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Holocene record of glacier variability from lake sediments reveals tripartite climate history for Svalbard

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The Arctic is responding sensitively to ongoing global climate change, warming and moistening faster than any other region on the planet. Holocene proxy paleoclimate time series are increasingly used to put this amplified response in perspective by understanding Arctic climate processes beyond the instrumental period. Glaciers rapidly respond to climate shifts as demonstrated by their current demise around the world. This response has a composite climate signature, marked by shifts in hydroclimate (winter precipitation) as well as (summer) temperature. Attendant changes in glacier size are recorded by variations in glacigenic rock flour that may be deposited in downstream lakes. Here, we present a Holocene reconstruction of glacier activity, based on sediments from Hajeren, a glacier-fed lake on northwest Spitsbergen in the High Arctic Svalbard archipelago. Owing to undisturbed sediments and robust age control, we could resolve variability on a sub-centennial scale. To ensure the accurate detection of glacier activity, we applied a toolbox of physical, magnetic and geochemical proxies in conjunction with multivariate statistics. Our findings indicate a three-stage Holocene climate history for Svalbard, driving by melt water pulses, episodic Atlantic cooling and a decline in orbitally driven summer insolation. Correspondence between inferred advances, including a Holocene glacier maximum around 9.5 ka BP, suggests forcing by the melting LIS during the Early Holocene. Following a late Holocene Thermal Maximum around 7.4 ka BP, glaciers disappeared from the catchment. Glaciers reformed around 4.2 ka BP during the regional onset of the Neoglacial, supporting previous findings. This transition did, however, not mark the onset of persistent glacier activity in the catchment, but a series of centennial-scale cycles of growth and decay, including events around 3.3 and 1.1 ka BP. As orbitally driven insolation declined towards the present, the glaciation threshold progressively lowered. The forcing behind these advances remains elusive, but their agreement with other glacier reconstructions from the region indicates a North Atlantic signature. Prolonged glacier activity commenced after 0.7 ka BP during the Little Ice Age, in agreement with other evidence from Svalbard. Comparatively high reconstructed temperatures during this timeframe suggest that glacier growth was precipitation-driven. Our findings highlight the sensitivity of small glaciers to climate shifts, demonstrating their potential to resolve centennial-scale perturbations. Moreover, this study underlines the value of lake sediments from glacier-fed lakes in understanding Holocene climate in the Arctic.