

User Manual:

Solar Spectral Irradiance Meter

SolarSIM-D2



User information

Spectrafy strongly recommends reading this instruction manual prior to installation and operation of your Solar Spectral Irradiance Meter (SolarSIM-D2).

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 modifications to the user manual without prior notice.

Warranty and liability

Spectrafy guarantees that the Solar Spectral Irradiance Meter (SolarSIM-D2) 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 direct Solar Spectral Irradiance Meter (SolarSIM-D2) from Spectrafy. Please become familiar with this instruction manual for a full understanding of the use of your SolarSIM-D2.

The SolarSIM-D2 is designed to be a cost-effective tool for accurately determining the solar spectrum and direct normal irradiance (DNI) 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 six narrow wavelength bands within a full angle of 5° . The SolarSIM-D2's proprietary software uses these measurements to resolve the direct solar spectrum, in addition to major atmospheric processes, such as air mass, Rayleigh scattering, aerosol extinction, ozone and water vapour absorptions.

If you have any questions, please feel free to contact a Spectrafy representative or e-mail info@spectrafy.com

1 Main components

The exploded view of SolarSIM-D2 components is shown in Figure 1, which includes

- a front cap,
- a front window,
- bandpass filters,
- an enclosure,
- a backplate, and
- a connector.

1.1 Front cap

The front cap is used to secure the front window glass to the enclosure via six screws.

1.2 Front glass

The front glass prevents the ingress of moisture and debris.

1.3 Bandpass filters

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

1.4 Enclosure

The anodized aluminum enclosure secures SolarSIM-D2 components in place, while providing robust protection from the environment.

1.5 Backplate

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

1.6 Connector

The connector provides the power and communication to the SolarSIM-D2 electronics.

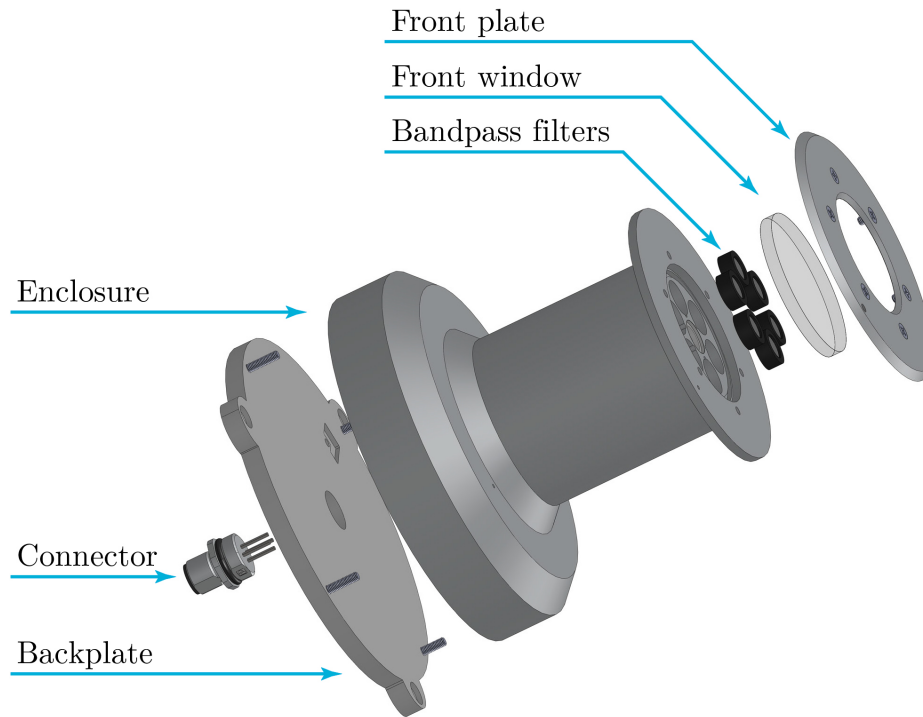


Figure 1: The exploded view of SolarSIM-D2 components.

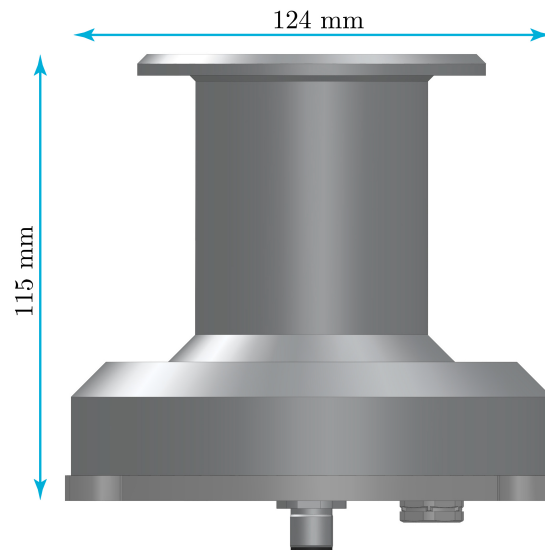


Figure 2: SolarSIM-D2 main dimensions.

2 Installation

2.1 Contents of delivery

Per each ordered SolarSIM-D2 the received package should contain:

- a SolarSIM-D2 $\times 1$,
- a communication cable $\times 1$,
- a SolarSIM-D2 Communication Box $\times 1$ (optional),
- a mounting plate $\times 1$ (optional),
- mounting screws $\times 3$,
- mounting springs $\times 3$, and
- a USB key loaded with the SolarSIM-D2 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-D2 installation requires fastening it to the 165 mm \times 165 mm mounting plate via three M4 screws and springs, as demonstrated in Figure 3. The mounting plate is 4.8 mm thick and has four through holes of 4.5 mm diameter for external fastening, as shown in Figure 4. The screws for external mounting are not provided. The procedure for mechanical installation is described as follows:

1. Place the SolarSIM-D2 on the mounting plate as per Figure 4.
2. Place the spring under the SolarSIM-D2 so that it roughly aligns with one of the mounting holes on the SolarSIM-D2.
3. Insert the mounting screw through the SolarSIM-D2'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. Once the SolarSIM-D2 is on the sun, adjust the mounting screws to align the SolarSIM-D2 to the sun using the alignment pinhole.

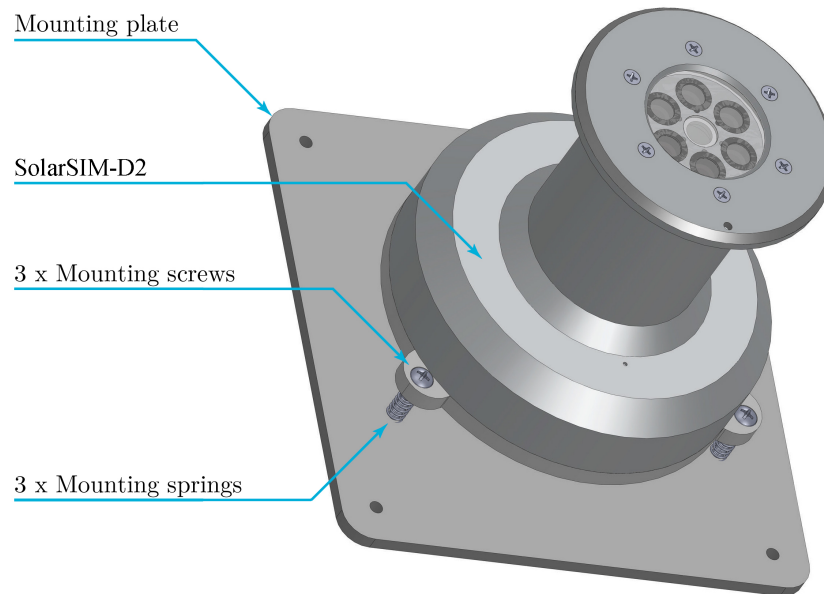


Figure 3: Assembled SolarSIM-D2 on a mounting plate.

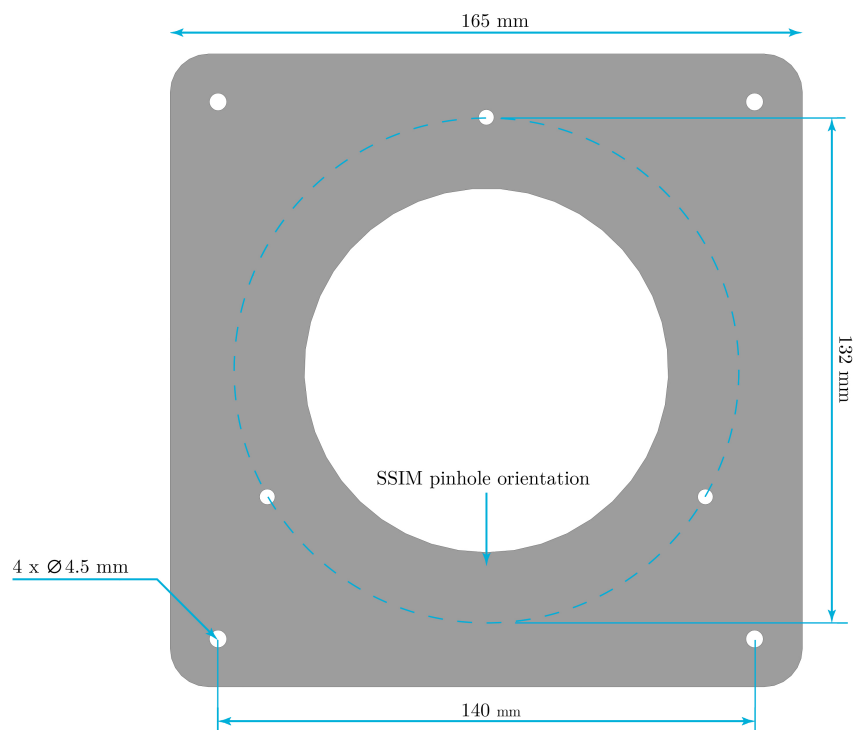


Figure 4: Dimensional drawing of a mounting plate.

3 Maintenance

The SolarSIM-D2 needs very little maintenance. The most important task is to make sure that the front window of the SolarSIM-D2 is clean at all times, as the accumulation of dirt can lead to misrepresented data. Furthermore, the alignment of the SolarSIM-D2 should be checked regularly.

3.1 Cleaning

As a general rule, we recommend cleaning the SolarSIM-D2'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 alignment of the instrument using the pinhole, provided it is sunny. If the sun's spot size is not centred within the pinhole, adjust the appropriate mounting screws to re-align the SolarSIM-D2.

3.3 Desiccant

The desiccant is used to maintain an appropriate humidity level within the SolarSIM-D2. It should appear blue to begin with, as visible through the front window. Once the desiccant is saturated, it will turn red. The colour of the desiccant should be checked regularly as part of the cleaning procedure. The lifetime of the desiccant is expected to exceed two years, although it may vary based on the local climatic conditions. The desiccant can be replaced as part of the SolarSIM-D2's recalibration procedure.

3.4 Recalibration

We recommend that the SolarSIM-D2 is returned to Spectrafy for recalibration **every two years** in order to maintain the SolarSIM's specified measurement accuracy.

4 Connectivity

The SolarSIM-D2 offers unparalleled connectivity options suitable for most use case scenarios. The connectivity solutions include

1. A SolarSIM-D2 Communication Box,
2. A serial-over-Ethernet converter, or
3. A datalogger.

Option 1 uses the SolarSIM-D2 Communication Box (COMBOX) - a seamless link between a PC and the SolarSIM-D2, as shown in Figure 5. 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-D2. 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 to interface with the SolarSIM-D2 via 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-D2 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 the use of the SolarSIM 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-D2. This raw data must be specifically formatted by the user into a .csv file, which is then fed into the SolarSG software to generate a complete SolarSIM-D2 data set, as further eluded to in Section 6.3. This option is ideal for remote test sites and locations with existing datalogger systems.

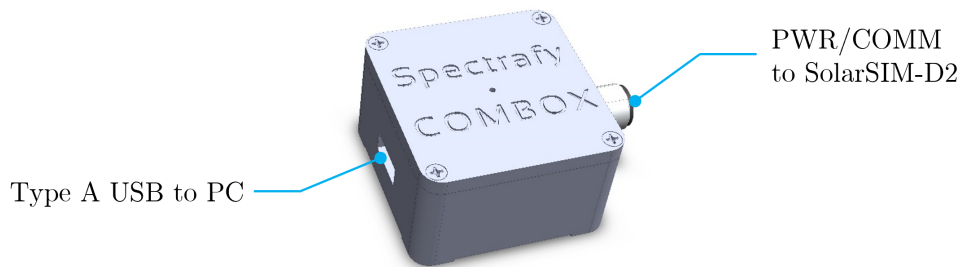


Figure 5: The COMBOX interfaces the SolarSIM-D2 to a PC.

4.1 SolarSIM-D2 COMBOX

The COMBOX, depicted in Figure 5, is the most convenient way to acquire data from the SolarSIM-D2. Please follow these steps to install the COMBOX:

1. Connect one end of the communication cable to the SolarSIM-D2.
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-D2.
5. Wait for the PC 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-D2 can be connected to a networked PC via a suitable serial-over-Ethernet (SOE) converter - such as the ICP DAS I-7188-E2¹. The user must connect the SolarSIM-D2 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-D2 with the voltage higher than **12 VDC** will damage the SolarSIM-D2 electronics.

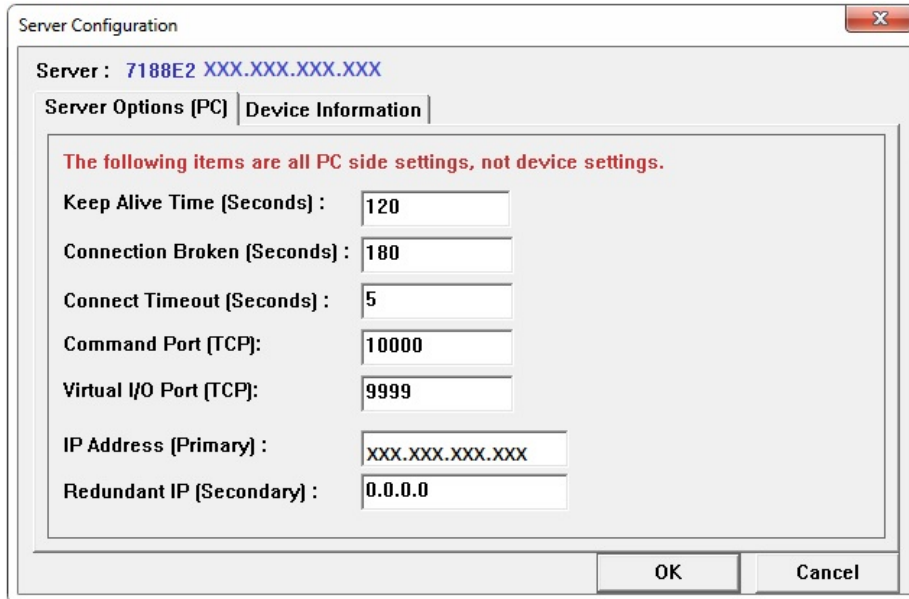
The network must assign a static IP address to the SOE converter. Afterwards, a virtual communication link can be established via the VxComm software². The latter must be configured as per Figures 6 and 7. Once properly configured, the VxComm software creates a virtual serial port on the networked PC, which the SolarSIM DAQ application uses to communicate to the SolarSIM-D2.

¹https://www.icpdas-usa.com/i_7188e2.html

²http://ftp.icpdas.com/pub/cd/8000cd/napdos/driver/vxcomm_driver/windows/

Table 1: Wiring guide for the SolarSIM-D2.

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



Server Configuration

Server : 7188E2 XXX.XXX.XXX.XXX

Server Options [PC] | Device Information

The following items are all PC side settings, not device settings.

Keep Alive Time (Seconds) : 120

Connection Broken (Seconds) : 180

Connect Timeout (Seconds) : 5

Command Port (TCP): 10000

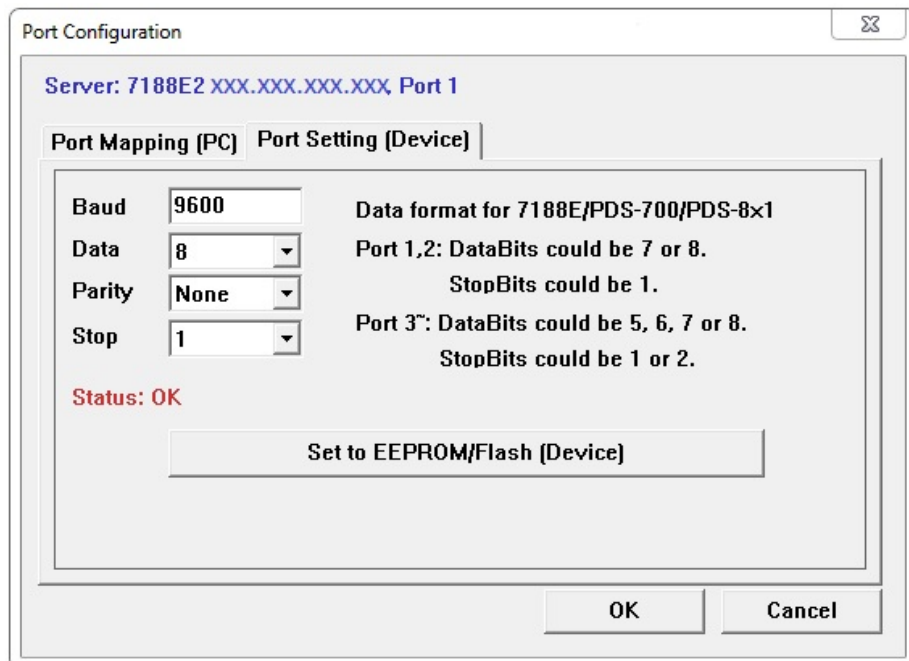
Virtual I/O Port (TCP): 9999

IP Address (Primary) : XXX.XXX.XXX.XXX

Redundant IP (Secondary) : 0.0.0.0

OK Cancel

Figure 6: Server configuration for VxComm software. Note, the SolarSIM-D2 supports only the ASCII RS-485 communication mode.



Port Configuration

Server: 7188E2 XXX.XXX.XXX.XXX, Port 1

Port Mapping [PC] | Port Setting [Device]

Baud 9600

Data 8

Parity None

Stop 1

Data format for 7188E/PDS-700/PDS-8x1

Port 1,2: DataBits could be 7 or 8.
StopBits could be 1.

Port 3~: DataBits could be 5, 6, 7 or 8.
StopBits could be 1 or 2.

Status: OK

Set to EEPROM/Flash (Device)

OK Cancel

Figure 7: Port configuration for VxComm software. Note, the SolarSIM-D2 supports only the ASCII RS-485 communication mode.

4.3 Datalogger

The connectivity with a datalogger is similar to the SolarSIM-D2's integration with the SOE converter. The SolarSIM-D2 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-D2 DAQ Application

The SolarSIM DAQ application provides the user with the real-time status of the instrument, data acquisition and storage, and daily data plots. The SolarSIM DAQ 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 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 8. The user should follow the installation instructions as prompted by the software.

5.2 Software settings

Once the SolarSIM-D2 DAQ software is installed, the user must define the location-specific geographic settings for the SolarSIM-D2 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

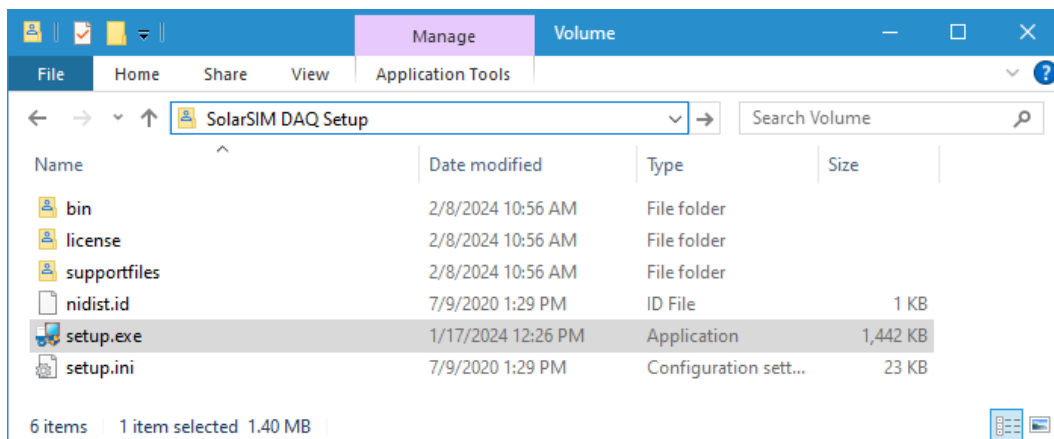


Figure 8: Installation of the SolarSIM-D2 DAQ software.

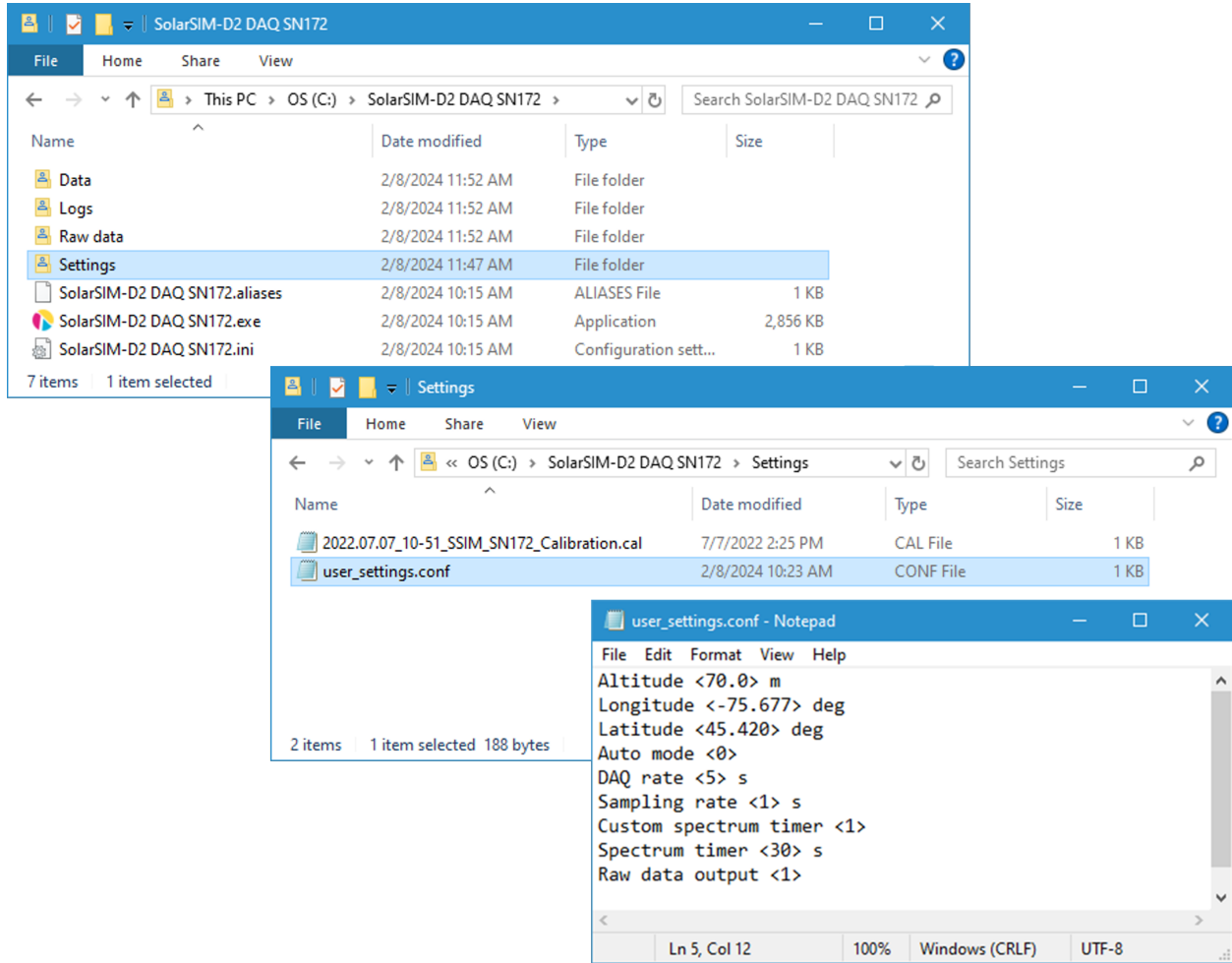


Figure 9: Adjustment of the SolarSIM-D2 DAQ user settings.

directory, as shown in Figure 9. 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-D2 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-D2 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-D2 software is launched by double-clicking the SolarSIM-D2 DAQ SNxxx.exe in the installation directory, where **xxxx** is a 3-digit serial number of your SolarSIM-D2. 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-D2 calibration file. If the SolarSIM-D2 DAQ detects multiple calibration files, the application will prompt the user to select the serial number of the desired SolarSIM-D2, as shown in Figure 11.

The SolarSIM-D2 DAQ software then searches for the serial port to which the SolarSIM-D2 is connected. If the SolarSIM-D2 is not detected, the program displays the message as shown in Figure 12 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.

The SolarSIM-D2 DAQ software is depicted in Figure 14. The fully licensed version of the software displays the real-time direct normal spectral irradiance, the daily plots of the broadband direct normal irradiance, subcell currents for up to nine user-defined subcell spectral responses, aerosol optical depth for six key wavelengths, e.g. at 500 nm, total ozone column content, precipitable water vapour amount, ambient temperature and pressure, individual SolarSIM-D2 channel currents, and the elevation angle. Data for plots, other than the ambient temperature and pressure, 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-D2.

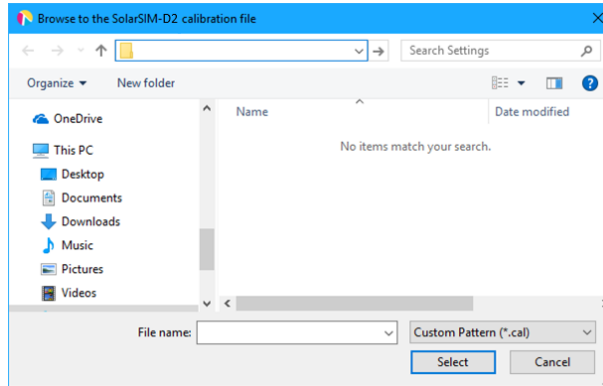


Figure 10: Browsing to the calibration file.

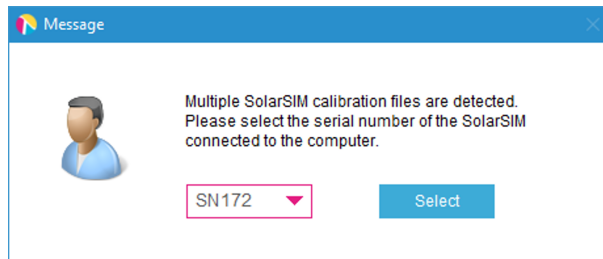


Figure 11: Selecting multiple calibration files.



Figure 12: Failing to detect the SolarSIM-D2.

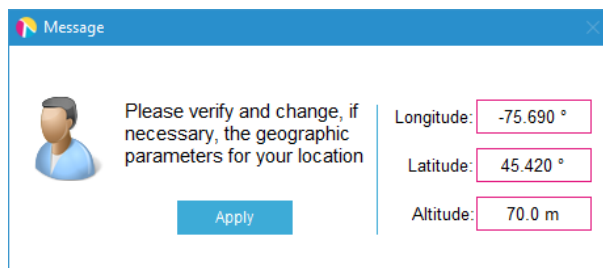


Figure 13: Changing and verifying geographic settings.

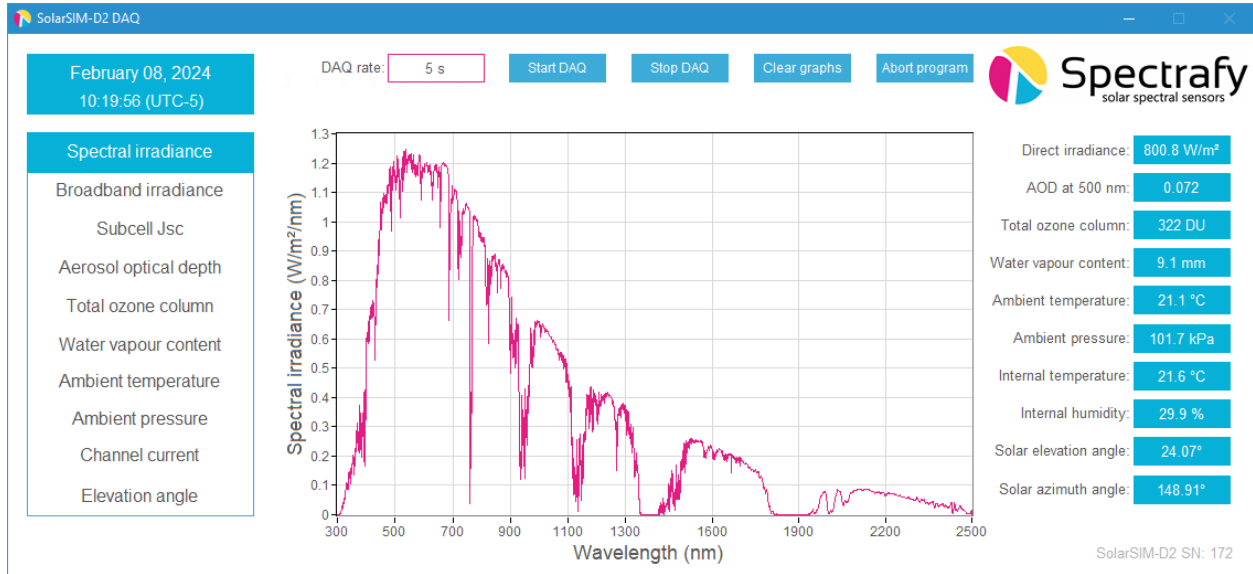


Figure 14: SolarSIM-D2 DAQ application.

5.4 Data type and storage

The SolarSIM DAQ stores the SolarSIM-D2 data in the **Data** folder, located in the installation directory. The software outputs two data file 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-D2 spectrum file is presented in Figure 15. As shown, the wavelength column is not included to minimize the file size. Rather the 3721 values of the spectral irradiance in units of $\text{W/m}^2/\text{nm}$ 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 spectral ozone absorption, water vapour absorption and aerosols transmission are also recorded in this file if this functionality is enabled, as shown in Figure 15.

The daily summary data files are stored in the **Data** folder. A snippet of the SolarSIM-D2 data file is shown in Figure 16. It contains the data for the elevation and azimuth angles, the ambient temperature and pressure, the internal temperature and humidity, the broadband direct normal irradiance, the total ozone column content, the precipitable water vapour amount, the aerosol optical depth at six wavelengths, individual channel currents, and nine subcell current density values.

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 ~ 180 bytes per timestamp. The spectral file size is ~ 157 KB per measurement. The size of the entire spectral file data set depends on the amount of daily sunlight, but with a 30 s DAQ rate and with 8 hr of sunshine per day, it adds up to ~ 150 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 from 280-4000nm (W/m ² /nm)	Aerosol optical depth	Ozone transmission	Water vapour transmission
1.32E-16	4.40E-01	1.44E-14	1.00E+00
5.37E-15	4.39E-01	2.60E-13	1.00E+00
2.42E-13	4.38E-01	6.71E-12	1.00E+00
1.75E-12	4.37E-01	4.01E-11	1.00E+00
2.03E-11	4.36E-01	4.86E-10	1.00E+00

Figure 15: SolarSIM-D2 spectrum data file snippet.

Timestamp	Time zone (hr)	Elevation (deg)	Azimuth (deg)	Ambient temperature (C)	Ambient pressure (kPa)	Internal temperature (C)	Internal humidity (%)
2022-09-01 12:30:10	-7	57.648	193.748	37.65	82.05	39.85	24.6
2022-09-01 12:30:20	-7	57.64	193.824	37.64	82.05	39.83	24.5
2022-09-01 12:30:30	-7	57.632	193.9	37.63	82.05	39.82	24.6
2022-09-01 12:30:40	-7	57.625	193.975	37.62	82.05	39.79	24.6
2022-09-01 12:30:50	-7	57.617	194.051	37.61	82.04	39.8	24.6

DNI (W/m ²)	O ₃ (DU)	H ₂ O (mm)	AOD 368 nm	AOD 412 nm	AOD 500 nm	AOD 675 nm	AOD 862 nm	AOD 1024 nm
468.8	250	13.48	0.8168	0.7666	0.6918	0.6565	0.6476	0.6414
281.76	-1	-1	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
441.26	-1	-1	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
570.73	267	13.41	0.7187	0.6535	0.5593	0.4992	0.4705	0.4514
773.89	269	13.31	0.4808	0.4064	0.3079	0.2414	0.2088	0.1886

I1 (uA)	I2 (uA)	I3 (uA)	I4 (uA)	I5 (uA)	I6 (uA)	Jsc 1 (mA/cm ²)	Jsc 8 (mA/cm ²)	Jsc 9 (mA/cm ²)
8.958	18.046	23.576	21.2	17.671	6.582	0	0	0
5.572	11.134	14.317	12.823	10.507	3.873	0	0	0
8.286	16.774	21.965	19.861	16.714	6.222	0	0	0
10.266	21.06	28.043	25.52	21.83	8.195	0	0	0
13.771	28.34	37.985	34.624	29.765	11.214	0	0	0

Figure 16: SolarSIM-D2 daily summary file snippet.

5.6 Changing default language for non-Unicode characters

For users of computers with non-Latin based languages, such as Chinese, the SolarSIM-D2 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 17. Then navigate to the Administrative tab and select **Change system locale...**, as demonstrated in Figure 18. Lastly, change the language to **English** from the drop down menu, as shown in Figure 19, and press OK.

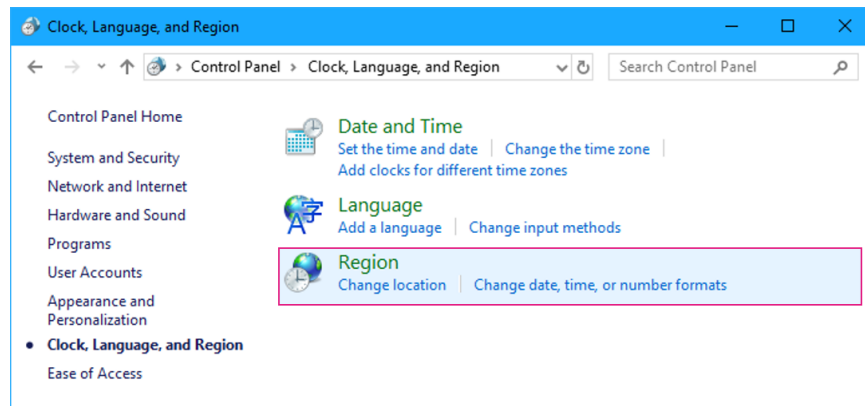


Figure 17: Clock, Language, and Region settings in the Control Panel.

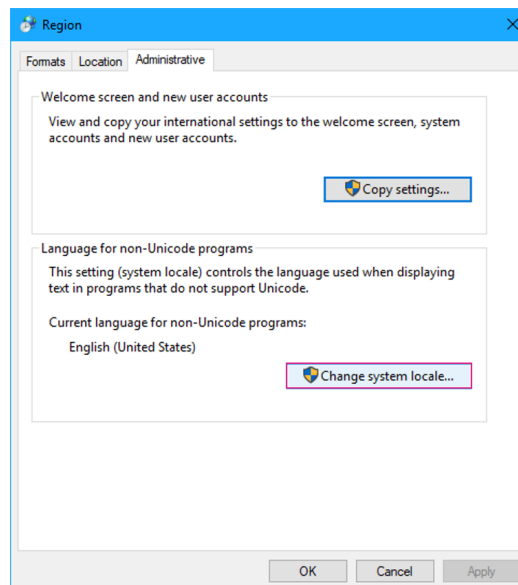


Figure 18: Changing the system locale in the Administrative tab of the Region settings.

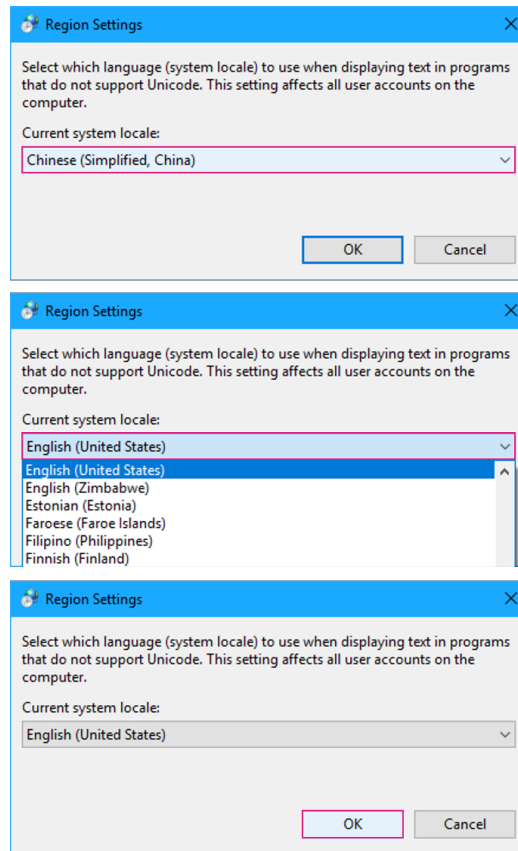


Figure 19: Changing the default language for non-Unicode characters..

6 Datalogger setup

The SolarSIM-D2 can be interfaced with any datalogger, provided the latter has the RS-485 functionality. However, compared to other SolarSIM-D2 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-D2:

1. Setup the serial communication between the datalogger and the SolarSIM-D2.
2. Send the serial command from the datalogger to the SolarSIM-D2.
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-D2 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-D2 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-D2 data:

Nxxx_E

where **xxx** corresponds to the 3-digit serial number of your SolarSIM-D2. In return, the SolarSIM-D2 sends an ASCII string with the ambient pressure, ambient temperature, internal temperature, internal humidity, and six voltages from the detectors. The following ASCII

Table 3: SolarSIM-D2 serial port configuration.

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

string is a sample output:

N115_1013.120,2500.000,2700.000,1530.000,2500.032,4999.999,
0000.001,1274.004,2746.321,3291.214/r/n

The aforementioned string can be parsed as:

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

where P_{out} , T_{out} , T_{in} , H_{in} , and V_{1-6} are the ambient pressure, the ambient temperature, the internal temperature, the internal humidity, and the six voltages from the detectors, respectively. The aforementioned example string is parsed in Table 4. Please note, this string structure applies to the SolarSIM-D2 with the serial number 112 and above.


Table 4: Processed output example for Nxxx_E command.

Parameter	Symbol	Value	Units
Ambient pressure	P_{out}	101.312	kPa
Ambient temperature	T_{out}	-16.67	°C
Internal temperature	T_{in}	-14.00	°C
Relative humidity	H_{in}	15.3	%
Voltage channel 1	V_1	2500.032	mV
Voltage channel 2	V_2	4999.999	mV
Voltage channel 3	V_3	0000.001	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

6.3 Raw data file format

The SolarSG software requires a .csv file in a specific format based on the SolarSIM-D2 raw data output. The file must have the following headings with the corresponding data: Timestamp, Timezone (hr), Ambient temperature (C), Ambient pressure (kPa), Internal temperature (C), Internal humidity (%), V1 (mV), V2 (mV), V3 (mV), V4 (mV), V5 (mV), and V6 (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 20. The raw data file must be named as yyyy-mm-dd_SSIM_Raw_Data_SNxxx.csv, where yyyy, mm, dd correspond to the year, month, and day when the raw data was generated, while xxx is the 3-digit serial number of your SolarSIM-D2.

Timestamp	Timezone (hr)	Ambient temperature (C)	Ambient pressure (kPa)	Internal temperature (C)
2022-09-01 12:30:10	-7	37.65	82.05	39.85
2022-09-01 12:30:20	-7	37.64	82.05	39.83
2022-09-01 12:30:30	-7	37.63	82.05	39.82
2022-09-01 12:30:40	-7	37.62	82.05	39.79
2022-09-01 12:30:50	-7	37.61	82.04	39.8



Internal humidity (%)	V1 (mV)	V2 (mV)	V3 (mV)	V4 (mV)	V5 (mV)	V6 (mV)
24.6	671.416	1353.099	1767.905	1589.704	1324.976	493.159
24.5	417.403	834.65	1073.38	961.324	787.555	289.989
24.6	621.012	1257.712	1647.086	1489.239	1253.16	466.144
24.6	769.482	1579.141	2102.99	1913.753	1636.919	614.158
24.6	1032.421	2125.23	2848.737	2596.609	2232.158	840.646

Figure 20: SolarSIM-D2 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-D2 into the spectral data. This software is located on the provided USB key inside a folder with contents as per Figure 21, which initially include:

1. atmParam.data
2. SolarSG.exe
3. SSIM_Calibration_SNxxx.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-D2 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-D2, as shown in Figure 21. 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**\\Direct folder, where one can find **daily summary files** and **spectra** folders containing the identical data that SolarSIM-D2 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.

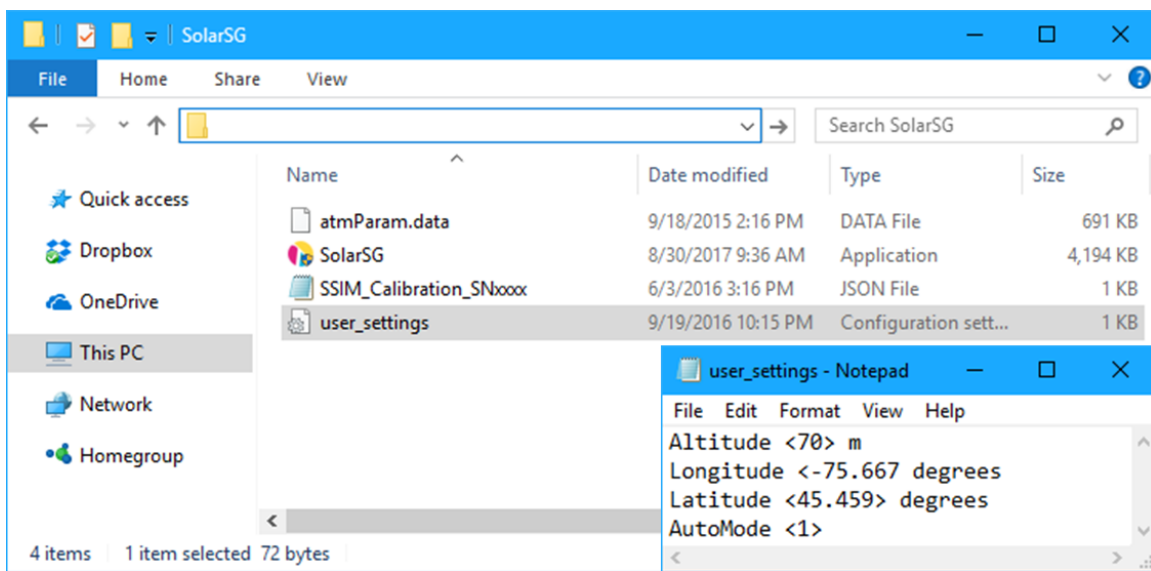


Figure 21: Modifying geographic settings for the SolarSG application.

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:

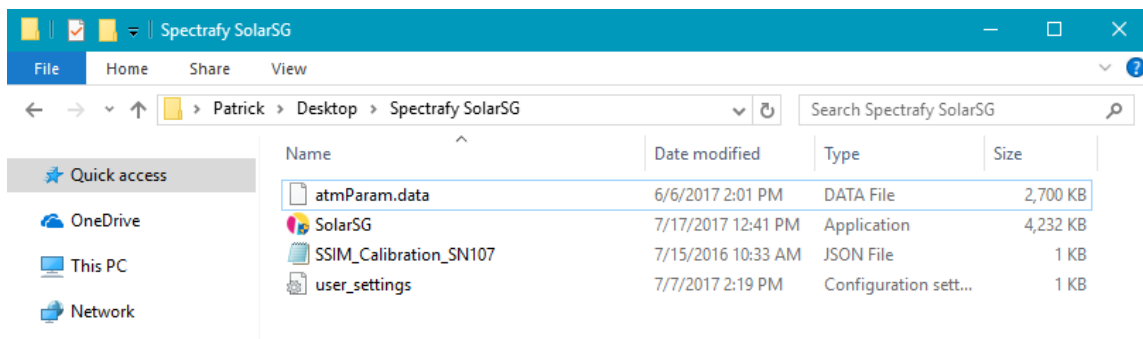


Fig. 1 SolarSG folder showing SolarSG executable, SSIM_Calibration_SNxxx, atmParam.data and user_settings files are all present.

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.

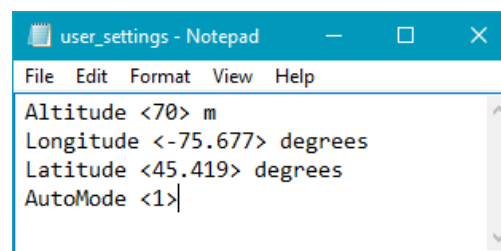


Fig. 2. user_settings file showing altitude, longitude and latitude of the SolarSIM location and Automode set to 1(on).

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.

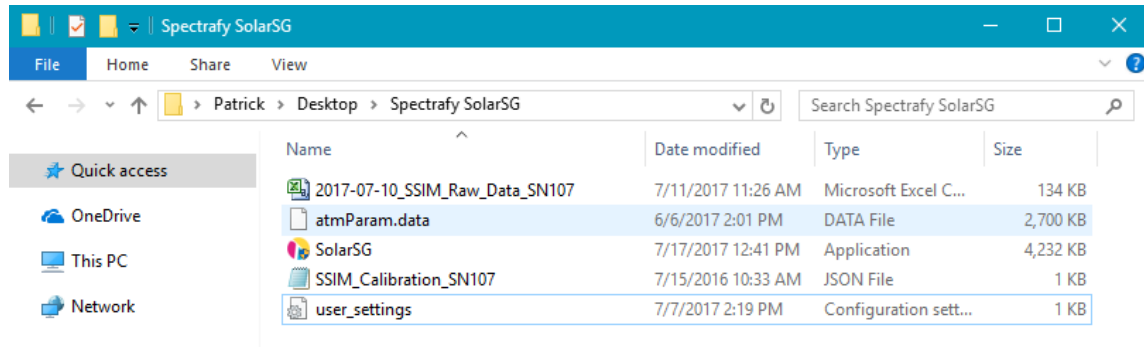


Fig. 3. Operating folder showing the rata data file present.

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

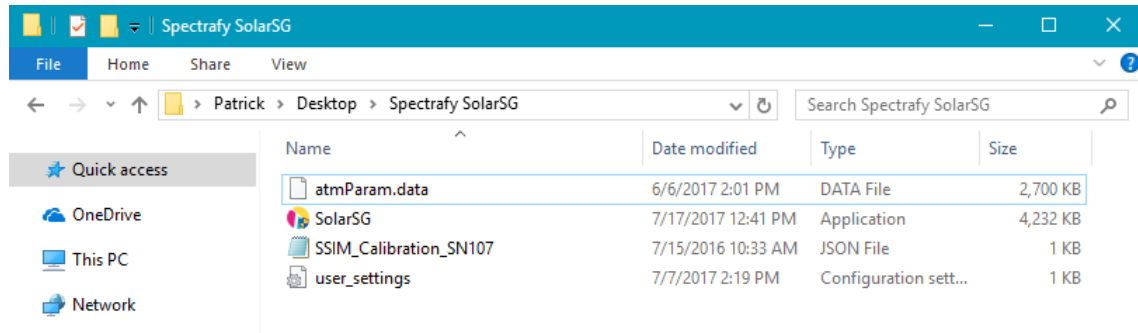


Fig. 4. SolarSG folder showing SolarSG executable, SSIM_Calibration_SNxxx, atmParam.data and user_settings files are all present.

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

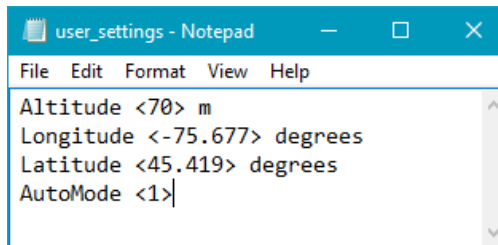


Fig. 5. user_settings file showing altitude, longitude and latitude of the SolarSIM location and Automode set to 1(on).

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.