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Isotope calibrated Greenland temperature record over Marine Isotope Stage 3 and its relation to CH_4

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Greenland temperature variations on millennial time scales were characteristic for the last ice age. Abrupt warmings, known as Dansgaard-Oeschger (DO) events, can be traced in the $\delta^{18}O_{ice}$ record of Greenland ice cores. However, it has been shown that $\delta^{18}O_{ice}$ is not a direct temperature proxy. Measurements of the isotopic composition of gases trapped in the ice can be used to calibrate the paleothermometer. Here we present a continuous temperature record based on high resolution $\delta^{15}N$ measurements and firn model studies. It covers a sequence of 9 DO events (9-17) during the time period from 38 to 64 kyr BP. Temperature changes of 8 to 15 ˚C were observed for these events. We can relate the discrepancy between the modern and the glacial $\delta^{18}O_{ice}$-T relationship to a combination of source temperature changes and changes in the annual distribution of precipitation. A detailed comparison of the temperature evolution with measurements of the atmospheric methane (CH_4) concentration shows that CH_4 and temperature rises at the onset of DO events are in phase. Furthermore, a strong correlation between both parameters on millennial and submillennial timescales supports

the idea that even submillennial scale signals of the Greenland temperature record are at least hemispheric in their extent. On the other hand, differences in the shape of the CH_4 and temperature evolution during parts of the time point to a contribution of CH_4 source changes which depend not directly on northern temperature.