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Consistently dated records from three Greenland ice cores reveal regional millennial-scale isotope gradients with possible Heinrich Event imprint

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We here present records from the NGRIP, GRIP and GISP2 ice cores tied to the same chronology for the past 104 ka at an unprecedented time resolution. The three ice cores have been linked by matching distinct peaks in volcanic proxy records and other impurity records from the three ice cores, assuming that these layers of elevated impurity content represent the same, instantaneous event in the past at all three sites. In total there are more than 900 identified marker horizons between the three cores including previously published match points, of which we introduce a minor revision. Our matching is independently confirmed by new and existing volcanic ash layers (tephra). The depth-depth relationship from the detailed matching is used to transfer the most recent and widely used Greenland ice core chronology, the GICC05modelext timescale, to the two Summit cores, GRIP and GISP2. Furthermore, we provide gas chronologies for the Summit cores that are consistent with the GICC05modelext timescale by utilizing both existing and new unpublished gas data.
A comparison of the GICC05modelext and the former GISP2 timescale reveals major discrepancies in short time intervals during the glacial section. We detect a pronounced change in the relative annual layer thickness between the two Summit sites and NGRIP across the Last Glacial termination and early-to-mid Holocene, which can be explained by a relative accumulation increase at NGRIP compared to the Summit region as response to the onset of the Holocene and the climatic optimum. Between stadials and interstadials we infer that the accumulation contrast typically was nearly 10% greater at Summit compared to at NGRIP.
The δ^{18}O temperature-proxy records from NGRIP, GRIP and GISP2 are generally very similar and display a synchronous behavior at climate transitions, but the δ^{18}O differences between Summit and NGRIP is slowly changing over the last glacial-interglacial cycle superimposed by abrupt millennial-to centennial scale anomalies. We suggest that the latitudinal δ^{18}O gradient during the glacial is result of 1) relatively higher degree of precipitation with a Pacific signature at NGRIP, 2) increased summer bias at Summit, and 3) enhanced Raleigh distillation process due to and increased source-to-site distance, and we conclude that this is governed by North American Ice Sheet (NAIS) volume and North Atlantic sea-ice extent and/or sea-surface temperatures (SST) at orbital timescales, while changing sea-ice extent and SSTs are the driving mechanisms on shorter timescales. We assert that δ^{18}O difference maxima can be linked to Heinrich Events, which is associated with southwards expansion of polar waters and low SSTs in the North Atlantic, and ths propose a direct link between the marine realm and the Greenland ice core records.

The work presented is under review for publication in Quaternary Science Reviews.
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