectral sensor Telops' Hyper-Cam. The emissivity spectra of all soil samples were calculated and analyze. The soil minerals quartz, clay minerals and carbonates, and their abundance, from major to minor, in all soil sample were determined. The resulted mineral content was correlated with the chemical elements abundances and mineral composition, obtained from chemical analyses. We also applied a "deep learning" approach in which the soil emissivity spectra were correlated with the chemical information, using a "data mining" machine term "PARACUDA-II®, to extract "soil spectral models" for each chemical attribute. The analyses revealed significant models for many soil such as: SiO_2, $Fe2O_3$, CaO, TiO_2, LOI, Specific surface area, Clay content and aggregate size distribution.