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Hyper-spectral imaging: A promising tool for quantitative pigment analysis of varved lake sediments

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Varved lake sediments are good archives for past environmental and climate conditions from annual to multi-millennial scales. Among other proxies, concentrations of sedimentary photopigments have been used for temperature reconstructions. However, obtaining well calibrated annually resolved records from sediments still remains challenging. Most laboratory methods used to analyse lake sediments require physical subsampling and are destructive in the process. Hence, temporal resolution and number of data are limited by the amount of material available in the core. Furthermore, for very low sediment accumulation rates annual subsampling is often very difficult or even impossible.

To address these problems we explore hyper-spectral imaging as a non-destructive method to analyse lake sediments based on their reflectance spectra in the visible and near infrared spectrum. In contrast to other scanning methods like X-ray fluorescence, VIS/NIR reflectance spectrometry distinguishes between biogeochemical substances rather than single elements. Among others Rein (2003) has shown that VIS-RS can be used to detect relative concentrations of sedimentary photopigments (e.g. chlorins, carotenoids) and clay minerals.

In this study hyper-spectral imaging is used to infer ecological proxy data from reflectance spectra of varved lake sediments. Hyper-spectral imaging permits the measurement of an entire sediment core in a single run at high spatial (30x30μm/pixel) and spectral resolutions ($\sim$2.8nm) within the visual to near infrared spectrum (400-1000nm). This allows the analysis of data time series and spatial mapping of sedimentary substances (e.g. chlorophylls/bacterio-chlorophylls and diagenetic products) at sub-varve scales.

The method is demonstrated on two varved lake sediments from northern Poland showing the distributions of relative concentrations of two types of sedimentary pigments (Chlorophyll-a + derivatives and Bacterio-pheophytin-a) within individual varve years. The relative concentrations from the spectral data set have then been calibrated with absolute concentrations derived by High-Performance-Liquid-Chromatography (HPLC). This results in very high-resolution data sets of absolute sedimentary pigment concentrations suitable for the analysis of seasonal pigment variations.