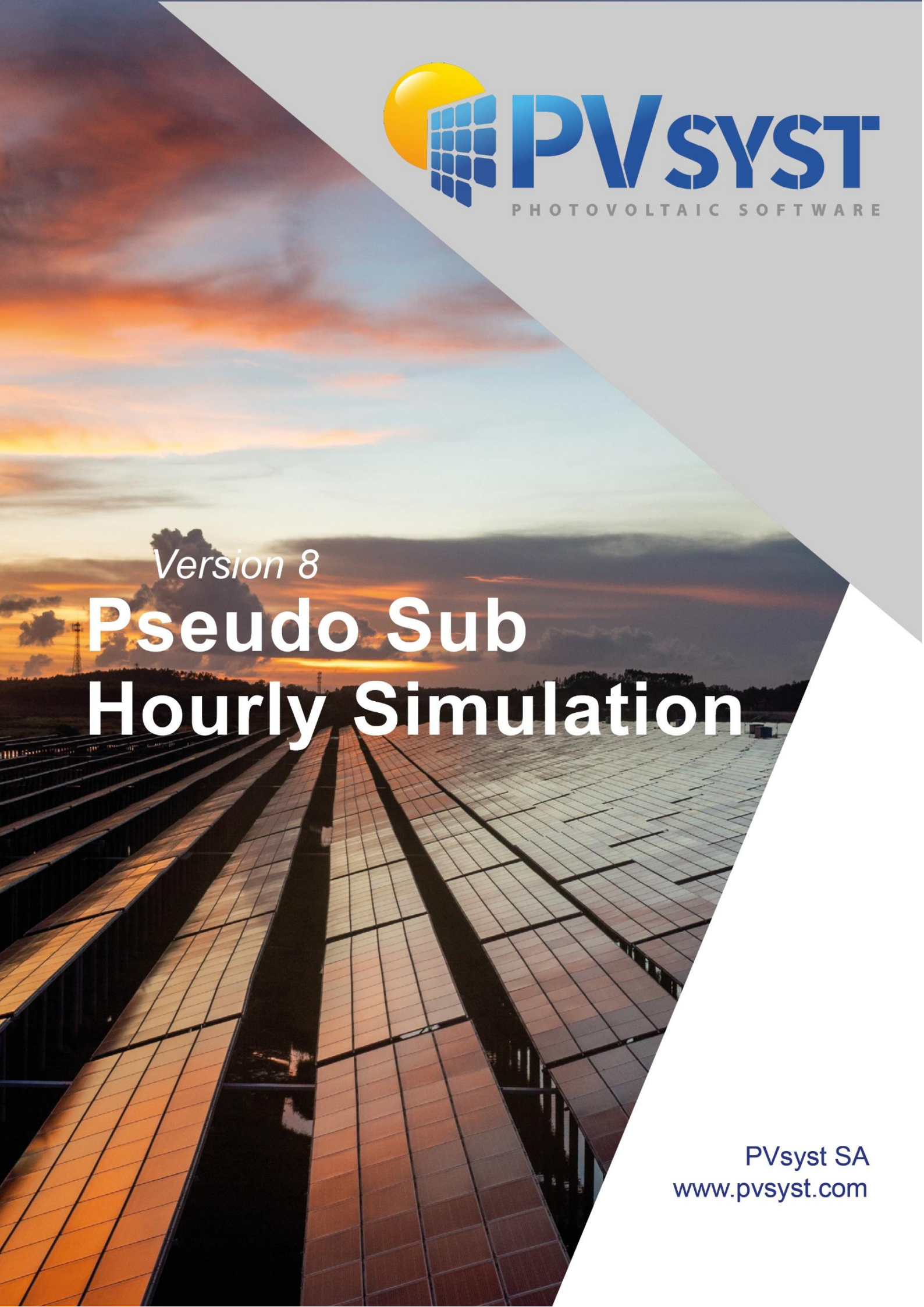


PVSYST
PHOTOVOLTAIC SOFTWARE

Version 8

Pseudo Sub Hourly Simulation

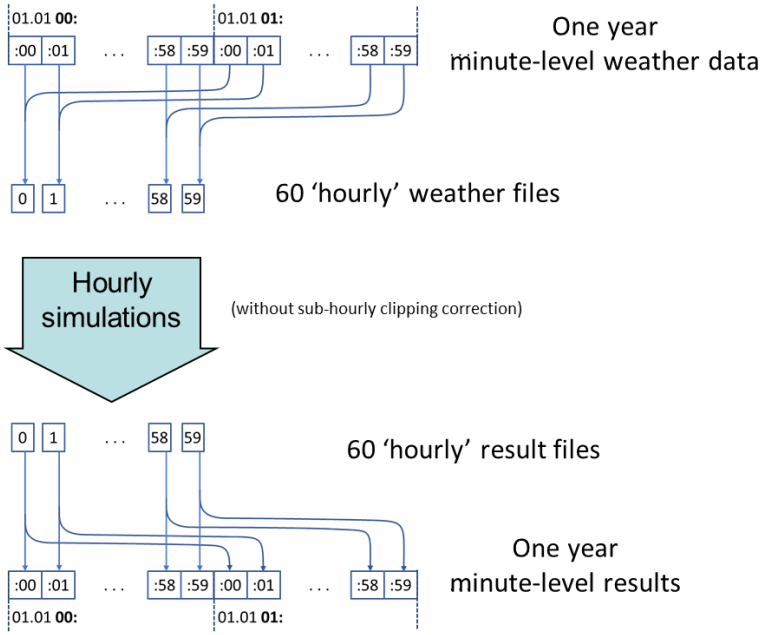
PVsyst SA
www.pvsyst.com

Contents

1 Working principle

The basic idea of the approach consists in the following steps illustrated in the figure below:

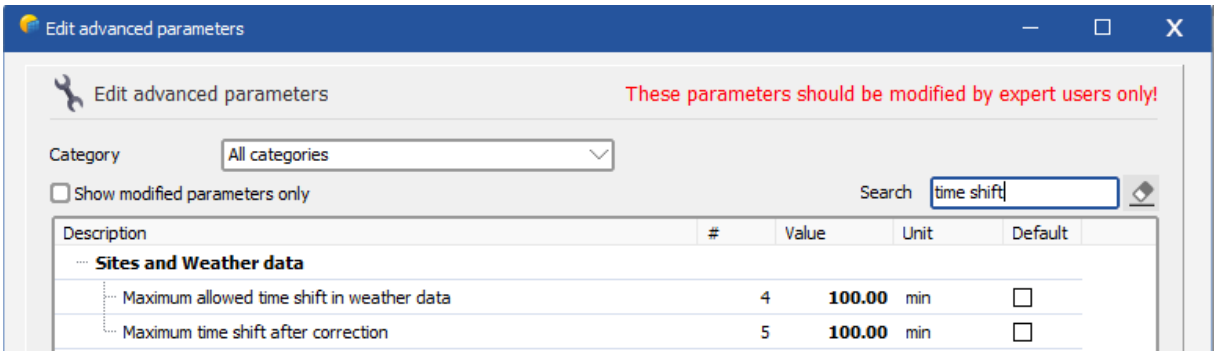
- Split minute-level data into minute stamp slices, one for each minute stamp in the hour
- Apply the necessary time shift, and run them through the hourly simulation
- Re-assemble the (up to 60) hourly outputs to obtain the result of an equivalent sub-hourly simulation



In the following paragraphs we will explain in detail each of the steps.

1.1 PVsyst prerequisites

This procedure necessitates to heavily rely on time shifts for the conversion of weather data in MET files. In order to avoid the limitations applied to hourly data, it is essential to modify two advanced parameters (Home window > Settings > Edit advanced parameters):



1.2 Data requirements

Data should be in 30, 20, 15, 12, 10, 5, 4, 3, 2, or 1 minute stamps.

Sub-hourly variations of irradiance can happen on short time scales (of the order of a couple minutes). The correction will be more accurate with finer resolution data.

Data should satisfy the usual requirements for weather data that will be imported in PVsyst. It should contain at least one of GHI, POA, DNI, as well as an ambient temperature measurement. Data should be organized as one time stamp per line.

Example: 1-minute data file

```
DATE (MM/DD/YYYY),HST,Global Horizontal [W/m^2],Air Temperature [deg C],Rel Humidity [%],Avg Wind Speed @ 10m [m/s]
1/1/2013,00:00,0,22.38,77.69,2.502
1/1/2013,00:01,0,22.37,77.72,2.499
1/1/2013,00:02,0,22.36,77.8,2.316
1/1/2013,00:03,0,22.35,77.91,2.252
1/1/2013,00:04,0,22.34,77.99,2.259
1/1/2013,00:05,0,22.32,77.97,2.332
...
```

The text above shows the plain text document with different colors for the columns.

In a spreadsheet program like Excel or LibreOffice Calc, the same snippet would look like this:

DATE (MM/DD/YYYY)	HST	Global Horizontal [W/m^2]	Air Temperature [deg C]	Rel Humidity [%]	Avg Wind Speed @ 10m [m/s]
01.01.2013	00:00	0	22.38	77.69	2.502
01.01.2013	00:01	0	22.37	77.72	2.499
01.01.2013	00:02	0	22.36	77.8	2.316
01.01.2013	00:03	0	22.35	77.91	2.252
01.01.2013	00:04	0	22.34	77.99	2.259
01.01.2013	00:05	0	22.32	77.97	2.332

1.3 Splitting data

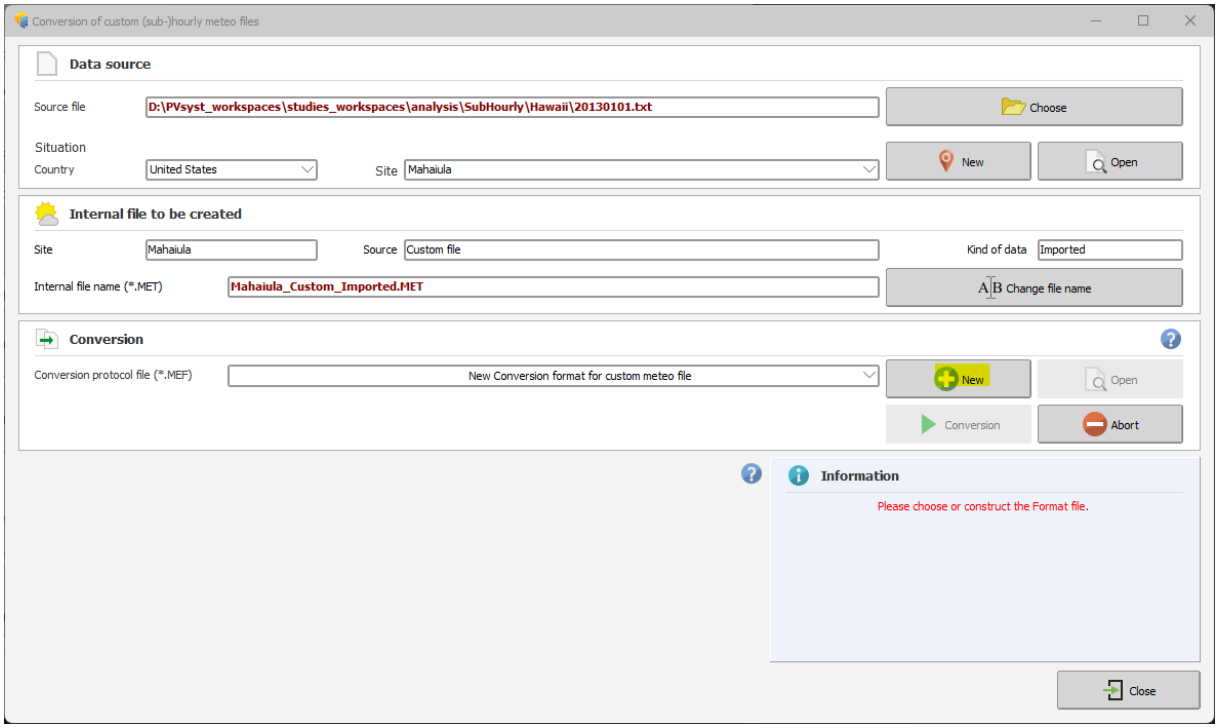
Starting from chronologically arranged data, the data should be split into several files, one for each different minute stamp in the data.

Example: contents of time stamp :01 data file

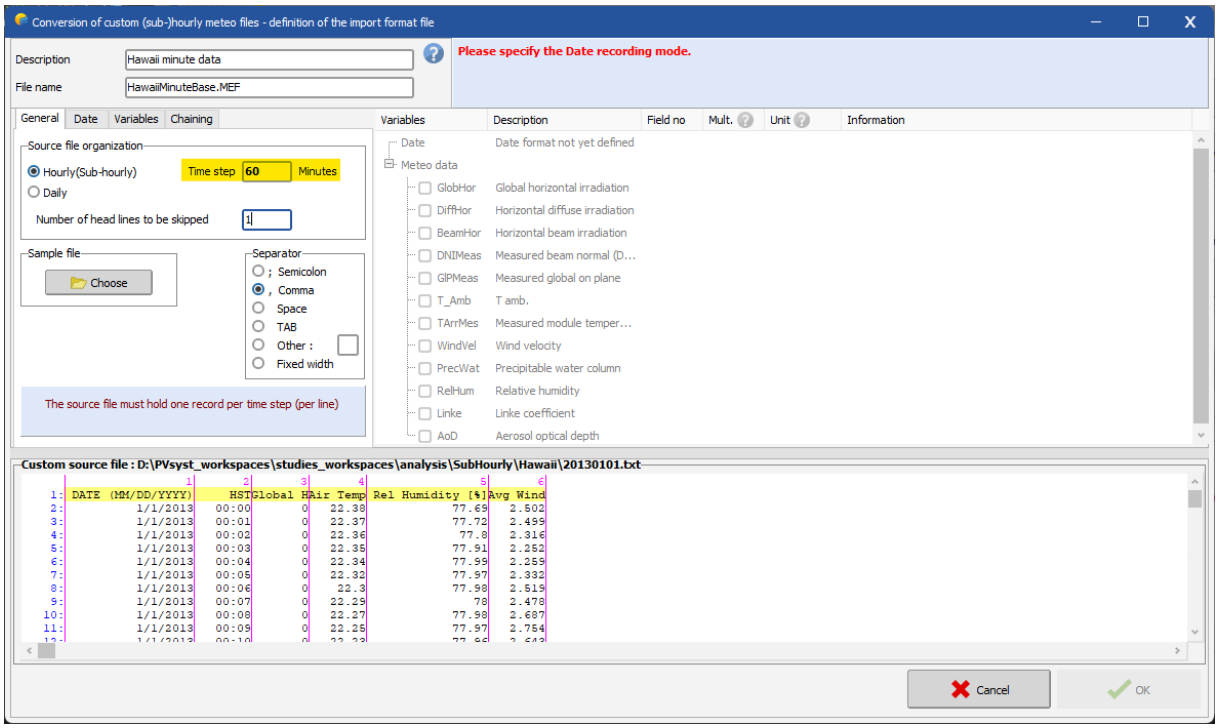
```
DATE (MM/DD/YYYY),HST,Global Horizontal [W/m^2],Air Temperature [deg C],Rel Humidity [%],Avg Wind Speed @ 10m [m/s]
1/1/2013,00:01,0,22.37,77.72,2.499
1/1/2013,02:01,0,21.6,77.54,2.723
1/1/2013,03:01,0,21.8,79.81,3.049
1/1/2013,04:01,0,21.42,77.86,1.679
1/1/2013,05:01,0,21.25,78.61,1.439
1/1/2013,06:01,0,20.87,77.86,1.534
1/1/2013,07:01,0.480912,20.83,77.84,2.252
...
```

1.4 MEF conversion format

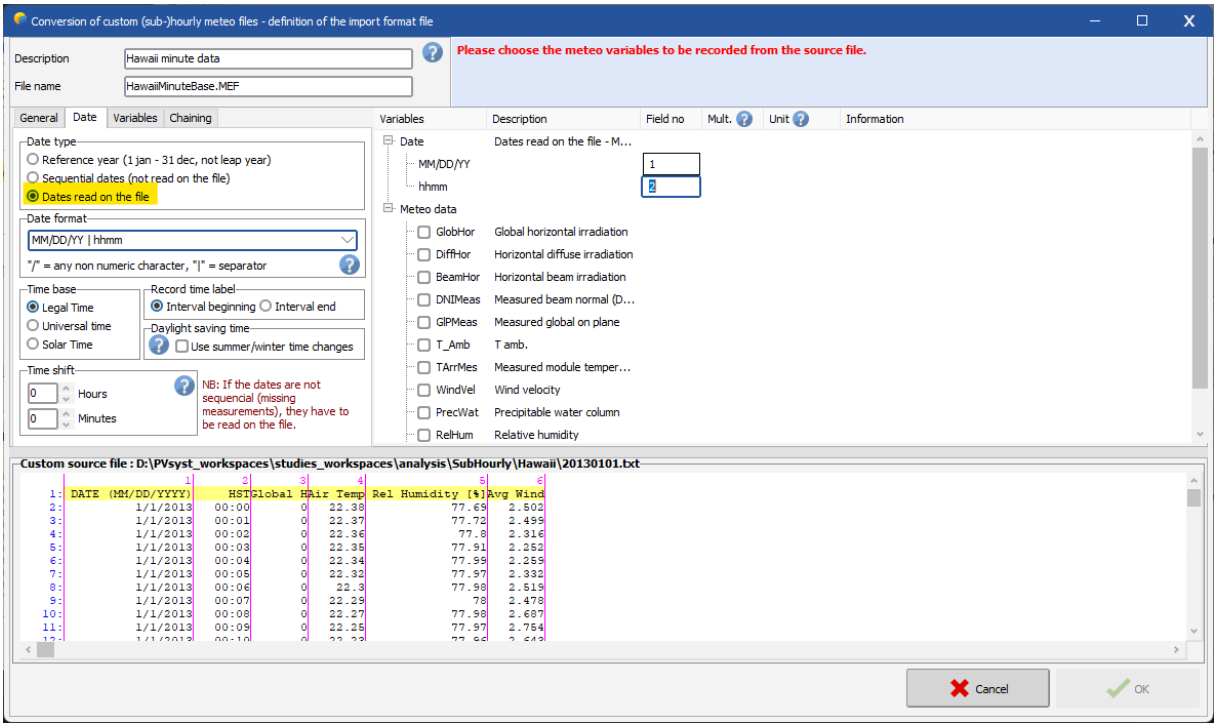
Each file should be processed with a specific MEF format file. The base for the MEF file can be built in PVsyst.



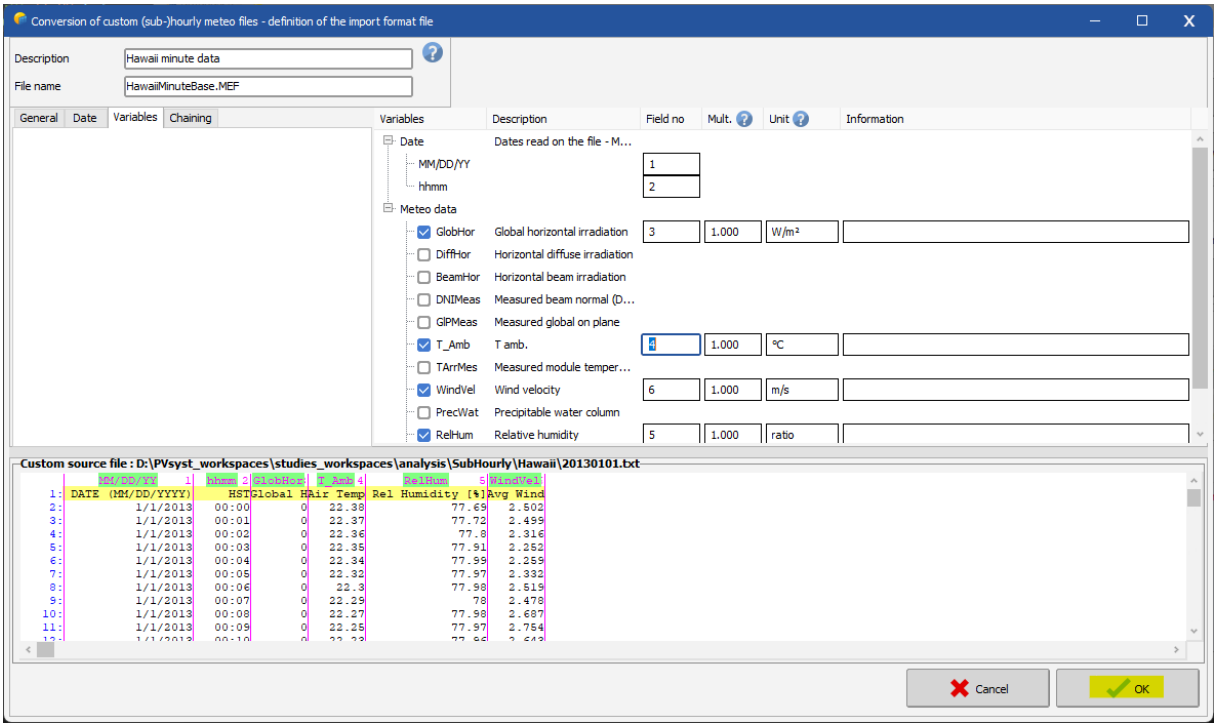
Since the split minute stamp data are each in hour intervals, the “Time step” parameter should be 60.



Date format will be the same for all files. Choose the option “Dates read on the file”.



Once the variables have been chosen, the base MEF file can be saved.



1.5 Time shift

On the basis of one MEF file, one can either make modifications for the other ones in PVsyst or directly by modifying the file contents.

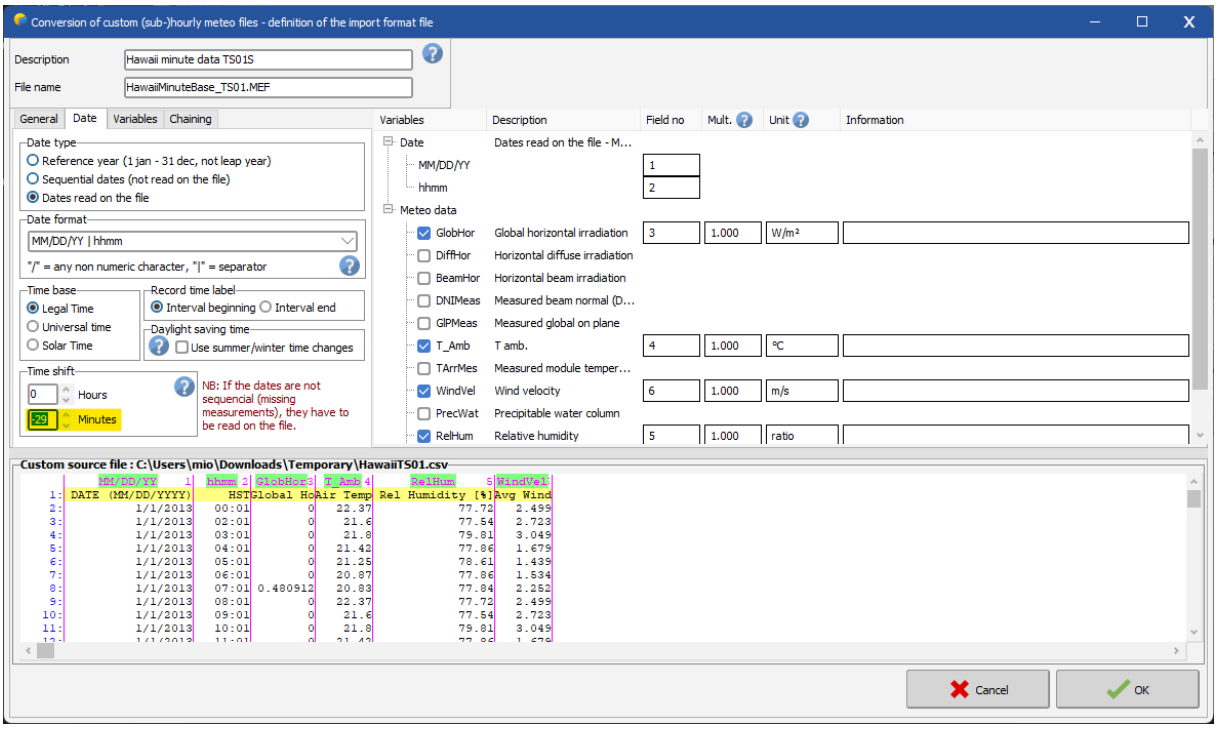
The time shift ensures that the sun position will be set at the correct position during the import and simulation. With a time shift of zero, PVsyst will displace the sun position at the 30' minute after the time stamp (in case the time stamp is at the beginning of the recording interval), to be at the middle of the recording interval.

Since the middle of the recording interval in sub-hourly simulations does not happen at the 30' minute mark, the time shift should be adjusted. The time shift should be chosen as the difference between the 30' mark and the middle of the interval for the given file. Rounding up or down 1 minute is of negligible consequence.

Example: in 15 minute data, the time shift is given in the following table. The middle of the time intervals is 15/2 minutes after the time stamp. The necessary time shift is middle of the interval minus 30 minutes.

Minute stamp	Middle of the time interval	Minute time shift
0	7.5	-22
15	22.5	-7
30	37.5	8
45	52.5	23

Example: adjusting the time shift for time stamp :01, i.e., at -29 minutes.



This parameter can also be modified directly in the MEF file, in a text editor. The tag to be modified or added is “TimeShiftF”. This may or may not change in future PVsyst versions. When in doubt, always modify directly through PVsyst as above.

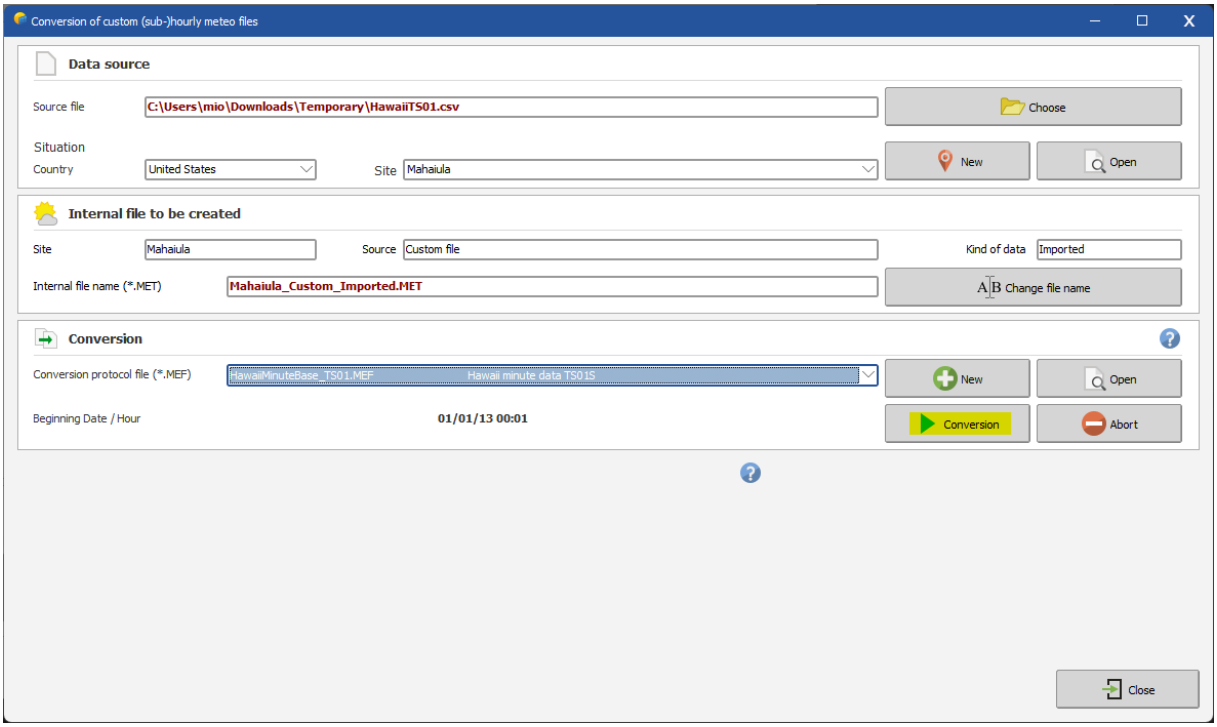
```
PVObject_=pvMeteoFormat
  Comment=Hawaii minute data TS01S
  Version=7.4.5
  Flags=$00E1
  DateMode=ReadOnFile
  DateFmtType=MMxDDxYY_hhmm
  FileType=SingleFile
  Separ=$002C
  NLigDeb=1
  MeasureStep=60
  TimeShiftF=-29
  TypeInterv=1
```

1.6 Creating the MET files

Once the MEF files are ready, it is straightforward to use the Custom file import functionality in PVsyst to create one MET file for each minute stamp.

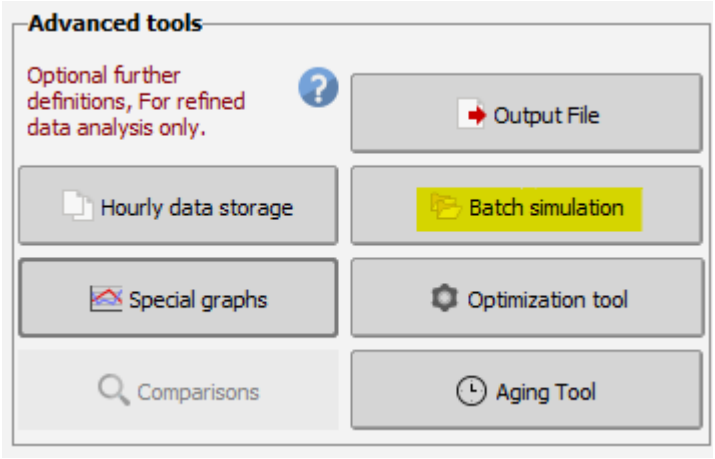
Make sure that the name is appropriate and different for each import (e.g., reflects the time stamp), by clicking on “Change file name”.

Once ready for the import, click on “Conversion”.



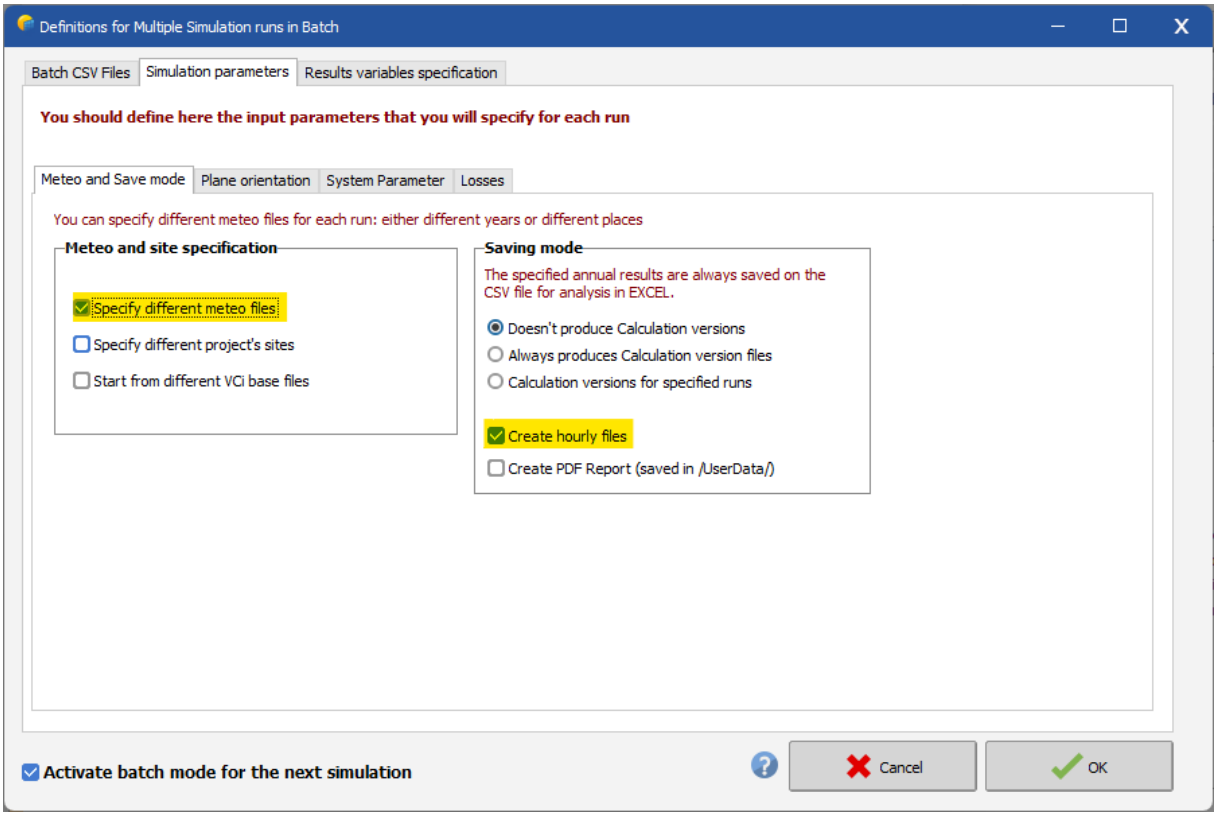
1.7 Batch simulation

The simulations for each minute stamp can be run with the batch mode:

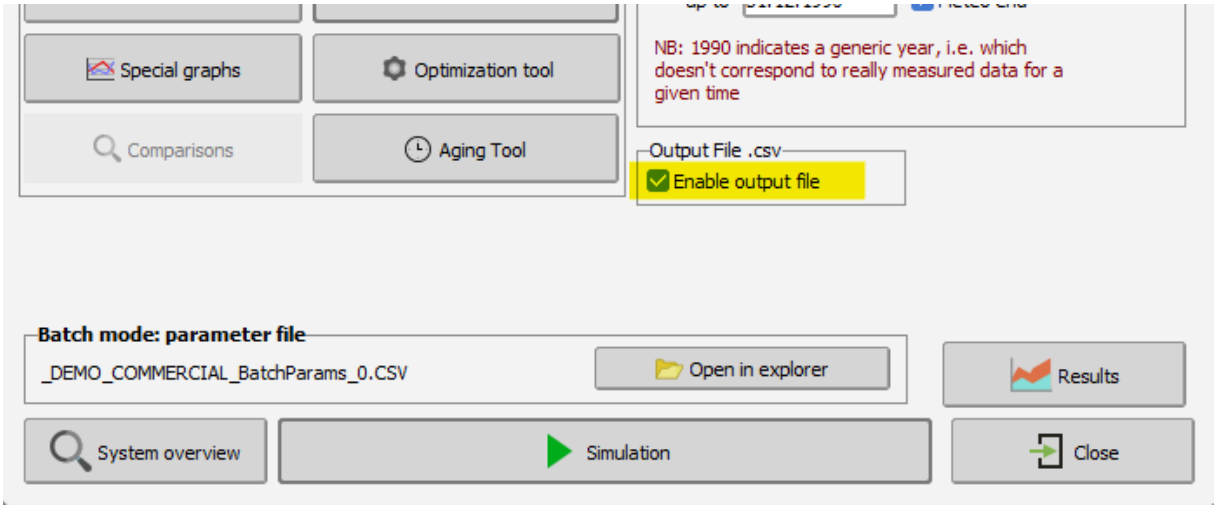


Two parameters are essential:

- "Specify different meteo files"
- "Create hourly files"



You should also make sure that the output file format is properly defined before running the simulation, and that the checkbox "Enable output file" is checked.



The contents of the batch parameter file should contain the MET files to be used.

Example: batch file to run minute-level simulations.

```
PVsyst simulations Batch mode;;;
Simulation parameters definition;;;
File created on 11/03/24 13:06;;;
;;;
Project;;;_DEMO_COMMERCIAL.PRJ
Variants based on;;VC1;_DEMO_COMMERCIAL_MARSEILLE_With self consumption_Without storage
;;;
Please define the parameters to be varied for each run;;;
Do not modify the column titles!;;;
"Only the lines beginning by ""SIM_"" will be executed";;;
;;;
Ident;Meteo data;Create hourly;Simul
;*.MET file;file;Comment
;;File name;
;;;
SIM_1;Haw_TS0.MET;Haw_TS0.CSV;minute stamp 0
SIM_2;Haw_TS1.MET;Haw_TS1.CSV;minute stamp 1
SIM_3;Haw_TS2.MET;Haw_TS2.CSV;minute stamp 2
SIM_4;Haw_TS3.MET;Haw_TS3.CSV;minute stamp 3
SIM_5;Haw_TS4.MET;Haw_TS4.CSV;minute stamp 4
```

```
SIM_6;Haw_TS5.MET;Haw_TS5.CSV;minute stamp 5
SIM_7;Haw_TS6.MET;Haw_TS6.CSV;minute stamp 6
SIM_8;Haw_TS7.MET;Haw_TS7.CSV;minute stamp 7
...
```

1.8 Gathering results

The batch run will result in a collection of output CSV files, one for each minute stamp. Since each row in these files represents a single and unique time stamp, it is possible to group data together once again.

2 Advanced considerations

The main processes in the simulation are well modeled as instantaneous processes; i.e., they do not depend on preceding time steps. This is why it is possible to split the simulation into independent minute stamps, and obtain reasonably accurate results.

However for certain secondary processes, the instantaneous modeling is not such a good approximation. Therefore, switching to a model that depends on the previous time steps can improve the accuracy further.

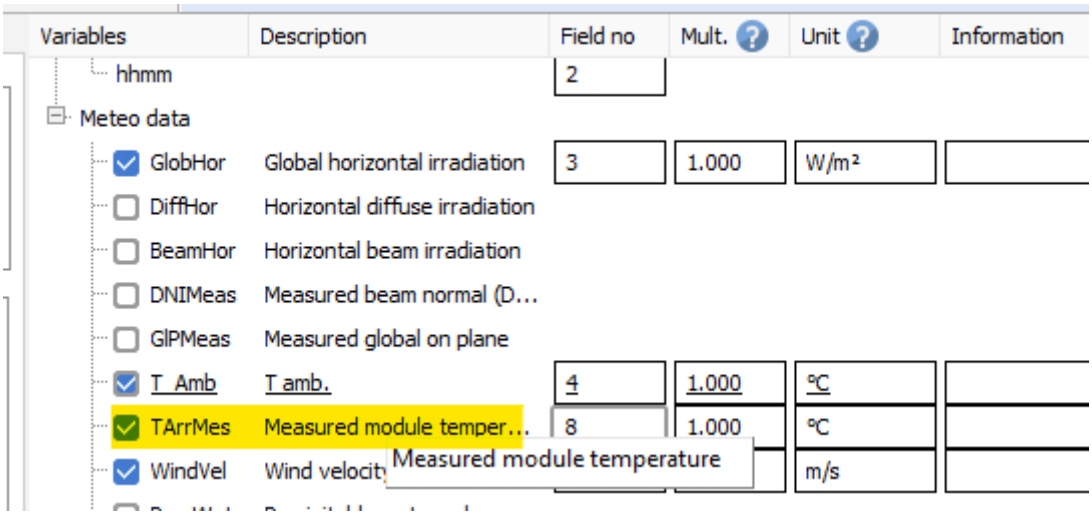
2.1 Array temperature modeling

Due to a thermal inertia of PV modules and structures of the order of minutes, a detailed modeling for the array temperature at the sub-hourly scale necessitates a dependence on the previous state of the system.

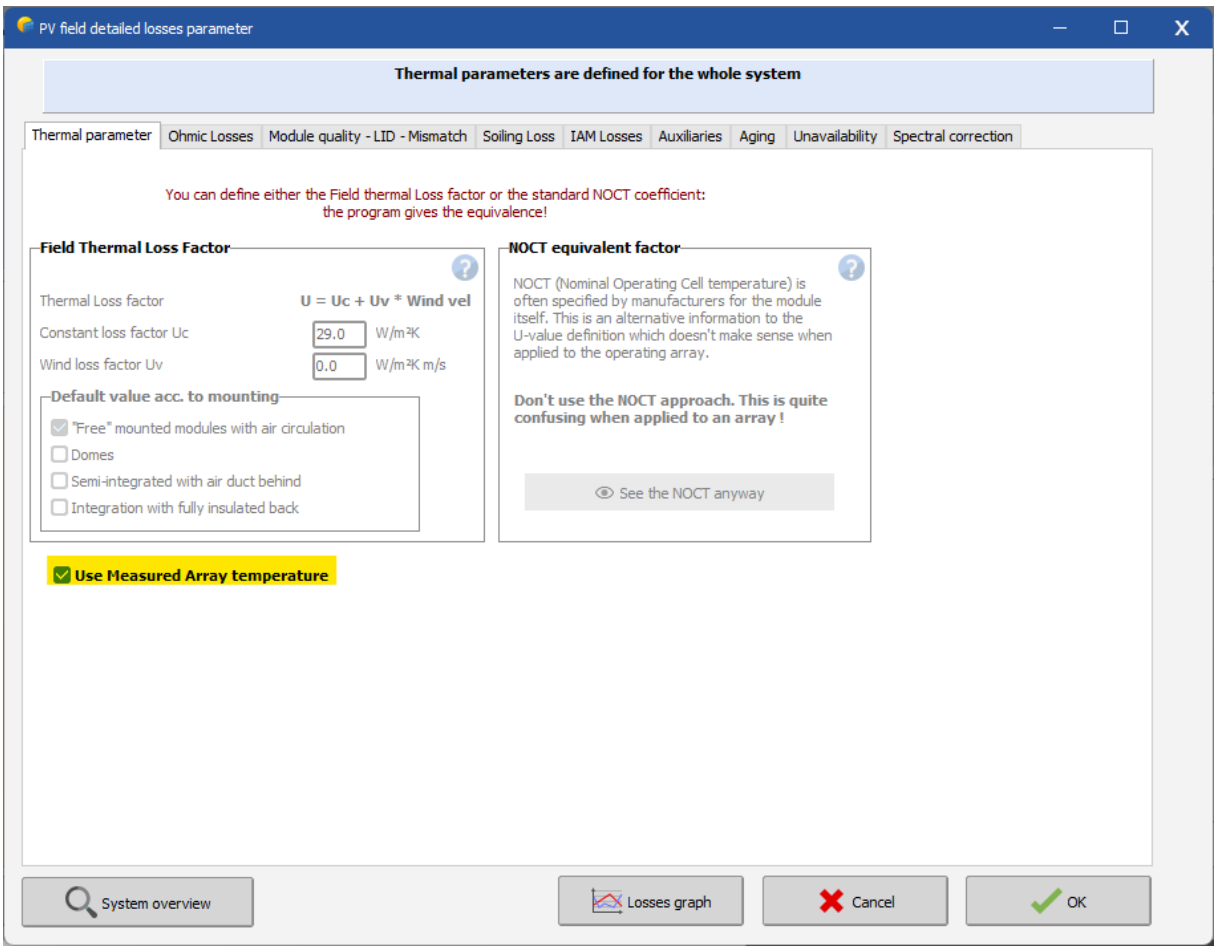
PVsyst allows using the array temperature as input variable of the simulation. One way to use this to account for thermal inertia, is to run the pseudo-sub-hourly simulation twice.

The first time, you should use the default instantaneous model for the array temperature. Gathering the results, you can analyze the temperature values obtained from the instantaneous model. It is then possible to establish a more accurate array temperature evolution by using an exponential smearing of the values, such as the Prilliman model (10.1109/JPHOTOV.2020.2992351).

By including the new array temperature data together with the weather raw data, you can now use “TArrMes” among the variables of the MEF.



In the variants to be simulated, Detailed losses > Thermal parameter, you can then select the option to use this array temperature data.



2.2 Transposition of irradiance

As outlined in (https://userarea.eupvsec.org/proceedings/EU-PVSEC-2023/4DV.4.43/) transposition models, and in particular the typical Perez transposition coefficients are adapted to hourly value transposition, but generate a small bias when used on sub-hourly data.

In order to side-step this issue partially, it is possible to use POA values directly as input for the simulation. Note however that the separation between diffuse components and direct may be still affected by the biases in the Perez or Hay modeling, among other models used.