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ACE  
Quick Start Guide  
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## *Analysing the carbon cycle*

### **QUICK START GUIDE**

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



## Contents

Introduction .....	2
Included with your ACE station.....	3
Overview .....	4
ACE Station layout and external functions .....	5
ACE Station accessories .....	6
Measurement modes.....	7
Schematics for both types of ACE Station: .....	9
ACE Network modes: .....	10
Using the ACE Station for the first time:.....	10
Inserting the collar .....	10
Connecting things up .....	11
Switching on.....	12
Setting the date and time .....	15
Switching off .....	15
Operating in Closed mode: .....	16
Running a single Closed mode experiment.....	16
Programming a Closed mode experiment .....	17
Operating in Open mode: .....	18
Running a single Open mode experiment .....	18
Programming an Open mode experiment .....	19
<b>Experimental data</b> .....	21
Reviewing data.....	21

Deleting data.....	22
Downloading data from an ACE Station.....	22

## Introduction

This short guide aims to provide you with a point of reference whilst you are familiarising yourself with the features and functions now available to you.

Reading this quick start guide as you set up and try out your ACE Station will enable you to follow the comprehensive, technical manual to use and maintain your ACE Station long term.

**“ACE Station”** is defined as a single, independent soil flux measuring system comprising the soil chamber with radiation parasol and the arm that pivots from the control console.

**“ACE Network”** is defined as up to 30 ACE Stations being connected together via a Master Control Unit (see separate manual with MC Unit).

## Included with your ACE station

- Inside your ACE Station transit packaging is your ACE Station fitted with your chosen soil chamber.  
Either:
  - Large (Closed mode) 2.6 litre metal chamber
  - Large (Closed mode) 2.6 litre clear chamber
  - Small (Open mode) 1 litre metal chamber
  - Small (Open mode) 1 litre clear chamber

(Any additional chambers will be in separate transit packaging.)
- Stainless steel collar with insertion pad:  
To accurately define the soil area being analysed. Station feet with spikes enable secure positioning of the ACE Station, even in rough terrain.
- 10m power cable:  
To connect the ACE Station to a suitable power source.
- Spares Kit: All user-replaceable parts.
- SD card: For data storage (plugged into the control console).
- Quick reference Menu Structure Card: inside the console lid.
- The ACE Station is covered in blue, protective plastic film. Please remove all film prior to use.

## Overview

The ACE Station is designed for long-term, unattended, field measurement of soil CO<sub>2</sub> flux.

At user-set time intervals, the “swinging arm” mechanism automatically covers the soil to carry out soil CO<sub>2</sub> flux measurements. Once these measurements are completed, the chamber on its swinging arm will automatically re-expose the soil area.

Each ACE Station features a highly accurate CO<sub>2</sub> infrared gas analyser housed inside the arm, close to the chamber assembly. This ensures the fastest possible response to CO<sub>2</sub> changes, and avoids any gas “hang ups” or water vapour drop out.

Each ACE Station is a complete, fully independent soil flux system. A Station is programmed at the control console with 5 keys that drive a series of easy to use menus. Gas exchange data, soil flux calculations and other sensor measurements are displayed and recorded at the control console. Data is stored and transferred by SD card.

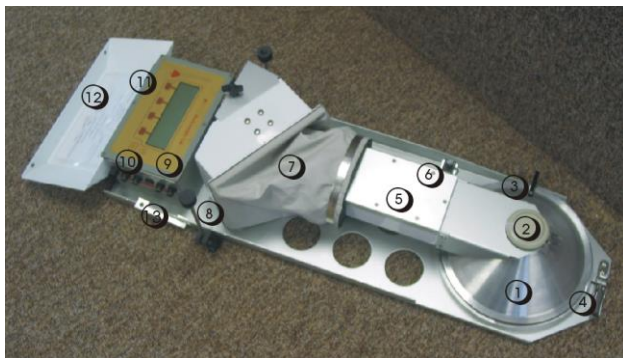
ACE Stations are available in either a ‘Closed zero’ system or an ‘Open zero’ configuration.

Soil flux is expressed as Net CO<sub>2</sub> Exchange Rate (NCER). In addition to CO<sub>2</sub> exchange data, a Photosynthetically Active Radiation (PAR) sensor is provided, mounted on the chamber. Up to 6 soil temperature sensors and 4 soil moisture sensors may also be connected to each ACE Station.

To scale up measurements, up to 30 ACE Stations can be connected together in an ACE Network via an ACE Master Control Unit. Details of ACE Networks are available in separate documentation.

## ACE Station layout and external functions

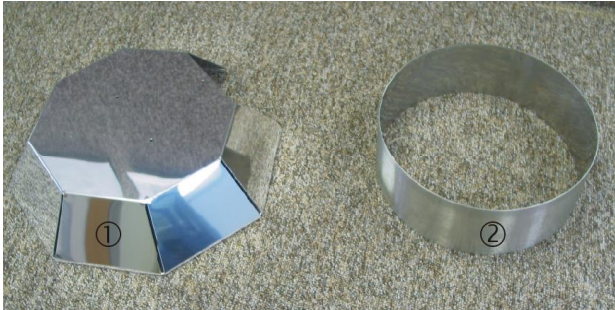
1. Measurement Chamber
2. Pressure release vent
3. Chamber guide
4. Collar fixing clip
5. ACE Station arm
6. PAR sensor
7. Station arm casing and jacket
8. Positioning feet
9. Control console
10. Additional sensor connectors
11. SD card drive
12. Control console lid
13. Control console lid strap



## ACE Station accessories

### 1. Radiation parasol

### 2. Soil chamber collar





## Measurement modes

Your ACE Station has been supplied in one of two fundamentally different measurement modes;

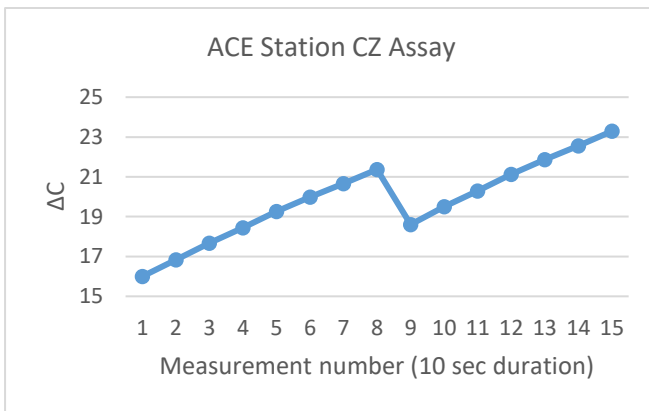
Closed with zero reading

Open with zero reading

### Closed mode with zero

The simplest measuring mode. A measurement is made every 10 seconds, once the large 2.6L chamber is sealed. CO<sub>2</sub> inside the chamber will then increase depending on the soil activity. The CO<sub>2</sub> flux is determined from the increase in CO<sub>2</sub> concentration after a user-defined time period.

Finally, a zero measurement is made after the lid has opened at the end of an assay. This value is used to re-calculate ambient CO<sub>2</sub> and so produce calibrated  $\Delta$ CO<sub>2</sub> and NCER values.



The figure above is an example data set plotted to show delta C against time.

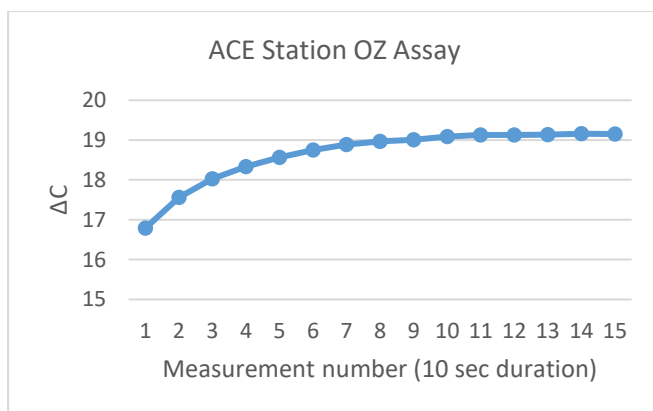
The first value is C<sub>ambient</sub> (default value is 16). The next 7 readings are uncorrected raw data. The final 7 zero corrected

readings are at the right of the graph, these are used to calculate NCER.

### Open mode with zero

When the chamber seals, ambient air is passed through the smaller 1L chamber at a controlled flow rate. The soil flux is determined when equilibrium conditions are reached within the chamber. A CO<sub>2</sub> measurement is made every 10 seconds. Finally, a zero measurement is made after the lid has opened at the end of an assay. This value is used to recalculate ambient CO<sub>2</sub> and so produce calibrated  $\Delta\text{CO}_2$  and NCER values.

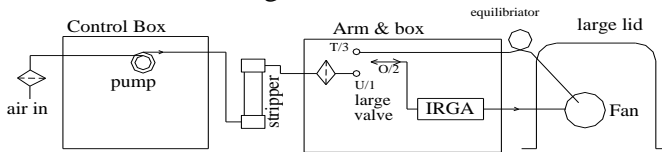
Open system assays, although slower, are regarded as more accurate by many researchers as they are less influenced by changes within the enclosed chamber or variations in the soil structure.



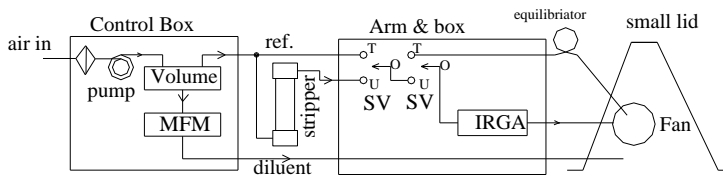
The figure above is an example data set plotted to show  $\Delta\text{C}$  against time.

## Schematics for both types of ACE Station:

Closed configuration with zero



Open (equilibrium) configuration with zero



### Key to diagrams:

IRGA = Infrared gas analyser

MFM = Mass Flow Meter

SV = Solenoid Valve

("T" & "U" are the two latching inputs and "O" the Output)

Small arrows indicate gas flow direction



Symbol = Hydrophobic filter

## ACE Network modes:

If you are working with an ACE Network comprising older and newer stations, you may have some Stations with the zero/ambient mode fitted and some Stations without (see main manual for explanation of previous models). In these circumstances, it is possible to manually enter the ambient CO<sub>2</sub> concentration into Stations without the ambient reading option. This is described in **Switching on section, point 6**.

## Using the ACE Station for the first time:

### Inserting the collar

Using the stainless steel collar ensures that you are defining and confining the area of soil that you are analysing. The process of inserting the collar into the soil, however, will naturally disturb the soil and the soil fluxes that are taking place. It is therefore recommended that the soil collar is positioned a few hours before any experimental measurements are made.

The collar should be inserted into the soil as far as is necessary to eliminate diffusion through the soil away from the measurement area, which could result in underestimating soil flux. For example, if the soil is loose, the collar should be inserted quite deeply.

*Note: It is recommended that the insertion pad provided is used to insert the collar as this will minimise any possible damage to the collar. In Closed mode the distance from the top of the collar to the soil surface should be noted. This will need to be entered into the HEIGHT parameter on the configuration page of the software (see section Operating in Closed mode).*

The collar should be inserted so the rim is horizontal. When the Station is connected to the collar, ensure that it is also horizontal and that the 'O' ring remains properly in its groove. If there is a tendency for the 'O' ring to lift out, press it back all the way round as the collar slides into the base ring. The 'O' ring will slide much easier if lubricated with silicone grease.

## Connecting things up

Because there is no complex gas circuitry to connect up, set up is relatively quick and easy.

1. If your ACE Station is fitted with the optional ambient reading, ensure the chemical column behind the Station arm casing is filled with fresh soda lime.

*Note: There are two ways to check to see if the ambient reading option is fitted to your ACE Station.*

- a) Chemical column is fitted behind the cover.*
- b) In the diagnose menu the InCfg (initial config) variable will give you the factory configuration of the hardware. It is possible to change the operating mode so that hardware is not used even though it is fitted. To do this, press [I] to turn ACE Station on. Then press [I] / [I] / CONFIG / SELECT. Continue to press SELECT until you reach Mmode. Pressing + or – keys will enable you to select OpenZ or CloseZ.*

2. Locate the ACE Station onto the collar and secure using the collar fixing clip.

3. Use the positioning feet with or without ground spikes to secure the ACE Station.


4. Insert SD card into drive.

5. Using the power leads provided, connect up the ACE Station to a suitable power supply. For example, this can be an external battery charged by a solar panel or wind turbine. As a general guide a typical 40Ah car battery will provide

power, for a single ACE Station, for approximately 28 days of continuous use.

The ACE station has blue plastic film applied to the Control box cover and the arm cover, these prevent damage during manufacture and can be removed when the ACE is installed.

## Switching on

1. Switch the ACE Station on using  key.
2. Initially the ACE Station will boot up whilst displaying the software version number and instrument serial number. An ACCESSING MEMORY CARD message may also briefly appear.
3. You are now in the **first display screen**, showing:  
**Cref:** Ambient CO<sub>2</sub> concentration entering chamber, in mmol m<sup>-3</sup>.  
**NCER:** Displayed when in an experimental mode.  
**Soil temp 1 & 2:** Displayed as a temperature in °C.  
**Soil moisture 1 & 2:** Displayed as a voltage.  
**Q:** PAR

When you are in an experimental mode you will, in addition, see on the first display screen, showing:

**CO<sub>2</sub>:** The CO<sub>2</sub> concentration inside the chamber.

**Delta CO<sub>2</sub>:** In the Open mode, this value is the measured CO<sub>2</sub> concentration inside the chamber for the first 9 measurements. It is then a running average of the last 6 differentials between Cref and CO<sub>2</sub> concentration inside the chamber.


**Rdngs:** The number of measurements (every 10 seconds) taken in current experiment.

***Net CO<sub>2</sub> Exchange rate is defined as NCER (μmol m<sup>-2</sup> s<sup>-1</sup>)***

***NCER = Us (Δc)***

**Where Us:** molar flow of air per square meter of soil,  $\text{mol m}^{-2} \text{s}^{-1}$

**$\Delta c$ :** difference in  $\text{CO}_2$  concentration through soil chamber

4. By pressing  you access the **second display screen**, showing:

**Soil temp 3 – 6:** Displayed as a temperature in  $^{\circ}\text{C}$ .

**Soil moisture 3 & 4:** Displayed as a voltage.

**U:** Flow rate into the chamber in  $\mu\text{mol s}^{-1}$  (Open mode only).

**Battery power:** Displayed as a bar graph.

**Record:** The number of records in the currently selected data file.

5. To access the **third display screen** press .

This is the configuration screen for programming experiments:

**Period:** Time in minutes between the start of measurement assays. This period should not be set lower than **Lim T** unless set to zero, to indicate no timed measurement cycles.

**Lim T:** Maximum time for a single measurement assay. A single measurement assay is normally terminated by the  $\Delta\text{Cset}$  function. This allows the assay to terminate if, for example, the soil becomes inactive.

**$\Delta\text{Cset}$ :** Point at which measurement assay terminates (unless Lim T is reached first). In the Closed mode,  $\Delta\text{Cset}$  is the difference between the  $\text{CO}_2$  concentration at the start of the assay (ambient) and the end of the assay and can be set to 10 for very active soils. In the Open mode,  $\Delta\text{Cset}$  is the average of the  $\Delta\text{CO}_2$  between successive readings. The setting of this value will depend on the soil activity, but 5 is a reasonable starting value.

**Uset:** Applicable for Open mode only, to set flow rate of ambient air into chamber ( $\text{ml min}^{-1}$ ). The flow rate set is dependent on the soil activity.

**Lid. Vol:** Volume in litres of the soil chamber being used. The Open chamber is 1.0L. The Closed chamber is 2.6L.

**Height:** The distance from the soil to the top of the collar (in mm). This is used to determine the total volume, when added to the volume of the chamber.

**Ch dia:** Internal diameter of chamber. Should always be set at 230 (23cm) when using any of the standard ACE chambers manufactured by ADC BioScientific, unless otherwise advised.

**Mmode:** Selects measurement mode e.g. Open with zero/ambient.

**Log:** Name of data file currently selected to store data.


6. By pressing **CONFIG/MORE** you can access:


**Camb:** Manually entered value for ambient CO<sub>2</sub> at start of assay (only when the ambient reading option is not fitted).

**Lock:** This is a software lock to prevent tampering of settings.


a) To activate, press SELECT until **a-lock** is selected. Then press + to lock software. If you now turn the ACE Station off, when it next turns on 'PANEL IS LOCKED' will appear.

b) To deactivate, press PANEL IS LOCKED. You are now asked to enter the PIN. Using >, + and – keys enter default pin for all ACE Stations; **ADCB**.

Press  to exit and return to fully functional first display screen.

7. At any time, the software may be interrupted and reset to the opening menu by pressing the left hand two buttons and simultaneously. .

**Tip: When accessing lower levels of the software pressing the PAGE button will return you to the previous top screen.**

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	



## Setting the date and time

The date and time will have been preset for the UK, so this is one of the first functions that the user may want to change.

1. Press PAGE to access third display screen.
2. Select TIME + DATE.
3. Pressing SELECT allows you to access the components of time and date. Use the + and – keys to alter as required. Press PAGE to return to third display screen

## Switching off

1. If you turn your ACE Station off and you do not want it to restart for an experiment you must set PERIOD to zero. To do this, access third display screen then press CONFIG/SELECT to move cursor to PERIOD and press – key to select 0.
1. On the first display screen press POWER OFF.
2. You are then invited to select the position of the chamber at turn off. Press OPEN or CLOSED. The arm will then move into the chosen position before the ACE Station turns off.
3. The Stations also have a switch on the control box which disconnects the internal battery. This feature is for transportation as it allows the user to check with certainty that the station is permanently turned off without first needing to switch it on to view the setting of the period.

## Operating in Closed mode:

### Running a single Closed mode experiment

1. Press **start** on the first menu screen.
2. The chamber will open to uncover the soil area. WAITING FOR PURGE message will appear. Air is now circulated inside the chamber to ensure that the CO<sub>2</sub> concentration is at ambient prior to the experiment taking place. This should take around 45 seconds.

*Note: LIM.T will commence as soon as the chamber starts the purge sequence.*

3. The chamber will close and cover the soil area. The first display screen will now appear together with the message EXPERIMENTAL ASSAY NOW TAKING PLACE.
4. The first display screen will continue to be shown until the assay is completed due to either **lim.T** or **ΔCset** being reached. At this point PERFORMING CALCULATIONS message appears.
4. The chamber will open to uncover the soil area.
5. Running a single experiment will not affect the experiment programmed by setting **period** (see below). Should a programmed experiment be due during a single one then it will take place after the single experiment is completed.

## Programming a Closed mode experiment

1. Press PAGE to select third menu screen. Press **config**.
2. Press **select** to move cursor to **Mmode**. Use **+** and **-** keys to select **ClosZ**.
3. Press **select** to move cursor to **period**. Use **+** and **-** keys to select time between measurement cycles in minutes. For most applications it is  $\geq 60$  minutes.
4. Press **select** to move cursor to **lim.T**. Use **+** and **-** keys to select maximum time for each measurement assay in minutes. For a Closed mode experiment we recommend that **lim.T** should be set to a minimum of 5 minutes.
5. Press **select** to move cursor to  **$\Delta$ Cset**. Use **+** and **-** keys to select at which differential CO<sub>2</sub> reading the measurement assay should terminate. A value of 10 is a reasonable starting point.
6. Press **select** to move cursor to **lid.vol**. Use keys as above to select 2.7.
7. Press **select** to move cursor to **height**. Measure and enter distance from the soil surface to the top of the soil chamber collar.
8. Press **select** to move cursor to **ch.dia**. Ensure this is set at 0.23.
9. Press **select** to move cursor to **log**. Press **+** or **-** key to select log file that you wish to record data onto. Press **set file**. Use arrow keys to select log file then press **set log**. Alternatively, select **new file** then **set log**. Now use **>**, **+** and **-** keys to name new file. Press PAGE to create new file.
10. Press **more**, then **select** to move cursor to **camp**. Unless known, enter value of 16mmol m<sup>-3</sup>.

11. Press SELECT to move cursor to A-LOCK. Select YES or NO.

12. Turn the ACE off and the first assay will occur 'PERIOD' minutes later (this puts the ACE into a dormant state and will conserve power).

## Operating in Open mode:

### Running a single Open mode experiment

1. Press **start** on the first menu screen.

2. The chamber will open to uncover the soil area. WAITING FOR PURGE message will appear. Air is now circulated inside the chamber to ensure that the CO<sub>2</sub> concentration is at ambient prior to the experiment taking place. This should take in the region of 20 seconds.

*Note: Lim.T will commence as soon as the chamber starts the purge sequence*

3. The chamber will close and cover the soil area. The first display screen will now appear together with the message EXPERIMENTAL ASSAY NOW TAKING PLACE.

4. The first menu screen will continue to be shown until the assay is completed due to either **lim.T** or **ΔCset** being reached. At this point PERFORMING CALCULATIONS message appears.

5. The chamber will open to uncover the soil area.

6. Running a single experiment will not affect the experiment programmed by setting **period** (see below). Should a programmed experiment be due during a single one then it will take place after the single experiment is completed.

## Programming an Open mode experiment

1. Press PAGE to select the third display screen.
2. Press **config**
3. Press **select** to move cursor to **Mmode**. This should read **OpenZ** for 'Open Zero'.
4. Press **select** to move cursor to **period**. Use **+** and **-** keys to select time between measurement cycles in minutes. For most applications, period will be set to 60 minutes.
5. Press **select** to move cursor to **lim.T**. Use **+** and **-** keys to select maximum time for each measurement assay in minutes. For an Open mode experiment, we recommend that **lim.T** should be set to a minimum of 5 minutes. A shorter time avoids heating the soil or changing the CO<sub>2</sub> gradient above the soil (leading to reduced NCER values). A long time may give more accuracy in a shaded sample area.
6. Press **select** to move cursor to **uset** for flow rate in  $\mu\text{mol sec}^{-1}$ . Use **+** and **-** keys to set depending on the activity of the soil. The more active the soil, the higher **uset** should be. We would recommend starting with a flow rate of 3000  $\mu\text{mol sec}^{-1}$  to test and then adjust to your sample area.
7. Press **select** to move cursor to **ch.dia**. Ensure this is set at 230.
8. Press **select** to move cursor to **lid.vol**. Use keys as above to select 1.0
9. Press **select** to move cursor to **Δcset**. Use **+** and **-** keys to select at which differential CO<sub>2</sub> reading the measurement assay should terminate. A value of 20 is a reasonable starting point.
10. Press **select** to move cursor to **log**. Press **+** or **-** key to select the log file that you wish to record data to.

11. Press **set file** then use the arrow keys to select log file then press **set log** for an existing file. Alternatively, select **new file** **set log**. Now use **>**, **+** and **-** keys to name a new file. Press PAGE to create the new file.
12. Now use the **+** and **-** keys to name the new file. Press PAGE and a message will appear whilst your new log data file is created.
13. Press **more** to see an additional menu, then **select** to move cursor to **camb**. Unless known, a value of  $16\text{mmol m}^{-3}$  is the factory default.
14. Press **select** to move cursor to auto lock, if you want to lock the screen whilst the ACE is unattended during an assay. Select using the **adj** keys. On returning to the ACE, you will be prompted to enter a password to unlock. The factory default password is set to '**adcb**'. Entering this password will unlock the buttons for use.
15. Press **start**, on any main menu screen, before leaving the ACE to log data. The first assay will occur 'period, (eg. 60 minutes) later. You can now 'power off' the ACE and it will remain dormant to conserve power until it takes the first measurement.

## Experimental data

### Reviewing data

ACE experimental data stored on a Compact Flash card may be reviewed on the ACE Station display screen.

1. Press PAGE to access third display screen.
2. Press LOGGING.
3. Press SET FILE.
4. Use arrow keys to select data file name. Press OPTIONS/REVIEW. It is now possible to review individual experimental assays in the chosen data file. Each record is spread over three data review screens.

#### **First data review screen:**

Record no.

Date

Time

CREF

$\Delta\text{CO}_2$

NCER

Q (PAR)

U (flow)

VBATT (battery voltage at end of experimental assay)

Press MORE to access **second data review screen.**

Soil temperature 1-6

Soil moisture 1-3

Press MORE to access **third data review screen.**

Soil moisture 4

Comment label for log record

#### **Comment label for log record**

An 8 character label that contains information on the experimental assay.

## Deleting data

1. Press PAGE to access third display screen
2. Press LOGGING
3. Press SET FILE
4. 4. Use arrow keys to select data file name. Press OPTIONS/DELETE. You are then ask to press DELETE again to erase the file or CANCEL.

## Downloading data from an ACE Station

1. Connect an RS232 cable between the port on the side of the ACE Station console and your PC or laptop device (you may need to use a USB port to RS232 adaptor cable for your computing device).

This allows for direct, live data transfer through a Terminal Emulating Software. Free programs are widely available online, for example TeraTerm.

Check for compatibility and of course security of any download with your computer operating system.

In combination with direct data transfer, you can program a macro in Excel™ to create a graphical display of the data, to allow visual monitoring of any experiment run with an ACE Station.



Go to the HyperTerminal application on your device.

2. Press PAGE to access third display screen. Press LOGGING/SET FILE. Use arrow keys to select data file.

3. Press OPTIONS / SEND.

4. Select protocol for data transfer. Choose either ASCII or XMODEM. Set the data rate to be the same as the PC (9600 baud is a good rate to use). Data transfer will now take place with a real-time transfer count on ACE Station display screen.

5. When data transfer has finished. TRANSFER COMPLETED OK will be displayed. Press OK to return to the ACE Station menu.