Practical Solutions for Large-scale CO_2, H_2O, and CH_4 Emission Measurements

As cap-and-trade programs are implemented in regions around the world, consulting firms, land managers, and industrial consultants are seeking methods to measure greenhouse gas emissions and uptake at large scales. With these measurements, stakeholders can quantify greenhouse gas uptake to determine eligibility for carbon credits earned, and greenhouse gas emissions to determine how many credits are used.

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Over the last several decades, members of the scientific community have refined a technique for large-scale land area emission measurements known as the eddy covariance flux method. Flux refers to exchange – the number of gas molecules that move into or out of an area over a known time frame. Eddy covariance is the method used to measure these greenhouse gas fluxes.

Until recently, the eddy covariance method required technical scientific expertise and was considered difficult to use. However, many of the difficulties have been solved and today people can use eddy covariance to measure greenhouse gas emissions from many areas - including landfills, industrial sites, managed ecosystems, wetlands, urban areas, and more.

Why Measure the Big 3 Greenhouse Gases?

Flux measurements are used to answer research and regulatory questions related to global changes, including climate change, population growth, and land use changes. Private consulting firms and governmental organisations address some of these issues by measuring greenhouse gas exchange, carbon sequestration, and emissions from industrial sites and landfills.

For example, cap-and-trade (also known as emissions trading) programs seek to create economic incentives to reduce emissions of carbon dioxide and other greenhouse gases. Successful emission trading depends on accurate measurements of emissions.

Carbon dioxide and methane flux measurements are used to determine regional emission and uptake rates and refine models of the global carbon cycle. Water vapour flux measurements are used for land and water management, precision agriculture, and studies of climate change. These measurements are important for computing fluxes of other gases as well, because water vapour affects the measured density of the other gases, including CO_2 and CH_4. The eddy covariance method is suitable for these measurements in many situations.

How Does Eddy Covariance Work?

An eddy covariance system for greenhouse gas flux consists of a gas analyser to measure the gas density (typically CO_2/H_2O) and a 3-dimensional sonic anemometer to measure wind speed and direction. It may also include analysers for CH_4 flux and other sensors to record meteorological variables, such as air temperature, rainfall, and more. Typical eddy covariance systems are powered by a solar power supply, and may include telemetry components to facilitate remote data transfer and configuration changes.

As wind moves across the surface of Earth, it does so in the form of rotating vortices called eddies. As a result, the air is almost always moving either up or down, much like a wave in the ocean or swirling smoke. When an eddy is moving upward or downward, it will move air with a specific gas content, temperature, and energy.

To measure the gas flux, the anemometer measures wind speed in 3 dimensions, while the gas analyser simultaneously measures gas density or concentration in the same air parcel (eddy). All of these measurements are conducted at high speed – typically 10 or 20 samples per second – to measure the gas in eddies of air as they move through the anemometer and gas analyser.

The final fluxes for an area are computed using computer software, which synchronises data from the gas analyser and anemometer to determine the amount of gas (e.g., H_2O, CO_2, or CH_4) that entered or left the area over a given time period. Typically, software automatically computes flux results and provides diagnostic information about the dataset.

Bringing Simplicity to Complex Measurement Systems

In the past, eddy covariance systems were considered complex and difficult to use. However, LI-COR engineers set out to simplify eddy covariance systems and improve their reliability. "Difficulty configuring systems and reliable data processing were the biggest barriers to widespread, reliable eddy covariance measurements," says Dave Johnson, product manager. "We focused on these problems and we've created something that anyone can use to get dependable and accurate flux results. Whether you're new to flux measurements, or an experienced researcher, there is no need to be intimidated by eddy covariance anymore."

To make eddy covariance systems easier to use, LI-COR addressed three major issues. First, LI-COR created an eddy covariance system that records the core measurements without requiring an external system controller or datalogger. This component controls the gas analyser and records data from the sonic anemometer and gas analyser together on a removable 16 GB USB drive. It is configured through an intuitive Windows software interface, eliminating the need to write computer code or scripts to configure the system. It includes Ethernet communication, making it possible to control the system and transfer data remotely using a local network, line-of-sight radio, cellular modem, or satellite network.

Second, LI-COR created a fully self-contained eddy covariance file type that includes all the information that is required to compute fluxes. Prior to this innovation, critical data was often stored in separate data files, or even hand-written notes, making it difficult to process data sets and leading to poor data management practices. The new files, called GHG files (with a .ghg file extension), are logged by LI-COR analysers and automatically compressed to conserve data storage space.

Third, LI-COR released free eddy covariance processing software called EddyPro. EddyPro reads GHG files directly and computes flux results from the data. It provides a computation mode called Express, which uses widely accepted algorithms to compute reliable flux results with ease. It also has a mode called Advanced, which provides state-of-the-art processing options for data sets that require alternative computation algorithms and in-depth analysis.

EddyPro can use data from additional biological and meteorological (biomet) sensors in computations. This data is used to enhance flux computations, interpret results, and fill gaps in the data set. Not only do these innovations simplify eddy covariance, they save time and improve consistency of computations.

Modular Eddy Covariance Systems

LI-COR provides CO_2/H_2O eddy covariance systems in both open-path and closed-path configurations. The LI-7500A Open Path CO_2/H_2O Analyser provides the lowest power requirements and can be operated with a solar power supply. The LI-7200 Enclosed CO_2/H_2O Analyser is best suited for areas with frequent rain or snowfall. It requires more power, but still can be operated by a solar power supply system. Both the LI-7500A and LI-7200 function as an eddy covariance system hub (with the included LI-7550 Analyser Interface Unit) and provide gas analyser control, sonic anemometer inputs, and GHG file logging for direct processing in EddyPro.

For methane flux measurements, the LI-7700 Open Path CH_4 Analyser is a drop-in addition to LI-COR eddy covariance systems. Methane data are logged in GHG files, making it easy to compute methane flux in EddyPro.

To accommodate different site conditions, LI-COR offers 4 models of sonic anemometer, including omnidirectional and c-clamp styles. Anemometers that are purchased as part of an eddy covariance system include pre-wired cables that provide a simple and robust connection between the anemometer and gas analyser.

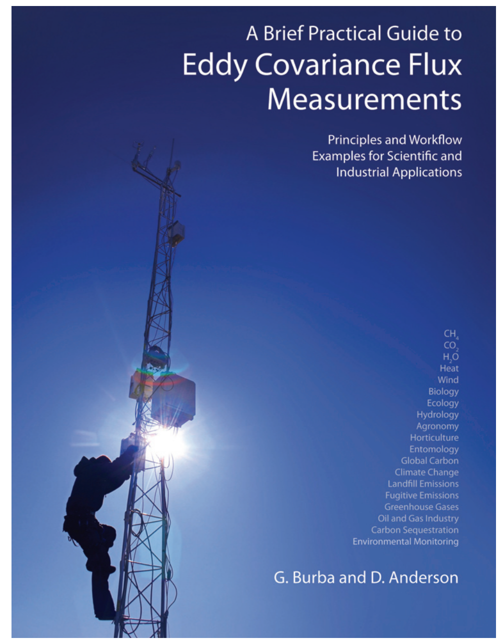
Furthermore, LI-COR developed a biomet system that operates in tandem with the eddy covariance station. The biomet station can record data from nearly any additional sensor, provide system control for automated sensors, and can record data from well over 40 additional channels. Biomet data are also recorded in the self-contained GHG files.

LI-COR offers a heavy-duty scientific instrument tripod that will support the eddy covariance system in high wind conditions. It is available with instrument mounting accessories to accommodate most station and sensor requirements. We also provide resources to help select suitable solar power supplies and telemetry components.

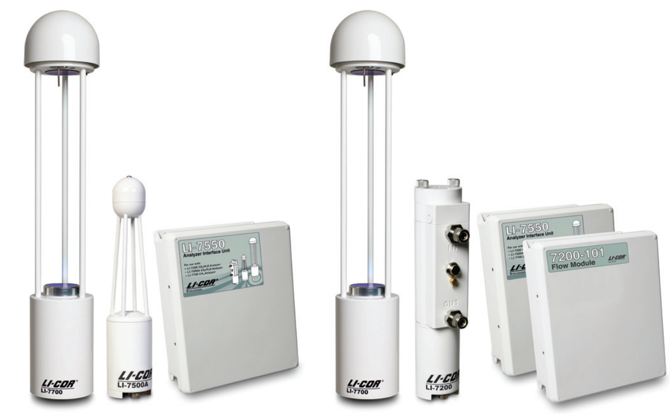
Training and Support

Measuring greenhouse gas emissions involves more than just sensors and systems – training and support are useful to ensure proper deployment and operation of systems. LI-COR provides training opportunities around the world to help people learn to use the eddy covariance method for emissions monitoring. Three-day training courses cover topics from system setup, deployment, maintenance, and data processing. To learn more, review the training schedule at http://www.licor.com/ec-training or download a free copy of "A Brief Practical Guide to Eddy Covariance Flux Measurements" from http://www.licor.com/ec-book.

Today it is more important than ever to measure greenhouse gas exchange, with benefits that determine the allocation of carbon credits, improve agricultural productivity, and explore the relationship between greenhouse gases and climate. As more organisations need to account for sinks and sources of greenhouse gases, LI-COR continues to develop technologies and new products that make this possible. Now non-experts can deploy eddy covariance systems, compute greenhouse gas flux, and help contribute to greenhouse gas accounting anywhere in the world. Contact LI-COR to learn more about eddy covariance systems.



LI-COR provides training and educational resources to help people learn how to use eddy covariance to measure emissions.



Open path and enclosed path eddy covariance systems are compatible with omnidirectional and c-clamp style anemometers. They are available with a tripod, mounting hardware, and accessories.

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