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Feedbacks Between Sea Ice Cover and Precipitation Sources: Physical Basis for a Time-Dependent δ^{18}O-T Relationship

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The GISP2 δ^{18}O record exhibits remarkable stability during the Holocene when compared to the highly-variable glacial period. While temperature changes at Summit, Greenland have been much smaller during the Holocene, there have nevertheless been long-term millennial-scale variations which are visible in borehole temperature reconstructions and other paleoclimate records. Standard δ^{18}O-T calibrations for both the modern and glacial period fail to simultaneously explain these variations and those of the last glacial. Additionally, gas fractionation-based estimates of rapid temperature changes suggest that the δ^{18}O-T relationship has changed substantially between the last glacial and the Holocene, raising the question: Why did the signal-to-noise ratio of the GISP2 isotopic signal change so dramatically?

Using a Lagrangian source diagnosis, we show that the distribution of water vapor sources is sensitive to both ice sheet topography and sea-ice cover during the glacial, whereas it is not during the Holocene. These effects, combined with seasonality, explain the reduced signal-to-noise ratio and provide a physical basis for the use of a time-dependent isotopic calibration.