Measurement of N_2O isotopes at the high-altitude station Jungfraujoch

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Nitrous oxide (N_2O) is a strong greenhouse gas and the strongest ozone-depleting substance emitted in the 21st century. The substantial increase in atmospheric N_2O mixing ratio since the preindustrial era has raised worldwide concern. This increase has largely been attributed to increased nitrogen (N) fertilizer use in agriculture. However, due to the long life time of N_2O (~ 120 years) in the atmosphere, spatial and temporal gradients are small, which makes it difficult to distinguish sources and plan mitigation strategies. In addition, the factors governing seasonal and interannual variabilities in N_2O concentration and growth rate remain poorly constrained. Recently, modelling of the N_2O cycle combined with atmospheric isotope measurements has been proven as an effective approach for decoding the atmospheric N_2O budget. However, long-term data with high precision is still limited.

In this study, we present N_2O mole fractions and isotopic compositions in background air monitored at the high-altitude Jungfraujoch (JFJ) research station, from 2014 to now. N_2O mole fractions were determined *in situ* by GC-ECD (2005-2015) and OA-ICOS (since January 2015), while air samples for isotopic analysis were collected weekly/bi-weekly and analysed subsequently by quantum cascade laser absorption spectroscopy at Empa with a repeatability below 0.1‰ [1]. $\delta^{15}N^{bulk}$ of N_2O significantly decreased over the past years, likely due to ^{15}N-depleted anthropogenic sources. In contrast, no statistically significant trend was observed for $\delta^{15}N$-site preference (SP) and $\delta^{18}O$ of N_2O, however a distinct seasonal variability was detected. The observed changes might reflect the seasonal variation in N_2O production processes or stratospheric destruction. For example, N_2O site preference was generally lowest in the summer months (July to September) and highest in winter (January), which can be explained by a larger contribution of N_2O produced by heterotrophic denitrification, with low SP, as compared to nitrification in warm, humid summers. In addition, the seasonal pattern of N_2O-SP may be partly attributed to stratosphere-troposphere exchange coupled with stratosphere N_2O sink. To further enhance our understanding of the global N_2O cycle, a box modelling approach will be applied and the temporal and spatial coverage will be extended by including N_2O isotope measurements from the Cape Grim Air Archive on the Southern Hemisphere.

References

E. Harris et al., Tracking nitrous oxide emission processes at a suburban site with semicontinuous, in situ measurements of isotopic composition, J. Geophys. Res. Atmospheres, 122, 1850–1870, 2017.