PRODUCT MANUAL

Sensor

DustVue

In-Field Soiling Measurement for Operational and Site Assessment (IEC 61724-1 Compliant)

Revision: 08/2023

RELIABLE MONITORING SINCE 1974

Campbell SCIENTIFIC®

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:

Area: 1 in^2 (square inch) = 645 mm^2

Length: 1 in. (inch) = 25.4 mm
1 ft (foot) = 304.8 mm
1 yard = 0.914 m
1 mile = 1.609 km

Mass: 1 oz. (ounce) = 28.35 g
1 lb (pound weight) = 0.454 kg

Pressure: 1 psi (lb/in^2) = 68.95 mb

Volume: 1 UK pint = 568.3 ml
1 UK gallon = 4.546 litres
1 US gallon = 3.785 litres

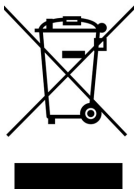
In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

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, per The Waste Electrical and Electronic Equipment (WEEE) Regulations 2013. 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.

Table of contents

1. Introduction

The DustVue Soiling Loss Sensor provides solar energy professionals with information needed to evaluate and manage the impact of soiling on power production at the site. Plant operators can use this information to determine when to clean the array, which saves the cost of unnecessary cleanings and also helps to minimize damage caused by frequent cleanings.

The DustVue is designed to be the principle component of an independent soiling measurement station, or as an add-on peripheral to any new or existing meteorological station. The DustVue is delivered field ready and requires no programming. The DustVue will work with any photovoltaic (PV) panel up to 700 W. Smaller wattage panels can be used. Consult Campbell Scientific before purchasing if using a panel smaller than 20 W. Two highly accurate and rugged back-of-panel temperature sensors are included.

2. Precautions

READ AND UNDERSTAND the Safety section at the back of this manual.

> **DANGER:**
> Fire, explosion, and severe-burn hazard. Misuse or improper installation of the internal lithium battery can cause severe injury. Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent lithium batteries properly.

> **WARNING:**
> • Protect from overvoltage.
> • Protect from water.
> • Protect from ESD (electrostatic discharge).

IMPORTANT: Maintain a level of calibration appropriate to the application. Campbell Scientific recommends factory recalibration of the DustVue every three years.

3. Initial inspection

The DustVue ships with the following:

- DustVue enclosure
- 2 back-of-panel temperature sensors: CS241-17-PT Surface-Mount Temperature Sensors
- UV-resistant 8 in. cable ties used to secure the temperature sensor cables
- Flat-bladed screwdriver for connecting wires to terminals
- USB 2.0 Cable Type A Male to Micro B Male for computer communications
- CR310 Certificate of Calibration
- 8 GB USB flash drive with ***Device Configuration Utility*** software

Upon receipt of the DustVue, inspect the packaging and contents for damage. File damage claims with the shipping company.

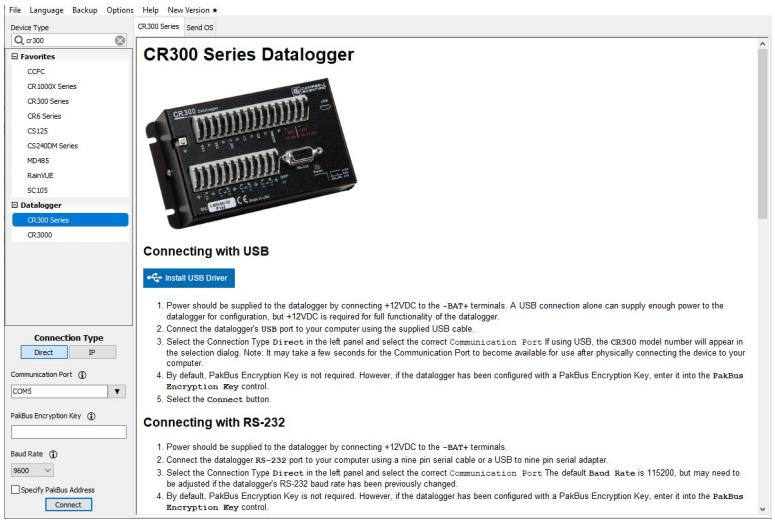
Immediately check package contents. Thoroughly check all packaging material for product components that may be concealed. Check model numbers, part numbers, and product descriptions against the shipping documents. Model or part numbers are found on each product. On cabled items, the number is often found at the end of the cable that connects to the measurement device. The Campbell Scientific number may differ from the part or model number printed on the sensor by the sensor vendor. Ensure that you received the expected cable lengths. Contact Campbell Scientific immediately about discrepancies

4. QuickStart

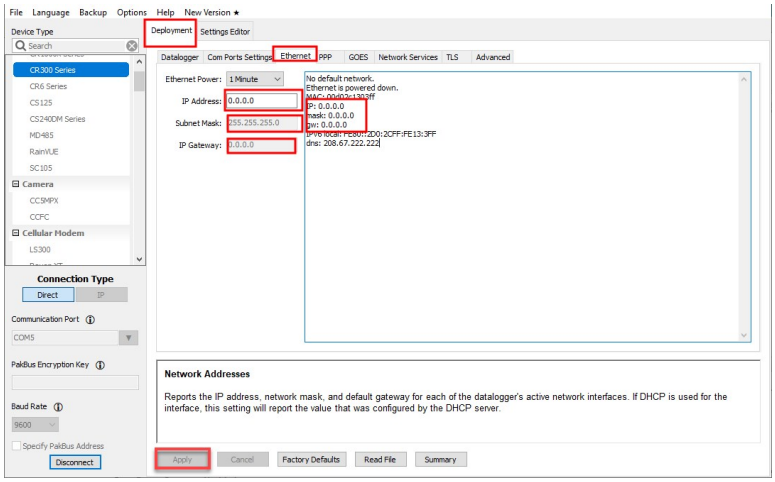
4.1 Configuration

Device Configuration Utility software is required to set time, set/view IP addresses, change Ethernet settings, and view data. This software can be installed from the USB drive sent with the DustVue. It is also available as a free download at www.campbellsci.com/devconfig.

1. Open the ***Device Configuration Utility***
2. In the **Device Type** panel, select CR300 Series.
3. Follow the steps shown in the right panel of the window to connect.

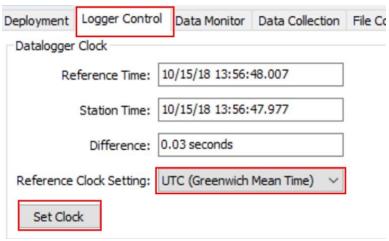


4. Set the Ethernet settings
    a. Select the **Deployment** tab.
    b. Fill in the Ethernet information appropriate for your network.



    c. Press Apply on the bottom left of the screen to save the Ethernet network settings.

5. Set time. Although set at the factory, confirm time settings are correct and if necessary, reset the clock at the time of deployment.
    a. In the **Logger Control** tab use the drop down next to **Reference Clock Setting** and select **UTC (Greenwich Mean Time)**. Click **Set Clock** to apply the setting.



4.2 User entered values

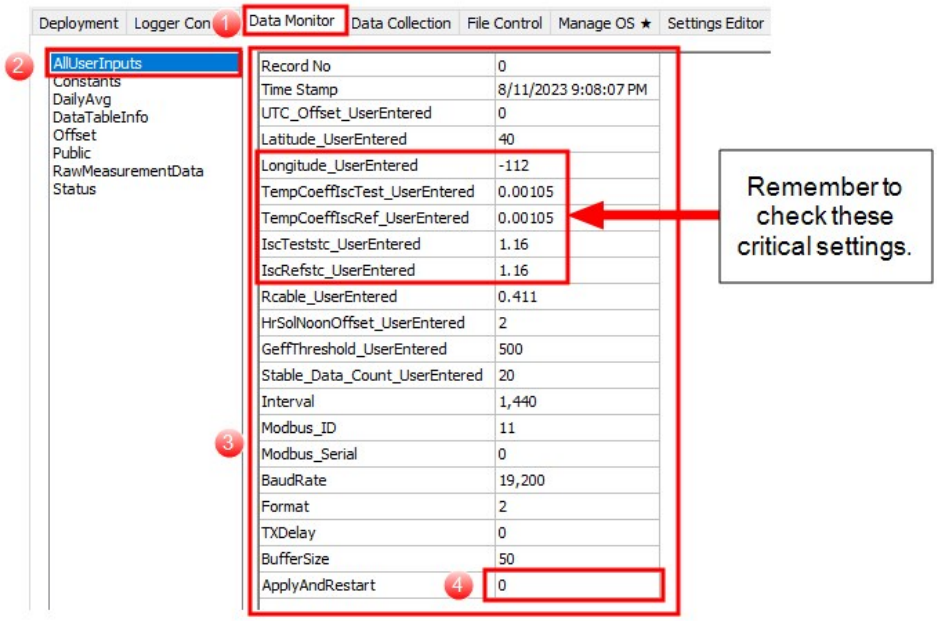
UserEntered values will be applied at the factory prior to shipping if they are provided to Campbell Scientific when the DustVue is ordered.

Confirm all **UserEntered** values are entered correctly at the time of deployment.

> **CAUTION:**
> Be sure to check the *Longitude_UserEntered*, *TempCoefflscTest_UserEntered*, *TempCoefflscRef_UserEntered*, *IscTeststc_UserEntered*, and *IscRefstc_UserEntered* values.

If any **UserEntered** values need to be changed, do the following the steps:

1. Select the **Data Monitor** tab.



2. Select the **AllUserInputs** table.
3. For each value that needs to be changed, do the following.

a. Double click on the value in the field that needs to be changed:

b. Enter the correct value:

c. Press Enter to set the correct value.

4. When all values are corrected, set the **ApplyandRestart** variable to 1 and press Enter to reset the system and apply all the values.

4.2.1 Definitions of UserEntered and solar panel

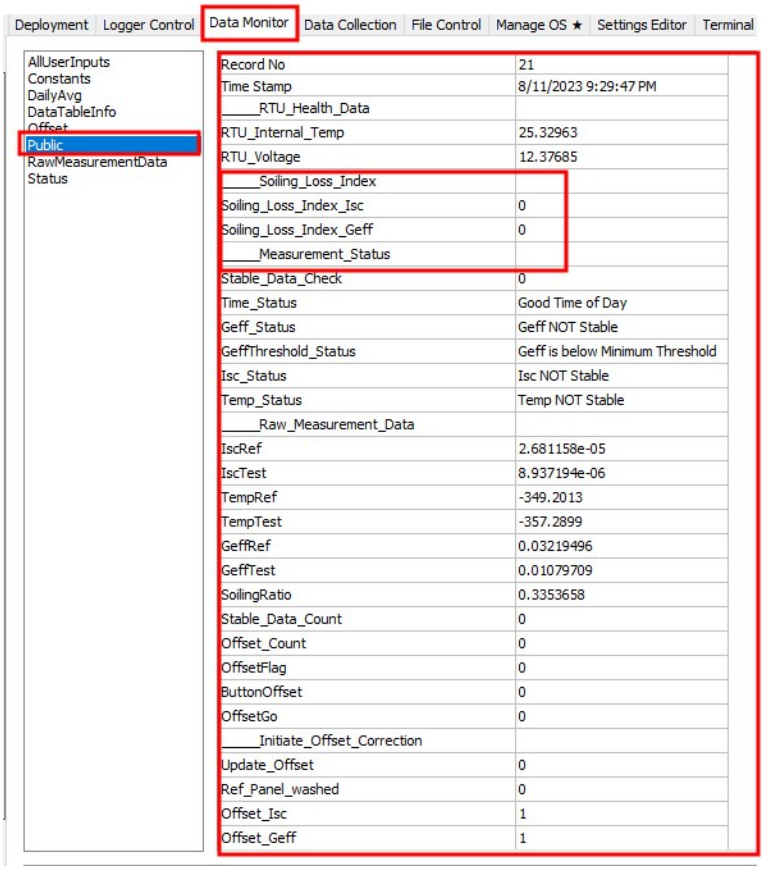
Table 4-1: User entered values and descriptions

Variable name	Description
UTC_Offset_UserEntered	User-entered UTC offset of site location, hours
Latitude_UserEntered	User-entered latitude of site location
Longitude_UserEntered	User-entered longitude of site location
TempCoefflscTest_UserEntered	User entered temperature coefficient of Isc of the test panel. Default = 0.105%/°C. Configured at the factory if value is provided
TempCoefflscRef_UserEntered	User entered temperature coefficient of Isc of the reference panel. Default = 0.105%/°C. Configured at the factory if value is provided
IscTeststc_UserEntered	Published panel short-circuit current (Isc) of the test panel at STC
IscRefstc_UserEntered	Published panel short-circuit current (Isc) of the reference panel at STC
HrSolNoonOffset_UserEntered	User editable field that defines the number of hours before and after solar noon that will include measurements for calculating soiling index. Default = 2 hours
GeffThreshold_UserEntered	User editable field that defines the minimum effective irradiance for calculating soiling index. Default = 500 W/m^2
Stable_Data_Count_UserEntered	User editable field that defines the minimum number of stable data counts for (re)calculating soiling index. Also the minimum number of stable data counts for performing an offset correction. Default = 20

Table 4-1: User entered values and descriptions	
Variable name	Description
ModBus_ID	User editable field defining the Modbus address. Default = 11 (should not require modification for Modbus TCP Communication)
ApplyAndRestart	Enter a value of 1 to save user entered/edited values and restart the DustVue

4.3 View data

The DustVue outputs data over Modbus TCP (see Modbus register map (p. 17). Live data is shown in the Public table. To verify the system is working as expected, review the **Raw_Measurement_Data** and the **Modbus_Register_Map** values.



The soiling loss index, based only on short-circuit current and effective irradiance (including temperature correction), will show the previous days soiling loss index, assuming the minimum number of stable data points are recorded.

> **NOTE:**
> Both panels will generally soil at the same rate. The soiling ratio is most important the day after the reference panel is cleaned.

If zero stable data points are recorded during the previous day, the **SLI** will show NAN. If the minimum number of stable data are recorded, the soiling loss indexes will update at midnight.

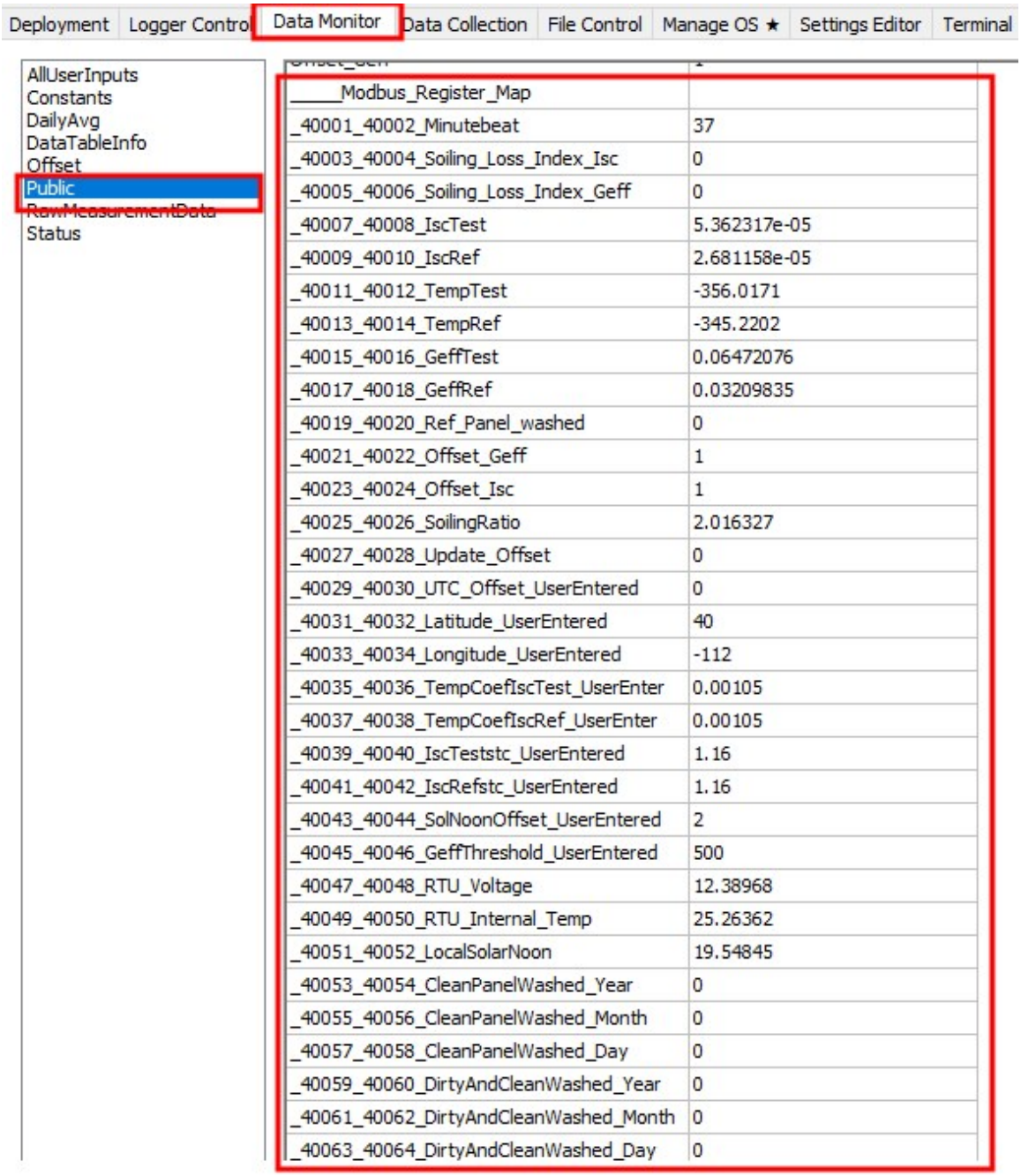
4.4 Modbus settings and data

The following table shows default Modbus settings for the DustVue. Any device querying information from the DustVue must have the same settings in order to receive the information.

Table 4-2: Modbus configuration

Parameter	Default setting
Comport	Ethernet, port 502
Baud Rate	Not applicable for Modbus TC/IP. Defined by connection speed.
Parity	No parity
Modbus address	11
Data	32-bit, float
Data format	CDAB

The Modbus data can be viewed in the **Public** table.



5. Overview

The DustVue uses the comparison-of-short-circuit method for assessing solar module performance and losses due to soiling. Numerous studies have compared the advantages and disadvantages of the different methods used to calculate losses due to soiling. These studies

show that the short-circuit current of a solar module is directly proportional to the light intensity and is a reliable method to measure changes in light intensity that reaches the solar cells.

The DustVue can be directly integrated with on-site SCADA using Modbus TCP or it can be added to new or existing solar meteorological monitoring systems (bottom of Figure 5-1 [p. 9]).

The DustVue supports many communication options, including: Internet protocols, Modbus, PakBus, and PakBus encryption. (See Modbus TCP communications (p. 10) for a complete list).

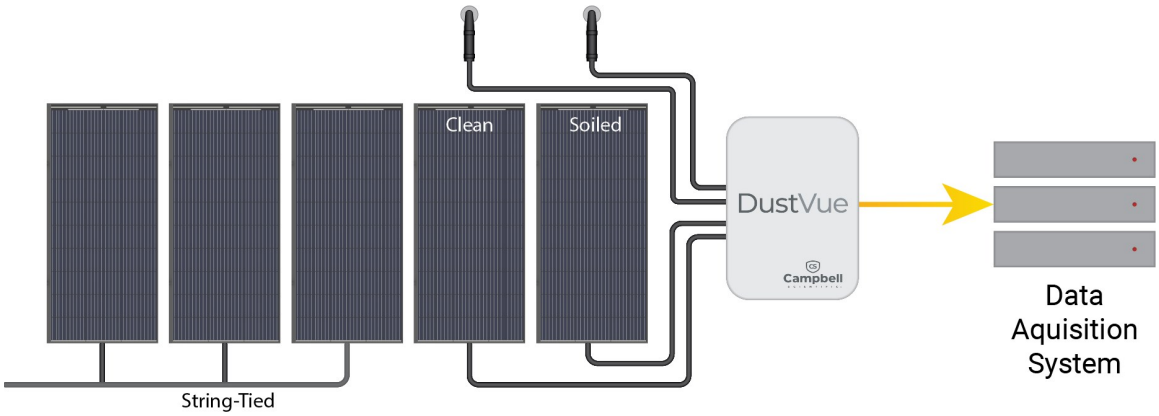


Figure 5-1. Example applications

6. Specifications

The DustVue is tested and guaranteed to meet electrical specifications in a standard –40 to +70 °C non-condensing environment.

Uncertainty on soiling loss index:	~1%
Data logger recommended recalibration rate:	Every 3 years
Compatible solar panels:	Compatible with panels up to 700 W

6.1 Back-of-module temperature measurements

Operating temperature range:	-40 to +150 °C
Class A PRT accuracy:	±(0.15 + 0.002t) °C
Element type:	Precision 1000 ohm Class A platinum sensing element (PT-1000)

6.2 Modbus TCP communications

Format:	TCP IP
Supported functions:	03
Modbus address:	11
Data type:	32-bit float, CDAB

6.3 System

Clock accuracy:	±1 minute per month
Clock resolution:	1 ms
Program execution:	1 min

6.4 Power requirements

Charger input (CHG):	16 to 32 VDC, current limited at 0.9 A. Power converter or solar panel input.
External batteries (BAT):	12 VDC, lead-acid 7 Ah battery, typical
Internal lithium battery:	3 V coin cell CR2016 (Energizer) for battery-backed clock. 6 year life with no external power source.
Typical power requirements:	
Sleep:	1.5 mA
Active 1 Hz scan with analog measurement:	5 mA
USB power (USB):	For programming and limited functionality

6.5 Compliance

IEC 61724-1 (2021) compliant. View compliance documents at www.campbellsci.com/dustvue.

6.6 Maintenance button

Press < 5 s: Records cleaning of reference panel. Recommend cleaning reference panel at least once a week, depending on site and user requirements

Press > 5 s: Records cleaning of both panels to initiate an offset correction procedure. Recommend doing once a year

7. Installation

7.1 Connector panel

Figure 7-1 (p. 11) shows the connector panel.

WARNING:
To prevent injury, completely cover the PV panels to limit output and current and voltage during installation. Do not short PV panel + and – wires.

Figure 7-1. DustVue connector panel

8. Operation

8.1 Measurement

To estimate soiling loss index (SLI), the DustVue system compares the outputs and temperatures of two identical PV panels mounted side by side: one clean, and the other soiled naturally.

Current measurements and back-of-panel temperature measurements are made. To help minimize PV panel degradation, the panel is maintained in an open-circuit hold state between measurements.

From short-circuit current and back-of-panel temperature, the effective irradiance of each panel is calculated in accordance with IEC 60904, and the SLI is calculated according to Eq. 2 (p. 13).

A daily-average SLI is calculated, available for SCADA (supervisory control and data acquisition), and stored in onboard memory. For immediate feedback, a real-time index and quality factor are available. Raw measured data are stored and available for analysis or independent post-processing. Descriptions of available values are shown in Variable description (p. 15)

In accordance with IEC 61724-1 (2021), the DustVue calculates the daily soiling loss index during the hour before and the hour after solar noon. Only the values showing effective irradiance greater than 500 W/m^2 are included to minimize the effects from the zenith angle of the sun, PV panel current dependence on irradiance level, and air mass density. The DustVue also filters out data that is classified as unstable (IEC 61724-1 [2021]), such as data during cloud cover. A variable, *Stable_Data_Count*, increments when all criteria are met.

8.2 Soiling loss index details

In terms of quantities that can be measured directly from a PV panel, soiling loss index (SLI) is defined as the loss in the irradiance reaching the solar cells of a PV panel. If all other factors are the same, this loss is primarily due to the loss in transmission properties of the glass as a result of soiling.

Irradiance (W/m^2) is calculated from short-circuit current as:

$$G_{eff} = I_{SC} \left(\frac{[1 - \alpha(T - T_0)]}{I_{SC,STC}} \right) * 1000 \qquad \text{Eq. 1}$$

Where:

- G_{eff}= effective irradiance reaching the solar cells (W/m^2)
- $I_{SC,STC}$ = short-circuit current at standard test conditions (STC)

- T = back-of-panel temperature (°C)
- T_0 =back-of-panel temperature at STC, typically 25 °C
- α = temperature coefficient of short-circuit current

SLI uses the effective irradiances of a clean reference panel and a dirty test panel. It is defined as

$$SLI = \left(1 - \frac{G_{eff,Test}}{G_{eff,Ref}}\right) \times 100\% \quad \text{Eq. 2}$$

Where $G_{eff,Ref}$ is the effective irradiance calculated from the clean reference panel, and $G_{eff,Test}$ is the effective irradiance calculated from the test panel.

8.3 Offset correction

PV panels often differ in power output under identical conditions, even when they are the same model from the same manufacturing batch. This offset in power output can be determined upon installation and updated after each cleaning of both panels. The offset correction is initiated by pressing the **Maintenance** button for 5 s or more. The procedure determines the offset, and then implements a correction factor into the measurement sequence to remove any effects that may be caused by differences in panel power output under identical conditions. Carefully clean both panels before initiating the offset correction process. Cleaning should be completed before 11 am.

> NOTE:
> Regardless of when the offset process is initiated, the offset will be updated at midnight on the next day when the minimum number of data points required to calculate a good offset is met.

After both panels are clean:

1. Press and hold the **Maintenance** button for a duration of greater than 5 seconds.
2. A variable named **Update_Offset** will be raised to 1. The time this button was pressed will be recorded in the data table named offset.
3. Results will be available when the minimum number of data points has been met for calculating a good offset value. This is typically midnight if the offset was initiated in the morning, or midnight of the following day if the offset was initiated in the afternoon or evening.

NOTE:
This procedure (maintenance button press greater than 5 s) is only used to remove an offset when both panels are clean. This is not the same as the regular maintenance procedure (maintenance button press < 5 s after reference panel is cleaned).

If the maintenance button is inadvertently pressed for more than 5 s and the offset correction is not needed, the process can be aborted by accessing the DustVue through the assigned IP address and using ***Device Configuration Utility*** to reset the **Offset Correction** variable to 0 before midnight.

9. Maintenance

For more accurate soiling-rate results, clean the reference (clean) panel as often as the pyranometer is cleaned, a minimum of once per week. Clean with distilled water and a lint-free cloth. After cleaning, press the **Maintenace** button and hold for less than 5 s.

Appendix A. Variable description

Table A-1: Glossary of variable names	
Variable name	Description
RTU_Internal_Temp	Panel temperature of DustVue, °C
RTU_Voltage	Battery voltage of DustVue, VDC
Soiling_Loss_Index_Corrected	Soiling loss index with offset correction applied, %
Soiling_Loss_Index_Raw	Soiling loss index without offset correction applied, %
Live_Index_Corrected %	Real-time index of reference to test panel with offset correction applied,
Live_Index_Raw	Real-time index of reference to test panel without offset correction applied, %
Stable_Data_Check	Variable indicating if environmental conditions are stable, True (–1)/False (0)
Time_Status	Variable indicating if the time of day is appropriate for performing soiling loss index calculations
Geff_Status	Variable indicating if the measured effective irradiance is appropriate for performing soiling loss index calculations
Isc_Status	Variable indicating if the measured short-circuit current is appropriate for performing soiling loss index calculations
Temp_Status	Variable indicating if the measured back-of-panel temperature is appropriate for performing soiling loss index calculations
IscTest	Short-circuit current of test panel, Amps
IscRef	Short-circuit current of reference panel, Amps
TempTest	Back-of-panel temperature of test panel, °C
TempRef	Back-of-panel temperature of reference panel, °C

Table A-1: Glossary of variable names	
Variable name	Description
GeffTest	Effective irradiance of test panel, W/m^2
GeffRef	Effective irradiance of reference panel, W/m^2
Offset_Geff	Measured offset between reference and test panels, %
Stable_Data_Count	Incrementally counts when conditions are appropriate for performing soiling loss index
Update_Offset	Boolean variable that user triggers when the offset correction is to be performed
UTC_Offset_UserEntered	User-entered UTC offset of site location, hours
Latitude_UserEntered	User-entered latitude of site location
Longitude_UserEntered	User-entered longitude of site location
AlphaTest_UserEntered	Published panel short-circuit current (Isc) temperature coeffecient of the test panel (if published in units of %/°C, then enter published value/100)
AlphaRef_UserEntered	Published panel short-circuit current (Isc) temperature coeffecient of the reference panel (if published in units of %/°C, then enter published value/100)
IscTeststc_UserEntered	Published panel short-circuit current (Isc) of the test panel at STC
IscRefstc_UserEntered	Published panel short-circuit current (Isc) of the reference panel at STC
LocalSolarNoon	Solar noon of site location, as determined by user-entered site location data

Appendix B. Modbus register map

Table B-1: Modbus register map

Variable	Parameter	Register start	Register stop	Low range	High range	Units
ModbusData(1)	Heartbeat	40001	40002	0	99	
ModbusData(2)	Soiling_Loss_Index_Current	40003	40003	–20	20	%
ModbusData(3)	Soiling_Loss_Index_Irradiance	40005	40006	–20	20	%
ModbusData(4)	Current_Test_Module	40007	40008	–10	20	Amp
ModbusData(5)	Current_Reference_Module	40009	40010	–10	20	Amp
ModbusData(6)	BOM_Test_Temperature (back-of-module test, module temperature)	40011	40012	–30	150	°C
ModbusData(7)	BOM_Ref_Temperature	40013	40014	°C	-30	150
ModbusData(8)	Effective_Irradiance_Test	40015	40016	0	1200	W/m^2
ModbusData(9)	Effective_Irradiance_Reference	40017	40017	0	1200	W/m^2
ModbusData(10)	Reference_Module_Washed	40019	40020	0	1	
ModbusData(11)	Effective_Irradiance_Offset	40021	40022	1	10	
ModbusData(12)	Current_Offsett	40023	40024	1	10	
ModbusData(13)	Soiling_Ratio (Ratio of test module vs reference module)	40025	40026	0	1	
ModbusData(14)	Update_Offset (offset update triggered)	40027	40028	–1	0	
ModbusData(15)	User_Entered_UTC_Offset (hour offset from UTC time)	40029	40030	–12	12	Hrs
ModbusData(16)	User_Entered_Latitude	40031	40032			Degrees
ModbusData(17)	User_Entered_Longitude	40033	40034			Degrees
ModbusData(18)	User_Entered_Test_Temperature_Coeff	40035	40036	0	No Max	Amp

Table B-1: Modbus register map						
Variable	Parameter	Register start	Register stop	Low range	High range	Units
ModbusData(19)	User_Entered_Reference_Temperature_ Coeff	40037	40038	0	No Max	Amp
ModbusData(20)	User_Entered_Test_Short_Circuit_Curr_ STC	40039	40040	0.5	20	Amp
ModbusData(21)	User_Entered_Reference_Short_Circuit_ Curr_STC	40041	40042	0.5	20	Amp
ModbusData(22)	User_Entered_Solar_Noon_Offset (hour offset from solar noon to start measurements)	40043	40044	0	2	Hrs
ModbusData(23)	User_Entered_Effective_Irradiance_ Threshold	40045	40046	100	500	W/m^2
ModbusData(24)	RTU_Voltage	40047	40048	9	13	Volts
ModbusData(25)	RTU_Internal_Temperature	40048	40050	–40	70	°C
ModbusData(26)	LocalSolarNoon	40051	40052	12:00	13:00	Hrs
ModbusData(27)	CleanPanelWashed_Year	40053	40054			
ModbusData(28)	CleanPanelWashed_Month	40055	40056			
ModbusData(29)	CleanPanelWashed_Day	40057	40057			
ModbusData(30)	DirtyAndCleanWashed_Year	40059	40060			
ModbusData(31)	DirtyAndCleanWashed_Month	40061	40062			
ModbusData(32)	DirtyAndCleanWashed_Day	40063	40064			

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.

Before returning any equipment for service, please contact us first to obtain a return material authorization (RMA) number. To find out how to do this, visit the *Returning Products for Service (RMA)* page of your regional Campbell Scientific office. Please visit our Contact Us page if you need to find out which office serves your country.

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 | 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.com 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

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- 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, 6 meters (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.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

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.

Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.
- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

Use and disposal of batteries

- Where batteries need to be transported to the installation site, ensure they are packed to prevent the battery terminals shorting which could cause a fire or explosion. Especially in the case of lithium batteries, ensure they are packed and transported in a way that complies with local shipping regulations and the safety requirements of the carriers involved.
- When installing the batteries follow the installation instructions very carefully. This is to avoid risk of damage to the equipment caused by installing the wrong type of battery or reverse connections.
- When disposing of used batteries, it is still important to avoid the risk of shorting. Do not dispose of the batteries in a fire as there is risk of explosion and leakage of harmful chemicals into the environment. Batteries should be disposed of at registered recycling facilities.

Avoiding unnecessary exposure to radio transmitter radiation

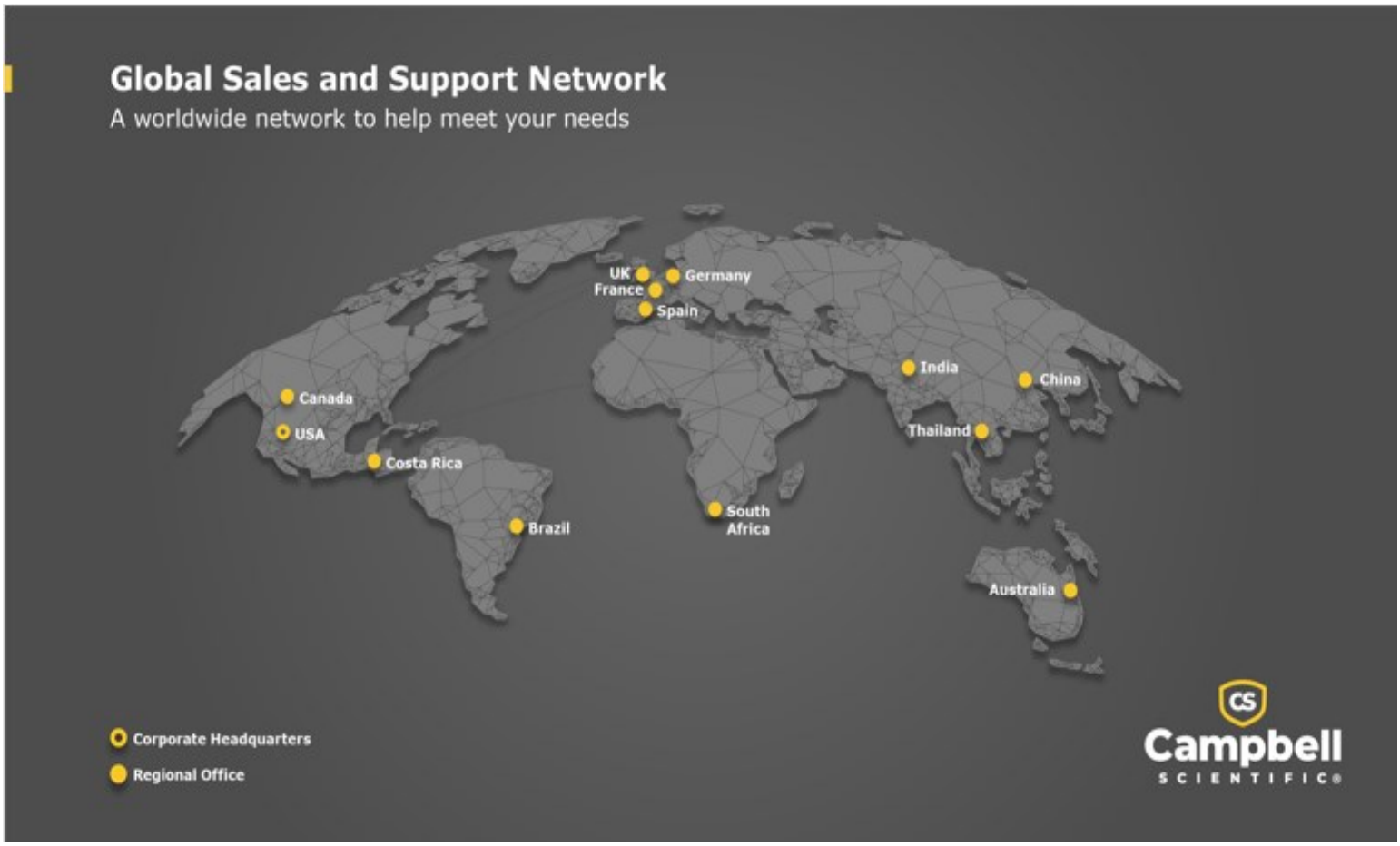
- Where the equipment includes a radio transmitter, precautions should be taken to avoid unnecessary exposure to radiation from the antenna. The degree of caution required varies with the power of the transmitter, but as a rule it is best to avoid getting closer to the antenna than 20 cm (8 inches)

when the antenna is active. In particular keep your head away from the antenna. For higher power radios (in excess of 1 W ERP) turn the radio off when servicing the system, unless the antenna is installed away from the station, e.g. it is mounted above the system on an arm or pole.

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.



Campbell Scientific Regional Offices

Australia

Location: Garbutt, QLD Australia
Phone: 61.7.4401.7700
Email: info@campbellsci.com.au
Website: www.campbellsci.com.au

Brazil

Location: São Paulo, SP Brazil
Phone: 11.3732.3399
Email: vendas@campbellsci.com.br
Website: www.campbellsci.com.br

Canada

Location: Edmonton, AB Canada
Phone: 780.454.2505
Email: dataloggers@campbellsci.ca
Website: www.campbellsci.ca

China

Location: Beijing, P. R. China
Phone: 86.10.6561.0080
Email: info@campbellsci.com.cn
Website: www.campbellsci.com.cn

Costa Rica

Location: San Pedro, Costa Rica
Phone: 506.2280.1564
Email: info@campbellsci.cc
Website: www.campbellsci.cc

France

Location: Montrouge, France
Phone: 0033.0.1.56.45.15.20
Email: info@campbellsci.fr
Website: www.campbellsci.fr

Germany

Location: Bremen, Germany
Phone: 49.0.421.460974.0
Email: info@campbellsci.de
Website: www.campbellsci.de

India

Location: New Delhi, DL India
Phone: 91.11.46500481.482
Email: info@campbellsci.in
Website: www.campbellsci.in

South Africa

Location: Stellenbosch, South Africa
Phone: 27.21.8809960
Email: sales@campbellsci.co.za
Website: www.campbellsci.co.za

Spain

Location: Barcelona, Spain
Phone: 34.93.2323938
Email: info@campbellsci.es
Website: www.campbellsci.es

Thailand

Location: Bangkok, Thailand
Phone: 66.2.719.3399
Email: info@campbellsci.asia
Website: www.campbellsci.asia

UK

Location: Shepshed, Loughborough, UK
Phone: 44.0.1509.601141
Email: sales@campbellsci.co.uk
Website: www.campbellsci.co.uk

USA

Location: Logan, UT USA
Phone: 435.227.9120
Email: info@campbellsci.com
Website: www.campbellsci.com