Name of research institute or organization:

Laboratory for Air Pollution and Environmental Technology, Empa

Title of project:

Isotopic composition of N_2O at Jungfraujoch High Altitude Station

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, makes 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].

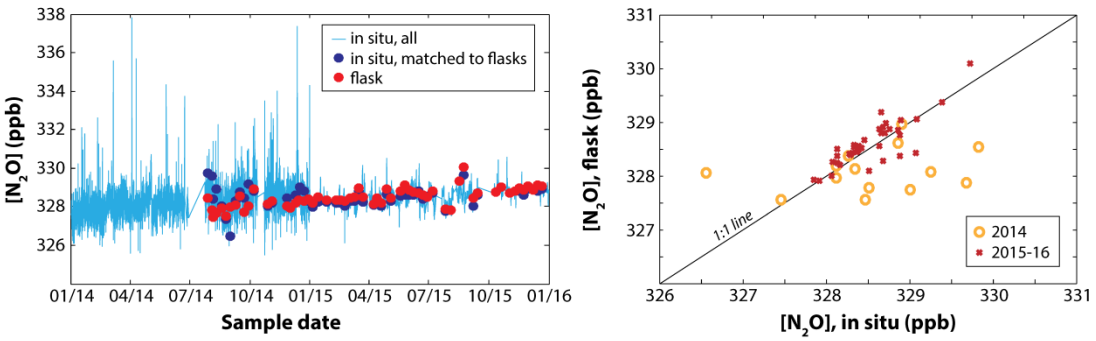

Figure 1. Comparison of N_2O mixing ratios measured in flask samples using QCLAS at the Empa GAW-WCC lab and in situ at Jungfraujoch using GC-ECD or OA-ICOS in 2014 and 2015-16, respectively (data courtesy of M. Steinbacher, Empa). In situ data is shown as a blue line and the flask data as red circles; blue circles highlight the in situ data points time-matched to the flask collections. The limited compatibility in 2014 was mainly due to the restricted performance of the in-situ analytical technique (GC-ECD).

This project aims to continue monitoring the mixing ratios and isotopic composition of N_2O at the Jungfraujoch high altitude research site using biweekly/weekly sampling with high precision offline analysis at Empa. In 2015-16, 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 pre-concentration unit coupled to quantum cascade laser absorption spectroscopy (QCLAS) [6], and mole fraction is measured directly using QCLAS in the GAW-WCC laboratory at Empa. Figure 1 shows a comparison of the mixing ratios measured in flask samples to the in-situ N_2O measurements made as part of the GAW program at Jungfraujoch, illustrating the integrity of the flask sampling procedure. 110 samples have been collected and measured since the project started in April 2014, making this the largest N_2O isotopic dataset from a background measurement station in Europe.

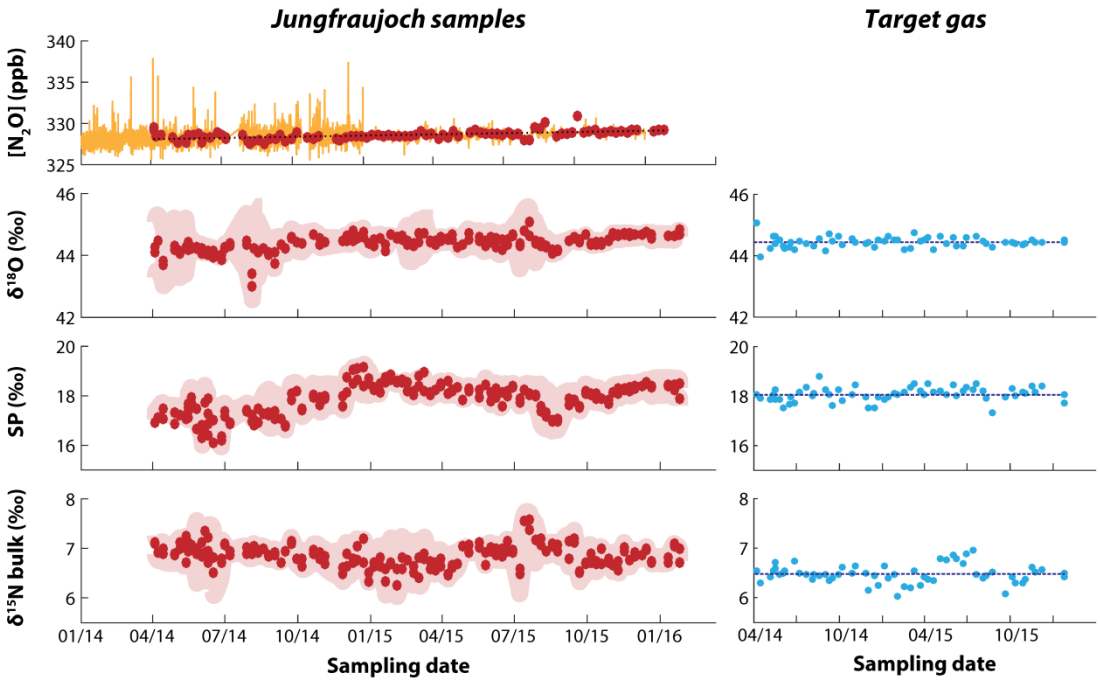

Figure 2. Top left: N_2O mixing ratio at Jungfraujoch from in situ measurements (orange line) and flask samples (red circles). Lower left panels show isotope data: Individual weekly samples are shown as red circles, with the 2σ uncertainty indicated as the shaded area. The right panel shows isotope measurements made for a tank of compressed air "target gas" to monitor drift and repeatability.

The results in Figure 2 show a distinct trend in N_2O mixing ratio of +1.2 ppb y^{-1}, higher than the global average of 0.73 ppb y^{-1} [7]. $\delta^{15}N$ bulk also shows a significant decreasing trend due to isotopically light anthropogenic sources. The rate of decrease is -0.043‰ y^{-1}, which is higher than the range of previously reported values (-0.020 to -0.041‰ y^{-1}, see [8]). Site preference and $\delta^{18}O$ show seasonal variations, thus their long-term trend cannot be distinguished. 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

Collaborating partners/networks:

Paul Krummel, Ray Langenfelds and Paul Steele / CSIRO Marine and Atmospheric Research, Aspendale, Australia

Scientific publications and public outreach 2016:

Refereed journal articles and their internet access

"Using Isotopic Fingerprints to Trace Nitrous Oxide in the Atmosphere", Highlights of Analytical Sciences in Switzerland, *Chimia,* 71, 1, doi: 10.2533/chimia.2017.1, 2017.

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