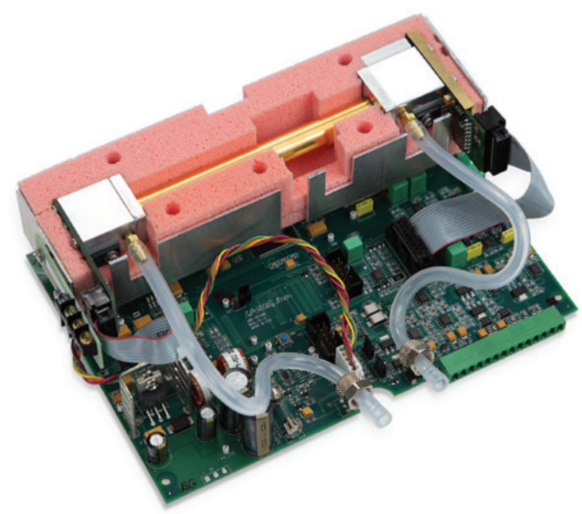
CO_2 Monitoring for Greenhouses, Indoor Air Quality, and Water Quality

Carbon dioxide is best known as a greenhouse gas and climate change driver, but CO_2 concentration is also important for plant health, ocean ecology, and indoor air quality. Off-the-shelf systems are available for monitoring CO_2 levels in various situations and applications. In some cases, you may want to integrate a CO_2 analyser into your own custom-built system.

> *"In continuous monitoring applications, CO_2 analysers need to operate with as little maintenance and as little downtime as possible. A major consideration is contamination of the optical bench, especially in locations with a high level of particulate matter in the air."*

This year, the National Oceanic and Atmospheric Administration (NOAA) reported monthly global average ambient CO_2 levels exceeding 400 ppm for the first time since they started tracking global atmospheric CO_2 levels in 1958. In order to determine the global average, flask samples are collected from numerous remote sites around the world and shipped to NOAA's Earth System Research Laboratory in Boulder, Colorado. One of the instruments used to determine CO_2 levels in each sample is the LI-7000 CO_2/H_2O Analyser. This research-grade differential analyser has the speed, precision, and accuracy needed for the task. But there are other reasons for measuring CO_2 levels besides ambient atmospheric measurements. Carbon dioxide measurements play an important role in fields such as horticulture, oceanography, and indoor air quality management.

This article introduces analysers and systems suitable for continuous CO_2 concentration monitoring. In addition to the LI-7000, LI-COR Biosciences makes a range of analysers for various applications. The LI-820 CO_2 Analyser and LI-840A CO_2/H_2O Analyser both deliver the reliability, repeatability, and ease of use LI-COR is known for, but with a wider measurement range, lower cost, and smaller size. These analysers are research-grade instruments using non-dispersive infrared (NDIR) technology with a single path, dual wavelength infrared detection system. They are widely used for indoor air quality and greenhouse control systems, partial pressure of CO_2 in the water (pCO_2) measurements, and dissolved inorganic carbon (DIC) measurements.



LI-840A CO_2/H_2O Analyser

Greenhouse Monitoring and Control Systems

The concentration of carbon dioxide in the air affects the health and growth of plants. In a closed greenhouse with little ventilation, plants can draw down CO_2 significantly below ambient atmospheric levels during the day, affecting the plant growth. Daytime ventilation can bring greenhouse CO_2 concentrations closer to ambient. CO_2 enrichment—boosting CO_2 above ambient concentrations—can be a profitable choice for some crops. Potted plants, cut flowers, vegetables and rooted cuttings have all been shown to benefit from CO_2 enrichment during the daytime hours (Mortensen, 1987).

An analyser such as LI-COR's LI-820 CO_2 Analyser or LI-840A CO_2/H_2O Analyser can be configured to trigger a ventilation system or the injection of CO_2 and/or H_2O, with the goal of keeping levels within a desired range. They give accurate, stable readings over a wide range of environmental conditions—more extreme than those found in greenhouses. This stability and accuracy is important with high value greenhouse crops. Errors in monitoring could reduce profits and increase the cost of CO_2 enrichment or waste energy through heat loss from excess ventilation.

Indoor Air Quality and Building System Efficiency

Multiple studies have documented the health problems associated with indoor pollutants, a phenomenon commonly known as sick building syndrome (Fisk, 2009). Some level of ventilation is essential in large buildings to avoid the accumulation of harmful pollutants. However, excess ventilation greatly increases energy costs for heating or cooling. A monitoring and control system can be used to manage the ventilation system, creating healthier conditions without ventilating more than necessary. Ventilation based on CO_2 concentration is one way to do this. Since most of the excess CO_2 inside buildings is human-generated, CO_2 concentration above ambient can be a surrogate for human-generated pollutants such as body odor and emissions from office equipment (Seppänen, 1999).

The LI-820 CO_2 Analyser and LI-840A CO_2/H_2O Analyser work well for indoor air quality applications. With configurable alarm relay outputs, these analysers can trigger demand-controlled ventilation systems at pre-determined CO_2 levels (and H_2O in the case of the LI-840A). They can also trigger an alarm if the CO_2 concentration gets too high in industrial settings where CO_2 is added to an enclosed space.

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Monitoring Elevated CO_2 in Fisheries

In 2012, researchers at Oregon State University linked increasing pCO_2 to the collapse of oyster seed production at a commercial oyster hatchery (Barton et. al., 2012). Elevated carbon dioxide in seawater is lowering the pH of the water. This acidification inhibits larval oysters from forming shells at a fast enough pace. The researchers theorise rising atmospheric CO_2 levels may lead to additional acidification of oceans and more severe impacts on shellfish.

Oyster hatcheries are developing strategies for mitigating the damage caused by elevated CO_2 concentration. Water quality monitoring is important in these efforts. A 2015 article in the San Francisco Chronicle describes how UC Davis and the Hog Island Oyster Company are using minute-by-minute data about water conditions to help restore oyster production along the coast of California (Johnson, 2015).

Measurements of pCO_2 or DIC are important for monitoring and understanding ocean acidification. These measurements can be made aboard oceanic vessels, moorings, buoys, or in laboratories. LI-COR has published an Application Note ("Measuring pCO_2 and Dissolved Inorganic Carbonates in Water") which provides a general description of how measurements of pCO_2 and DIC are made. It is available for download from the LI-COR website: www.licor.com/pCO2.

Demand for ocean-atmosphere CO_2 monitoring systems led to the development and commercialisation of an Autonomous pCO_2 Monitoring System by the Battelle Memorial Institute, in collaboration with the Monterey Bay Aquarium Research Institute (MBARI) and NOAA. The autonomous CO_2 monitoring system is designed for continuous monitoring of the CO_2 concentration in air and the pCO_2 in water, to determine whether the ocean is absorbing or releasing CO_2 at a particular location and time. This information will add critical details to our understanding of the role of oceans in CO_2 exchange, and how it varies over time and space.

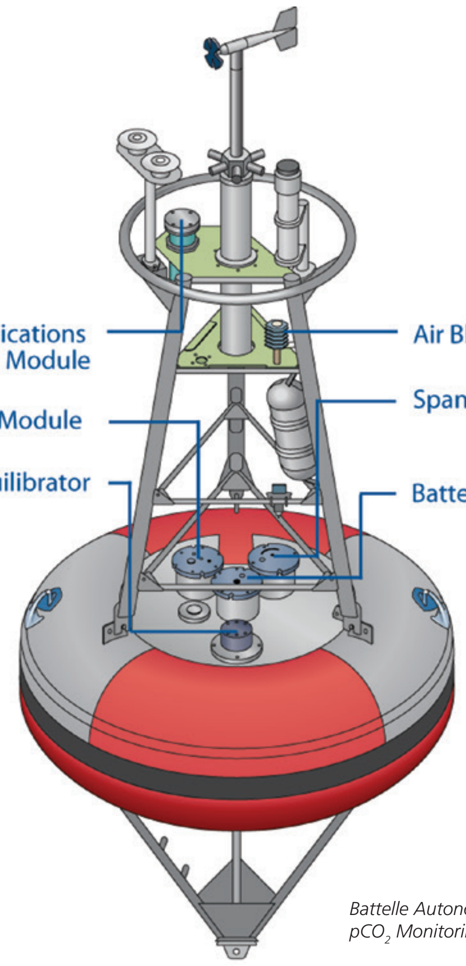
The Battelle Autonomous pCO_2 Monitoring System uses an LI-820 for CO_2 analysis. It is equipped with on-board calibration gases and battery power, which are designed to provide over one year of continuous operation. Two-way communications equipment provides fully autonomous transfer of data and configuration files between the system and land based laboratories, so data can be analysed in nearly real time. Contact Battelle (www.battelle.org) to learn more about their system.

Another source for pCO_2 measurement systems is SubCtech ("Subsea Technologies for the Marine Environment"). SubCtech makes a full range of mobile pCO_2 measuring systems. These systems include research-grade LI-COR analysers. Systems are available for small boat applications and buoys up to typical "underway" ship systems. Options for CO_2 measurements in-air are also available. Find more information at http://subctech.eu/.

Analyser Maintenance

In continuous monitoring applications, CO_2 analysers need to operate with as little maintenance and as little downtime as possible. A major consideration is how to deal with contamination of the optical bench, especially in locations with a high level of particulate matter in the air. The optical bench in an LI-820 or LI-840A can easily be cleaned by the user. This reduces downtime from contamination and eliminates the need for factory recalibration. Another consideration is the analyser infrared source, which will eventually need to be replaced. The infrared source in the LI-820 or LI-840A is estimated to last 2+ years (more than 17,000 hours) in continuous operation and can be replaced by regular staff without factory recalibration.

The choice of analysers or measurement systems depends in large part on your application. Contact LI-COR with any questions or to learn more about monitoring CO_2 and H_2O. They can help you sort through the options.



Battelle Autonomous pCO_2 Monitoring System

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