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Inferring Holocene thermal maximum temperatures for central Iceland from glaciological modelling and empirical evidence

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Ice- and marine-core paleoclimate records furnish a picture of high-latitude Northern Hemisphere climate characterized by a pronounced warm period in the early to mid Holocene. Questions remain as to the effects of Holocene climate on the fluctuations of glaciers and ice caps, as the relationship between large-scale climate reconstructions and detailed terrestrial environmental records has not been clearly established. In this study, we compare the history of Langjökull ice cap, central Iceland, as interpreted from the sediments of proglacial lake Hvítárvatn, to the results of forward modelling of the ice cap driven by representations of Holocene climate. We thereby examine the climate conditions under which the simulated glacier fluctuations are compatible with the local terrestrially-derived empirical record. We use a hydrologically-coupled shallow-ice dynamics model, driven by air temperature fluctuations following the NGRIP oxygen isotope record, referenced to a spatially-resolved 1961–1990 temperature map of the area. A reference precipitation field is derived from modern winter balance measurements. Under certain climate conditions, the simulated Langjökull reaches its present size from ice-free conditions in roughly 2000 years, and nearly all simulations sustain a period of 3000–6000 years of ice-free conditions in the mid-Holocene. Qualitative consistency with the empirical record is obtained for Holocene Thermal Maximum (HTM) temperatures $\geq 3^{\circ}$C relative to present-day, and HTM temperatures

of up to 5°C cannot be ruled out on the basis of our modelling. Such temperatures would imply largely ice-free conditions for Iceland in the mid Holocene.