PRODUCT MANUAL

Sensor

DustVue™10

Solar-Module Soiling Sensor with Collocated PV Cells

09/2025

RELIABLE MONITORING SINCE 1974

Campbell SCIENTIFIC®

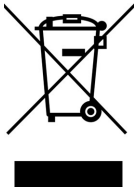
Please read first

About this manual

Please note that this manual was produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this. 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 Europe, Middle East, and Africa (EMEA) or Asia Pacific (APAC) 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 EMEA or APAC use. Please note, however, *that when a power supply adapter is ordered from Campbell Scientific it will be suitable for use in your country*.

Reference to some radio transmitters, digital cell phones and aerials (antennas) 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 EMEA or APAC market; in some cases alternatives are offered.

Recycling information for countries subject to WEEE regulations 2012/19/EU



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 2012/19/EU. Campbell Scientific 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 support, please contact Campbell Scientific, or your local agent.

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1. Introduction

The DustVue™10 is a stand-alone sensor that measures potential loss in electrical power production due to soiling on a PV (photovoltaic) power plant due to dust accumulation on the panels using a method in accordance with IEC 61724-1. The DustVue 10 is uniquely positioned to provide the most accurate PV module soiling data while accounting for complexities like bifaciality on solar PV sites with a simple, user-friendly sensor. Soiling losses depend on local site and weather conditions, such as humidity levels, air temperature, soil composition and type, human activities, and wind patterns. The chemical composition of dust particles and spectral response of PV cell material also play a crucial role. The DustVue 10 uses PV cells as sensing elements. To minimize any potential spectral mismatch, the PV cells are made of similar materials as PV panels to ensure surface properties of the sensor match those of PV panels.

The DustVue 10 is an industrial-grade digital sensor that can be read using Modbus RTU protocol on RS-485. Power and signal lines have industrial class 4 surge protection for continuous operation and reliability, even in the harsh conditions of a solar PV farm.

2. Precautions

- READ AND UNDERSTAND the Safety section at the back of this manual.
- Before mounting, the installers should read the sensor manual and quick deploy guide thoroughly.
- The sensor can be configured using USB power only but is fully operational only with 12 to 32 VDC applied through the M12-5 pin connector.
- Placement of the cable inside a rugged conduit is advisable for cable runs over 4.5 m (15 ft), especially in locations subject to digging, mowing, traffic, power tools, animals, or lightning strikes.
- The DustVue 10 should be installed to be in the same plane as the array of PV panels when used as a part of the operational performance monitoring station.
- The reference cells used do not have absolute radiometric calibration and hence the irradiance values will not match with other irradiance sensors at the site.
- These values are relative to each other and should be used as such.

- In-field calibration (offset correction) should be performed on a clear sky day during the offsets update period (± 1 hr before and after solar noon). For most locations this will need to be done no more than four times per year.

3. Initial inspection

- Upon receipt of the DustVue 10, inspect the packaging and contents for damage. File damage claims with the shipping company.
- The DustVue 10 is ordered as a stand-alone sensor; cable and mounting hardware are purchased separately. See common accessories here: www.campbellsci.com/order/dustvue10.

4. QuickStart

Figure 4-1 (p. 2) shows all the key components of the sensor.

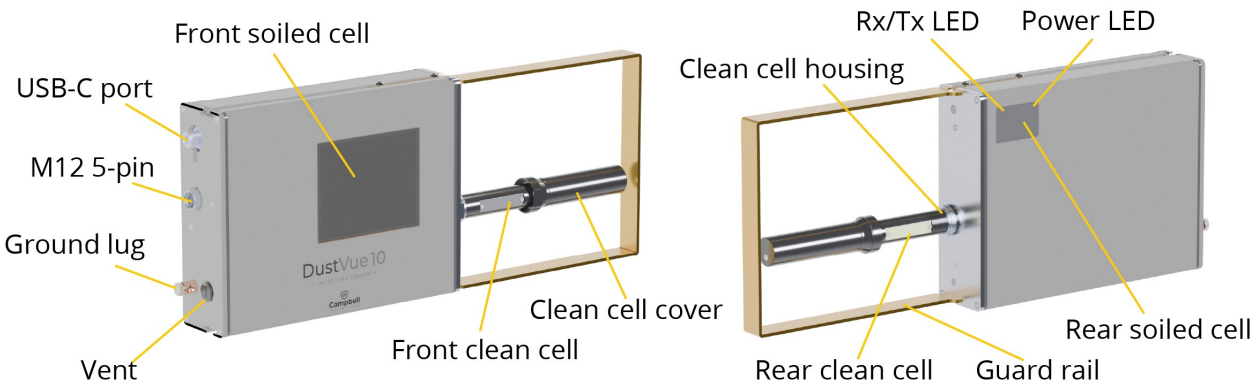


Figure 4-1. DustVue 10 components

1. Connect the DustVue 10 to a computer using the USB C cable (included).

> **NOTE:**
> A Campbell Scientific data logger and the DustVue 10 should not be connected to the computer at the same time.

2. Open a web browser and in the address bar type www.linktodevice.com (or 192.168.66.1) to access the web user interface (Web UI) of the sensor for easy configuration.
3. On first use, navigate to the **Configuration** tab (Figure 4-2 [p. 3]).

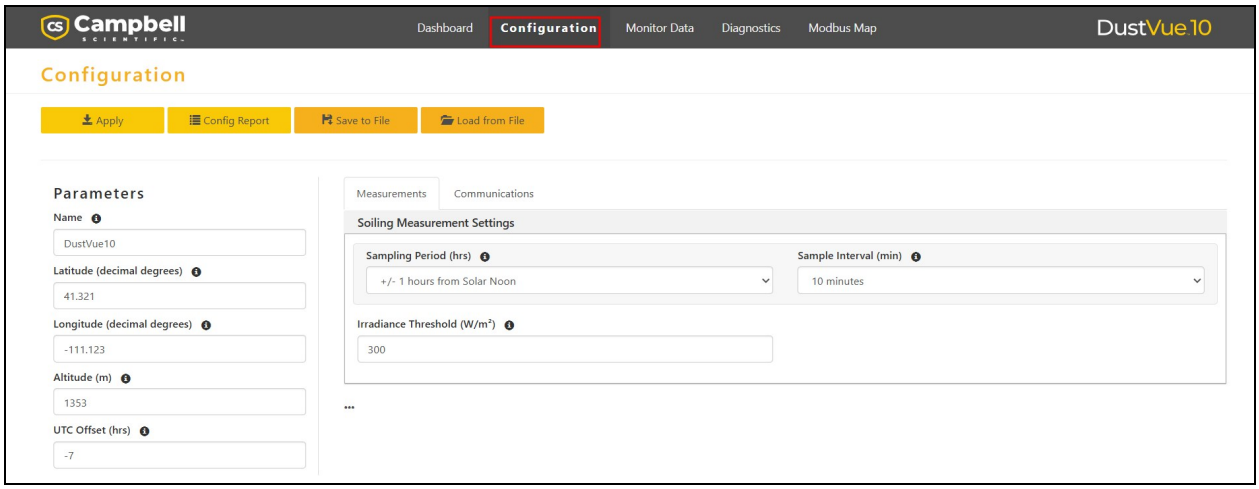


Figure 4-2. Configuration tab

The following location parameters need to be entered by the installer (Figure 4-3 [p. 4]).

a. **Latitude**: Enter site's latitude in decimal degrees (±xx.xxx)
b. **Longitude**: Enter the site's longitude in decimal degrees (±xxx.xxx)
c. **Altitude (m)**: Enter the site's altitude in meters (xxxx)

d. **UTC Offset (hrs)**: Enter the UTC offset in a standard time in hours (±xx)

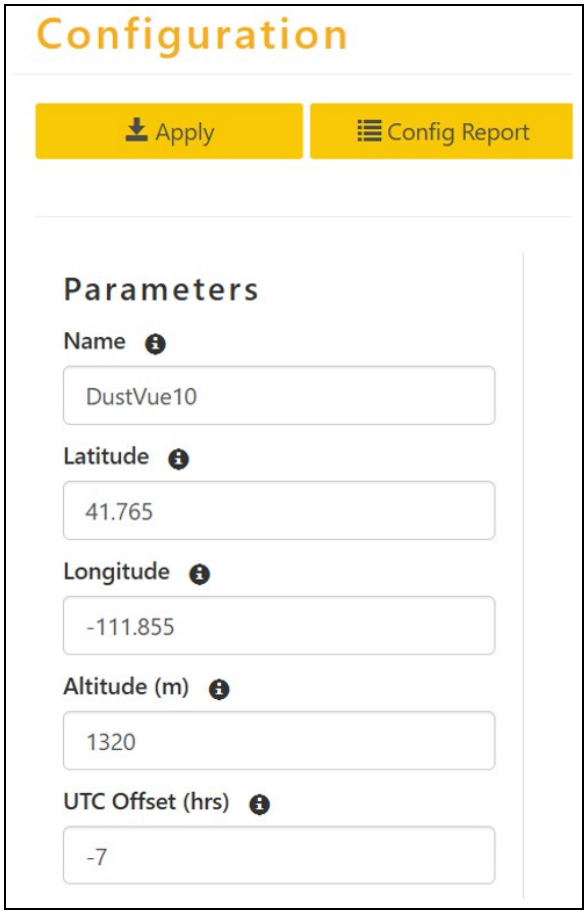


Figure 4-3. Configuring location parameters

e. Click the **Measurements** tab (Figure 4-4 [p. 5]) to configure the following measurement parameters.

   i. **Sampling Period (hrs)**: On a single axis tracker, we recommend ±2 hours and on a fixed tilt install ±1 hour.

   ii. **Sample Interval (min)**: This specifies the time interval when a clean cell measurement will be made provided the solar irradiance measured by the soiled cells is greater than the default or user settable minimum threshold and the irradiance is stable. A sample interval of 10 minutes is recommended.

   iii. **Irradiance Threshold (W/m2)**: Clean cells will not be exposed below this irradiance level. Until this threshold is exceeded, no soiling data will be

reported. A value in the range of 300 W/m^2 to 500 W/m^2 is a good choice for most locations.

> **CAUTION:**
> The reference cells have not been radiometrically calibrated as this is not required for a soiling measurement. An approximation of expected solar irradiance values should be used to set the effective irradiance threshold.

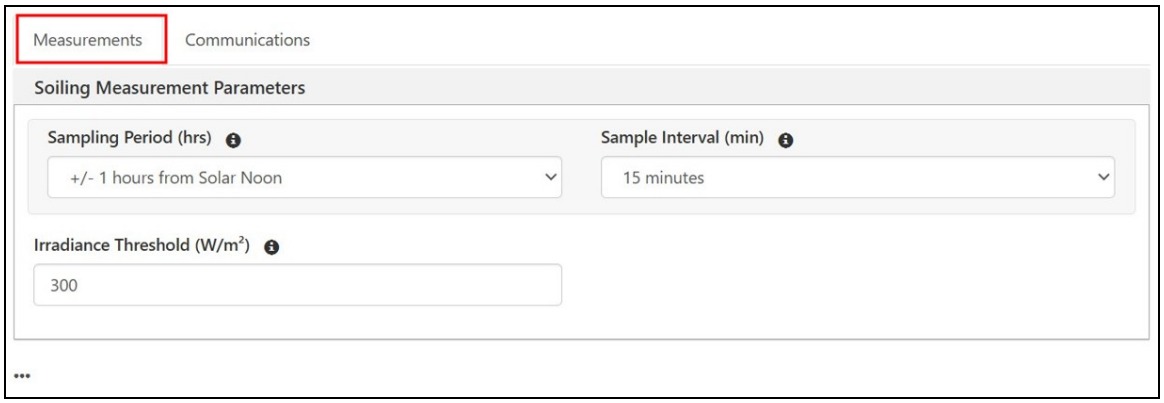


Figure 4-4. Configuring measurement parameters

f. Click the **Communications** tab. Make sure the settings for the serial port are correct and that the **Modbus ID** matches the Modbus address of the sensor.

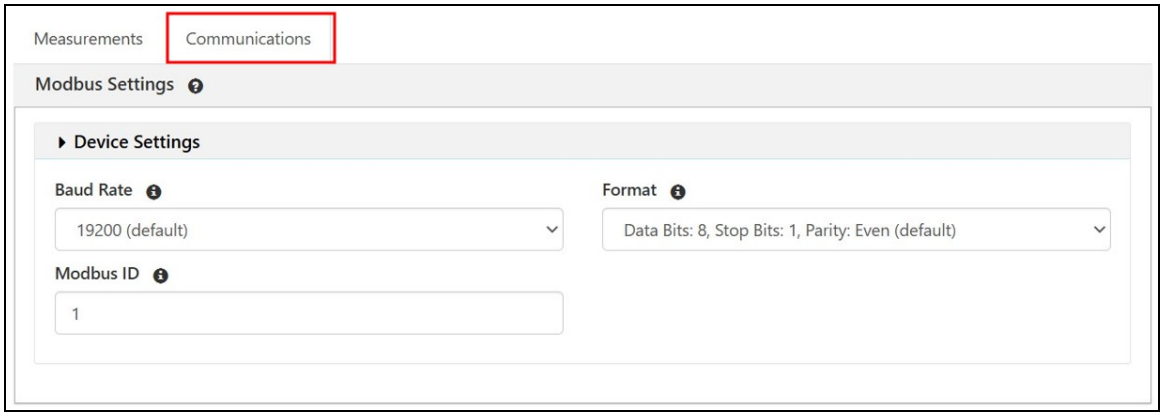
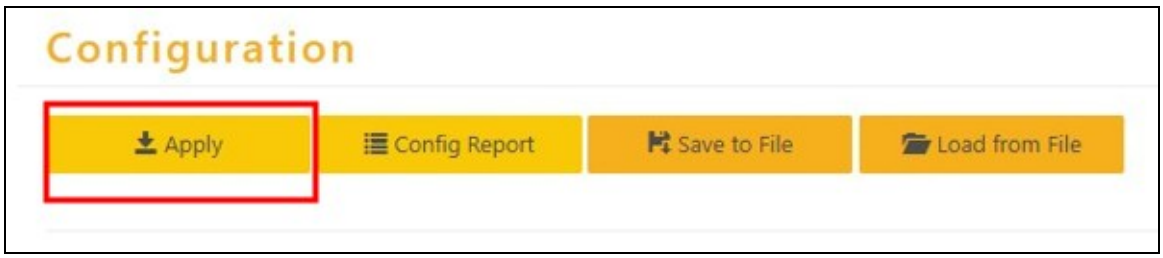


Figure 4-5. Configuring communications parameters

g. Click **Apply** after entering the values. The sensor will initialize after confirming your choice in the pop-up window.



4. Offset correction:

> **NOTE:**
> Perform this calibration when the sky is clear and the DustVue 10 is properly mounted.

a. Click **Dashboard**.

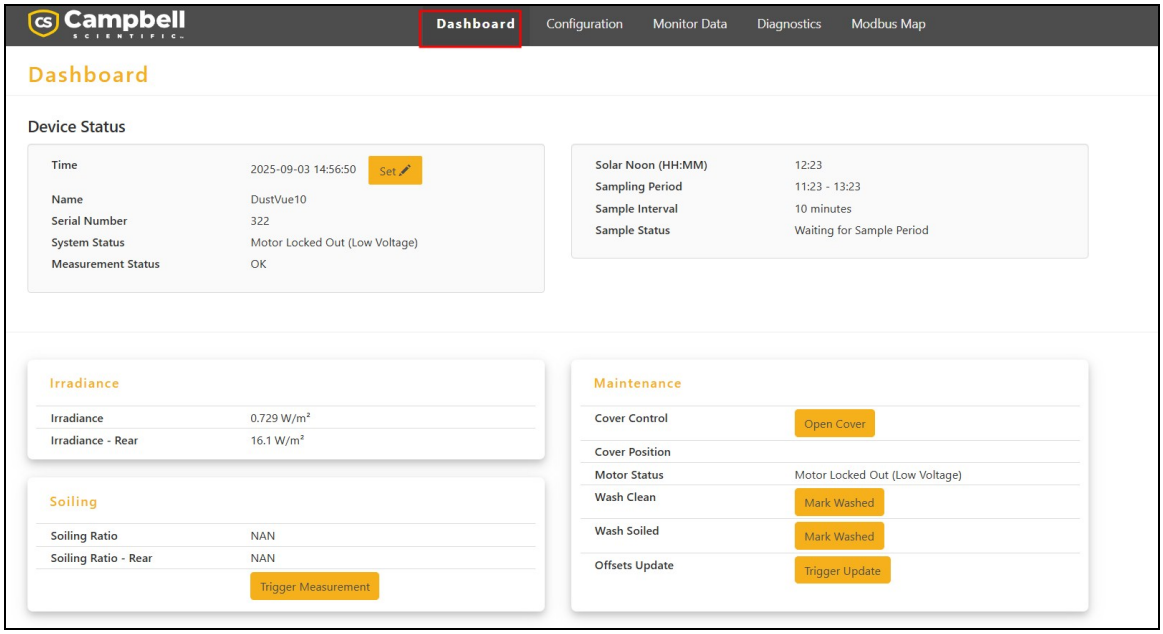


Figure 4-6. Dashboard tab displays current results and sensor status.

b. Set the time to local standard time by clicking **Set**. The clock can be synchronized with the computer clock or entered manually. It can also be set using Modbus register (see the registers 40103 to 40113 in Table 7-3 [p. 20]).

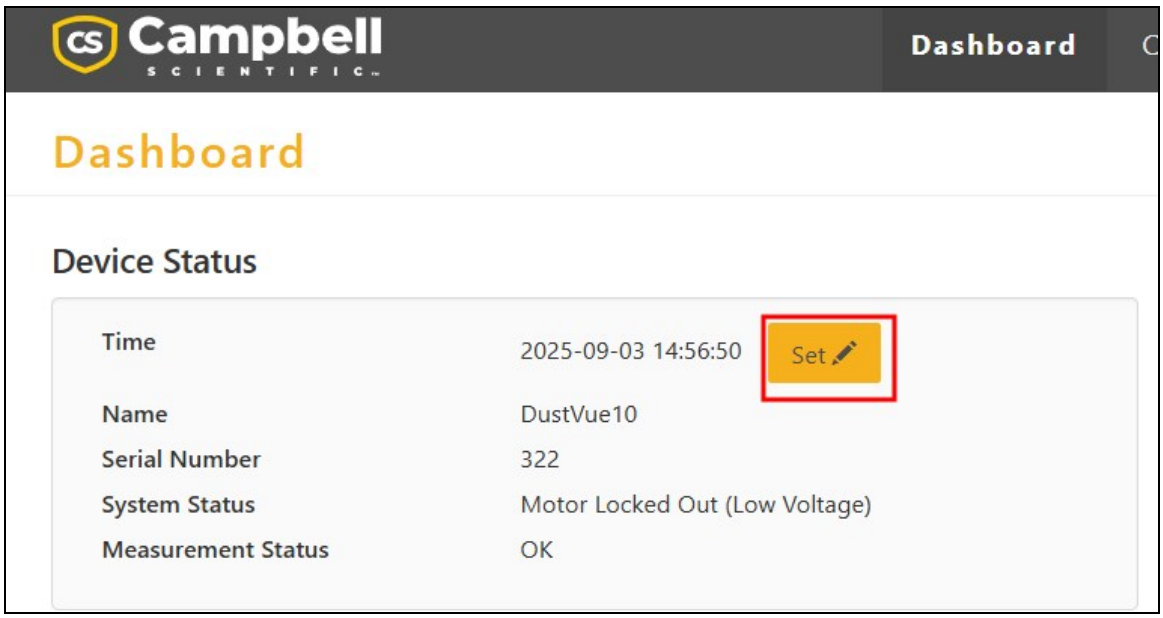


Figure 4-7. Set clock

c. Click **Open Cover** to expose the reference cells.

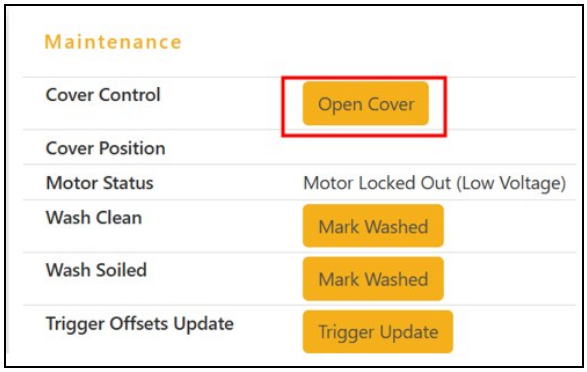


Figure 4-8. Cover control

d. Use an alcohol swab or a damp (clean water) soft lint free cloth to clean the front and rear reference cells.

e. Click the **Cover Control** button to close the cover. The cover also automatically closes after 5 minutes.

f. Click **Wash Clean** > **Mark Washed**. This will log the cleaning date and time in a Modbus register.

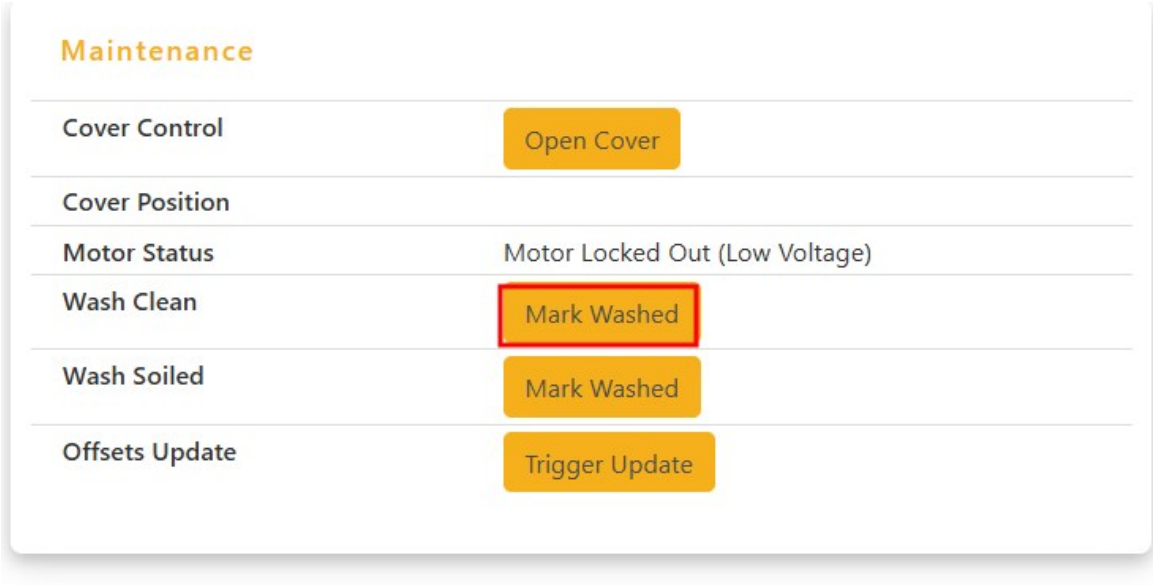


Figure 4-9. Wash Clean > Mark Washed button

g. Clean the front and rear soiled cells then click **Wash Soiled** > **Mark Washed**.

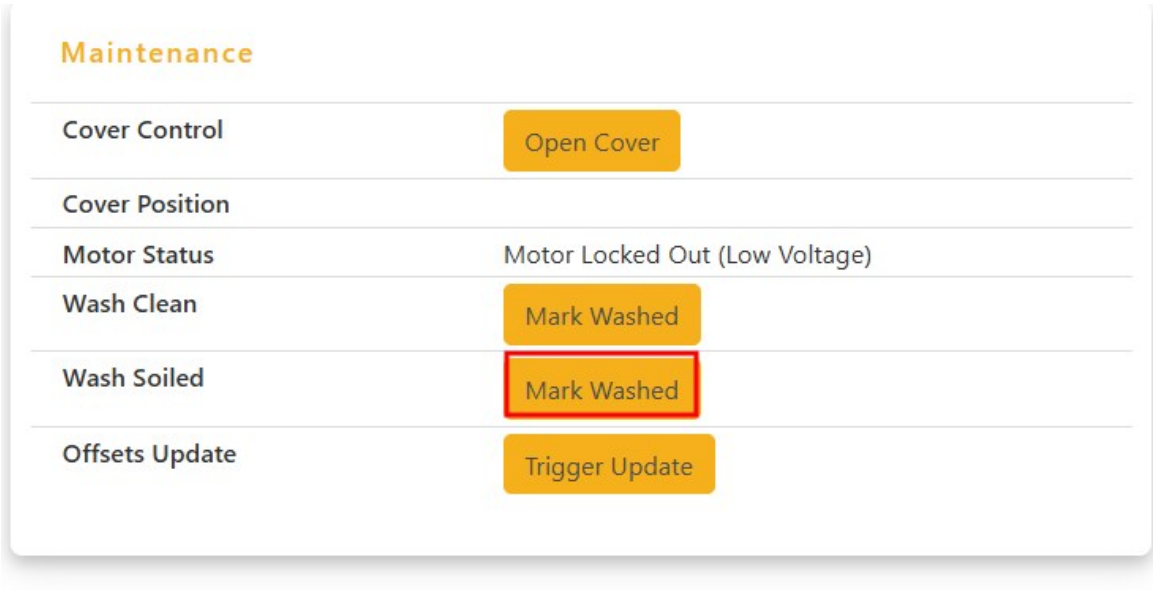


Figure 4-10. Wash Soiled > Mark Washed button

h. Click **Trigger Update** to calibrate the soiled cells against the clean reference cell (Figure 4-11 [p. 9]). This forces a soiling measurement irrespective of the sample period and current time. The measurement starts on top of the minute.

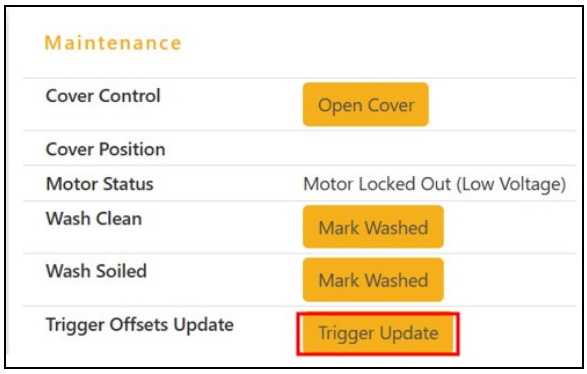


Figure 4-11. Maintenance section on Dashboard tab

The calibration will be performed within ±1 hour of solar noon if the threshold condition is met. If the offset update is triggered outside this time period, it will wait until the start of the period, which could be the next day. If the irradiance is below the

required threshold, it will continue to check for sufficient irradiance during the ±1 hour interval around solar noon. If this interval elapses without success, it will attempt to do the calibration the next day starting at one hour before solar noon.

The sensor will open the cover for approximately 2 minutes and measure the soiled and clean cells multiple times to calculate an average offset value between the cells. This self-calibration procedure is needed not more than four times a year.

i. Click **Trigger Measurement** under **Soiling** to force a soiling ratio measurement to verify the sensor operation. This forces a soiling measurement irrespective of the sample period and current time. The measurement starts on top of the minute.

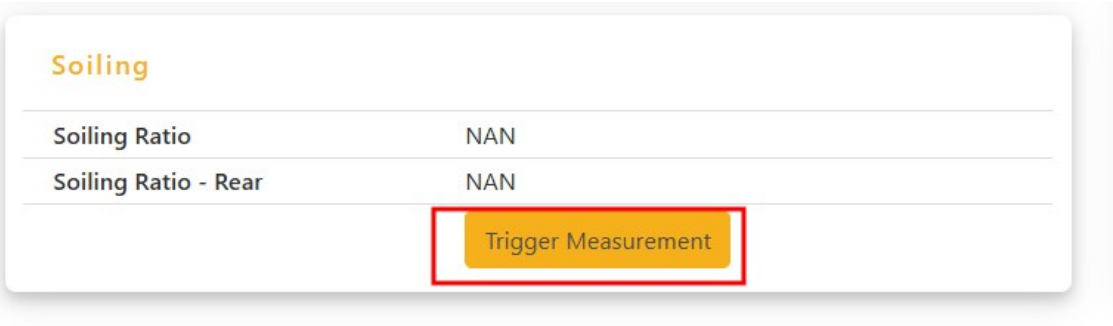


Figure 4-12. Soiling section on Dashboard tab

Once deployed, the sensor data will be collected over RS-485 bus using Modbus RTU. A sample ***CRBasic*** program can be found in Example program (p. 33).

5. You can view and download detailed data by clicking **Monitor Data**.
6. The **Diagnostics** tab (Figure 4-13 [p. 10]) shows RS-485 communications and updates sensor firmware (see Updating firmware [p. 28]).

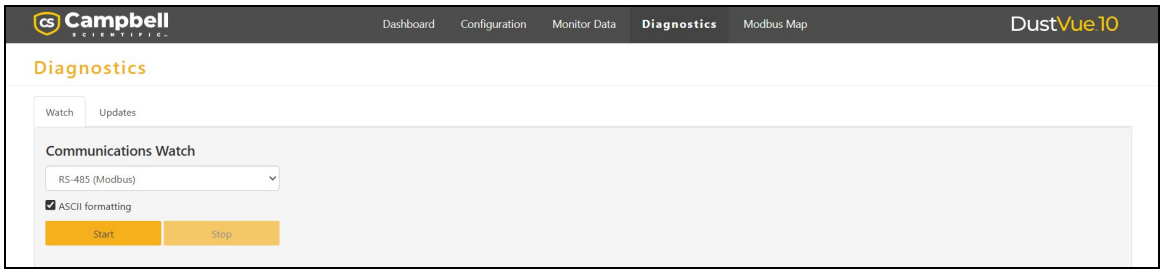
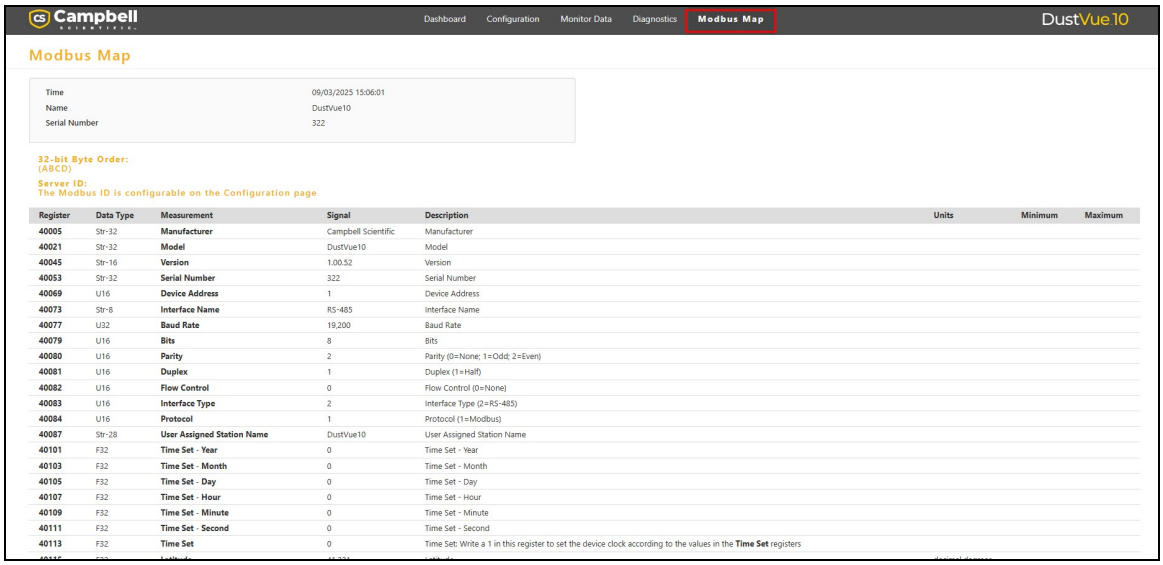


Figure 4-13. Diagnostics tab

7. The **Modbus Map** tab on the web UI displays the current Modbus map of the sensor and is updated with live values as the sensor operates. Accessing the Modbus map over the web UI is the most reliable way to ensure compatibility with the Modbus map on the sensor corresponding with the firmware version on the DustVue 10. An example Modbus map is provided in Modbus register map (p. 18).



Register	Data Type	Measurement	Signal	Description	Units	Minimum	Maximum
40005	Str-32	Manufacturer	Campbell Scientific	Manufacturer			
40021	Str-32	Model	DustVue10	Model			
40045	Str-16	Version	1.00.52	Version			
40053	Str-32	Serial Number	322	Serial Number			
40069	U16	Device Address	1	Device Address			
40073	Str-8	Interface Name	RS-485	Interface Name			
40077	U32	Baud Rate	19,200	Baud Rate			
40079	U16	Bits	8	Bits			
40080	U16	Parity	2	Parity (0=None; 1=Odd; 2=Even)			
40081	U16	Duplex	1	Duplex (1=Half)			
40082	U16	Flow Control	0	Flow Control (0=None)			
40083	U16	Interface Type	2	Interface Type (2=RS-485)			
40084	U16	Protocol	1	Protocol (1=Modbus)			
40087	Str-28	User Assigned Station Name	DustVue10	User Assigned Station Name			
40101	F32	Time Set - Year	0	Time Set - Year			
40103	F32	Time Set - Month	0	Time Set - Month			
40105	F32	Time Set - Day	0	Time Set - Day			
40107	F32	Time Set - Hour	0	Time Set - Hour			
40109	F32	Time Set - Minute	0	Time Set - Minute			
40111	F32	Time Set - Second	0	Time Set - Second			
40113	F32	Time Set	0	Time Set: Write a 1 in this register to set the device clock according to the values in the **Time Set** registers			

Figure 4-14. Modbus map

5. Overview

The DustVue 10 measures PV soiling loss by comparing outputs from two collocated PV reference devices. There are two PV reference cells kept in a dust-tight housing (Figure 4-1 [p. 2]): one facing up to measure incoming irradiance and the other facing down to measure the irradiance reflected from the ground (Clean Front and Clean Rear). Other PV reference cells are under the PV glass (Soiled Cells) facing both up and down. Cell temperatures of the cells are measured using thermistors. Cell irradiance values are calculated in accordance with IEC 60904-2. The soiled cells are measured every minute and if certain criteria are met, including the irradiance value exceeding the configured irradiance threshold (described in the QuickStart [p. 2]), then a stability check is performed by the sensor.

The cover on the clean cells is opened and irradiance is measured by both front and rear facing clean cells if the following conditions are met:

- The irradiance is stable
- The irradiance is higher than the set threshold
- The time is within the sampling interval around solar noon

A comparison of clean to soiled cell irradiance is used to calculate a soiling ratio.

The recommended measurement interval for the clean cells is expected to be ±2 hours of solar noon for sensors installed on a single axis tracker and ±1 hour for fixed tilt installations. A less frequent sample interval minimizes the exposure of clean cells to the environment, thereby reducing the chances of it getting soiled, resulting in a maintenance-free operation for an extended period.

The soiled cells are comprised of multiple cells that are measured individually. If a soiling event nonuniformly impacts a section of the sensor, the sensor calculates and reports a spatially averaged soiling ratio after removing outliers. By setting a bit in the **Bitwise Measurement Flags register** (40255), the sensor will flag uneven soiling (see Table 7-5 [p. 22]) so that the user can inspect the sensor on the next site visit and determine the cause of the uneven soiling (bird droppings).

The soiling ratio is a number between 1 to 0. In the absence of any soiling loss, the ratio will be 1 and a ratio of 0.8 would mean a soiling loss of 20%.

Power and activity LEDs are on the bottom side near the rear facing cells. When the sensor is powered, the **Power** LED will turn on according to the following power and sensor configuration states:

Table 5-1: Power LED

LED state	Description
Off	No power
1 flash every 10 seconds	Fully powered system, sensor configured
3 flashes every 10 seconds	Powered using USB, sensor configured
Always on	Powered but sensor not configured
Flashing red and blue	Firmware issue; contact Campbell Scientific

6. Specifications

Soiling ratio uncertainty (front):	±1%
Soiling ratio uncertainty (rear):	±5%
Input power:	12 to 32 VDC
Current draw	
Active:	0.5 A at 24 V, during active measurement
Idle:	~1 W
Communications:	Modbus RTU over RS-485
User configurable settings	
Serial port setting:	8 data bits, 1 stop bit, even parity
Baud rate:	19200
Modbus address:	1

7. Installation

Pre-Construction site Assessment: The DustVue 10 can be used for solar resource assessment campaigns as well as for operational performance monitoring purposes. For solar resource assessment applications, the DustVue 10 should be installed in an appropriate plane of array (POA) or horizontal position. Care should be taken so that it does not impact other measurements. The clean cell assembly should be oriented upwards if the sensor is mounted in a fixed tilt position.

Post-Construction: The DustVue 10 is a great addition to an operational performance monitoring station. If the site has single axis trackers, the DustVue 10 should be installed on the array torque tube close to other array-mounted weather monitoring stations. Campbell Scientific recommends that the sensor be sited within the array to measure a soiling loss representing the average losses over that region of the PV plant. This typically means that the DustVue 10 is positioned somewhere within the array. The clean cell assembly will align itself with the torque tube using the mounting hardware. When purchased as a part of entire weather monitoring station like SunSentry, the sensor can be daisy chained with other pyranometers and back-of-module temperature sensors using our surge protection coupler and should be the first

sensor in the chain. This configuration minimizes the voltage drop caused by longer cable lengths. The maximum recommended cable length is 50 m (150 feet) with 24 VDC input supply. The cable length in a daisy chain can easily surpass this limit.

Mounting to tracker torque tubes:

1. The following is the mounting bracket used to attach the DustVue 10 to a tracker torque tube.

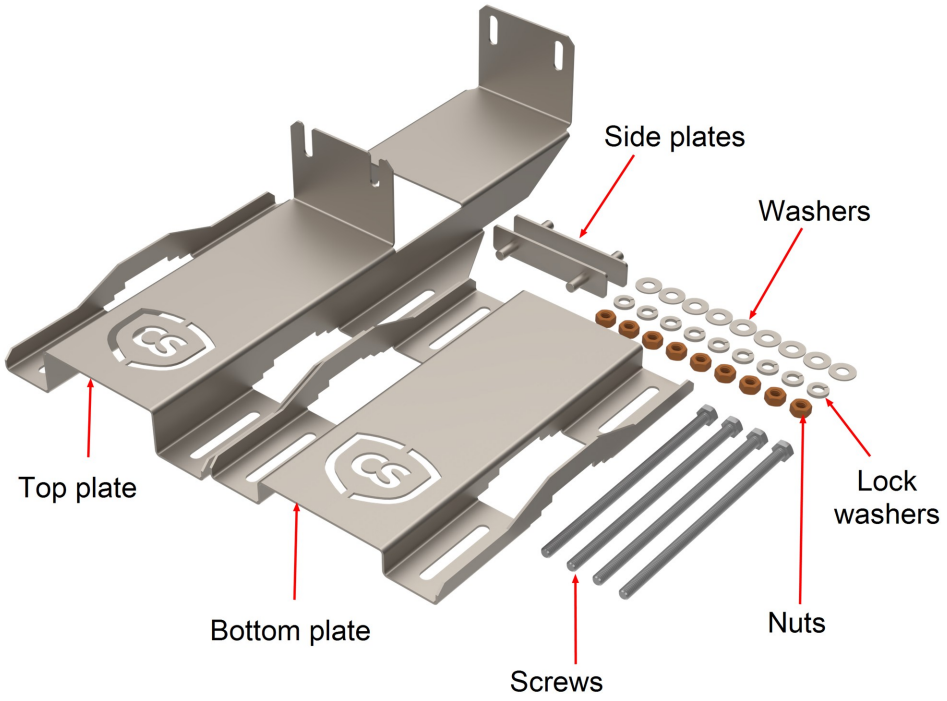


Figure 7-1. Tracker torque tube mounting bracket

2. Secure the bracket to the tracker torque tube by using the four screws, four nuts, eight washers, and eight lock washers (see Figure 7-1 [p. 14] and Figure 7-2 [p. 15]).

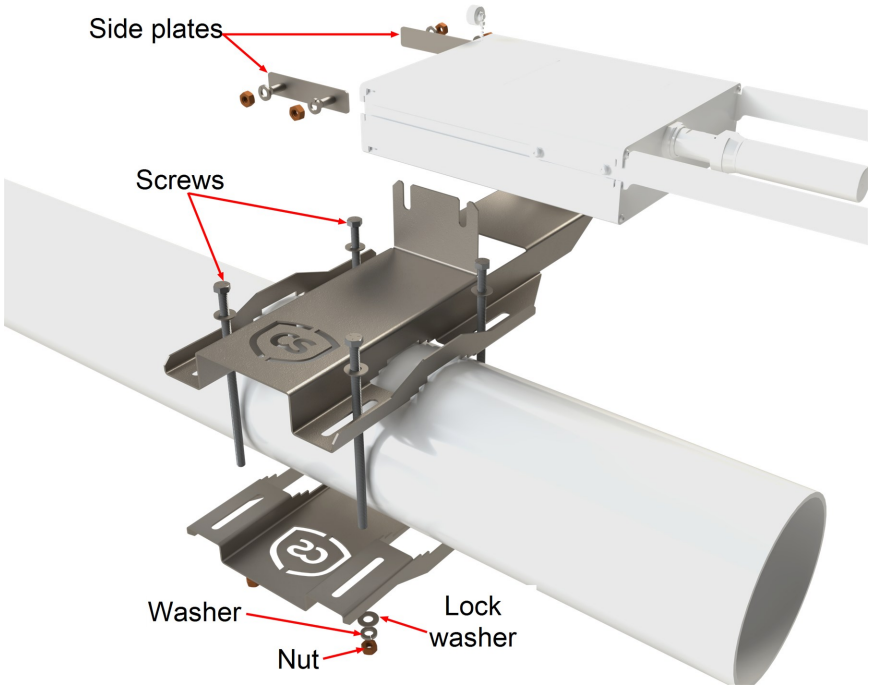


Figure 7-2. Exploded view of mounting bracket

3. Slide the side plates on the bracket (see Figure 7-2 [p. 15]).

4. Fasten the DustVue 10 to the bracket using the nuts and washers.

> **NOTE:**
> The sensor should be mounted so that the cells on the bottom have a clear view of the ground below.

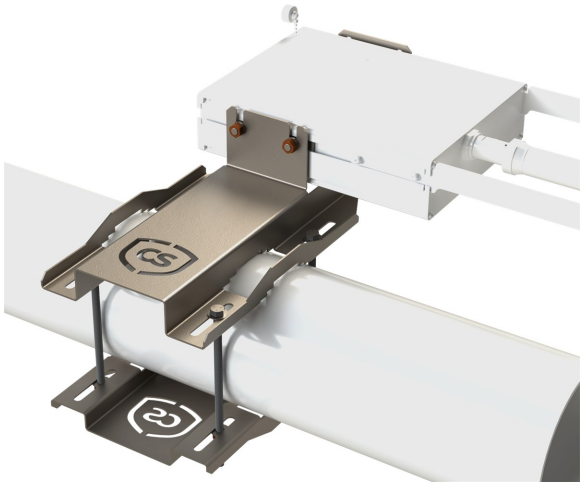


Figure 7-3. DustVue 10 mounted to crossarm

The DustVue 10 can also be mounted to a unistrut.

> **NOTE:**
> The sensor should be mounted so that the cells on the bottom have a clear view of the ground below.

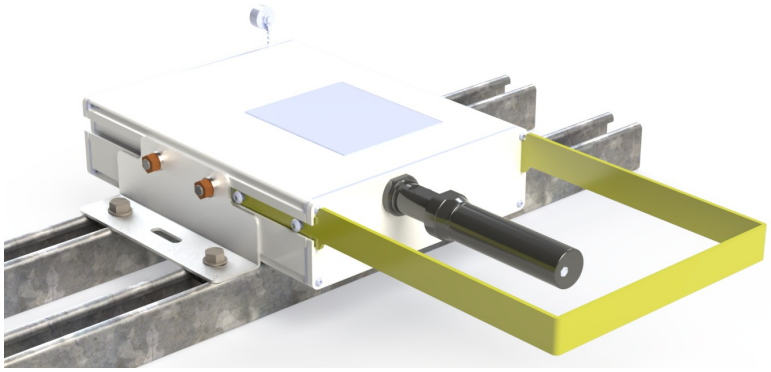


Figure 7-4. DustVue 10 mounted on a unistrut

7.1 Wiring

Table 7-1 (p. 17) shows data logger connections when using RS485CBL supplied by Campbell Scientific, Inc.

Table 7-1: Wire color, function, and data logger connection

Wire color	Pin	Wire function	Data logger connection[1]	Power supply connection
Red	1	Power		+
Black	4	Power ground		–
Green	5	RS-485 (A-)	C odd	
White	2	RS-485 (B+)	C even	
Clear		Shield	G	

[1]Assumes the sensor directly connects to the data logger.

7.2 Long cable lengths

If running on 12 V supply, the cable length should be limited to 12 m (40 ft). A 24 V supply is required to use the maximum recommended cable length of 50 m (150 ft). Up to 32 V supply can be used to extend the distance greater than 50 m, if needed.

> CAUTION:
> Longer cable lengths are prone to noise pickup, especially in the electrically noisy environment of a PV solar farm.

7.3 CRBasic programming

The RS-485 output can be directly read by a CR6-series, CR1000X-series, CR350-series, or Modbus RTU RS-485 network. Other Campbell Scientific data loggers can use an MD485 multidrop interface to read the RS-485 output.

A CR6, CR1000X-series, or CR350-series data logger programmed as a Modbus client can retrieve the values stored in the input registers (see Modbus register map [p. 18]). To do this, the CRBasic program requires the `SerialOpen()` instruction followed by `ModbusClient()` instruction.

NOTE:
ModbusClient() was formerly ModbusMaster(). Campbell Scientific, in conjunction with the Modbus Organization, is now using "client-server" to describe Modbus communications. The Modbus client(s) initiates communications and makes requests of server device(s). Server devices process requests and return an appropriate response (or error message). See https://modbus.org for more information. Existing programs that use the old Modbus terminology will still compile in the data logger.

The SerialOpen instruction has the following syntax:

```
SerialOpen (ComPort, Baud, Format, TXDelay, BufferSize, Mode)
```

The Format parameter is typically set to logic 1 low; even parity, one stop bit, 8 data bits. The Mode parameter should configure the ComPort as RS-485 half-duplex, transparent.

The ModbusClient() instruction has the following syntax:

```
ModbusClient (Result, ComPort, Baud, Addr, Function, Variable, Start, Length,
Tries, TimeOut, [ModbusOption])
```

The Addr parameter must match the sensor Modbus address.

See Example program (p. 33) for more information.

7.4 Modbus register map

Data Type: All measurement parameters are reported with data type of 32 bit Float. Some metadata have mixed formats (see the Modbus maps).

Server ID: The Modbus ID is configurable on the **Configuration** page.

Modbus Map is also available on the **Modbus** tab of the Web UI.

Table 7-2: Modbus register map

Register	Data type	Read/Write	Measurement	Signal	Description
40005	Str-32	R	Manufacturer	Campbell Scientific	Manufacturer
40021	Str-32	R	Model	DustVue10	Model
40045	Str-16	R	Version	1.00.52	Version
40053	Str-32	R	Serial Number	206	Serial Number
40069	U16	R	Device Address	12	Device Address (use Modbus ID setting register to change)
40073	Str-8	R	Interface Name	RS-485	Interface Name
40077	U32	R	Baud Rate	19,200	Baud Rate
40079	U16	R	Bits	8	Bits
40080	U16	R	Parity	2	Parity (0=None; 1=Odd; 2=Even)
40081	U16	R	Duplex	1	Duplex (1=Half)
40082	U16	R	Flow Control	0	Flow Control (0=None)
40083	U16	R	Interface Type	2	Interface Type (2=RS-485)
40084	U16	R	Protocol	1	Protocol (1=Modbus)
40087	Str-28	R	User Assigned Station Name	DustVue10	User Assigned Station Name

Table 7-3: Modbus settings registers						
Register	Data type	Read/Write	Measurement	Signal	Description	Units
40101	F32	R/W	Time Set - Year	0	Time Set - Year	
40103	F32	R/W	Time Set - Month	0	Time Set - Month	
40105	F32	R/W	Time Set - Day	0	Time Set - Day	
40107	F32	R/W	Time Set - Hour	0	Time Set - Hour	
40109	F32	R/W	Time Set - Minute	0	Time Set - Minute	
40111	F32	R/W	Time Set - Second	0	Time Set - Second	
40113	F32	R/W	Time Set	0	Time Set: Write a 1 in this register to set the device clock according to the values in the Time Set registers	
40115	F32	R/W	Latitude	45	Latitude	decimal degrees
40117	F32	R/W	Longitude	-111	Longitude	decimal degrees
40119	F32	R/W	Altitude	1,370	Altitude	m
40121	F32	R/W	UTC Offset	-7	UTC Offset	hrs
40123	F32	R/W	Irradiance Threshold	300	Irradiance Threshold	W/m^2
40125	F32	R/W	Modbus ID	12	Modbus ID	

Table 7-4: Modbus control registers					
Register	Data type	Read/Write	Measurement	Signal	Description
40201	F32	R/W	Control Reg - Prevent Open	0	User can set this register to 1 to prevent the cover from opening
40203	F32	R/W	Control Reg - Open Cover	0	1 = open the cover 0 = normal operation (cover stays open 5 min. max)
40205	F32	R/W	Control Reg - Wash Clean	0	User can set this register to 1 to trigger an update to the Last Wash Clean registers
40207	F32	R/W	Control Reg - Wash Soiled	0	User can set this register to 1 to trigger an update to the Last Wash Soiled registers
40209	F32	R/W	Control Reg - Update Offset	0	User can set this register to 1 to trigger an offsets update. This also triggers an update to the Last Offset Update registers
40249	F32	R/W	Control Reg - Reboot	0	User can write 57005 to this register to reboot the device

Table 7-5: Modbus system data registers								
Register	Data type	Read/ Write	Measurement	Signal	Description	Units	Min.	Max
40251	F32	R	Bitwise System Status Code	2	0 = Normal operation (Status OK) Convert the code from decimal to binary to see which bits are set. Bit 0: Motor error Bit 1: Motor lockout (low voltage) Bit 2: Backup battery voltage is low			
40253	F32	R	Bitwise Measurement Status Code	0	0 = Normal operation (nothing preventing sample) Convert the code from decimal to binary to see which bits are set Bit 0: Irradiance is below opening threshold Bit 1: Irradiance is not stable enough to open Bit 2: Open cover triggered by user (will not sample) Bit 3: Prevent open triggered by user (will not sample)			

Table 7-5: Modbus system data registers								
Register	Data type	Read/ Write	Measurement	Signal	Description	Units	Min.	Max
40255	F32	R	Bitwise Measurement Flags	0	0 = Normal operation (Measurement OK) Convert the code from decimal to binary to see which bits are set. Bit 0: Soiling ratio measurement is outside normal range Bit 1: Soiling ratio rear measurement is outside normal range Bit 2: Uneven soiling detected on soiled panel			
40257	F32	R	Time - Year	2,025	Current Device Time - Year			
40259	F32	R	Time - Month	9	Current Device Time - Month			
40261	F32	R	Time - Day	5	Current Device Time - Day			
40263	F32	R	Time - Hour	11	Current Device Time - Hour			
40265	F32	R	Time - Minute	59	Current Device Time - Minute			
40267	F32	R	Time - Second	19	Current Device Time - Second			
40269	F32	R	Solar Noon - Hour	12	Calculated solar noon - Hour	hr	0	23
40271	F32	R	Solar Noon - Minute	22	Calculated solar noon - Minute	min	0	60

Table 7-5: Modbus system data registers

Register	Data type	Read/ Write	Measurement	Signal	Description	Units	Min.	Max
40273	F32	R	Sampling Period Status	1	1 = Sampling Period is open; 0 = Sampling Period is closed		0	1
40275	F32	R	Irradiance	0	Irradiance	W/m^2		
40277	F32	R	Irradiance - Rear	0	Irradiance of rear-facing cell	W/m^2		
40279	F32	R	Soiling Ratio Sample Count	0	This register increments throughout the day every time a soiling ratio sample is taken			
40281	F32	R	Cover Seal Heater Status	0	1 = Heater On 0 = Heater Off		0	1
40283	F32	R	Internal RH	0	Internal Relative Humidity	%	0	100
40285	F32	R	Temp - Clean Reference	0	Temperature of the clean reference	°C		
40287	F32	R	Temp - Soiled	0	Temperature of the soiled panel	°C		
40289	F32	R	Temp - Rear Soiled	0	Temperature of the rear soiled panel	°C		

Table 7-6: Modbus timestamps registers

Register	Data type	Read/ Write	Measurement	Signal	Description	Units	Min.	Max
40301	F32	R	Last Soiling Ratio - Year	0	Time of last soiling ratio calculation - Year	year		
40303	F32	R	Last Soiling Ratio - Month	0	Time of last soiling ratio calculation - Month	month		
40305	F32	R	Last Soiling Ratio - Day	0	Time of last soiling ratio calculation - Day	day		
40307	F32	R	Last Soiling Ratio - Hour	0	Time of last soiling ratio calculation - Hour	hr		
40309	F32	R	Last Soiling Ratio - Minute	0	Time of last soiling ratio calculation - Minute	min		
40311	F32	R	Last Wash Clean - Year		Date of last clean cell wash - Year	year		
40313	F32	R	Last Wash Clean - Month		Date of last clean cell wash - Month	month	1	12
40315	F32	R	Last Wash Clean - Day		Date of last clean cell wash - Day	day	1	31
40317	F32	R	Last Wash Soiled - Year		Date of last soiled cell wash - Year	year		
40319	F32	R	Last Wash Soiled - Month		Date of last soiled cell wash - Month	month	1	12
40321	F32	R	Last Wash Soiled - Day		Date of last soiled cell wash - Day	day	1	31
40323	F32	R	Last Offset Update - Year	0	Date of last offset update - Year	year		

Table 7-6: Modbus timestamps registers

Register	Data type	Read/ Write	Measurement	Signal	Description	Units	Min.	Max
40325	F32	R	Last Offset Update - Month	0	Date of last offset update - Month	month	1	12
40327	F32	R	Last Offset Update - Day	0	Date of last offset update - Day	day	1	31

Table 7-7: Modbus soiling data registers

Register	Data type	Read/ Write	Measurement	Signal	Description	Units	Min.	Max
40351	F32	R	Last Soiling Ratio	0	Last soiling ratio	ratio	0	1
40353	F32	R	Last Soiling Ratio - Rear	0	The value in this register is the most recent soiling ratio measurement taken by the device. This value is available to be read, but Campbell Scientific recommends using the Daily Soiling Ratio, which is an average of all the measurements taken throughout the day.	ratio	0	1

Table 7-7: Modbus soiling data registers

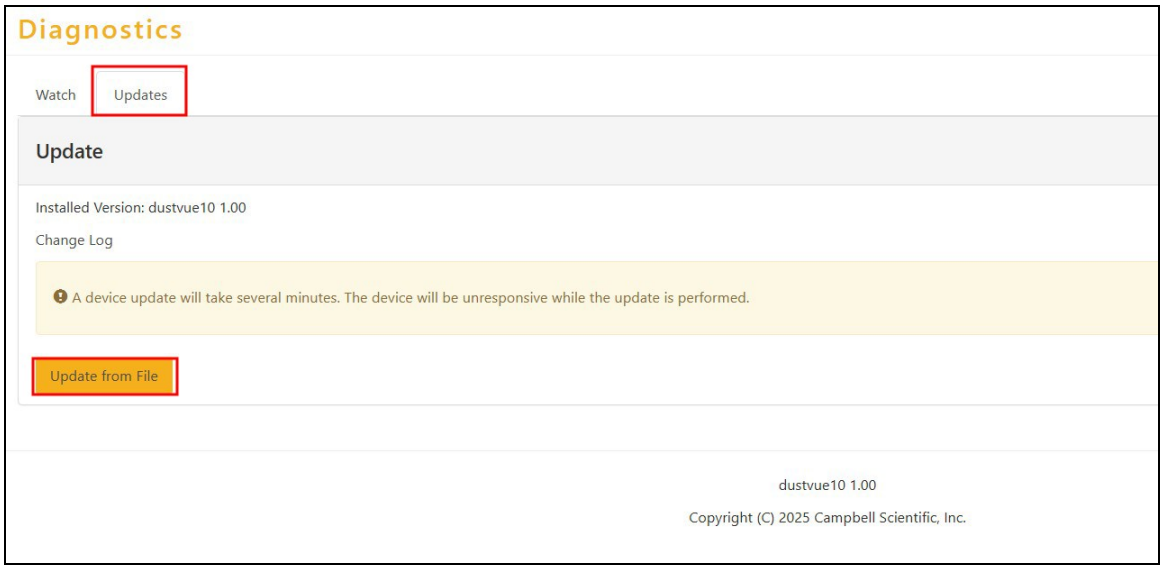
Register	Data type	Read/ Write	Measurement	Signal	Description	Units	Min.	Max
40355	F32	R	Daily Soiling Ratio	0	The value in this register is an average of all the soiling ratio measurements taken throughout the previous day (or previous sampling period). If there were no measurements taken on the previous day, this register will show NAN.	ratio	0	1
40357	F32	R	Daily Soiling Ratio - Rear	0	Daily rear-facing soiling ratio average	ratio	0	1
40359	F32	R	Daily Soiling Ratio Num Samples	0	Number of samples used to calculate the daily soiling ratio		0	

8. Maintenance and troubleshooting

8.1 Updating firmware

CAUTION:
Updating the firmware may result in loss of historic data and settings from the sensor.

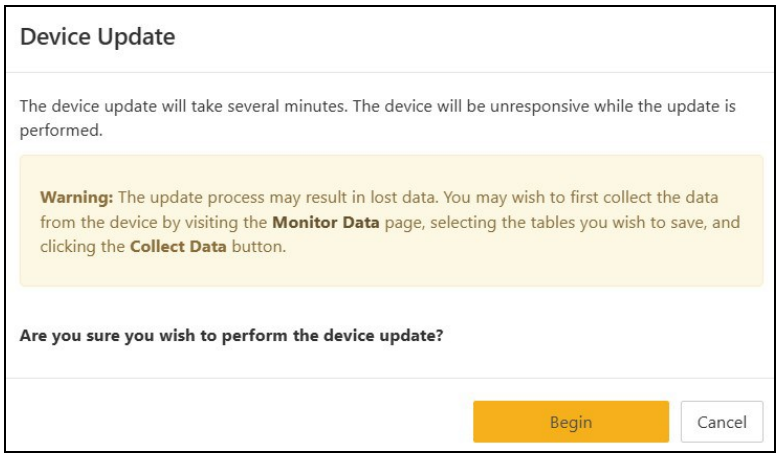
1. Find the DustVue 10 operating system at www.campbellsci.com/downloads, click **Download Now**, and click **Save File**. This will download a .web.obj.gz file on your computer.
2. Use a USB C cable to connect the DustVue 10 USB port to a computer USB port.
3. Access the web UI (see QuickStart [p. 2]).
4. Click the **Diagnostics** tab.
5. Click **Updates**.



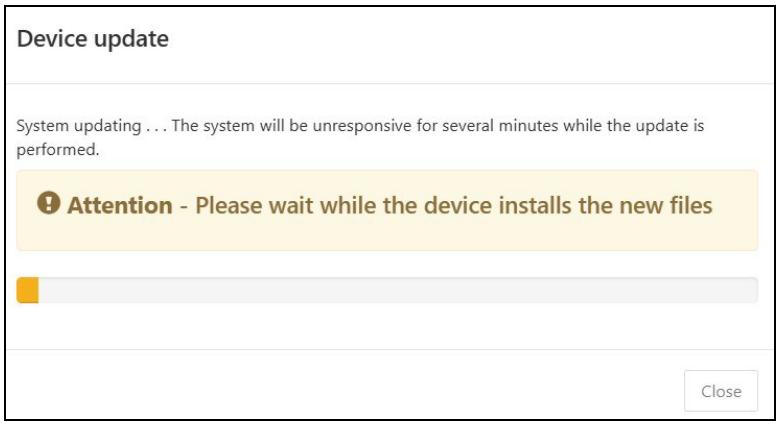
6. Click **Update from File**.
7. Select the file. The file will end in a .web.obj.gz extension (for example, dustvue10_1.00.web.obj.gz)

8. Click **Begin**. The operating system will start downloading.

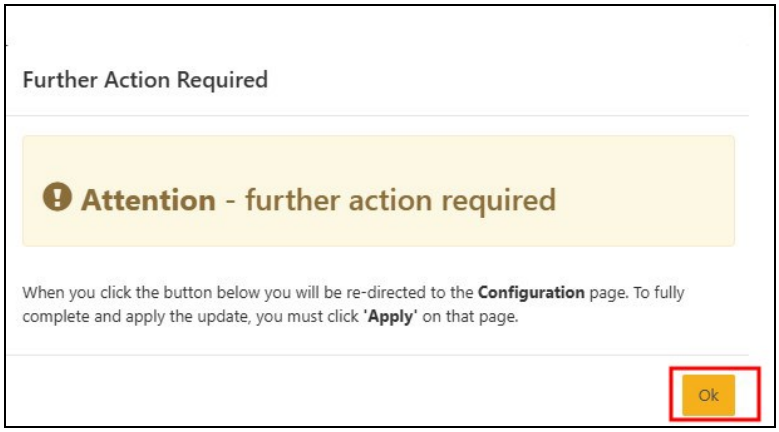
> **CAUTION:**
> Do not remove power or disconnect the device during the operating system download.



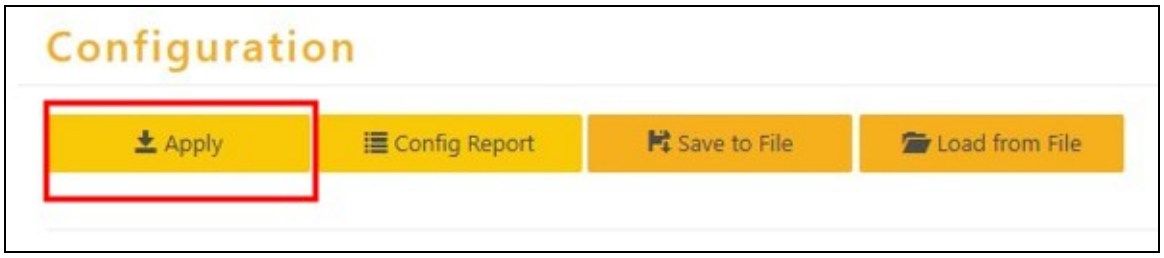
9. The device will take a few minutes to update its files. Wait until the device finishes completely before navigating away from this page.



10. Click **Ok** to navigate to the **Configuration** page.



11. On the **Configuration** page, click **Apply** to finish and complete the update.



12. Remove the USB cable.

8.2 Downloading data tables

The DustVue 10 is a Modbus RTU on RS-485. It can connect directly to a SCADA system or integrated with any device capable of reading Modbus on RS-485, such as Campbell Scientific data loggers. A list of our compatible data loggers is available on the product web page.

The DustVue 10 can also store a local copy of historic data that can be downloaded using the web UI if needed.

8.3 Calibration and recalibration

The DustVue 10 provides a soiling ratio, which is a relative measurement between collocated sensors. As such, it does not require radiometric calibration of the sensors. A relative calibration between clean and soiled cells is all that is needed, and it should be performed in the field after installation.

8.4 Maintenance

The sensor makes a determination of soiling ratio by comparing outputs from two collocated PV reference cells. To get a good representative measurement, periodically check the reference cells and clean them when needed. Typically, the cleaning schedule can be every 6 to 12 months. However, Campbell Scientific suggests cleaning both the soiled and reference cells whenever the solar plant is cleaned. This resets the soiling ratio.

The DustVue 10 has a clock that should be set on every site visit or at least once every six months. The **Dashboard** page displays the current time and the clock can be set on this page. The clock can also be set using Modbus. It is a good practice to program the SCADA system to set the clock at a fixed interval.

8.5 Troubleshooting

The following is a list of some common problems and their suggested solutions.

Table 8-1: Problems and suggested solutions

Problems	Suggested solutions
No measurement shown on **Dashboard**	• Check for the configuration for all location and timing settings • Ensure that sensor clock displaying correct time
Some of the **Device Status** fields are empty.	Navigate to the **Configuration** page, verify the settings, and click **Apply to Station**.

Table 8-1: Problems and suggested solutions	
Problems	**Suggested solutions**
NAN (not a number) reported for the **Soiling Ratio**	• NAN are reported before a soiling ratio measurement has been taken after initial setup. • Check the **Sampling Period**, **Sample Interval** and **Sample Status** to see when the next sample is expected to be taken. Make any adjustments to the **Sample Period** or **Interval** via the **Configuration** page. • Try manually triggering a soiling ratio measurement by clicking **Trigger Soiling Ratio**. At the top of the next minute, a soiling ratio measurement should begin. The cover will open, a measurement will be taken, the cover will close, and the soiling ratio values should update. • If the above steps do not work, check the cover for problems. Check the **Motor Status** value. Try clicking **Open Cover**. The cover should open and the Motor Status should say **OK**. Close the cover by clicking the button again. If the cover will not open and close without error, maintenance is required.
Missing or unexpected information is displayed on the **Dashboard**, **Monitor Data**, or **Diagnostics** page	• Your browser may be loading some old files from cache which could be causing problems. Try forcing the browser to retrieve a fresh copy of the page thus ignoring cached content. The method for doing this varies across browsers but is typically performed by holding **Shift** or **Ctrl** while clicking the refresh button. Another common way is by pressing **Shift**+**F5**, or **Ctrl**+**F5**. • Or you can try clearing your browsers history and cache.

Appendix A. Example program

CRBasic Example 1: CR1000X-series program that measures the DustVue 10

```
'CR1000X Series Datalogger
' ____________________________________________________
' | Title: DustVue Example Program (CR1000Xe) |
' | Notes: Use this program as a template to create your |
' | program to read and write to the registers on |
' | your new DustVue 10 Sensor. |
' |____________________________________________________|
' Wiring Diagram
'
'Color | Function
'-------|--------
' Brown | Power +
' Black | Power -
' Blue | RS485 - Common
' Gray | C1*
' White | C2*
'
' (*) = As Configured In Data logger Program)

' Public Vars
' --------------------------------------------------------
Public DailySoilingRatio(3)
Public StatusCode
Public MBRes(4)
Public OpenCover
Public Position As String
Public Status As String * 85
' --------------------------------------------------------

' Private Vars
' --------------------------------------------------------
Dim CurrPosition
Dim Bits(3)
' --------------------------------------------------------

'Aliases
' --------------------------------------------------------
Alias DailySoilingRatio(1)=DailySR
Alias DailySoilingRatio(2)=DailySR_R
Alias DailySoilingRatio(3)=DailySR_Samples
Alias MBRes(1) = DailySoiling_MB_Res
```

CRBasic Example 1: CR1000X-series program that measures the DustVue 10

```
Alias MBRes(2) = StatusCode_MB_Res
Alias MBRes(3) = Position_MB_Res
Alias MBRes(4) = WriteMotorReg_MB_Res
' --------------------------------------------------------

'Tables
' --------------------------------------------------------
' Const table to allow user to edit settings
ConstTable(UserVars,0)
  Const BaudRate = 19200
  Const Format = 2
  Const TXDelay = 0
  Const BufferSize = 0
EndConstTable

' Daily Soiling Information
DataTable(DailySoilingData,1,-1)
  DataInterval(0,1,Min,10)
  Sample(1,DailySR,IEEE4)
  Sample(1,DailySR_R,IEEE4)
  Sample(1,DailySR_Samples,IEEE4)
EndTable

' System Status Information
DataTable(SystemStatus,1,01)
  DataInterval(0,1,Sec,10)
  Sample(1,StatusCode,Long)
  Sample(1,Status,String)
EndTable
' --------------------------------------------------------

' Functions
' --------------------------------------------------------
Function DecodeStat(number)
  If number = NAN Then
    Status = "Error: No status recieved from DV Unit. Check Communication"
  ElseIf number = 0 Then
    Status = "OK"
  Else
    ' Compile status string
    Status = "ERROR: "
    If((number AND Bits(1)) > 0) Then Status += "Motor Error, "
    If((number AND Bits(2)) > 0) Then Status += "Motor lockout (low voltage), "
    If((number AND Bits(3)) > 0) Then Status += "Backup battery voltage is low, "

    ' Trim off last comma/space
    Status = Left(Status, Len(Status)-2)
```

CRBasic Example 1: CR1000X-series program that measures the DustVue 10

```
  EndIf
EndFunction
' -----------------------------------------------------

'Main Program
BeginProg
  ' Set values for bitwise comparison
  Bits(1) = 1
  Bits(2) = 2
  Bits(3) = 4

  ' Open ComC1 for Modbus Communications
  SerialOpen (ComC1,BaudRate,Format,TXDelay,BufferSize,4)

  Scan (1,Sec,0,0)
    ' get daily soiling ratio data
    ModbusClient(MBRes(1),ComC1,BaudRate,1,4,DailySoilingRatio,355,3,3,300,2)

    ' get the status code
    ModbusClient(MBRes(2),ComC1,BaudRate,1,4,StatusCode,251,1,3,30,2)

    ' Read from the DustVue to see what the current position of the cover is
    ModbusClient(MBRes(3),ComC1,BaudRate,1,4,CurrPosition,203,1,3,300,2)

    ' Decode the position attained from the logger into a string open/closed
    If CurrPosition = 0 Then
      Position = "Closed"
    Else
      Position = "Open"
    EndIf

  ' if open cover is not 0 then send the command write to register 154 to open it
  ' if it is already opened and it is equal to 0 close the cover
  If OpenCover <> 0 Then

    ' We need to use option 16 (write multiple registers) becuase this value
    ' is a 32 bit float meaning it takes up 2 registers
    ModbusClient(MBRes(4),ComC1,BaudRate,1,16,OpenCover,203,1,3,300,2)
  Else
    ModbusClient(MBRes(4),ComC1,BaudRate,1,16,0,203,1,3,300,2)
  EndIf

    ' Decode the bitwise status code returned via Modbus
    DecodeStat(StatusCode)

    ' Populate tables
    CallTable(DailySoilingData)
```

CRBasic Example 1: CR1000X-series program that measures the DustVue 10

```
    CallTable(SystemStatus)
  NextScan
EndProg
```

Limited warranty

Covered equipment is warranted/guaranteed against defects in materials and workmanship under normal use and service for the period listed on your sales invoice or the product order information web page. The covered period begins on the date of shipment unless otherwise specified. For a repair to be covered under warranty, the following criteria must be met:

1. There must be a defect in materials or workmanship that affects form, fit, or function of the device.

2. The defect cannot be the result of misuse.

3. The defect must have occurred within a specified period of time; and

4. The determination must be made by a qualified technician at a Campbell Scientific Service Center/ repair facility.

The following is not covered:

1. Equipment which has been modified or altered in any way without the written permission of Campbell Scientific.

2. Batteries; and

3. Any equipment which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact to determine which Campbell Scientific office serves your country. For directions on how to return equipment, see Assistance.

Other manufacturer's products, that are resold by Campbell Scientific, are warranted only to the limits extended by the original manufacturer.

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MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Campbell Scientific hereby disclaims, to the fullest extent allowed by applicable law, any and all warranties and conditions with respect to the products, whether express, implied, or statutory, other than those expressly provided herein.

Campbell Scientific will, as a default, return warranted equipment by surface carrier prepaid. However, the method of return shipment is at Campbell Scientific's sole discretion. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This warranty and the Company's obligation thereunder is in lieu of all other

warranties, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

In the event of any conflict or inconsistency between the provisions of this Warranty and the provisions of Campbell Scientific's Terms, the provisions of Campbell Scientific's Terms shall prevail. Furthermore, Campbell Scientific's Terms are hereby incorporated by reference into this Warranty. To view Terms and conditions that apply to Campbell Scientific, Logan, UT, USA, see Terms and Conditions. To view terms and conditions that apply to Campbell Scientific offices outside of the United States, contact the regional office that serves your country.

Assistance

Products may not be returned without prior authorization. Please inform us before returning equipment and obtain a **return material authorization (RMA) number** whether the repair is under warranty/guarantee or not. See Limited warranty for information on covered equipment.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact to determine which Campbell Scientific office serves your country.

When returning equipment, a RMA number must be clearly marked on the outside of the package. Please state the faults as clearly as possible. 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, when equipment is returned to Campbell Scientific, Logan, UT, USA, it is mandatory that a "Declaration of Hazardous Material and Decontamination" form be received before the return can be processed. If the form is not received within 5 working days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. For details on decontamination standards specific to your country, please reach out to your regional Campbell Scientific office.

> NOTE:
> All goods that cross trade boundaries may be subject to some form of fee (customs clearance, duties or import tax). Also, some regional offices require a purchase order upfront if a product is out of the warranty period. Please contact your regional Campbell Scientific office for details.

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.

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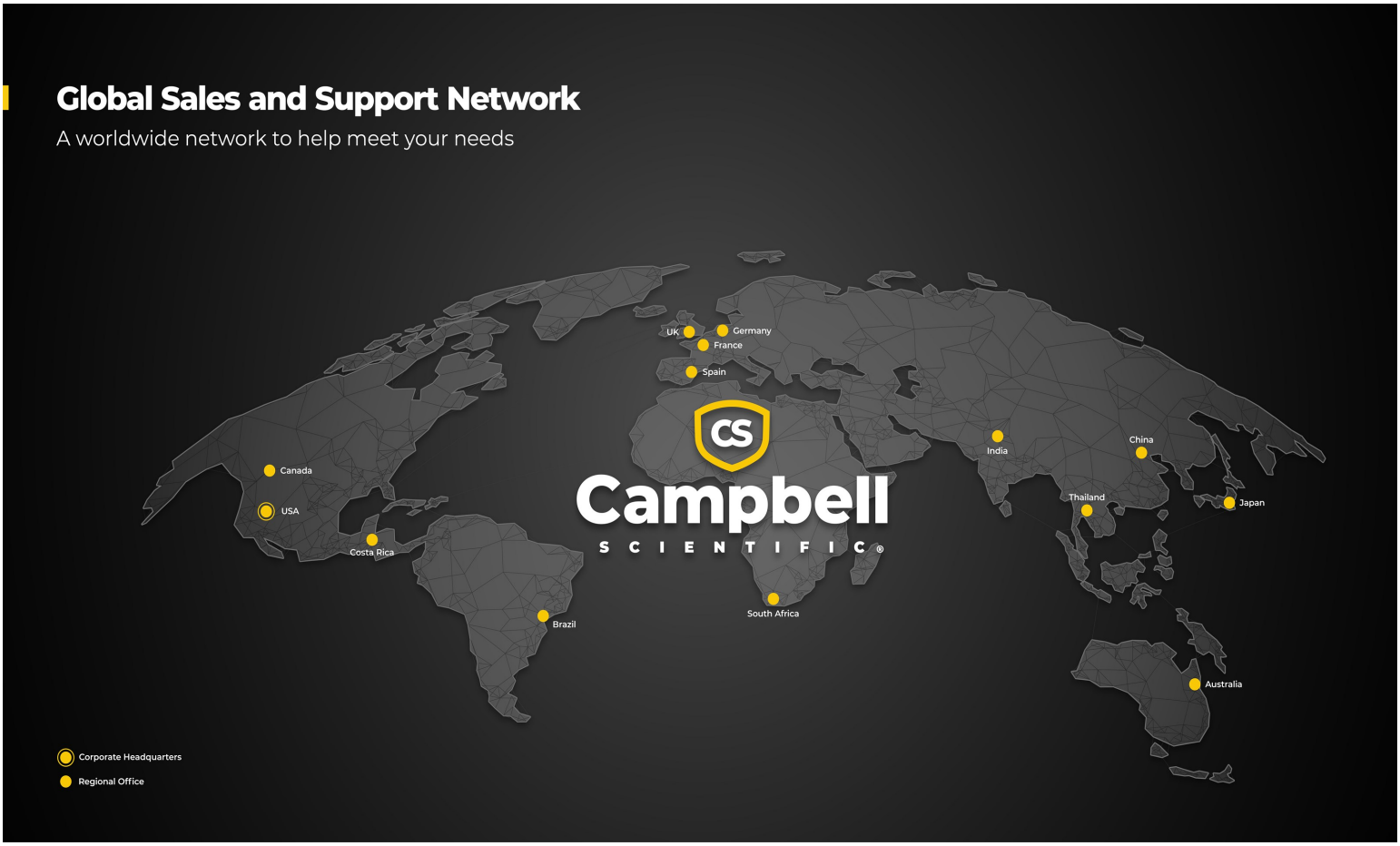

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