Chasing greenhouse gas

The InGOS network measures greenhouse gas over Europe. The data is used for construction of measurement-based EU emission maps

Tall and small measurement towers, high-altitude observing stations on European mountain tops, research planes and ships, all come together in the FP7 InGOS project. InGOS began two years ago and is currently halfway through its research and showing results. Within InGOS, just over 30 scientific teams across Europe join forces in their evaluation of non-CO_2 greenhouse gases and open their facilities for researchers worldwide. The gases they aim for are methane (CH_4), nitrous oxide (N_2O), hydrogen (H), sulphur hexafluoride (SF_6) and a multitude of so-called 'halocarbons'.

The data obtained with the different measurement platforms is used to construct independent, measurement-based emission maps over Europe. Indeed, the concept has been taken from a rather simple idea: a pocket of air entering the EU domain from the Atlantic in the south of France, heading north-east and leaving the EU at the Polish border a few days later 'picks up' emitted gas along its trajectory over the EU and meanwhile 'hits' multiple InGOS stations.

The InGOS measurements along the air mass trajectory are used to calculate the emission levels of the inbetween area. This can prove difficult for a single trajectory, but with 30 stations providing over half a million concentration measurements per gas species each year, that trick actually works. Even better, methane emission levels for several sources, in a number of countries, have actually been re-evaluated and modified, triggered by discrepancies between emission inventory maps and those based on air measurement. This concept has its value far beyond the EU territory. The techniques and algorithms developed can be exported to help other countries as well to evaluate their emission patterns in space and time. On top of that, InGOS provides important ground truthing input for satellite missions, putting the local InGOS experimental work into a global perspective.

Air sampling

To measure these trace gas species the researchers use state-of-the-art instrumentation, a mix of laser spectrometers, gas chromatographs and mass spectrometers in combination with detailed meteorological observations. Calibration gas cylinders are crucial to fine-tune and intercalibrate all these systems. The InGOS calibration gas facilities in Jena (Germany) and Bristol (UK) provide these cylinders. Meetings and workshops are organised with the aim to harmonise existing and upcoming datasets. Some of the InGOS stations like Mace Head, Schauinsland or Jungfraujoch have already been running for 20-30 years, whereas others just started a few years ago. The exchange of knowledge between the laboratories is an important added value of this kind of FP7 programme. Harmonisation is not just for the fun of the participating scientist. The air mass trajectory trick only works well if stations show exactly the same concentration level for the same air sample. With a mismatch there, the correlation between actual in air concentration levels and those reported by a mis-reading instrument will inevitably blur the measurement-based emission pictures.

The halocarbons

As for the halocarbons, their production, for example for cleaning, air conditioning, fire extinguishing or foam production, is increasing. As a consequence, their role in the climate is on a fast track upwards. Teams at EMPA in Switzerland and Bristol University in the UK lead this work in InGOS and their observations show how, after the implementation of the Montreal protocol, some of these species are decreasing, but other species are increasing and new species emerge. The InGOS monitoring sites works together with the AGAGE project to keep track of these developments.

Methane at multiple scales

Methane originates from natural gas use, from ruminating cows or wetlands. Nitrous oxide is used in a hospital to keep a patient asleep, but the main emissions come from fertiliser production and use, manure application and waste water. For these two gases both anthropogenic and ecosystem related sources are active. It is the interplay between human activity and natural processes that adds to the complexity of emission estimation. A grazed grass field can show N_2O hotspots with emission levels that are three orders of magnitude above the levels observed on a similar grass spot just a metre away. Landfills are known to emit more or less methane with changes in the atmospheric pressure. And N_2O outbursts from fertilised fields are often shown, not after fertilisation itself, but after subsequent rain, days or even weeks later. All these kinds of spatial and temporal variation in the emissions of CH_4 and N_2O contribute significantly to the overall uncertainty in our net national and EU GHG emission levels.

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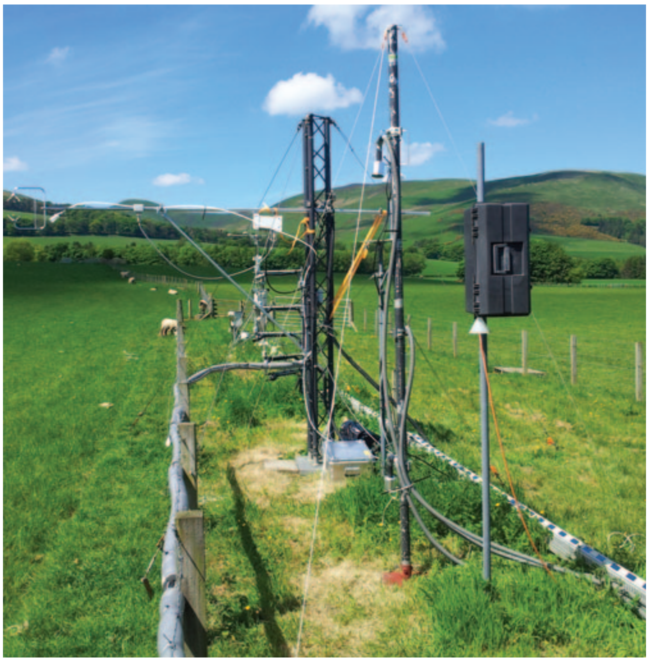
To tackle this, measurements at multiple scales are needed. Small spatial scale experiments evaluate the process of gas formation, at field scale measures for emission control can be evaluated. Regional and national scale experiments evaluate upscaling of the emission estimates that feed into the national emission inventories. This type of work is carried out at universities, and research institutes all over Europe. And projects like InGOS are vital to provide options for interaction.

Transnational Access (TNA)

The TNA and service activities of the InGOS project facilitate the process of harmonisation and optimisation of the monitoring activities all over Europe. The above mentioned exchange of calibration standards, for example, makes sure that experimental results by the INRA team at Grignon close to Paris can indeed be compared with those done by Helsinki University in the Hyytiala forest in Finland. And of course, InGOS does not only send gas flasks around Europe, the Transnational Access (TNA) programme, facilitates EU scientists themselves to visit InGOS partner sites and carry out experimental work together.

Supported by this TNA scheme, three important field campaigns were carried out looking at the ecosystem exchange of CO_2, CH_4 and N_2O. In 2012 the Cabauw tall tower in the Netherlands hosted a campaign where state-of-the-art measurement systems for methane emission studies were compared. The area is a net methane source to the atmosphere and the results of the campaign will both feed into a PhD thesis at Helsinki University and be published and available for the research community worldwide.

At the site in Roskilde, Denmark, the RISOE team organised a campaign where several groups used their chamber and micrometeorological techniques to evaluate soil emissions after fertilisation on a willow field. The field campaign was linked to a special international training course for young scientists to teach them the 'dos and don'ts' in N_2O emission measurements.



CEH Edinburgh took over the co-ordination of a similar campaign on grassland at Easter Bush, Edinburgh, UK. There the focus was on the micrometeorological methods and detailed evaluation of different laser based systems that can measure N_2O emissions on the hectare field scale. Here too, publication of the campaign results will provide essential lessons to better carry our experiments to come.

Two further years

The InGOS project will run for two more years providing well over four million concentration measurements in the months to come. Young scientists across Europe will be invited to join a tour of InGOS, along important measurement sites, learning the skills from 'the oldies' that started out this work three decades ago. Climate is, by definition, the 30-year average weather type. From now, the measurement data can actually integrate on that timescale over multiple locations in different climate conditions in Europe; a fact-finding mission that is essential for a sound discussion on what happens in our atmosphere.

InGOS
Integrated non-CO_2 Greenhouse gas Observing System

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