Poster

High-resolution hyperspectral imaging (380-1000 nm) of varved lake sediments

Martin Grosjean, Wojtek Tylmann and Benjamin Amann

In order to calibrate biogeochemical lake sediment proxy data to meteorological time series (calibration-in-time; i.e. 'tree-ring approach') and to, finally, make quantitative high-resolution climate reconstructions an enormous amount of sedimentary proxy data is required. This is particularly the case in varved sediments that offer the unique opportunity to investigate climate variability and phenomena at the interannual, seasonal or even meteorological time scales.

In this context, high-resolution non-destructive scanning and imaging techniques (µXRF, spectrocolorimetry in the visible range VIS-RS, colour indices L*, gray values from X-ray radiography, etc.) are fundamental and the only way to acquire large data sets at sub-varve resolution (typically 100 µm to 1 mm).

Spectrocolorimetric techniques in the visible range VIS-RS (380-730 nm) have the great advantage that they provide direct species-specific information about organic and lithogenic sediment compounds (e.g., illite, chlorite and mica, photopigments, carotenoids, etc.), which makes the interpretation of the sediment formation processes and their relation to climate more reliable. In recent studies, scanning VIS-RS data have shown to be most suitable for calibration, validation and quantitative climate reconstruction from varved and non-varved lake sediments (von Gunten et al., 2009, revised; Trachsel et al., 2010; Elbert et al., 2012, in review). However, the disadvantage of the currently used instruments is the relatively coarse sensor field (> 2 mm) which compromises the potential advantage of varved sediments and in particular the information at sub-varve scales.

Here we present a prototype of a novel hyperspectral sediment core scanner and examples with data from biogenic varves (lakes in Poland) and clastic varves (lakes in the Swiss Alps). The core scanner consists of a hyperspectral camera that takes spectral scans at 3 nm resolution in the range between 380-1000 nm. The pixel size can be as small as 40 x 40 µm providing typically several data points for both laminae couplets in the varves in a 2D view (xy of the split sediment core surface); irregular or tilted (i.e. not perpendicular to the scan direction) bedding of individual varves is not a problem. The scan field has a width of a maximum of 6 cm. The moving tray with the sediment core is synchronized with the hyperspectral scanner and allows scanning of 1.40 m long cores.

References

von Gunten, L., Grosjean, M., Kamenik, K., Fujak, M., Urrutia, R. (revised). Calibration of bio-geochemical and physical proxies from non-varved lake sediments with climate data: methodology and case studies. Journal of Paleolimnology.

Elbert, J., Grosjean, M., Fischer, D., von Gunten, L., Urrutia, R., Wartenburger. R., Rein, B. (in review). Systematical testing of in-situ reflectance spectroscopy (VIS-RS 380-730 nm) as a novel high-resolution scanning tool for biogeochemical analysis of lake sediments. Journal of Paleolimnology.

Elbert, J., Grosjean, M., von Gunten, L., Urrutia, R., Fischer, D., Wartenburger, R., Ariztegui, D., Fujak, M., Hamann, Y. (2012). Quantitative high-resolution winter (JJA) precipitation reconstruction from varved sediments of Lago Plomo 47°S, Patagonian Andes, AD 1530 – 2001. The Holocene.

Trachsel, M., Grosjean, M., Schnyder, D., Kamenik, C., Rein, B. (2010). Scanning reflectance spectroscopy (380–730 nm): a novel method for quantitative high-resolution climate reconstructions from minerogenic lake sediments. Journal of Paleolimnology 44, 979-994. DOI 10.1007/s10933-010-9468-7.

von Gunten, L., Grosjean, M., Rein, B., Urrutia, R., Appleby, P. (2009). A quantitative high-resolution summer temperature reconstruction based on sedimentary pigments from Laguna Aculeo, Central Chile, back to AD 850. The Holocene 19/6, 873-881.

Keynote

Past climates reconstruction: from transfer functions to data assimilation in process models

Joel Guiot

Quantitative palaeoclimate reconstruction is evolving. The statistical transfer functions calibrated on modern data sets and applied to fossil assemblages have provided a number of valuable results. The concept is arrived at its limit. Exogenous variables (e.g. atmospheric CO_2 ratio) can bias the reconstructed signals. Replacing statistical black boxes by inversed mechanistic models of vegetation is a solution that has already proven itself (Guiot et al., 2009). It also provides an elegant solution for a multi-proxy approach (e.g. pollen, lake levels, stable isotopes), which is essential given that the biological assemblages are the result of a combination of climatic factors. At the same time, assimilation of climate reconstructions in the climate models has been very powerful to build physically consistent climate fields (Widmann et al., 2010). Methodological developments are still needed to complete this type of approach. In particular, by coupling climate models to proxy models, proxies can be assimilated directly without going through statistical reconstructions, which are often subject to biases. In conclusion, as no approach is perfect, we recommend to use all of these approaches in parallel (including the transfer functions) to better understand the uncertainties associated with reconstructions. This keynote will present the evolution of the climate reconstructions from simple statistical techniques to complex model inversion and will conclude with some perspectives.

References

Guiot, J., Wu, H. B., Garreta, V., Hatte, C. & Magny, M., 2009. Climate of the Past 5, 571-583

Widmann, M., Goosse, H., van der Schrier, G., Schnur, R., Barkmeijer, J., 2010. Climate of the Past, 6, 627-644