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Laboratory hyperspectral imaging a powerful tool for a fast-high-resolution analysis of natural sample: application to sediment core

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The aim of this presentation is to overview some applications of hyperspectral imaging for sediment core analysis in paleo-environmental studies. The increase of the sensibility and the resolution of sensors, as well as the development of performant data processing methods allow the analyze of natural sample in a very informative (chemical, physical and biological) and time effective way. Hyperspectral imaging is a method at the interface of spectroscopy and imaging where a spectrum is obtained for each pixel in the sample image. In laboratory conditions, many spectroscopic range can use this kind of method, from the X-ray to the infrared, also fluorescence and Raman. The dataset obtains is called a datacube due to his three dimensions (two spatials and one spectral), a fourth temporal dimension can be added.

For that, both methods of image processing and spectral processing methods (chemometrics) can be used independently or together to improve sample knowledge. Quantitative modelling allows to establish a relationship between the spectra and destructive analysis (Particle Size Distribution, RockEval). These supervised models can then theoretically use on other samples without any sampling. Known structures can be discriminating accurately with classification methods, for example lamina or floods, with the labeling of some pixels to a known group. Unknown ones defined by chemical, physical or biological compounds can be determinates with similar methods and then explained by environment hypothesis. For these chemometrics methods, discriminant spectral wavelengths are identified and therefore sediment properties (chemical, physical or biological). Image processing of the core image or of the quantitative or qualitative map can be used to reveal surface structures (instant event, lamina) or local anomalies (coal, grain). The image resolution allows to see structures that the eye cannot see precisely, as infra-millimeter lamina. The use of spectro-spatial methods together and a time model allow to have a chronicle of structural sediment compositions and events.

In this study, we use visible and near infrared hyperspectral imaging (pixel sizes: 60 and 240 micrometers) and X-Ray Fluorescence spectroscopy (240 micrometer) to analyze the lake Le Bourget sediment core (Savoie, France). Quantitative prediction models have been made for LOI550, Particle Size Distribution and fractions, some RockEval variables with correlation coefficients of the model upper than 0.8 and consistent uncertainties. Lamination counting was also realized with spectral classification methods and image processing, and this is in agreement with eye counting. With these two methods, seasonal variations can be separated in the eutrophic part of the core and compare. Hyperspectral imaging can also be used to find the optimal sampling areas for routine destructive analysis and to create predictive models. The use of several sensors, with data fusion methods, has shown that the increase of the amount of spectro-chemical information allowed to improve the robustness of predictive models. Hyperspectral imaging present already many possibilities to improve our knowledge on natural sample.