SOLAR RADIATION

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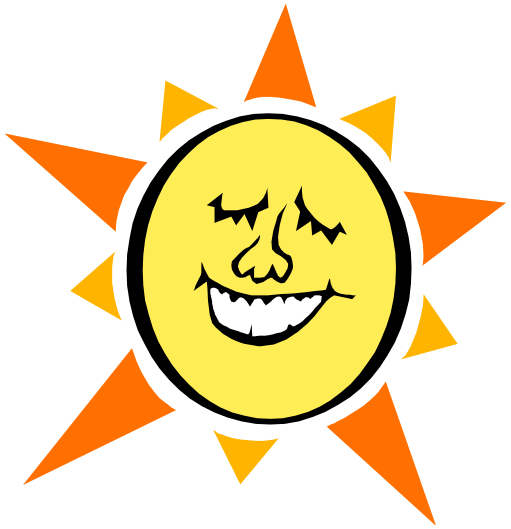
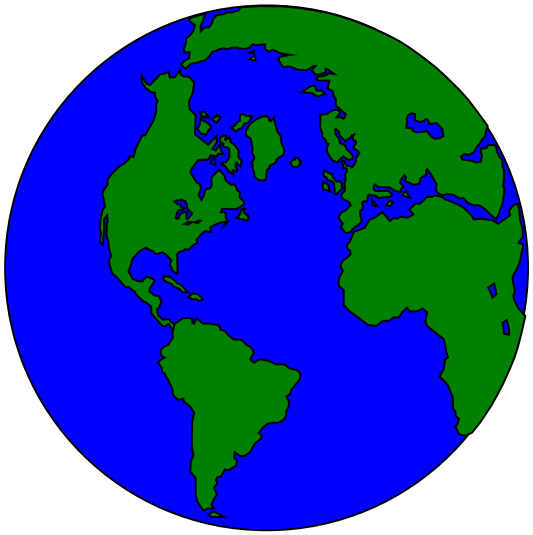
AUSTRIA

SOLAR RADIATION - 1

SOLAR CONSTANT

1352 W/m²

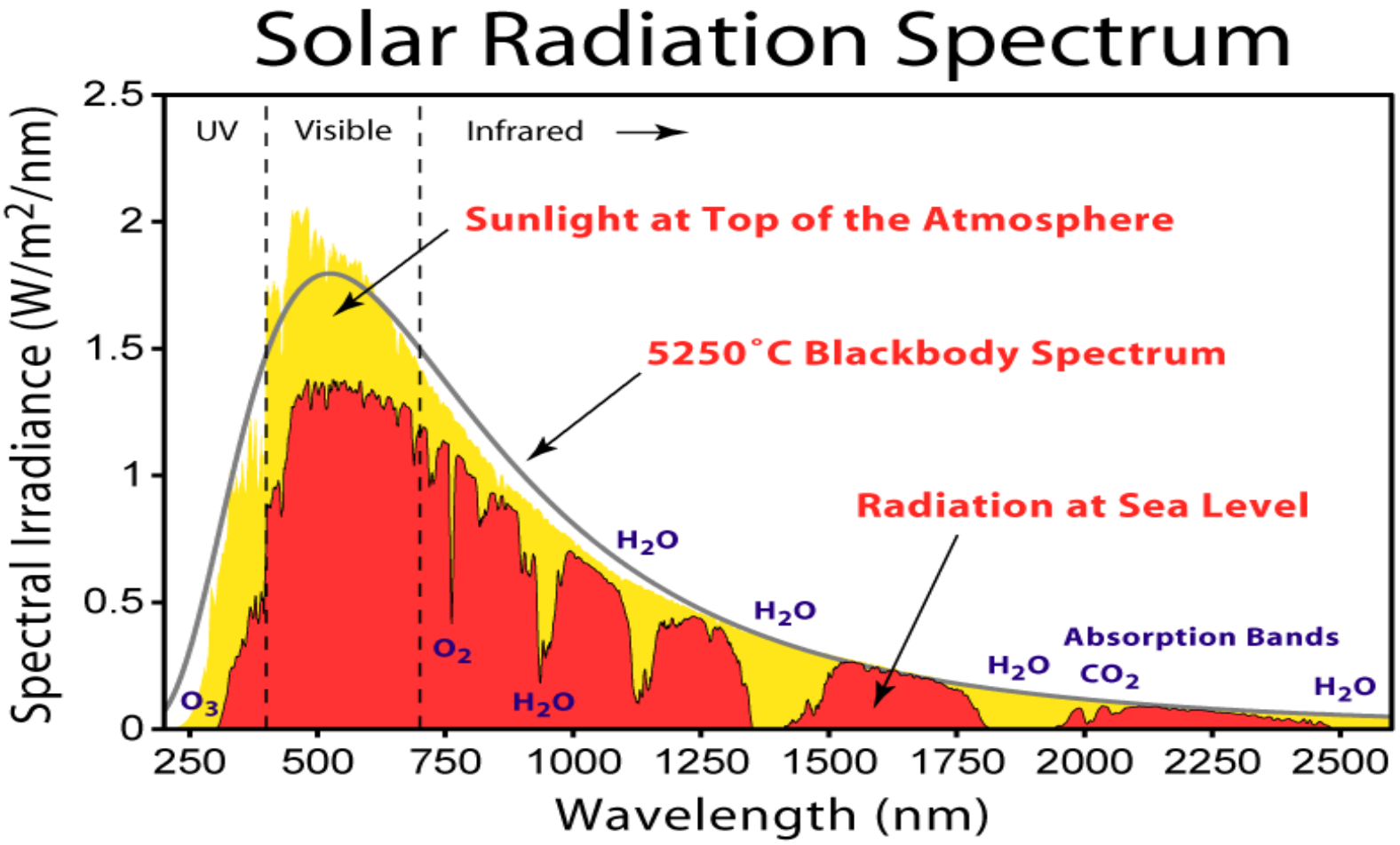




GLOBAL IRRADIATION

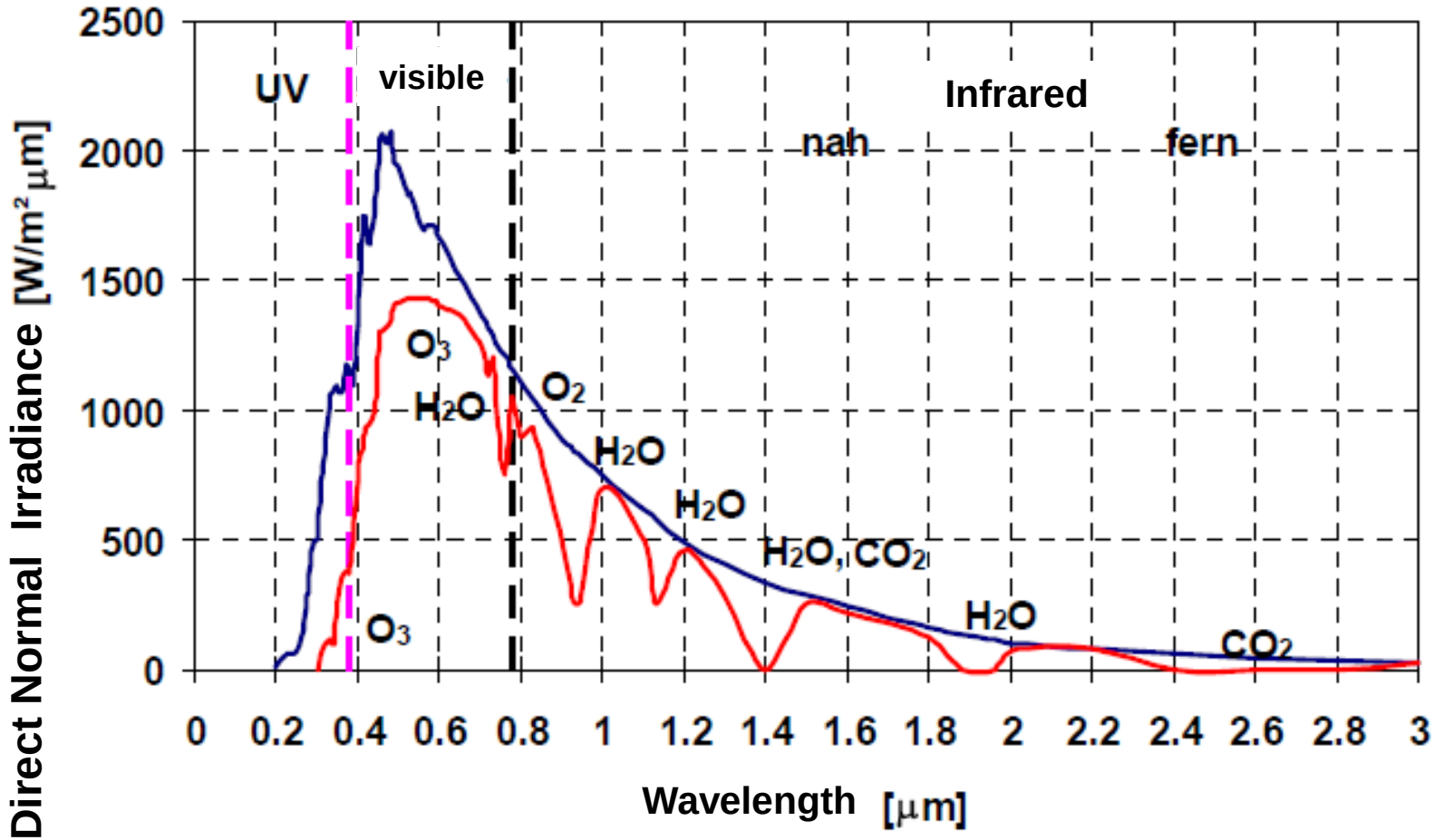
800 - 1000 W/m²

Solar Radiation Spectrum

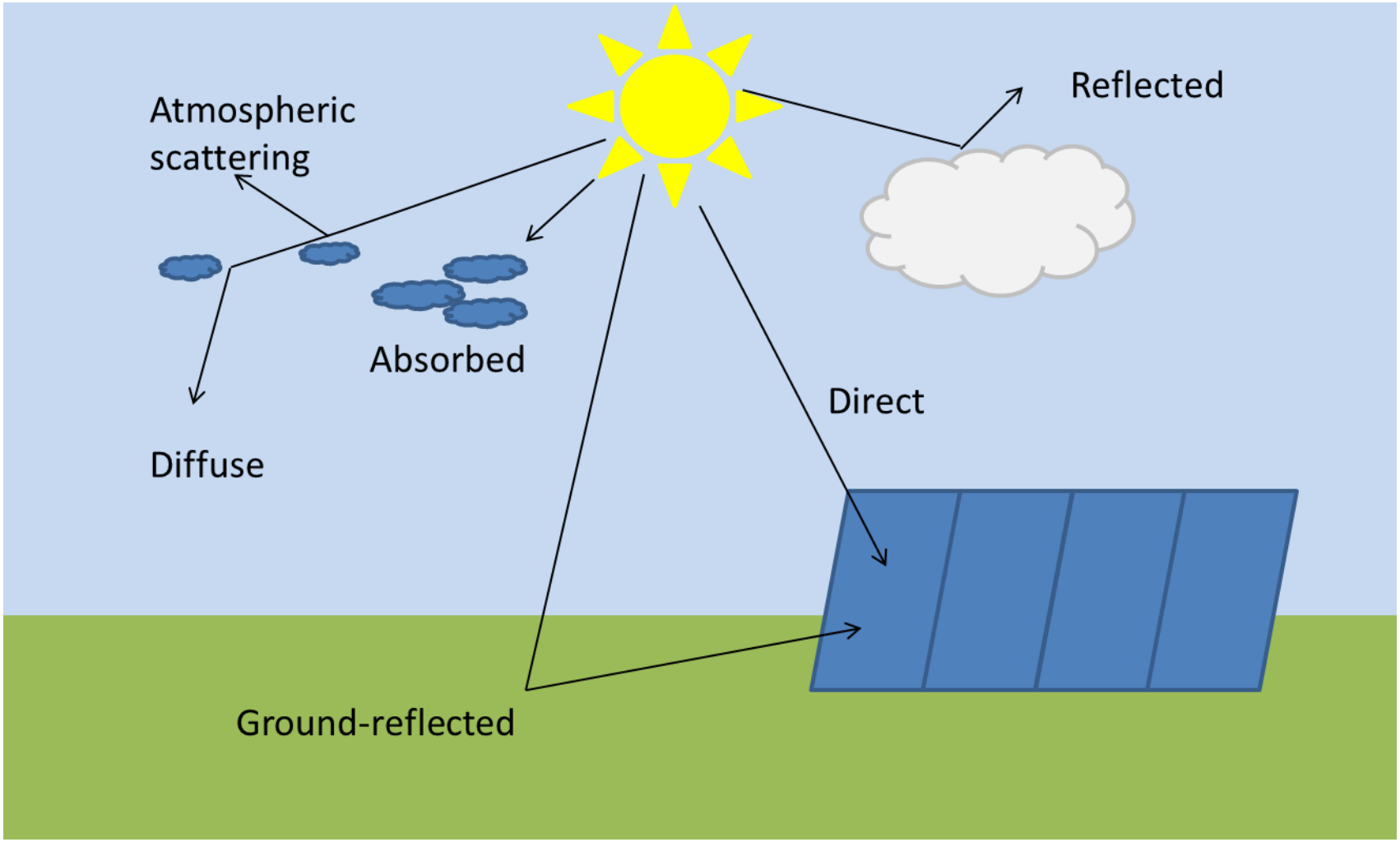


Solar radiation spectrum of at an average solar constant of I0=1353 kWh/m²
Source: http://www.howtopowertheworld.com

SOLAR RADIATION - 4



SOLAR RADIATION - 3

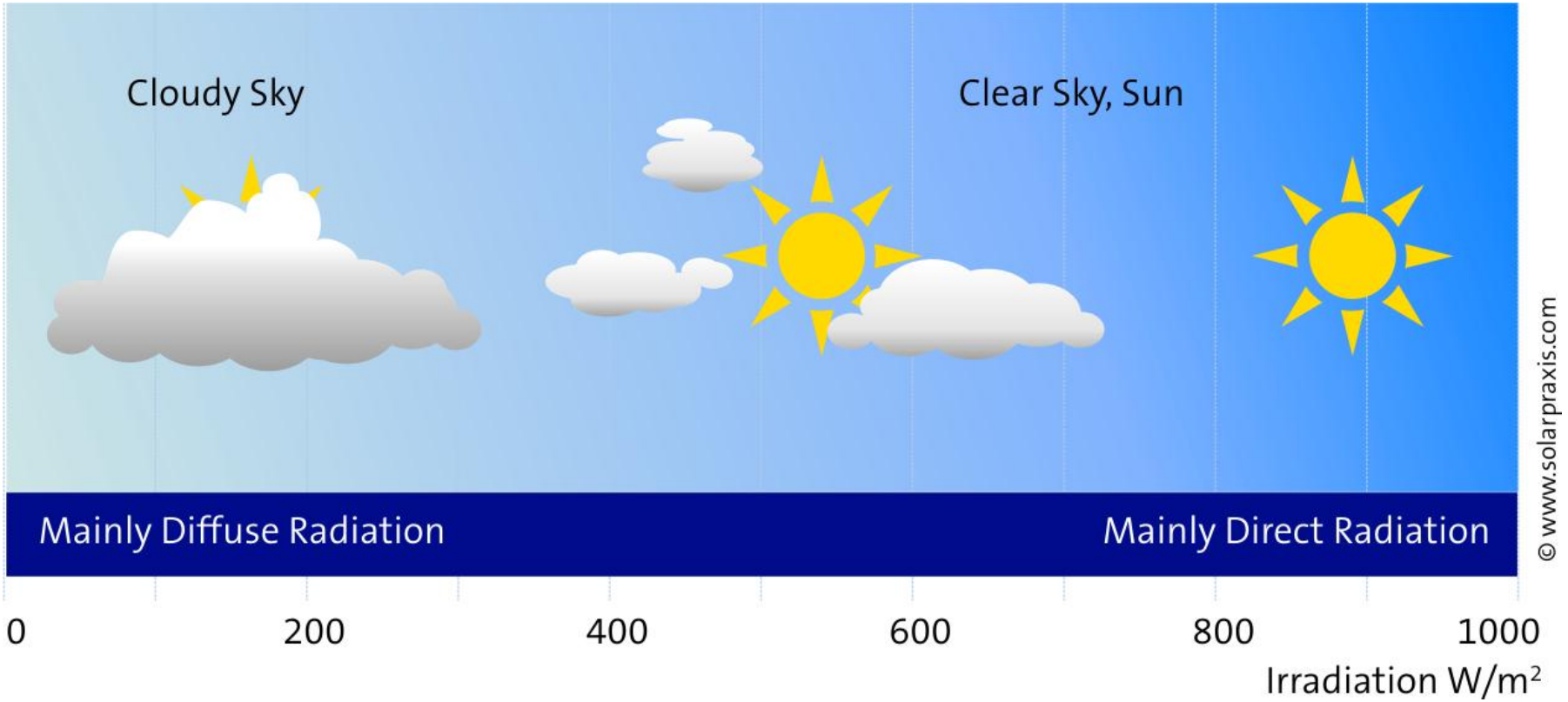


SOLAR RADIATION - 2

	Clear, blue sky 	Scattered clouds 	Overcast sky 
Solar irradiance [W/m²]	600 - 1000	200 - 400	50 - 150
Diffuse fraction [%]	10 - 20	20 - 80	80 - 100

Global irradiance and diffuse fraction, depending on the cloud conditions

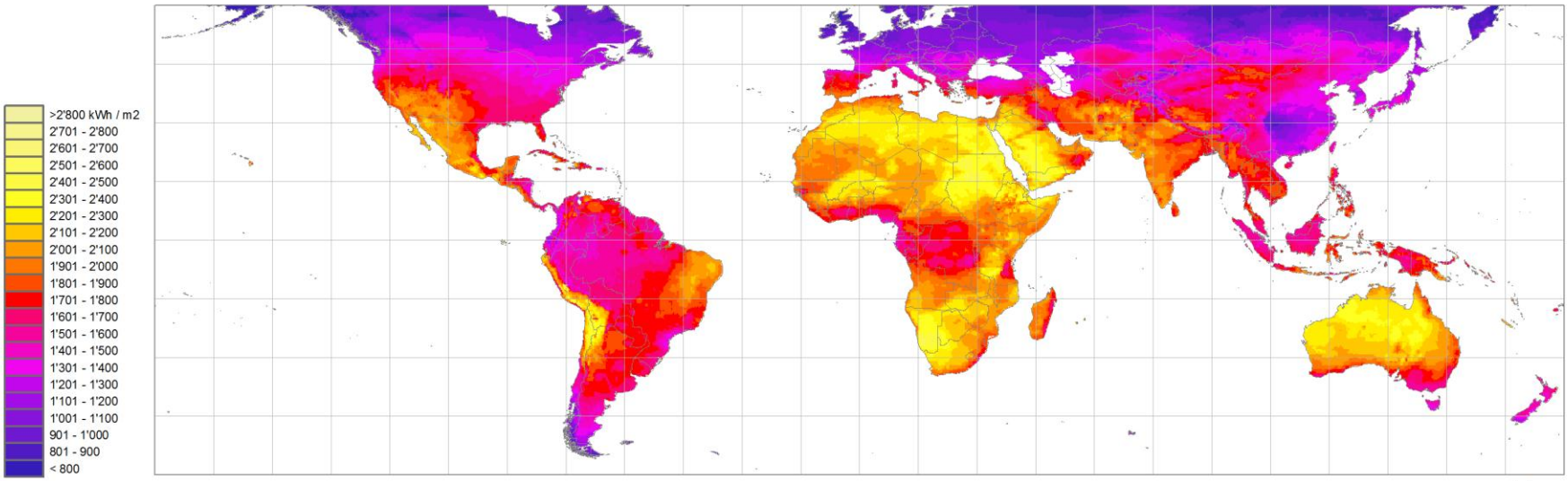
SOLAR RADIATION - 2



SOLAR RADIATION - 6

1000 – 1200 kWh/m² a

Yearly sum of Global Horizontal Irradiation (GHI)



Source: Meteonorm 7.0 (www.meteonorm.com); uncertainty 8%
Period: 1986 - 2005; grid cell size: 0.25°

November 2012

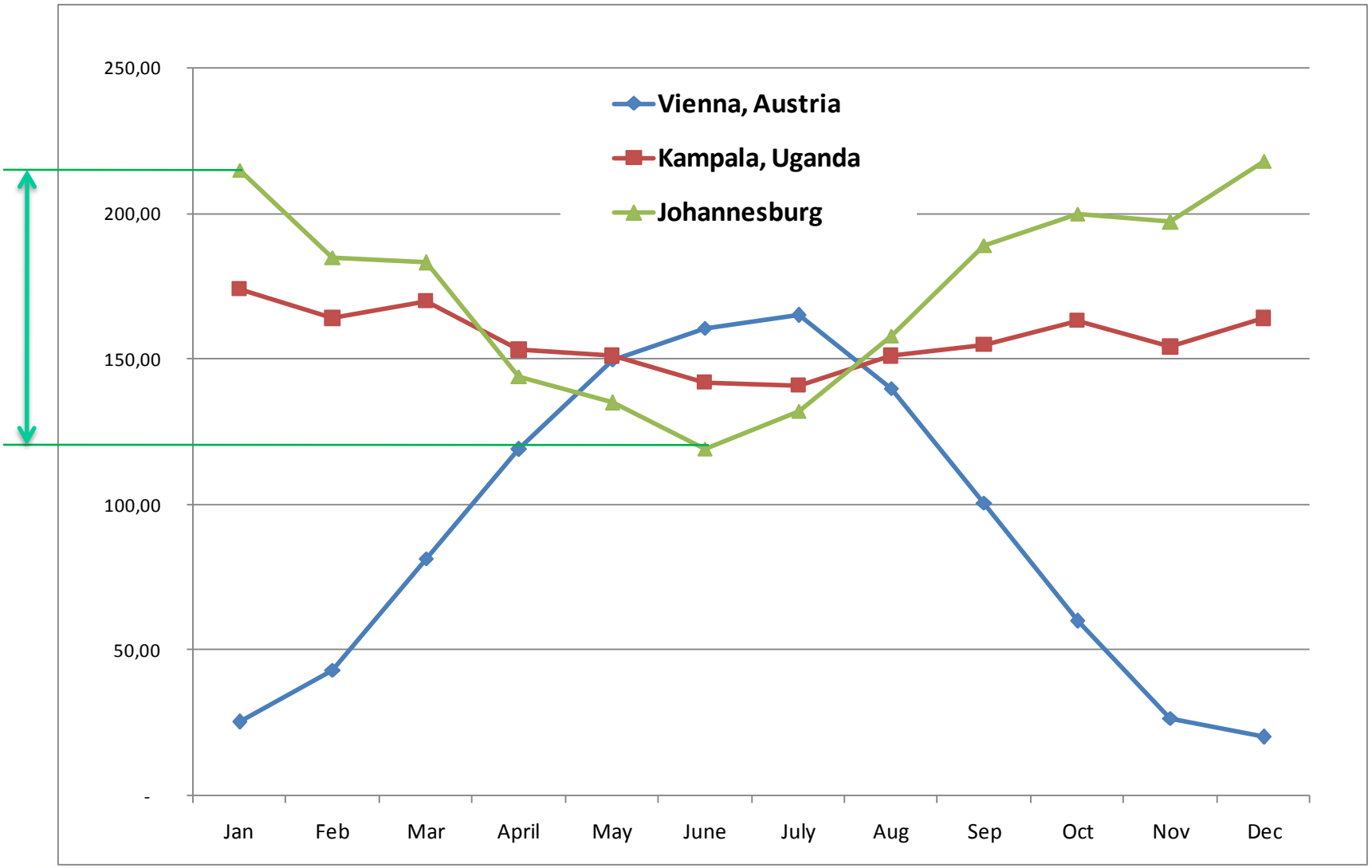
SOLAR RADIATION - 7

	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year	Lat
Vienna, Austria	25.2	43	81.4	118.9	149.8	160.7	164.9	139.7	100.6	59.8	26.3	19.9	**1090**	48.2 N
Kampala, UG	174	164	170	153	151	142	141	151	155	163	154	164	**1882**	00.2 N
Johannesburg	215	185	183	144	135	119	132	158	189	200	197	218	**2076**	26.1 S

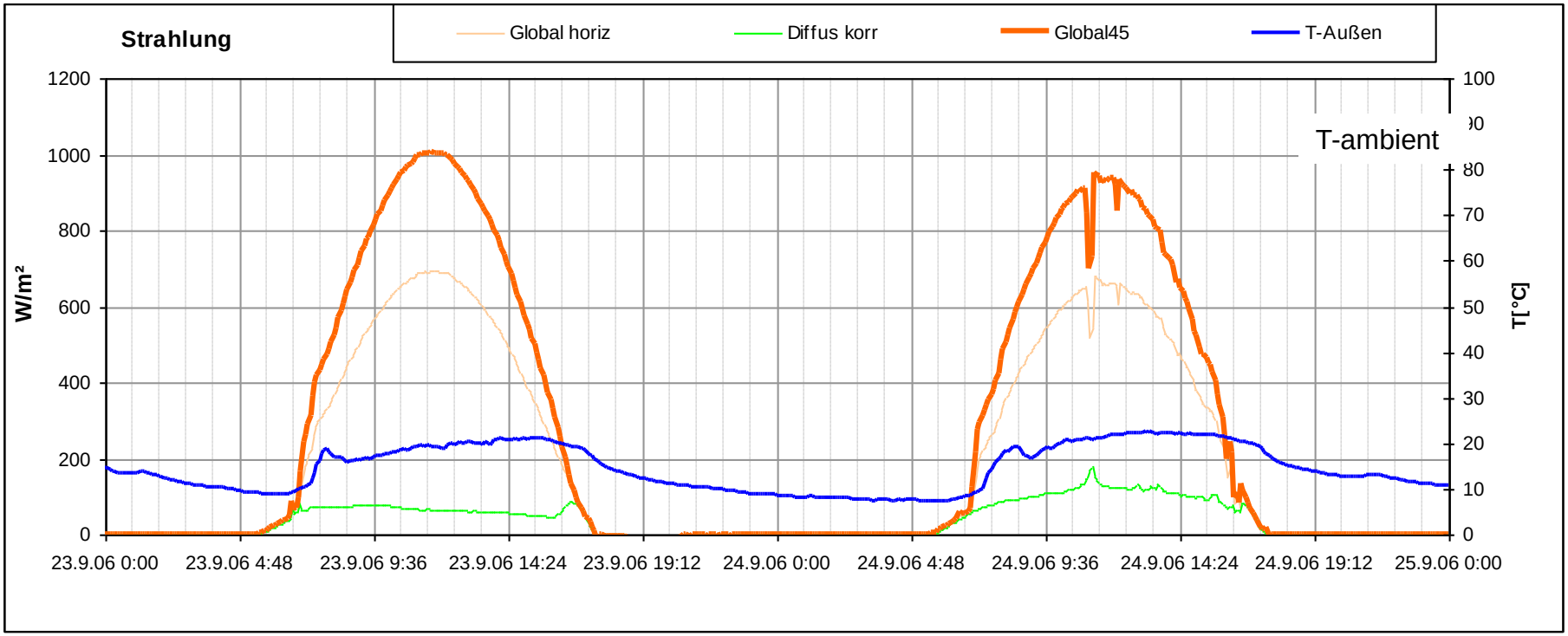
Average monthly and yearly values of global solar radiation on a horizontal surface in kWh/m²

Depending on the geographic location the yearly global insolation on a horizontal surface may vary between 1000 and 2200 kWh/m^2

SOLAR RADIATION - 8



SOLAR RADIATION DATA



Global radiation on the horizontal and a 45° inclined surface for two clear days, latitude 47°.

SOLAR RADIATION DATA

http://www.meteotest.ch

http://www.retscreen.net

MEASURING INSTRUMENTS

Campbell- Stokes

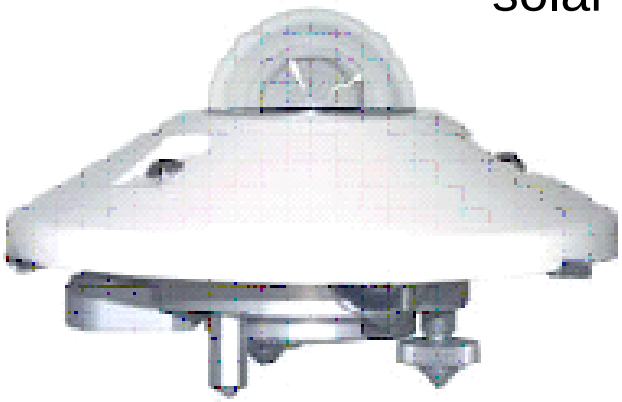
Sunshine Recorder

It consists of a solid glass sphere as a lens that produces an image of the sun on the opposite surface of the sphere. A strip of inflammable paper is mounted around the appropriate part of the sphere, and the solar image burns a mark on the paper whenever the beam radiation is above a critical level. If the sun is covered by clouds, the line on the paper is interrupted. The lengths of the burned portions of the paper gives and index of the duration of bright sunshine.

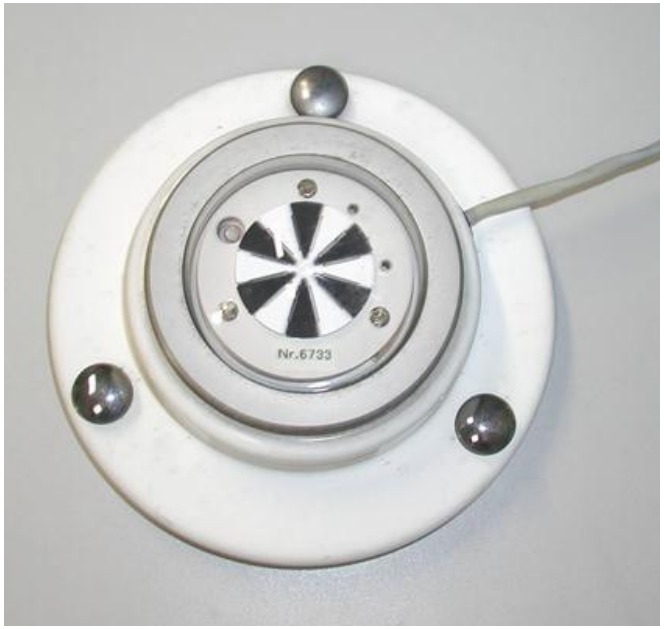
MEASURING INSTRUMENTS

Pyranometer

Pyranometers are instruments for measuring global radiation (direct and diffuse). The detectors of these instruments must have a response independent of the wavelength of radiation over the solar energy spectrum. The detectors convert the solar radiation into an electrical voltage, which is an indicator for the solar radiation.



MEASURING INSTRUMENTS



Black and White Pyranometer

The black and white pyranometer consist of star-shaped white and black thermal elements. The temperature differences between white and black surfaces result in thermal stress, which is the indicator for the solar radiation.

MEASURING INSTRUMENTS

Measurements of diffuse radiation…

…can be made with pyranometers by shading the instrument from the direct (beam) radiation. This is done by means of a shading ring.

Adjustments need to be made for changing declination.

MEASURING INSTRUMENTS

Pyrheliometer

A pyrheliometer is an instrument using a collimated detector for measuring solar radiation from the sun and a small proportion of the sky around the sun at normal incidence. It is used for measuring the beam radiation

Solar Radiation on Tilted Surface

$$\bar{H}_T = \bar{H}_b \bar{R}_b + \bar{H}_d \left(\frac{1+\cos\beta}{2} \right) + \bar{H}\ \rho_g \left(\frac{1-\cos\beta}{2} \right)$$

$$\frac{\bar{H}_d}{\bar{H}} = 1.391 - 3.560\bar{K}_T + 4.189\bar{K}_T^2 - 2.137K_T^3$$

$$\frac{\bar{H}_d}{\bar{H}} = 1.311 - 3.022\bar{K}_T + 3.427\bar{K}_T^2 - 1.821K_T^3$$

$$\bar{H}_b = \bar{H} - \bar{H}_d$$

See Page 27 of the manual

ANGLE OF TILT

Latitude [degree]	Best collector tilt in:					
	June	Orientation	**Sept./March**	Orientation	**December**	Orientation
50 N	26.5	S	50	S	73.5	S
40 N	16.5	S	40	S	63.5	S
30 N	6.5	S	30	S	53.5	S
20 N	3.5	N	20	S	43.5	S
15 N	8.5	N	15	S	38.5	S
10 N	13.5	N	10	S	33.5	S
Equator = 0	**23.5**	**N**	**0**	**-**	**23.5**	**S**
10 S	33.5	N	10	N	13.5	S
15 S	38.5	N	15	N	8.5	S
20 S	43.5	N	20	N	3.5	S
30 S	53.5	N	30	N	6.5	N
40 S	63.5	N	40	N	16.5	N
50 S	73.5	N	50	N	26.5	N

As a general rule, the optimum angle of tilt is equal to the degree of latitude of the site

Tilt and orientation of the collector

Tracking systems ???

Thank you for your attention