

# ACE



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



### ACE Station

Independent Station for automated soil CO<sub>2</sub> flux measurements, data-logging and secure data storage

### Soil chamber options

- Small chamber for open mode
- Large chamber for closed mode
- Transparent or opaque chambers

### ACE Master Controller

Up to 30 ACE Stations may be linked to a Master Controller, forming an ACE Network

### Sensors

Connect multiple sensors for soil temperature and soil moisture

### Function:

Automatically covers the soil, measures soil CO<sub>2</sub> flux, then opens to re-expose soil to ambient conditions after each measurement is completed.

### Measurement Technique:

Time intervals, or required differential CO<sub>2</sub> values between automatic measurements are user-set in either an open or closed system ACE Station.

A single ADC CO<sub>2</sub> IRGA is housed directly next to the soil analysis area to provide highly accurate data.

### Application:

Worldwide, in diverse and often harsh environments. Examples from published papers include:

- Tillage vs no-tillage agriculture in Slovak Republic
- Mid-boreal and subarctic soils in Canada
- Wheat/maize crops in China
- Lawn soils in urban areas
- Paddy fields in China
- Antarctic vegetation



# ACE Station

Each ACE Station is a complete, fully integrated soil CO<sub>2</sub> flux analysis system comprising a soil chamber, heat reduction parasol and arm that pivots from the control console, where measurements are both displayed and recorded.

Each ACE Station operates independently for data collection and logging.

An external power source with an output voltage of 12-40VDC is required. A 40Ah car battery will power an ACE Station for around 28 days (based on measurement frequency of once per hour). The power efficient ACE Station can be powered continuously by battery, with solar panel or wind turbine.



## Long-term unattended operation:

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

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

The novel “swinging arm” mechanism is proven to be reliable, field rugged and to ensure a consistent seal when the chamber is covering the soil.

When the chamber is in the exposed position, the ACE Station enters a low power consumption mode.

## Easy to install and program:

The ACE Station is easy to set up and program.

The control console features a large display screen. Programming is achieved using just 5 keys to drive a series of intuitive menus.



Cref	50.0			△C	10.0
NCER	12.4	temp1	13.4	temp2	10.1
Q	275	humi1	13	humi2	23
power off      lock      calibrate					
temp3	NA	temp4	NA	temp5	NA
temp6	NA	humi3	17	humi4	18
u	220	power	record		4
CF card      output					
period	30	Mmode	open	uset	222
lid vol	1.82	height	0.03	△set	0.80
Ch dia	380	lim.T	10	log	off
logging      time / date      config      diagnose					

## Data Logging:

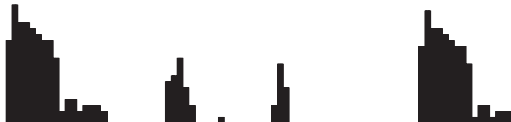
Gas exchange measurements, soil flux calculations and sensor measurements are all displayed and recorded by the ACE Station.

Data is stored internally and can be accessed by SD card or USB cable.

1	22.7	7	22.5	13	n/a	19	10.6	26	u/r
2	14.6	8	23.0	14	14.7	20	n/a	27	33.5
3	14.4	9	24.1	15	14.8	21	o/r	28	33.2
4	55.3	10	23.3	16	55.2	22	11.2	29	12.7
5	22.9	11	23.2	17	25.2	23	12.4	30	55.6
6	22.8	12	23.0	18	24.7	24	33.6	31	44.3
ok						25	44.2	32	u/r

Record	1	dt	01:06:06	tm	13:07
Cref	430	Cmeas	474	$\Delta C$	44
U	230	NCER	17.0	T1	23.4

1st - last	prev	next	more
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12.0										
0.0	time									



## Open and Closed system modes:

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

In both measurement modes, with the chamber in the covered position, a  $\Delta\text{CO}_2$  value 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.

Transparent versions of both the open and closed chambers are available for measuring net  $\text{CO}_2$  exchange within the chamber area. In applications of high photosynthetic activity, open mode transparent chambers are recommended.

### Closed Mode:

A measurement is made once the chamber is sealed.  $\text{CO}_2$  inside the large 2.6L chamber will then increase according to soil activity. The rate of soil flux is determined from the  $\Delta\text{CO}_2$  after a user-defined time interval.

These measurements are simple and fast.



### Open Mode:

When the chamber seals, ambient air is passed through the smaller 1.0L chamber at a controlled flow rate.

Soil  $\text{CO}_2$  flux is then determined at equilibrated conditions within the chamber. These measurements, although slower, are regarded as more accurate by many researchers as they are less influenced by changes within the enclosed chamber or variations in the soil structure.

The open chamber is designed with a pressure release valve and fan to minimise any internal pressure gradients.



An open system ACE Station may also be used in a closed mode by fitting a closed system chamber head.

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## Automatic calibration:

Every ACE Station is fitted with Zero/Ambient  $\text{CO}_2$  concentration re-calculation for accurate NCER values.

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## Flux, moisture and temperature data:

Soil flux is expressed as Net  $\text{CO}_2$  exchange rate (NCER) in  $\mu\text{mol m}^{-2} \text{sec}^{-1}$ .

In addition to the  $\text{CO}_2$  exchange data a PAR sensor is provided, mounted on the ACE Station chamber.

As many as 6 soil temperature sensors and 4 soil moisture sensors may also be directly connected to each ACE Station. Sensor measurements are displayed and recorded alongside the gas exchange and soil flux data.



# ACE Network

Although an ACE Station will function independently at a single sample location, it is typical that a number of Stations will be used in combination, as a Network deployed across a field site.

As many as 30 ACE Stations can be connected together in an ACE Network via an ACE Master control unit. This Master control unit will supply power to and collect data from all Stations within the network.



The ACE Master control unit is connected to each ACE Station by electrical cable only. Each ACE Station can be a maximum of 100 meters away from the Master control unit.

Individual ACE Stations can be removed from, or added to, the ACE network without interrupting data collection.



## ACE Master

The ACE Master control unit is a waterproof, steel enclosure featuring a graphic display, CompactFlash card drive, a maximum of 30 ACE Station docking ports and 2 battery ports.

ACE Master control unit is available in 3 options with either 10, 20 or 30 ACE Station docking ports.

Programming control of an ACE Network is achieved using just 5 keys to drive a series of intuitive menus.

The ACE Master control unit monitors all Stations within the experimental network and flags any problems encountered.

The graphic display may be used to review and plot experiments in the field. For example:

- 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.

## Applied to worldwide research:

Measuring CO<sub>2</sub> efflux from agricultural soil in relation to tractor wheel traffic and the amount of manure applied to the soil (Altikat et al., 2018).

Monitoring CO<sub>2</sub> land/atmosphere flux in the High Arctic, Svalbard to further our understanding of factors affecting CO<sub>2</sub> fluxes in sensitive ecosystems in the Arctic (Cannone et al., 2019).

Measuring CO<sub>2</sub> flux between the atmosphere and the maize field fertilized with digestate from an agricultural biogas plant (Czubaszek, Robert 2019).

Measuring the carbon capture efficiency, yield, nutrient uptake and trafficability of different grass species on a cultivated peat soil (Berglund Ö, Berglund K, Jordan S, Norberg L, 2019).

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A list of citations and set of application notes are available to request from:

[www.adc.co.uk](http://www.adc.co.uk)  
[sales@adc.co.uk](mailto:sales@adc.co.uk)  
or a local support centre

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## Application Notes include:

- “Setting the timing of closed mode measurements with an ACE Station”
- “ACE Station operates for up to 28 days from a single 40Ah battery”
- “Extracting gas samples from an ACE Station for the analysis of soil CH<sub>4</sub> and N<sub>2</sub>O flux”
- “Extending the air inlet to prevent water ingress (in areas prone to flooding)”
- “Measuring CO<sub>2</sub> efflux from agricultural soil”

## Options and Accessories:

At ADC BioScientific, we recognise that every application is unique and has specifications, such as the ability to extract gases from the soil chamber for laboratory analysis. We are always willing to discuss such requirements.

A comprehensive range of the most commonly required accessories are available for ACE Stations and ACE Networks.

- Transit case
- Mains supply kit with 50m DC power cable
- 100m DC power lead for use with 1 ACE Station
- Soil moisture sensors by Delta T Devices
- Soil temperature thermistor probes
- Additional soil chambers

Comprehensive installation kits, spares kits and manuals are supplied as standard.







Courtesy of The University of Vermont, Kenya

For the investigation of plant, soil and atmospheric interactions, ADC BioScientific Ltd. expertly produce a wide range of portable, user-friendly and cost-effective devices, from photosynthesis to soil respiration systems. We are committed to enabling carbon cycle research worldwide through quality instrumentation and local, technical support.

ADC BioScientific Ltd. also supply: Portable Photosynthesis Systems, Leaf Area Meters, Chlorophyll Content Meters, Advanced Fluorometers, Automated Soil CO<sub>2</sub> Exchange Systems, Portable Soil Respiration Systems and Field Gas Analysers.

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## Technical Specifications

### ACE Station

Measurement of CO<sub>2</sub>: Standard range nominally 40mmol m<sup>-3</sup> (0-896ppm at standard temperature and pressure)  
0.05mmol m<sup>-3</sup> resolution (1ppm).  
Infrared gas analyser housed directly adjacent to soil chamber.  
Differential open or closed system.

Measurement of PAR: 0 - 3000µmol 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 to 5L min<sup>-1</sup>

Flow control accuracy: +/- 3% of FSD

Display: 240 x 64 dot matrix LCD

Programming: Each ACE station has a user-friendly interface driven by only 5 keys

Recorded data: Removable SD card. Micro USB port.

Internal battery: 12V standby 1.0Ah battery back up (Networked Station only)

Power supply: External battery, solar panel or wind turbine. One 40Ah car battery provides power for ca.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

Weight: 9.0 kg

### Master Control Unit

Construction: Steel electrically 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 ports.

Dimensions: 40 x 40 x 20 cm

Weight: 12.0 kg

[www.adc.co.uk](http://www.adc.co.uk)