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Clay minerals abundances estimation under hyperspectral laboratory data

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In urban areas, mapping of clay mineralogy is essential to survey and predict ground instability hazards. Swelling areas are detected from clay maps and are used to cope with damages caused by expansive soils on infrastructures. Clay minerals in temperate zone soils are mainly composed of smectite, illite and kaolinite. Smectites highly contribute to soil swelling. Geotechnical engineering practices for clayed soil mapping are expensive and time-consuming. They are based on field and extensive laboratory studies. Then, spatial distribution of clay is assessed using aerial photographs and low-scale geological maps. Thereby, small heterogeneities in geological features are rarely detected, and spatial information remains qualitative.

Imaging spectroscopy is an alternative to conventional methods for clay mapping. Several studies reveal the interest of reflectance data, using specific absorption features of clay minerals. Recent development in unmanned aerial vehicles (UAV) offers new opportunities for carrying hyperspectral cameras in reflective domain [0.4 – 2.5 μm], and obtain data with higher signal to noise ratio and spatial resolution. These advances open new perspectives for accurate and cheaper clay mapping based on the clay specific absorptions features overlay on the soil reflectance spectrum on the reflective range [0.4 - 2.5 μm].

Usually, mineralogic clays are intimately mixed and thus it is of importance to understand how the spectral and spatial variabilities can vary with the change of scale. This paper presents an experiment to tackle this problem. This originality of this study is it allows us to evaluate the influence of the change of scale from laboratory (0.75 mm) up to the UAV one (few cm) on the clay discrimination.

The experiment is composed of a light source illuminating a sample of size 20*20 cm² placed on a translation setup. The reflected signal is acquired by two hyperspectral cameras (HySpex - Norsk Elektro Optikk - SWIR-320m-e and VNIR-1600 cameras) allowing to cover the entire reflective domain 0.4-2.5 μm . By translating the sample, a full hypercube image is acquired with a spatial resolution of 0.75 mm.

53 samples were prepared with different abundances of pure illite, kaolinite, montmorillonite (smectite) mineral clay and Fontainebleau sand (quartz > 90%). It allows use to analyses binary mixture of clays, but also mixture of three minerals (2 clays and sand).

The acquired data are then preprocessed to overcome the non uniformity of the incident irradiance, instrument noise and small-BRDF-effect. Different data deconvolution are tested: continuum removal and derivatives. Then different results are presented:

- Evaluation of the change of scale on the spatial variability of the spectral reflectance
- Evaluation of the change of scale on the unmixing process using methods from literature.

Fully constraint linear unmixing on binary samples have scores improved when degrading spatial resolution. Continuum removed and derivative data reach a minimum score of 10 % error (known endmembers, binary mixtures).