User Manual:

SolarSIM-E

Automated Shadowband

User information

Spectrafy strongly recommends reading this instruction manual prior to installation and operation of your SolarSIM-E.

If you have any comments about this manual or our products, please send them to:

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Spectrafy reserves the right to make changes to this user manual without prior notice.

Warranty and liability

Spectrafy guarantees that the SolarSIM-E has been thoroughly tested to ensure that it meets all of the stated specifications. A one year warranty is provided from date of invoice, subject to correct installation and operation. Spectrafy accepts no liability for any loss or damages arising from improper usage of this product.

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Introduction

Dear customer, thank you for purchasing the SolarSIM-E automated shadowband. Please become familiar with this instruction manual for a full understanding of your device.

The SolarSIM-E automated shadowband leverages Spectrafy's patented spectral sensors, a SolarSIM-E, to produce highly accurate measurements of global, direct and diffuse irradiance from a single, ISO 9060 Class A sensor. In addition, the ability to resolve both broadband and spectral irradiance yields unmatched insights for both research and solar resource assessment applications.

A compelling alternative to more expensive, solar tracker based solutions and more accurate than traditional silicon based shadowbands, the SolarSIM-E is fully automated and maintenance free. The SolarSIM-E takes shadowband measurements to a new level accuracy.

By combining the precision of an ISO 9060 Class A pyranometer, the fast response of photodiode measurements, and the insight of spectral correction, the SolarSIM-E provides an unmatched solution for quantifying the solar resource.

If you have any questions, please feel free to contact us or e-mail at `info@spectrafy.com`

1 Main components

Main components of the SolarSIM-E are shown in Figure 1, which include

- a shadowband controller,
- a shadowband,
- a shadowband hard stop
- a SolarSIM-G,
- three connectors,
- a mounting plate,
- a bubble level, and
- levelling feet.

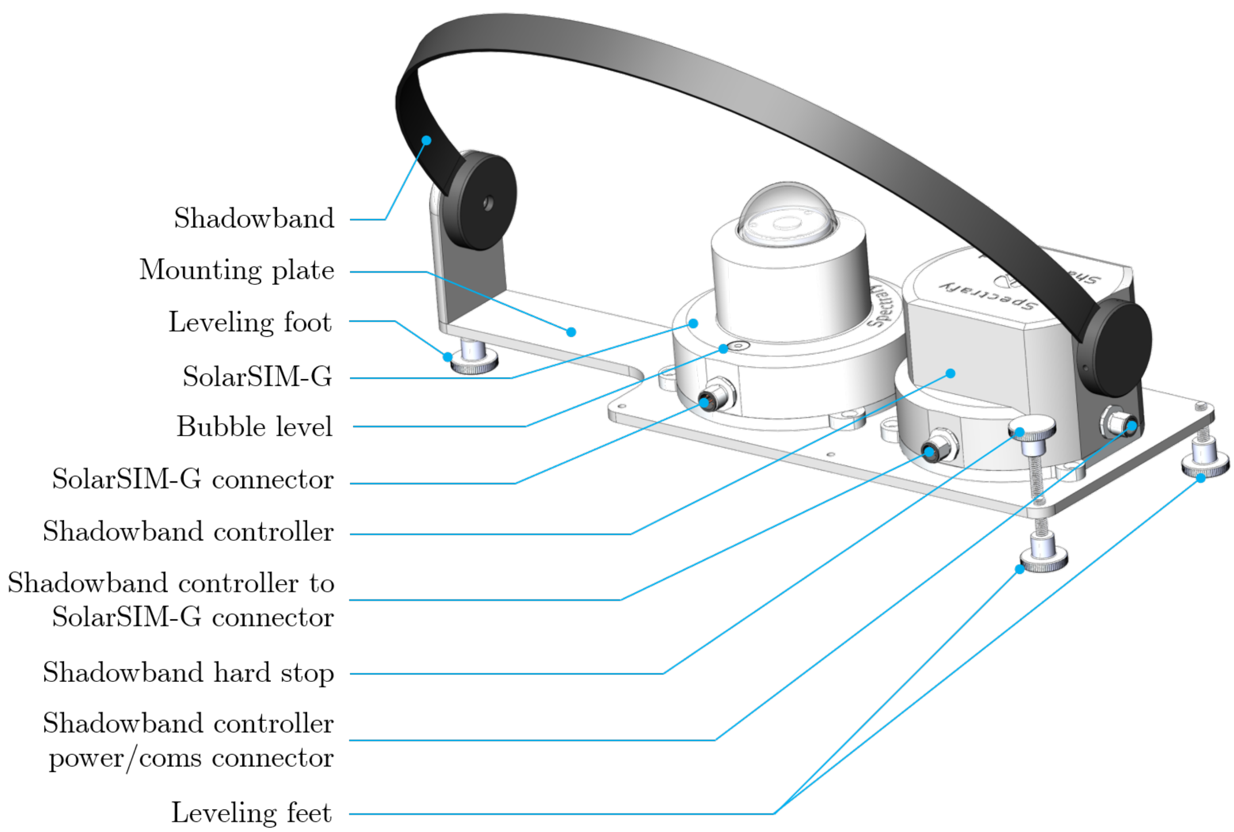

Figure 1: Main components of the SolarSIM-E.

1.1 Shadowband controller

The shadowband controller houses the circuit board and the stepper motor. It scans the sky by incrementally rotating a shadowband to determine the sun's position. It then performs the shaded (diffuse) and unshaded (global) measurements with the aid of the SolarSIM-G. The raw data from the SolarSIM-G is passed to a server PC for processing.

1.2 Shadowband

the black-powder coated aluminum shadowband blocks the sun to allow the SolarSIM-G to perform diffuse horizontal measurements.

1.3 Shadowband hard stop

Nine bandpass filters transmit a narrow band of spectral irradiance to the detectors.

1.4 SolarSIM-G

The bubble level ensures the SolarSIM-E is leveled when measuring the irradiance in global horizontal orientation.

1.5 Bubble level

The bubble level ensures the SolarSIM-E is levelled when measuring the irradiance in global horizontal orientation.

1.6 Mounting plate

The anodized aluminum backplate seals the back of the enclosure with four screws.

1.7 Levelling feet

The anodized aluminum backplate seals the back of the enclosure with four screws.

1.8 Connectors

The anodized aluminum backplate seals the back of the enclosure with four screws.

2 Installation

2.1 Contents of delivery

Per each ordered SolarSIM-E the received package should contain:

- a SolarSIM-E ×1,
- a communication cable ×1,
- a SolarSIM-E Communication Box ×1 (optional),
- a mounting plate ×1 (optional),
- mounting screws ×3,
- mounting springs ×3, and
- a USB key loaded with the SolarSIM-E software.

Please check the contents of the package and note if any damages have occurred during shipment. A claim should be filed with the shipment carrier should this be the case. Additionally, please contact a Spectrafy representative to facilitate the repair or replacement of the instrument and/or its accessories.

2.2 Mechanical installation

The SolarSIM-E installation requires fastening it to the mounting plate via three M4 screws and springs, as demonstrated in Figure **??**. The mounting plate is 7.3 mm thick and has three slots with a 132 mm diameter that are 4.5 mm wide for external fastening, as shown in Figure 2. The screws for external mounting are not provided. The procedure for mechanical installation is described as follows:

1. Place the SolarSIM-E on the mounting plate as per Figure 2.
2. Place the spring under the SolarSIM-E so that it roughly aligns with one of the mounting holes on the SolarSIM-E.
3. Insert the mounting screw through the SolarSIM-E's mounting hole and the spring. Then thread the screw into the mounting plate for a few revolutions, only.
4. Repeat steps 2 and 3 for the remaining two screws and springs.
5. Tighten all screws to compress the springs by about 10 mm.
6. Adjust the mounting screws until the bubble level is centered with the bulls eye.

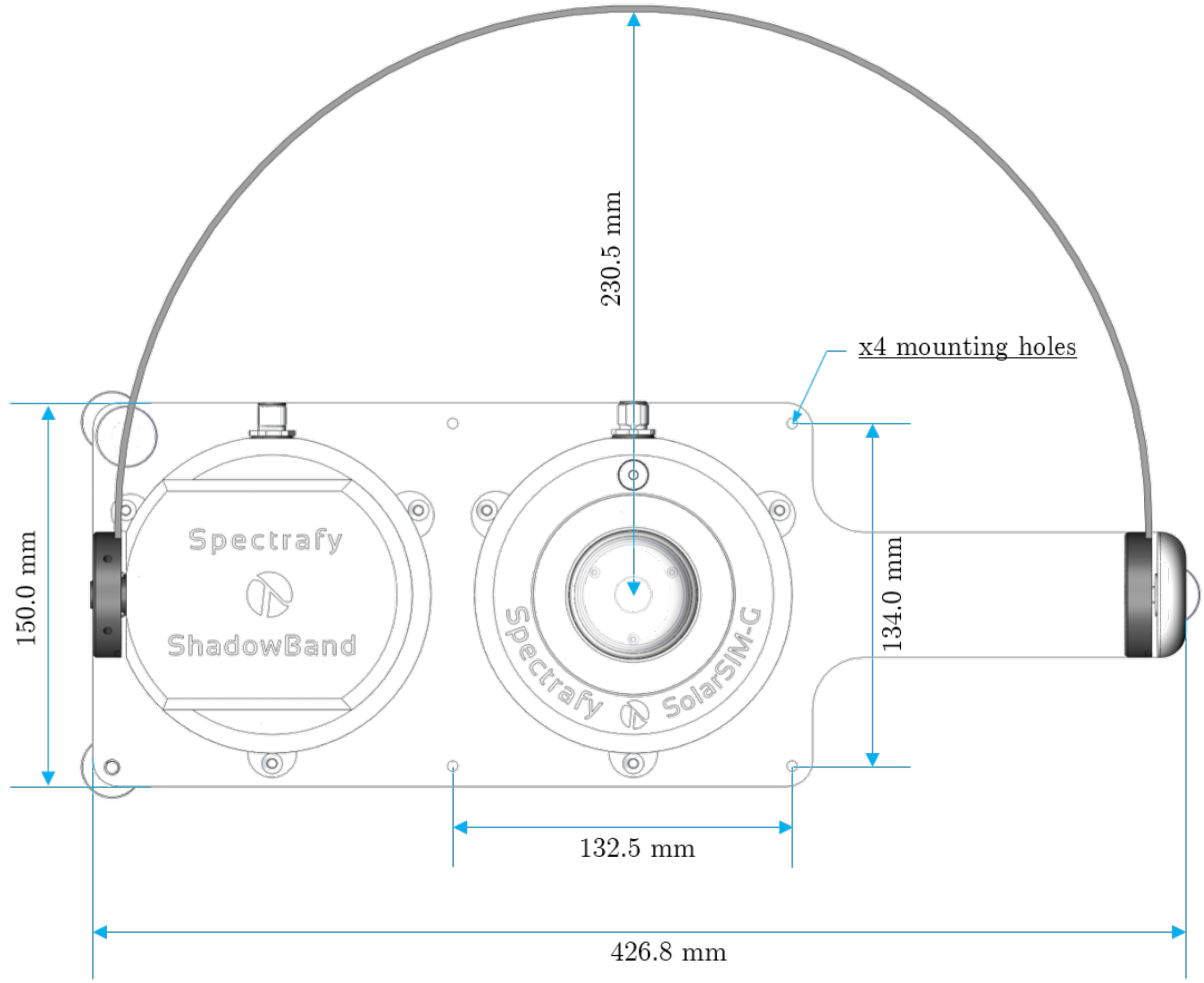

Figure 2: Main dimensions of the SolarSIM-E on a mounting plate. Four mounting holes are used to secure the device to a test platform or a table.

3 Maintenance

The SolarSIM-E requires very little maintenance. The most important task is to make sure that the glass dome of the SolarSIM-E is clean at all times, as the accumulation of dirt can lead to misrepresented data. Furthermore, the horizontal alignment of the SolarSIM-E should be checked periodically.

3.1 Cleaning

As a general rule, we recommend cleaning the SolarSIM-E's front glass with a dry, non-abrasive cloth, or paper towel, once per week, in order to maintain optimum performance. This frequency can be altered depending on your local climatic conditions.

3.2 Alignment

With each cleaning, it is also advised to check the leveling of the instrument using the bubble level. If the bubble is not centered within the circle, adjust the appropriate mounting screws to re-level the SolarSIM-E.

3.3 Desiccant

The desiccant is used to maintain an appropriate humidity level within the SolarSIM-E. The internal humidity of the device is reported within the daily summary data files and can therefore be monitored over time. The lifetime of the desiccant is expected to exceed two years, although it may vary based on local climatic conditions. The desiccant can be replaced as part of the SolarSIM-E's re-calibration procedure.

3.4 Recalibration

We recommend that the SolarSIM-E is returned to Spectrafy for recalibration `every 1-2 years` in order to maintain the SolarSIM's specified measurement accuracy.

4 Connectivity

The SolarSIM-E offers two connectivity options suitable for typical use-case scenarios:

1. A COMBOX or
2. A serial-over-Ethernet converter.

Option 1 uses a COMBOX - a seamless link between a PC and the SolarSIM-E, as shown in Figure 3. First, an AC wall adaptor is plugged into a receptacle and its barrel jack is plugged in to a COMBOX. Then a standard 6 ft USB cable is connected to the COMBOX and the PC's USB port. Finally, a 10 m RS-485 communication cable is connected to the COMBOX and the SolarSIM-E. This option is ideal for test sites and locations where one has the access to a personal computer (PC) or when quick, in-field spectral measurements are necessary with a laptop.

Option 2 allows the user to interface with the SolarSIM-E via a serial-over-Ethernet converter, provided there is Internet access. For this option the user must manually connect the power and communication wires to the SolarSIM-E by following the wiring guide in Section 4.2. This option is ideal for test sites and locations which have Internet access, but no PC nearby. Both options 1 and 2 make use of the SolarSIM-E DAQ graphical user interface, which must be installed on a Windows-based PC or a server, as explained in Section 5.

4.1 COMBOX

The COMBOX is a convenient option to establish the communication between a PC and the SolarSIM-E. Please follow these steps to setup the COMBOX with the SolarSIM-E:

1. Connect 12V barrel jack to the COMBOX. A blue LED light on the top of the COMBOX indicates power ON status.
2. Connect the control cable between the COMBOX and the SolarSIM-E.

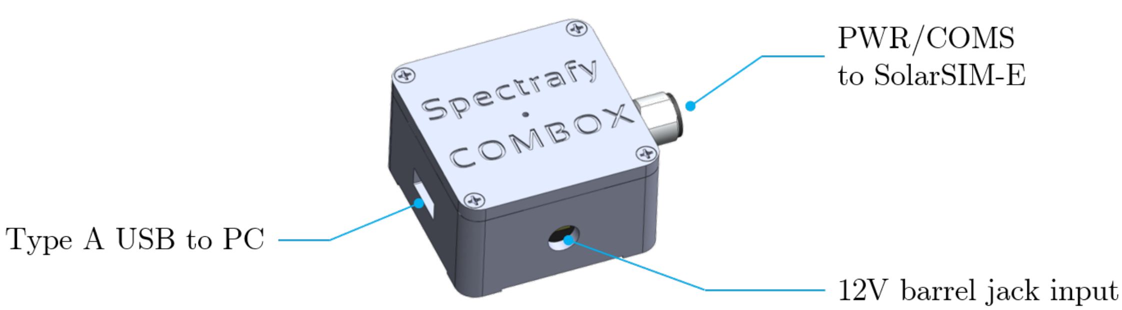

Figure 3: The COMBOX interfaces SolarSIM-E to a PC.

3. Connect the type A male-to-male USB cable between the PC and COMBOX.
4. Wait for the PC to install the FTDI drivers, which may take a few minutes.

4.2 Serial-over-Ethernet converter

For remote test site applications the SolarSIM-E can be connected to a networked PC via a suitable serial-over-Ethernet (SOE) converter - such as the ICP DAS I-7188-E2[1]. The user must connect the SolarSIM-E communication cable wires as per Table 1. More specifically, the D+ or A and D− or B lines, brown and black wires, respectively, must be connected to the corresponding terminal block inputs on the SOE device, while the blue and white wires - to the positive and common ground sides of the 12 VDC power supply, respectively. The SOE converter and the power supply must have a common ground. Note, supplying the SolarSIM-E with the voltage higher than **12 VDC** can damage the SolarSIM-E's electronics.

The network must assign a static IP address to the SOE converter. Afterwards, a virtual communication link can be established via the VxComm software[2]. The latter must be configured as per Figures 4 and 5. Once properly configured, the VxComm software creates a virtual serial port on the networked PC, which the SolarSIM-E DAQ application uses to communicate to the SolarSIM-E.

5 SolarSIM-E DAQ Application

The SolarSIM-E DAQ application provides the user with the real-time status of the instrument, data acquisition and storage, and daily data plots. The SolarSIM-E DAQ software acquires raw data from the SolarSIM-E over the serial port and thus can be used with either a COMBOX or a SOE converter. This section will go over the software installation, the program settings, and the general know-how for using the SolarSIM-E DAQ.

[1] `https://www.icpdas-usa.com/i_7188e2.html`
[2] `http://ftp.icpdas.com/pub/cd/8000cd/napdos/driver/vxcomm_driver/windows/`

Table 1: Wiring guide for the SolarSIM-E's power and communication connector.

Colour	Label	Function
Blue	V_{in}	Input voltage (+12 VDC)
White	GND	Common ground
Black	D−	Negative RS-485 input
Brown	D+	Positive RS-485 input

*12 VDC only

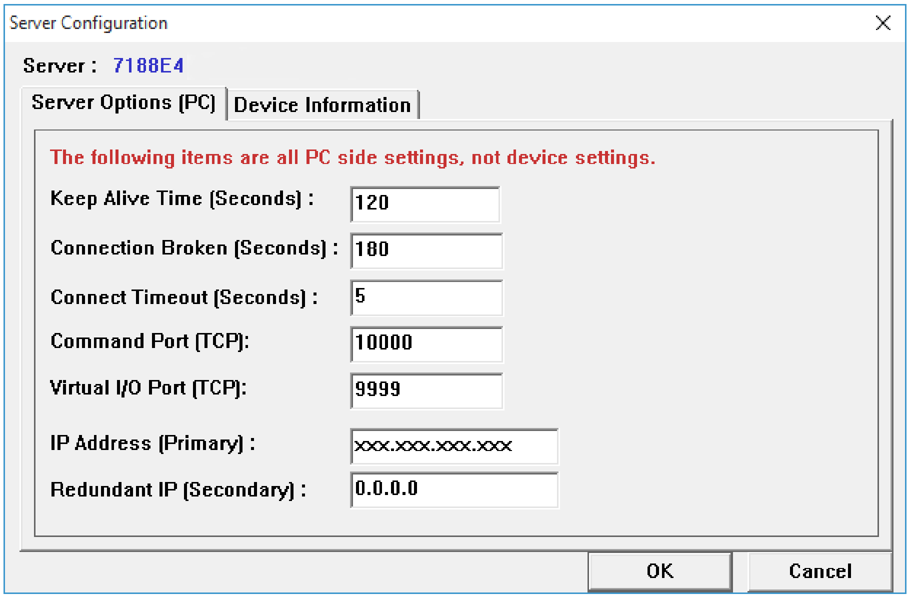

Figure 4: Server configuration for VxComm software. Note, the SolarSIM-E supports only the ASCII RS-485 communication mode.

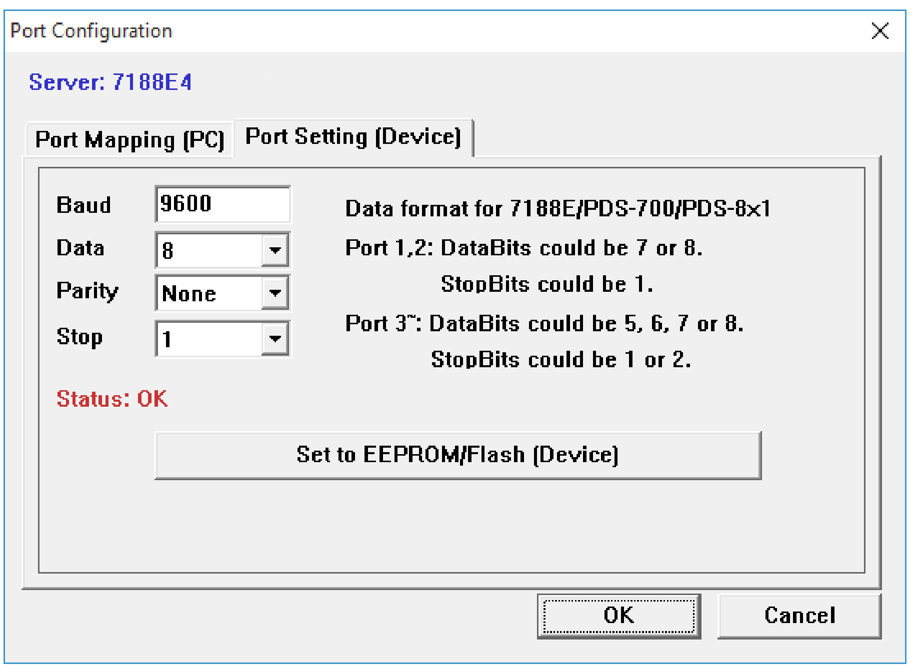

Figure 5: Port configuration for VxComm software. Note, the SolarSIM-E supports only the ASCII RS-485 communication mode.

5.1 Software installation

The software installation is performed by executing the setup.exe inside the **SolarSIM setup** folder located on the provided USB key, as shown in Figure 6. The user should follow the installation instructions as prompted by the software.

5.2 Software settings

Once the SolarSIM-E software is installed, the user must define the location-specific geographic settings for the SolarSIM-E to work properly. This process can be accomplished in two ways. The first option is for the user to change the values for altitude, longitude, and latitude in the **user_settings.conf** file, located in the **Settings** folder of the installation directory, as shown in Figure 7. The second option is to modify these parameters when automatically prompted by the software, as will be explained in Section 5.3. The modifications of the remaining parameters is optional. If **Auto mode** is ON, upon launching, the application does not interact with the user and begins the data collection automatically. The **DAQ timer** sets the data acquisition rate for the entire SolarSIM-E data set. If it is desired to have a separate data rate for the spectral data, the user can turn ON the **Custom spectrum timer** and change the spectral data acquisition to a desired rate via the **Spectrum timer**. Please refer to Table 2 for the summary of the user settings.

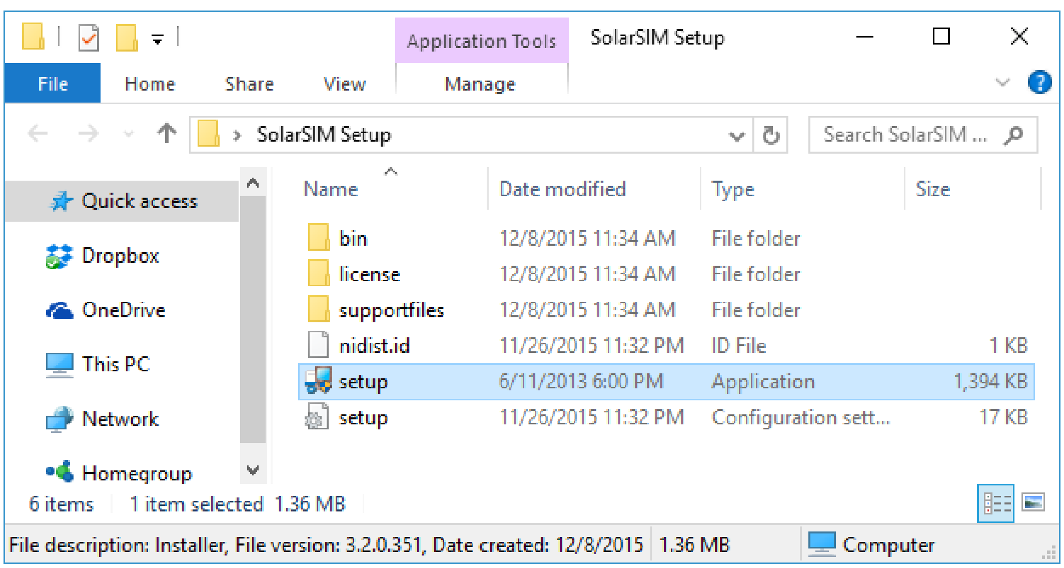

Figure 6: Installation of the SolarSIM-E software

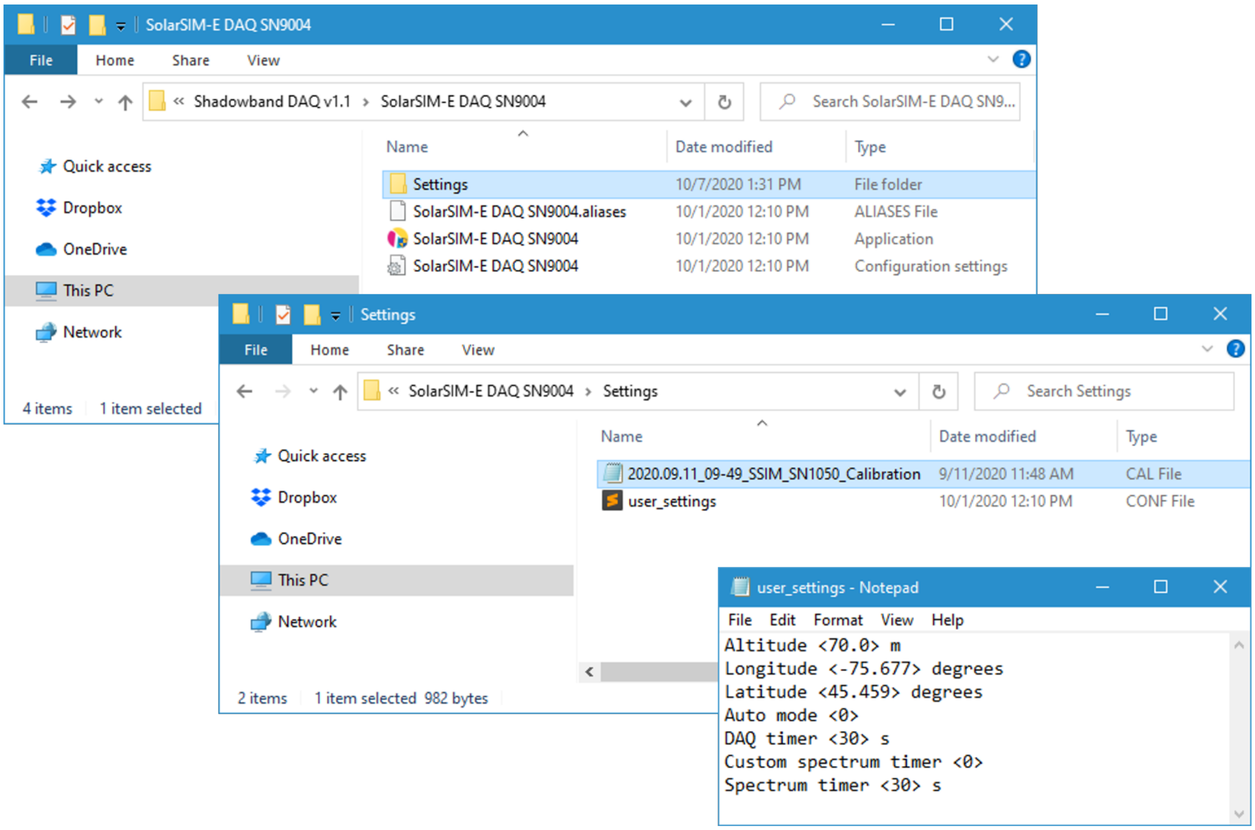

Figure 7: Adjustment of the SolarSIM-E user settings.

Table 2: SolarSIM-E DAQ program settings.

Setting	Value range	Units
Altitude	0.0 to 9000.0	metres
Longitude	0.00 to 180.00*	degrees
Latitude	0.00 to 90.00**	degrees
Auto mode	0 or 1	OFF or ON
DAQ timer	30.0 to 3600.0	seconds
Custom spectrum timer	0 or 1	OFF or ON
Spectrum timer	30.0 to 3600.0	seconds

*longitude is negative for western hemisphere
**latitude is negative for southern hemisphere

5.3 Using the software

The SolarSIM-E software is launched by double-clicking the SolarSIM-E DAQ.exe in the installation directory. The application runs automatically in the administrator mode, as it is a prerequisite to save data in the Program files directory. Once launched, the program automatically searches for the SolarSIM-E calibration file. If none is found, the SolarSIM-E DAQ will prompt the user to browse to the calibration file's directory, as shown in Figure 8. Browse to the provided USB key and select the appropriate calibration file. The application then copies this file to the `Settings` folder and will not ask for it again. If the SolarSIM-E DAQ detects multiple calibration files, the application will prompt the user to select the desired SolarSIM-E, as shown in Figure 9.

Once the calibration file is loaded, the SolarSIM-E DAQ software searches for the serial port to which the SolarSIM-E is connected. If the SolarSIM-E is not detected, the program displays the message as shown in Figure 10 and exits. In this case, please ensure that your PC detects the serial port by viewing the available serial or COM ports in the `Device manager`. If similar problem arises with the SOE converter, please double-check the setup procedure as explained in Section 4.2.

Once the SolarSIM-E is found, the SolarSIM-E DAQ prompts the user to verify and/or change the geographic settings, which include altitude, longitude and latitude, as shown in Figure 11. If these parameters are incorrect, the user can change them by modifying the appropriate values in the pop-up window. When ready, press `Apply`, and the program will save these settings permanently by writing them to the `user_settings.conf` file. Please note that the latitude and longitude must be negative for southern and western hemispheres, respectively.

The SolarSIM-E DAQ is depicted in Figure 12. The software displays the daily plots of the photodiode currents, the ambient temperature and pressure, the GHI in the 350–1830 nm and the 280–4000 nm ranges, the aerosol optical depth, the ozone content, the water vapour amount, and, elevation and azimuth angles. Data for all plots, other than the ambient temperature and pressure, is recorded between the sunrise and the sunset. Furthermore, the real-time plot of the solar spectrum is provided.

The desired DAQ timer rate (left of the `Start DAQ` button) should be set before beginning the data acquisition. It has a default value of 5 s, but it can be changed by modifying the `user_settings.conf` file. The DAQ timer value can be set between 1.0 s and 3600 s (1 hr) with 0.1 s resolution. Finally, the user can press the `Start DAQ` button to begin data collection from the SolarSIM-E.

5.4 Data type and storage

The SolarSIM-E DAQ stores the SolarSIM-E data in the `Data` folder, located in the installation directory. The software outputs two data files types: the solar spectral files and the daily summary data files. The spectral data is stored in the `Data\Spectra\yyyymmdd` directory, where `yyyy`, `mm`, and `dd` correspond to the year, month, and day, respectively. A snippet of the SolarSIM-E spectrum file is presented in Figure ??. As shown, the wavelength column is not included in order to minimize the file size. Rather the 3721 values of the spectral irradiance in units of W/m^2/nm are presented in a single column format. The value in row 2 corresponds to the spectral irradiance at 280 nm, while the value in row 3722 corresponds to

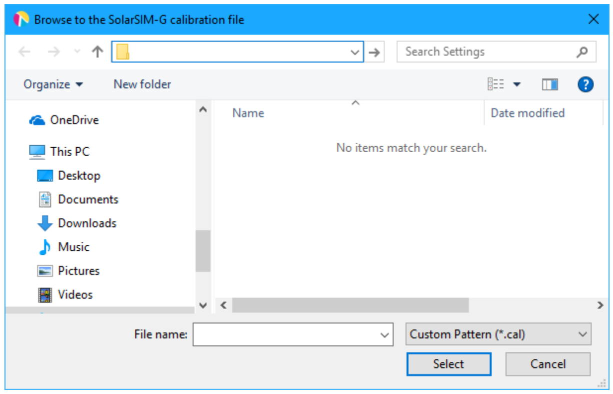

Figure 8: Browsing to the calibration file.

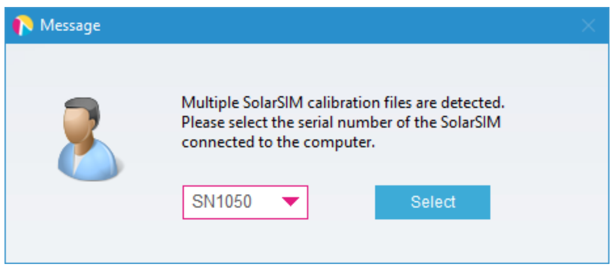

Figure 9: Selecting multiple calibration files.

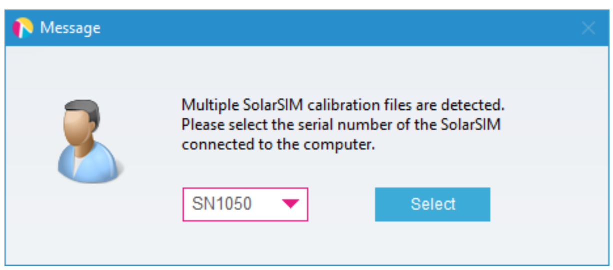

Figure 10: Failing to detect the SolarSIM-E.

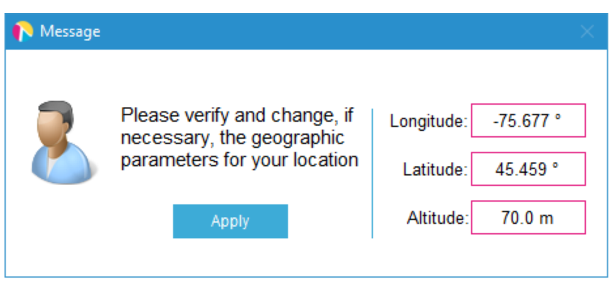

Figure 11: Changing and verifying geographic settings.

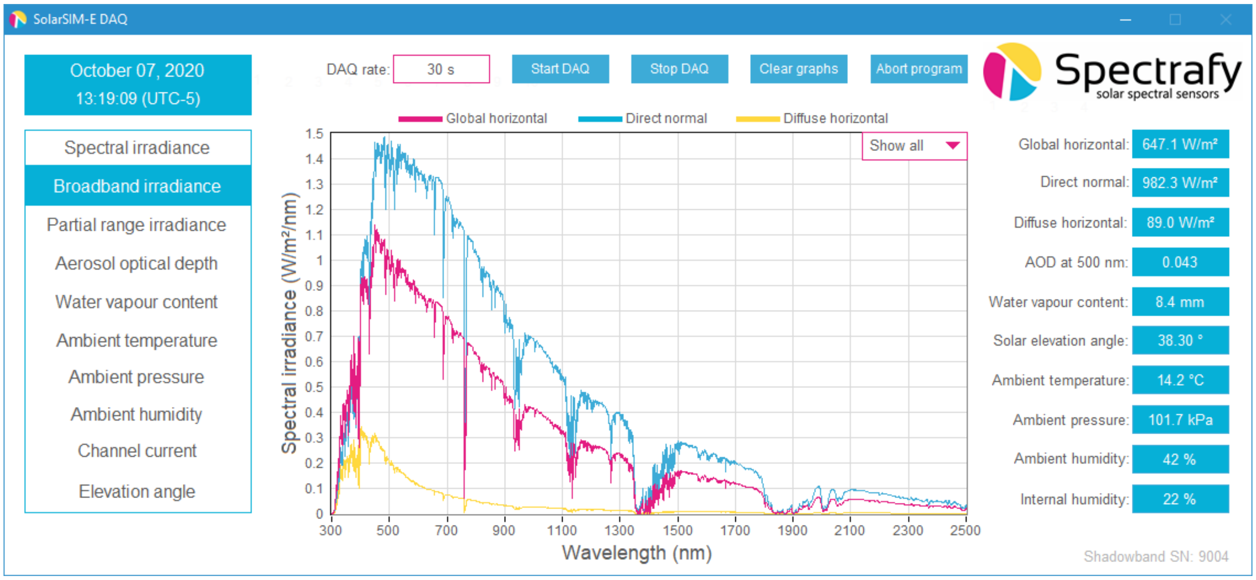

Figure 12: SolarSIM-E DAQ application

the spectral irradiance at 4000 nm.

The daily summary data files are stored in the Data folder. A snippet of the SolarSIM-E data file is shown in Figure ??. It contains the values for the elevation and azimuth angles, the ambient temperature, the ambient pressure, the internal humidity, the GHI in the 280–4000 nm ranges, custom range GHI values (optional), and the currents from the detectors for each timestamp.

5.5 Data collection size

At 5 s data acquisition resolution the daily summary file's size is ∼2MB or ∼115 bytes per measurement. The spectral file size is ∼37 KB per measurement. The size of the entire spectral file data set depends on the amount of daily sunlight, but with 5 s data acquisition resolution and with 8 hr of continuous sunshine, it adds up to ∼210 MB. The user is advised to use the Custom spectrum timer and Spectrum timer options in the user_settings.ini file to reduce the daily spectral data set size as desired.

5.6 Changing default language for non-Unicode characters

For users of computers with non-Latin based languages, such as Chinese, the SolarSIM-E DAQ may improperly display non-Unicode characters. To solve this problem, the user must change the default language for non-Unicode programs to English. To do so, first locate the Clock, Language, and Region settings in the Control Panel, then click on Region settings, as show in Figure 13. Then navigate to the Administrative tab and select Change system locale..., as demonstrated in Figure 14. Lastly, change the language to English from the drop down menu, as shown in Figure 15, and press OK.

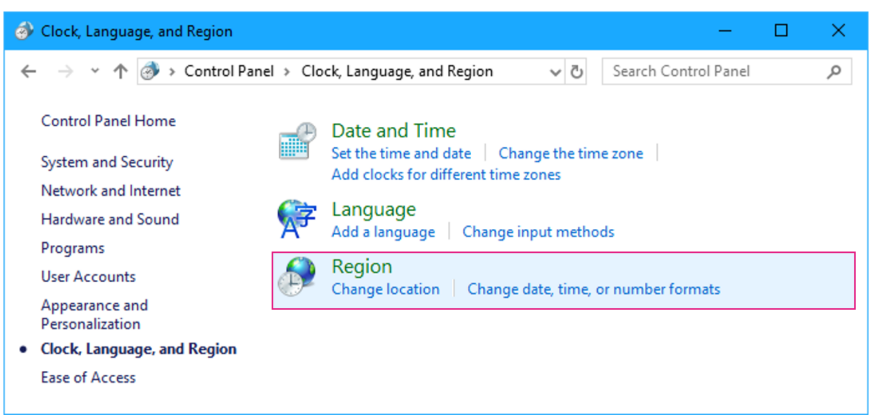

Figure 13: Clock, Language, and Region settings in the Control Panel.

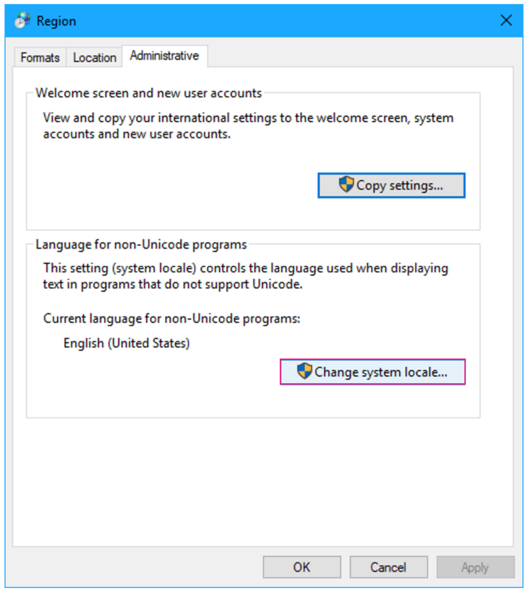

Figure 14: Changing the system locale in the Administrative tab of the Region settings.

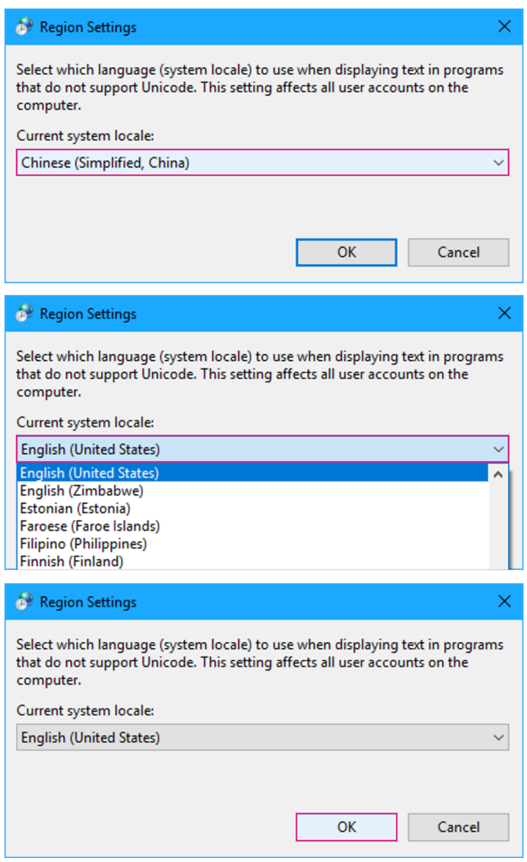

Figure 15: Changing the default language for non-Unicode characters..