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Multiple climatic signals inferred from the varved sediments of a coastal lake in the Canadian High Arctic

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The Arctic is extremely sensitive to climate change, and an influential part of the global climate system. However, the assessment of climate change and impacts from the Arctic remains a challenge mainly due to short and sparse meteorological records. In this context, data from natural paleoclimate archives are fundamental to place climate variability into perspective and assess the sensitivity of Earth's climate to natural and anthropogenic forcings. In particular, Arctic lakes are excellent potential archives. They are sensitive to extreme seasonal variations in surface processes and have a limited direct human impact. Nevertheless, the study of Arctic lakes is an analytical and technical challenge because: (i) limnological information are often lacking due to difficult accessibility; (ii) 210Pb inventories are low and terrestrial macrofossils for 14C dating are rare, which limits the development of precise sediment chronologies; and (iii) sediment accumulation rates are often low, which may restrict the temporal resolution and length of the paleoclimate records.

Here, we present a high-resolution record from the varved sediments (annual laminations) of a saline coastal lake located in the Canadian High Arctic (unofficial name Chevalier Lake; Melville Island, NT). The particular interest of this location is the catchment area: 152 times larger than the lake area (Ac = 350 km^2; AL = 2.3 km^2). This particularity generates high sedimentation rates, atypical of previously studied arctic lakes.

Two sediment cores were recovered from the centre and a more proximal zone of the lake. We used microstratigraphy supported by X-ray fluorescence data (Zr/K for particle size, Fe/Rb for the winter clay cap distinction) to develop a precise and cross-dated varve chronology covering the last 400 years. Dating of the uppermost section could be validated with preliminary 137Cs data.

Stratigraphical analysis reveals the presence of three sediment units within the meter-long sediment sections with: (i) thick coarse-silt/sand deposits interpreted as short but extreme rainfall-induced events; and (iii) sediment couplets interpreted as a varve year associated with spring snowmelt runoff followed by quiescent conditions. Typical varves are associated with distinct sediment units such as a spring nival unit characterized by light-grey fine silts, a summer rainfall unit characterized by dark-grey coarse silts, and a systematic oxidised (Fe oxides) clay cap following calm winter conditions when ice cover is present. Interestingly, results also reveal that varved sections have similar thicknesses in the two cores, while layers interpreted to be generated by short extreme events are much thicker in the proximal core.

From this research we conclude that: (i) the thickness and internal structure of the varves can be used to assess multiple seasonal climatic changes and impacts on the lake catchment; and (ii) flood-induced layers can be used to reconstruct the history of extreme climate events in this part of the Arctic over the last 400 years.