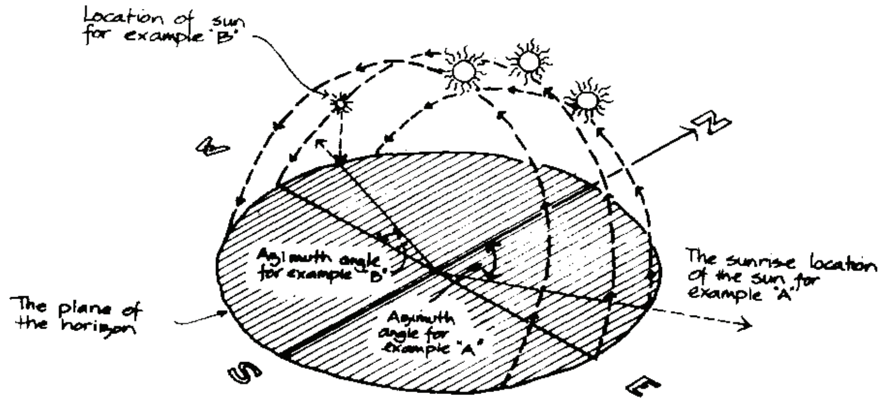
Simple Solar Study

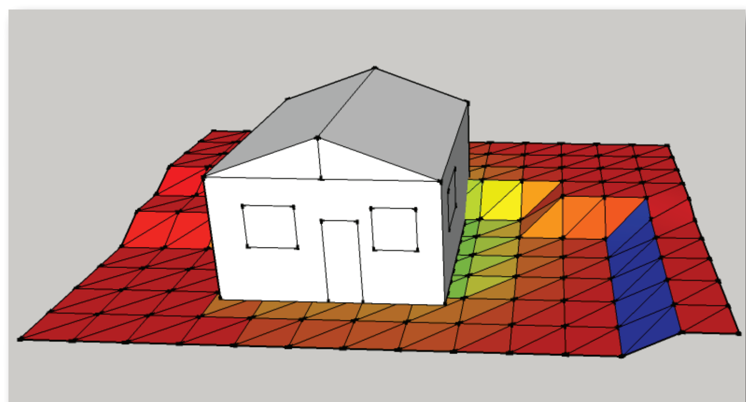
An indoor/outdoor daylighting analysis plugin for SketchUp
by Brian Monwai



"National design handbook prototype on passive solar heating and natural cooling of buildings", www.nzdl.org

Synopsis

The Simple Solar Study plugin calculates the path of the sun over a user-defined period and reports the amount of light incident upon a target surface for that time period. Multiple methods, including referencing a weather file, can be used to determine amount of light. Sun rays can be blocked by solid structures or partially transmitted through faces on layers denoted as glass. Results are expressed in terms of daylight factor (ratio of calculated irradiance compared to theoretical maximum) or total irradiation (in watts per meter squared).



Installation

SimpleSolarStudy.rb/.rbz is installed to the normal SketchUp plugins directory. The Simple_Solar_Study folder contains documentation (basic html and this more complete PDF).

Usage

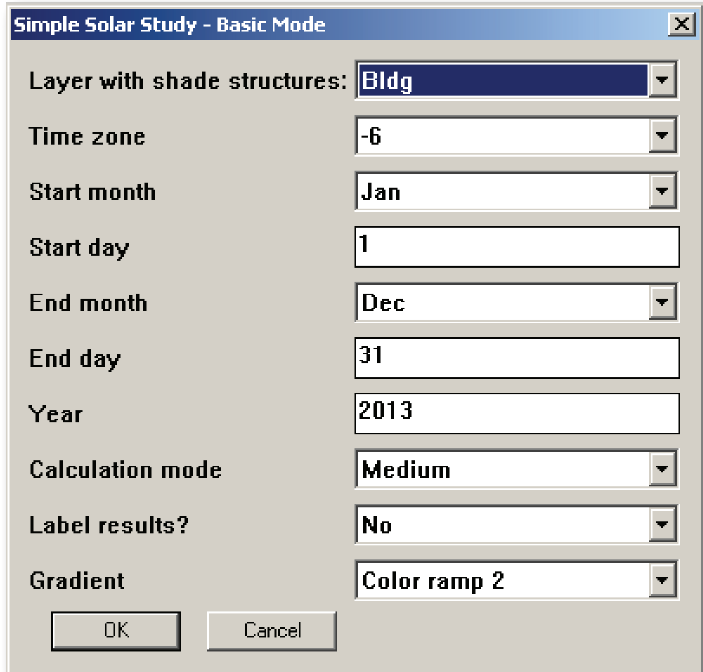
1. Geo-reference the model (one time)
This establishes the latitude and longitude with which to calculate the sun's position. Geo-referencing also identifies the north direction (generally along the green axis).

2. Group faces to be analyzed (one time)
Most often the target surface will be a set of contiguous faces that form the ground plane, but SimpleSolarStudy does not require the faces to be contiguous. They must, however, be grouped together. One way to create the analysis surface is to use the Sandbox tools, which automatically create a group. It should be noted, however, that the triangular faces created by the Sandbox tools can lead to confusing results at edge conditions. Faces can be grouped using the Edit | Make Group menu or the context-sensitive right-click menu. If the target surface is to be tilted (advanced mode only), the faces within the group should be tilted rather than tilting the group as a whole.

3. Select a group of faces to analyze

4. Run SimpleSolarStudy from SketchUp's "Plugins" menu. There are two modes: basic and advanced.

BASIC MODE



Layer with shade structures: Select the layer that contains faces that might cast shadows on the target surface. Note: the number of faces exponentially increases computation time, so some care should be taken to isolate faces that will actually block the sun.

Time zone: This is used to calculate solar position over the year. Time zone is relative to Greenwich Mean Time or Universal Coordinated Time, so -5 is Eastern Standard Time in the United States, +3 is Kenyan Time and +9 is Japan Standard Time. Daylight savings time is ignored.

Start month/day and *End month/day:* This is the time period for analysis. Dates are inclusive, so specifying a start date of March1 and end date of March 1 will result in 24 hours of analysis. Default is a full year.

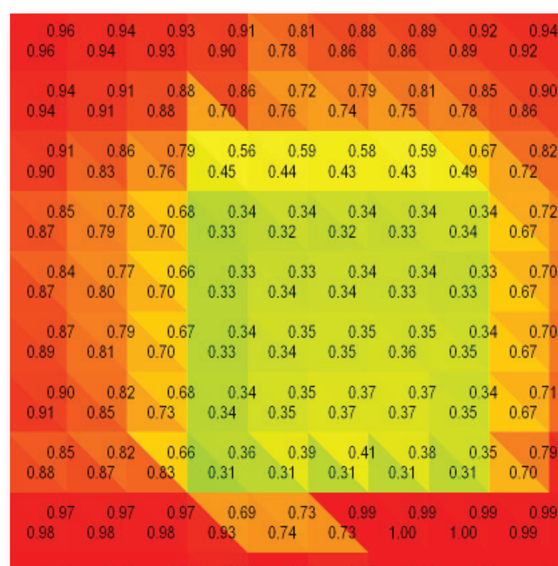
Year: The plugin only supports a time period that begins and ends in the same calendar year.

Calculation mode:

Coarse — The plugin will count the number of hours of available daylight (sunrise to sunset) and the number of hours daylight hits each face. The daylight factor for each face is expressed as a ratio of those two numbers. Any tilting of the target face is ignored.

Medium — Same as "Coarse", but the closer the sun is to its zenith, the more heavily it is weighted. In other words, it takes into account the fact that the sun is not as strong at sunrise or sunset. Any tilting of the target face is ignored.

Fine — This mode uses the Bird-Hulstrum clear sky model (1981) to calculate direct and diffuse sunlight on the target faces. The model takes into account such factors as scattering of light through the atmosphere and basic reflectivity from the ground. The intensity of the direct light component is adjusted for tilted target surfaces while the diffuse light component ignores tilt angles. The max value for the daylight factor calculation is based on light striking a horizontal surface. This means surfaces tilted toward the sun could result in a daylight factor greater than one.

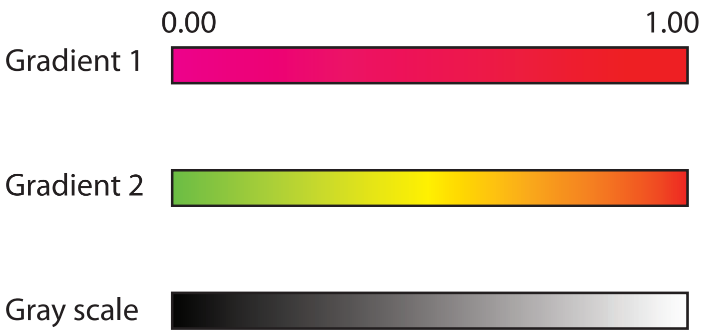


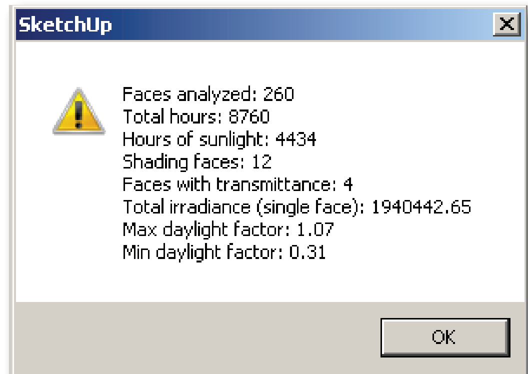
TMY3 — This mode uses a weather file in TMY3 (typical meterological year) format to compare observed solar irradiation to the Bird-Hulstrum clear sky model.

The weather file should approximately match the latitude/longitude of the model. More information about the TMY3 file format is available from the U.S. National Renewable Energy Laboratory at http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/ . Weather files for 1020 locations around the United States can be downloaded from the same website.

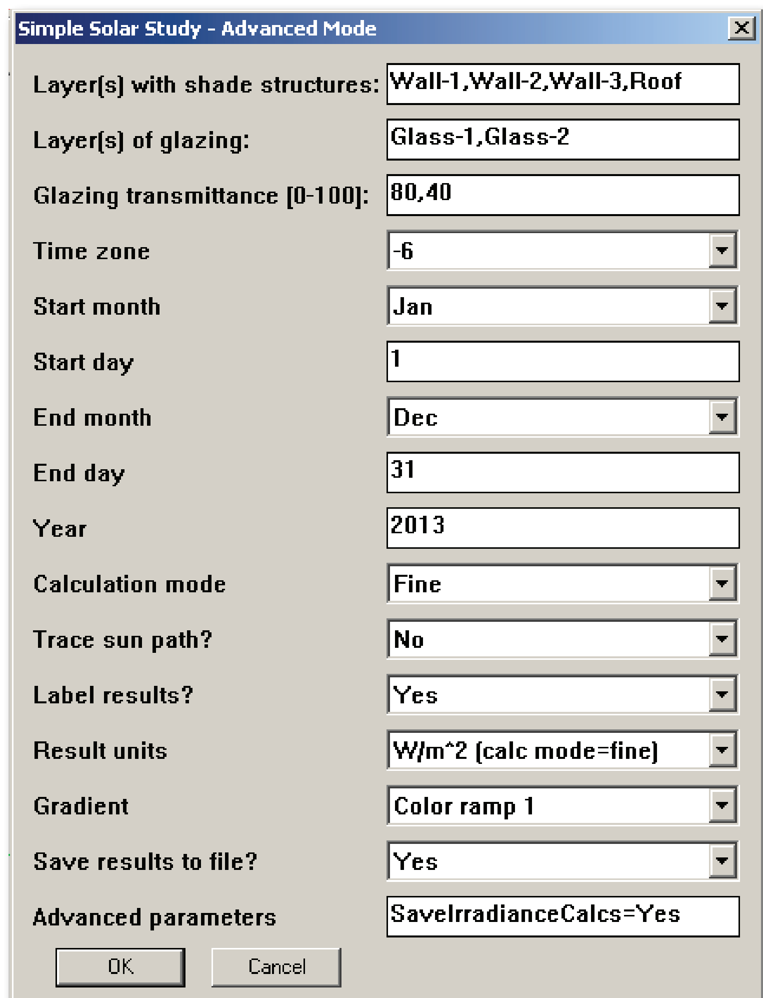
Label results: If yes, each face is labeled with its calculated daylight factor. A top/non-perspective view of the surface is probably the best way to read the labels.

Gradient: A color is applied to each face based on its daylight factor.





After the calculations are run, the plugin reports some basic statistics in a dialog box.



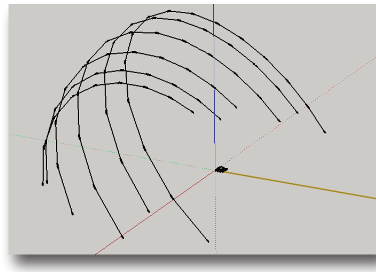
ADVANCED MODE

If run in advanced mode, Simple Solar Study provides a few extra options.

Layer(s) with shade structures: Advanced mode supports multiple layers. Instead of a dropdown selector, the user enters a comma-separated list of layer names (case-sensitive).

Layer(s) of glazing: In Advanced mode, layers containing glass can be entered (case-sensitive). Layers of glazing have a compounding effect, so if you have double-pane glass in your model, you might want to put each pane on its own layer and only tell Simple Solar Study about one of the layers.

Glazing transmittance: This is the visible transmittance of the faces on the glazing layers. A value of 0 would mean no light passes through. The entries in the comma-separated list correspond to the glazing layers, so in the example at right, objects on the "Glass-1" layer are 80% transmissive while those on "Glass-2" transmit 40% of light through them. According to the Daylighting Guide from Lawrence Berkeley National Lab, clear glass might have a visual transmittance of 88% while heavily tinted glass can be down in the 38%. If a single transmittance number is used, it will be applied to all glazing layers.



Trace sun path? This option draws edges between sun positions from sunrise to sunset on the first day of the month from January through June.

Result units: Basic mode always expresses results in terms of daylight factor. In Advanced mode, the output can be expressed in watts per meter squared. Note: this is only meaningful if the Calculation mode is set to "Fine". This option could conceivably be used to estimate solar energy output from a set of photovoltaic panels. Accounting for PV efficiency and actual size of the PV array is left to the user.

Save results to file? Selecting "Yes" will prompt you for a file name and save the daylight factor of each face to a comma-separated file for reading in your favorite spreadsheet program.

Advanced parameters: This field provides a way to enter undocumented options (which will now be documented). Parameter/value pairs are separated by commas, (spaces are ignored):

```
parameter1=value1, parameter2=value2, ....
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SaveSolarCalcs=Yes	This will save the intermediate solar position calculations to a CSV file. In "Coarse" and "Medium" calculation modes, the values saved are date, time, declination, equation of time, hour angle, elevation (degrees from horizontal) azimuth (degrees clockwise from north), sunstrength. In "Fine" calcuation mode, sunstrength is replaced by direct beam normal to the surface (W/m^2), direct radiation on horizontal surface (W/m^2), diffuse radiation on a horizontal surface (W/m^2), global/total radiation on a horizontal surface (W/m^2).
SaveIrradianceCalcs=Yes	This option only works in "Fine" calculation mode. Whereas SaveSolarCalcs gives radiation values for a generic surface at moments in time, SaveIrradianceCalcs outputs the radiation incident (or non-incident) upon each analysis face for each solar position.
LabelLayerName=<name>	This parameter lets the user choose the layer name to be used (or created) for daylight factor labels. The default layer name is "Solar study labels".
SunpathLayerName=<name>	This parameter lets the user choose the layer to be used (or created) for tracing the sun's path. Default is "Solar study sunpath".
Lat=<num>	Override the geo-referenced latitude. Positive latitudes are North.
Long=<num>	Overrride the geo-referenced longitude. Negative latitudes are West.
SunDist=<num>	Radius of the sun (centered on a point on the target surface). Default is 10,000.
Pressure=<num>	Barometric pressure in millibars (default 1013 is sea level)

Ozone=<num>	Ozone thickness of atmosphere in cm (typically 0.05 to 0.4, default is 0.35)
Water=<num>	Water vapor thickness of atmosphere in cm (typ 0.01 to 6.5, default is 4.0)
Aerosol-500=<num>	Aerosol optical depth at 500nm (typ 0.02 to 0.5, values > 0.5 represent clouds and volcanic dust, etc., default is 0.35)
Aeorsol-380=<num>	Aerosol optical depth at 380nm (typ 0.1 to 0.5, default is 0.35)
FwdScatter=<num>	Foward scattering of incoming radiation (1.0 for all forward vectors, 0.0 for all backward scattering, default is 0.84)
Reflectance=<num>	# ground reflectance (typ 0.2 for land, 0.25 for vegetation, 0.9 for snow, default is 0.20)

Credits

Code for the calculating the Julian day, the Julian century, and an implementation of the Bird and Hulstrum clear sky radiation model are translated from solrad_ver16.xls with permission from **Greg Pelletier**, Washington State Dept of Ecology.

Other calculations and algorithms are based on Excel formulas in BIRD_08_16_2012.xls by **Daryl Myers**, National Renewable Energy Laboratory, C code from solpos.c by **Martin Rymes**, National Renewable Energy Laboratory, and Javascript code in the online NOAA Solar Calculator, available at http://www.esrl.noaa.gov/gmd/grad/solcalc/.

Versions of Simple Solar Study before v0.93 were based on the SketchUp plugin Sunposition, v1.2.1 by Gabriel Miller, 2009

Publications referenced:

- Meeus, Jean. **Astronomical Algorithms**. Richmond, Va: Willmann-Bell, 1991.
- Stine, William B, and Raymond W. Harrigan. **Solar Energy Fundamentals and Design: With Computer Applications**. New York: Wiley, 1985.
- Bird, R E, and Roland Hulstrom. *A Simplified Clear Sky Model for Direct and Diffuse Insolation on Horizontal Surfaces*. Golden, Colo: Solar Energy Research Institute, 1981.

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