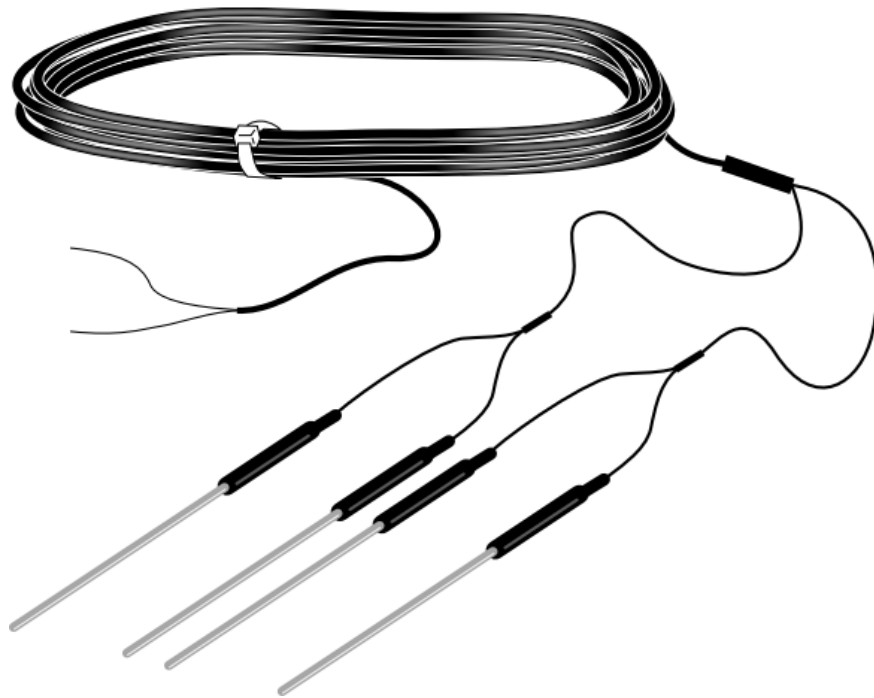


# TCAV

---

## Averaging Soil Thermocouple Probe





# Guarantee

---

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific
- Batteries
- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the "Declaration of Hazardous Material and Decontamination" form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers' expense.

Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.



Campbell Scientific Ltd,  
80 Hathern Road,  
Shepshed, Loughborough, LE12 9GX, UK  
Tel: +44 (0) 1509 601141  
Fax: +44 (0) 1509 270924  
Email: [support@campbellsci.co.uk](mailto:support@campbellsci.co.uk)  
[www.campbellsci.co.uk](http://www.campbellsci.co.uk)



# Safety

---

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.** FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at [www.campbellsci.eu](http://www.campbellsci.eu) or by telephoning +44(0) 1509 828 888 (UK). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

## General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

## Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines.**
- Maintain a distance of at least one-and-one-half times structure height, or 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

## Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

## Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.



# PLEASE READ FIRST

---

## About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

<b>Area:</b> 1 in <sup>2</sup> (square inch) = 645 mm <sup>2</sup>	<b>Mass:</b> 1 oz. (ounce) = 28.35 g 1 lb (pound weight) = 0.454 kg
<b>Length:</b> 1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km	<b>Pressure:</b> 1 psi (lb/in <sup>2</sup> ) = 68.95 mb
	<b>Volume:</b> 1 UK pint = 568.3 ml 1 UK gallon = 4.546 litres 1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a “#” symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

## Recycling information



At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.



Campbell Scientific Ltd, 80 Hathern Road, Shepshed, Loughborough, LE12 9GX,  
UK Tel: +44 (0) 1509 601141 Fax: +44 (0) 1509 270924  
Email: [support@campbellsci.co.uk](mailto:support@campbellsci.co.uk)  
[www.campbellsci.co.uk](http://www.campbellsci.co.uk)





# Table of Contents

---

*PDF viewers: These page numbers refer to the printed version of this document. Use the PDF reader bookmarks tab for links to specific sections.*

<b>1. Description .....</b>	<b>1</b>
<b>2. Using the TCAV with Soil Heat Flux Plates .....</b>	<b>1</b>
2.1 Installation.....	2
2.2 Calculating Soil Heat Flux .....	3

## **Figures**

1-1. TCAV Thermocouple Probe .....	1
2-1. Placement of Thermocouples and Heat Flux Plates .....	2



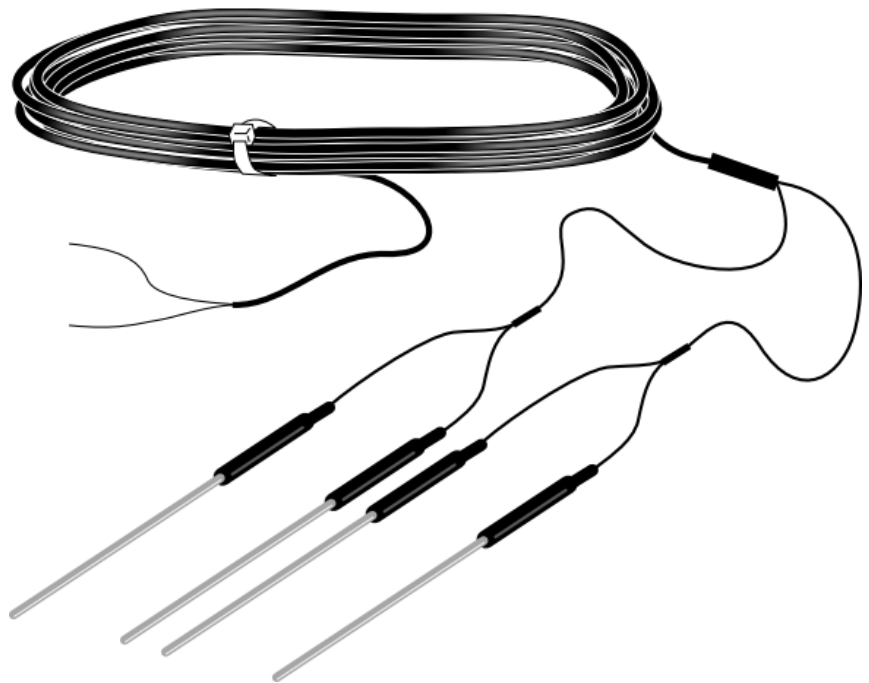
# ***TCAV – Averaging Soil Thermocouple Probe***

---

## **1. Description**

The TCAV is a temperature probe which parallels four thermocouple junctions into one. One channel is required to measure the output voltage which represents the average temperature of the four junctions. The TCAV is most often used to obtain the average temperature of a soil layer for use in calculating stored energy.

The probe is constructed with type E thermocouple wire (chromel-constantan) and can be measured with one of the datalogger thermocouple measurement instructions, **TCSe()** or **TCDiff()**. **TCDiff()** is recommended because it reduces noise and ground loop problems.



*FIGURE 1-1. TCAV Thermocouple Probe*

## **2. Using the TCAV with Soil Heat Flux Plates**

The TCAV is used in conjunction with soil heat flux plates to calculate the heat flux at the surface of the soil. The plates are buried at a fixed depth of between 5 and 8 cm to reduce errors due to vapor transport of heat.

## 2.1 Installation

The TCAV and two heat flux plates are typically installed as in FIGURE 2-1. The TCAV is constructed so two thermocouples can be used to obtain the average temperature of the soil layer above one heat flux plate and the other two above the second plate. One datalogger channel is required to measure the output voltage which represents the average temperature of the four junctions. The thermocouple pairs may be up to one meter apart.

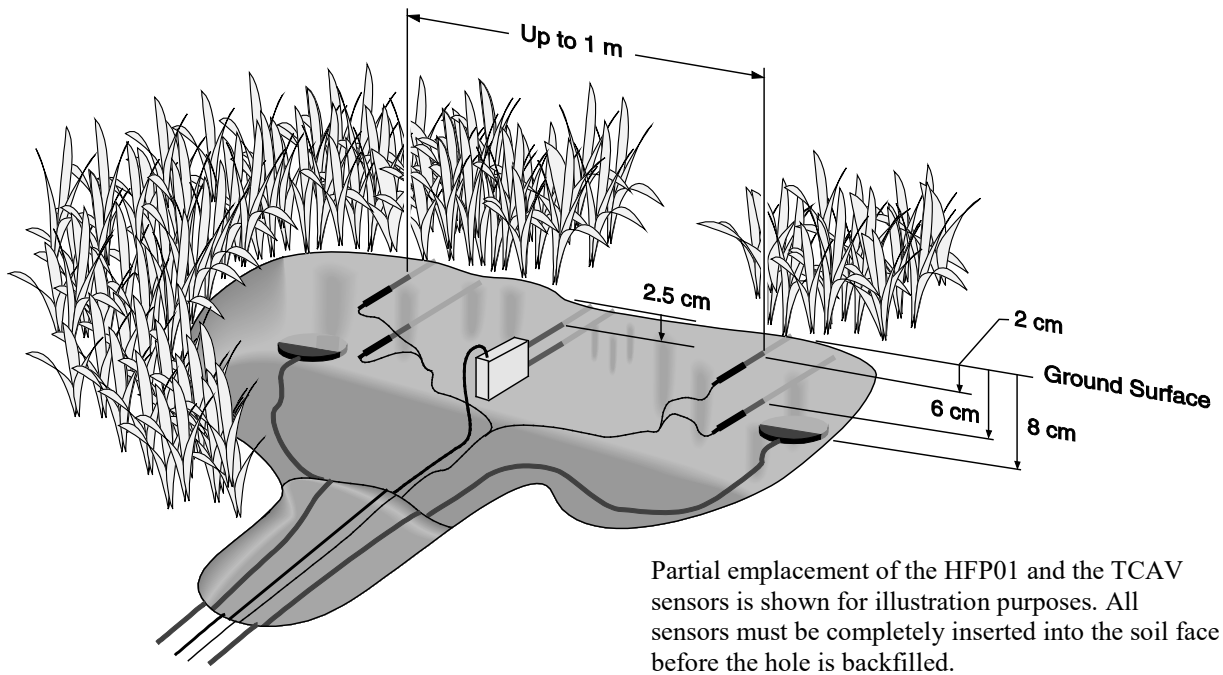


FIGURE 2-1. Placement of Thermocouples and Heat Flux Plates

The location of the two heat flux plates/thermocouples should be chosen to be representative of the area under study. If the ground cover is extremely varied, it could be necessary to have additional sensors to provide a valid average.

Use a shovel to cut a vertical slice in the soil and remove the soil to one side of the cut. Try to keep the soil that is removed intact so that it can be replaced with as little disruption as possible.

The sensors are installed in the undisturbed face. The depths are measured from the top of the soil. A horizontal cut is made with a knife to install a heat flux plate. The stainless steel tubes encasing the thermocouple junctions are pressed into the soil, keeping the tubes horizontal. (When removing the thermocouples, grip the tubing, not the thermocouple wire.)

To minimize thermal conduction down the sensor lead wires, wrap them around the edge of the hole keeping the leads at the same level as the sensor for as long as possible. Replace the soil in the same position as it was. Do not run the leads directly to the surface.

## 2.2 Calculating Soil Heat Flux

The soil heat flux at the surface is calculated by adding the measured flux at a fixed depth (in this case 8 cm) to the energy stored in the layer above the heat flux plates. The heat capacity of the soil and the change in temperature over the output interval are required to calculate the average stored energy,  $S$  ( $W\ m^{-2}$ ):

$$S = (T_i - T_{i-1}) \cdot D \cdot C_s / t$$

Where:

$T_i$  is the current temperature ( $^{\circ}C$ ),  
 $T_{i-1}$  is previous temperature ( $^{\circ}C$ ),  
 $D$  is depth to heat flux plate (m),  
 $C_s$  is the soil heat capacity ( $J\ m^{-3}\ ^{\circ}C^{-1}$ ), and  
 $T$  is the time interval (s).

One method of calculating  $C_s$  is to add the specific heat of the dry mineral soil,  $C_{sd}$ , to that of the soil water,  $C_w$  ( $4190\ J\ kg^{-1}\ ^{\circ}C^{-1}$ ). The values used for  $C_{sd}$  and  $C_w$  are on a mass basis ( $J\ kg^{-1}\ ^{\circ}C^{-1}$ ).  $C_s$ , the heat capacity of the moist soil on a volume basis ( $J\ m^{-3}\ ^{\circ}C^{-1}$ ) is:

$$C_s = BD \cdot (C_{sd} + W \cdot C_w)$$

This calculation requires site specific inputs for bulk density ( $BD$ ,  $kg\ m^{-3}$ ), mass basis water content ( $W$ ,  $kg\ water/kg\ soil$ ), and  $C_{sd}$ , the specific heat of the dry soil.  $840\ J\ kg^{-1}\ ^{\circ}C^{-1}$  is a reasonable value for  $C_{sd}$  for most mineral soils (Hanks and Ashcroft, Applied Soil Physics, Published by Springer-Verlag, New York, 1980).

## Campbell Scientific Worldwide Offices

---

### Australia

Location: Garbutt, QLD Australia  
Email: [info@campbellsci.com.au](mailto:info@campbellsci.com.au)  
Website: [www.campbellsci.com.au](http://www.campbellsci.com.au)

### Brazil

Location: São Paulo, SP Brazil  
Email: [andread@campbellsci.com.br](mailto:andread@campbellsci.com.br)  
Website: [www.campbellsci.com.br](http://www.campbellsci.com.br)

### Canada

Location: Edmonton, AB Canada  
Email: [dataloggers@campbellsci.ca](mailto:dataloggers@campbellsci.ca)  
Website: [www.campbellsci.ca](http://www.campbellsci.ca)

### China

Location: Beijing, P. R. China  
Email: [info@campbellsci.com.cn](mailto:info@campbellsci.com.cn)  
Website: [www.campbellsci.com.cn](http://www.campbellsci.com.cn)

### Costa Rica

Location: San José, Costa Rica  
Email: [info@campbellsci.cc](mailto:info@campbellsci.cc)  
Website: [www.campbellsci.cc](http://www.campbellsci.cc)

### France

Location: Antony, France  
Email: [info@campbellsci.fr](mailto:info@campbellsci.fr)  
Website: [www.campbellsci.fr](http://www.campbellsci.fr)

### Germany

Location: Bremen, Germany  
Email: [info@campbellsci.de](mailto:info@campbellsci.de)  
Website: [www.campbellsci.de](http://www.campbellsci.de)

### South Africa

Location: Stellenbosch, South Africa  
Email: [sales@csafrica.co.za](mailto:sales@csafrica.co.za)  
Website: [www.campbellscientific.co.za](http://www.campbellscientific.co.za)

### Southeast Asia

Location: Bangkok, Thailand  
Email: [info@campbellsci.asia](mailto:info@campbellsci.asia)  
Website: [www.campbellsci.asia](http://www.campbellsci.asia)

### Spain

Location: Barcelona, Spain  
Email: [info@campbellsci.es](mailto:info@campbellsci.es)  
Website: [www.campbellsci.es](http://www.campbellsci.es)

### UK

Location: Shepshed, Loughborough, UK  
Email: [sales@campbellsci.co.uk](mailto:sales@campbellsci.co.uk)  
Website: [www.campbellsci.co.uk](http://www.campbellsci.co.uk)

### USA

Location: Logan, UT USA  
Email: [info@campbellsci.com](mailto:info@campbellsci.com)  
Website: [www.campbellsci.com](http://www.campbellsci.com)

Please visit [www.campbellsci.com/contact](http://www.campbellsci.com/contact) to obtain contact information for your local US or international representative.