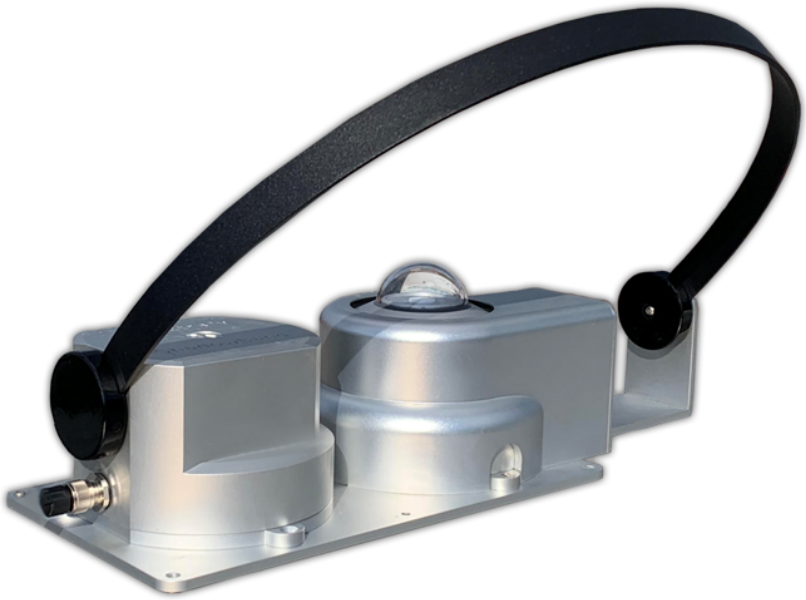
Spectrafy
solar spectral sensors

User Manual:

SolarSIM-E

Automated Shadowband



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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 sensor, the SolarSIM-G, 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 by e-mail at `info@spectrafy.com`

1 Main components

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

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

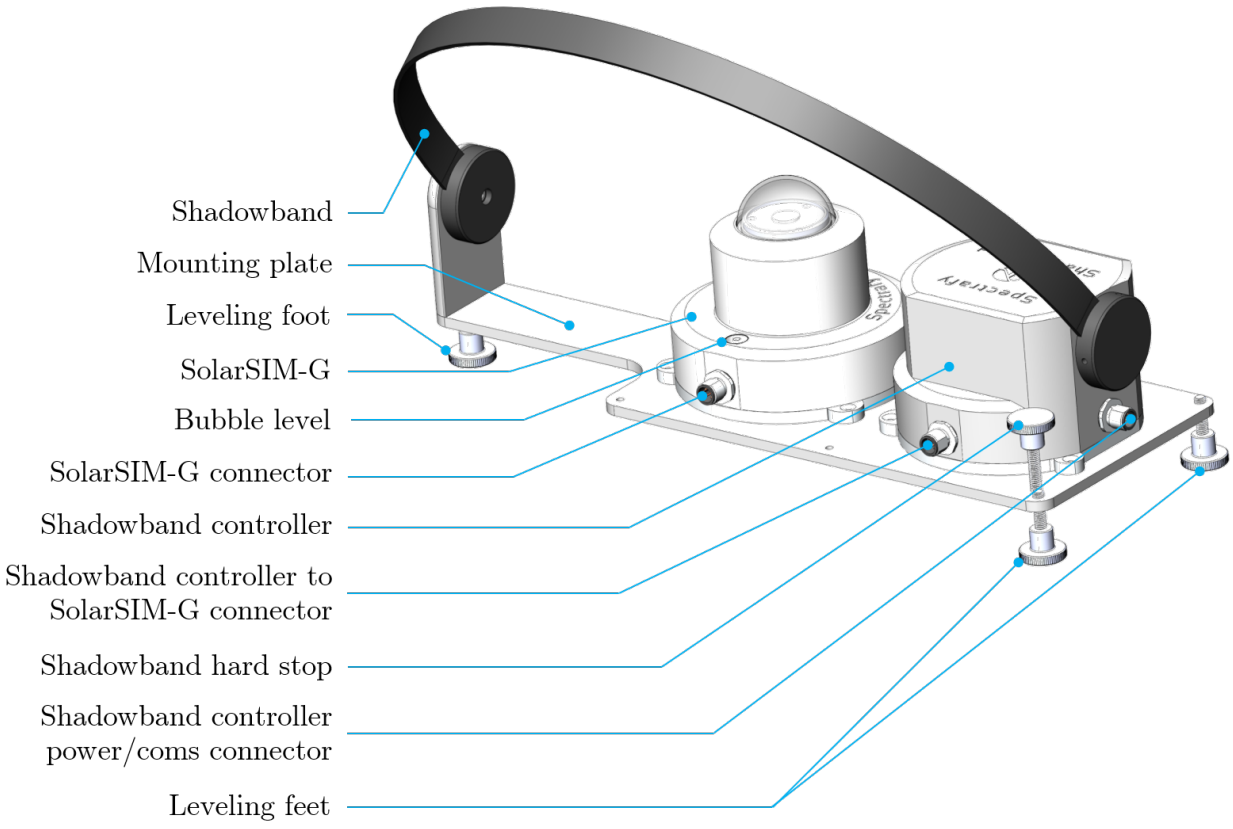

Figure 1: Main components of the SolarSIM-E.

1.1 Shadowband controller

The shadowband controller houses the printed circuit board and the stepper motor. It scans the sky by incrementally rotating the 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 transmitted 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

The shadowband hard stop prevents the shadowband from being rotated too far when the latter is travelling to the home position.

1.4 SolarSIM-G

The SolarSIM-G performs the spectral global and diffuse irradiance measurements.

1.5 Bubble level

The bubble level whether the SolarSIM-E is level or not.

1.6 Mounting plate

The anodized aluminum mounting plate consolidates all components of the SolarSIM-E.

1.7 Levelling feet

The levelling feet enable efficient levelling of the SolarSIM-E.

1.8 Connectors

The shadowband controller has two connectors: the power/comms and the SolarSIM-G connector. The power/comms connector provides power and communication to the controller. The SolarSIM-G connector provides power and communication to the SolarSIM-G.

2 Installation

2.1 Contents of delivery

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

- 1 × SolarSIM-E ,
- 1 × SolarSIM-G cable (0.5 m),
- 1 × shadowband controller cable (10m)) ×1,
- 1 × COMBOX,
- 1 × AC/DC wall adapter,
- 1 × male-to-male Type A USB cable, and
- 1 × USB key loaded with the SolarSIM-E software.

Please check the contents of the package to note if any damage has 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's installation requires a suitable location, that is unobstructed by other instruments and objects. The entire device assembly with a shadowband fits within a circle with a diameter of 461 mm diameter, as shown in Figure 2. The procedure for mechanical installation is described as follows:

1. Place the SolarSIM-E on a testing platform such that the long axis of the mounting plate is oriented East-West and the SolarSIM-G's connector points roughly due North, i.e. in Figure 2, North would be up.
2. Adjust the levelling feet until the bubble level is centred within the bulls eye.
3. Drill four mounting hole on a test platform corresponding to four mounting holes (4.2 mm diameter) in Figure 2, then secure the SolarSIM-E with four screws and nuts. Check the bubble level position once again.
4. Plug the shadowband controller cable to the power/comms connector.

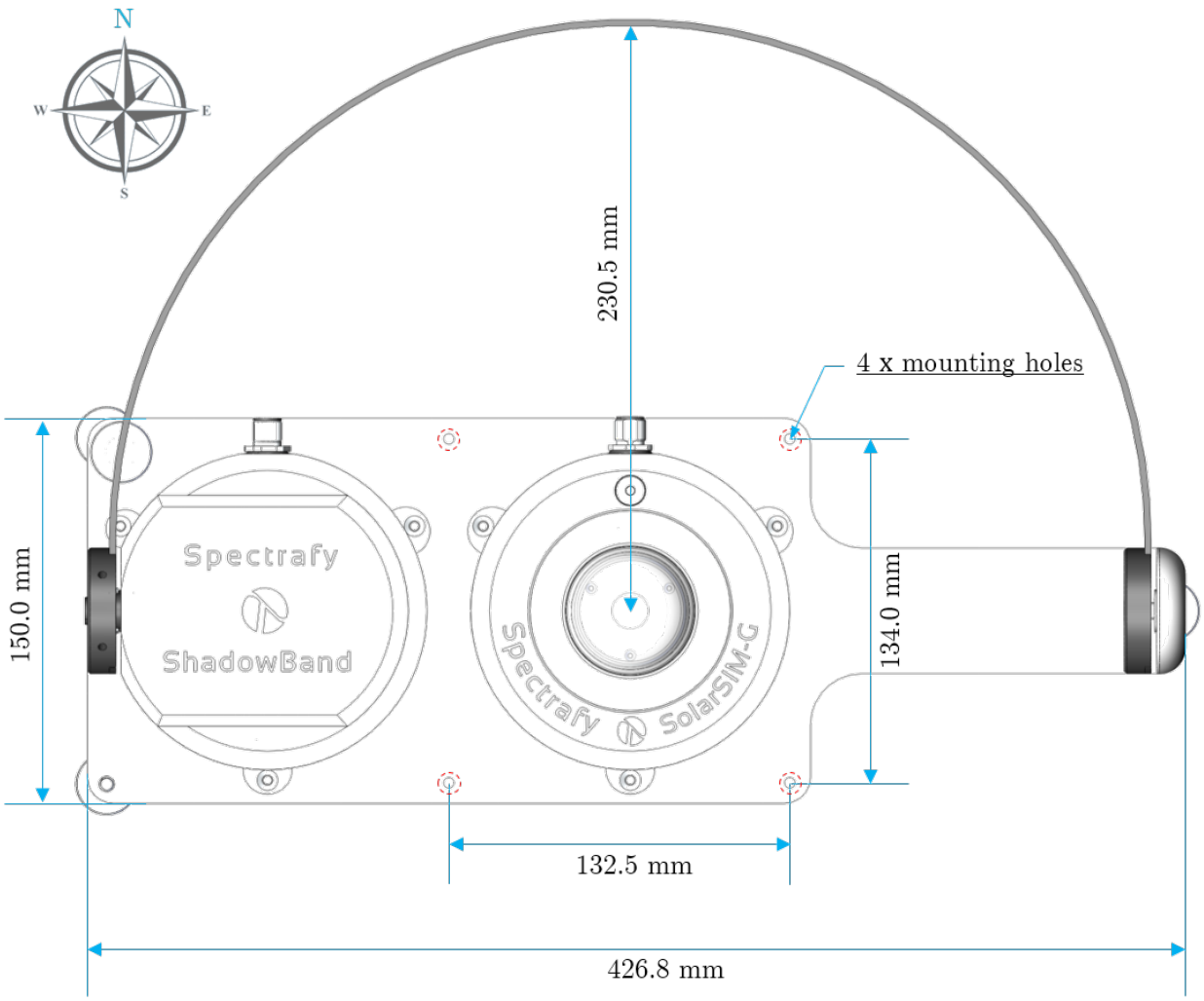

Figure 2: Main dimensions of the SolarSIM-E on a mounting plate. Four mounting holes, highlighted in red-dotted circles, secure the device to a test platform or a table. Note the SolarSIM-G connector should point due North.

3 Maintenance

3.1 Cleaning

As a general rule, we recommend cleaning the SolarSIM-G's glass dome 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 bubble level. If the bubble is not centred within the circle, adjust the appropriate levelling feet to re-level the SolarSIM-E.

3.3 Recalibration

Spectrafy recommends that the SolarSIM-G is returned to Spectrafy for recalibration `every 1-2 years` in order to maintain the specified measurement accuracy of the SolarSIM-E.

4 Connectivity

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

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

Option 1 uses a Spectrafy COMBOX - a seamless link between a PC and the SolarSIM-E, as shown in Figure 3. This option is ideal for test sites where one has the access to a 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.

Figure 3: A Spectrafy COMBOX interfaces the SolarSIM-E to a PC.

4.1 COMBOX

A Spectrafy COMBOX is a convenient option for communicating between a PC and the SolarSIM-E. Please follow these steps to set up the COMBOX with the SolarSIM-E:

1. Connect the 12V barrel jack to the COMBOX. A blue LED will light up on the top of the COMBOX to indicate the power ON status.
2. Connect the 10 m control cable between the COMBOX and the SolarSIM-E's power/-comms connector.
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 must be connected 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 a 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 VxComm software 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.

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- (B)	Negative RS-485 input
Brown	D+ (A)	Positive RS-485 input

*12 VDC only

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

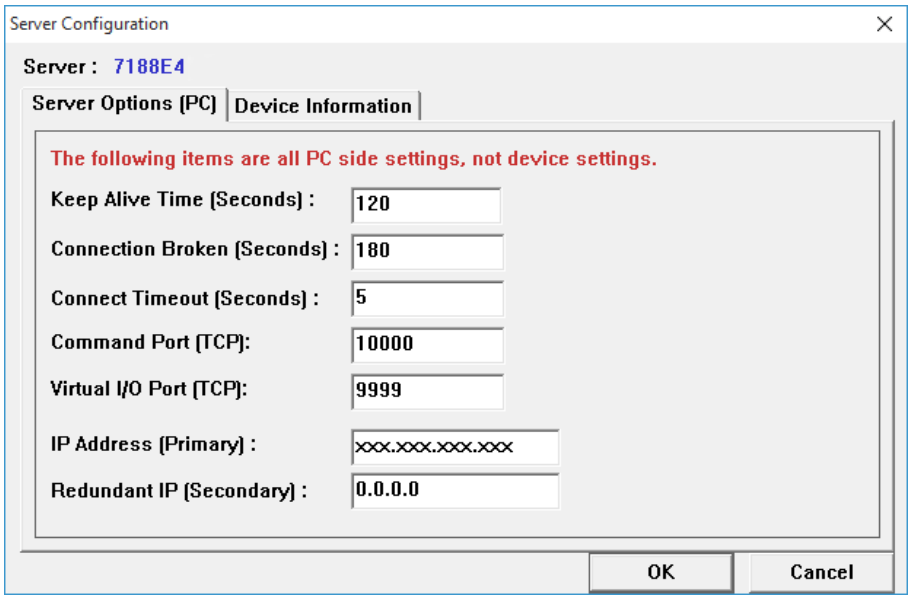

Figure 4: Server configuration for VxComm software. Note, the SolarSIM-E supports only the ASCII RS-485 communication mode.

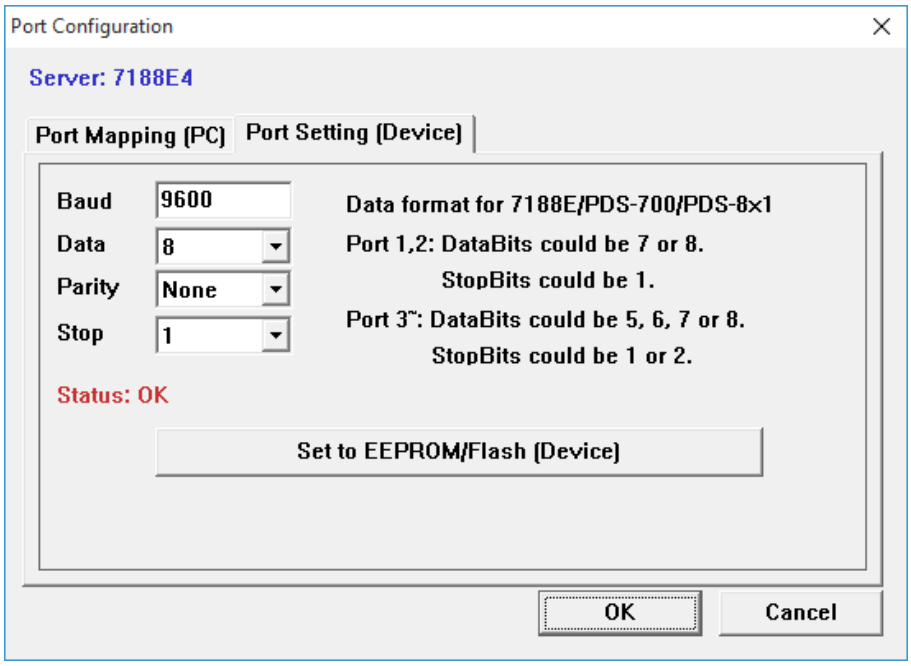

Figure 5: Port configuration for VxComm software. Note, the SolarSIM-E supports only the ASCII RS-485 communication mode.

5 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 describes the software installation, the program settings, and the general know-how for using the SolarSIM-E DAQ.

5.1 Software installation

The software is installed 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 in order 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, the application does not interact with the user upon launching and begins the data collection automatically.

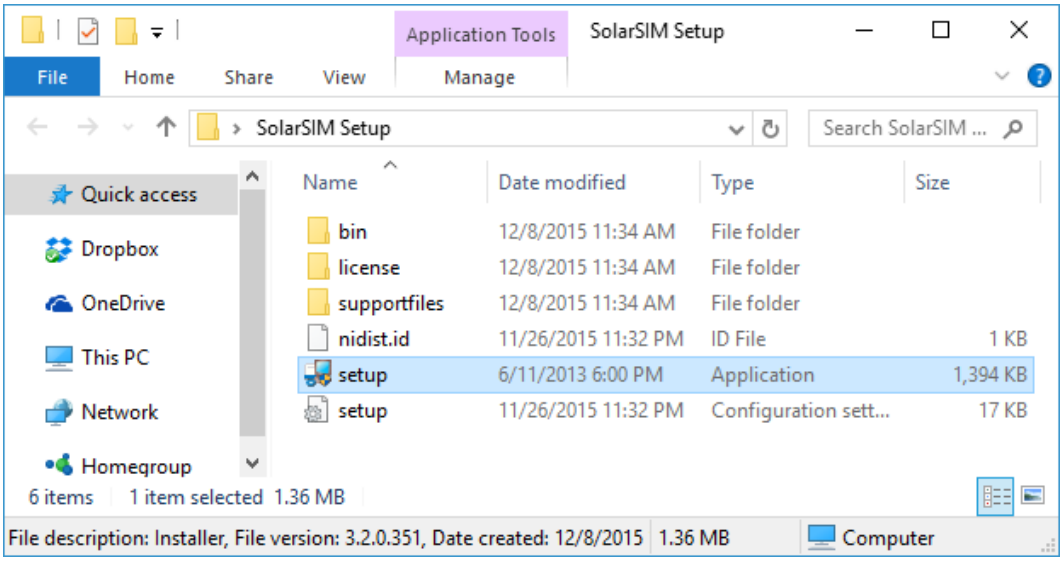

Figure 6: Installation of the SolarSIM-E software

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.

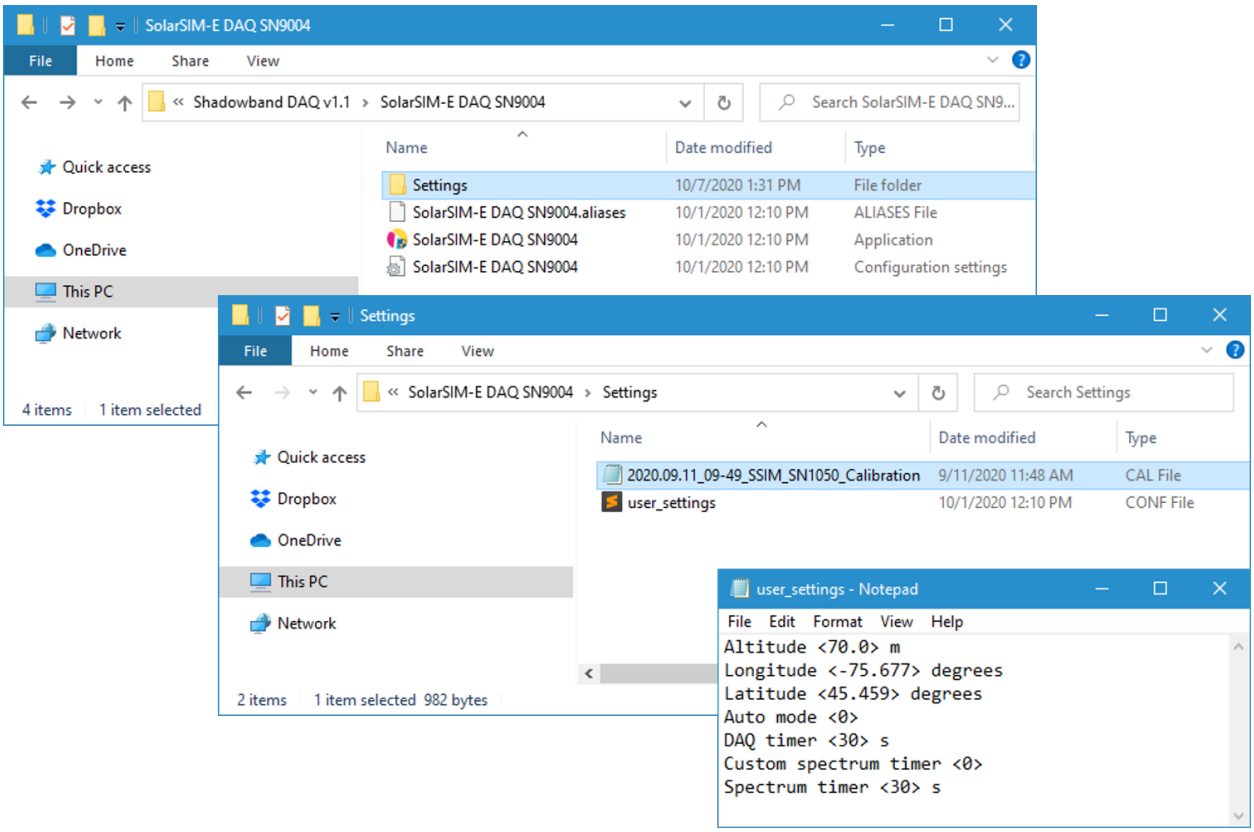

Figure 7: Adjustment of the SolarSIM-E user settings.

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. 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.

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 8 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 a similar problem arises with the SOE converter, please double-check the setup procedure as explained in Section 4.2.

Once the SolarSIM-E is detected, 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 9. 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.

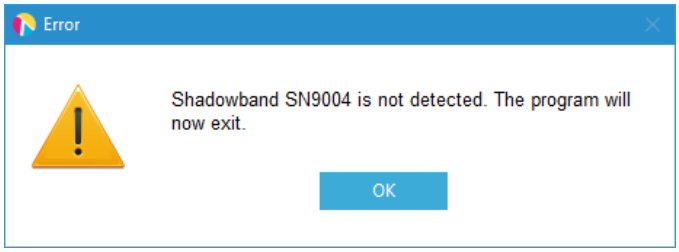

Figure 8: Failing to detect the SolarSIM-E.

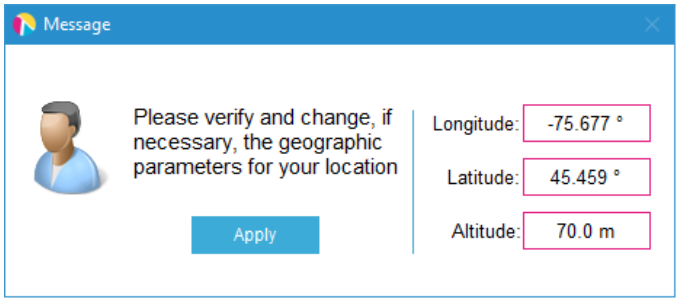

Figure 9: Changing and verifying geographic settings.

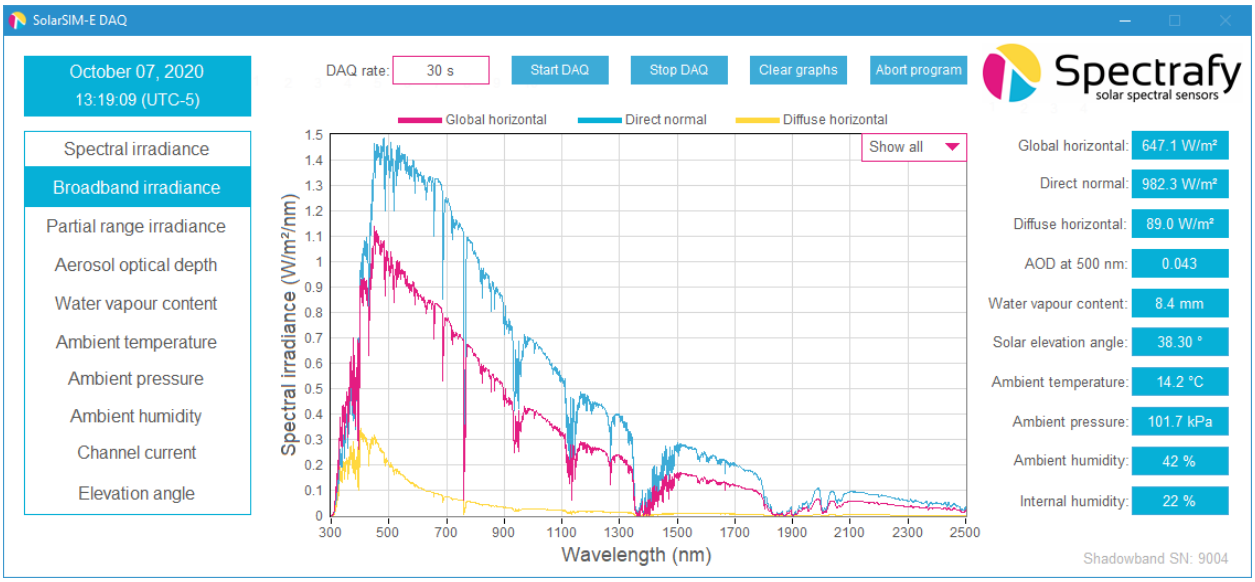

Figure 10: SolarSIM-E DAQ application

The SolarSIM-E DAQ is depicted in Figure 10. The software displays various data outputs, such as the real-time spectral plots, daily broadband irradiance plots, aerosol optical depth, precipitable water vapour amount, and other plots - depending on the user's license. Data for all plots, other than the ambient temperature,pressure and humidity, is recorded between the sunrise and the sunset.

The desired DAQ timer rate (the pink box to the left of the `Start DAQ` button) should be set before beginning the data acquisition. It has a default value of 30 s, but this default value can be changed by modifying the `user_settings.conf` file as detailed in Section 5.2. The DAQ timer value can be set between 30 s and 3600 s (1 hr) with 1 s resolution. Finally, by pressing the `Start DAQ` button the user can begin data collection from the SolarSIM-E.

5.4 Data type and storage

The SolarSIM-E DAQ stores the processed data in the `Data` folder, located in the installation directory. The software outputs two data files types: spectral file and daily summary files.

5.4.1 Spectral files

The spectral data is stored as a single file for every timestamp in the `Data\Spectra\yyyymmdd` directory, where `yyyy`, `mm`, and `dd` correspond to the year, month, and day, respectively. To minimize the spectral file size, the wavelength column is omitted. The values in row 2 correspond to the spectral irradiance and/or aerosol optical depth at 280 nm, while the values in row 3722 corresponds to the spectral irradiance and/or aerosol optical depth at 4000 nm.

5.4.2 Daily summary files

One daily summary file is generated per day in the Data folder and it contains processed time-series data from the SolarSIM-E, such as the broadband irradiance data, elevation and azimuth angles, ambient temperature and pressure, and many other outputs.

5.5 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 11. Then navigate to the Administrative tab and select Change system locale..., as demonstrated in Figure 12. Lastly, change the language to English from the drop down menu, as shown in Figure 13, and press OK.

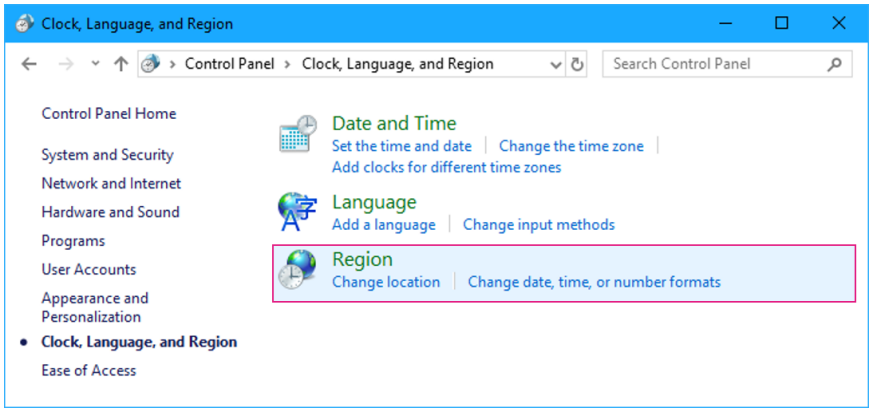

Figure 11: Clock, Language, and Region settings in the Control Panel.

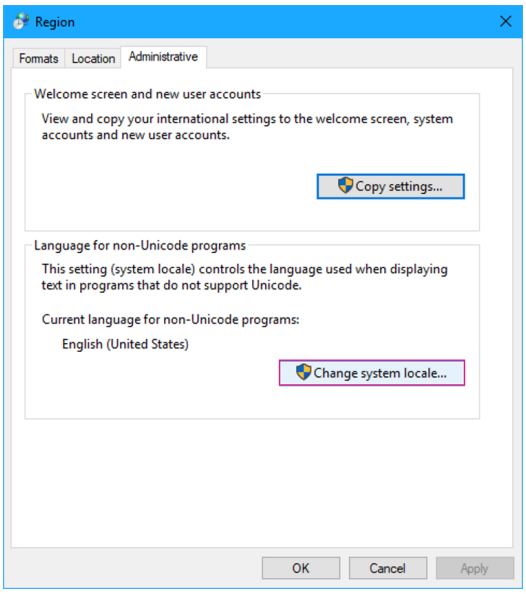

Figure 12: Changing the system locale in the Administrative tab of the Region settings.

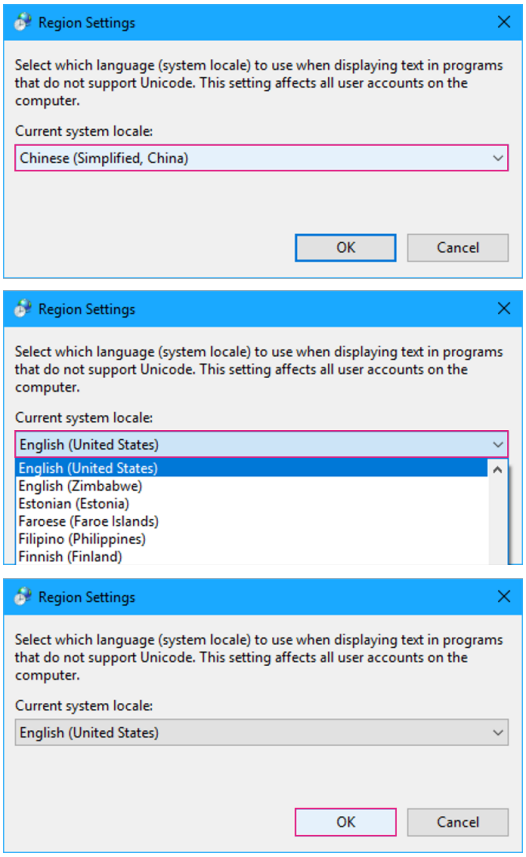

Figure 13: Changing the default language for non-Unicode characters.