



**User Manual:**

**Solar Spectral Irradiance Meter**

**SolarSIM-G**



## User information

Spectrafy strongly recommends reading this instruction manual prior to installation and operation of your global Solar Spectral Irradiance Meter (SolarSIM-G).

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

Spectrafy Inc.  
4 Florence St., Suite 204  
Ottawa, Ontario, Canada  
K2P 0W7  
Tel: 1-613-237-2020  
[info@spectrafy.com](mailto:info@spectrafy.com)  
[www.spectrafy.com](http://www.spectrafy.com)

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

## Warranty and liability

Spectrafy guarantees that the Solar Spectral Irradiance Meter (SolarSIM-G) has been thoroughly tested to ensure that it meets all of the stated specifications. A two 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 Solar Spectral Irradiance Meter (SolarSIM-G) from Spectrafy. Please become familiar with this instruction manual for a full understanding of the use of your SolarSIM-G.

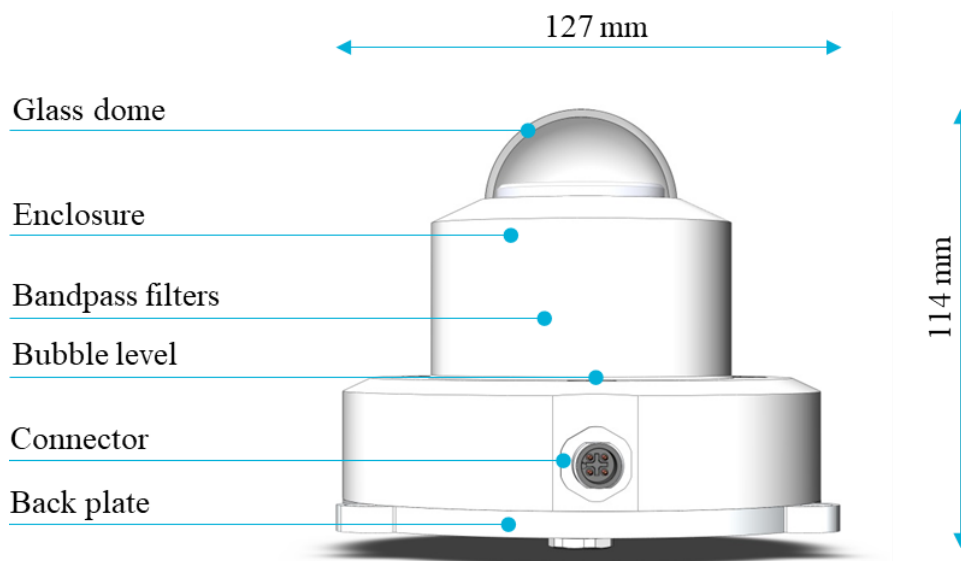
The SolarSIM-G is designed to be a cost-effective tool for accurately determining the solar spectrum and global horizontal/tilted irradiance (GHI/GTI) as part of on-site solar resource assessments and module performance characterization studies. The instrument uses silicon photodiodes, integrated with hard-coated bandpass filters to measure the solar spectral irradiance in nine narrow wavelength bands. The SolarSIM-G's proprietary software uses these measurements to resolve the global solar spectrum and the global irradiance.

If you have any questions, please feel free to contact a Spectrafy representative or e-mail [info@spectrafy.com](mailto:info@spectrafy.com)

## 1 Main components

The side view of SolarSIM-G components is shown in Figure 1, which includes

- a glass dome,
- an enclosure,
- bandpass filters,
- bubble level,
- a connector, and
- a backplate.



**Figure 1:** SolarSIM-G components and main dimensions.

## **1.1 Glass dome**

The glass dome prevents the ingress of moisture and debris.

## **1.2 Enclosure**

The anodized aluminum enclosure secures SolarSIM-G components in place, while providing robust protection from the environment.

## **1.3 Bandpass filters**

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

## **1.4 Bubble level**

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

## **1.5 Connector**

The connector provides the power and communication to the SolarSIM-G.

## **1.6 Backplate**

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

## 2 Installation

### 2.1 Contents of delivery

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

- a SolarSIM-G  $\times 1$ ,
- a communication cable  $\times 1$ ,
- a SolarSIM-G COMBOX  $\times 1$  (optional),
- a mounting plate  $\times 1$  (optional),
- mounting screws  $\times 3$ ,
- mounting springs  $\times 3$ , and
- a USB key loaded with the SolarSIM-G software.

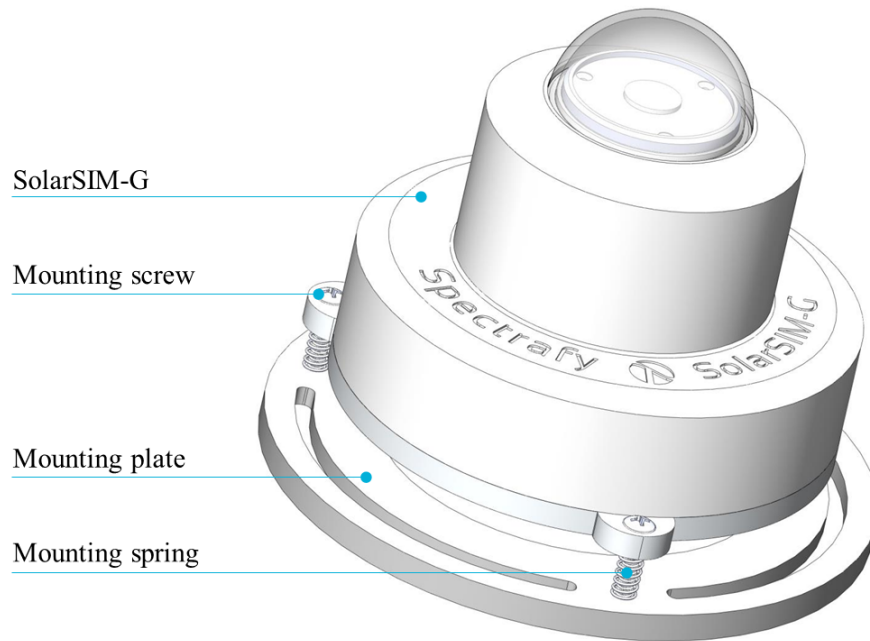
Please check the contents of the package and note if any damages have occurred during shipment. A claim should be filed with the shipment carrier should this be the case. Additionally, please contact a Spectrafy representative to facilitate the repair or replacement of the instrument and/or its accessories.

### 2.2 Mechanical installation

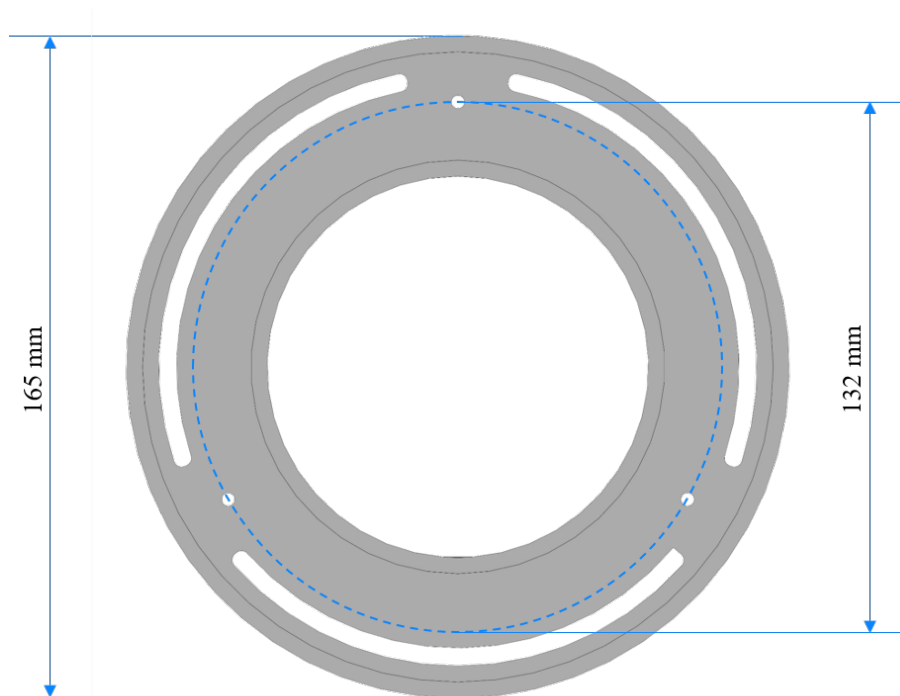
The SolarSIM-G installation requires fastening it to the mounting plate via three M4 screws and springs, as demonstrated in Figure 2. The mounting plate is 7.3 mm thick and has three slots with a 132 mm diameter that are 4.5 mm wide for external fastening, as shown in Figure 3. The screws for external mounting are not provided. The procedure for mechanical installation is described as follows:

1. Place the SolarSIM-G on the mounting plate as per Figure 3.
2. Place the spring under the SolarSIM-G so that it roughly aligns with one of the mounting holes on the SolarSIM-G.
3. Insert the mounting screw through the SolarSIM-G'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:** Assembled SolarSIM-G on a mounting plate.



**Figure 3:** Dimensional drawing of a mounting plate.

## 3 Maintenance

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

### 3.1 Cleaning

As a general rule, we recommend cleaning the SolarSIM-G'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-G.

### 3.3 Desiccant

The desiccant is used to maintain an appropriate humidity level within the SolarSIM-G. 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-G's re-calibration procedure.

### 3.4 Recalibration

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

## 4 Connectivity

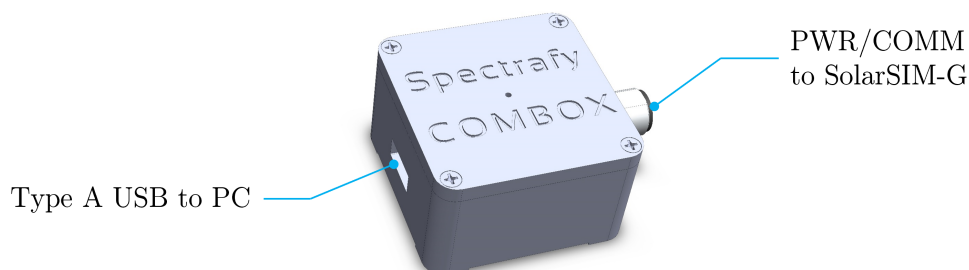
The SolarSIM-G offers various connectivity options suitable for most use case scenarios. The connectivity solutions include:

1. A SolarSIM COMBOX
2. A serial-over-Ethernet converter, or
3. A datalogger.

Option 1 uses the SolarSIM Communication Box (COMBOX) - a seamless link between a PC and the SolarSIM-G, as shown in Figure 4. A standard 6 ft USB cable is connected from the COMBOX to a PC. On the other side, a 10 m RS-485 communication cable is connected from the COMBOX to the SolarSIM-G. 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-G 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-G 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-G DAQ graphical user interface, which must be installed on a Windows-based PC or a server, as explained in Section 5.

Option 3 uses a datalogger to acquire raw data from the SolarSIM-G. This raw data must be specifically formatted by the user into a .csv file, which is then fed into the SolarSG software to generate the complete SolarSIM-G data set, as further detailed to in Section 6.3. This option is ideal for remote test sites and locations with existing datalogger systems.



**Figure 4:** The COMBOX interfaces the SolarSIM-G to a PC.

## 4.1 SolarSIM-G Communication Box

The COMBOX is the best option for stable communication between a PC and the SolarSIM-G. Please follow these steps to install the COMBOX:

1. Connect one end of the communication cable to the SolarSIM-G.
2. Connect the other end to the COMBOX.
3. Connect one end of a male-to-male USB cable to the COMBOX.
4. Connect the other end of a male-to-male USB cable to a PC. A blue LED on the top of the COMBOX indicates power to the SolarSIM-G.
5. Wait for the PC to install the FTDI drivers, which may take a few minutes.
6. Once the FTDI drivers are installed, restart the PC.

## 4.2 Serial-over-Ethernet converter

For remote test site applications the SolarSIM-G can be connected to a networked PC via a suitable serial-over-Ethernet (SOE) converter - such as the ICP DAS I-7188-E2<sup>1</sup>. The user must connect the SolarSIM-G communication cable wires as per Table 1. More specifically, the D+ and D- 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-G with the voltage higher than 12 VDC will damage the SolarSIM-G 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<sup>2</sup>. The latter must be configured as per Figures 5 and 6. Once properly configured, the VxComm software creates a virtual serial port on the networked PC, which the SolarSIM-G DAQ application uses to communicate to the SolarSIM-G.

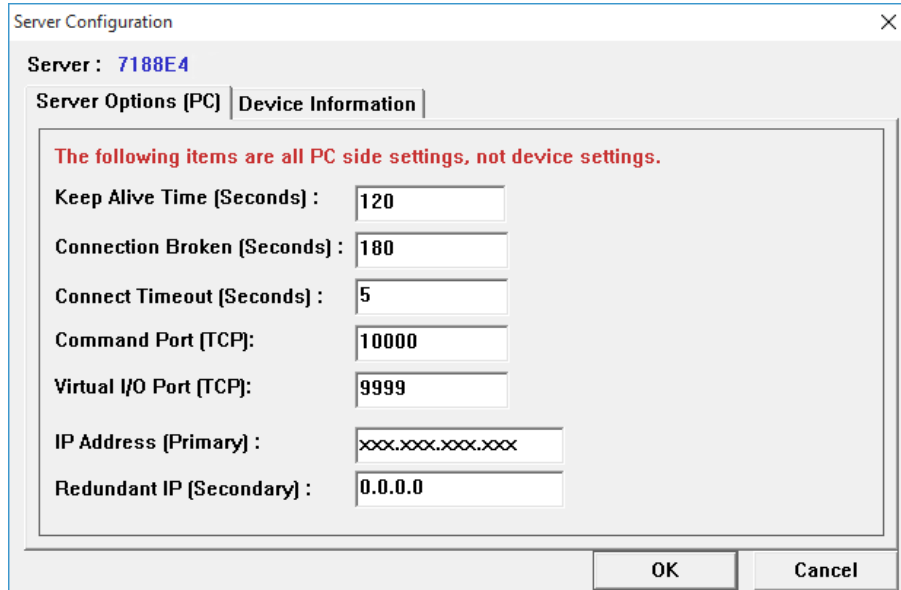
<sup>1</sup>[https://www.icpdas-usa.com/i\\_7188e2.html](https://www.icpdas-usa.com/i_7188e2.html)

<sup>2</sup>[http://ftp.icpdas.com/pub/cd/8000cd/napdos/driver/vxcomm\\_driver/windows/](http://ftp.icpdas.com/pub/cd/8000cd/napdos/driver/vxcomm_driver/windows/)

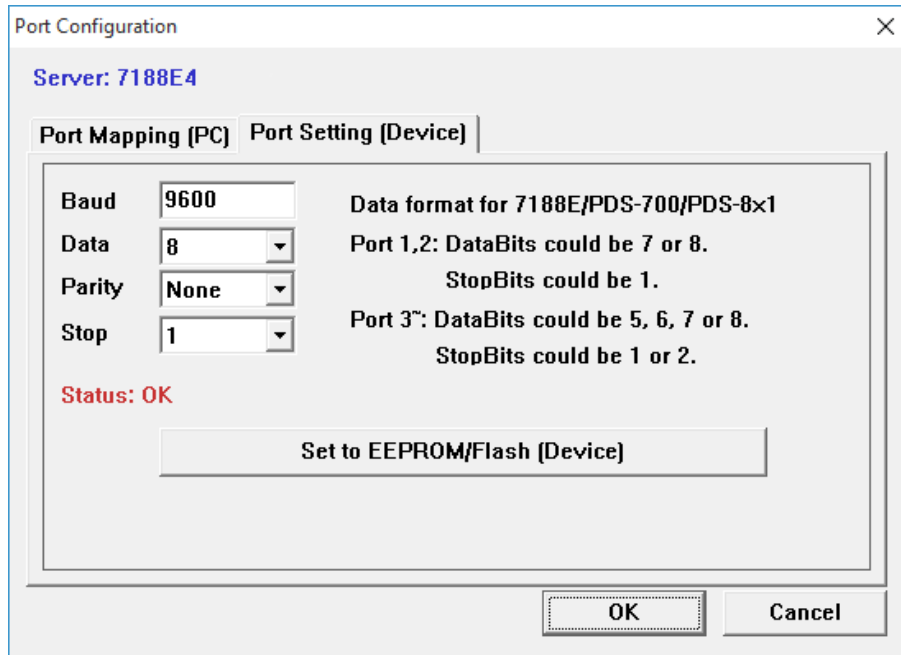
**Table 1:** Wiring guide for the SolarSIM-G.

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 5:** Server configuration for VxComm software. Note, the SolarSIM-G supports only the ASCII RS-485 communication mode.



**Figure 6:** Port configuration for VxComm software. Note, the SolarSIM-G supports only the ASCII RS-485 communication mode.

### 4.3 Datalogger

The connectivity with a datalogger is similar to the SolarSIM-G's integration with the SOE converter. The SolarSIM-G communication cable is connected to the corresponding datalogger inputs as per Section 4.2. The datalogger must have a spare RS-485 port.

## 5 SolarSIM-G DAQ Application

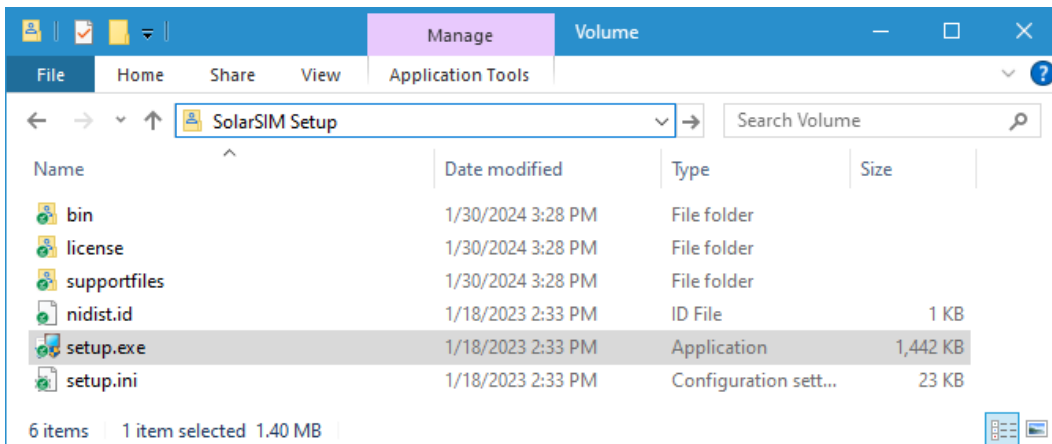
The SolarSIM-G DAQ application provides the user with the real-time status of the instrument, performs the data acquisition and storage of data, and displays daily data plots for various parameters. The SolarSIM-G DAQ software communicates via a serial port and thus can be used with either a COMBOX or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

### 5.1 Software installation

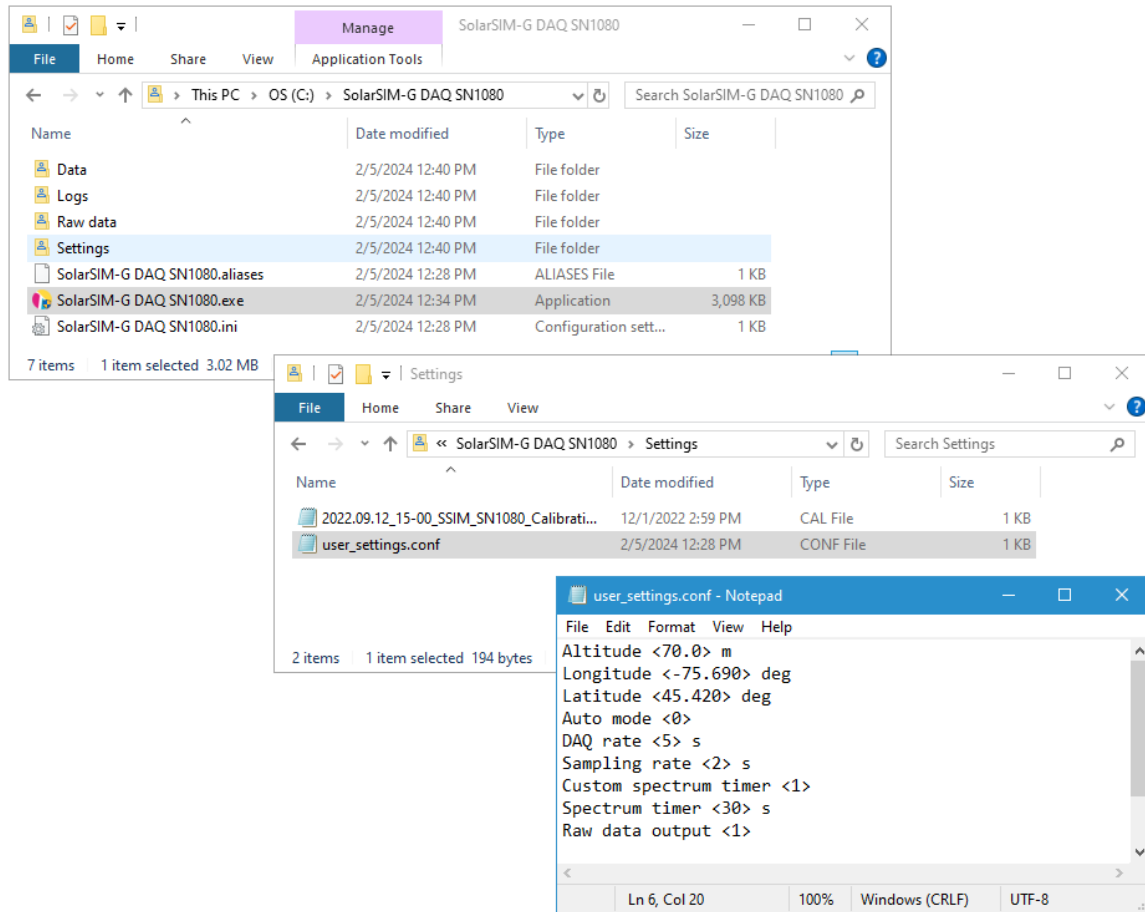
The software installation is performed by executing the setup.exe inside the SolarSIM setup folder located on the provided USB key, as shown in Figure 7. The user should follow the installation instructions as prompted by the software.

### 5.2 Software settings

Once the SolarSIM-G software is installed, the user must define the location-specific geographic settings for the SolarSIM-G 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



**Figure 7:** Installation of the SolarSIM-G DAQ software



**Figure 8:** Adjustment of the SolarSIM-G DAQ user settings.

directory, as shown in Figure 8. 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 resolution for the entire SolarSIM-G data set, while the **Sampling rate** determines how often to poll the measurements over the duration of the DAQ rate. 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**. Finally, if the user desires to save the raw data from the instrument, the **Raw data output** setting should be set to ON. Please refer to Table 2 for the summary of the user settings.

**Table 2:** SolarSIM-G 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 rate	1 to 3600	seconds
Sampling rate	1 to 3600	seconds
Custom spectrum timer	0 or 1	OFF or ON
Spectrum timer	1 to 3600	seconds
Raw data output	0 or 1	OFF or ON

\*longitude is negative for western hemisphere

\*\*latitude is negative for southern hemisphere

### 5.3 Using the software

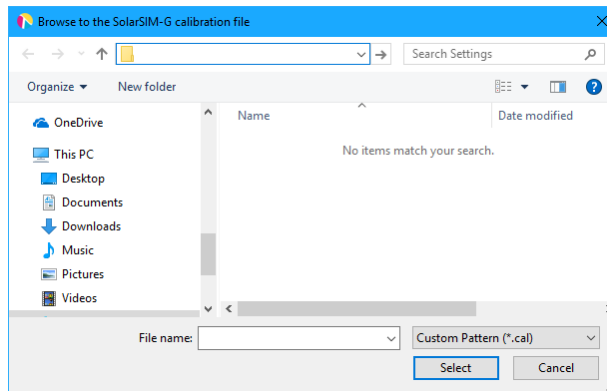
The SolarSIM-G software is launched by double-clicking the SolarSIM-G DAQ SNxxxx.exe in the installation directory, where xxxx is a 4-digit serial number of your SolarSIM-G. The application runs automatically in the **Administrator mode**, as it is a prerequisite to save the data in the **Program files** directory. Once launched, the program automatically searches for the SolarSIM-G calibration file. If the SolarSIM-G DAQ detects multiple calibration files, the application will prompt the user to select the serial number of the desired SolarSIM-G, as shown in Figure 10.

The SolarSIM-G DAQ software then searches for the serial port to which the SolarSIM-G is connected. If the SolarSIM-G is not detected, the program displays the message as shown in Figure 11 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 specified in Section 4.2.

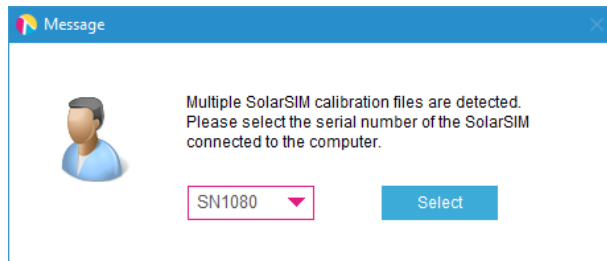
Once the SolarSIM-G's serial port is found, the SolarSIM-G DAQ prompts the user to verify and/or change the geographic settings, which include altitude, longitude and latitude, as shown in Figure 12. If these parameters are incorrect, the user can change them by modifying the appropriate values in the 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-G DAQ software is depicted in Figure 13. The fully licensed version of the software displays the real-time global spectral irradiance, the daily plots of the various irradiances (e.g. broadband, UV-A, UV-B, UV-E, photosynthetically active radiation or PAR), spectral correction factors for up to nine user-defined PV panel spectral responses, ambient temperature and pressure, internal temperature and humidity, individual SolarSIM-G chan-





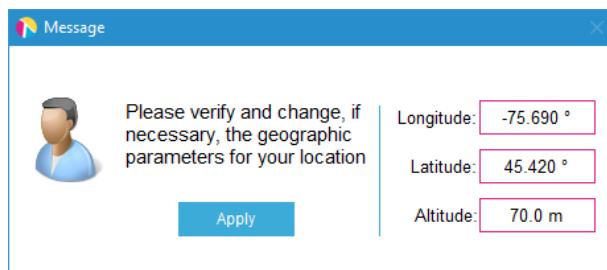
**Figure 9:** Browsing to the calibration file.



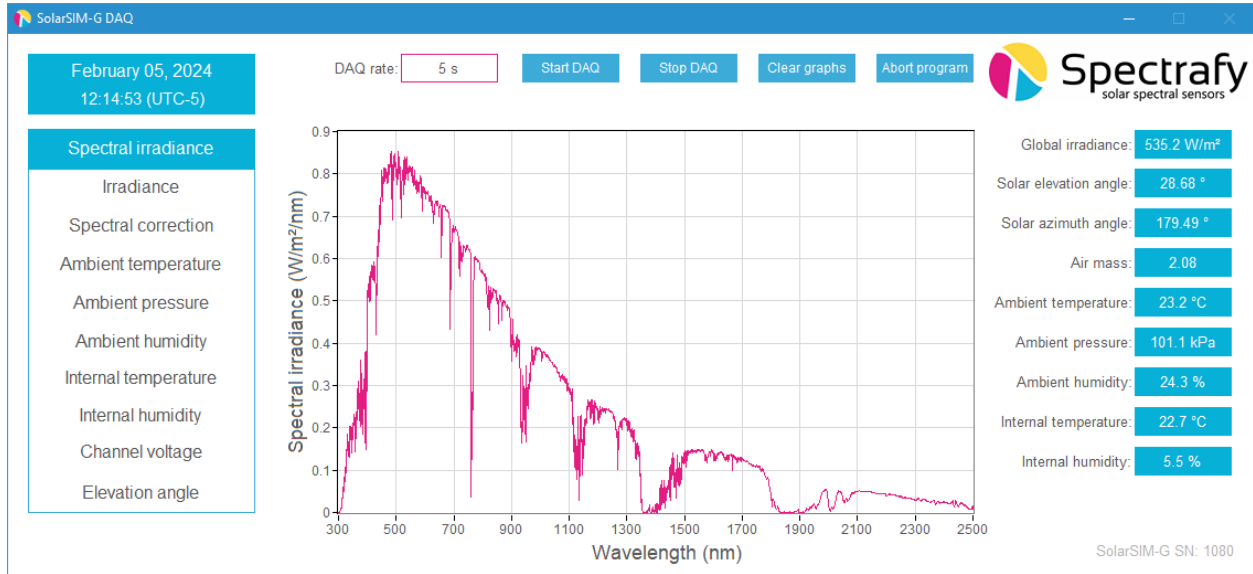
**Figure 10:** Selecting multiple calibration files.



**Figure 11:** Failing to detect the SolarSIM-G.



**Figure 12:** Changing and verifying geographic settings.



**Figure 13:** SolarSIM-G DAQ application

nel voltages, and the elevation angle. Data for plots, other than the ambient temperature and pressure, and internal temperature and humidity, is displayed between the sunrise and the sunset.

The desired DAQ 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 s and 3600 s. Finally, the user can press the **Start DAQ** button to begin data collection from the SolarSIM-G.

## 5.4 Data type and storage

The SolarSIM-G DAQ stores the SolarSIM-G’s processed data in the **Data** folder, located in the installation directory. The software outputs two processed 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-G spectrum file is presented in Figure 14. 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  $\text{W}/\text{m}^2/\text{nm}$  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 the spectral irradiance at 4000 nm.

The daily summary data files are stored in the **Data** folder. A snippet of the SolarSIM-G data file is shown in Figure 15. It contains the values for the elevation and azimuth angles, the ambient temperature, the ambient pressure, the ambient humidity, the internal temperature, the internal humidity, the broadband global irradiance, PAR, UV-A, UV-B, UV-E, and nine

spectral correction factors. Additionally, if the user has enabled the **Raw data output** setting, the software saves raw daily data files in the **Raw data** folder. See Section 6.3 for more information on the raw data files.

### 5.5 Data collection size

At a 5 s DAQ rate and assuming 8 hr of sunshine, the daily summary file size will be ~1 MB or ~170 bytes per timestamp. The spectral file size is ~37 KB per measurement, so for 8 hr of sunshine per day at a 30 s DAQ rate, the daily spectral data size will be ~36 MB. The user is advised to use the **Custom spectrum timer** and **Spectrum timer** options in the `user_settings.conf` file to reduce the daily spectral data set size as desired.

Spectral irradiance (280-4000nm) (W/m2/nm)
0.000036
0.000113
0.000188
0.001358
0.001553
0.003458
0.003846
0.006862
0.009112
0.009479

Figure 14: SolarSIM-G spectrum data file snippet.

Timestamp	Time zone (hr)	Elevation (deg)	Azimuth (deg)	Ambient temperature (C)	Ambient pressure (kPa)	Ambient humidity (%)	Internal temperature (C)	Internal humidity (%)	Global irradiance (W/m2)
2024-02-05 12:15:00	-5	28.68	179.535	23.17	101.1	24.1	22.69	5.4	536.47
2024-02-05 12:15:05	-5	28.68	179.558	23.18	101.1	24	22.72	5.4	536.45
2024-02-05 12:15:10	-5	28.68	179.581	23.19	101.1	24	22.74	5.4	536.12
2024-02-05 12:15:15	-5	28.68	179.603	23.21	101.1	24.1	22.79	5.4	536.73
2024-02-05 12:15:20	-5	28.68	179.626	23.22	101.1	24.2	22.8	5.4	536.98
2024-02-05 12:15:25	-5	28.68	179.649	23.24	101.1	24.1	22.82	5.4	536.13
2024-02-05 12:15:30	-5	28.681	179.672	23.25	101.1	24.1	22.86	5.4	535.96
2024-02-05 12:15:35	-5	28.681	179.695	23.27	101.1	24	22.92	5.5	536.56
2024-02-05 12:15:40	-5	28.681	179.717	23.28	101.1	23.9	22.94	5.4	536.09
2024-02-05 12:15:45	-5	28.681	179.74	23.29	101.1	24	22.96	5.4	535.89
2024-02-05 12:15:50	-5	28.681	179.763	23.31	101.1	24	22.98	5.4	535.94
2024-02-05 12:15:55	-5	28.681	179.786	23.32	101.1	24	23.03	5.4	535.1

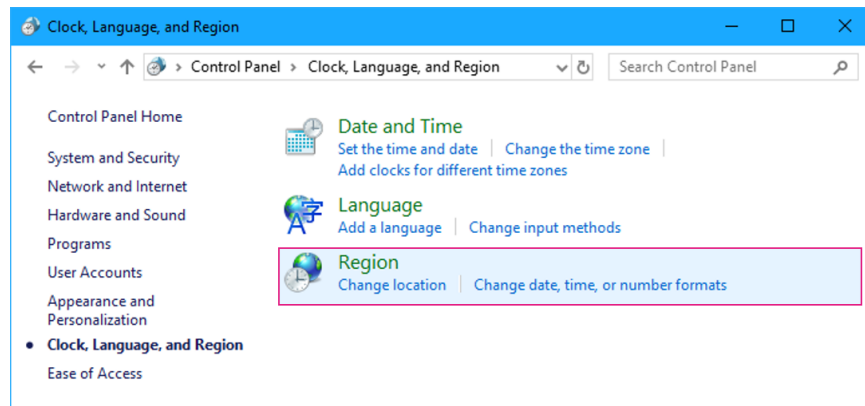


PAR (W/m2)	UV total (W/m2)	UV-A (W/m2)	UV-B (W/m2)	UV-E (W/m2)	SCF 1	SCF 2	SCF 3	SCF 4	SCF 5	SCF 6	SCF 7	SCF 8	SCF 9
220.79	18.515	18.321	0.235	0.028	0	0	0	0	0	0	0	0	0
220.815	18.493	18.304	0.229	0.027	0	0	0	0	0	0	0	0	0
220.673	18.492	18.303	0.229	0.027	0	0	0	0	0	0	0	0	0
220.926	18.529	18.338	0.231	0.028	0	0	0	0	0	0	0	0	0
220.988	18.502	18.312	0.229	0.027	0	0	0	0	0	0	0	0	0
220.57	18.488	18.298	0.23	0.027	0	0	0	0	0	0	0	0	0
220.482	18.49	18.299	0.231	0.028	0	0	0	0	0	0	0	0	0
220.914	18.496	18.304	0.232	0.028	0	0	0	0	0	0	0	0	0
220.454	18.505	18.313	0.232	0.028	0	0	0	0	0	0	0	0	0
220.509	18.542	18.345	0.238	0.028	0	0	0	0	0	0	0	0	0
220.118	18.503	18.312	0.232	0.028	0	0	0	0	0	0	0	0	0
220.144	18.469	18.283	0.226	0.027	0	0	0	0	0	0	0	0	0

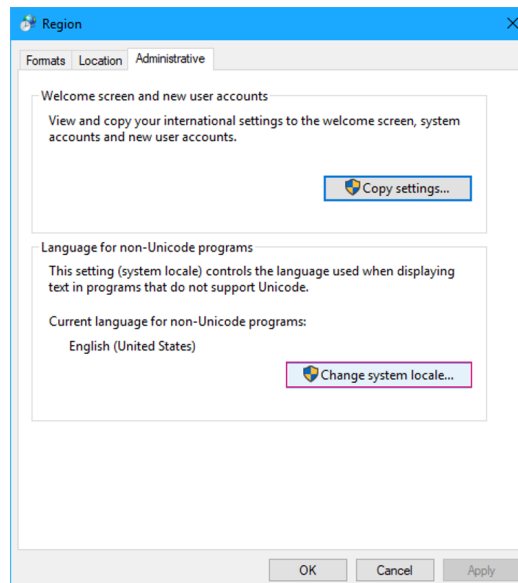
Figure 15: SolarSIM-G daily summary file snippet.

## 5.6 Changing default language for non-Unicode characters

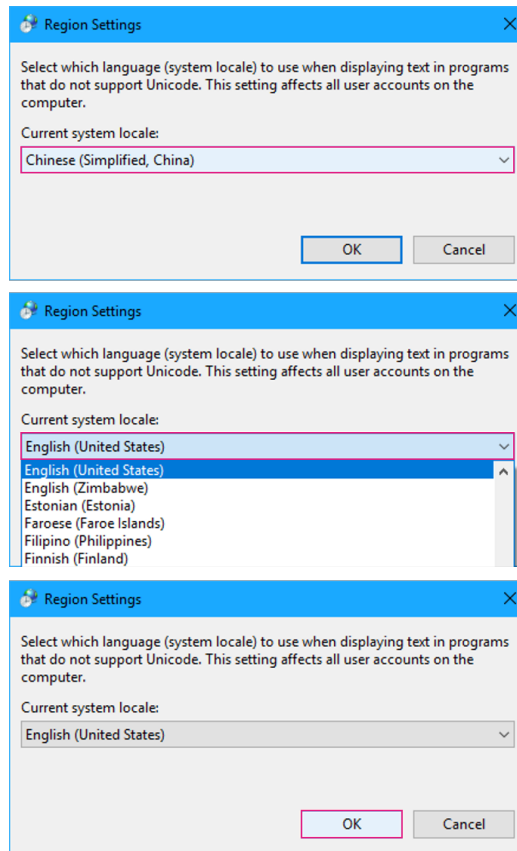
For users of computers with non-Latin based languages, such as Mandarin, the SolarSIM-G DAQ may improperly display non-Unicode characters. To solve this problem, the user must change the default language for non-Unicode programs to English. To do so, first locate the Clock, Language, and Region settings in the Control Panel, then click on Region settings, as show in Figure 16. Then navigate to the Administrative tab and select **Change system locale...**, as demonstrated in Figure 17. Lastly, change the language to **English** from the drop down menu, as shown in Figure 18, and press OK.



**Figure 16:** Clock, Language, and Region settings in the Control Panel.



**Figure 17:** Changing the system locale in the Administrative tab of the Region settings.



**Figure 18:** Changing the default language for non-Unicode characters..

## 6 Datalogger setup

The SolarSIM-G can be interfaced with any datalogger, provided the latter has the RS-485 functionality. However, compared to other SolarSIM-G connectivity options, this approach is slightly more involved. In a nutshell, the user must execute the following steps to process the data from the SolarSIM-G:

1. Setup the serial communication between the datalogger and the SolarSIM-G.
2. Send the serial command from the datalogger to the SolarSIM-G.
3. Retrieve the raw data from the datalogger.
4. Format the raw data into a specific format.
5. Place the formatted raw data files into the SolarSG software's directory and run the application.

This section discusses in detail how to proceed with each step, including the serial port configuration, sending and parsing the serial command, formatting the SolarSIM-G raw data into a required format, and how to use the SolarSG software.

### 6.1 Serial port configuration

Prior to configuring the serial port on a datalogger, the user must wire the SolarSIM-G by following instructions from Section 4.2. The serial port is then configured with standard serial parameters as per Table 3.

### 6.2 Serial commands

There is only one serial command that one needs to use to acquire the SolarSIM-G data:

`Nxxxx_E`

where `xxxx` corresponds to the 4-digit serial number of the SolarSIM-G. In return, the SolarSIM-G sends an ASCII string with the ambient temperature, ambient pressure, ambient humidity, internal temperature, internal humidity, and nine voltages from the photodiodes.

**Table 3:** SolarSIM-G serial port configuration.

Parameter	Value
Baud rate	9600
Parity	None
Data bits	8
Stop bits	1

The following ASCII string is a sample output:

```
N1010_2500.000,1013.120,4750.000,2600.000,1050.000,2500.032,4999.999,
0000.001,1274.004,2746.321,3291.214, 3924.385,1900.500,0500.123/r/n
```

The aforementioned string can be parsed as:

N“serial number”\_“( $T_{\text{out}} + 50$ )  $\times$  75”, “ $P_{\text{out}} \times 10$ ”, “ $H_{\text{out}} \times 100$ ”, “( $T_{\text{in}} + 50$ )  $\times$  75”, “ $H_{\text{in}} \times 100$ ”, “ $V_1$ ”, “ $V_2$ ”, “ $V_3$ ”, “ $V_4$ ”, “ $V_5$ ”, “ $V_6$ ”, “ $V_7$ ”, “ $V_8$ ”, “ $V_9$ ”, “end of line character”

where  $T_{\text{out}}$ ,  $P_{\text{out}}$ ,  $H_{\text{out}}$ ,  $T_{\text{in}}$ ,  $H_{\text{in}}$ , and  $V_{1-9}$  are the ambient temperature, the ambient pressure, the ambient humidity, the internal temperature, the internal humidity, and the nine voltages from the detectors, respectively. The aforementioned example string is parsed in Table 4.


**Table 4:** Processed output example for Nxxxx\_E command.

Parameter	Symbol	Value	Units
Ambient temperature	$T_{\text{out}}$	-16.67	$^{\circ}\text{C}$
Ambient pressure	$P_{\text{out}}$	101.312	kPa
Ambient humidity	$H_{\text{out}}$	47.50	%
Internal temperature	$T_{\text{in}}$	-15.33	$^{\circ}\text{C}$
Internal humidity	$H_{\text{in}}$	10.50	%
Voltage channel 1	$V_1$	2500.032	mV
Voltage channel 2	$V_2$	4999.999	mV
Voltage channel 3	$V_3$	0.001	mV
Voltage channel 4	$V_4$	1274.004	mV
Voltage channel 5	$V_5$	2746.321	mV
Voltage channel 6	$V_6$	3291.214	mV
Voltage channel 7	$V_7$	3924.385	mV
Voltage channel 8	$V_8$	1900.500	mV
Voltage channel 9	$V_9$	500.123	mV

### 6.3 Raw data file format

The SolarSG software requires a .csv file in a specific format based on the SolarSIM-G raw data output. The file must have the following headings with the corresponding data: Timestamp, Time zone (hr), Ambient pressure (kPa), Ambient temperature (C), Ambient humidity (%), Internal temperature (C), Internal humidity (%), V1 (mV), V2 (mV), V3 (mV), V4 (mV), V5 (mV), V6 (mV), V7 (mV), V8 (mV), and V9 (mV). Each data row must consists of comma separated values only, with no spaces in between. The timestamp must be strictly in the yyyy-mm-dd HH:MM:SS format, where yyyy, mm, dd, HH, MM, and SS is the year, month, day, hour, minute, and second, respectively. The SolarSG software uses the time stamp and the timezone from the raw data file to determine the UTC time, which is necessary for the solar position algorithm. Therefore, the user must ensure that each time stamp plus the timezone corresponds to the UTC time. The snippet of the raw data file is presented in Figure 19. The raw data file must be named as yyyy-mm-dd\_SSIM\_Raw\_Data\_SNxxxx.csv, where yyyy, mm, dd correspond to the year, month, and day when the raw SolarSIM-G data was generated, while xxxx is a 4-digit serial number of your SolarSIM-G.

Timestamp	Timezone (hr)	Ambient temperature (C)	Ambient pressure (kPa)	Ambient humidity (%)	Internal temperature (C)	Internal humidity (%)
2024-02-05 12:15:00	-5	23.17	101.10	24.1	22.69	5.4
2024-02-05 12:15:05	-5	23.18	101.1	24	22.72	5.4
2024-02-05 12:15:10	-5	23.19	101.1	24	22.74	5.4
2024-02-05 12:15:15	-5	23.21	101.1	24.1	22.79	5.4
2024-02-05 12:15:20	-5	23.22	101.1	24.2	22.8	5.4
2024-02-05 12:15:25	-5	23.24	101.1	24.1	22.82	5.4
2024-02-05 12:15:30	-5	23.25	101.1	24.1	22.86	5.4
2024-02-05 12:15:35	-5	23.27	101.1	24	22.92	5.5
2024-02-05 12:15:40	-5	23.28	101.1	23.9	22.94	5.4
2024-02-05 12:15:45	-5	23.29	101.1	24	22.96	5.4
2024-02-05 12:15:50	-5	23.31	101.1	24	22.98	5.4
2024-02-05 12:15:55	-5	23.32	101.1	24	23.03	5.4

CH1 (mV)	CH2 (mV)	CH3 (mV)	CH4 (mV)	CH5 (mV)	CH6 (mV)	CH7 (mV)	CH8 (mV)	CH9 (mV)
656.27	861.197	915.651	1037.778	1390.468	1154.396	1343.071	1547.116	211.009
656.009	860.349	915.761	1037.208	1392.791	1154.443	1342.699	1548.676	210.887
656.002	860.242	915.43	1036.219	1391.239	1154.385	1342.167	1546.346	210.695
657.288	861.401	914.932	1038.341	1395.028	1154.814	1342.388	1547.544	211.063
656.233	861.652	916.606	1037.799	1393.237	1155.562	1344.624	1546.449	211.262
655.884	859.078	914.017	1036.538	1392.559	1152.631	1343.128	1546.665	211.023
655.69	859.883	914.376	1035.788	1389.433	1155.024	1343.137	1544.223	210.741
655.855	859.558	915.594	1038.964	1394.204	1154.803	1342.261	1546.942	210.939
656.316	859.488	913.391	1036.235	1390.827	1154.048	1342.24	1549.112	211.123
657.092	860.481	913.963	1037.159	1388.31	1151.47	1341.874	1546.426	211.095
656.342	858.749	911.698	1034.531	1388.856	1155.598	1342.831	1547.023	211.335
655.531	858.664	912.759	1033.331	1389.235	1151.222	1335.589	1544.627	211.001

Figure 19: SolarSIM-G raw data file snippet.



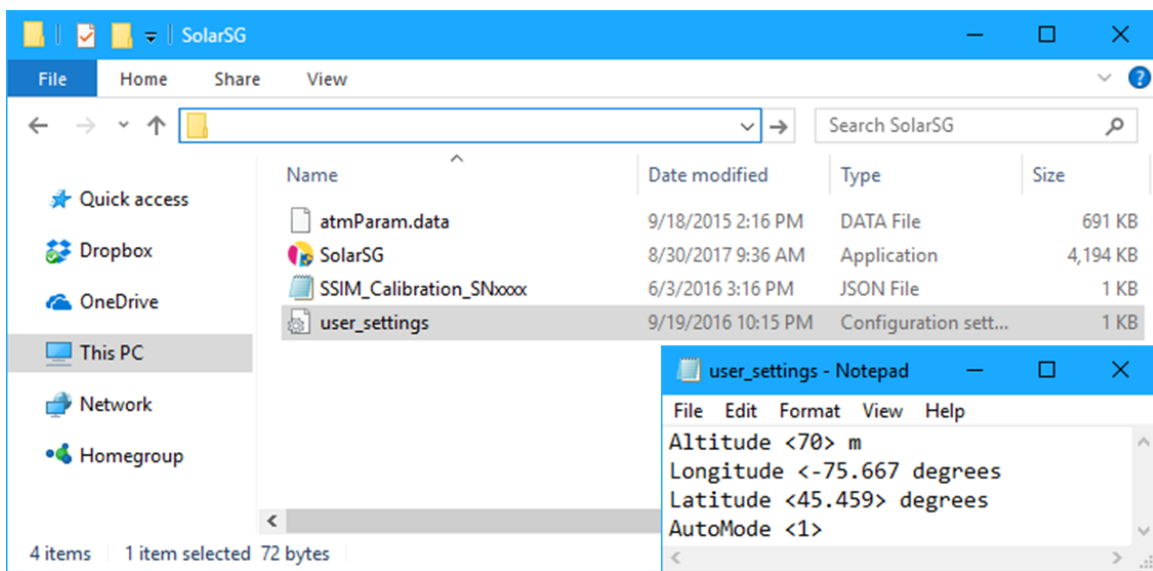
## 6.4 SolarSG application

The SolarSG application is an executable that the user must run to process the raw data from the SolarSIM-G into the spectral data. This software is located on the provided USB key inside a folder with contents as per Figure 20, which initially include:

1. atmParam.data
2. SolarSG.exe
3. SSIM\_Calibration\_SNxxxx.json
4. user\_settings.ini

Please note, the calibration file for the SolarSG application is in a .json format, in contrast to the .cal file format used by the SolarSIM-G DAQ. Prior to running the SolarSG application the user must configure the local geographic settings in the user\_settings.ini file, by modifying the altitude, longitude, and latitude, corresponding to the location of your SolarSIM-G, as shown in Figure 20. Please refer to Table 2 for the allowed ranges and the positive/negative convention of these parameters. Finally, place the raw data .csv file(s) formatted as per Section 6.3 in the SolarSG directory and launch the application.

Once launched, the SolarSG application scans the directory for new raw data files. If raw data files are found, the software processes each file line-by-line. The SolarSG application creates Processed Data\\Global folder, where one can find daily summary files and spectra folders containing the identical data that SolarSIM-G DAQ generates as explained in Section 5.4. The archive folder contains all processed raw data files. For more detailed use of the SolarSG application, please refer to the Appendix section.



**Figure 20:** Modifying geographic settings for the SolarSG application.

## **Appendix: Using the SolarSG Application**

# 1. Introduction

The SolarSG application has two functions:

- 1) To process **batches of SolarSIM raw data .csv files**. The processed data is output and stored as daily summary files and per-timestamp spectral files.
- 2) To process **raw data for a single timestamp** using a command line or equivalent interface. The daily summary data is returned as a standard output (SDTOUT) and the spectral data file is stored in the file path defined by the user.

## 2. Processing batches of raw data files

1. Create a folder (e.g. SolarSG) and place the SolarSG executable, **SSIM\_calibration\_SNxxx**, **atmParam.data**, and **user\_settings** files in it:

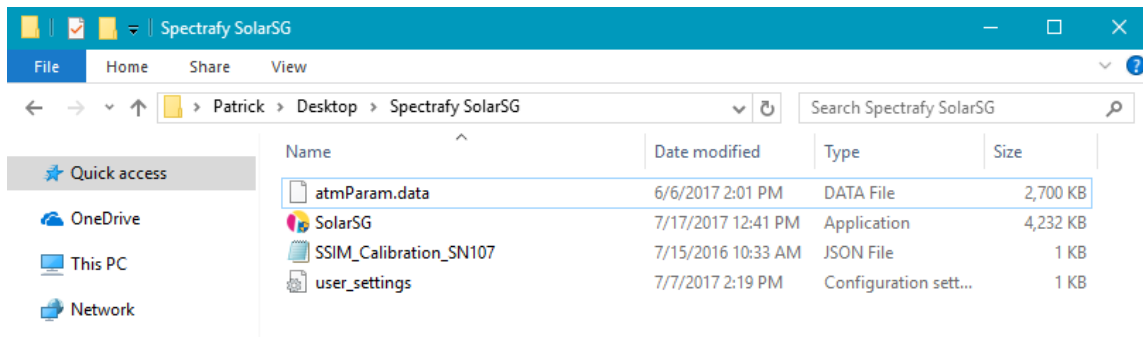


Fig. 1 SolarSG folder showing SolarSG executable, SSIM\_Calibration\_SNxxx, atmParam.data and user\_settings files are all present.

2. Open the **user\_settings.ini** file in a text editor and set the AutoMode to 1(on) or 0(off). With the AutoMode off you will be prompted to validate the user settings each time the SolarSG runs.

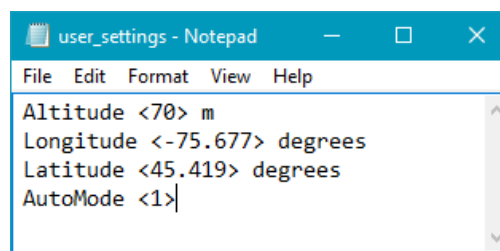


Fig. 2. user\_settings file showing altitude, longitude and latitude of the SolarSIM location and Automode set to 1(on).

3. If you are already working with the SolarSIM raw data .csv files, skip to Step 4. Otherwise, format your SolarSIM raw data into daily .csv files with the following format:
  - a. **SolarSIM-D2**  
 Filename format: **yyyy-mm-dd\_SSIM\_Raw\_Data\_SNxxx.csv**

Raw data columns: Timestamp, Time zone (hr), Ambient temperature (C), Ambient pressure (kPa), Internal temperature (C), Internal humidity (%), V1 (mV), V2 (mV), V3 (mV), V4 (mV), V5 (mV), V6 (mV)

**b. SolarSIM-G**

Filename format: **yyyy-mm-dd\_SSIM\_Raw\_Data\_SNxxxx.csv**

Raw data columns: Timestamp, Time zone (hr), Ambient temperature (C), Ambient pressure (kPa), Ambient humidity (%), Internal temperature (C), Internal humidity (%), V1 (mV), V2 (mV), V3 (mV), V4 (mV), V5 (mV), V6 (mV), V7 (mV), V8 (mV), V9 (mV)

Further details regarding how to format raw data files can be found in Section 6.2 of the SolarSIM-D2 and SolarSIM-G User manuals.

4. Place the raw data file(s) in the SolarSG Folder (one or many raw data files can be placed in the Operating folder for processing at the same time.

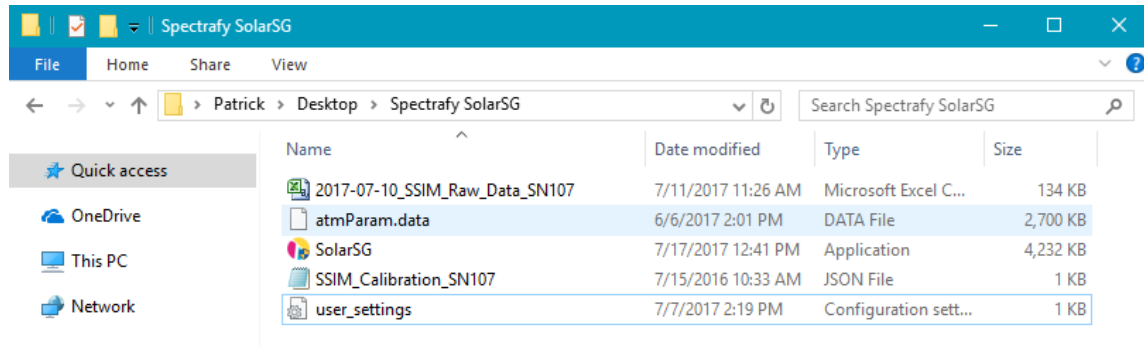


Fig. 3. Operating folder showing the rata data file present.

5. Double-click the SolarSG application – it will start processing the raw data.
6. Processed data will be stored in the folder “-\\Processed Data\\Direct” or “-\\Processed Data\\Global” within the SolarSG Folder for the SolarSIM-D2 or SolarSIM-G, respectively.
  - a. If nothing happens, check the error logs to make sure everything is set up properly.

### 3. Processing raw data for a single timestamp

1. Create a folder (SolarSG) and place the SolarSG executable, `SSIM_calibration_SNxxx`, `atmParam.data`, and `user_settings` files in it

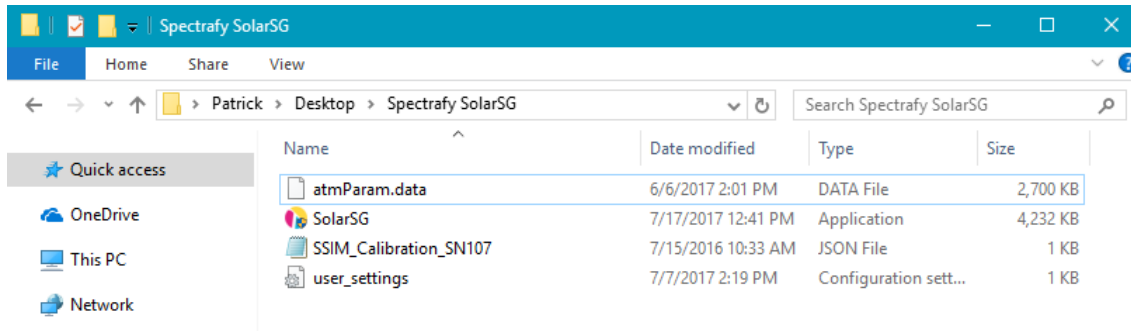


Fig. 4. SolarSG folder showing SolarSG executable, `SSIM_Calibration_SNxxx`, `atmParam.data` and `user_settings` files are all present.

2. Open the `user_settings.ini` file in a text editor and make sure the `AutoMode` parameter is set to 1.

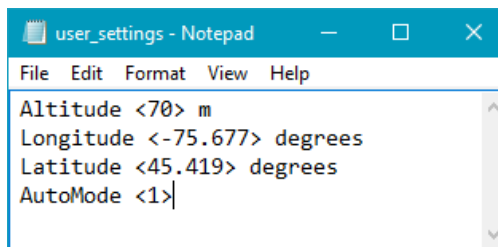


Fig. 5. `user_settings` file showing altitude, longitude and latitude of the SolarSIM location and Automode set to 1(on).

3. Call the `SolarSG.exe` from command prompt or equivalent according to the following examples:

**a. SolarSIM-D2**

- i. Command line input to generate processed data *with* a spectrum:

```
~/ SolarSG.exe d "yyy-mm-dd hh:mm:ss,
timezone,ambient_pressure,ambient_temperature,internal_temperature,internal_humidity,
V1,V2,V3,V4,V5,V6,C:\filepath\to\spectrum.csv,C:\filepath\to\calibration_file.json"
```

- ii. Command line input to generate processed data *without* a spectrum:

```
~/ SolarSG.exe d " yyy-mm-dd hh:mm:ss,
timezone,ambient_pressure,ambient_temperature,internal_temperature,internal_humidity,
V1,V2,V3,V4,V5,V6,-1,C:\filepath\to\calibration_file.json"
```

SolarSIM-D2 output data string format:

```
“yyyy-mm-dd hh:mm:ss,timezone,elevation,azimuth,ambient_temperature,ambient_pressure,  
internal_temperature,DNI,Ozone,PWV,AOD 368nm,AOD 412nm,AOD 500nm,AOD 675nm,AOD 862nm,AOD  
1024nm,I1,I2,I3,I4,I5,I6”
```

## **b. SolarSIM-G**

- i. Command line input to generate processed data *with* a spectrum:

```
~/ SolarSG.exe g “yyyy-mm-dd hh:mm:ss,  
timezone,ambient_temperature,ambient_pressure,ambient_humidity,internal_temperature,  
internal_humidity,V1,V2,V3,V4,V5,V6,V7,V8,V9,C:\filepath\to\spectrum.csv,C:\filepath\to\calibr  
ation_file.json”
```

- ii. Command line input to generate processed data *without* a spectrum:

```
~/ SolarSG.exe g “yyyy-mm-dd hh:mm:ss,  
timezone,ambient_temperature,ambient_pressure,ambient_humidity,internal_temperature,  
internal_humidity,V1,V2,V3,V4,V5,V6,V7,V8,V9,-1,C:\filepath\to\calibration_file.json”
```

### SolarSIM-G output data string format:

```
“yyyy-mm-dd hh:mm:ss,timezone,elevation,azimuth,ambient_temperature,ambient_pressure,  
ambient_humidity,internal_temperature,internal_humidity,GHI”
```

### SolarSIM-G output data string format with precipitable water vapour (PWV) upgrade:

```
“yyyy-mm-dd hh:mm:ss,timezone,elevation,azimuth,ambient_temperature,ambient_pressure,  
ambient_humidity,internal_temperature,internal_humidity,GHI,PWV”
```

Note, the PWV value is reported in mm.