ID de Contribution: **106** Type: **Talk**

Study of the impact of sources of variability on the mineralogical characterization of soils by hyperspectral imagery

jeudi 22 mai 2025 10:45 (15 minutes)

This work aims to improve hyperspectral image processing methods for the identification and quantification of soil minerals. These methods allow the radiometric signal measured for each pixel of the image to be interpreted in terms of physico-chemical properties. Due to the limited spatial resolution of the images, the reflectance spectrum corresponding to a given pixel is generally a mixture of supposedly pure spectra from different materials known as endmembers. In practice, endmember spectra are not unique due to matrix effects such as surface moisture content or grain size, and the measurement configuration that may change from one scene to another [1].
Two main families of models are used to process hyperspectral images: physics-based models [2] and data-driven models [3]. Physics-based models make it possible to understand the spectral variability of the data, but they require knowledge of the intrinsic optical properties of the soil components, which are generally unknown. Data-driven models seek correlations between reflectance spectra and the physico-chemical properties of soils, but their "black box"nature often makes them difficult to interpret and to generalize to different contexts.
This work combines the advantages of physics-based and data-driven models in order to improve the interpretation of hyperspectral imagery with respect to different sources of spectral variability. Emphasis will be placed on matrix effects due to soil moisture content and grain size, which are among the most important and constraining sources of variability in soil mineralogical composition analysis. We will study their impact on absorption band parameters (amplitude, position, shape, asymmetry, etc.) of minerals obtained by spectral deconvolution methods. In particular, we will analyze the detection limits of the absorption bands of certain minerals of interest as a function of soil surface moisture.

[1] Borsoi R.A., Imbiriba T., Bermudez J.C.M. et al. (2021), Spectral variability in hyperspectral data unmixing: A comprehensive review, IEEE Geoscience and Remote Sensing Magazine, 9(4):223-270.

[2] Dupiau A., Jacquemoud S., Briottet X. (2023), Reflectance of wet natural soils in the solar domain: contributions and limitations of physical models, in Radiometry of wet surfaces. When water matters (L. Simonot, Ed.), EDP Sciences, pp. 11-26.

[3] Chen J., Zhao M., Wang X. et al. (2023), Integration of physics-based and data-driven models for hyperspectral image unmixing: A summary of current methods, IEEE Signal Processing Magazine, 40(2):61-74.

Speaker information

PhD 2nd year

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Classification de Session: Exploring Surfaces and Skies: Planets, Moons, and Earth

Classification de thématique: Earth, Environment and Space Sciences: Remote Sensing