



# Automated Soil CO<sub>2</sub> Exchange System



## Soil flux: an important component of total carbon budget

Rapidly rising atmospheric CO<sub>2</sub> concentration and its potential impact on future climatic conditions is an issue of increasing global economic and political significance.

Soil respiration can be defined as the net CO<sub>2</sub> production of a soil. The amount of gas exchange taking place is frequently used as an indicator of microbial soil activity and so is used to characterise the "health" of that soil. The rate of soil flux is influenced by a variety of environmental parameters especially organic matter content, soil moisture and soil temperature.

Natural biomass respiration from soil is a major carbon source. Understanding soil flux and its relationship with other sources and sinks within the carbon cycle are currently subject to increasing scientific scrutiny in relation to global climatic change.

The ADC BioScientific ACE system (Automated Soil CO<sub>2</sub> Exchange System) is designed for the long-term, unattended monitoring of soil flux for both temporal and spatial studies. Individual ACE Stations can be used independently or as part of an ACE Network of multiple ACE Stations.

- **Automated operation**

Automatically exposes soil area between measurements



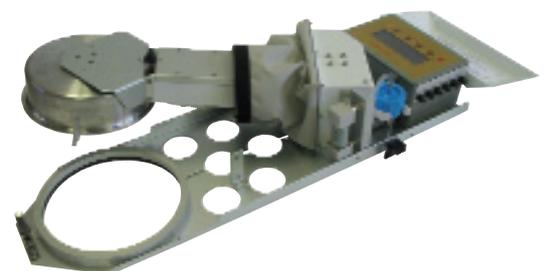
- **CO<sub>2</sub> analyser in chamber**

Highly accurate CO<sub>2</sub> IRGA housed directly inside soil chamber assembly



- **Compact complete system**

Fully integrated, independent measurement Station



- **Network**

Up to 30 ACE Stations may be connected together in an ACE experimental network



# ACE Station

## Integral CO<sub>2</sub> analyser inside soil chamber assembly - *designed for superior soil flux measurements*

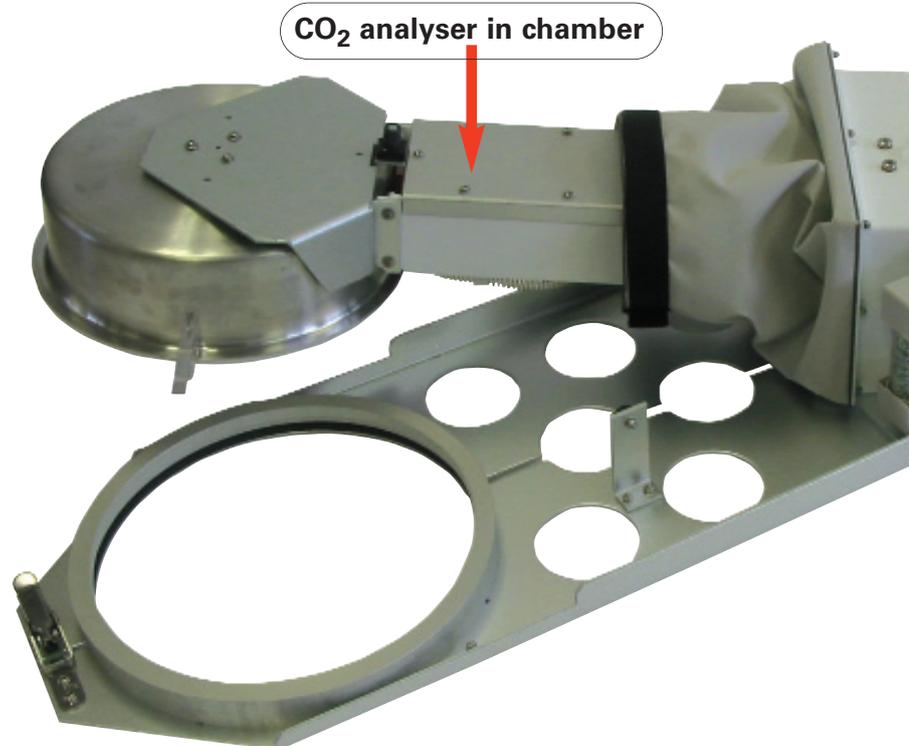
Each ACE Station features a highly accurate CO<sub>2</sub> infrared gas analyser housed directly inside the soil chamber assembly. There are therefore no long gas tubing connections between the soil chamber and a separate analyser.

The close proximity of the analyser ensures accurate, straightforward and robust field measurements. The fastest possible response times to CO<sub>2</sub> changes is assured. Any potential gas “hang-ups” or water vapour drop out in long lengths of tubing is avoided. Experimental set-up is much simpler and the system is much more field robust. The ACE Station is also very power efficient as there is no requirement to pump gas from the chamber to the analyser that could be several metres of tubing away.

Typically a 40Ah car battery will run an ACE Station continuously for around 28 days.

The gas circuitry of the ACE Station includes a permeation drier that prevents the water vapour concentration increasing inside the chamber and so removes the need to measure or compensate for water vapour within the system.

- **Fast CO<sub>2</sub> response time**
- **Avoids gas hang-ups or water vapour drop out**
- **Power efficient**
- **Easy to install**
- **Field rugged**



## Long-term unattended operation

The automated design of the ACE Station allows the soil area being analysed to be exposed to ambient conditions between measurement cycles.

At user-set time intervals, the chamber will automatically cover the soil to carry out soil flux measurements. Once these measurements are completed, the chamber will automatically re-expose the soil area.

The soil measurement area is defined by a stainless steel soil collar that is placed into the soil several hours prior to the positioning of the ACE Station.

The novel “swinging arm” mechanism is designed to be both reliable, field rugged and to provide a good seal when the chamber is covering the soil.

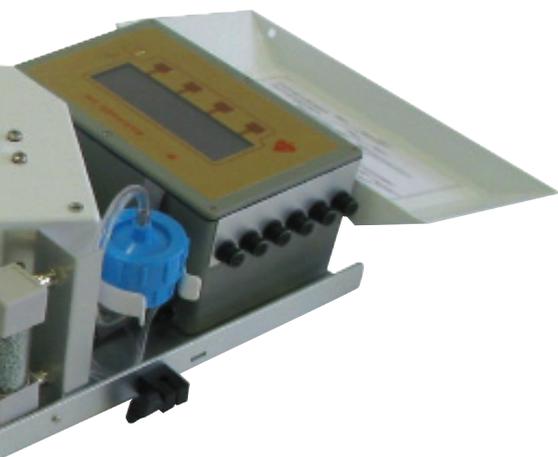
When the chamber is in the exposed position, the Station will power down to an idle or low power mode.

## Complete system

Each ACE Station is a complete, fully integrated soil flux measurement system comprising the aluminium soil chamber, heat reduction parasol and arm that pivots from the control console, where measurements are both displayed and recorded.

Each ACE Station can operate fully independently for single point measurements.

The power efficient ACE Station can be powered by battery, solar panel or wind turbine.



## Open and closed operational modes

ACE Stations are available in either a closed system or an open system configuration.

In both measurement modes with the chamber in the covered position, a delta CO<sub>2</sub> is determined from the difference between the reference gas entering the chamber and the analysis gas within the chamber at the end of the experiment.

**Open Mode:** When the chamber seals, ambient air is passed through the smaller 1.0L chamber at a controlled flow rate. Soil flux or rate of change is then determined once equilibrated conditions are reached within the chamber. These Open mode measurements, although slower, are regarded as more accurate by many researchers as they are less influenced either by changes within the enclosed chamber or by variations in the soil structure.

The Open mode chamber features a novel pressure equilibrator to ensure that no pressure gradients or variations occur between the inside of the chamber head and outside atmospheric pressure. This equilibrator already proven in the ADC SRS series of portable soil respiration systems is also insensitive to outside varying wind speeds and directions.

An open system ACE Station may also be used in a closed mode by the user exchanging the open system head for a closed system head.

**Closed Mode:** A measurement is made once the chamber is sealed. CO<sub>2</sub> inside the large 2.6L chamber will then increase due to soil activity. The rate of soil flux is determined from the increase in CO<sub>2</sub> concentration after a user-defined time interval. Closed mode measurements are simple and fast.

## 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 analyser 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. No PC or PDA type device is required.

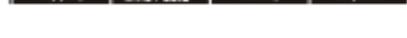
Experimental times and the period between measurements can be programmed. Experiments may be programmed to end after a set time or once a user defined CO<sub>2</sub> concentration is reached within the chamber.

Gas exchange data, soil flux calculations and other sensor measurements are all displayed and recorded by the ACE Station.

Data storage is on easily exchangeable Compact Flash cards. A 1G card can store in the region of 4,000,000 data sets.



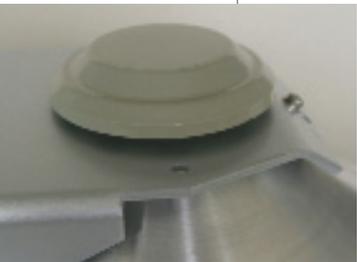
Conf	50.0			ΔC	10.0
MG/H	12.4	temp1	13.4	temp2	16.1
Q	275	humid1	18	humid2	23
<div style="display: flex; justify-content: space-around;"> <span>power off</span> <span>lock</span> <span>calibrate</span> </div>					
temp3	NA	temp4	NA	temp5	NA
temp6	NA	humid3	17	humid4	18
"	220	power		record	4
<div style="display: flex; justify-content: space-around;"> <span>CF card</span> <span>output</span> </div>					
wind	0.0	MassC	open	lock	299
dir vel	1.82	height	0.03	Auto	0.00
Ch dia	380	lim.T	10	log	off
<div style="display: flex; justify-content: space-around;"> <span>temp1</span> <span>dir / data</span> <span>temp2</span> <span>temp3</span> </div>					





## Transparent ACE chambers

For applications where there is small vegetation growing on the soil surface, transparent versions of both the open and closed chambers are available for measuring true net CO<sub>2</sub> exchange rate within the chamber area. It is recommended that, in applications of high photosynthetic activity, open mode transparent chambers are used.



## Zero / ambient option

For more accurate NCER data, and absolute ambient CO<sub>2</sub> measurements each Station can be fitted with a Zero/ambient CO<sub>2</sub> concentration option. This includes a CO<sub>2</sub> stripper column that provides a zero CO<sub>2</sub> reference for each experiment.



## Flux, moisture and temperature data

Soil flux is expressed as Net CO<sub>2</sub> Exchange Rate (NCER) in  $\mu\text{mol m}^{-2} \text{sec}^{-1}$ .

In addition to the CO<sub>2</sub> exchange data, a PAR sensor is provided as standard, 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 may then 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.





# ACE Network

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

Although an ACE Station can function fully independently for single point measurements, it is typical that a number of Stations will be used in combination, as a network, at an experimental field site.

Up to 30 ACE Stations can be connected together in an ACE Network via an ACE Master control unit. This Master control unit electrically multiplexes all ACE Stations within the experiment.

Connections between the ACE Master control unit and each ACE Station is by simple 2-core electrical cable only. As each ACE Station is a fully integrated system with an integral CO<sub>2</sub> IRGA, no long lengths of gas tubing are needed to be run 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 analyser many metres of tubing away.

Individual ACE Stations can be taken out of the ACE Network without the need to stop the whole experiment. Multiple ACE Stations can be measured simultaneously.

## ACE Master control unit

The ACE Master control unit is housed inside a weatherproof, steel enclosure that features a graphic display, dual Compact Flash card drive, RS232, up to 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 programs, supplies power and monitors all Stations within the experimental network and flags any problems encountered. Data from all ACE Stations is stored at the Master control unit.

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 Station, one parameter, all time points
- All Stations, one parameter, one time point

Power is via 12V batteries, mains power or a suitable alternative supply.



1	29.7	7	29.5	15	24.5	18	19.8	26	14.7	34	14.7
2	14.8	8	23.0	14	14.7	20	14.8	27	35.5		
3	14.4	9	24.1	15	14.8	21	14.7	28	33.2		
4	25.3	10	23.3	16	25.2	22	16.2	29	12.7		
5	22.8	11	21.2	17	25.2	23	12.4	30	55.6		
6	29.8	12	23.0	18	24.7	24	33.8	31	44.8		
						25	44.2	32	14.7		

Record	1	dir	01-06-06	tm	13:07
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# ADC BioScientific Ltd

ADC BioScientific is one of the world's leading developers of high quality, field portable and easy to use gas exchange instrumentation for a variety of geoscience research applications.

For over 30 years ADC's name has been synonymous with soil respiration research, with an outstanding reputation for both laboratory and field based instrumentation.

Today, in hundreds of research institutes throughout the world, ADC gas exchange instrumentation is playing a vital role in improving our understanding of the carbon cycle and its impact on life on earth.

The ACE Automated Soil CO<sub>2</sub> Exchange System offers soil researchers many performance advantages compared to other available techniques and provides true value for money.



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## Technical Specification

### ACE Station

Measurement of CO <sub>2</sub>	Standard range nominally 40.0 mmols m <sup>-3</sup> (0-896ppm at standard temperature and pressure) 0.05mmols m <sup>-3</sup> resolution (1ppm). Infrared gas analyser housed directly adjacent to soil chamber. Differential open or closed system.
Measurement of PAR:	0-3000µmols m <sup>-2</sup> sec <sup>-1</sup> . Silicon photocell.
Measurement of soil temperature:	6 selectable inputs for thermistors.
Measurement of soil moisture:	4 selectable inputs for commercially available sensors.
Flow control to chamber:	200ml – 5L min <sup>-1</sup> . (200-3700µmols <sup>-1</sup> ).
Flow control accuracy:	+/- 3% of f.s.d.
Display:	240 x 64 dot matrix LCD.
Programming:	Each ACE Station has a user-friendly interface driven by only 5 keys.
Recorded data:	Removeable Compact Flash cards
Internal battery:	12V standby 1.0Ah battery back up (Networked Station only).
Power supply:	External source battery, solar panel or wind turbine. One 40Ah car battery provides power for approximately 28 days of continuous use.
RS232 output:	User selectable rates of up to 19200 baud.
Electrical connections:	Robust, waterproof 3 pin and 5 pin RS232.
Dimensions:	82 x 33 x 13 cm
Closed chamber volume:	2.6L
Open chamber volume:	1.0L
Soil collar diameter:	23cm
ACE Station weight:	9.0kg

### ACE Master control unit

Construction:	Steel sealed enclosure.
Electrical connections:	30 ACE Station docking ports.
Display:	Graphic 240 x 64 dot matrix LCD.
Programming:	User-friendly interface driven by only 5 keys.
Recorded data:	Dual Compact Flash card drive.
RS232 output:	User selectable rates of up to 19200 baud.
Power connection:	100 – 240 VAC Dual 12V battery docking ports.
Dimensions:	40 x 40 x 20 cm
Master Control Unit weight:	12.0kg