Product Manual

TCAV

Averaging Soil Thermocouple Probe

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MONITORING

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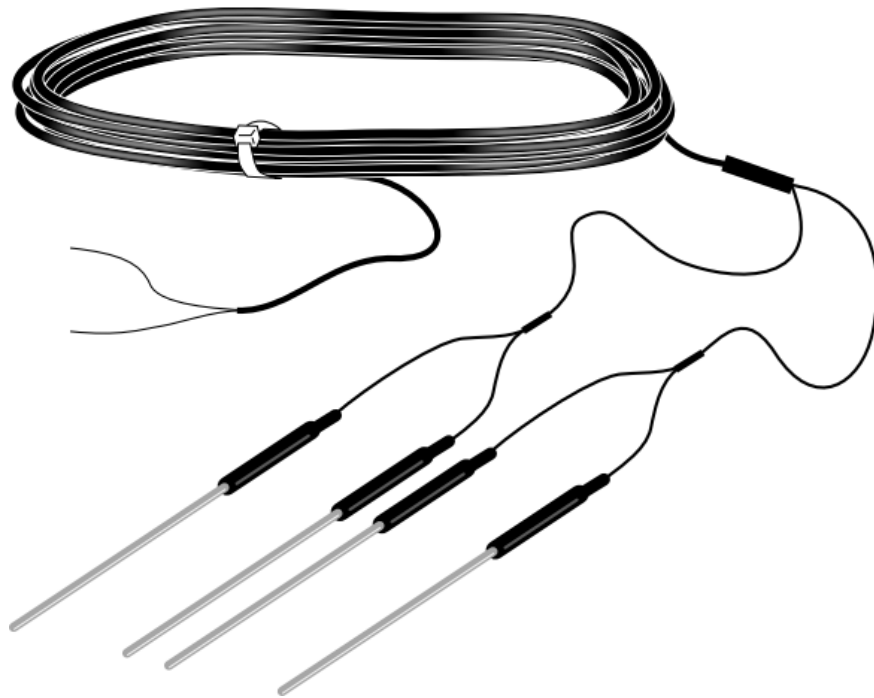
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General
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance 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, 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.

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TCAV – Averaging Soil Thermocouple Probe

1. Introduction

The TCAV typically provides the average temperature of the soil for energy-balance in flux systems. It parallels four thermocouples together into one 24 AWG wire. Each member of a thermocouple pair can then be buried at a different depth. The thermocouple pairs may be up to one meter apart.
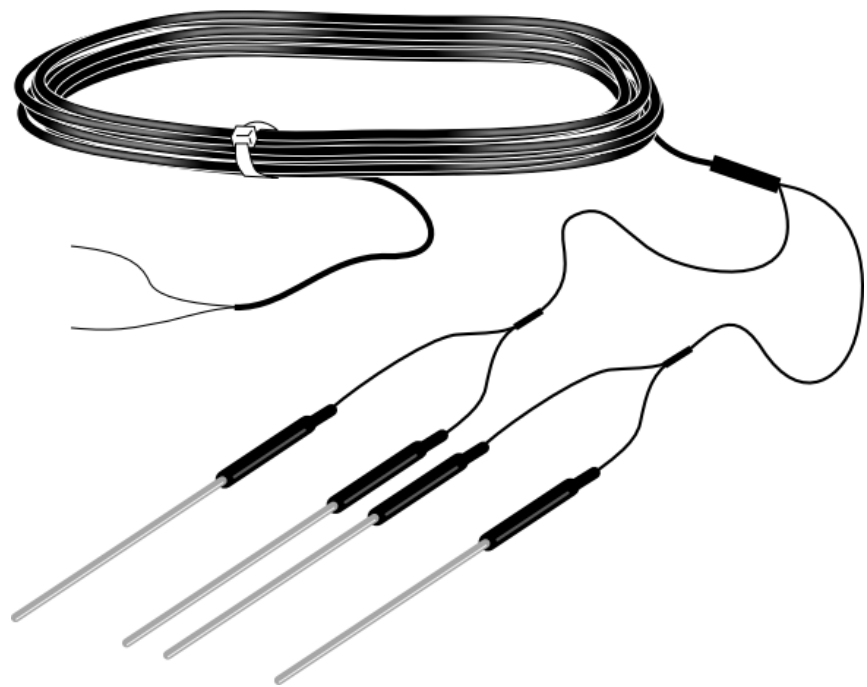

FIGURE 1-1. TCAV Thermocouple Probe

2. Precautions

- READ AND UNDERSTAND the *Safety* section at the front of this manual.

- Handle the TCAV with care.

- While opening the shipping package, avoid cutting or damaging the cable jacket. If damage to the cable is suspected, contact Campbell Scientific.

3. Initial Inspection

- Upon receipt of the sensor, inspect the packaging for any signs of shipping damage and, if found, report the damage to the carrier in accordance with policy. The contents of the package should also be inspected and a claim filed if any shipping related damage is discovered.

- The model number is printed on a label on the cable. Check this information against the shipping documents to ensure the correct product is received.

4. QuickStart

A video that describes data logger programming using *Short Cut* is available at: *www.campbellsci.com/videos/cr1000x-datalogger-getting-started-program-part-3*. *Short Cut* is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. *Short Cut* is available as a download on *www.campbellsci.com*. It is included in installations of *LoggerNet*, *RTDAQ*, *PC400*, or *PC200W*.

The following procedure shows using *Short Cut* to program the type-E thermocouple of the TCAV. A reference temperature measurement is required. For this tutorial, the data logger panel temperature measurement is used as the reference temperature measurement.

1. Open *Short Cut* and click **Create New Program**.

2. Double-click the data logger model.

3. In the **Available Sensors and Devices** box, type Type E Thermocouple or locate the sensor in the **Sensors** > **Temperature** folder. Double-click **Type E Thermocouple**. The temperature defaults to degree C. This can be changed by clicking the **Temperature** box and selecting one of the other options.
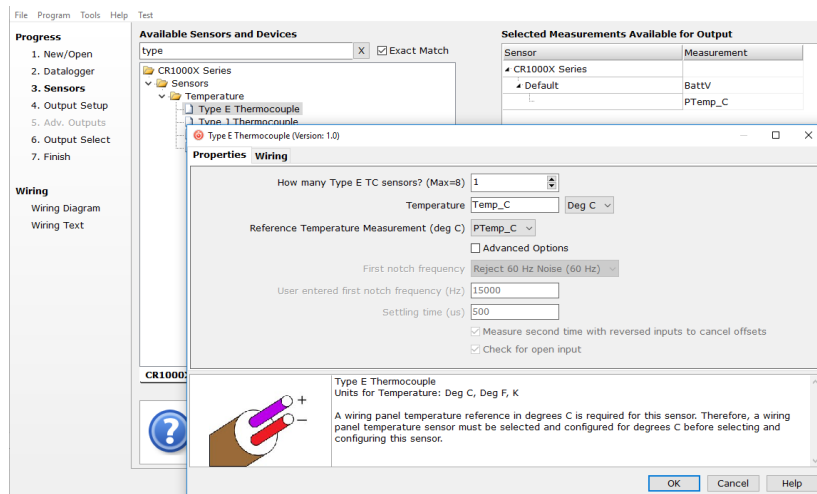
4. Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.
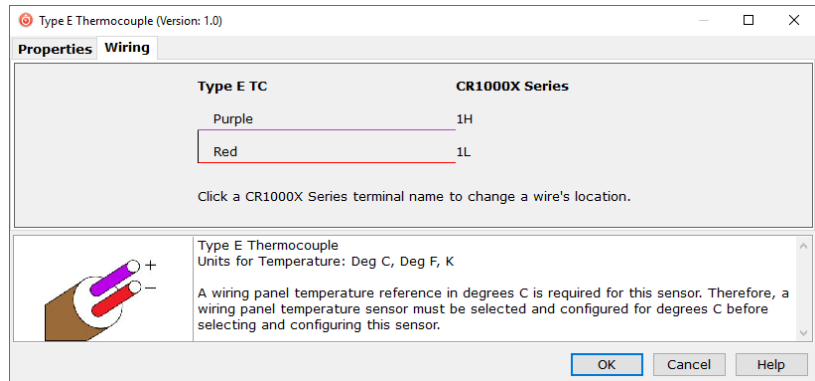
5. Repeat steps three and four for other sensors you want to measure. Click **Next**.

6. In **Output Setup**, type the scan rate, meaningful table names, and **Data Output Storage Interval**.
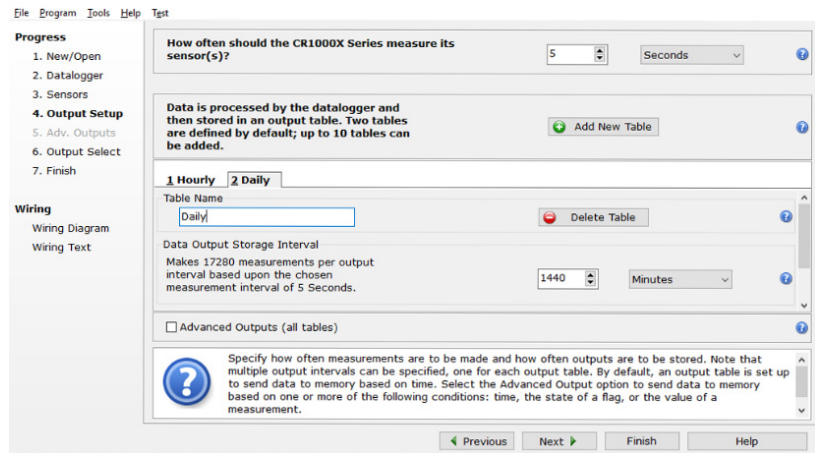
7. Select the measurement and its associated output option.

8. Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.

9. If the sensor is connected to the data logger, check the output of the sensor in data display in *LoggerNet*, *RTDAQ*, *PC400*, or *PC200W* to make sure it is making reasonable measurements.

5.   Overview

The TCAV uses type E thermocouples, which are comprised of a chromel wire and a constantan wire joined at a measurement junction. A voltage potential is generated when the measurement end of the thermocouple is at a different temperature than the reference end of the thermocouple. The magnitude of the voltage potential is related to the temperature difference. Therefore,

temperature can be determined by measuring the differences in potential created at the junction of the two wires.

A reference temperature measurement is required for thermocouple measurements. The temperature sensor built into many of our data logger wiring panels typically provides this measurement.

6. Specifications

Type: Chromel-Constantan

Typical Output: 60 µV/°C

Weight: 0.45 kg (1 lb) with 15.24-m (50-ft) cable

7. Installation

Typically, the TCAV is used to calculate the heat flux at the surface of the soil. The standard set of sensors for measuring soil heat flux includes the TCAV Averaging Soil Thermocouple, HFP01SC Soil Heat Flux Plates, and CS616, CS650, or CS655 water content reflectometer.

7.1 Placement in Soil

The following shows a typical soil heat flux installation.

Partial emplacement of the heat flux plate and the TCAV sensors is shown for illustration purposes. All sensors must be completely inserted into the soil face before the hole is backfilled.
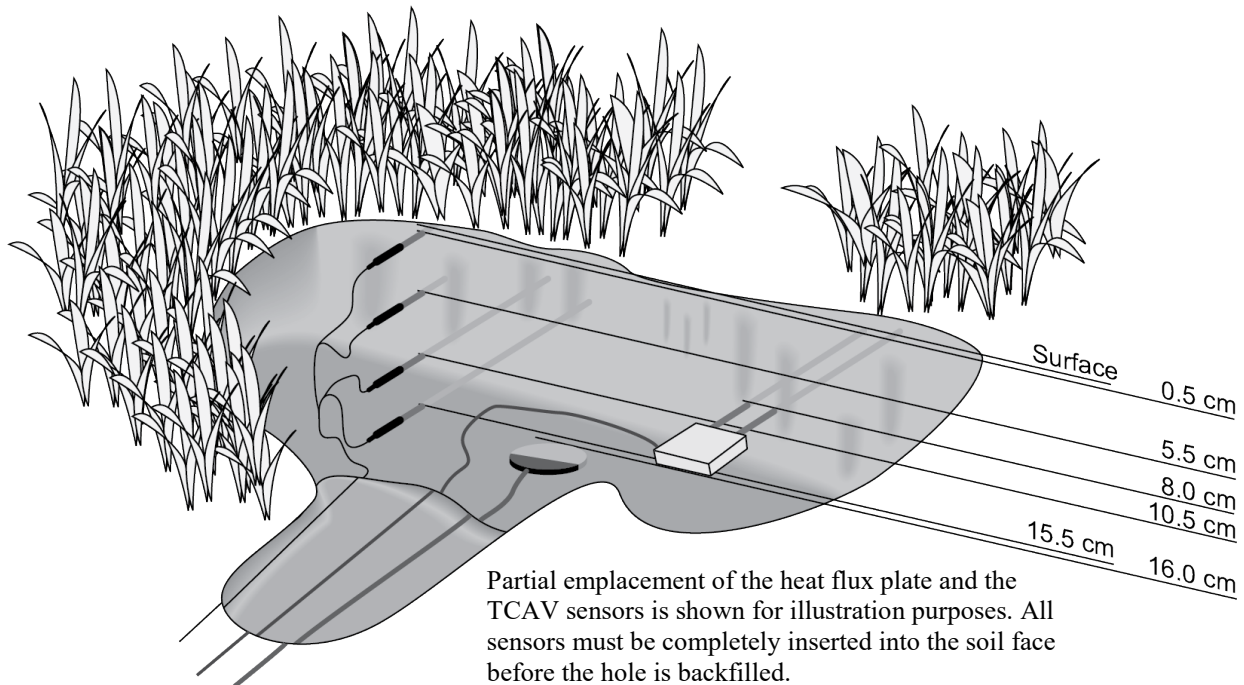
FIGURE 7-1. Sensor placement for soil heat flux measurements

The location of the heat flux plate and thermocouple 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. Keep the soil intact so that it can be replaced with minimal disruption.

The sensors are installed in the undisturbed face. Measure the sensor depths from the top of the soil. With a small knife, make a horizontal cut below the surface into the undisturbed face of the hole. 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 wires, wrap them around the edge of the hole keeping the wires 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 wires directly to the surface.

7.2   Wiring to the Data Logger

<table>
<tr><td colspan="4">TABLE 7-1. Wire Color, Function, and Connections to the Data Logger</td></tr>
<tr><td rowspan="2">Wire Color</td><td rowspan="2">Function</td><td colspan="2">Data Logger Terminals</td></tr>
<tr><td>Differential</td><td>Single-Ended</td></tr>
<tr><td>Purple</td><td>Analog signal</td><td>**U** configured for differential high[1], **DIFF H** (differential high, analog-voltage input)</td><td>**U** configured for single-ended[1], **SE** (single-ended, analog-voltage input)</td></tr>
<tr><td>Red</td><td>Signal reference</td><td>**U** configured for differential low[1], **DIFF L** (differential low, analog-voltage input)</td><td>⏚ (analog ground)</td></tr>
<tr><td colspan="4">[1] **U** terminals are automatically configured by the measurement instruction.</td></tr>
</table>

7.3   Programming

The probe is measured with a thermocouple CRBasic instruction, **TCSe()** or **TCDiff()**. **TCDiff()** is recommended because it reduces noise and ground loop problems. The **TCDiff()** instruction has the following form:

```
TCDiff( Dest, Reps, Range, DiffChan, TCType, TRef, RevDiff,
SettlingTime, integration or fN1, Mult, Offset )
```

Choose TypeE for the TCType. A reference temperature measurement (TRef) is required and is typically provided by the thermistor built into the wiring panel of the data logger. The **PanelTemp()** instruction measures the thermistor built into the data logger panel.

7.4   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}):

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

Where:

T_i is the current temperature (°C),
T_{i-1} is previous temperature (°C),
D is depth to heat flux plate (m),
C_s is the soil heat capacity (J m^{-3} °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} °C^{-1}). The values used for C_{sd} and C_w are on a mass basis (J kg^{-1} °C^{-1}). C_s, the heat capacity of the moist soil on a volume basis (J m^{-3} °C^{-1}) is:

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

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} °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).

Appendix A. Importing Short Cut Code Into CRBasic Editor

Short Cut creates a .DEF file that contains wiring information and a program file that can be imported into the *CRBasic Editor*. By default, these files reside in the C:\campbellsci\SCWin folder.

Import *Short Cut* program file and wiring information into *CRBasic Editor*:

1. Create the *Short Cut* program. After saving the *Short Cut* program, click the **Advanced** tab then the **CRBasic Editor** button. A program file with a generic name will open in CRBasic. Provide a meaningful name and save the CRBasic program. This program can now be edited for additional refinement.

NOTE	Once the file is edited with *CRBasic Editor*, *Short Cut* can no longer be used to edit the program it created.

2. To add the *Short Cut* wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder, and copy the wiring information, which is at the beginning of the .DEF file.

3. Go into the CRBasic program and paste the wiring information into it.

4. In the CRBasic program, highlight the wiring information, right-click, and select **Comment Block**. This adds an apostrophe (') to the beginning of each of the highlighted lines, which instructs the data logger compiler to ignore those lines when compiling. The **Comment Block** feature is demonstrated at about 5:10 in the *CRBasic | Features* video ▶.

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