

InGOS - Integrated non-CO₂ Observing System

Detailed workplan, appendix to the online application. Request for access to an infrastructure (TNA1). The plan must not exceed 6 pages in 12 pt single line spacing, applications exceeding this limit will not be evaluated. The following information should be included in order to be evaluated:

- 1. Project name (acronym), name and contact information of the researcher(s), duration of the project (dates, number of working days), type and name of the infrastructure requested**

Project Name: InGOS N₂O soil chamber inter-comparison campaign 2014

Names of researchers:

Christian Brümmer, Jeremy Smith, Jean-Pierre Delorme, Antje Moffat, Miriam Hurkuck

Contact of researcher: Thünen Institute of Climate-Smart Agriculture, Bundesallee 50, 38116 Braunschweig, christian.bruemmer@ti.bund.de, miriam.hurkuck@ti.bund.de

Duration of project (C. Brümmer, J. Smith, J.-P. Delorme, A. Moffat): 12.06.-19.06.2014

Duration of project (M. Hurkuck): 12.06.2014-31.07.2014

Type / Name of infrastructure: Warm machinery hall Hyytiälä Forestry field station (TNA1), participation at soil chamber inter-comparison campaign, placing our Thünen chamber onto calibration tank, testing chamber performance

2. Background

a. Significance of the research

Accurate determination of ambient nitrous oxide (N₂O) concentrations and the associated exchange between soil and atmosphere has been in the focus of environmental research for several years. With its long residence time in the troposphere and its relatively large energy absorption capacity per molecule, which is almost 300 times higher than the same mass unit of carbon dioxide over a 100-year period (IPCC, 2007), N₂O is of high relevance for the Earth's greenhouse gas budget. Precise measurements of N₂O - particularly at the field scale - are therefore essential for specific applications in ecosystem research such as the study of N cycling, fertilization effects, and for the compilation of full greenhouse gas budgets. The most common method to measure soil-atmosphere exchange of N₂O is the operation of static chambers (Hutchinson and Mosier, 1981; Schiller and Hastie, 1996). The N₂O flux is calculated from the concentration increase (or decrease) over time while the air-tight chamber is usually attached to a soil frame. Different chamber designs and air sampling procedures exist, either with manual, semi-automated, i.e. automatic sampling but manual

transport of air samples in syringes or vials to the GC, or fully automated gas collection, where the air samples are directly pumped (or sucked) via carrier gas to a temperature-stable housing equipped with a GC in the field (e.g., Brümmer et al., 2008; Butterbach-Bahl et al., 1997; Flessa et al., 2002; Papen and Butterbach-Bahl, 1999; Rosenkranz et al., 2006). With recent progress in the development of fast-response technologies for analyzing a variety of N and C trace gases, e.g. tunable diode laser absorption spectrometers (TDLAS), quantum cascade lasers (QCL) and devices originating from individual applications such as Fourier transform infrared (FTIR) spectrometers, and in the context of standardizing measurements of greenhouse gases, it is of high relevance to compare and cross-validate existing chamber designs with regard to pressure effects, sufficient mixing, closure time, saturation effects, etc. The upcoming campaign in Hyytiälä is an ideal opportunity to study these individual chamber characteristics.

b. Previous research relevant to the topic and how the proposed project links to this
In 2008, Pihlatie et al. carried out a comparison campaign at the Hyytiälä forestry station using static chambers to measure CH₄ emissions from soils. The campaign aimed at quantifying errors resulting from different chamber design, operation and flux calculation methods. The main findings were that the chamber design affects flux under- and overestimation and an increasing chamber volume significantly reduced flux underestimation. It could be further found that the tested chambers underestimated CH₄ fluxes by on average 33 % when calculated using the linear fit. The exponential flux calculation, however, did not result in significantly different chamber fluxes compared to a reference flux. These results show that both chamber design as well as the flux calculation method influence soil CH₄ flux estimates. Similar to CH₄, N₂O flux measurements are subject to errors when using static chambers (see above). It is thus needed to quantitatively assess the uncertainties in N₂O flux estimates related to chamber measurements and flux calculation methods.

c. Links with current research of the applicant

The Thünen research group is currently conducting soil efflux measurements of N₂O, CH₄, and CO₂ using the above-mentioned newly developed chamber system in conjunction with QC lasers. Measurements are taking place at a semi-natural peatland site ('Bourtanger Moor') in Northwest Germany and at an agricultural site ('Dedelow') in Northeast Germany, which is alternately planted with rapeseed and winter wheat/barley. Furthermore, the Thünen research group participated in the 2013 InGOS N₂O analyzer cross-validation campaign at a fertilized and harvested willow field in Riso, Denmark. Results of this campaign are about to be submitted to a peer-reviewed journal and will be available soon (see Brümmer et al., 2014). Beside activities on chamber measurements, the Thünen group is involved in a number of other greenhouse gas studies including eddy flux determination of not only inert gases such as CO₂, water vapor, N₂O, but also in experiments of estimating biosphere-atmosphere exchange of reactive nitrogen species (e.g., Brümmer et al., 2013; Hurkuck et al., 2014).

3. Objectives

a. Hypothesis and research objectives

Until recently chamber measurements are subject to systematic (e.g. pressure changes inside the chamber, leaking of chambers) and random errors (e.g. low spatial coverage of measurements) (Pumpanen et al., 2004; Pihlatie et al., 2013; Christiansen et al., 2011). Although N₂O laser instrumentation helps to eliminate random errors during single chamber measurements, it does not solve errors associated with high spatial variabilities of soil N₂O efflux. It is hypothesized that estimation of soil fluxes could be carried out by means of sampling N₂O concentrations in the soil airspace. Even though this approach is not very accurate, it is expected to provide information about the range and variability of soil fluxes. This campaign aims (1) at gaining more knowledge about systematic and random errors during chamber N₂O measurements and (2) at providing methods to control these. It is a further purpose (3) to evaluate the possibilities of using information about soil N₂O concentrations in conjunction with manual chamber measurements for soil N₂O efflux estimates.

b. Connection with the InGOS objectives and the ‘fitness’ of the use of the requested infrastructure to the objectives

It has been stated by the InGOS project that there is need to support and integrate the observing capacity of Europe on non-CO₂ greenhouse gases as the emissions of these gases are very uncertain and it is unknown how future climate change will feedback into these emissions. One of the main aims of the infrastructure project is to work on standardizing relevant measurements, strengthening existing observation sites into supersites, capacity building in new member states, and preparing the integration of the network with other networks already in place or currently being set up (e.g. ICOS). The intended campaign including its requested infrastructure will exactly tackle the stated research questions (i.e. systematic and random errors in chamber measurements), particularly those related to standardizing relevant measurements and preparing the integration of measurement standards into infrastructures like ICOS, which are currently set up.

4. Methods and materials (legal and ethical issues)

a. Research method, explaining how to reach the objective

Uncertainties in flux estimates related to chamber design will be assessed by comparing a known flux (reference flux) and a chamber flux. The experimental set up includes a calibration tank which establishes a reference flux through a sand bed with a known density and porosity on top of the tank. The flux is created by injecting a gas with a known concentration into the calibration tank with known volume. Parallel chamber measurements on top of the sand bed allow for direct comparison of chamber and reference fluxes and subsequent quantification of potential flux under- and overestimation of the tested chamber. Specific scientific aims of the project are (1) to evaluate the importance of storage effects to the systematic error of the flux estimate, (2) to evaluate methods of extrapolating the flux to undisturbed flux, (3) to compare estimates of flux saturation during

the measurement, (4) to test plausibilities in using linear fits for flux estimation and correction of systematic errors, (5) to test exponential fits for flux estimation, and (6) to test possibilities of using soil gas concentration for flux estimation. General aims for participants of the project are (a) to measure leaking rates of used chambers and (b) to measure the sensitivity for storage problems.

b. Research materials, instrumentation

Instrumentation for the campaign includes N₂O lasers (LosGatos from Helsinki group and 2 Aerodyne QCL from our Thünen group), calibration tank with adjustable sand bed and circular shape, fans to create wind and anemometer to measure wind speeds. Each research group participating in this campaign brings their own chambers.

c. Governance procedures, safety precautions, permit requirements and procedures

At the time of this writing the InGOS N₂O soil chamber inter-comparison campaign 2014 has been excellently organized by a group from University of Helsinki, particularly by Janne Korhonen and Mari Pihlatie. Each participating group has a time slot of a couple of days for testing their respective chambers. As we bring two N₂O QCL lasers, our Thünen group will help setting up the equipment and will test our own chamber system during the official start of the campaign. All work will be performed under common safety precautions when operating QC lasers, pumps and pressurized gas tanks. To our knowledge, no specific permissions are required for the intended research work.

5. Implementation: timetable, budget, distribution of work

a. Timetable for the research including personnel efforts, favorably table wise

12-19 Jun (all group members: M. Hurkuck, A. Moffat, J.-P. Delorme, J. Smith, C. Brümmer):
Provision of two Aerodyne QC lasers; setting up all relevant equipment for entire campaign; quality checks of laser performance; testing Thünen chamber
No. of working days: 6 (per person)

23 Jun-31 Jul (M. Hurkuck):

Assistance in chamber tests for all other participating groups; laser maintenance
No. of working days: 29

b. Total budget for travel and logistical support as requested

J. Smith, A. Moffat, and C. Brümmer will travel to Hyytiälä via plane and train. M. Hurkuck and J.-P. Delorme will travel by van (transport of two laser systems and chamber).

C. Brümmer, A. Moffat, J. Smith:

Flights: Berlin-Helsinki (+ return): 3 x 208.53 €

Train: Braunschweig-Berlin: 58 € + 87 € + 63 €; Helsinki-Orivesi: 6 x 20 €

M. Hurkuck, J.-P. Delorme:

Ferry: Travemünde-Helsinki (+ return) (person + van): 761 €

Accommodation (A. Moffat, J.-P. Delorme, J. Smith, C. Brümmner): Total no. of days 6

Accommodation (M. Hurkuck): Total no. of days 35

c. Plan for specific logistical needs like visa, import/export licenses etc.
Not applicable.

6. Expected results and possible risks

a. Expected scientific impact of the research

Results of the campaign are expected to better quantify uncertainties associated with specific chamber designs. This is of high relevance to the scientific community in order to reduce errors in greenhouse gas budget estimations as well as for the comparability of fluxes obtained by different chamber systems across Europe with regard to an intended standardization of flux determination techniques in the framework of research infrastructures such as ICOS.

b. Applicability and feasibility of the research results

See Section 6a.

c. Publication plan

As outlined in the campaign program by the local organizers, it is the idea to publish the results in peer-reviewed journals. Regarding the specific aims of the campaign, chances are high that at least two papers - presumably one with a focus on physical characteristics of specific chamber designs and another one with a focus on the influence of different flux calculation methods - will emerge from this initiative. Very good experience has been made in former comparison campaigns, which always led to high quality and high impact papers.

d. Data access plan

To our knowledge, this has not been mentioned yet, but will certainly be done at the beginning of the campaign. A surely elegant way would be free data access to the public once the intended papers have been published.

7. Key literature

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chromatography vs. quantum cascade laser-based N₂O flux measurements using a novel chamber design, in preparation, 2014.

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- Pumpanen, J., Kolari, P., Ilvesniemi, H., Minkinen, K., Vesala, T., Niinisto, S., Lohila, A., Larmola, T., Morero, M., Pihlatie, M., Janssens, I., Yuste, J. C., Grunzweig, J. M., Reth, S., Subke, J. A., Savage, K., Kutsch, W., Ostreng, G., Ziegler, W., Anthoni, P., Lindroth, A., and Hari, P.:** Comparison of different chamber techniques for measuring soil CO₂ efflux, *Agricultural and Forest Meteorology*, 123, 159–176, 2004.
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