Water isotope proxies and forward modeling in lakes with contrasting residence times yield estimates of Arctic Holocene precipitation seasonality and amount

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Arctic precipitation is predicted to increase in the coming century, due to greater northward atmospheric moisture transport and evaporation from ice-free Arctic seas. These two mechanisms have differing seasonal expressions: northward moisture transport dominates during the summer, whereas local evaporation occurs mainly during fall and winter. Quantifying precipitation seasonality during previous warm periods would aid development of a mechanistic understanding of the dynamics controlling Arctic precipitation. We present two methods to reconstruct Arctic precipitation seasonality: one using stable hydrogen isotopes (δ^2H) in aquatic plant waxes in proximal lakes with contrasting water residence times, and the other using aquatic plant wax δ^2H and chironomid chitin $\delta^{18}O$ from the same lake sediment samples, proxies that are produced during different seasons. We apply these methods near Disko Bugt, western Greenland.

Catchment hydrology suggests that growing season lake water δ^2H in one of our study lakes reflects summer precipitation δ^2H and the other reflects winter-biased precipitation δ^2H. Aquatic plant leaf wax δ^2H in the "summer lake" declines steadily throughout the Holocene, from –205‰ at 9 ka to –230‰ at 2 ka. In contrast, aquatic plant leaf wax δ^2H in the "winter lake" is 100‰ ^2H-depleted from 6 to 4 ka compared to the early and late Holocene. Chironomid chitin $\delta^{18}O$ in the "winter lake", however, becomes ^{18}O-enriched during the middle Holocene, in direct contrast with the leaf wax δ^2H from the same archive. We use the Environment sub-model of LakePSM, a lake proxy system model in PRYSM, to assess the changes in precipitation amount and isotopic composition required to cause our reconstructed water isotope trends. We interpret these records to reflect an increase in both summer and winter precipitation amount during the middle Holocene. Increased winter precipitation is coincident with minimum sea ice extent in and maximum oceanic heat transport to Baffin Bay, both of which would have caused greater winter ocean evaporation and a concomitant increase in terrestrial precipitation. Increased summer precipitation may have occurred in response to increased northward atmospheric moisture transport. These methods may be applied to other sites with strong seasonal precipitation isotope variability and minimal lake water evaporative enrichment.