BemSolar Documentation

Release 1.0

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Introduction:

CHAPTER 1

Installation Steps

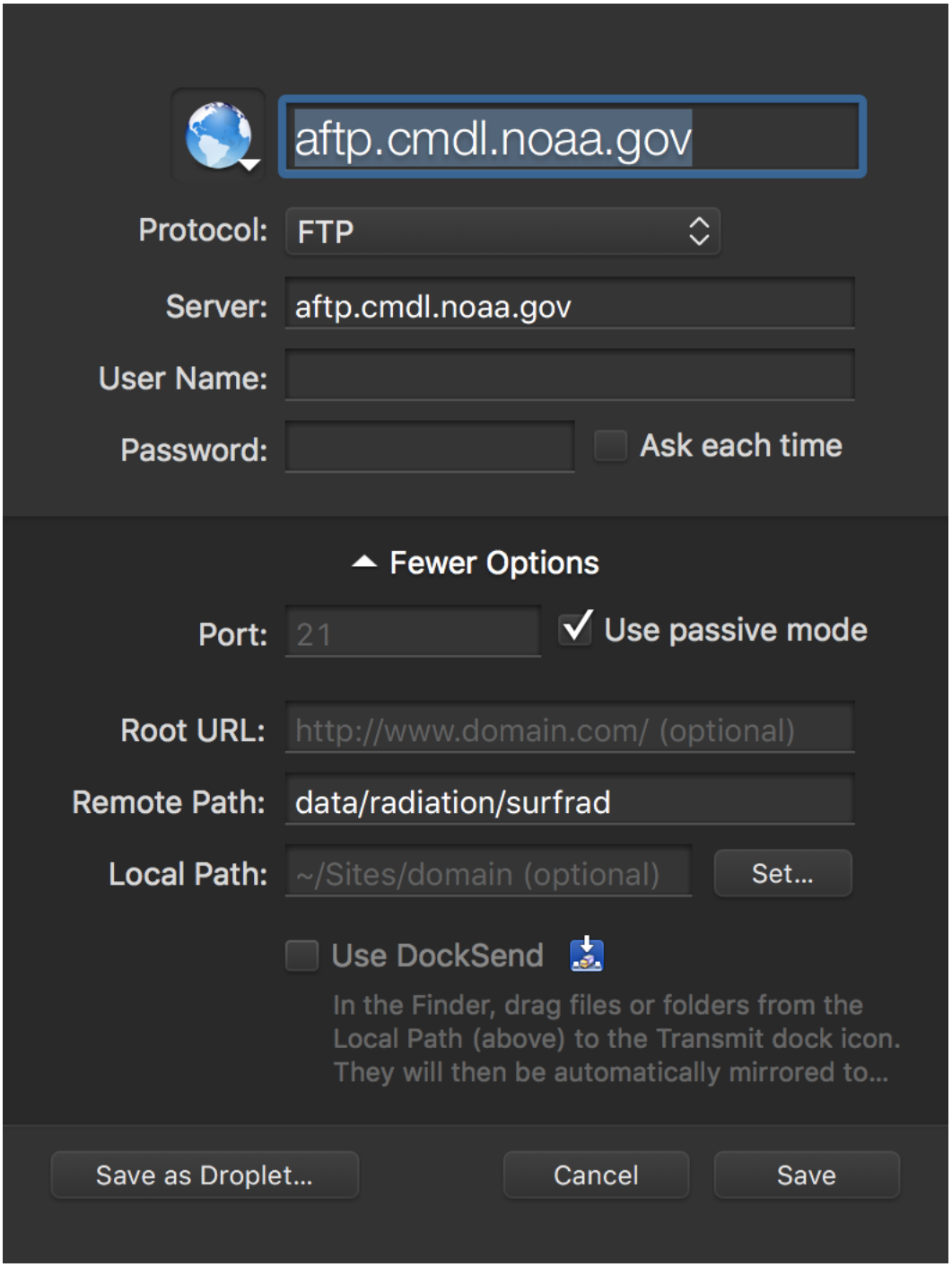
Developers - To get the latest version of the code, you can download the repository from github or clone the project in a local directory using git:

```
git clone https://github.com/polymtl-bee/surfrad.git
```

Once BemSolar is copied to a local directory, you need to download surfrad data from the NOAA (National Oceanic & Atmospheric Administration)

1.1 How to Download raw data

Head to the SURFRAD (Surface Radiation) Network website and click on the *Data Download (FTP)* link or use your favortie FTP client such as Transmit. Optionaly, enter the remote path like image below.


aftp.cmdl.noaa.gov
Protocol: FTP
Server: aftp.cmdl.noaa.gov
User Name:
Password:
Ask each time
Fewer Options
Port: 21
Use passive mode
Root URL: http://www.domain.com/ (optional)
Remote Path: data/radiation/surfrad
Local Path: ~/Sites/domain (optional)
Set...
Use DockSend
In the Finder, drag files or folders from the
Local Path (above) to the Transmit dock icon.
They will then be automatically mirrored to...
Save as Droplet...
Cancel
Save

CHAPTER 2

Understanding surfrad data

The Table 2.1 summarizes the content of a SURFRAD file and the description of each variable used. When open with NotePad++, the station name is on the first line, followed by the latitude, longitude and elevation on the second line. The other variables are organized in columns and each line represents a different measure at a certain time.

Table 2.1: Surfrad variables

Variable	FORTRAN type	Description
station_name	Character (8 bits unsigned)	Station Name (e. g., Goodwin Creek)
latitude	Real (32 bits signed)	Latitude in decimal degrees (e.g., 40.80)
longitude	Real (32 bits signed)	Longitude in decimal degrees (e.g., 105.12)
elevation	Integer (32 bits signed)	Integer elevation above sea level in meter
year	Integer (32 bits signed)	Integer year, i.e., 1995
jday	Integer (32 bits signed)	Integer Julian day (1 through 365 [or 366])
month	Integer (32 bits signed)	Integer number of the month (1-12)
day	Integer (32 bits signed)	Integer day of the month (1-31)
hour	Integer (32 bits signed)	Integer hour of the day (0-23)
min	Integer (32 bits signed)	Integer minute of the hour (0-59)
dt	Real (32 bits signed)	Decimal time (e.g., 23.5 = 2330)
zen	Real (32 bits signed)	Solar zenith angle (degrees)
dw_solar	Real (32 bits signed)	Downwelling global solar (Watts/m2)
uw_solar	Real (32 bits signed)	Upwelling global solar (Watts/m2)
direct_n	Real (32 bits signed)	Direct-normal solar (Watts/m2)
diffuse	Real (32 bits signed)	Downwelling diffuse solar (Watts/m2)
dw_ir	Real (32 bits signed)	Downwelling thermal infrared (Watts/m2)
dw_casetemp	Real (32 bits signed)	Downwelling IR case temp (K)
dw_dometemp	Real (32 bits signed)	downwelling IR dome temp. (K)
uw_ir	Real (32 bits signed)	Upwelling thermal infrared. (K)
uw_casetemp	Real (32 bits signed)	Upwelling IR case temp. (K)
uw_dome temp	Real (32 bits signed)	Upwelling IR dome temp. (K)
uvb	Real (32 bits signed)	global UVB (milliWatts/m2)
par	Real (32 bits signed)	Photosynthetically active radiation (Watts/m2)

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Table 2.1 – continued from previous page

Variable	FORTRAN type	Description
netsolar	Real (32 bits signed)	net solar (dw_solar - uw_solar) (Watts/m2)
netir	Real (32 bits signed)	net infrared (dw_ir - uw_ir) (Watts/m2)
totalnet	Real (32 bits signed)	net radiation (netsolar+netir) (Watts/m2)
temp	Real (32 bits signed)	10 meters air temperature (Celsius)
rh	Real (32 bits signed)	relative humidity (%)
windspd	Real (32 bits signed)	wind speed (m/s)
winddir	Real (32 bits signed)	wind direction (degrees, clockwise from North)
pressure	Real (32 bits signed)	station pressure (mb)

The Table 2.2 gives the name of the variables for each column in the SURFRAD file. As it's possible to see after the dw_solar variable, there is a QC Flag variable because SURFRAD follows the quality control (QC) philosophy of the BSRN. A QC Flag of 0 indicates that the data is good and a value greater than 0 means that the data is questionable. This project doesn't need these flags because in the function *dataVerification*, we automatically verify the data with our own restrictions. It is important to note that missing values are indicated by -9999.9 with a QC Flag of 1 and bad values are automatically deleted. For the missing values, the datetime array will continue to keep the minute or hour time step, but there will be NaN values for all the columns of the missing time.

Also, as explained in the READ ME file of SURFRAD, ''Reported times are the end times of the 1- or 3-min. averaging periods, i.e., the data given for 0000 UTC are averaged over the period from 2359 (or 2357) of the previous UTC day, to 0000 UTC.". All the files are organized in Universal Coordinated Time (UTC), so it's important to know the offset with the Standard Time of your location for the script *dataAnalysis.m*.

As specified in the README file of SURFRAD, the data before January 1 are reported as 3-minutes average and those after, as 1-minute average. So, for the data before 2009, I duplicated the value of the 3-minute average. For example, the rows of 00:00, 00:01 and 00:02 have the same values as 00:00 and so on. For more details, I recommend reading the READ ME file of SURFRAD.

Then, the minute time step table of *readSURFRAD.m* has the same values as those in the original file. The only difference is that you can choose the data to import in *readSURFRAD.m*. For the hour time step table, the values of the hour 00:00 UTC, for example, are the mean values of 00:00 UTC to 00:59 UTC. As specified in the description of the function *meanHour.m*, the Flag values are the average of the NaN and bad values flagged with 1. If this average is over 0.25, all the lines in the hour time step table will be -1.

Table 2.2: Surfrad variables

Column	Variable	Column	Variable
1	Year	25	uw_casetemp
2	Day number	26	QC Flag
3	Month	27	uw_dometemp
4	Day	28	QC Flag
5	Hour	29	uvb
6	Minute	30	QC Flag
7	dt	31	par
8	zen	32	QC Flag
9	dw_solar	33	netsolar
10	QC Flag	34	QC Flag
11	uw_solar	35	netir
12	QC Flag	36	QC Flag
13	direct_n	37	totalnet
14	QC Flag	38	QC Flag
15	diffuse	39	temp
16	QC Flag	40	QC Flag
17	dw_ir	41	rh
18	QC Flag	42	QC Flag
19	dw_casetemp	43	windspd
20	QC Flag	44	QC Flag
21	dw_dometemp	45	winddir
22	QC Flag	46	QC Flag
23	uw_ir	47	pressure
24	QC Flag	48	QC Flag

The Table 2.3 shows the variables for each column of an EPW file. Normally, there is a header in each file, but I automatically copy the one of the original file and write it in the new one with the function *createEPW.m*. So, if you have the original file from Energy Plus you just have to indicate to the function the names of the column that you want to change and it will create a new EPW file with the data that you indicated. It's important to note that if you open the EPW file with Element, the hour will start at 00:00 to 23:00 while with Excel, they start at 1:00 to 24:00.

Table 2.3: EPW file variables

Column	Description
1	Year
2	Month (1-12)
3	Day (1-31)
4	Hour (1-24 on Excel and 0-23 on Element)
5	Minute
6	DataSource
7	Dry Bulb Temperature [C]
8	Dew Point Temperature
9	Relative Humidity [%]
10	Atmospheric Pressure [Pa]
11	Extraterrestrial horizontal radiation [Wh/m2]
12	Extraterrestrial Direct-Normal Radiation [Wh/m2]
13	Horizontal infrared radiation intensity from sky [Wh/m2]
14	Global Horizontal Radiation [Wh/m2]
15	Direct Normal Radiation [Wh/m2]

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Table 2.3 – continued from previous page

Column	Description
16	Diffuse Horizontal Radiation [Wh/m2]
17	Global Horizontal Illuminance [lux]
18	Direct Normal Illuminance [lux]
19	Diffuse Horizontal Illuminance [lux]
20	Zenith Illuminance [lux]
21	Wind Direction [deg]
22	Wind Speed [m/s2]
23	Total Sky Cover [tenths]
24	Opaque Sky Cover [tenths]
25	Visibility [km]
26	Ceiling Height [m]
27	Present Weather Observation
28	Present Weather Code
29	Precipitable Water [mm]
30	Aerosol Optical Depth [thousandths]
31	Snow Depth [cm]
32	Days Since Last Snow
33	Albedo
34	Liquid Precip Depth [mm]
35	Liquid Precip Rate [Hour]

CHAPTER 3

Indices and tables

- genindex
- modindex
- search