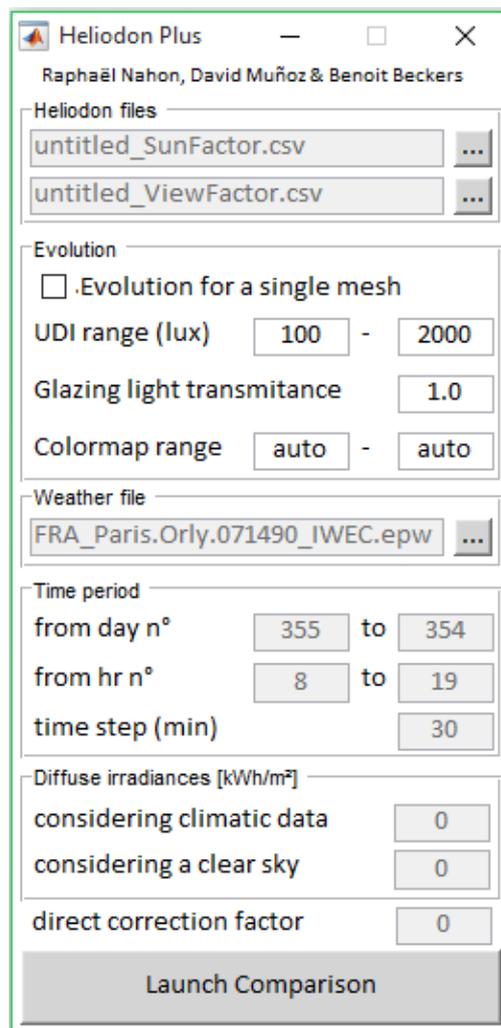


Heliodon Plus User Manual

Raphaël Nahon, David Muñoz y Benoit Beckers (May 2016)

What is Heliodon Plus

Heliodon Plus is a post processor that allows to import files in CSV format as they are generated in *Heliodon 2* [Beckers 2006] and a file with climatologic data in EPW format (Energy Plus), generated for instance by *Meteonorm*.



Performing a series of calculations, new information is obtained, which adds functionality to *Heliodon 2* and gives more support for decision-making by users.

To use *Heliodon Plus*, the only need is *Heliodon 2* to perform solar calculations over the studied case and a file with climatologic data of the zone where the case is set.

This tutorial shows the steps to follow to add through *Heliodon Plus* the climatologic information to the exported data from *Heliodon 2*.

Which data provides Heliodon Plus

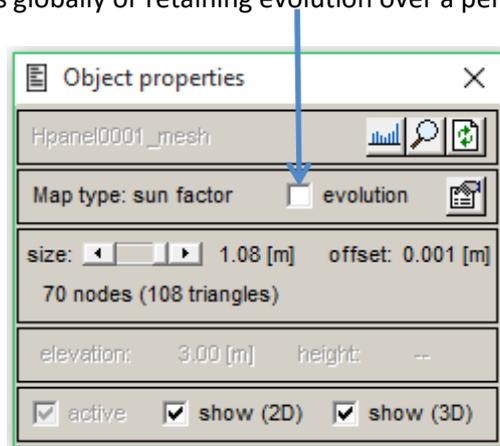
Heliodon Plus has been created to enrich the output data of *Heliodon 2* by adding the climatic factor to his equations, since *Heliodon 2* performs its calculations assuming a completely clear sky.

With the inclusion of a file of climatologic data, additional calculations very useful are obtained, as direct and diffuse solar radiation taking into account the attenuation of the clouds, the illuminance in lux and UDI (Useful Daylight Illuminance) factor on the surfaces of study, in addition to establish the percentage of light transmittance and can thus simulate the attenuation of direct light through a glass (e.g. a window).

Note: Remember that *Heliodon 2* does not calculate surface reflections and, therefore UDI values will be correct always assuming that all the walls are black.

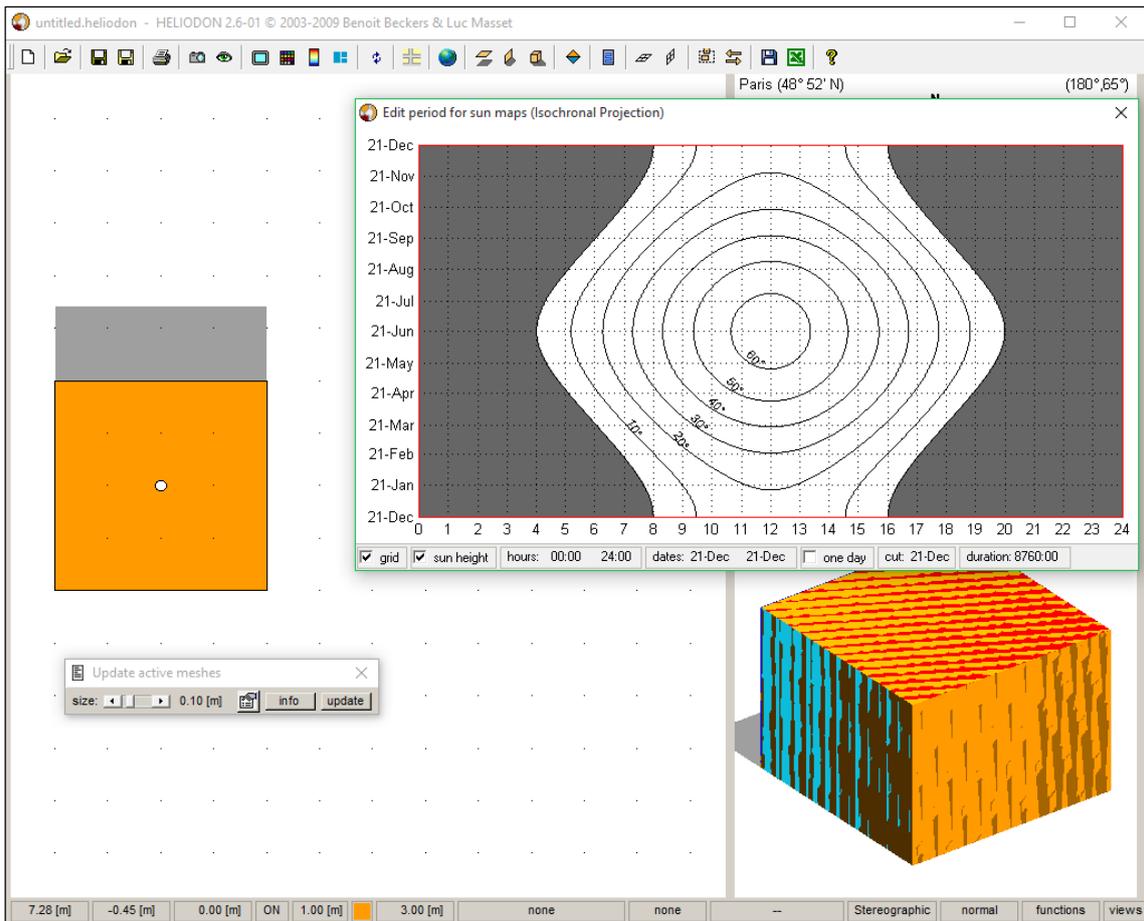
Preparing the input data

The first step is to decide what type of calculation we are interested in. In *Heliodon 2*, you can export energy calculations globally or retaining evolution over a period.



As explained in the *Heliodon 2* user manual, the period, the accuracy, the central date and time of the measurement range must be set before launching the calculation.

In the case of the example shown below, a prism has been created and the calculation has been set to 24 hours a day for a year, meshing all its faces.



Once done, we can export to CSV by clicking the appropriate button on the toolbar in *Heliodon 2*.



This will save a CSV document with the format shown in the following image, although the header may vary depending on the parameters you configure before running the calculation (e.g. choose latitude, range of days and hours, etc.), but always containing the same number of columns.

| | A | B | C | D | E | F | G | H | I | J |
|----|-----------------|----------------------|--------------------|-------------------|------------------|------------------|--------------------|-------------------------|-------------------------|--------------------|
| 1 | Town: | Paris | | | | | | | | |
| 2 | Latitude: | 48° 52' N | | | | | | | | |
| 3 | Number of days: | 365 | | | | | | | | |
| 4 | Starting day: | 21-Dec | | | | | | | | |
| 5 | Ending day: | 21-Dec | | | | | | | | |
| 6 | Starting hour: | 0:00 | | | | | | | | |
| 7 | Ending hour: | 24:00:00 | | | | | | | | |
| 8 | Grid precision: | 5 min | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | Object | Area (m²) | Total energy (kWh) | | | | | | | |
| 11 | Prism0001 | 63.9 | 47225.6 | | | | | | | |
| 12 | | | | | | | | | | |
| 13 | Object | Surface | Area (m²) | Mean daylight (h) | Min daylight (h) | Max daylight (h) | Total energy (kWh) | Min local flux (kWh/m²) | Max local flux (kWh/m²) | Variability factor |
| 14 | Prism0001 | Prism0001_mesh_roof | 16 | 4379 | 4379 | 4379 | 20525.9 | 1284.2 | 1284.2 | 1 |
| 15 | | Prism0001_mesh_face1 | 12 | 2189.5 | 2189.5 | 2189.5 | 6904.4 | 576 | 576 | 1 |
| 16 | | Prism0001_mesh_face2 | 12 | 3597.3 | 3597.3 | 3597.3 | 12534.6 | 1045.8 | 1045.8 | 1 |
| 17 | | Prism0001_mesh_face3 | 12 | 2189.5 | 2189.5 | 2189.5 | 6904.4 | 576 | 576 | 1 |
| 18 | | Prism0001_mesh_face4 | 12 | 781.7 | 781.7 | 781.7 | 356.4 | 29.7 | 29.7 | 1 |

You also have to launch and save the calculation of the view factor in CSV, switching from stereographic projection to orthographic projection in *Heliodon 2* [Beckers 2009]. This will generate a CSV document as the following.

| | A | B | C | D | E | F | G |
|----|------------|----------------------|------------------------|----------------------|---------------------|---------------------|--------------------|
| 1 | Town: | Paris | | | | | |
| 2 | Latitude: | 48° 52' N | | | | | |
| 3 | Grid size: | 100x100 | | | | | |
| 4 | | | | | | | |
| 5 | Object | Surface | Area (m ²) | Mean view factor (%) | Min view factor (%) | Max view factor (%) | Variability factor |
| 6 | Prism0001 | Prism0001_mesh_roof | 16 | 100 | 100 | 100 | 1 |
| 7 | | Prism0001_mesh_face1 | 12 | 50 | 50 | 50 | 1 |
| 8 | | Prism0001_mesh_face2 | 12 | 50 | 50 | 50 | 1 |
| 9 | | Prism0001_mesh_face3 | 12 | 50 | 50 | 50 | 1 |
| 10 | | Prism0001_mesh_face4 | 12 | 50 | 50 | 50 | 1 |

Once this is done, there are two CSV files with data calculations, one with the energy and the other one with the view factor.

For the climatologic file, you can use weather data from the nearest weather station to the studied case, choosing the *EnergyPlus* format (EPW).

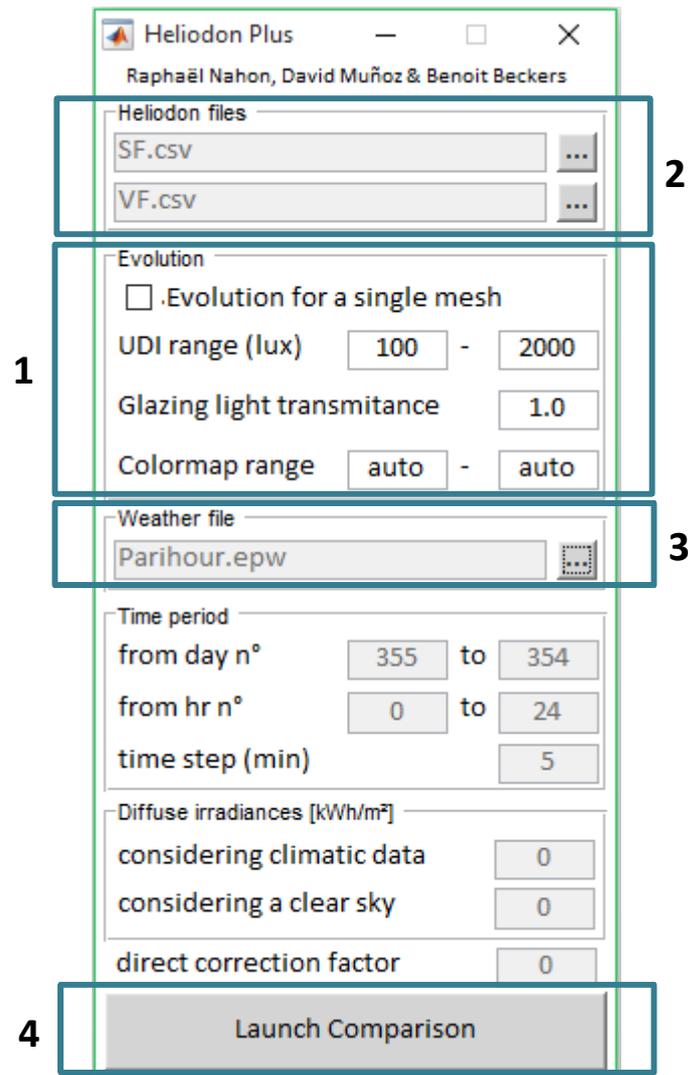
These three files contain everything you need to use *Heliodon Plus* and enrich the data.

Process

Example 1: Solar radiation without evolution

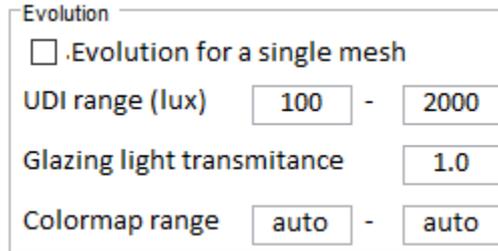
Here it will be shown a step by step to learn how to use the interface in *Heliodon Plus* to add climatologic data to information obtained by *Heliodon 2*. In this first example the data without evolution shown in the previous section of the manual will be used.

This is the *Heliodon Plus* interface and the function of each interactive element that composes it.



- 1) First, we must clarify that Heliodon Plus works differently depending on whether global or evolution calculations have been performed. So, the first thing to do is adjust the "checkbox" for indicating the case (checked when working with evolution, unchecked otherwise). Following our example, we leave unchecked the "checkbox", as the CSV files are results of a calculation without evolution. With the evolution it's possible to adjust the range of lux for calculations of natural light autonomy and set the percentage of light transmittance, as will be explained later in another example. In this case, the default parameters will be used, because they are not necessary when working without evolution. In addition, when evolution for a full year is calculated it is

possible to see graphics on the screen for get the information in a visual way. The two fields "Colour map range" are to fit between what values will be the colour bar graphs. These two fields will also be left in "auto" because they are not necessary without evolution.



Evolution

.Evolution for a single mesh

UDI range (lux) 100 - 2000

Glazing light transmittance 1.0

Colormap range auto - auto

- 2) Next, add the two CSV files generated by Heliodon from the menu, in the two containers of "Heliodon files" section. The above file is the direct solar radiation and the lower is the view factor. When the upper file is added, the fields of "Time period" section are updated, according to those used in *Heliodon 2*.

Important note: For proper operation of *Heliodon Plus* is recommended not include spacing characters in file names, although they can be included in the directory where the files are located.



Heliodon files

SF.csv ...

VF.csv ...

- 3) Then the climate data file (in ".epw" format) is added to the "Weather file" container. In this case, we used a meteorological data file of Paris.



Weather file

Parihour.epw ...

- 4) Finally, the "Launch Comparison" button is pressed and we must wait while the calculations are performed. In the folder containing the post processor *Heliodon Plus* a CSV new file called "output" (or "outputEvolution" if you work in *Heliodon 2* with the evolution and not with global calculations) with the resulting data appears. A bar will indicate the process and will close when the output file is completely generated.

Important note: Do not open the output file until the progress bar is completed and closed or data will not be completely written.

The resulting CSV file contains the most relevant input data and adds new variables:

- Direct radiation (Ib) in kWh: Product result from direct solar radiation by a correction factor calculated from climatic data entered into *Heliodon Plus*.
- Diffuse radiation (Id) in kWh: Product result of the view factor of the surfaces by diffuse irradiation considering climate information.

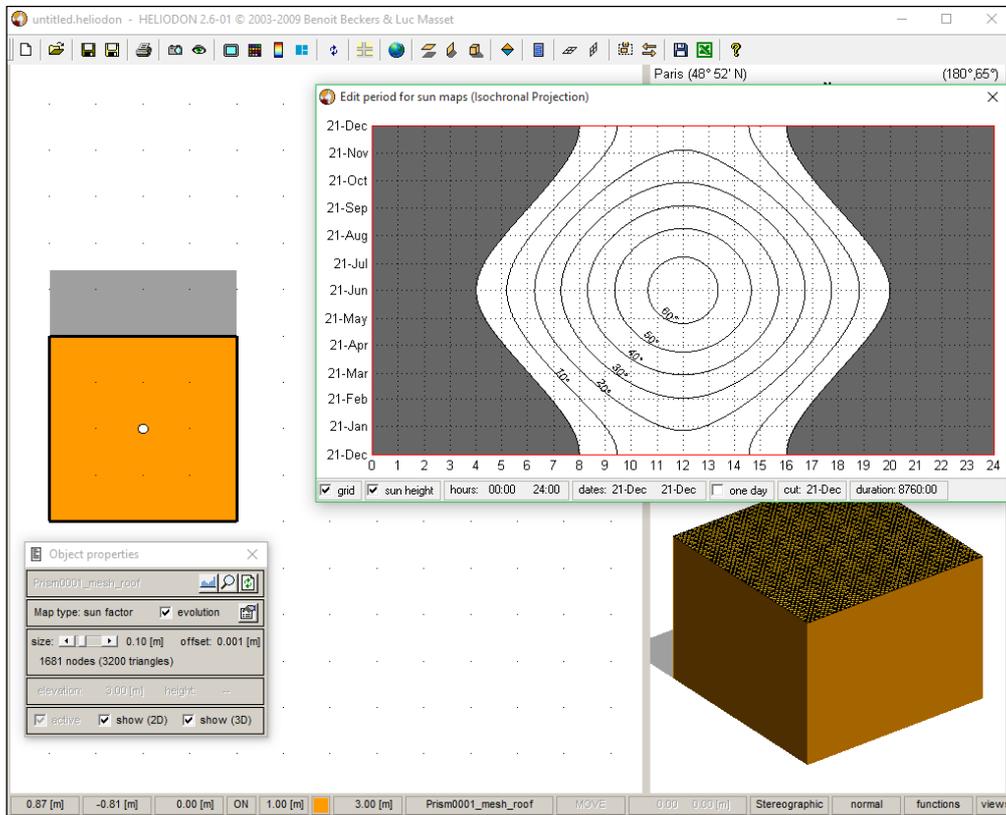
In the case shown, the output file is as follows.

| | A | B | C | D | E | F | G | H | I |
|----|-----------------|------------------------|------------------------|-------------------|--------------------|---------|-----------|----------|------------------|
| 1 | Town: | Paris | | | | | | | |
| 2 | Latitude: | 48° 52' N | | | | | | | |
| 3 | Number of days: | 365 | | | | | | | |
| 4 | Starting day: | 21-Dec | | | | | | | |
| 5 | Ending day: | 21-Dec | | | | | | | |
| 6 | Starting hour: | 0:00 | | | | | | | |
| 7 | Ending hour: | 24:00:00 | | | | | | | |
| 8 | Grid precision: | 5 min | | | | | | | |
| 9 | Object | Area (m ²) | Total energy (kWh) | | | | | | |
| 10 | Prism0001 | 63.9 | 47225.6 | | | | | | |
| 11 | Object | Surface | Area (m ²) | Mean daylight (h) | Total energy (kWh) | SVF (%) | Ib (kWh) | Id (kWh) | Direct + Diffuse |
| 12 | Prism0001 | Prism0001_mesh_roof | 16 | 4379 | 20525.9 | 100 | 7462.245 | 9687.392 | 17149.637 |
| 13 | | Prism0001_mesh_face1 | 12 | 2189.5 | 6904.4 | 50 | 2510.1128 | 3632.772 | 6142.8848 |
| 14 | | Prism0001_mesh_face2 | 12 | 3597.3 | 12534.6 | 50 | 4556.9868 | 3632.772 | 8189.7588 |
| 15 | | Prism0001_mesh_face3 | 12 | 2189.5 | 6904.4 | 50 | 2510.1128 | 3632.772 | 6142.8848 |
| 16 | | Prism0001_mesh_face4 | 12 | 781.7 | 356.4 | 50 | 129.5702 | 3632.772 | 3762.3422 |

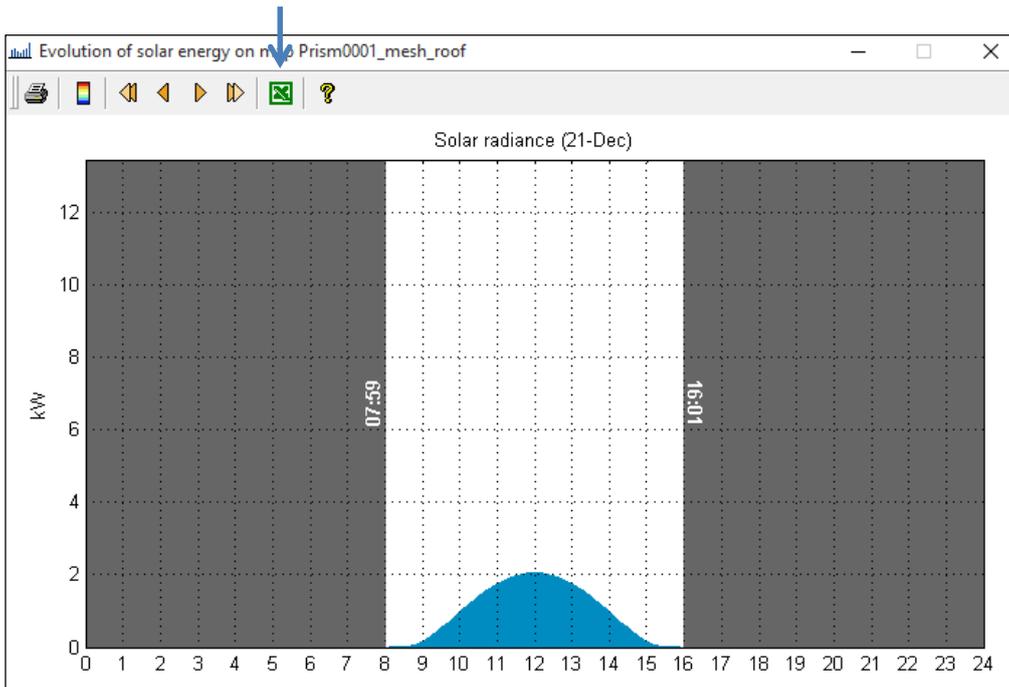
These new values and the sum thereof in the last column can be observed, allowing a comparison with the original theoretical data.

Example 2: Solar radiation evolution

Here is another example calculating this time the evolution on a single horizontal plane (remember that evolution is only possible when working with a single surface). For this the top face of the prism used in the previous case will be meshed to calculate the evolution of the direct solar radiation on it.



To export the CSV file, the button is on the toolbar of the resulting plot.



Then, the stereographic calculation must be performed and stored as shown in the previous example. This is the resulting CSV file of the stereographic calculation.

| | A | B | C | D | E | F | G | H | I | J |
|----|----------------------------|-----------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1 | Town: | Paris | | | | | | | | |
| 2 | Latitude: | 48° 52' N | | | | | | | | |
| 3 | Number of days: | 365 | | | | | | | | |
| 4 | Starting day: | 21-Dec | | | | | | | | |
| 5 | Ending day: | 21-Dec | | | | | | | | |
| 6 | Starting hour: | 0:00 | | | | | | | | |
| 7 | Ending hour: | 24:00:00 | | | | | | | | |
| 8 | Grid precision: | 5 min | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |
| 11 | Actual solar radiance (kW) | | | | | | | | | |
| 12 | | 21-Dec | 22-Dec | 23-Dec | 24-Dec | 25-Dec | 26-Dec | 27-Dec | 28-Dec | 29-Dec |
| 13 | 0:03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0:08 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0:13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0:17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

One can see that the file contains much more data than our previous example, since it gives the calculations at each step in the time range you specified.

Important note: When working storing evolution, direct radiation and diffuse radiation are not expressed in kWh, but in kW/m², as it works on a single surface and all values for each time step are obtained. Thus it will be possible to obtain the conversion factor to calculate the illuminance in lux from kW/m².

The orthographic file will always show a single surface.

| | A | B | C | D | E | F | G |
|---|------------|---------------------|------------------------|----------------------|---------------------|---------------------|--------------------|
| 1 | Town: | Paris | | | | | |
| 2 | Latitude: | 48° 52' N | | | | | |
| 3 | Grid size: | 100x100 | | | | | |
| 4 | | | | | | | |
| 5 | Object | Surface | Area (m ²) | Mean view factor (%) | Min view factor (%) | Max view factor (%) | Variability factor |
| 6 | Prism0001 | Prism0001_mesh_roof | 16 | 100 | 100 | 100 | 1 |

Important note: If the calculation was made with evolution, there is only data from a single surface and, therefore, the calculation of factor of view on the same surface must be performed only for the data relate correctly in Heliodon Plus.

This time you have to check the "checkbox" of Heliodon Plus indicating that the calculation is with evolution. Default values for the UDI (between 100 and 2000 lux) and the luminous transmittance (in 1.0) will be set by default. The same with the "auto" in the colour map range of the graphics. You could specify minimum and maximum values in the two fields or retyping "auto" to use the automatic mode.

Evolution

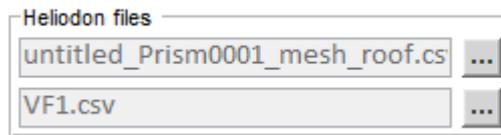
.Evolution for a single mesh

UDI range (lux) -

Glazing light transmittance

Colormap range -

Here the CSV files are added to their respective panels.



The same weather data file is maintained, it will be assumed that the calculation is performed in the same location as the previous example.



Launching the calculation, which takes a while to complete because this time there is much more data to process, a CSV file named "OutputEvolution" is obtained. One can see that it contains the same data as the original file by adding new stereographic end variables.

- Direct illuminance (Lb) in Lux: Product result of direct radiation (Ib) by a conversion factor calculated at each step of evolution.
- Diffuse illuminance (Ld) in Lux: Product result of diffuse radiation (Id) by a conversion factor also calculated at each step of evolution.
- UDI: Percentage of the total time that the mesh surface has useful day light (by default between a minimum of 100 lux and a maximum of 2000 lux, but adjustable from the interface). These measures are presented and used in several works [Nabil 2005, Nahon 2015, Reinhart 2006]

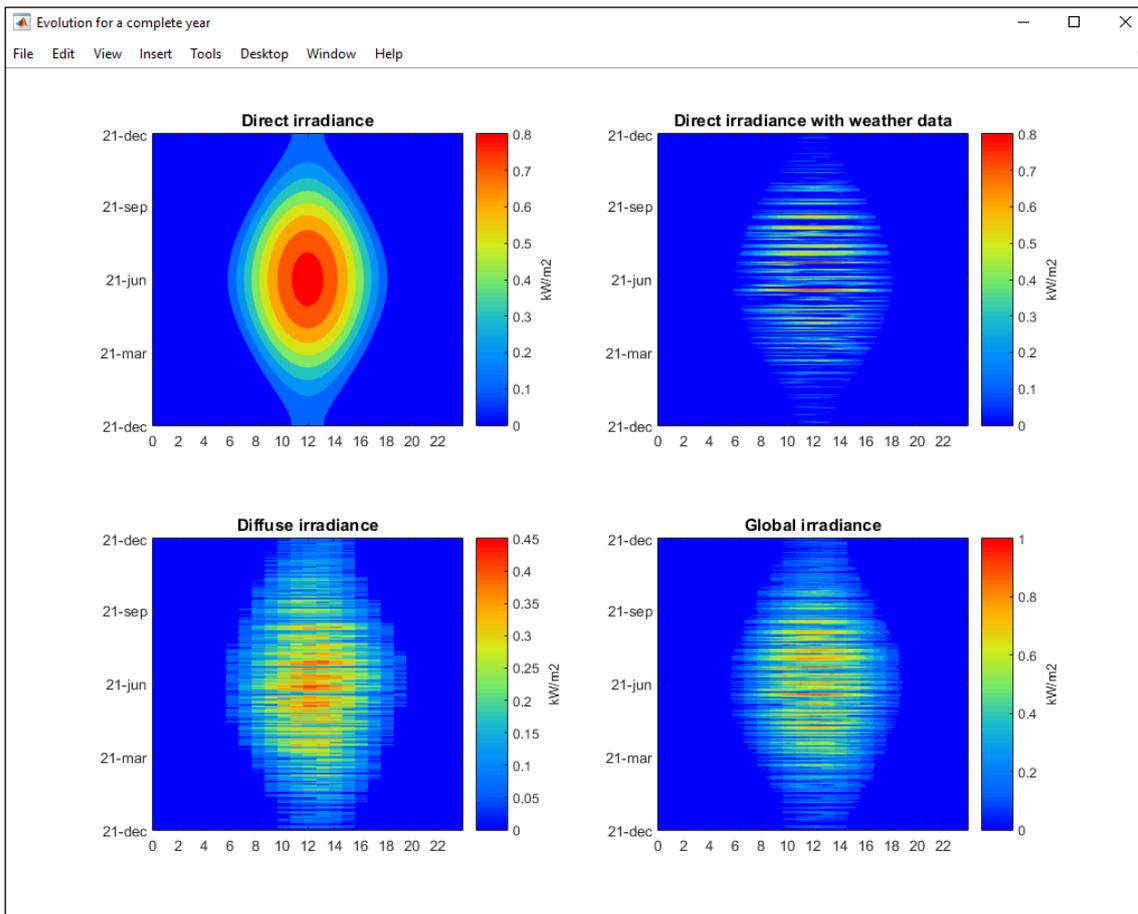
| | | | |
|------|---------|------|-----------------|
| 4070 | UDI (%) | 2.95 | (100 -2000 lux) |
|------|---------|------|-----------------|

With this procedure it's shown how *Heliodon Plus* generates a single CSV file that apart from all the information already provided by *Heliodon 2*, also contains the data of radiation and luminance (direct and diffuse), as well as the UDI in the end of the document.

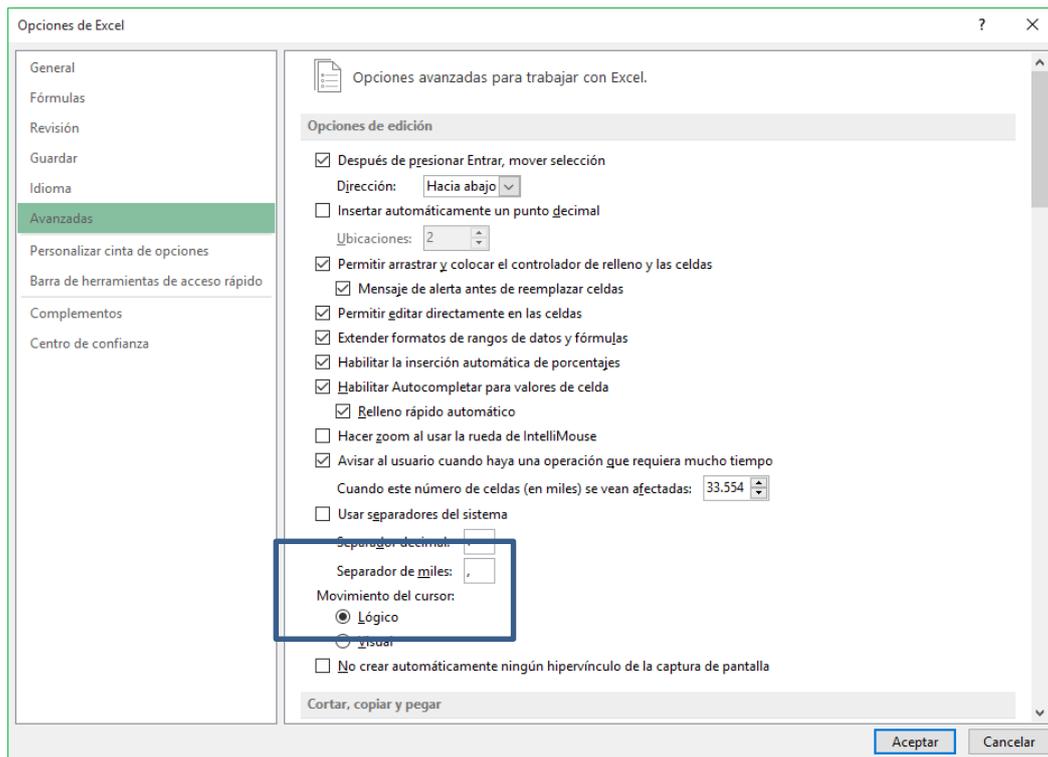
Moreover, as in this case we worked with the evolution and for a temporary period of a full year to complete the process, *Heliodon Plus* displays four charts to visually examine the results. The graphs show the following:

1. Direct irradiance (theoretical calculation of *Heliodon 2*)
2. Direct irradiance with weather data (corrected calculation with weather data)
3. Diffuse irradiance (calculated from view factor and weather data)
4. Global irradiance (sum of the previous two calculations)

These are the resulting plots of the example.



Important note: It is necessary that thousands and decimal separators are set to Excel as follows for the correctly read of "csv" files in Heliodon Plus. The decimal separator must be a period (.) And the thousands separator a comma (,).



References

[Beckers 2006] Benoit Beckers & Luc Masset, Heliodon 2, Software, references and manuals (in French and Spanish), 2006 <http://www.heliodon.net>

[Beckers 2009] Geometrical interpretation of sky light in architecture projects, B. Beckers, Actes de la Conférence Internationale Scientifique pour le BATiment CISBAT 2009, September 2009, EPFL, Lausanne, Suisse.

[Nabil 2005] Nabil, A., & Mardaljevic, J. (2005). Useful daylight illuminance: a new paradigm for assessing daylight in buildings. *Lighting Research and Technology*, 37(1), 41-57.

[Nahon 2015] Exploring metrics on the evaluation of the bioclimatic potential at early stages of urban project, R. Nahon, G. Besuievsky, E. Fernández, B. Beckers, O. Blanpain, International conference CISBAT on "Future buildings and districts sustainability from nano to urban scale", September 9-11, 2015, EPFL - Lausanne, Switzerland.

[Reinhart 2006] Reinhart, C. F., Mardaljevic, J., & Rogers, Z. (2006). Dynamic daylight performance metrics for sustainable building design. *Leukos*, 3(1), 7-31.