Greenhouse gases from human activities are the most significant drivers of observed climate change since the mid-20th century (1). As greenhouse gas emissions from human activities increase, they build up in the atmosphere and warm the climate, leading to many other changes around the world—in the atmosphere, on land, and in the oceans. These changes have both positive and negative effects on people, society, and the environment—including plants and animals. Because many of the major greenhouse gases stay in the atmosphere for tens to hundreds of years after being released, their warming effects on the climate persist over a long time and can therefore affect both present and future generations. (2).

Measuring emissions of greenhouse gases (GHGs), such as carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and water vapor (H₂O) from natural sources is a key part of global climate change study. The greenhouse gas emissions from different soil types are primarily biogenic by origin and the net production of each gas species in different soil and vegetation communities is known to vary a lot. The biological activity of micro-organisms living in the soil has an impact on the direction of the gas fluxes which determines whether the soil acts as a sink or a source of greenhouse gases.

One of the most widely used and well-established techniques to measure soil fluxes is the chamber method. Researchers worldwide are employing portable FTIR analyzers to study the GHG emissions integrated with a soil chamber. The field applications include, e.g. measurements of GHG’s from soils (agricultural soils, fluxes from microbial activities in the soil, biofuel crops), geothermal sources, ruminants, manure and water systems. The objective of this document is to list links to some of these research articles, posters, academic dissertations and other scientific writings on GHG measurements using a portable FTIR analyzer.

The following measurements are introduced:

- GHG measurements from soils
- GHG measurements from geothermal sources
- GHG measurements from ruminants
- GHG measurements from manure
- GHG measurements from aquatic environments

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2 http://www.epa.gov/climate/climatechange/science/indicators/ghg/index.html
GHG measurements from soils

Transparent and opaque chambers of known volume in combination with Gasmet™ Fourier Transform Infrared Spectroscopy (FTIR) analyzers have been used to measure GHG fluxes from soil samples (closed-loop system). Both automatic measurements, where fluxes from multiple chambers (requires a multiplexer unit) are measured by a single FTIR analyzer, and non-automatic measurements with a single chamber have been performed. Soil fluxes have been measured from different soil types, such as forests, deserts, mires, agricultural fields and biofuel crops (biofuels must meet certain greenhouse gas reduction targets).

Figure 1. Measuring GHG fluxes from the arctic soil using a Gasmet DX4015 integrated with a transparent chamber.


GHG measurements from geothermal sources

Scientists are trying to account for all the sources of GHGs in the atmosphere. FTIR analyzers have been used to measure greenhouse gas fluxes from geothermal sources in Italy in a case of sudden gas eruption, in Romania from geothermal and petroleum systems and in Greece from ophiolite hyperalkaline springs.

Figure 3. **Gasmet DX4040** together with a chamber was used to measure methane flux from geothermal sources.


GHG measurements from ruminants

Gasmet™ FTIR analyzers have been used to measure greenhouse gases from the ruminants by using open circuit respiration chambers, polyethylene film sealed crates and FTIR analyzers connected to automatic milking machines (Automatic Milking System, AMS). Obviously the most interesting gas to be measured and monitored have been methane (CH$_4$) since ruminants produce methane as a by-product of their digestion process. It has been estimated that methane causes 15% of the total greenhouse effect and around 2 – 8% of the total effect comes from ruminants.

![Gasmet DX4040 for measuring the methane emissions from ruminants (cows’ breath).](image)


GHG measurements from manure

It is known that the greenhouse gas fluxes and the nitrogen (NH₃, NO, NO₂) gas fluxes of animal wastes can be considerable during composting. The understanding of microbial processes and compost practices is the key factor in reducing the greenhouse gas and nitrogen gas losses. The moisture content and the temperature of manure have an impact on the production and consumption of gases.

Figure 5. Gasmet DX4015 analyzer integrated with LICOR long-term chamber and multiplexer.

Figure 6. Measuring gas fluxes from experimental dairy barnyard with DX4030.


GHG measurements from aquatic environments

GHG fluxes (mainly CO\textsubscript{2}, CH\textsubscript{4}, N\textsubscript{2}O and H\textsubscript{2}O vapor) have been measured from water systems, such as lakes, rivers and hydroelectric reservoirs, by extracting gases from the water surface with buoyant floating chambers and performing the analysis with Gasmet™ FTIR analyzers. Continuous Emission Monitoring systems (CEMs) have also been used in monitoring the greenhouse gas emissions from the wastewater treatment plants.

Figure 7. GHG measurements from the water/air-interface by using floating closed-loop chambers integrated with Gasmet DX4015.