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N_2O and $\delta^{15}N$-N_2O and $\delta^{18}O$-N_2O from polar ice cores: interpretable data for interglacials

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Ice cores provide a wealth of information on climate change. For instance, the history of the atmospheric greenhouse gas N_2O can be reconstructed using air entrapped in polar ice cores. N_2O has several sources in both terrestrial and marine ecosystems, predominantly wetland soils and oxygen minimum zones in the ocean. N_2O records generally follow the climatic changes during the glacial-interglacial cycles with higher N_2O mixing ratios during warmer climate stages. However, the underlying processes driving these changes are difficult to identify from N_2O mixing ratios alone. Additional information on the individual sources and sinks are provided by stable isotope measurements. The emission fluxes of the dominant N_2O sources are ascribed to several pathways (nitrification, denitrification), with characteristic fractionation factors for the nitrogen and oxygen isotope signatures of the generated N_2O ($\delta^{15}N$-N_2O and $\delta^{18}O$-N_2O). In the end, the individual proportions of pathways are responsible for distinct $\delta^{15}N$-N_2O and $\delta^{18}O$-N_2O for the average terrestrial and marine sources.

Here, we present new ice core measurements of $\delta^{15}N$-N_2O and $\delta^{18}O$-N_2O covering the Holocene, MIS 5 and MIS 11. For the past 15 kyrs the $\delta^{15}N$-N_2O record shows a continuous decrease starting at 15 kyrs to about 6 kyrs; during the past 6 kyrs $\delta^{15}N$-N_2O remains rather constant. The resemblance with a recently published global reconstruction of bulk $\delta^{15}N$ is remarkable (McLauchlan et al. 2013, Nature). Taken at face value this could mean that mainly the terrestrial source signature changed rather than a shift in the relative proportions of the terrestrial and marine source.

The integrity of N_2O ice core records relies on the assumption that the measurements truly represent the past atmosphere. However, comparative analyses of different ice cores from the same age intervals show offsets in the N_2O mixing ratios among the records. One likely assumption is that higher mixing ratios are due to in-situ production since N_2O should not be lost in the ice. In situ production appears to be evident at least for glacial sections of some ice cores.