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Invited talk

The CLIMPOL project: toward quantitative paleoclimate reconstructions from lake sediments in northeastern Poland

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The project CLIMPOL (Climate of northern Poland during the last 1000 years: Constraining the future with the past) aims at a quantitative reconstruction of climate change based on varved sediments from Lake Żabińskie in northeastern Poland. The lake is located in the Masurian Lakeland (54°07'54."N; 21°59'01.1"E) and presents features typical for kettle-hole lakes, i.e. small surface area (41.6 ha) and considerable depth (44.4 m). The reconstructions are based on high-resolution analyses using precise chronology and biological, sedimentological and geochemical proxies. The results are calibrated with a modern training set of lakes (transfer function) and calibration-in-time approach, and validated with early instrumental and documentary data available.

During a three-year long observation period we investigated limnological and hydrochemical conditions within the water column as well as recent sediment fluxes to understand the relationship between the lake water properties and the sediment formation processes. These observations indicated considerable seasonal variability in the fluxes of total organic carbon, biogenic silica and calcite. The annual sedimentation model was established based on the sediment composition variability and used for the interpretation of laminations preserved in the sediment record. Microscopic investigations of thin sections proved the annual character of these laminations. Three varve microfacies were distinguished along the sediment profile showing a different number of calcite laminae interbedded with diatoms, organic detritus and minerogenic admixtures. The chemical composition inferred from high-resolution XRF measurements allowed for the recognition of individual seasons within one varve. The varve chronology for the last millennium had very small uncertainty (1-2%) and was validated with independent dating methods, i.e. the ^{137}Cs activity peaks, the Askja tephra horizon and 32 AMS ^{14}C dates of terrestrial macrofossils distributed along the sediment profile. Overall, the whole dataset is consistent and highlights the reliability of the chronology with the accuracy of a decade.

The Polish training set for biological proxies (chironomids, chrysophytes, diatoms, pollen) consists of sediment trap and surface sediment samples from 50 lakes in northern Poland. Multivariate statistical analyses revealed the most important variables for the chironomid and chrysophyte assemblages. Transfer functions were developed and applied to an annually-varved sediment core from Lake Żabińskie for the period AD 1000-2010. As a reliability test, we reconstructed mean August temperatures since AD 1886 and compared the reconstruction with instrumental data for the Masurian Lakeland. This showed that inferences obtained with the training set were accurate at near-annual resolution and over decadal scales. The transfer function was then applied to the chironomid assemblages downcore to reconstruct the variations in temperature over the past millennium and key periods of climate change were reconstructed (MCA, LIA and 20C). Furthermore, statistical analysis of the chrysophyte data set revealed that the number of days with water temperature below 4°C (DB4°C) in the epilimnion, which is related to cold-season air temperature, is the most important variable for the chrysophyte assemblages. Striking correspondence between the DB4°C reconstruction and the combined volcanic and solar forcing prior to the 20th century suggests that winter climate in Poland responds mostly to natural forced variability. Very strong volcanic eruptions lead to particularly long winters while variability in Total Solar Irradiance plays a minor role.