SOLAR RADIATION

Werner Weiss

AEE - Institute for Sustainable Technologies (AEE INTEC)
A-8200 Gleisdorf, Feldgasse 19
AUSTRIA

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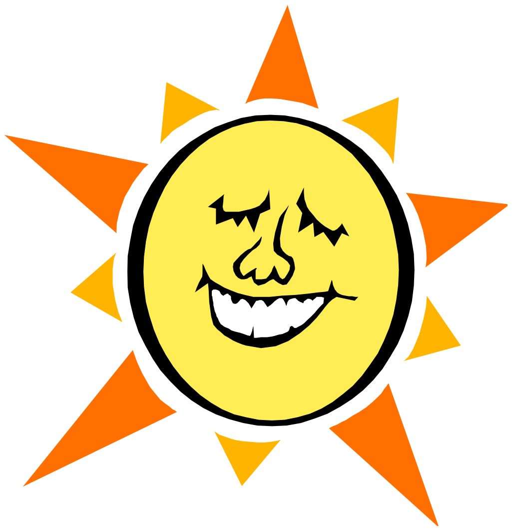
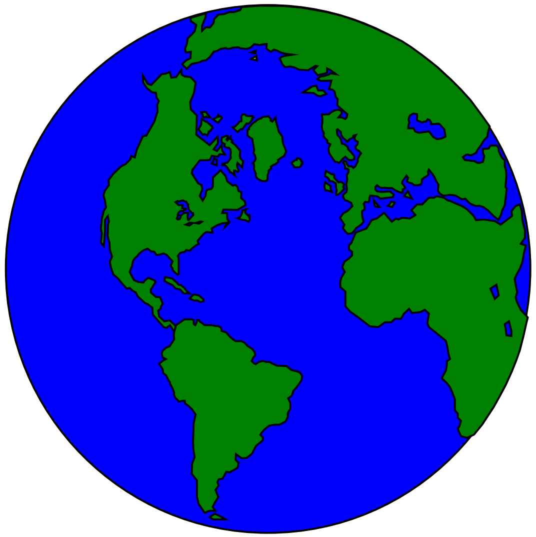
SOLAR RADIATION - 1

SOLAR CONSTANT

1360 W/m²





GLOBAL IRRADIATION

800 - 1000 W/m²

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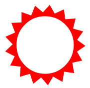
SOLAR RADIATION - 2

	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

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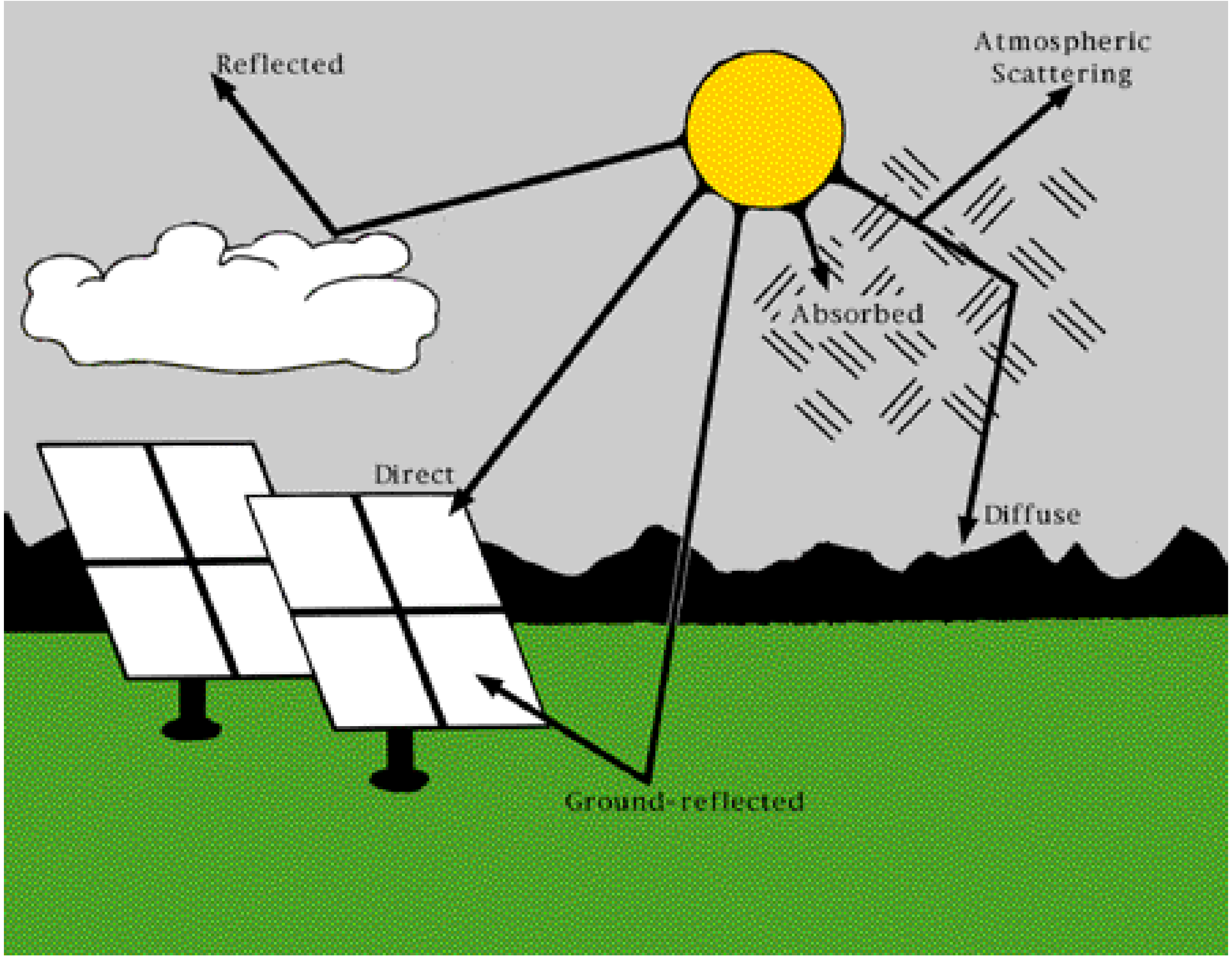

SOLAR RADIATION - 4

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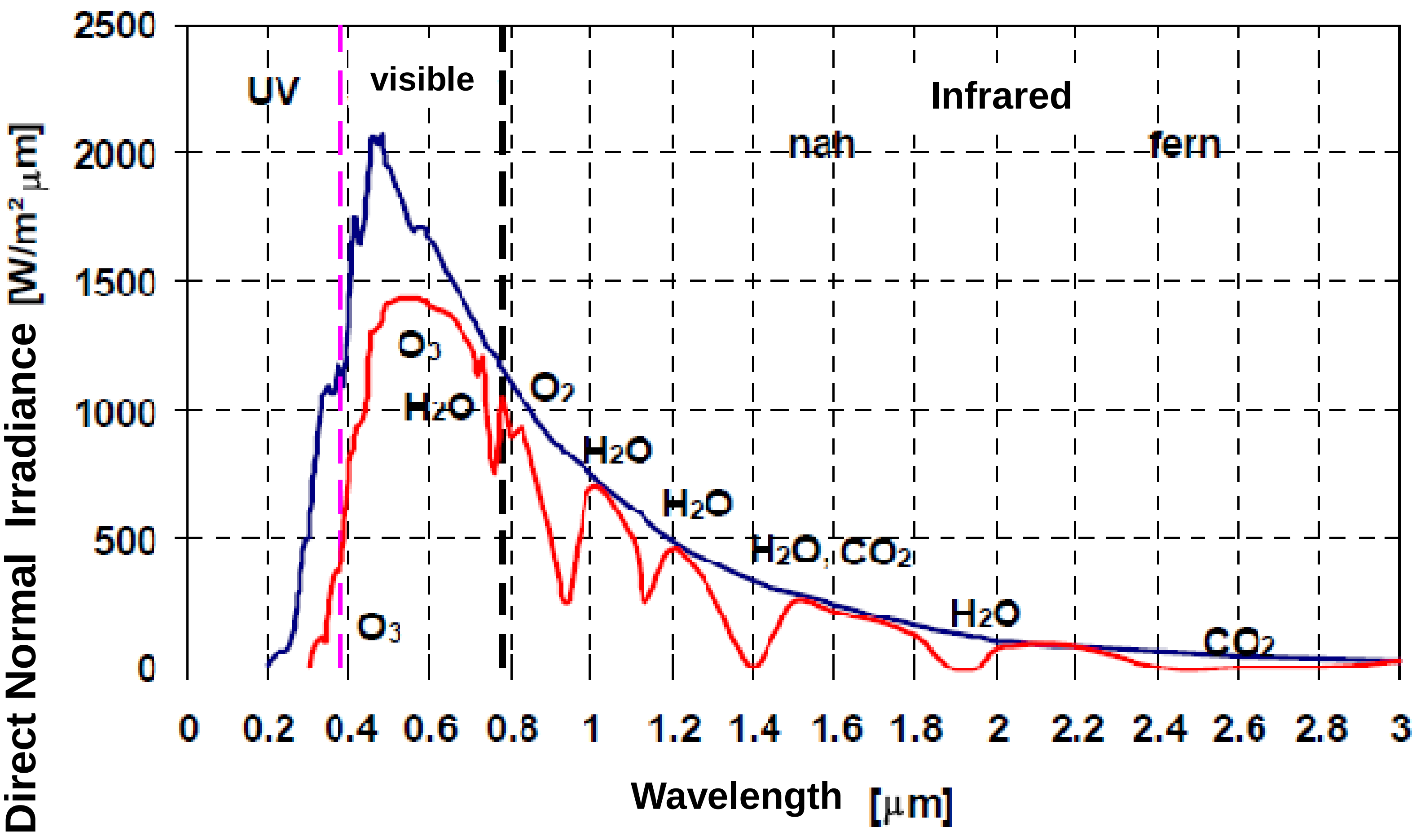

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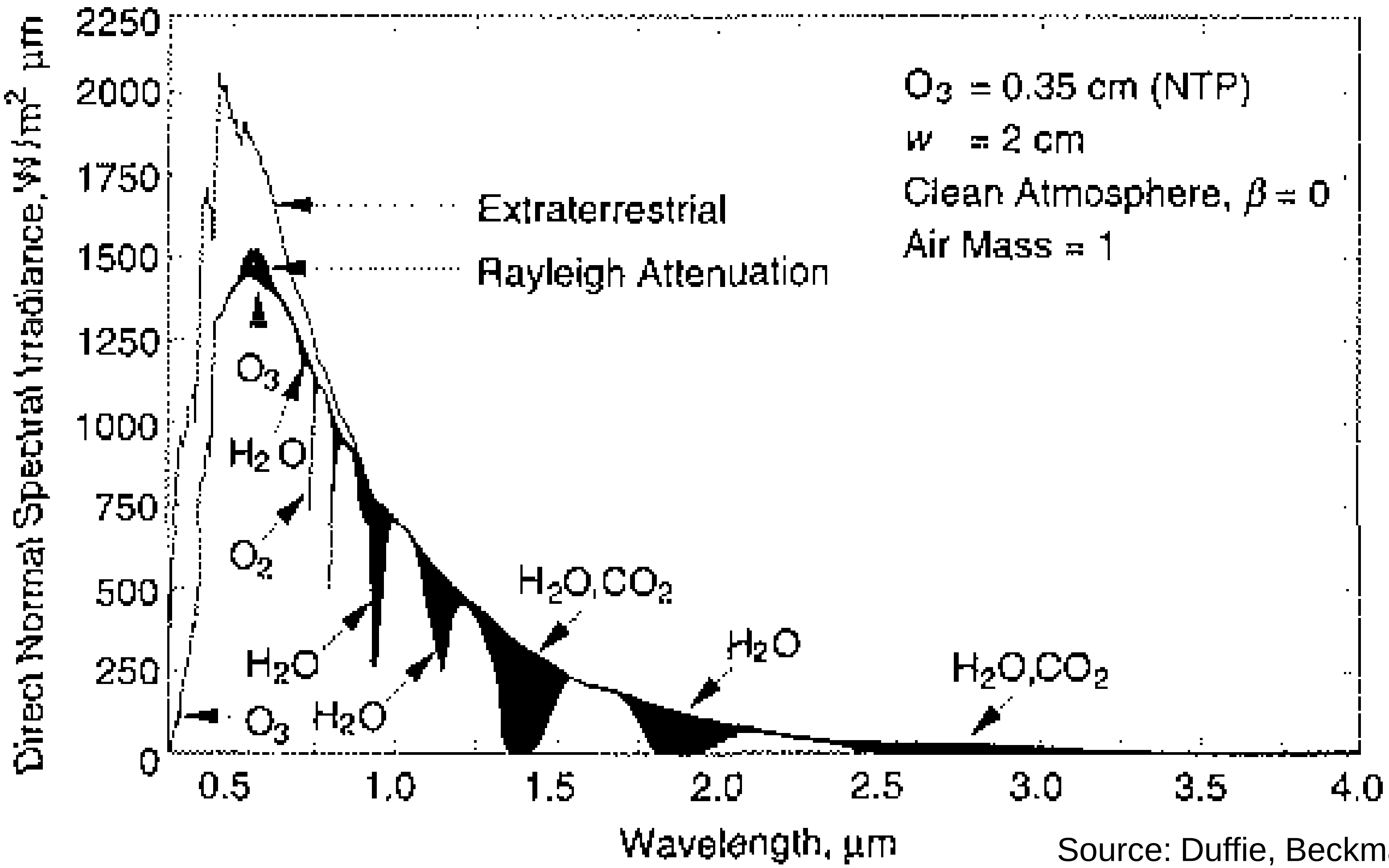

Source: Duffie, Beckman

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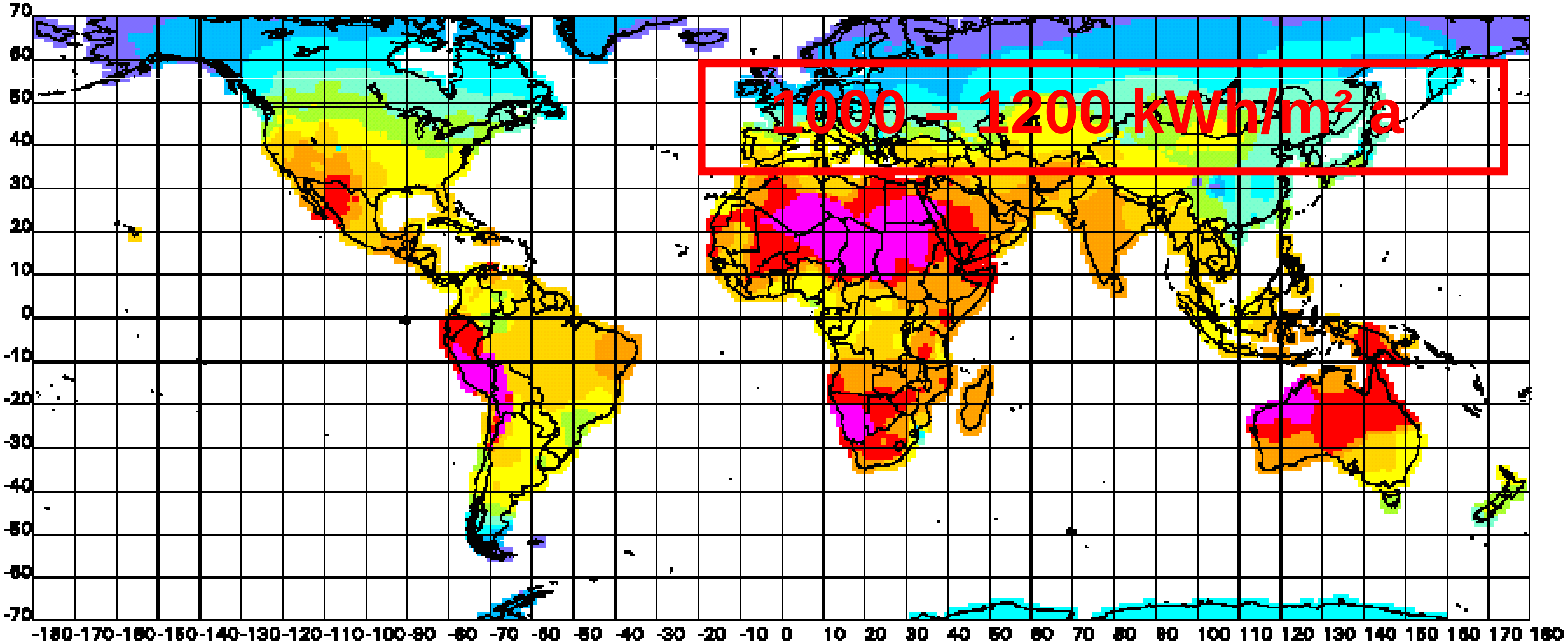
METEONORM 4.0

METEOTEST

Global Irradiation: year [kWh/m^2]

- 640 .. 900
- 900 .. 1050
- 1050 .. 1200
- 1200 .. 1350
- 1350 .. 1500
- 1500 .. 1700
- 1700 .. 1900
- 1900 .. 2100
- 2100 .. 2300
- > 2300
- non-study area



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	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

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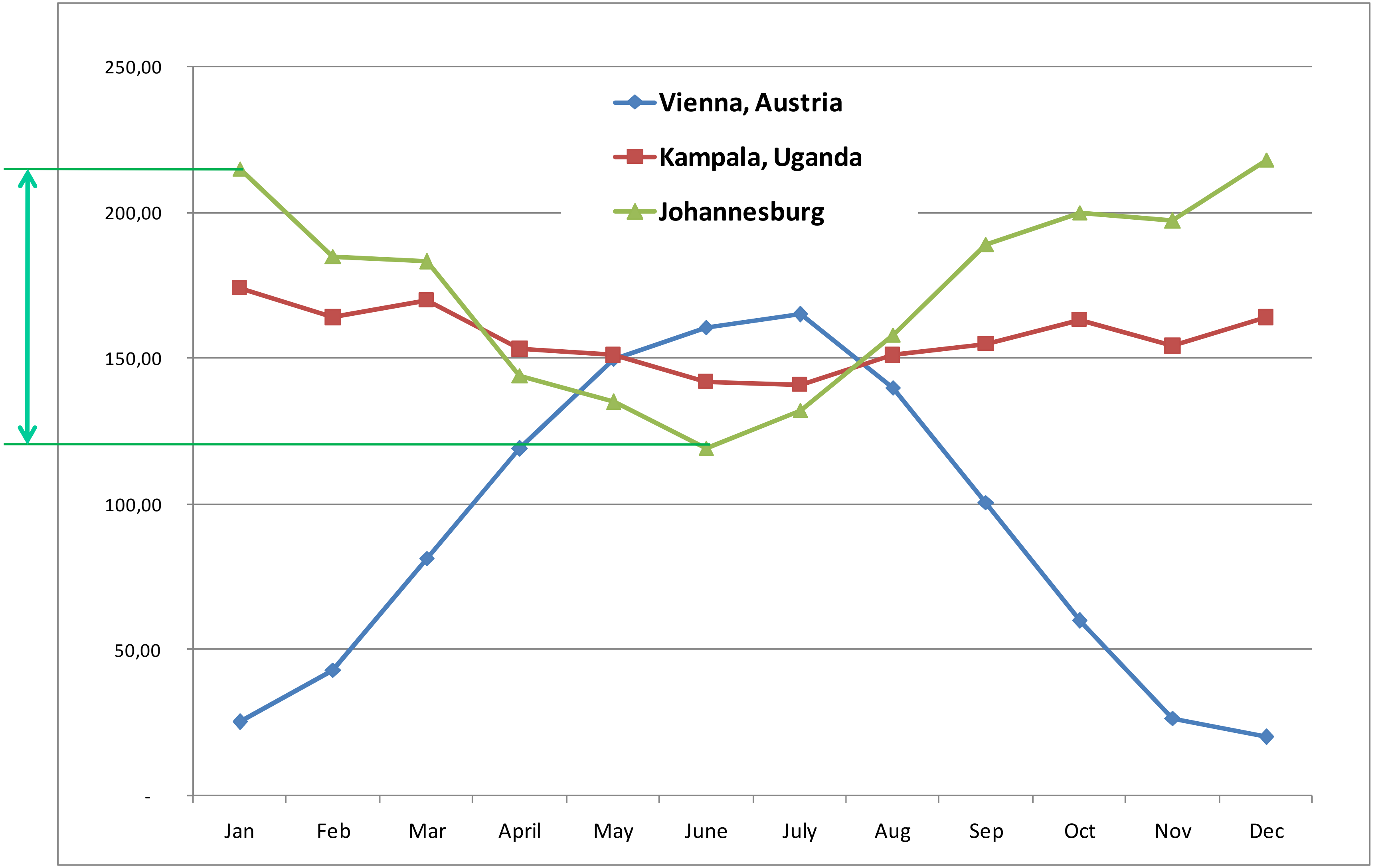

Annual global irradiation [kWh/m²]

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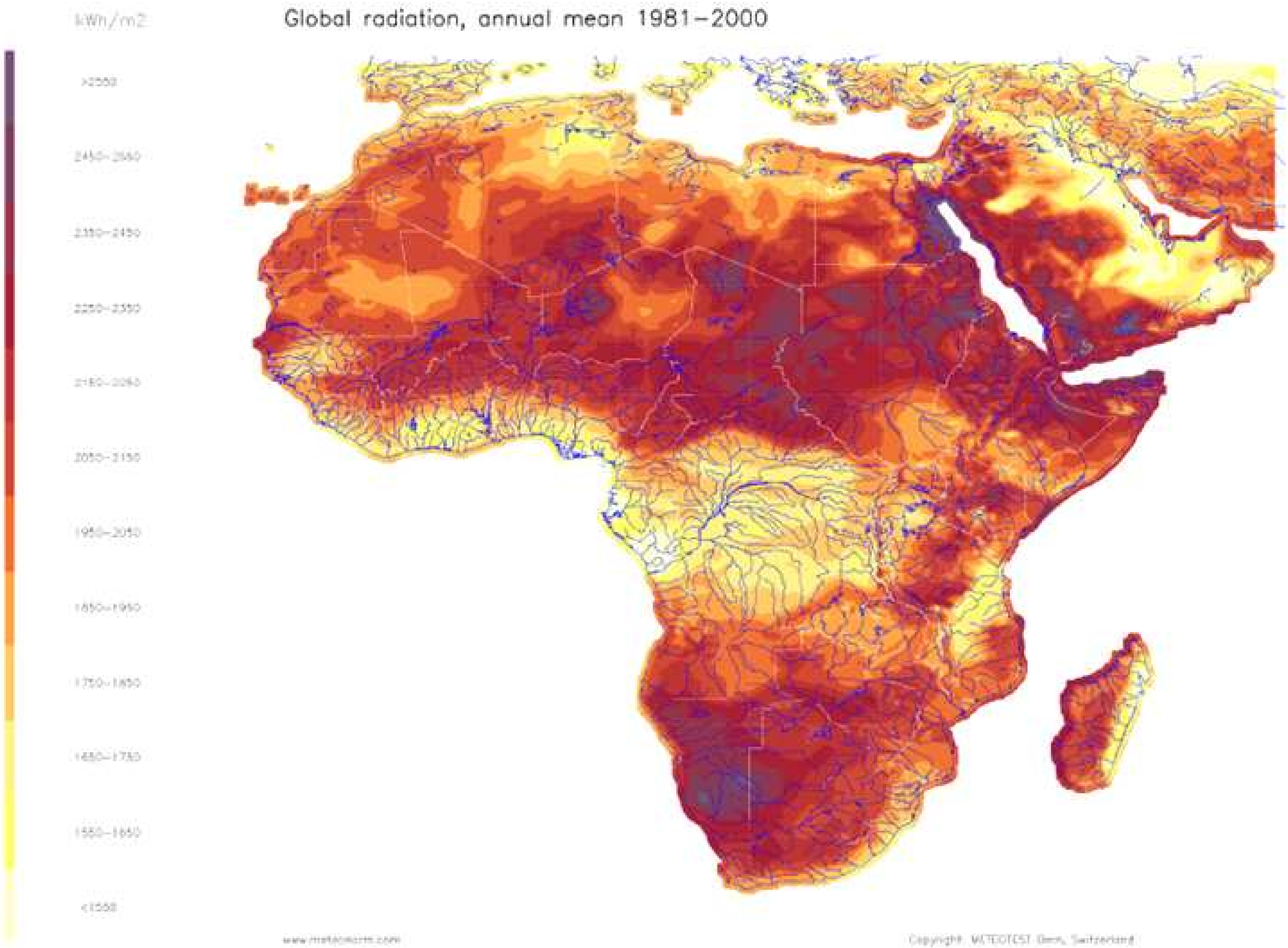

Source: Meteonorm

SOLAR RADIATION DATA

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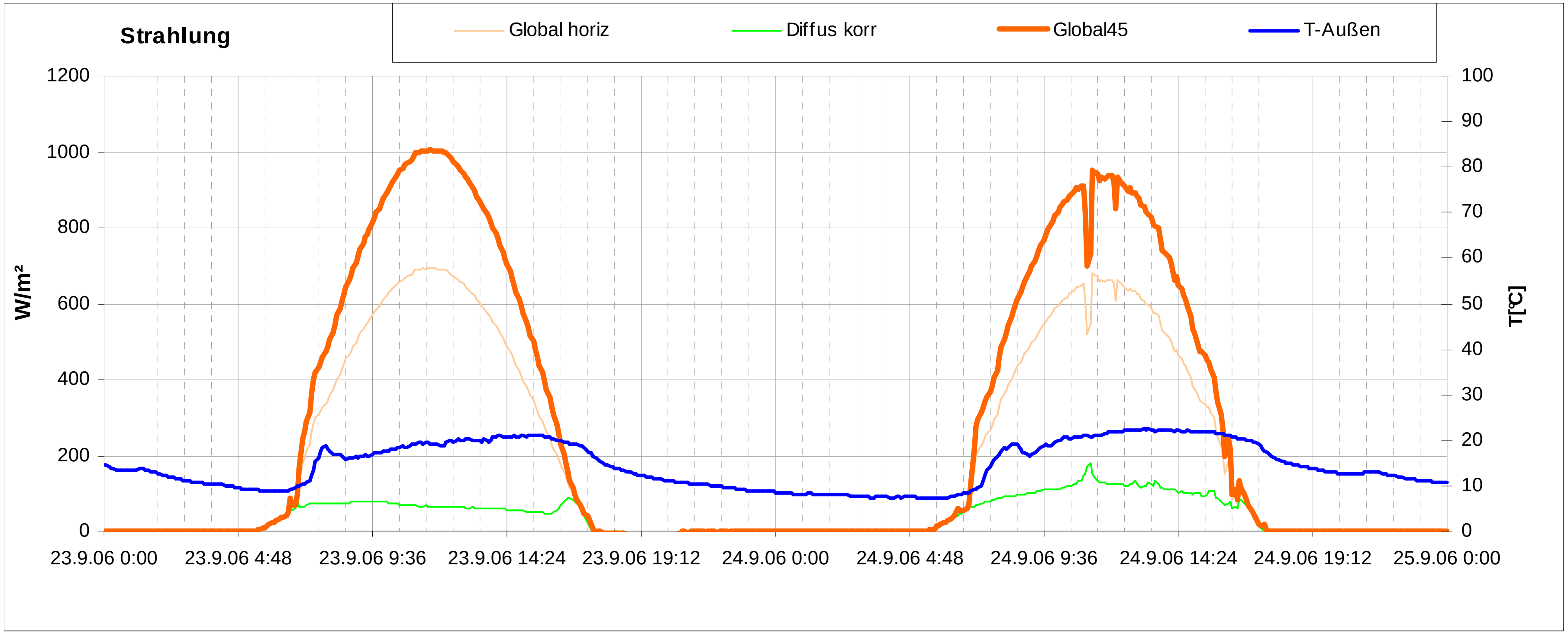

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http://www.meteotest.ch

http://www.retscreen.net

MEASURING INSTRUMENTS

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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.

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.

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

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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

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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

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Solar Radiation on Tilted Surface

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

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

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

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

See Page 21 f of the manual

ANGLE OF TILT

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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

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Tracking systems ???