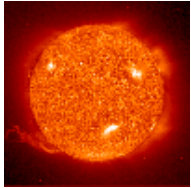


Electromagnetic radiation



SUN: Source of electromagnetic radiation

Description of electromagnetic radiation:

- **Wave character** (wavelength λ , frequency ν)
- **Particle character: photon** (energy $h\nu$)

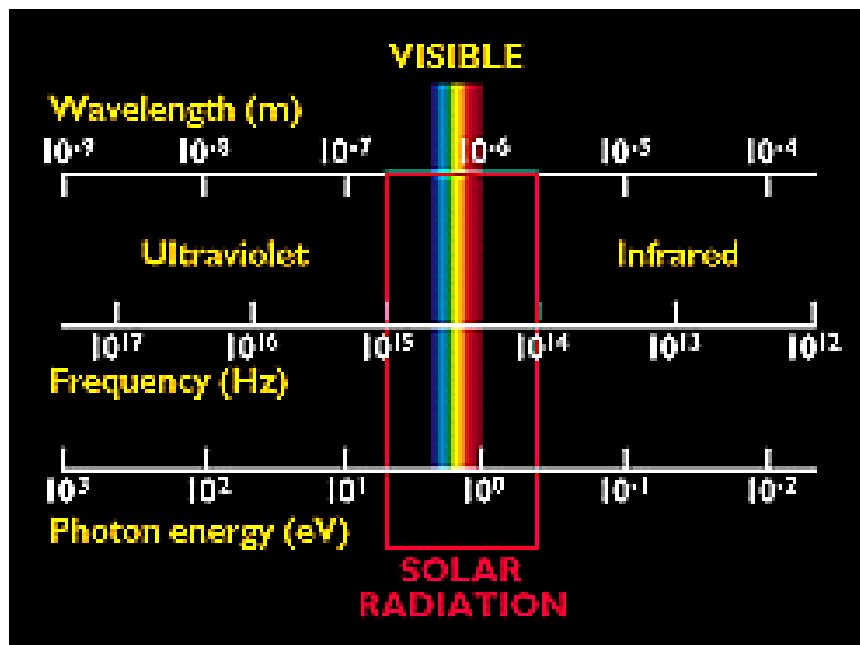
$$\nu = c/\lambda$$
$$h\nu = \frac{1}{q} \frac{hc}{\lambda}$$

c (speed of light in vacuum) = 2.998×10^8 m/s

h (Planck's constant) = 6.625×10^{-34} Js

q (elementary charge) = 1.602×10^{-19} C

Electromagnetic radiation



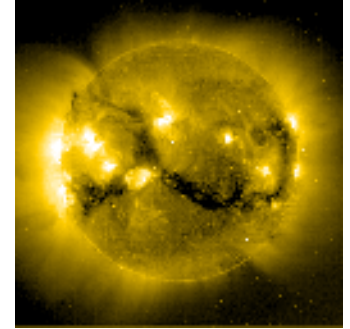
Spectrum range:

Wavelength: 2×10^{-7} to 3×10^{-6} m

Frequency: 1×10^{15} to 1×10^{14} Hz

Photon energy: 6.2 to 0.4 eV

Solar spectrum



- **SUN** – „gas sphere“ with a diameter of 1.4 million km
- **SUN** – source of all energy due to the thermonuclear reactions
- **Energy** from the Sun incident on the Earth – „light“ and „heat“
- „Light“ and „heat“ – **electromagnetic radiation / photons**
 - **white light** – composition of colors (rainbow)
 - **heat** – long wavelength, invisible „infrared“ radiation
- solar spectrum incident on the Earth:
 - **ultraviolet radiation**
 - **visible light**
 - **infrared radiation**

A. Poruba, Solartec

Electromagnetic radiation

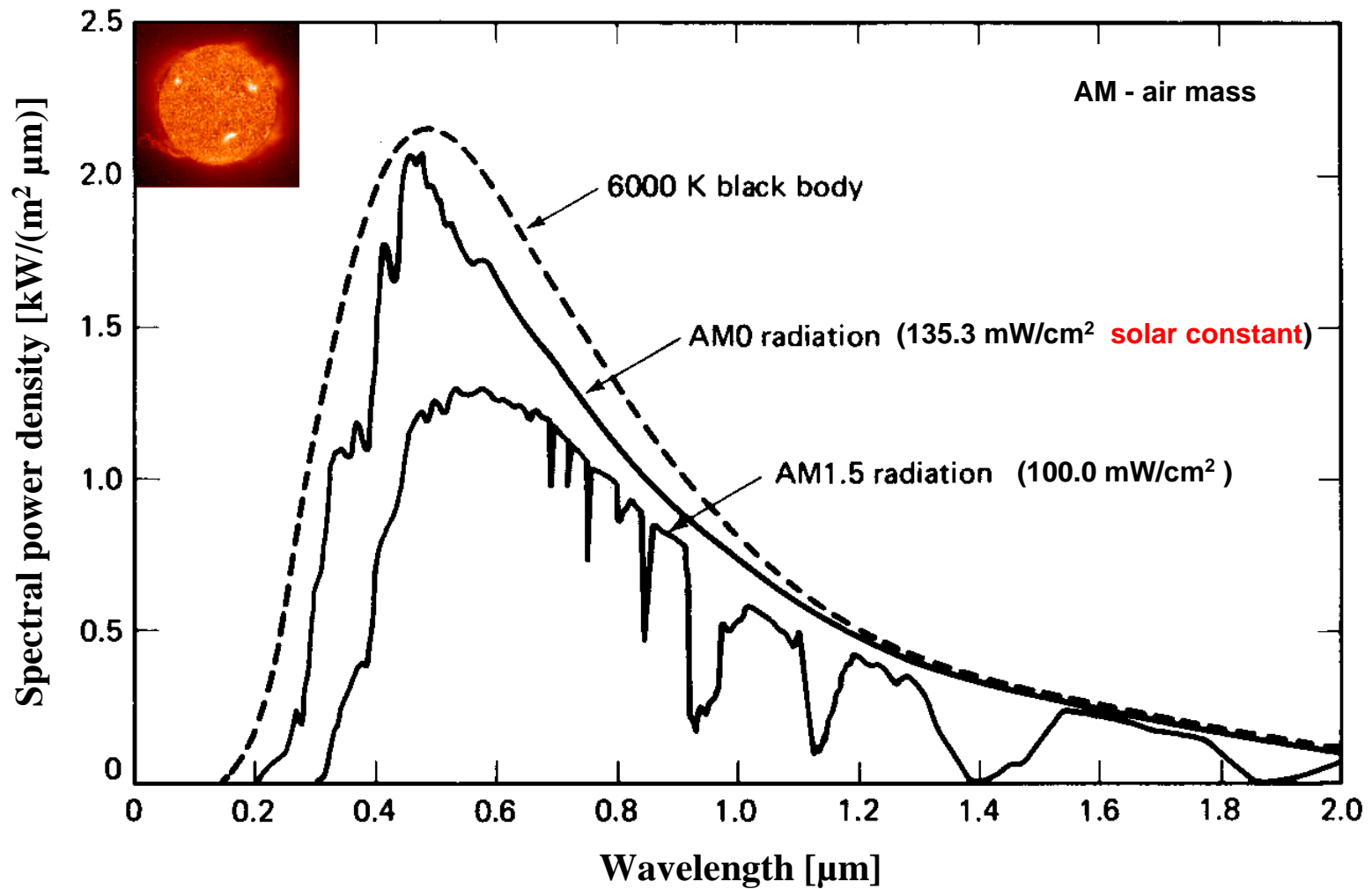
Spectral distribution

(number of photons as a function of wavelength/energy)

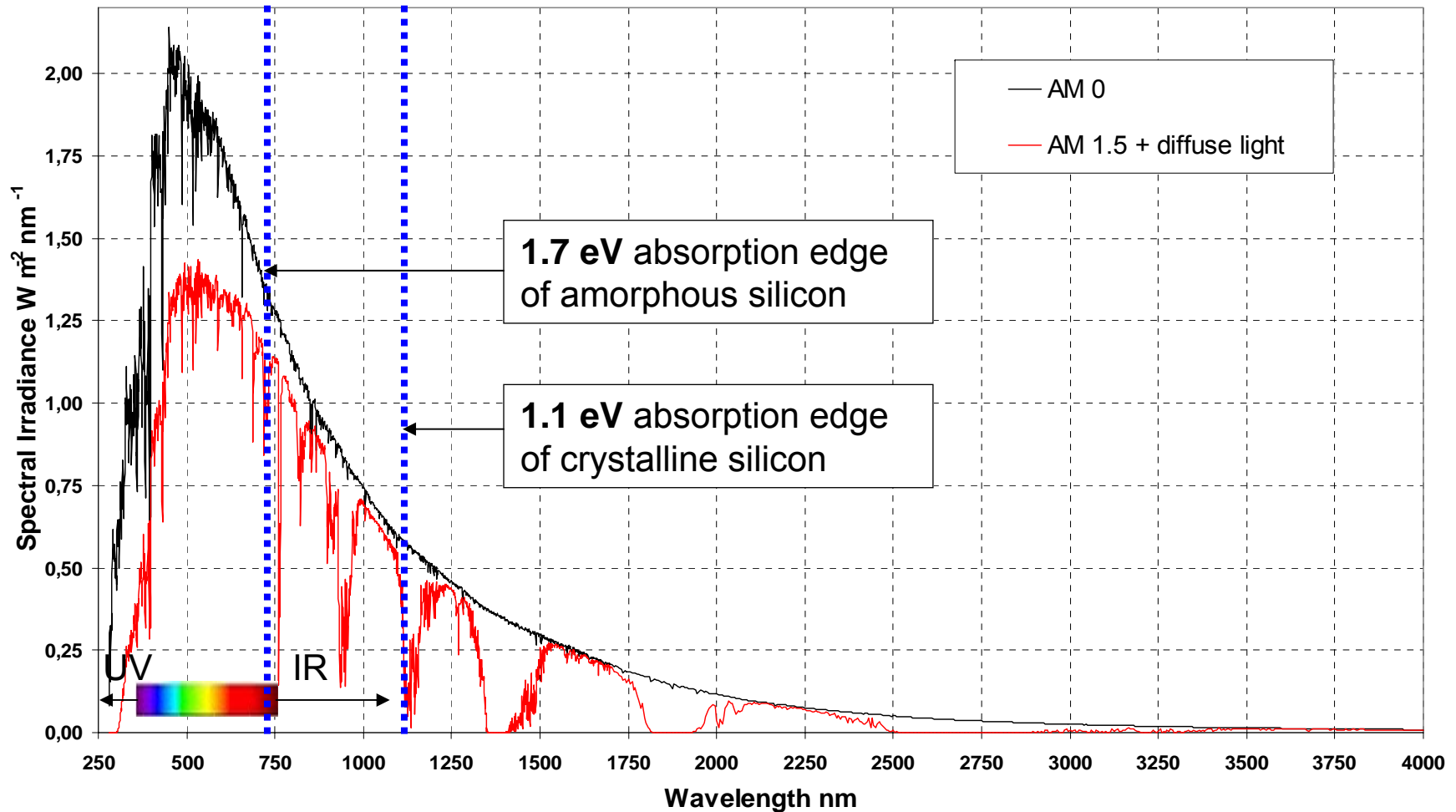
- **Photon flux density** ($\Phi(\lambda)$)
(number of photons per unit area, per unit time and per unit wavelength)
- **Spectral power density** ($P(\lambda)$)
(incident power per unit area and per unit wavelength)
- **Irradiance**
(incident total power from a radiant source per unit area)
- **Irradiation**
(irradiance integrated over a period of time)

$$\Phi(\lambda) = P(\lambda) \frac{\lambda}{hc}$$

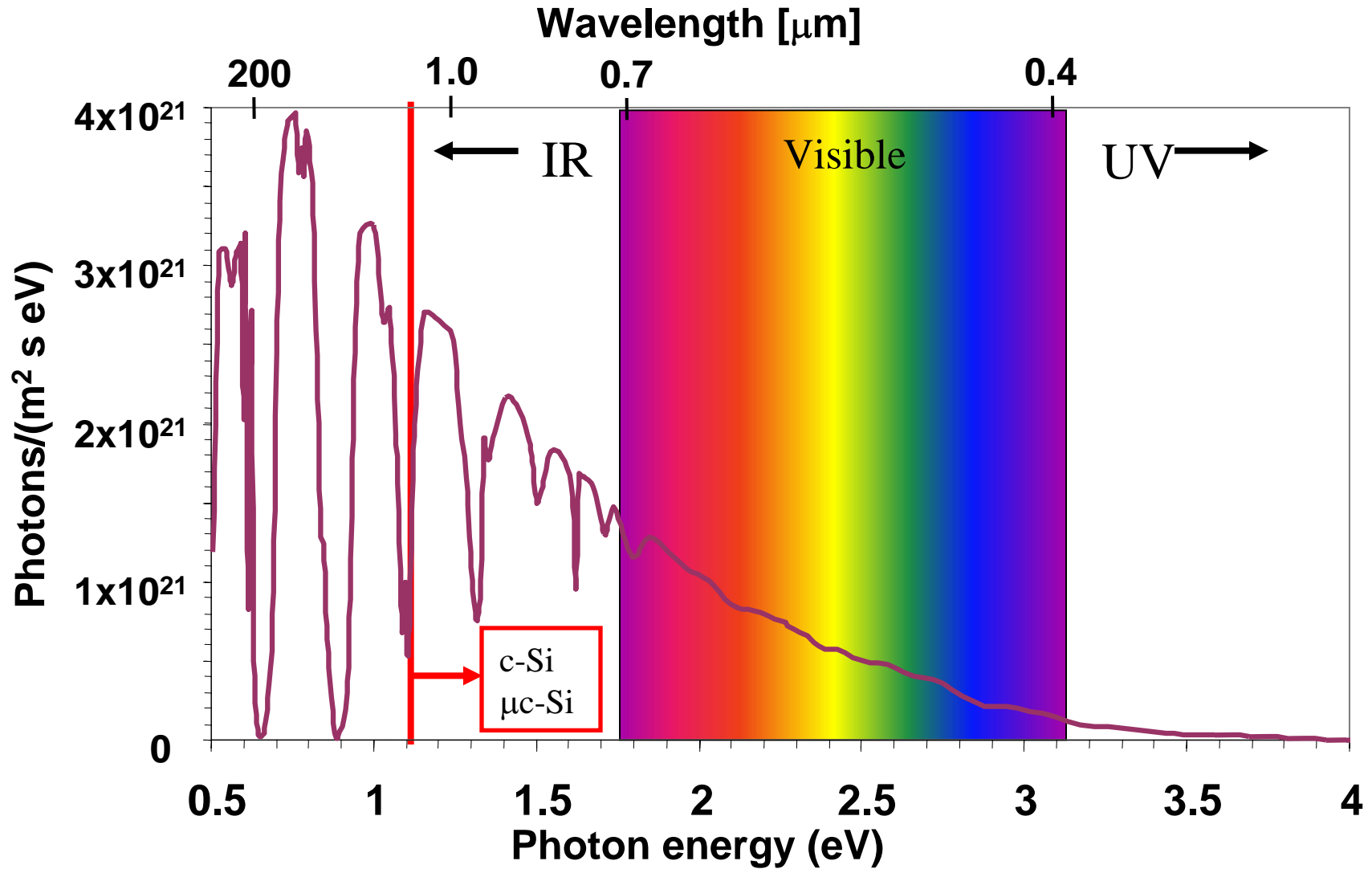
Solar spectral power density



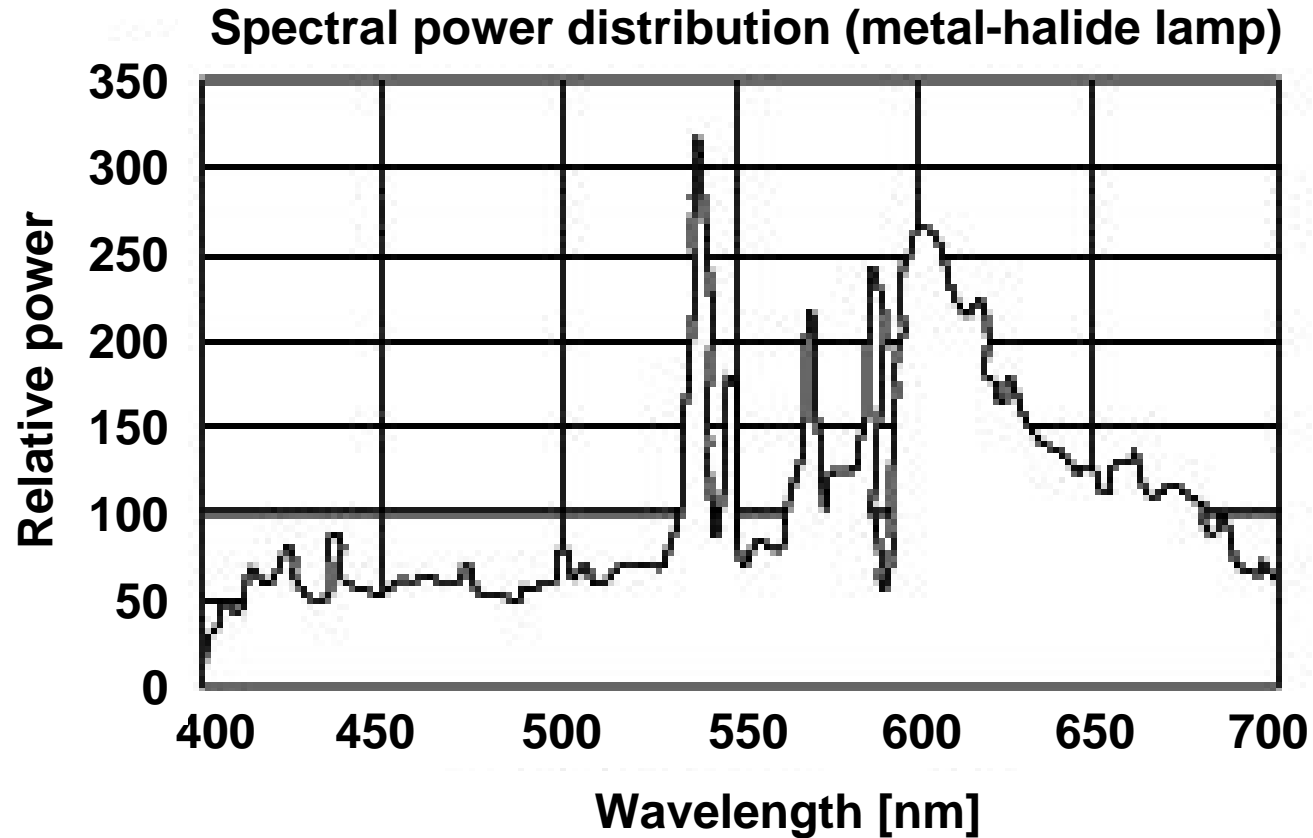
Solar spectral power density



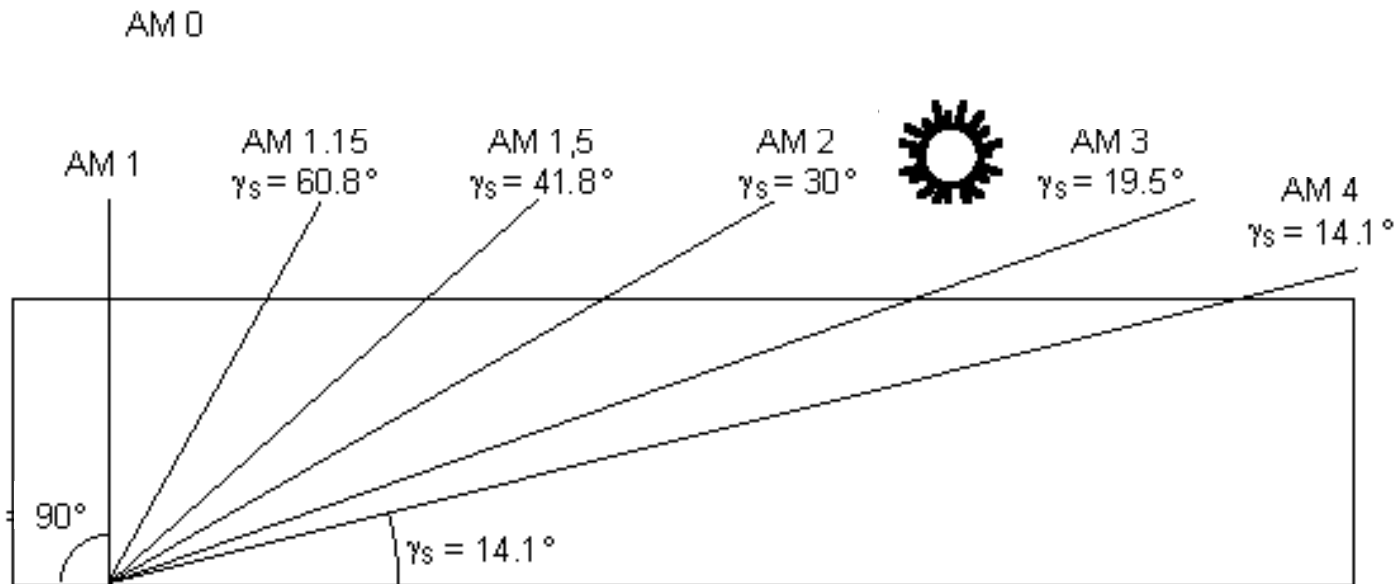
Solar photon flux density



Solar spectral power density



Solar irradiance



Air mass (AM):

$$AM = 1/\sin \gamma_s$$

AM0: 1353 W/m²

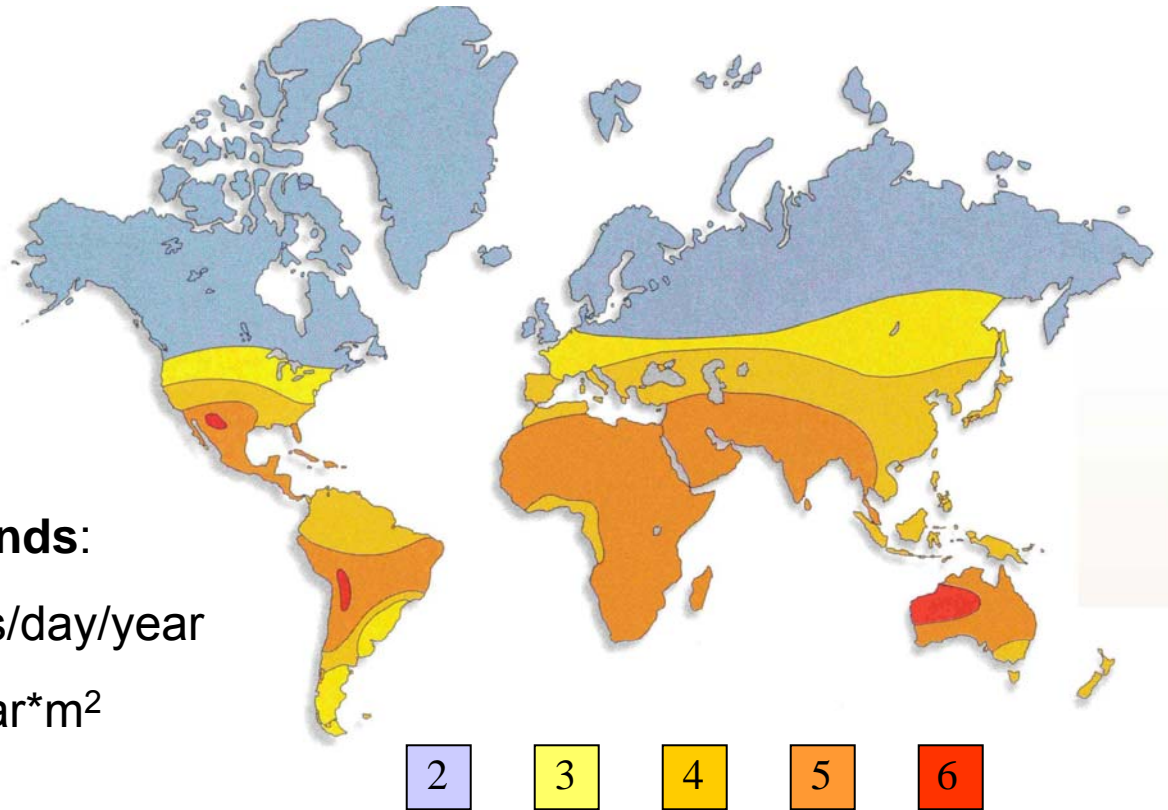
AM1: 925 W/m²

AM1.5: 827 W/m²

AM2: 691 W/m²

Solar irradiation

Solar irradiation (solar irradiance integrated over a period of time)



The Netherlands:

2.7 sun hours/day/year

1000 kWh/year*m²

Annual average of daily hours of sunlight