Soil Gas Flux

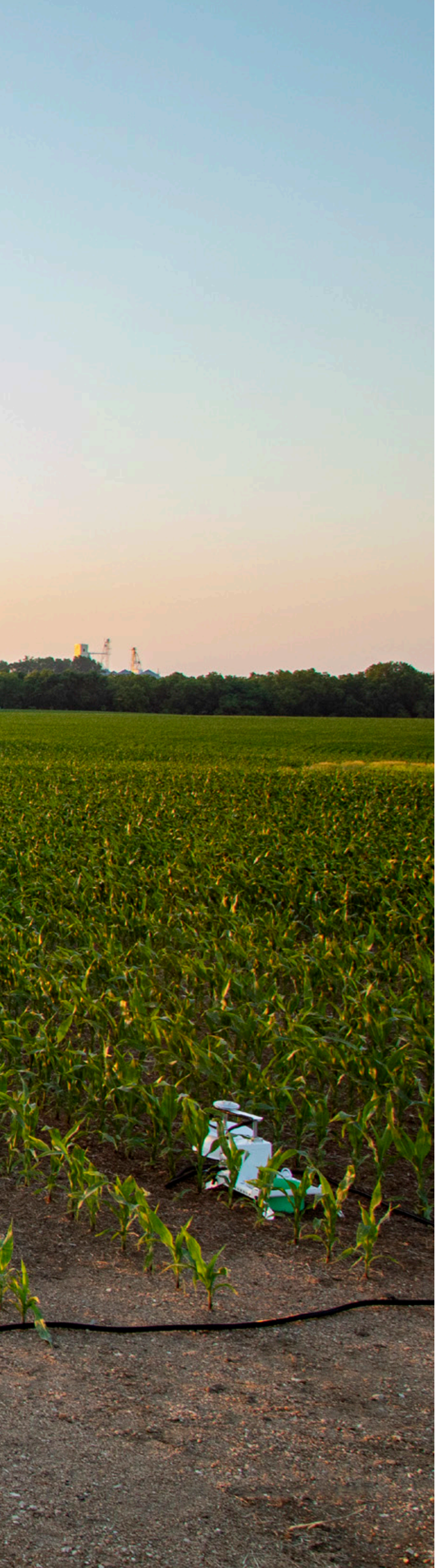
Measurement Solutions

Complete systems guided by scientific principles from the ground up

LI-COR®

Why measure soil gas flux?

Soils produce or consume a substantial amount of gases from the atmosphere through biological processes, including root respiration and organic matter decay. Gases—such as CO_2, CH_4, N_2O, and isotopologues—are continuously exchanged between the atmosphere and soil. Measuring soil gas flux can help researchers characterize greenhouse gas emissions, understand the mechanisms that regulate gas flux, and monitor carbon sequestration efforts, among other applications.



What makes LI-COR different?

In a typical chamber-based soil gas flux system, a chamber temporarily closes over the soil surface. Then a gas analyzer measures gas concentrations from the chamber air. In closed-chamber systems, fluxes are calculated using the rate of change in gas concentration over time and other parameters.

LI-COR is unique in that we design and manufacture complete systems for soil gas flux measurements. From patented hardware and analyzers that take the measurements, to SoilFluxPro™ Software that extends your flux data analysis capabilities—we have you covered.

LI-COR soil gas flux systems are modular and flexible to grow with your research. We offer gas analyzers that measure multiple key greenhouse gas species and have the portability and low-power requirements necessary for survey or long-term research. We also provide patented chambers for survey or long-term field deployments for soil respiration or net carbon exchange measurements.

Minimizing chamber influence through engineering

An inherent challenge to chamber design is the influence the chamber may have on measurements. LI-COR chambers include patented technology exclusive to LI-COR to minimize the effects of chamber placement on the soil, such as disturbances from chamber closing, poorly mixed chamber air, and chamber pressure perturbations.

Equalize chamber pressure

Any difference between the air pressure inside a soil chamber and ambient air will affect the flux rate. If the chamber is not properly vented, under windy conditions the Venturi effect can cause a mass flow of air from the soil into the chamber, leading to significant overestimation of soil gas flux.

To maintain pressure equilibrium, all LI-COR soil chambers feature a patented pressure vent.

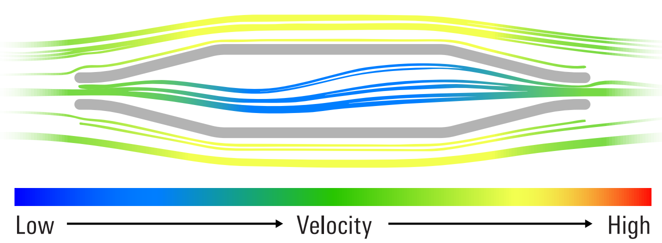


Figure 1. Cross section of the patented pressure vent used on all LI-COR chambers. As air is forced into the vent by wind, the average wind speed drops. As a result, most of the dynamic pressure is converted to static pressure, virtually eliminating the Venturi effect.[1] The patented vent (U.S. Patent 7,856,899) is radially symmetric to eliminate sensitivity to wind direction.[2]

Minimize soil disturbance

Any mechanical disturbance to the soil during a measurement can artificially influence gas fluxes. LI-COR chambers are placed over soil collars that are inserted before measuring. An automated mechanism seals the chamber around the collar. Because the chamber never touches the collar directly, any soil disturbance is negligible, and fluxes are minimally affected.

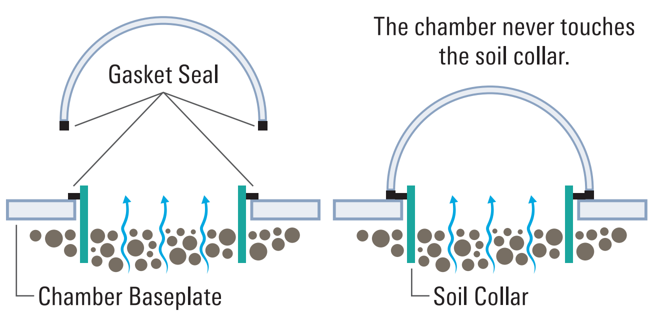


Figure 2. All LI-COR chambers feature a gasket seal around the soil collar with a second gasket on the chamber bowl to minimize disturbances to the soil collar when the chamber is placed or moved.

Optimize chamber air mixing

Air mixing is critical for accurate flux measurements, but fans create pressure gradients within the chamber that may suppress or enhance flux.

All LI-COR soil chambers are designed without fans, and mixing is achieved through a bowl-shaped chamber and air inlet/outlet positioning.

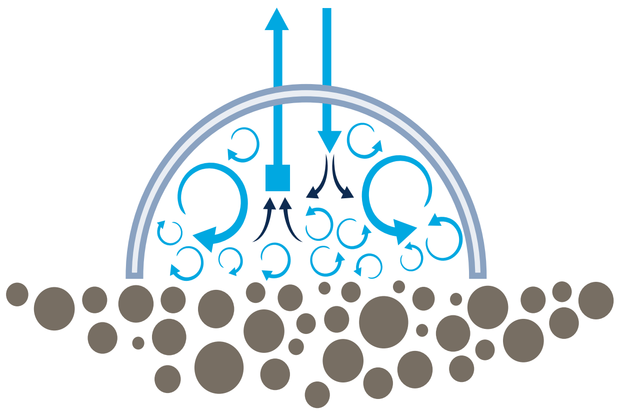


Figure 3. The shape of the chamber, along with air inlet and air outlet placement, ensures that the air within the chamber is well mixed.

Account for an altered diffusion gradient

When measuring gas concentration, you answer the question: "How much of a gas is at a location at a given moment?" When measuring gas flux, however, you answer the question: "How much of a gas is being emitted or absorbed from an area over a fixed period?"

Flux is determined from the rate at which gas concentrations change inside the chamber (Figure 4). However, once the chamber closes over a soil collar, gas concentrations increase and affect the gas diffusion gradient—suppressing the efflux. A linear regression often leads to flux underestimation. In some soils, such as porous soil, the underestimation can be significant.

The Smart Chamber, the LI-8250 Multiplexer, and SoilFluxPro™ Software all use an exponential function when computing fluxes to account for the impact of an altered diffusion gradient and to estimate flux at the time of chamber closing—when gas concentration is at ambient levels. Here we use CO_2 as an example to describe the exponential function:

$$C' = C'_s + [C'_0 - C'_s]e^{-\alpha t}$$

where C' is the instantaneous water vapor dilution-corrected chamber CO_2 mole fraction, C'_s is the water vapor dilution-corrected CO_2 concentration in the soil surface layer under the chamber, and α is a rate constant. With the initial slope ($\partial C'/\partial t$ at t=0) of the function, the flux is estimated at the time of chamber closing, when C' is close to the ambient level (C'_0).

$$\frac{\partial C'}{\partial t} = \alpha[C'_s - C'_0]e^{-\alpha t}$$

Calculating the flux from the measured parameters is accomplished with:

$$F_c = \frac{VP_0(1 - W_0)}{RS(T_0 + 273.15)} \frac{\partial C'}{\partial t}$$

where F_c is the soil CO_2 flux, V is volume, P_0 is the initial pressure, W_0 is the initial water vapor mole fraction, S is soil surface area inside the chamber, T_0 is initial chamber air temperature, and $\partial C'/\partial t$ is the initial rate of change in water vapor dilution-corrected CO_2 mole fraction.

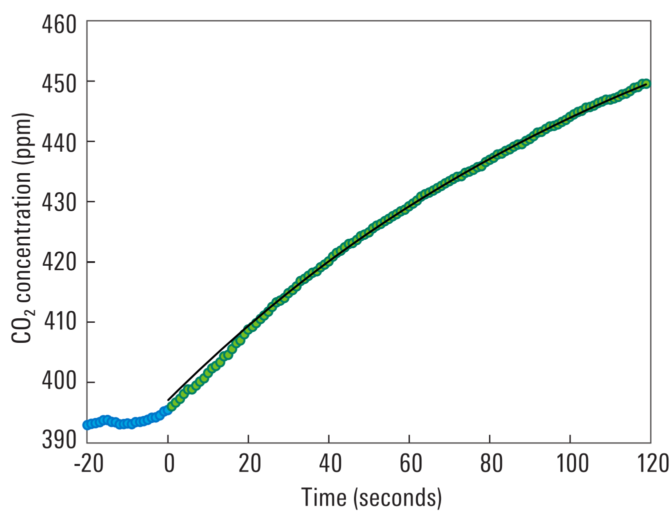


Figure 4. The CO_2 concentration in the chamber begins to increase the moment the chamber closes. As a result, the flux begins to decrease, indicated by the slope ($\partial C'/\partial t$) that decreases with time. Blue circles represent the pre-measurement CO_2 concentration; green circles represent the concentration during the measurement. An exponential fit can minimize the effect of an altered diffusion gradient.

References

1. Xu, L., Furtaw, M.D., Madsen, R.A., Garcia, R.L., Anderson, D.J., and McDermitt, D.K. (2006). On maintaining pressure equilibrium between a soil CO_2 flux chamber and ambient air. *Journal of Geophysical Research*, 111(D8). DOI: 10.1029/2005JD006435
2. Furtaw, M.D., McDermitt, D.K., and Xu, L. (2010). Vent and soil flux measurement system. U.S. Patent No. 7,856,899. Washington, DC: U.S. Patent and Trademark Office.

SoilFluxPro™ Software: Data processing simplicity

SoilFluxPro Software is a powerful, free software included with all LI-COR survey and long-term systems to help manage large datasets and simplify them into the details you are interested in. SoilFluxPro provides you with all the raw data and allows you to adjust critical parameters and recalculate entire datasets at the push of a button.

- Revise parameters, such as start and stop time, then recompute fluxes from both long-term and survey datasets
- Perform quality assurance and quality control checks using revised parameters
- Plot results and statistics quickly to evaluate measurements individually or in groups
- Compute statistics for individual measurements or whole datasets
- Create .kml files to map concentrations and fluxes on Google Earth™
- Compute fluxes from measurements made by third-party analyzers

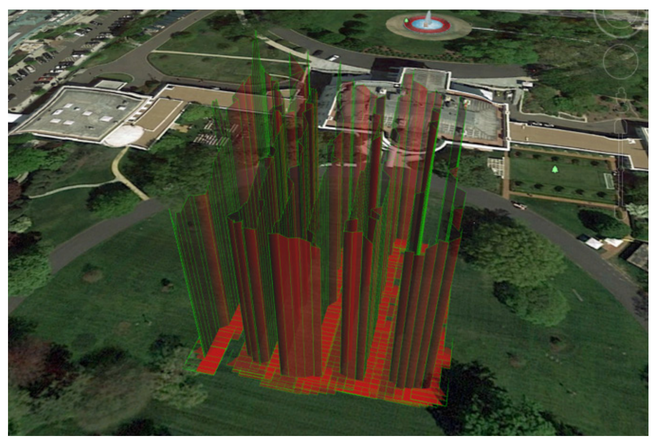
Why choose SoilFluxPro?

Quality control your soil gas flux results

With a LI-COR gas analyzer, the Smart Chamber and the LI-8250 Multiplexer calculate real-time fluxes. SoilFluxPro™ can be used to revise parameters, such as start and stop time, then recompute fluxes of entire datasets for quality assurance checks. Built-in tools allow for quality control and quick evaluation of your datasets.

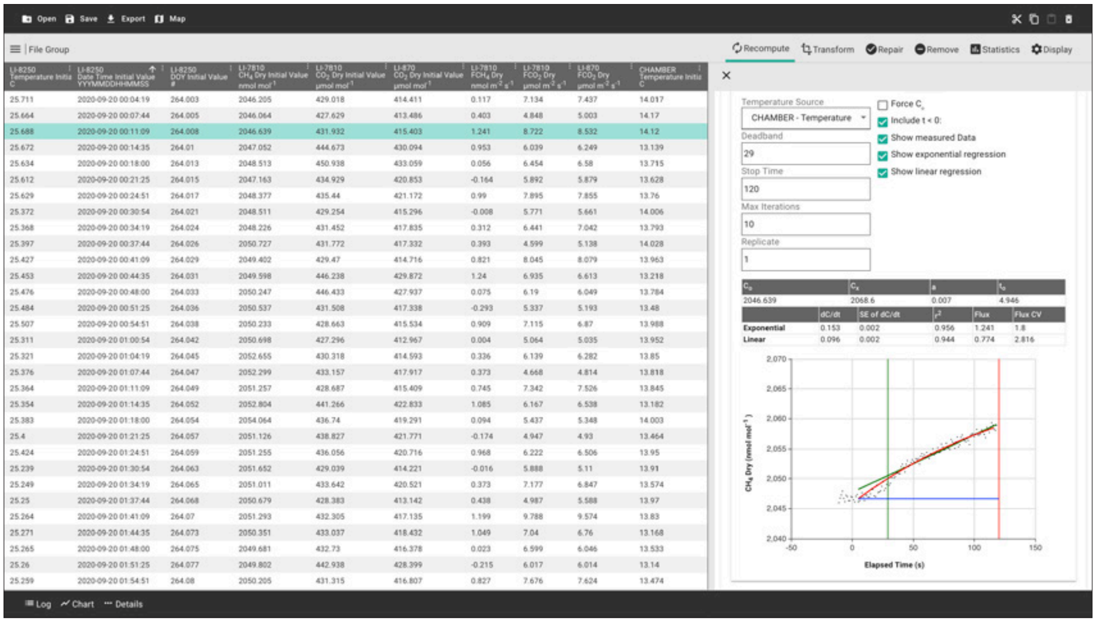
Keep the flexibility you started with

The Smart Chamber and LI-8250 Multiplexer both integrate analyzers of various gas species, including third-party analyzers. SoilFluxPro carries that integration through post-processing. Compute fluxes of trace gases and isotopologues using complex datasets imported from LI-COR and third-party analyzers.

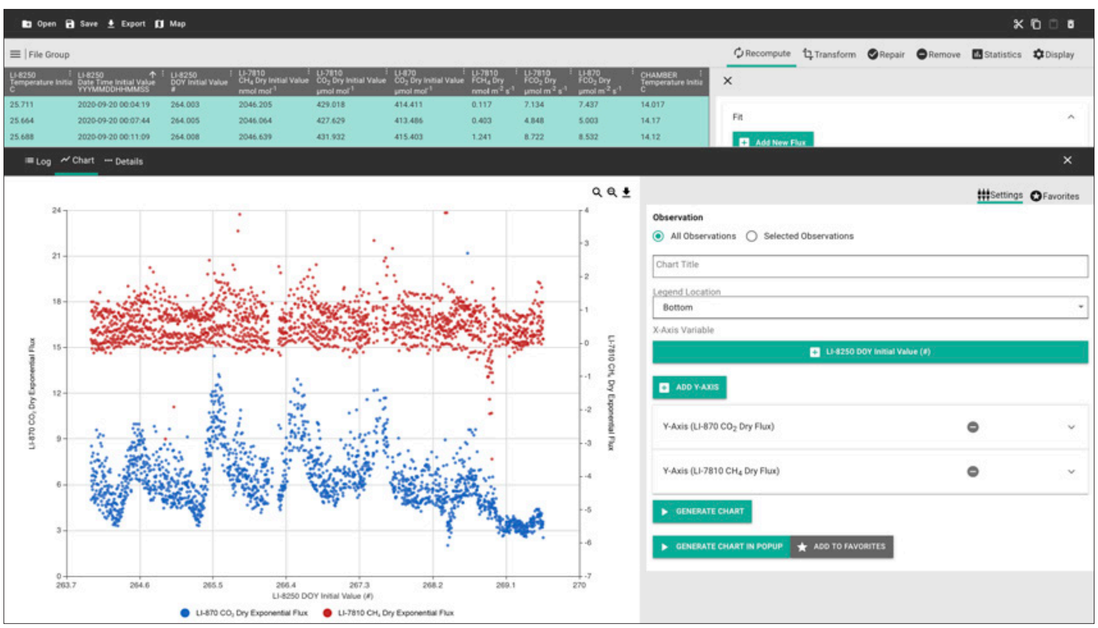


Map your soil gas fluxes

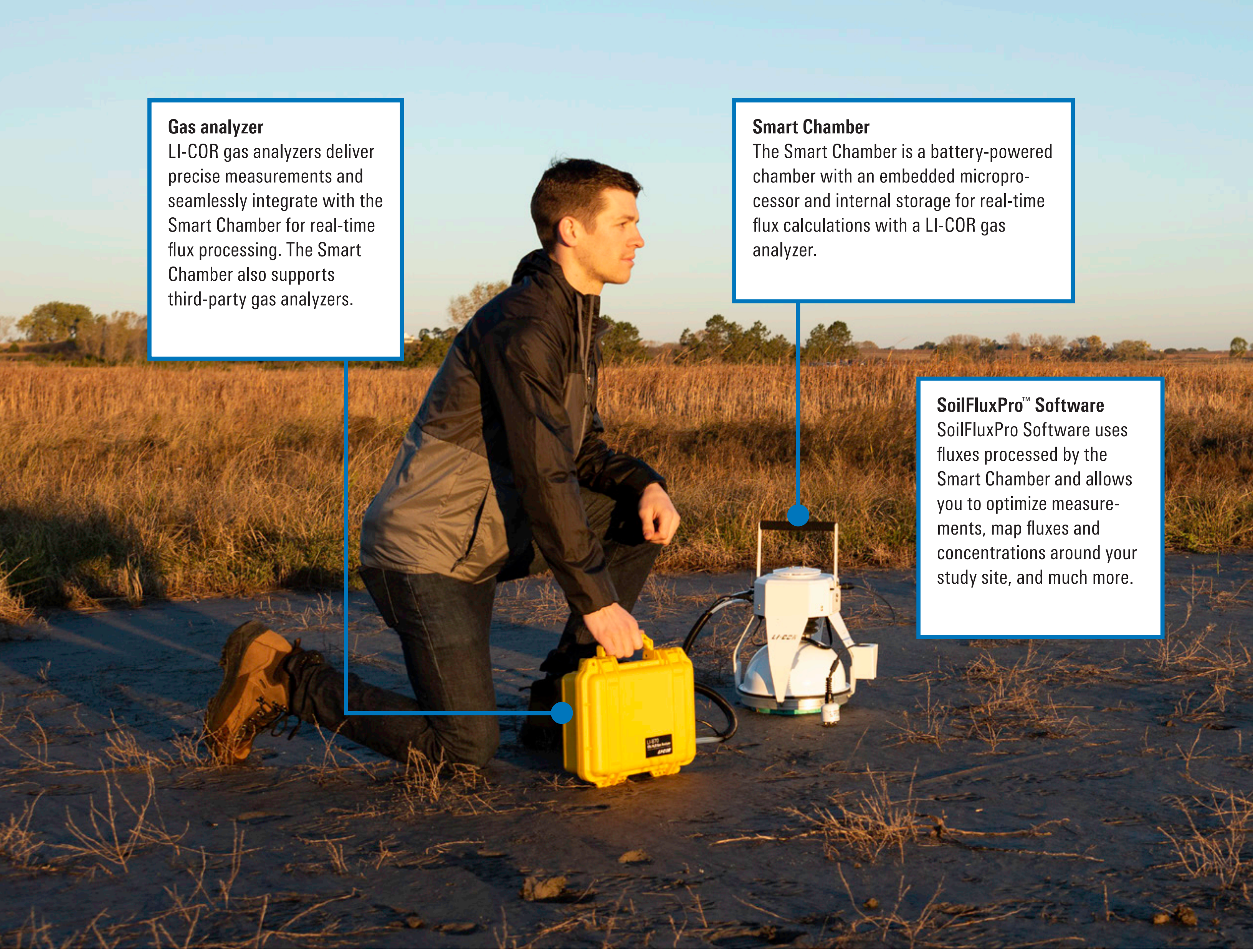
Each measurement is tagged with GPS location data. SoilFluxPro uses that data to create a .kml file with concentrations and fluxes. You can then export that .kml file to the Google Earth™ mapping service to see a variety of visualizations.



Easily revise key parameters, such as start and stop time, and instantly see the effect on your flux calculations. Shown are CH_4 concentration data used in the flux calculation from an LI-8250 Multiplexer using an LI-7810 CH_4/CO_2/H_2O Trace Gas Analyzer.



Graph fluxes, concentrations, and other variables to see changes over time or to compare with other variables. Shown are fluxes over time of CH_4 and CO_2 using data from an LI-7810 Trace Gas Analyzer and LI-870 CO_2/H_2O Analyzer, respectively. Data was collected concurrently by the LI-8250 Multiplexer.



Survey systems: Assess spatial variability

LI-COR survey systems are portable and allow a researcher to quickly make soil gas flux measurements to characterize flux over a large area of interest. A survey system is uniquely suited to:

- Assess the spatial variability of soil gas flux over a large area
- Move quickly from one collar to the next to measure many points across your site
- Deploy in locations where instruments cannot be left long term

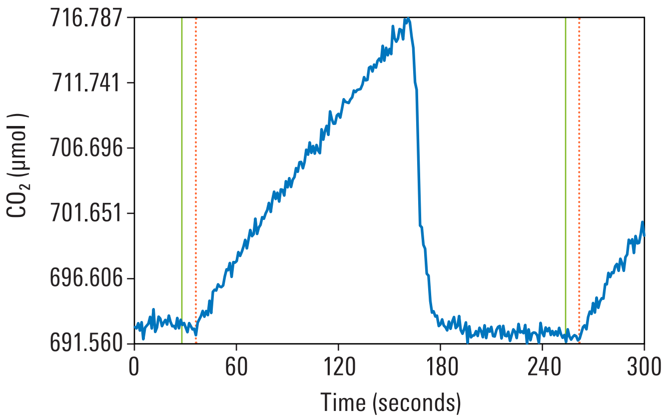
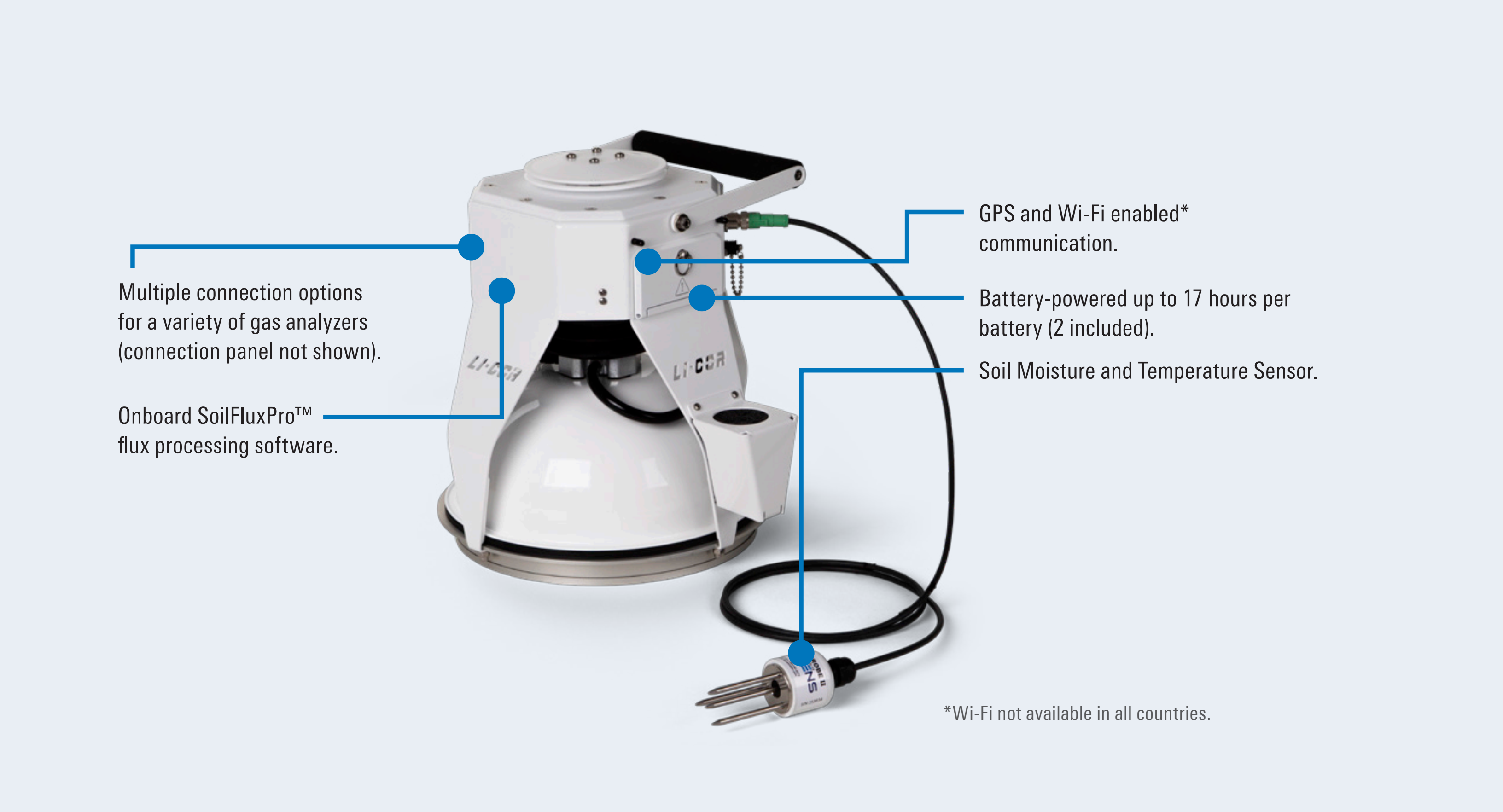


Figure 5. Monitor chamber closing, dead band, and CO_2 concentration changes. These variables are then used in flux calculations through the Smart Chamber's onboard software. Data shown are from an 8200-01S Smart Chamber with LI-870 CO_2/H_2O Analyzer.



Smart Chamber

The 8200-01S Smart Chamber is a portable and battery-powered chamber that features Wi-Fi connectivity and onboard flux processing with LI-COR gas analyzers. Connect, configure, and control the Smart Chamber using your mobile device or laptop via the embedded web server to see real-time flux data from multiple gas species.

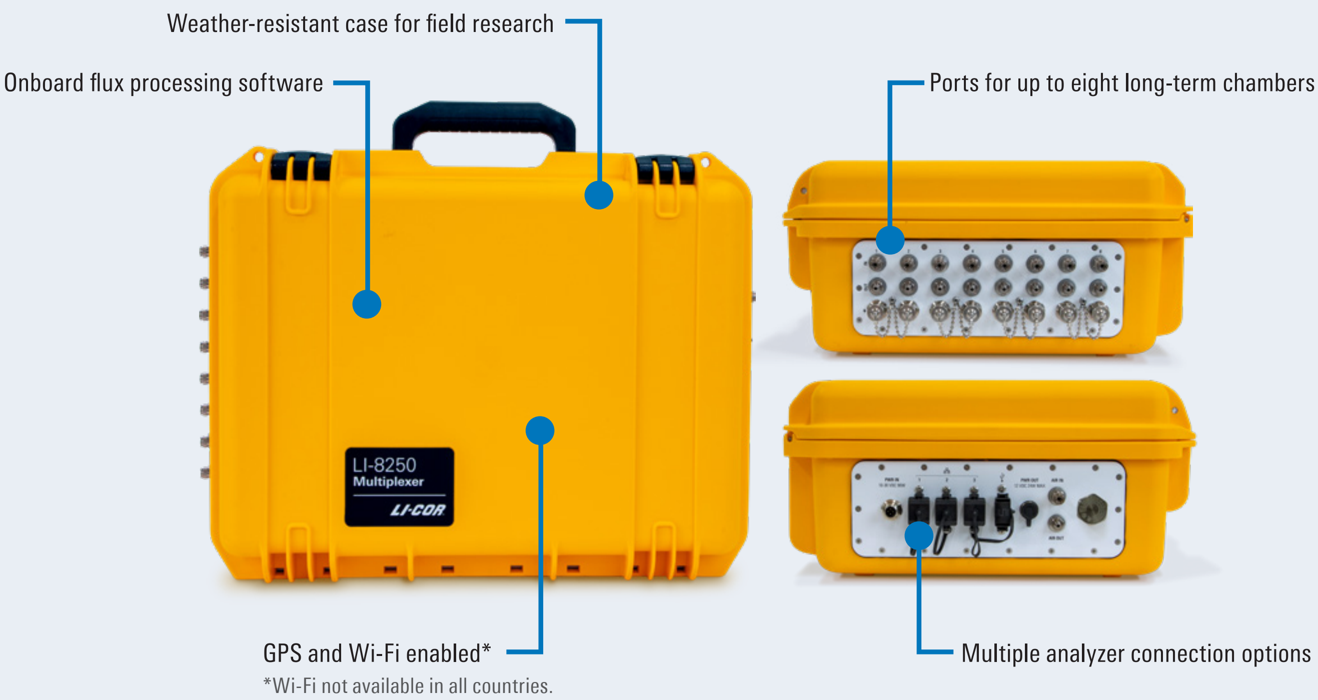
The Smart Chamber difference

- Includes the same patented technology unique to all LI-COR chambers
- Processes fluxes, integrated with auxiliary sensor, GPS, and time stamp data, in real-time with LI-COR gas analyzers
- View measurements, diagnostics, and data files from all LI-COR devices using an intuitive browser-based interface
- Collect third-party analyzer data concurrently with Smart Chamber data and merge them using SoilFluxPro™ Software
- Use the Trace Gas Sampling Kit to collect gas samples and log ancillary data with the Smart Chamber

Long-term systems: Evaluate spatial and temporal variability

A long-term system provides data useful for assessing both the spatial and temporal variability of soil gas flux. This is accomplished by making preconfigured, automated measurements over time using up to eight chambers placed around your study site. This information is valuable to:

- Examine how events, such as rainfall, impact soil gas flux
- Evaluate how flux is regulated by environmental variables, such as soil temperature and soil moisture
- Characterize diurnal and seasonal flux patterns



LI-8250 Multiplexer

The LI-8250 Multiplexer is the connection and control center of a long-term system directing the flow of gas between long-term chambers and gas analyzers. The LI-8250 processes fluxes on-site with a LI-COR gas analyzer, and you can see flux data live by connecting to the web server using Wi-Fi and your mobile device or laptop.

LI-8250 Multiplexer advantages

- View data, configure measurements, and interact with all connected LI-COR devices from a single point
- Make continuous automated measurements using any combination of up to eight clear and opaque chambers
- Research even in harsh conditions with a rugged design
- Receive summary and raw data files to monitor your site from anywhere when connected to your site's cellular modem

LI-COR long-term chambers

All LI-COR chambers include innovations to ensure the chambers have minimal impact on the soil environment and your measurements. Long-term chambers are intended to be left in the field for extended periods. Connect multiple SDI-12 sensors and light sensors to the chamber to collect ancillary data throughout your measurements.

- Patented vent design maintains ambient pressure in the chamber.
- Adjustable legs allow deployment on uneven surfaces and slopes.
- Chamber movement minimizes disturbance to soil gas concentrations.
- Clear chambers enable net carbon exchange measurements.

8200-104 Opaque Long-Term Chamber

The 8200-104 uses a reflective white enamel chamber that rotates to and from the soil collar for automated measurement of soil respiration.

8200-104C Clear Long-Term Chamber

The 8200-104C is specifically designed for net carbon exchange (NCE) research. A clear chamber allows plants within the collar to receive sunlight and continue photosynthesis during a measurement—helping you better understand the net carbon exchange within an ecosystem.

Custom chamber integration

If you have a chamber specifically designed for your application, the LI-8250 Multiplexer will allow you to integrate that chamber into a long-term soil gas flux system.

Gas analyzers

Choose a gas analyzer based on your gas of interest. LI-COR soil gas flux systems let you connect with a range of gas analyzers according to your research needs. When using LI-COR gas analyzers, you can automate measurements specific to your analyzer, see processed fluxes live from your mobile device or laptop, and examine key diagnostics for your measurement.

LI-870 CO_2/H_2O Analyzer

The LI-870 takes rapid and repeatable CO_2 and H_2O measurements for both survey and long-term systems.

- Powered directly by the 8200-01S Smart Chamber or LI-8250 Multiplexer
- Designed to be small and lightweight for a full day of survey measurements
- Features a user-serviceable optical bench in a durable, weather-resistant case

Trace Gas Analyzers

LI-COR Trace Gas Analyzers provide high performance with low power requirements and easily integrate into survey and long-term soil flux systems for an entirely comprehensive research solution.

- Utilize Optical Feedback-Cavity Enhanced Absorption Spectroscopy (OF-CEAS) and a suite of patented technologies
- Are powered by hot-swappable, long-lasting batteries or AC power
- Require minimal field enclosure for long-term deployment
- Are easily portable for survey measurements

LI-7810 CH_4/CO_2/H_2O Trace Gas Analyzer

The LI-7810 delivers high-precision CH_4 and CO_2 concentration measurements with benchtop precision and stability in a rugged, weather-resistant design.

LI-7820 N_2O/H_2O Trace Gas Analyzer

The LI-7820 offers high-precision N_2O measurements in a low power, reliable design that is built for field research.

Specifications

LI-8250 Multiplexer

General

Dimensions: 38.5 cm L × 52 cm W × 18.5 cm H
Weight: 7.7 kg
Weatherproof Rating: Tested to IEC IP55 standard
Operating Range:
Temperature: -20 to 45 °C
Humidity: 0 to 95% RH, non-condensing
User Data Storage: 8 GB total non-volatile
GPS: Accuracy 2.5 m CEP
Coverage Area:
Maximum radius from LI-8250 to chambers: 15.0 m with one extension tube.
Maximum diameter of measurement circle: 30.0 m with one extension tube on each chamber.
Plumbing:
Flow rate to/from chambers: ~2 to 3 lpm
Pump type: Diaphragm (pumps in the analyzers subsample air stream in the LI-8250)
Barometric Pressure Sensor:
Measurement Range: 20 to 110 kPa
Sensor Accuracy: ±0.4 kPa from 50 to 110 kPa
Resolution: 0.006 kPa

Communication

Seven LED Indicators: Power, Ready, Ethernet activity (3), USB activity (2)
Connectivity: Three Ethernet Ports, Wi-Fi (not available in some countries)
Wi-Fi Compatibility: 2.4 GHz, 802.11 a/b/g/n/ac
Connectivity Ports:
USB-A: One sealed and strain-relieved for connection to LI-870 CO_2/H_2O Analyzer
USB-A: Two standard, internal for USB mass storage (file transfer) or a country specific Wi-Fi adapter.
RJ-45 Ethernet: Three sealed and strain-relieved for connection to LI-COR Trace Gas Analyzers, non-LI-COR analyzers, site Ethernet network, or cellular modem. Connectors also accept standard, non-sealed RJ-45 Ethernet cables for lab use.
Output Port Connector: RS-485 communication plus 24 VDC power, full duplex, 115,200 baud. +24 VDC output power is current limited to 2.25 A ±15% per output port.

Power

Power Requirements: 10 to 30 VDC (120 VAC and 240 VAC with optional power supply). The LI-8250 powers the LI-870 when connected. Other analyzers are powered separately. See Table 1 for total system power requirements.

Table 1. Total system power requirements.

Typical Power Consumption (W)			
Instrument	Idle	Sampling/ Moving	Max/ Warm-up
LI-8250	4.4	16.1	19.5
8200-104 (each)	0.3	7.5	N/A
LI-870	3.9	3.9	14.0

Note: The max listed for the LI-8250 is a typical maximum, there is no additional warm-up power. Chamber power reaches 7.5 W only when opening or closing, not the entire time of sampling.

8200-104 Opaque and 8200-104C Clear Long-Term Chambers

General

Dimensions: 48.3 cm L × 38.1 cm W × 33.0 cm H
Weight: 7.3 kg
Chamber Volume: 3955 cm^3
Soil Area Exposed: 317.8 cm^2
Weatherproof Rating: Tested to IEC IP55 standard
Air Temperature Thermistor:
Operating Range: -20 to 50 °C
Accuracy: ±0.3 °C from -20 to 50 °C
Light Sensor Current Input:
Range: 0 to 100 µA
Resolution: 1.5 nA
Accuracy: ±(0.37 % of Reading + 8 nA) from -20 to 50 °C
SDI-12 Communications Interface:
Max Number of Devices: 10
Output Voltage: 12 VDC, 200 mA

LI-870 CO_2/H_2O Analyzer

General

Dimensions: 28.4 cm L × 27.9 cm W × 12.4 cm H
Weight: 2.31 kg
Operating Temperature Range:
-20 to 45 °C, without solar loading
Power Consumption:
After Warmup (without pump):
0.33 A @ 12 VDC (4.0 W) average
After Warmup (with pump):
0.42 A @ 12 VDC (5.0 W) average
Measurement Range:
CO_2: 0 to 20,000 ppm
H_2O: 0 to 60 mmol mol^{-1}
Measurement Accuracy:
CO_2: Within 1.5% of reading
H_2O: Better than 1.5% of reading

8200-01S Smart Chamber

General

Bowl Diameter: 20 cm
Chamber Volume: 4244.1 cm^3
Soil Area: 317.8 cm^2
Weight (including battery): 4.3 kg
Memory: 8 GB total non-volatile (includes operating system and user data files)
GPS: Accuracy 2.5 m CEP
Operating Temperature Range: -20 to 50 °C
Air Temperature Thermistor:
  Operating Range: -20 to 70 °C
  Accuracy: ±0.5 °C over 0 °C to 70 °C
Barometric Pressure Sensor:
  Operating Range: 50 to 110 kPa
  Accuracy: ±0.4 kPa
  Resolution: 1.5 Pa Typical

Communication

Wi-Fi Compatibility: 2.4 GHz, 802.11a/b/g/n/ac
SDI-12 Interface: Intended for connecting Stevens HydraProbe for soil moisture and temperature (included)
Connectivity Ports:
  USB-A: One sealed and strain-relieved for connection to LI-870 CO_2/H_2O Analyzer
  USB-B: One sealed and strain-relieved for connection to non-LI-COR gas analyzers
  RJ-45 Ethernet: One sealed and strain-relieved for connection to LI-COR Trace Gas Analyzers
  USB-A: One standard for connection to external Wi-Fi adapter
  Thermocouple Port: Intended for measuring soil temperature, using 6000-09TC (not included, optional)
Cable Length:
  1.2 m or 2 m (Ethernet, for LI-COR Trace Gas Analyzers)
  1.2 m (USB-B, LI-870 Power for LI-870 CO_2/H_2O Analyzer)

Power

Power Out: 10 to 17 VDC battery, unregulated, self-resetting fused, 2 A
Battery: 4S Li-Ion, 98 Wh, Smart-Battery with protection
Battery Life:
  34 hours use; 2 batteries, 17 hours per battery (2 minutes per collar active time, and 20 collars total per hour).
  20 hours use; 2 batteries 10 hours per battery (above use case and including powering LI-870 CO_2/H_2O Analyzer).

Trace Gas Analyzers

General

Measurement Technique: OF-CEAS (Optical Feedback-Cavity Enhanced Absorption Spectroscopy)
Measurement Rate: 1 sample per second (1 Hz)
Optical Cavity Volume: 6.41 cm^3
Flow Rate: 250 sccm (nominally)
Total Weight: 10.5 kg (including batteries)
Case Dimensions: 51 cm L x 33 cm W x 18 cm H
Operating Temperature Range: -25 to 45 °C (without solar load, under normal operating conditions)
Operating Humidity Range: 0 to 85% RH (non-condensing, without solar load, under normal operating conditions)
Sample Line Humidity Range: 0 to 99.9% non-condensing
Operating Pressure Range: 70 to 110 kPa
Connectivity: Ethernet, Wi-Fi (not available in some countries)
Wi-Fi Compatibility: 2.4 GHz, 802.11 a/b/g/n/ac
Power Consumption:
  Steady State Operation: 22 W at 25 °C
  Warmup (10.5 to 33 VDC power supply, pins 3 and 4): Up to 90 W
  Warmup (Universal power supply or 24 VDC power supply, pins 1 and 5): Up to 140 W with batteries charging
Power Supply: Universal Power Adapter (Input: 100 to 240 VAC, 50-60 Hz; Output: 24 VDC)
Battery Life: 8 hours typical with 2 batteries
H_2O Measurements
  Measurement Range: 100 to 60,000 ppm
  Precision (1σ):
    45 ppm at 10,000 ppm with 1 second averaging
    20 ppm at 10,000 ppm with 5 second averaging

LI-7810 $CH_4/CO_2/H_2O$ Trace Gas Analyzer

$CH_4/CO_2/H_2O$ Measurements
  Response Time (T_{10}-T_{90}): CH_4 ≤ 2 seconds, 0 to 2 ppm
CH_4 Measurements
  Measurement Range: 0.1 to 100 ppm
  Precision (1σ):
    0.60 ppb at 2 ppm with 1 second averaging
    0.25 ppb at 2 ppm with 5 second averaging
  Maximum Drift: < 1 ppb per 24-hour period
CO_2 Measurements
  Measurement Range: 1 to 10,000 ppm
  Precision (1σ):
    3.5 ppm at 400 ppm with 1 second averaging
    1.5 ppm at 400 ppm with 5 second averaging

LI-7820 N_2O/H_2O Trace Gas Analyzer

N_2O Measurements
  Measurement Range: 0 to 100 ppm
  Response Time (T_{10}-T_{90}): N_2O ≤ 2 seconds, 0 to 330 ppb
  Precision (1σ):
    0.40 ppb at 330 ppb with 1 second averaging
    0.20 ppb at 330 ppb with 5 second averaging

Specifications subject to change without notice.

Výhradní zastoupení v ČR a SR

Ekotechnika s.r.o.
K Třešňovce 700,
252 29 Karlík
Česká republika
www.ekotechnika.cz