InGOS – Integrated non-CO_2 Observing System

Detailed workplan, appendix to the online application. Request for access to an infrastructure (TNA1-TNA2-TNA3). 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):** N_2O Chamber intercomparison campaign 2014, Hyytiälä
   Name and contact information of the researcher(s): Michał Gałkowski, AGH University of Science and Technology, al. A. Mickiewicza 30, 30-059 Kraków, Poland, e-mail: Michal.Galkowski@agh.edu.pl, phone no.: +48 12 617 2971
   Duration of the project (dates, number of working days): 13-17 July 2014, 4 days
   Type and name of the infrastructure requested: TNA1 (supersite), SMEAR-II, Hyytiälä field station, Juupajoki, Finland

2. **Background**

   a. Significance of the research & previous research relevant to the topic and how the proposed project links to it

Chamber measurements are associated with systematic and random errors. The major error sources are systematic and random error of the estimation of the flux based single chamber measurement and the error associated by the large spatial variability of the soil flux and the low spatial coverage of the measurements. Systematic errors of CO_2 chambers have been quantified by Pumpanen et al. (2004) and systematic errors of static CH_4 by Pihlatie et al. (2013) and Christiansen et al. (2011). In this study, we aim to gain more knowledge on the errors, and also provide methods to control them.

Until recently, soil N_2O fluxes have been measured based on static chambers and analyzing air samples on a gas chromatograph (CG). Detecting small changes of N_2O concentration is difficult with a CG, and thus in many cases, the analysis of gas concentrations has been the largest source of error in soil N_2O flux estimations. Recently N_2O LASER instrumentation has become available soil N_2O flux measurement, and has practically eliminated this problem of random error when estimating the flux for a single chamber.

The random error of soil N_2O efflux associated with high spatial variability cannot be solved by N_2O LASER instrumentation. Low-cost methods for estimating the soil N_2O efflux from various spatial locations would be a solution for this problem. One option would be to sample the N_2O concentration in the soil airspace periodically, and estimate the flux based on this. While this method is probably not very accurate, it could give information about the range and variability of the flux. If the systematic errors of this method are small, the random errors can be got rid of by large number of samples. One purpose of this study is to evaluate the possibilities of using the information of soil N_2O concentration for estimating soil N_2O efflux. The same principles could be used for other compounds, such as CO_2 and CH_4 as well.

Another option is to support the N_2O laser measurements by measuring spatial variability of the N_2O soil flux based on manual chamber measurements. Such a measurement is laborious if systematic errors are to be avoided. However, if the amount of systematic error is known, it can be corrected. We also want to study this, and in conjunction with soil N_2O concentration measurements, a low-cost method for eliminating the uncertainty caused by high spatial variability could be developed.

Like in the case of spatial variability, N_2O laser instrumentation cannot alone solve the problems of systematic errors of estimating the soil N_2O flux from a single chamber. These errors are in general similar for other compounds, such as CO_2 and CH_4 as well, for which many kinds of systematic errors are reported. Typically these errors are related to pressure changes inside the chamber, effects of wind speed, or leaking of the chamber. The chamber measurements require the assumption that the soil gas storage under the chamber does not change, and the pressure and wind effects are violating this assumption. In an ideal case, the gas flux during the enclosure saturates, an exponential function is fitted to the gas concentration data against time, and the flux is calculated in the beginning of the enclosure using the fitted parameters of the exponential function. However, if gas is accumulating in the soil, the rate of change of gas concentration in the chamber headspace is too low in the beginning, causing erroneous curvature for the exponential function. This naturally leads to underestimation of the flux. If the case is the opposite, for example is the fan is ventilating the chamber headspace too efficiently, then using exponential fit causes overestimation to the flux. In this study, we want to find out how much the storage change can change the flux estimation, how to identify this in data analysis, and how to correct the flux for the storage effect. In addition, in this study we measure the leaking of the chambers.

b. Links with current research of the applicant

I am a PhD student at the University of Science and Technology with a thesis title "Nitrous oxide loads and emissions in the region of southern Poland". Part of my PhD project includes estimation of nitrous oxide sources from agricultural and urban dispersed sources using the static chamber technique coupled with gas chromatography (GC) measurements of the air samples collected *in-situ*.

Due to characteristics of this methodology of flux measurements, it is extremely difficult to realistically estimate the uncertainty of the obtained results. According to literature, systematic errors in static chamber N_2O flux estimations with GC measurements of the samples occur mainly due to

i) Large spatial variability of N_2O efflux,
ii) Lack of knowledge on the chamber-specific effects, e.g. chamber leakage, errors due to sample extraction techniques, etc.

The proposed project aims at tackling the second of these error sources via an intercomparison campaign, in which many different types of flux chambers are to be surveyed in a controlled environment, allowing the precise description of the systematic errors associated with each chamber. This insight will be invaluable in this part of my PhD thesis, as it will allow to estimate realistically the systematic errors performed during my field campaigns, which will in turn increase the scientific value of the obtained results through the application of necessary corrections, providing more realistic information on N_2O fluxes in the region.

The knowledge gained from the project will be further used in planning future measurements campaigns and projects, and could possibly also lead to improvement chamber design, which would allow further diminishing of the measurement errors. This is valid not only for the research on nitrous oxide, but also other greenhouse gases, which emissions are being measured by static flux chamber techniques (CO_2, CH_4, H_2) in our team.

3. Objectives

a. Hypothesis and research objectives

Hypothesis: It is possible to diminish the systematic errors in various N_2O flux measurement chamber systems by means of gaining detailed knowledge on the chamber environment during the measurement period and further application of that knowledge to perform necessary corrections to the data.

Research objectives:

- To evaluate the importance of storage effects to the systematic error of the flux estimate
- To evaluate the methods of extrapolating the flux to undisturbed flux
- To compare the ways of estimating the saturation of the flux during chamber measurement
- To test if it makes sense to use linear fit for flux estimation, and correcting the systematic error.
- To test if exponential fit with low number of points gives systematic error (especially important to manual sampling due to spatial variability)
- To test if soil gas concentration can be used to estimate flux

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

InGOS main object is to “improve and extend the European observation capacity for non-CO2 greenhouse gases”.

Acceptance of this request will, in applicant's opinion, lead to:

a) improvement and extension of European observation capacity of nitrous oxide fluxes by allowing to improve observations in the southern Poland region,
b) improvement of European observation capacity for nitrous oxide by comparison of the flux measurement system used at AGH University of Science and Technology to other similar systems, carefully examining it's advantages and disadvantages, thus extending the pool of knowledge in this area of science.

4. Methods and materials (legal and ethical issues)

a. Research method, explaining how to reach the objective

- Measurement of leaking rate of the chambers
  - With different wind speeds
  - With different collar installation depths
- Measurement of the sensitivity for storage problems
  - Venturi effect
  - Ventilating the chamber (different fan speeds possible)

See also the description in “Background” section.

b. Research materials, instrumentation

Measurements shall be performed using the infrastructure of SMEAR-II research station together with measurement devices provided by other intercomparison campaign participants. This include:

- N_2O lasers (LosGatos from Helsinki group and 2 from Braunschweig (Aerodyne))
- a calibration tank for the chamber placement of circular shape, possibility to fit 1m x 1m chamber, surface area of sand bed $2m^2$
- Fans needed to create wind outside the chamber
- Small anemometers needed to measure wind speeds (also inside the chamber; only wind velocity is needed, no direction)

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

No new procedures, safety precautions, permit requirements and procedures (other than those of the host institute) are necessary, according to applicant's knowledge.

5. Implementaton: timetable, budget, distribution of work

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

Time / Day	13.07	14.07	15.07	16.07	17.07
7:00 - 9:00		Removal of chambers; injection of gases; breakfast	Removal of chambers; injection of gases; breakfast	Removal of chambers; injection of gases; breakfast	Departure from Helsinki airport
9:00 - 12:00	Arrival in Helsinki Airport; transfer to Hyytiala	Measurements: 6 replicate series	Measurements: 6 replicate series	Measurements: 6 replicate series	
12:00 - 16:00		Lunch and furhter 6 replicate series of measurements	Lunch and furhter 6 replicate series of measurements	Lunch and furhter 6 replicate series of measurements	
16:00 - 18:00	Arrival at the station; initial setup of the instrumentation; Preparation of the instrumentation for the overnight leakage tests	3 replicate series of measurements + additional tests; dinner	3 replicate series of measurements + additional tests; dinner	Preparation to leave Hyytiala; transfer to Helsinki	
18:00 - 20:00		Preparation for the next day of measurements	Preparation for the next day of measurements		

*Only the timetable specific to the applicant has been included in the table.

b. Total budget for travel and logistical support as requested

270 EUR – plane ticket from Lisbon (Portugal) to Helsinki (Finland); journey start in Portugal due to scientific meeting attendance (until 12.07)
30 EUR – train ticket from Tikkurila (Helsinki) to Orivesi
30 EUR – train ticket from Orivesi to Pasila (Helsinki)
120 EUR – plane ticket from Helsinki (Finland) to Kraków, Poland
Summary: 450 EUR – total budget for travel and logistical support.

c. Plan for specific logistal needs like visa, import/export licenses etc.

No additional visas or travel permits / licenses are necessary.

6. Expected results and possible risks

a. Expected scientific impact of the research

The research proposed here will allow a realistic estimation of the systematic errors performed during the applicant field campaigns, which will in turn increase the scientific value of the obtained results through the application of necessary corrections, providing more realistic information on N_2O fluxes in the region.
It will also improve European observation capacity for nitrous oxide by comparison of the flux measurement system used at AGH University of Science and Technology to other similar

systems, carefully examining it's advantages and disadvantages, thus extending the pool of knowledge in this area of science.

b. Applicability and feasibility of the research results

Research results will be directly applied in the further scientific work of the applicant, specifically in the field campaigns performed during his PhD, but also in flux measurements of other greenhouse gases, measured by static flux chamber techniques (CO_2, CH_4, H_2) at the AGH University of Science and Technology. On a broader scale, this intercomparison campaign's result will be used by many scientific teams worldwide to improve the quality of nitrous oxide flux measurements.

c. Publication plan

At least 5 different publications are envisaged as a direct result of this intercomparison campaign, concerning various topics, e.g. the methodology of the comparison, numerical modelling of the transport inside the chamber, flux data analysis etc. The applicant will be a co-author of minimum one (synthetic article), with possible contribution to other papers, depending on the results.

d. Data access plan

Open data policy within group of contributors with co-author option for all participants is proposed by the organizers.

7. Key literature

a. List of references used in the working plan

Christiansen, J. R., Korhonen, J. F. J., Juszczak, R., Giebels, M., and Pihlatie, M.: Assessing the effects of chamber placement, manual sampling and headspace mixing on CH4 fluxes in a laboratory experiment, Plant and Soil, 343, 171-185, DOI 10.1007/s11104-010-0701-y, 2011.

Pihlatie, M. K., Christiansen, J. R., Aaltonen, H., Korhonen, J. F. J., Nordbo, A., Rasilo, T., Benanti, G., Giebels, M., Helmy, M., Sheehy, J., Jones, S., Juszczak, R., Klefoth, R., Lobo-do-Vale, R., Rosa, A. P., Schreiber, P., Serca, D., Vicca, S., Wolf, B., and Pumpanen, J.: Comparison of static chambers to measure CH4 emissions from soils, Agricultural and Forest Meteorology, 171, 124-136, DOI 10.1016/j.agrformet.2012.11.008, 2013.

Pumpanen, J., Kolari, P., Ilvesniemi, H., Minkkinen, 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, DOI 10.1016/j.agrformet.2003.12.001, 2004.