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CH_4 and N_2O concentrations from the deepest part of the NEEM ice core: affected by artifacts?

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During the last years, a new 2,533 m long deep ice core in the frame of the North Greenland Eemian Ice Drilling (NEEM) project was drilled in order to catch for a first time the last interglacial period called the Eemian in Greenlandic ice. Here, we present 278 new concentration measurements of the greenhouse gases methane (CH_4) and nitrous oxide (N_2O) in the depth interval 2,200 – 2,520 m of the deep NEEM ice. In a melt-refreeze step we extract the enclosed air bubbles and analyze the sample by gas chromatography yielding a precision of about 10 ppbv for CH_4 and 5 ppbv for N_2O. The known natural variability of CH_4 is restricted to the range from 350 ppbv to 800 ppbv and of N_2O from 200 ppbv to 300 ppbv by existing ice core measurements, e.g. from the Antarctic EPICA Dome C ice core.

Our new NEEM data show well defined natural concentration variations of CH_4 and N_2O in line with the stable water isotope temperature proxy $\delta^{18}O$, beside the two following exceptions. First, in the depth-interval from 2,200 – 2,220 m where the $\delta^{18}O$ signal points to problems in the stratigraphy of the bottom ice, both CH_4 and N_2O show large parallel variations, but clearly deviate from the temperature trend. Second, in the depth-interval (2,360 – 2,450 m) supposed to be of Eemian origin, both the atmospheric CH_4 and N_2O trends are interrupted by event-like spikes of extraordinary high concentrations (CH_4 up to 2,000 ppbv and N_2O up to 400 ppbv). Since greenhouse gases are well mixed over the whole globe (interhemispheric mixing time of 1-2 years) and since several Antarctic ice cores (EPICA Dome C, Talos Dome) show no counterparts of these high concentration events, it is virtually impossible that the measured signals are of atmospheric origin. We hypothesize that surface melt-layers combined with in situ production could be responsible for the scattered concentration pattern. However, neglecting these outliers and following the overall concentration trend, our new measurements do not exclude that the ice could be of Eemian origin. During the transition supposed to be Termination 2 CH_4 rises from around 430 ppbv up to 750 ppbv followed by a slow decrease down to 600 ppbv and a rapid drop to 510 ppbv. EPICA Dome C shows a slow increase from 360 ppbv to 530 ppbv and a rapid transition up to 725 ppbv followed by a slow decrease to 470 ppbv. Taken at face value this points to an interhemispheric methane gradient at the beginning of the Eemian, which is somewhat smaller than for the early Holocene, however, may still be in line with increasing boreal wetland sources at that time.