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Abstract

This study presents the reconstruction of palaeoclimatic conditions in Northern Iceland for the Holocene based on investigations of environmental climate proxy indicators. The aim was to provide a high-resolution terrestrial reference for the North Atlantic atmospheric and oceanic circulation system.

The period since the mid-19th century, when instrumental meteorological recording started in Iceland, has shown climate conditions close to, or even at, both Holocene pessimum and optimum levels. The 19th century part of the Little Ice Age represents a thermal minimum, whilst temperatures during the 1930s were close to the optimum thermal conditions that can be reconstructed for the Holocene.

A simple model describing the relationships between the extent of the sea-ice in the northern North Atlantic, temperature and precipitation conditions in Northern Iceland, and the equilibrium line altitudes of the glaciers in this area has been developed, providing a basis for quantitative palaeoclimatic reconstructions since the Preboreal.

Absolute calibration of temperature - vegetation relationships in the period of meteorological observations is not possible as not climate but the intensive human impact on the environment has been the predominant factor governing post-settlement vegetation distribution in Iceland. The variations of the upper limit of tree or shrub birch (Betula pubescens) growth (= shrub-line) in the period before ca. 900 AD can, however, provide relative proxy data on temperature variations for palaeoclimatic reconstructions.

Glaciers in Northern Iceland had reached extents at or within their Little Ice Age limits before ca. 9200 BP. Post-Preboreal glacier extents were, at most, only in slightly advanced positions relative to those of the Little Ice Age. For the time since the Preboreal, seven glacier advances pre-dating the Little Ice Age have been found. These have been dated to between ca. 5600 BP and ca. 5200 BP (Vatnsdalur I), before ca. 5200 BP (Lambárdalur I and II), before ca. 4700 BP (Þverárdalur), after ca. 3600 BP (Kóngsstaðadalur), and between ca. 3500 BP and ca. 2850 BP (Vatnsdalur II). (Throughout this work, BP refers to uncalibrated radiocarbon years, calibrated ages are given as cal BP.)

A reconstruction of the variations of Betula pubescens at the ecological upper limit of tree or shrub birch growth in Northern Iceland, covering the time since ca. 9200 BP, shows the

highest position of the shrub-line between ca. 6700 BP and ca. 6000 BP. This can be distinguished from a low position from ca. 6000 BP to ca. 5600 BP, and a very pronounced minimum around ca. 3300 BP. These depressions of the shrub-line can be correlated with evidence for glacier advances and increased geomorphological activity on slopes in Northern Iceland.

Radiometrically and tephrochronologically dated glacier advances in Northern Iceland mark thermal minima since the Preboreal, with climate conditions comparable to the extremes in the second half of the 19th century. The available vegetation data, however, does not allow to reconstruct the full extent of the positive temperature variation. For the Holocene thermal optima temperatures are, therefore, assumed to have been at least as high as during the 1930s as the warmest part of the period of instrumental meteorological recording. This gives a minimum of ca. 3 K for the range of Holocene temperature variation, which was accompanied by a doubling in precipitation from the thermal minima to the maxima.

The available dating control for the pre-19th century Holocene as yet only defines rather long intervals during which climatic conditions showed a pessimum or a positive variation. The temperature record for the last ca. 150 years demonstrates, however, that minima and maxima can occur within few decades, which is beyond the present temporal resolution of radiocarbon dating in Northern Iceland.

A tephrochronological record comprising ca. 70 tephra layers for the time since ca. 9700 BP has been established in Northern Iceland. The tephras have been geochemically fingerprinted by means of electron microprobe analyses. The age control is provided by multiple radiocarbon dates. The new detail available in the tephrochronological record of Northern Iceland provides an important control for radiocarbon dated chronologies of Holocene environmental and climatic change, and a high-resolution series of time markers for dating and correlating proxy records from different environments both within Northern Iceland and on a larger North Atlantic scale.

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