Name of research institute or organization:

Laboratory for Air Pollution and Environmental Technology, Empa

Title of project:

Isotopic composition of N_2O at Jungfraujoch

Part of this programme:

SNF Project 200021_163075: Assessment of the global N_2O budget based on seasonal and long-term isotope measurements at Jungfraujoch and the Cape Grim Air Archive.
SNF Project 200021_150237: N_2O from the Swiss midlands: regional sources and hot spots.

Project leader and team:

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Project description:

N_2O is a strong greenhouse gas with a global warming potential 298 times that of CO_2, and in addition it is the strongest ozone depleting substance emitted in the 21st century [1, 2]. N_2O concentrations are rising at a rate of 0.2-0.3% per year globally due to anthropogenic emissions. Anthropogenic sources of N_2O are dominated by disperse and highly variable agricultural soil emissions, which, combined with the long lifetime of N_2O, make source apportionment – and thus mitigation – challenging. Although the total global source and sink strengths for N_2O are relatively well-constrained, individual source contributions and the factors causing seasonality and interannual variability in N_2O concentration and growth rate are poorly known [3, 4]. Isotope measurements combined with modelling show great potential to unravel sources and processes, however currently data is sparse and precision is often limiting for interpretation [5].

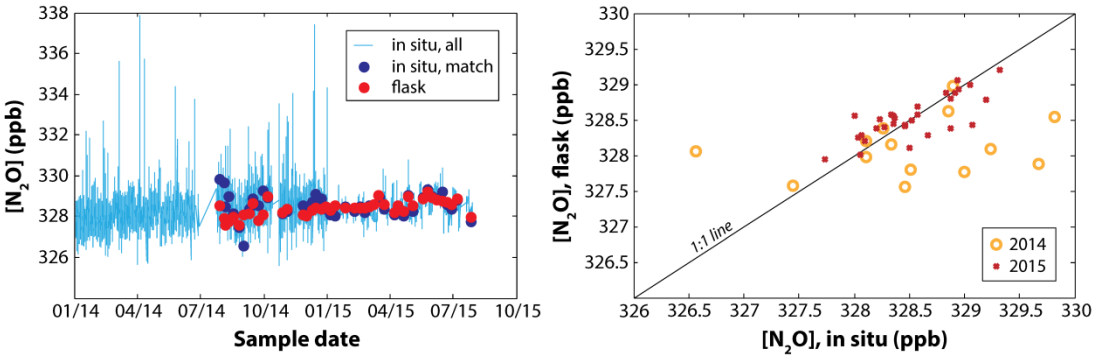

Figure 1. Comparison of N_2O mole fractions measured in flask samples using QCLAS at the Empa GAW-WCC lab and in situ at Jungfraujoch using GC-ECD or OA-ICOS in 2014 and 2015, respectively (data courtesy of M. Steinbacher, Empa). The limited compatibility in 2014, was mainly due to the restricted performance of the in-situ analytical technique (GC-ECD).

This project aims to monitor the mixing ratios and isotopic composition of N_2O at the Jungfraujoch high altitude research site using weekly sampling with high precision offline analysis at Empa. In 2015, this project was extended to include analogous measurements from the Cape Grim (Tasmania) air archive, to compare isotopic trends at Jungfraujoch to this important Southern hemisphere baseline site (SNF Project 200021_163075). Isotopic composition of the flask samples is measured at Empa using preconcentration coupled to

quantum cascade laser absorption spectroscopy (QCLAS) [6], and mole fractions are measured directly using QCLAS in the Global Atmosphere Watch's World Calibration Centre for Surface Ozone, Carbon Monoxide, Methane and Carbon Dioxide at Empa. Figure 1 shows a comparison of the mole fractions measured in flask samples to the in-situ N_2O measurements made as part of the National Air Pollution Monitoring Network (NABEL) at Jungfraujoch, illustrating the integrity of the flask sampling procedure. 79 samples have been collected and measured since the project started in April 2014, with 41 samples collected and measured so far in 2015, making this the largest N_2O isotopic dataset from a background measuring station in Europe. In-situ N_2O mole fraction observations started in 2005 using gas chromatography and electron capture detection (GC-ECD); since late 2014, N_2O mole fractions are also measured by Off-Axis Integrated Cavity Output Spectroscopy (OA-ICOS) which became the master instrument in January 2015 due to its superior performance.

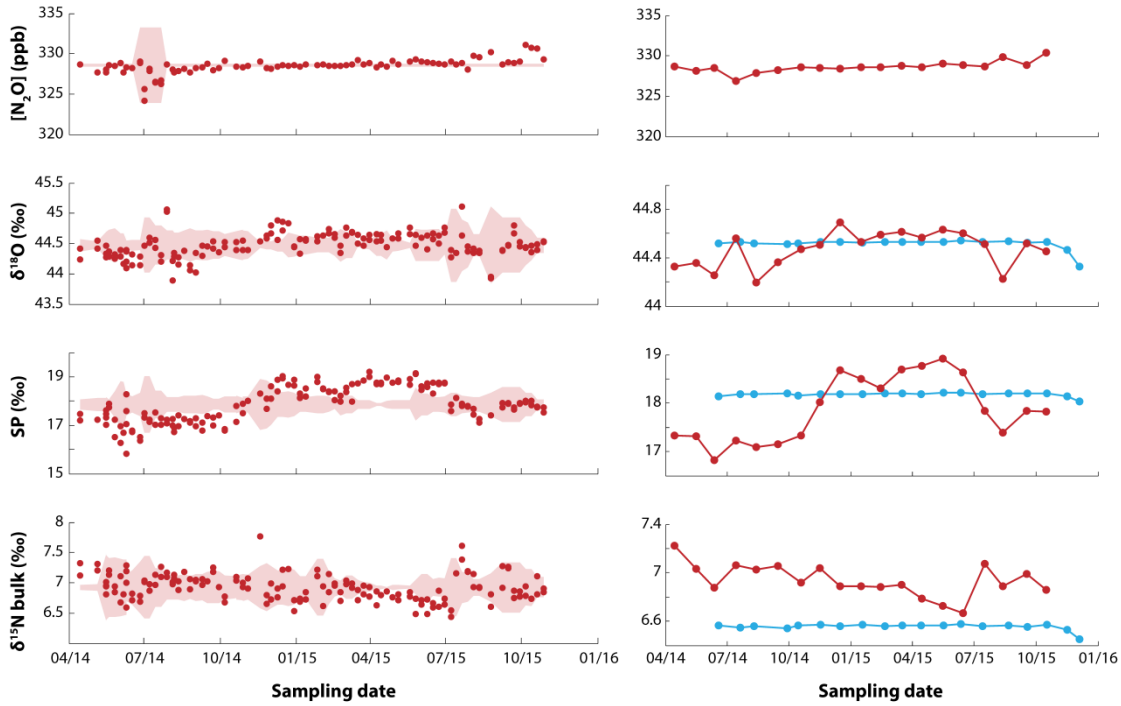

Figure 2. N_2O mole fraction and isotope data from flask samples collected at Jungfraujoch. Individual weekly samples are shown in the left panel, with the 2σ uncertainty indicated as the shaded area (deviating from the mean). The right panel shows monthly mean data in red, as well as monthly mean values for repeated measurements of compressed air in blue. The compressed air tank was changed in late 2015, accounting for the shift in the last two points.

The results in Figure 2 show a distinct trend in the N_2O mole fraction of +1.2 ppb y^{-1}, similar to the global average of 1.1 ppb between 2013 and 2014 [7]. $\delta^{15}N$ bulk also shows a decreasing trend due to isotopically light anthropogenic sources. The rate of decrease is -0.068‰ y^{-1}, which is higher than the range of previously reported values (-0.020 to -0.041‰ y^{-1}, see [8]). The N_2O site preference ($\delta^{15}N^{\alpha} - \delta^{15}N^{\beta}$) and $\delta^{18}O$ appear to show seasonal variations, thus their long-term trend cannot be distinguished, yet. Continuing these measurements into 2016 and comparing with seasonal and long-term trends from Cape Grim will provide exciting new insights into the global N_2O budget. In addition, the data are critical to provide an N_2O background to interpret isotope data from other sites in Switzerland.

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Key words:

Nitrous oxide, greenhouse gas, flask sampling, isotopic composition, seasonal variability

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