OPTI-SCIENCES *Presents -* ADC BioScientific Ltd.

ACE - The *next-generation* automatic long term unattended Soil CO_2 Flux system.

World Class Precision

40+ Years experience measuring CO_2

U.S. warranty and service center

Each station has its own IRGA integrated into the measuring chamber for a faster more reliable measurement.

IRGA drift is zeroed out on every station, and after each individual measurement assay, with CO_2 free air

Truly Wind Proof!

Each station can be put miles apart from other stations, or they can be multiplexed together.

Up to 30 individual stations may be multiplexed together for improved measuring accuracy.

You can start with one station, and build a multiple station system over time, as funding allows.

Open System with pressure equalization valve

Closed System Ideal for high wind environments

Transparent Open System with pressure equalization valve

The ACE Multiplexed System Stations may be 200m apart.

ADC BioScientific Ltd.
located in
Great Amwell, Herforshire
England.

Opti-Sciences, a manufacturer of precision Chlorophyll Fluorometers, is now the exclusive US distributor for ADC BioScientific products.

Opti-Sciences also operates the US Customer Service and Repair Center at it's international headquarters in Hudson NH.

ADC- a history of innovation, precision and portability.

In 1970 ADC introduces the *first* "Differential" Infrared Gas Analyzer (IRGA) system available anywhere for plant science. Before this time absolute IRGAs were used.

ADC introduced the *first* portable IRGA system with hand held leaf chamber in 1983.

ADC champions the first "Open" plant IRGA system in 1970. Open IRGA systems are now the standard in photosynthesis investigation.

The *first* micro-environmental control system for photosynthesis was an ADC innovation in 1983.

In 2006 ADC introduced the ACE long term automatic Soil CO_2 Flux system. While it was not the first system to market, ADC was able to learn from the shortcomings of other system and offer significant improvements.

One of the important limitations of early plant CO_2 gas exchange systems was that the infrared gas analyzer was far from the sampling chamber, causing potential gas hang-ups and water vapor dropout in the long tube between the chamber and the IRGA. Tube temperature, and light could change the temperature of the gas before it reached the IRGA chamber causing inaccurate readings.

Each individual ACE system has an IRGA right next to the sampling chamber to eliminate these effects. Other innovations such as offering both open or closed systems, reduced power consumption, and transparent systems for plant and soil enclosure have made the ACE system the technology leader.

Innovative IRGA (infrared gas analyser) design

Advantages of having the IRGA next to the sampling chamber:

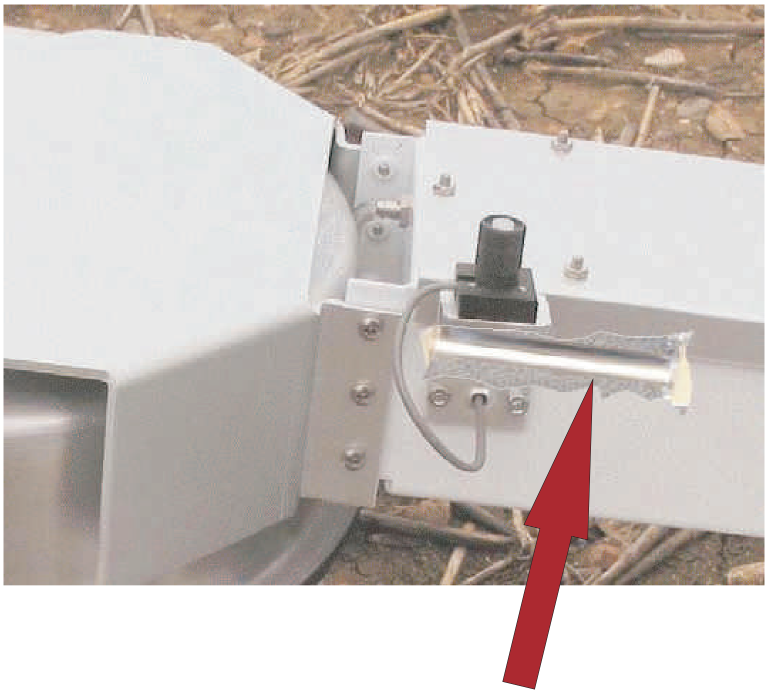
1. Gas hang up is eliminated as a problem.

2. Water vapor drop out is eliminated as a problem.

3. Energy consumption by individual measuring tools, and integrated multiplexed systems is reduced dramatically.

4. Improvement in measuring response times.

5. Since each separate unit contains an IRGA. Each station can be placed miles apart from other stations. Even when the units are multiplexed together, they may be up to 200 meters apart.



The IRGA measuring chamber is located next to the soil sample chamber

Early CO_2 gas exchange system used for Photosynthesis systems did not have the IRGA close to the sampling chamber. The result was that sunlight, sun flecks, and CO_2 transfer tube temperature differences created occasional difficulties. Temperature change could cause gas hang-ups, and water vapor drop out from the air sample that was being tested, creating inaccurate measurements. In the 1990's a company from Nebraska placed the IRGA near the sampling chamber for the first time, eliminating these problems. Today, most photosynthesis systems do the same thing.

ADC now provides this improved way to measure CO_2 in automated long term Soil CO_2 flux measuring systems.

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Innovative auto-zero concept eliminates IRGA drift for every measurement

All IRGA chambers made by all manufactures, have light sources and sensors that drift electronically. Systems with multiple IRGA chambers have multiple light sources and sensors that drift independently from each other. For this reason, ADC has come up with an innovative solution. Air that is free of CO_2 is used to auto- zero out this drift in every station and at end of every measurement!

More options reduce measuring error

Open Systems & Closed systems

Closed systems, by definition, are closed without a vent. Before the chamber closes and seals, air flows through the chamber. This purges any non-ambient CO_2 levels from the chamber before measurement. Closed systems take a CO_2 measurement of ambient air after the soil sample chamber is sealed. This becomes the CO_2 reference. The system continues to take measurements every ten seconds and the Pedersen (2001) algorithm is applied to determine NCER or Net CO_2 exchange rate. desired CO2 level and maximum measuring times can be programmed to ensure that optimal measurements times occur, and that chamber CO_2 buildup does not prevent reliable measurement . Since it is truly a closed system, even high winds can not be a factor in results, as may occur in systems that are semi-closed or closed systems with wind proof vents. Measurements are simple and fast. A horizontally mounted fan in the closed chamber circulates the air to minimize soil-air boundary layer resistance issues. Both individual assay information, and diurnal NCER measuring information is accessible along with soil temperature and soil moisture information derived from attached accessories. A horizontal fan inside the chamber allows chamber purging before closure, and minimized soil - air boundary layer resistance phenomenon.

In **Open systems**, air flows through the chamber before the chamber is closed and sealed. This purges any non-ambient CO_2 levels from the chamber before measurement. After the chamber is closed, fresh air is pumped into the chamber at a controlled and programable set flow rate. This mixes with the CO_2 from the soil, and after a period, equilibrium is reached. This period is determined by the user specifying a rate of change in the form of a difference in CO_2 measurements between successive readings, and an elapsed time. During the assay, the rate of change slowly reduces until it meets the customer's rate of change criteria, or the maximum selected time for the assay. Soil flux or rate of change is then determined once equilibrium conditions are reached within the chamber. Chamber flow rates and times are programable, accurately measured, and used in calculations. While open system measurements are slower, many researchers consider this type of measurement more accurate.

Since the air movement inside the chamber might cause increased chamber positive pressure, a wind proof equalization pressure vent prevents this from happening.

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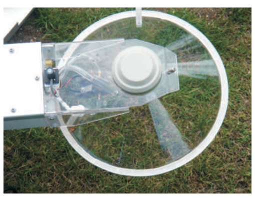
For the reasons described above, open path systems are not subject to CO_2 build up issues. They are also not as sensitive to soil structure variation, or to boundary layer resistance issues at the soil surface. Air flow in the chamber at the soil surface, minimizes boundary layer resistance phenomenon and improves measurement reliability.

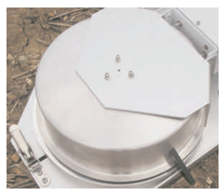
Soil measuring chamber options for a more reliable measurements



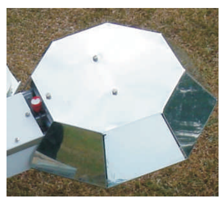
Transparent versions of both the "open" and "closed" chambers are available for measuring net CO_2 exchange within the chamber area.

The transparent chamber can allow measurements of combined plant and soil CO_2 flux..

Closed Mode: A measurement is made once the chamber is sealed. CO_2 inside the large 2.6L



Heat Reflector Cowling
Made for extreme environments

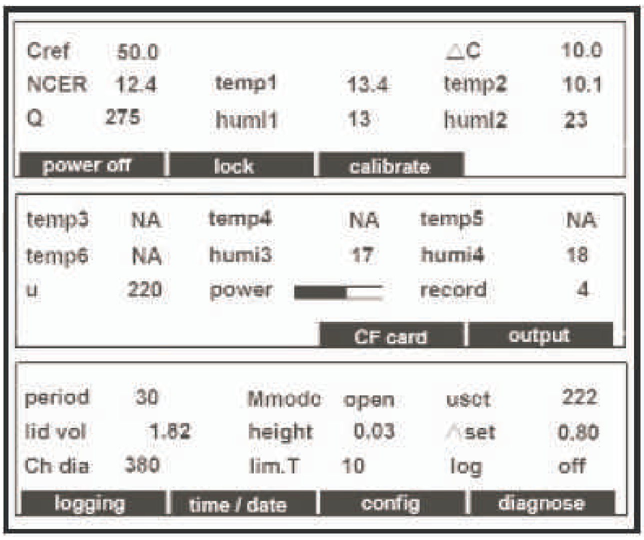


Open Mode: When the chamber seals, ambient air is passed through the smaller 1.0L chamber at a controlled flow rate. A wind proof pressure vent ensures optimal measurement

Paying attention to details

Individual units and multiplexed systems are easy to set up and program -

The ACE Station is easy to set up and program. As the system is fully integrated, there is no gas tubing or complex gas circuits to set up and connect between an analyzer and a separate soil chamber. The control console features a large display screen. Full programming is achieved using just 5 keys that drive a series of easy to use menus. Gas exchange data, soil flux calculations and other sensor measurements are all displayed and recorded by the ACE Station. 1 Gigabyte Compact Flash cards provide data storage that can easily be transferred to computers.



Flux, moisture, PAR (Photosynthetically Active Radiation) intensity, and temperature data

Soil flux is expressed as Net CO_2 exchange rate (NCER) in µmol m^{-2} sec^{-1} . In addition to the CO_2 exchange data, a PAR sensor is provided, mounted on the ACE Station chamber. *Up to 6 soil temperature sensors and up to 4 soil moisture sensors may also be directly connected to each ACE Station.* These measurements can be displayed and recorded alongside the gas exchange and soil flux data. The user may configure the system for use with many commercially available soil moisture probes. Barometric pressure is also measured for calculations.

Survey Soil Measurements - see the SRS -1000SD and SRS-2000SD

Soil survey measurements are done with a small highly portable open CO_2 gas exchange unit. By measuring several locations in a field, survey measurements determine overall field soil flux variability and provide information on the number of long term units necessary to meet experimental criterion.

The high quality soil chamber includes a detachable collar, & provides accurate soil flux measurements in ambient field conditions. It features a pressure release valve that minimizes any potential pressure gradients with the open design. An adapter is available for inexpensive PVC pipe soil collars.

Paying attention to details

Improved sampling area clearance -

ADC believes that scientific measuring tools should be designed to minimize their effects on the parameters that are being measured. Since light, heat, and moisture all affect soil respiration, the system that disturbs natural conditions the least offers a better design.

The ACE system sampling chamber moves completely away from the sampling area in between measurements, allowing more natural light, heat, and moisture to occur. *Furthermore, the entire instrument may be mounted at soil level or inches above soil level, mounted on the soil collar and mounting stakes with feet.*

Soil Temperature and moisture sensors -

The ACE system offers six ports for commercially available soil temperature sensors and four ports for commercially available moisture sensors. The temperature sensors may be either thermistors or thermocouples. They may be purchased from Opti-Sciences or purchased separately from other sources.The data can be stored within each measuring file. Up to 6 soil temperature sensors and up to 4 soil moisture sensors may also be directly connected to each ACE Station.

The data can be stored within each measuring file.

ACE Network

Although an ACE Station can function fully independently for single location measurements, it may also be configured for use with multiple stations in a Network.

Up to 30 ACE Stations can be connected together in an ACE Network via an ACE Master control unit. This Master control will supply power to and collect data from all stations and control all stations within the experiment.

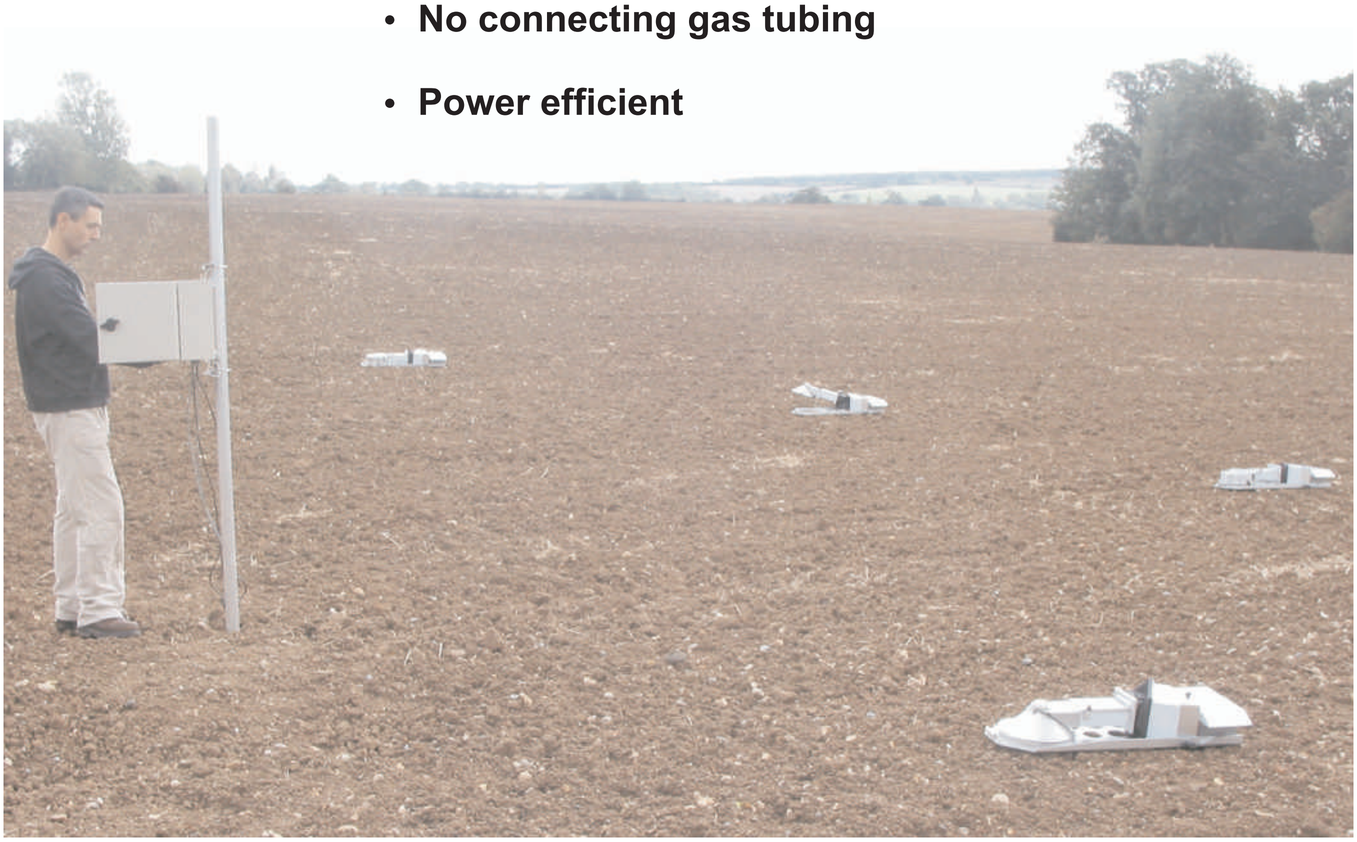
Connections between the ACE Master control unit and each ACE Station are made by simple electrical cables only.. As each ACE Station is a fully functional on its own with an integral CO_2 IRGA, it is not necessary to run gas tubing over the field site. As a result, each ACE Station can be in excess of 100 meters from the Master control unit.

The ACE network is very power efficient as no large pumps are required to transport gas from the chamber to an analyzer several meters away.

Individual ACE Stations can be taken out of the ACE network, and they can be used miles away from the master control unit.

The Ace Network advantage

- **Up to 30 ACE Station experiment**
- **200m diameter experimental area**
- **Easy to set up and program**
- **No connecting gas tubing**
- **Power efficient**



ACE Master Control Unit - for programing and control of multiple units as well as data management

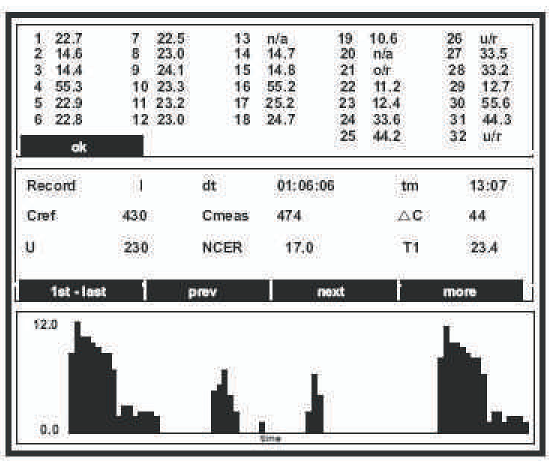
The ACE Master control unit is a small, waterproof, steel enclosure that features a graphic display, Two Compact Flash card ports, 30 ACE Station docking ports and 2 battery ports. Full programming and control is achieved using just 5 keys that drive a series of easy to use menus.

The ACE Master control unit monitors all Stations within the experimental network and flags any problems encountered. The Master control unit graphic display may be used to review and plot experiments in the field.

The researcher may review:

- One Station, all parameters, one time point
- One parameter, one time point, all Stations
- One Station, one parameter, all time points
- Power is via 12V or 24V batteries or a suitable alternative supply.such as solar, AC, or wind power.
- Data may be collected without disturbing an experiment.

Data may now also be collected remotely with a turnkey satellite solution for remote areas, or with a turnkey cellular solution for less remote areas



Three separate viewing screens on the Master Control Unit

Power

The Ace system uses minimal power by design. Because air is only pumped very short distances and not through long tubes connected to a central multiplexer, power requirements are substantially lower.

A single unit will run for approximately 28 days with a 12 volt 40 Ah car battery. Two Batteries may be connected to the Master control unit to run the whole system.

Alternative methods include 24 volt batteries, or alternating current with the proper power converter, solar, or wind power.

Contact us for references

Prove it to your self.

OPTI-SCIENCES

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Technical specifications

Measurement of CO2	Standard Range: 0 - 40.0mmols m^{-3} or -(0-896ppm at standard temperature and pressure), 1ppm resolution (0.05mmols m^{-3}) noise level 1-2 ppm Infrared gas analyzer housed directly adjacent to the soil chamber. *Either open or closed systems are available*
Parameters	Closed stations report NCER or Net CO_2 Exchange Rate determined by the Pedersen (2001) algorithm. Individual assay measurements are made every ten seconds. Open stations report ΔC or Change in CO_2 level in the Open design. Individual assay measurements are made every ten seconds. PAR – Photosynthetically Active Radiation *Other parameters reported* Multiple Soil temperature readouts in °C. Multiple Soil moisture readouts as voltages Record number Date Time Cref - Ambient CO_2 concentration entering chamber. Battery power Number of measurements in the current experiment Maximum time limit for measurement 0- 40 minutes ΔCset - A set point at which the CO_2 level change terminates the measurement. Barometric pressure is measured and used in calculations.
IRGA drift correction	Every station uses auto-zero to zero out IRGA drift before each measurement. Span drift less than 3% over 12 months
Measurement of PAR	0-3000:μmols m^{-2} sec^{-1}
Measurement of Soil Temperature	6 selectable inputs for thermistor or thermocouple devices for different soil depths. Adapters are available for aftermarket products
Measurement of Soil Moisture	4 selectable inputs for commercially available sensors. They may be purchased with the system or independently.
Flow Control to Chamber	200ml-5lml min^{-1} (200-3700μmols $^{-1}$)
Flow Accuracy	+/- 3% of f.s.d.
Display	240 X 64 dot matrix LCD
Programming	Each chamber has a user-friendly interface that is menu driven, and controlled with 5 keys.
Recorded Data	Removable compact flash cards 1 Gigabyte storage capacity per station.
Power Supply	External battery, solar panel, wind turbine, AC with converter. One 40Ah car battery provides power for approximately 28 days of continuous use
Output	1 Gigbyte Compact Flash data storage card, and RS232 port with User selectable rates of up to 19,200 baud (remote solutions available)
Electrical Connections	Robust waterproof 3 pin din.
Dimensions	82 X 33 13 cm.
Closed Chamber Volumes	2.6L
Open Chamber Volumes	1.0L
Soil Collar Diameter	23cm.
Weight	9.0kg

Continued on next page

ACE Master Control Unit Technical Specifications

Construction	Steel electrically sealed enclosure
Connections	Either 10, 20, or 30 ACE station docking port versions, 2 battery ports, two Data card ports and an RS232 port.
Dimensions	30 X 30 X 15 cm.

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