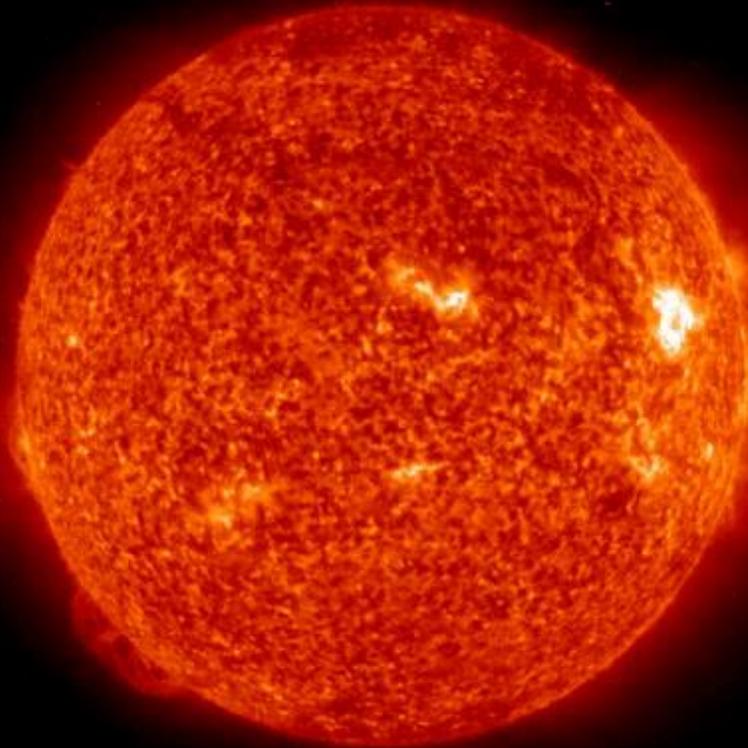


Introduction to Solar Energy

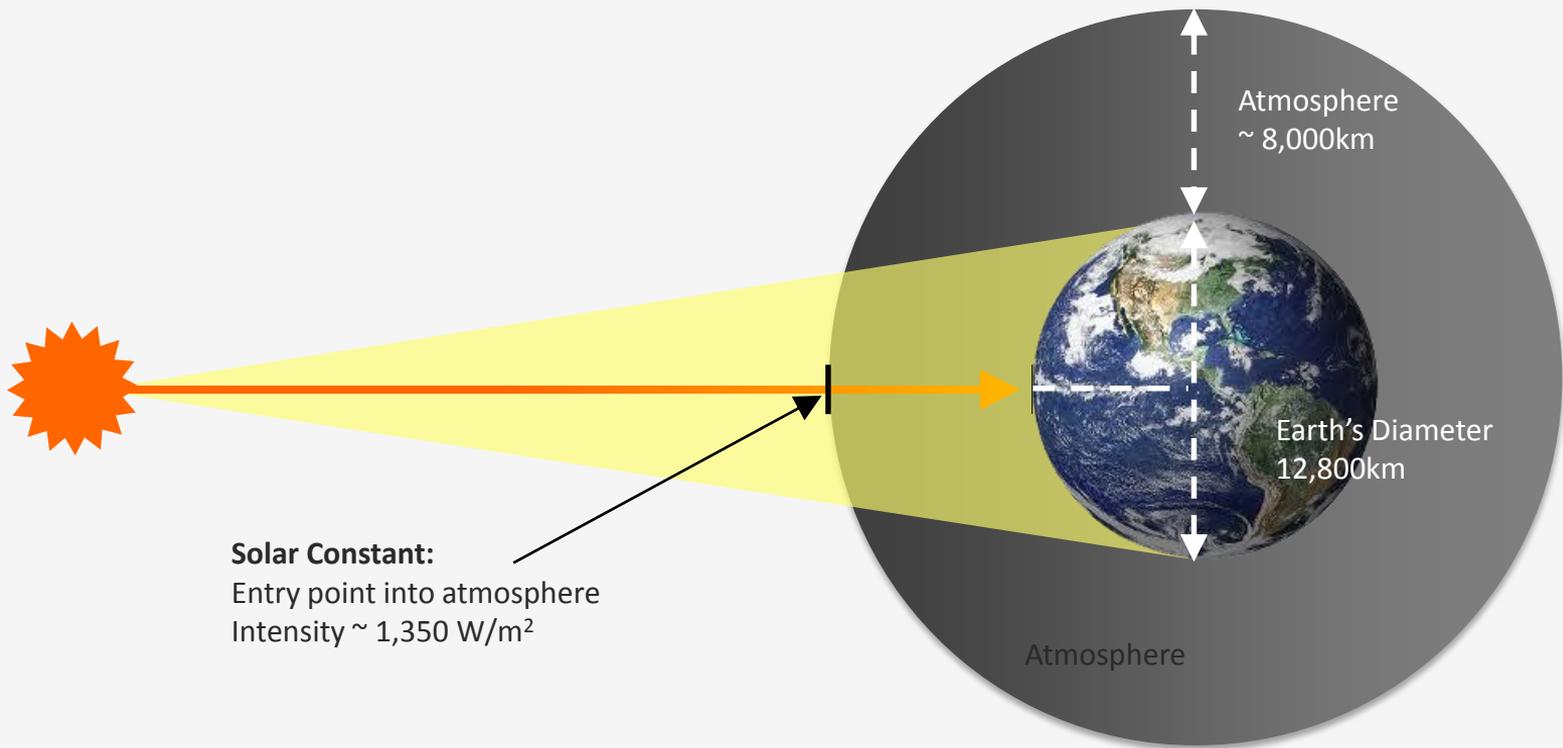
Solar Light II

Week 1.6.2

Arno Smets



(Source: NASA)



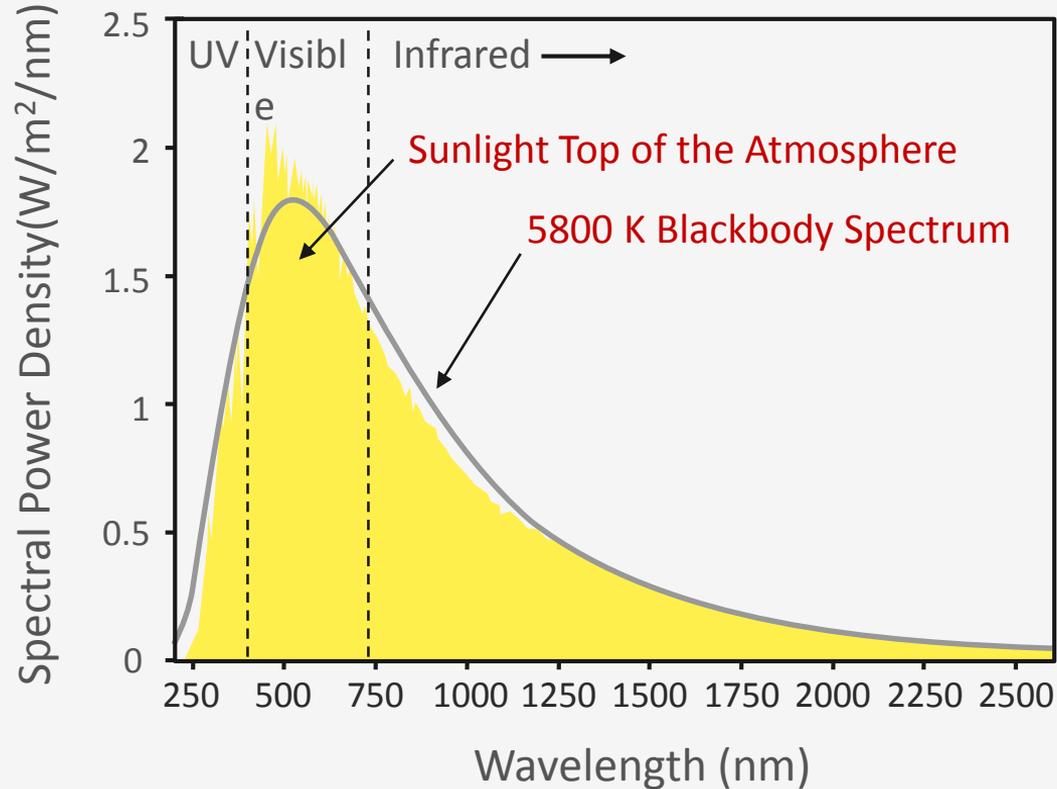
Solar Constant:
Entry point into atmosphere
Intensity $\sim 1,350 \text{ W/m}^2$

Atmosphere
 $\sim 8,000 \text{ km}$

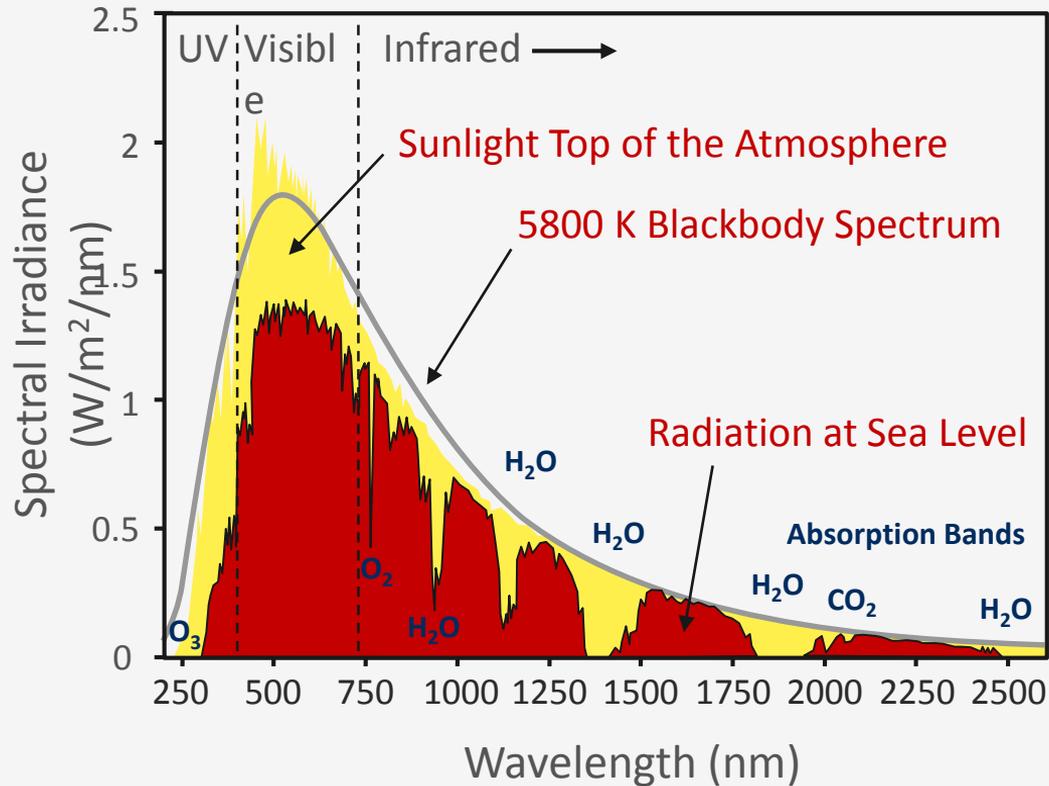
Earth's Diameter
 $12,800 \text{ km}$

Atmosphere

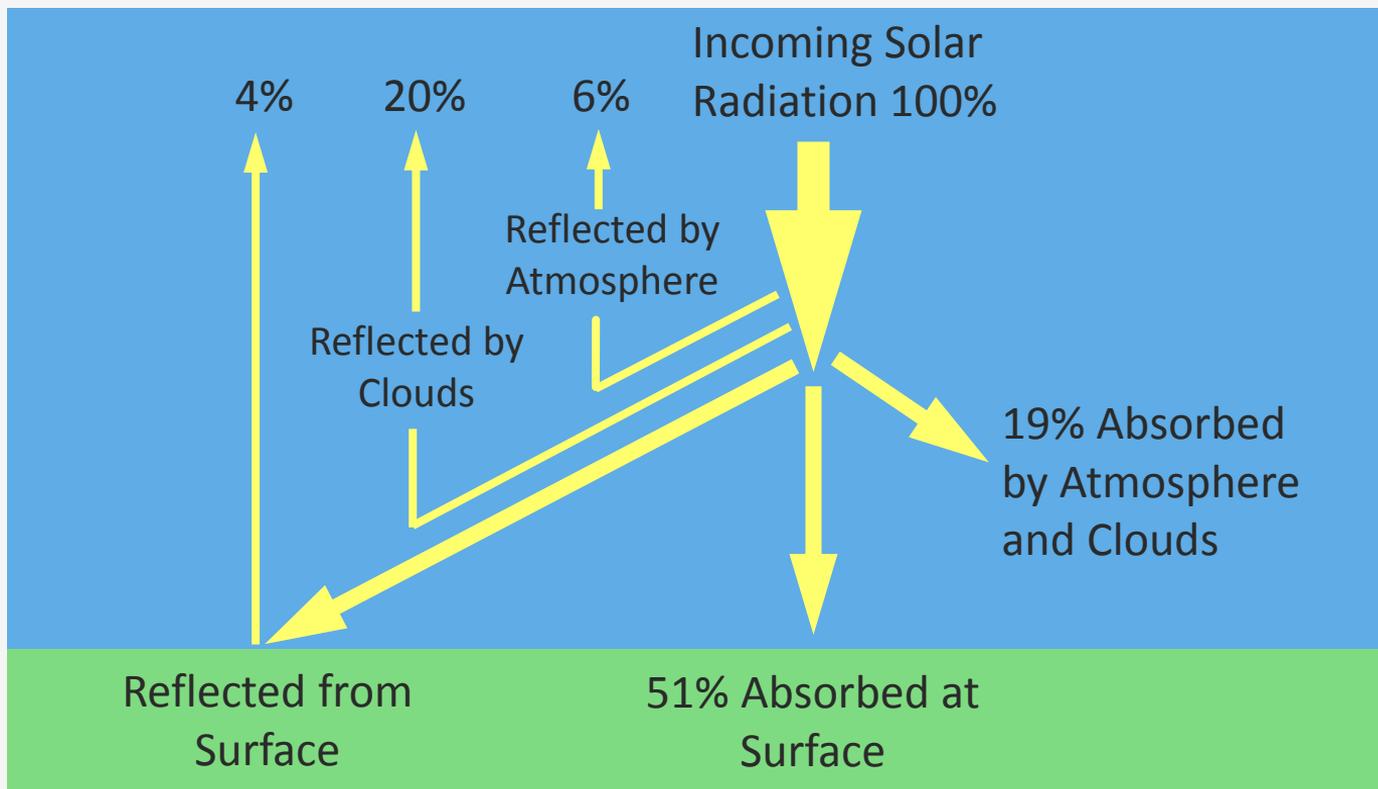
Extraterrestrial solar spectrum



Extraterrestrial and terrestrial solar spectrum



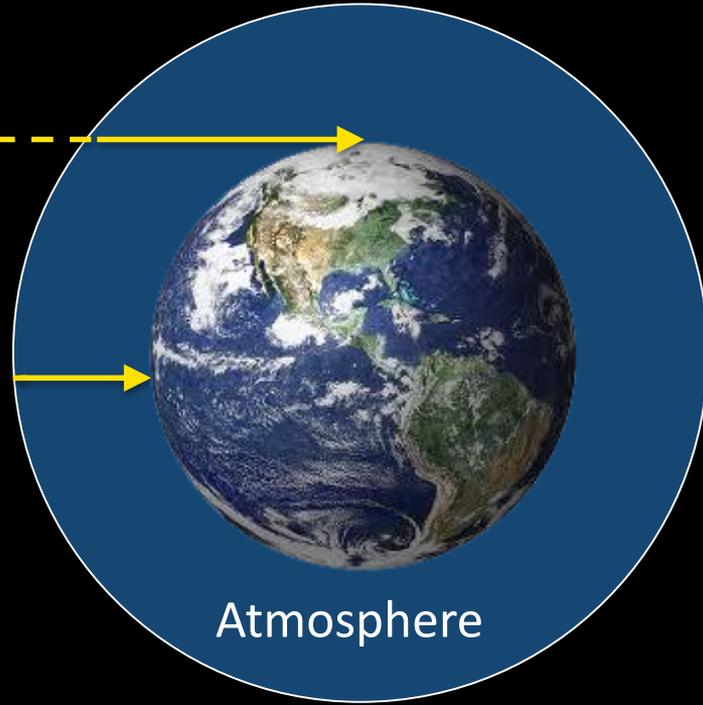
Losses in Solar Radiation



Sunlight



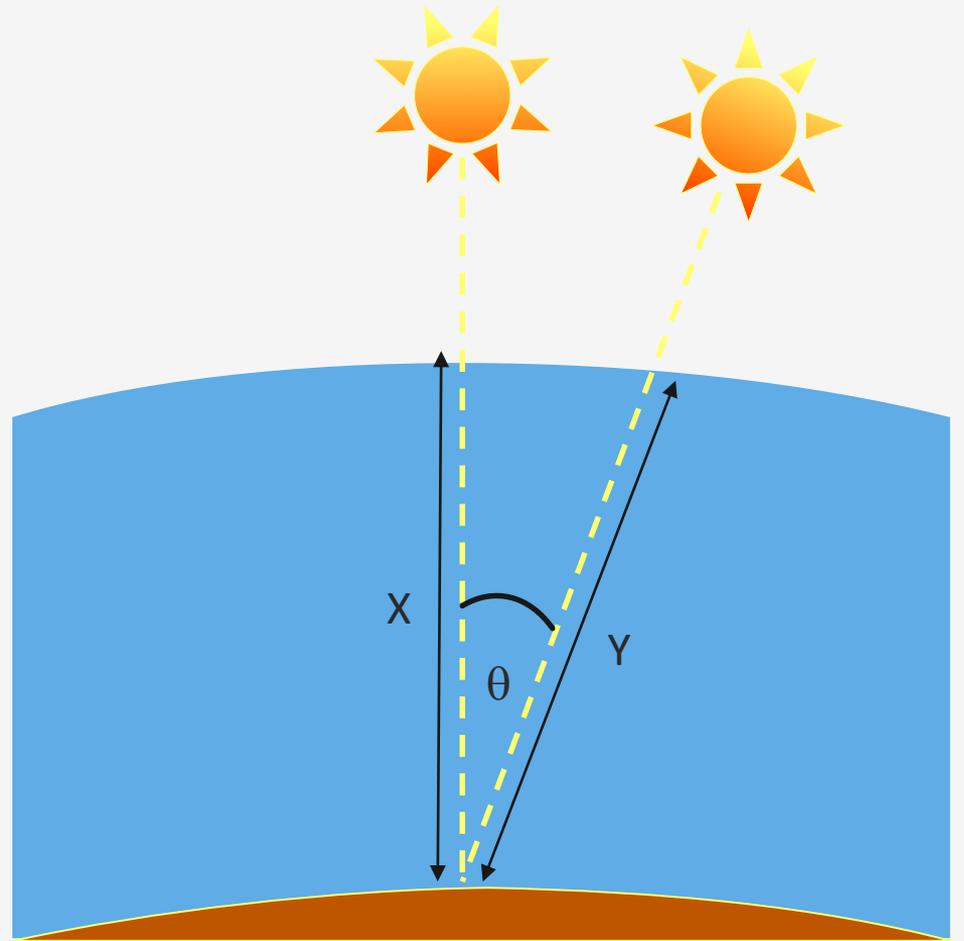
Sunlight



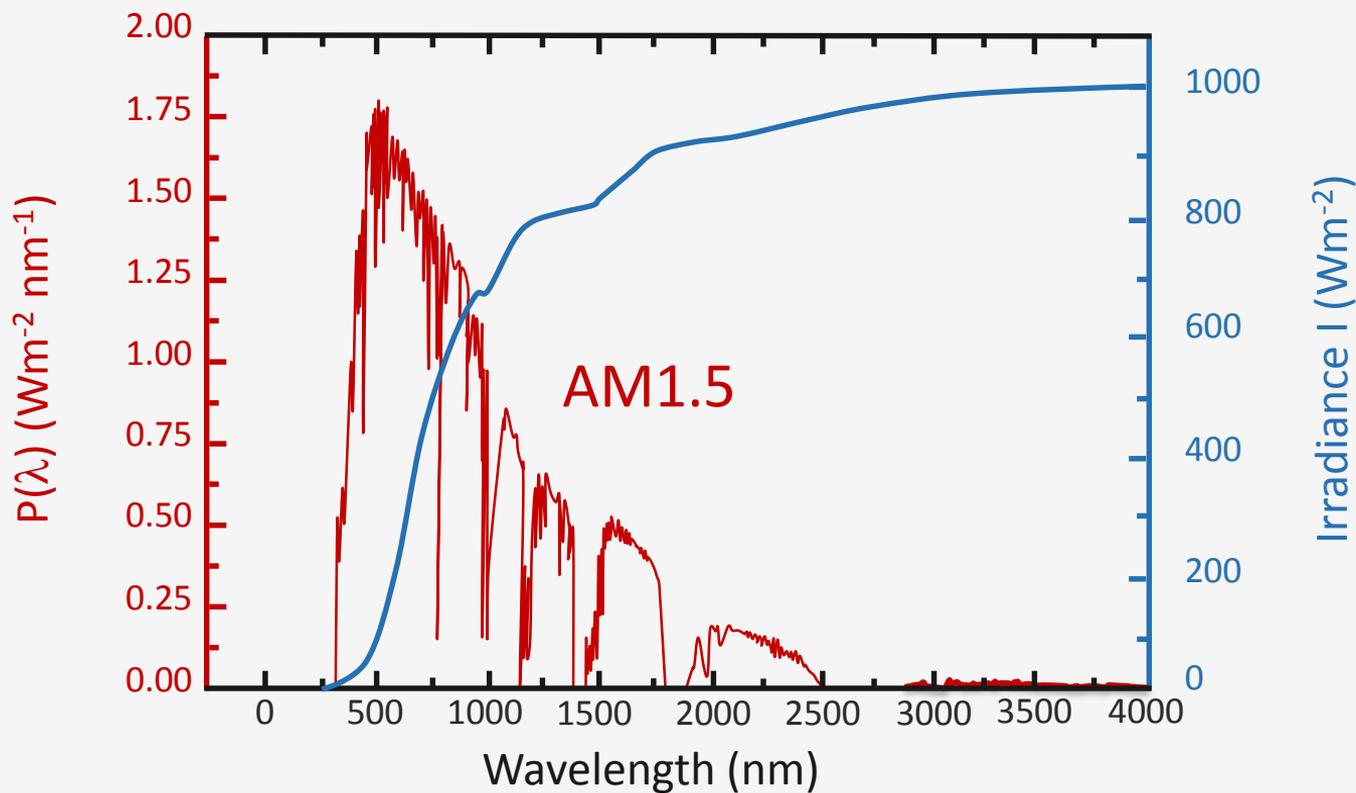
Atmosphere

Air mass

$$AM = \frac{1}{\cos \theta}$$



Irradiance and spectral power density for AM1.5



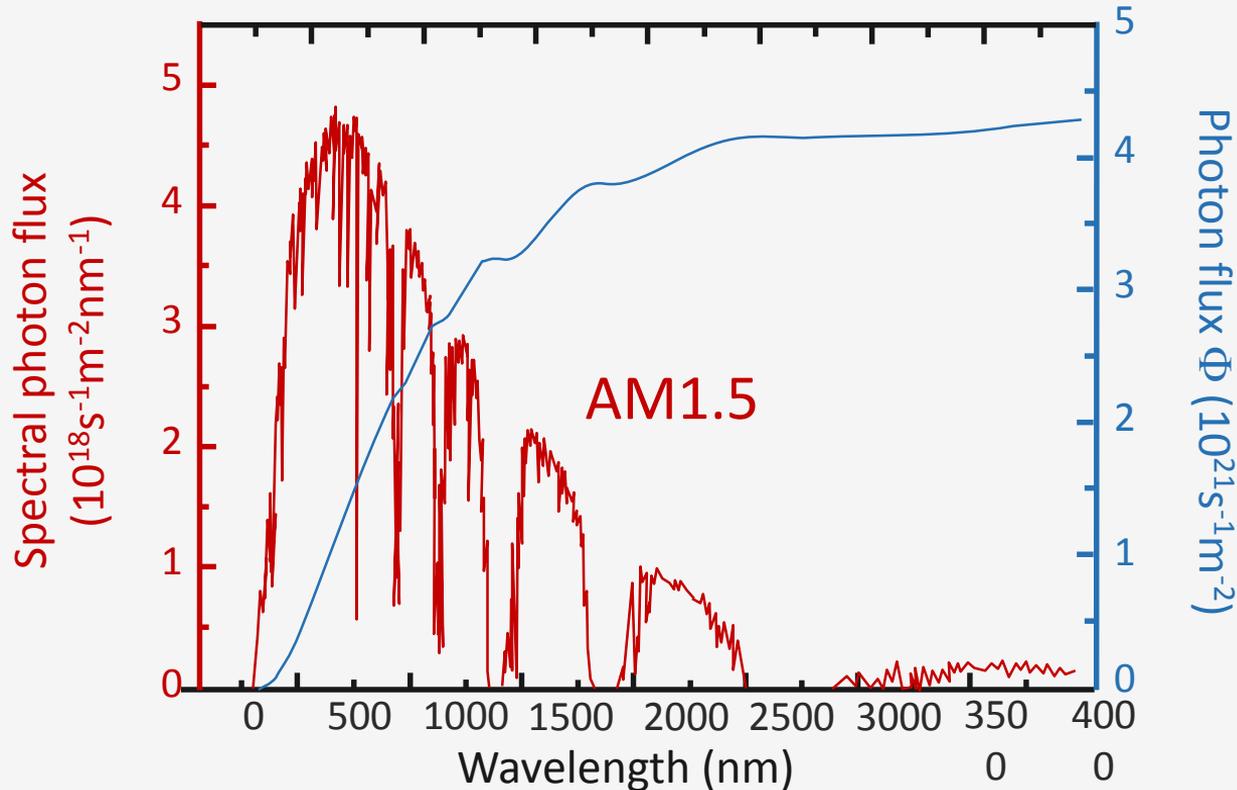
Spectral Photon Flux and Spectral Power Density

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

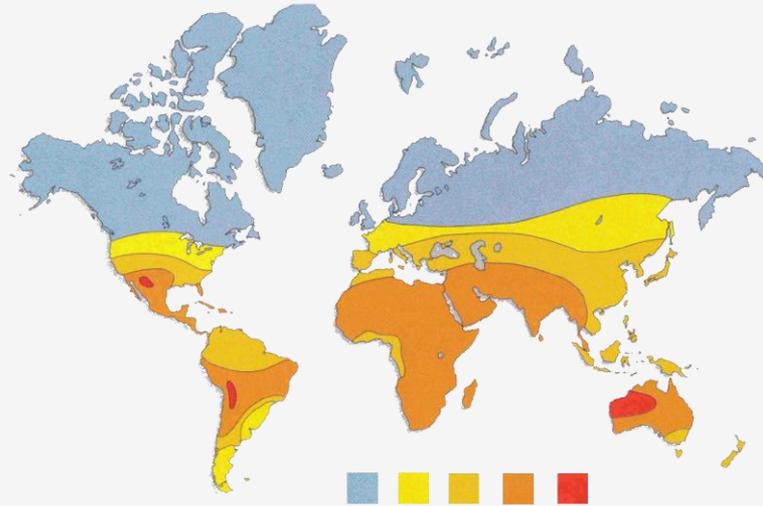
Photon Flux and Spectral Photon Flux

$$\Phi = \int_0^{\lambda} \Phi(\lambda) d\lambda$$

Relation Irradiance and spectral power density for AM1.5

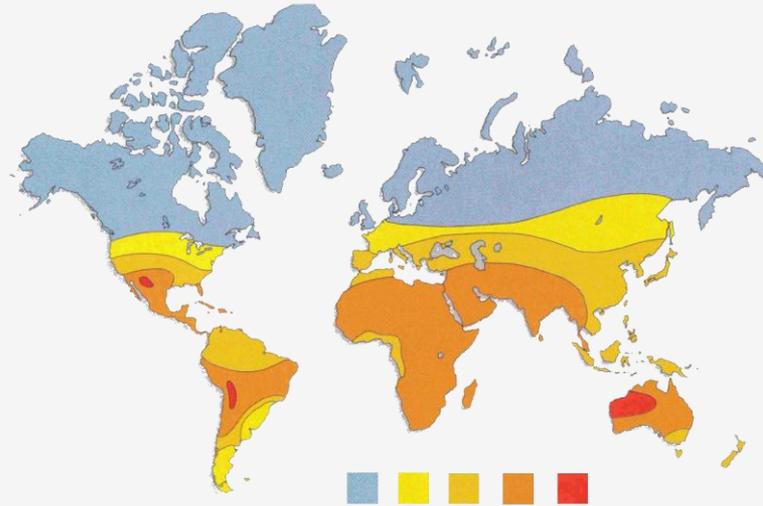


Solar irradiation on Earth



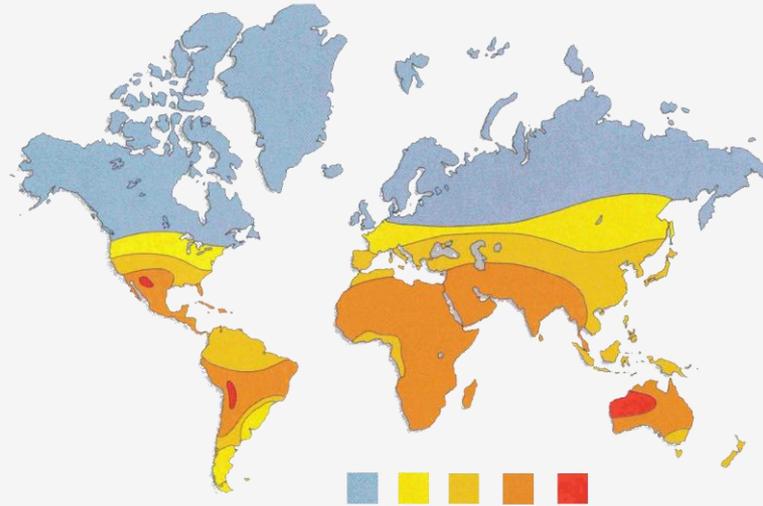
1 sun hour = 1 kWh/m² = 1000 W/m² x 1 hour

Solar irradiation on Earth



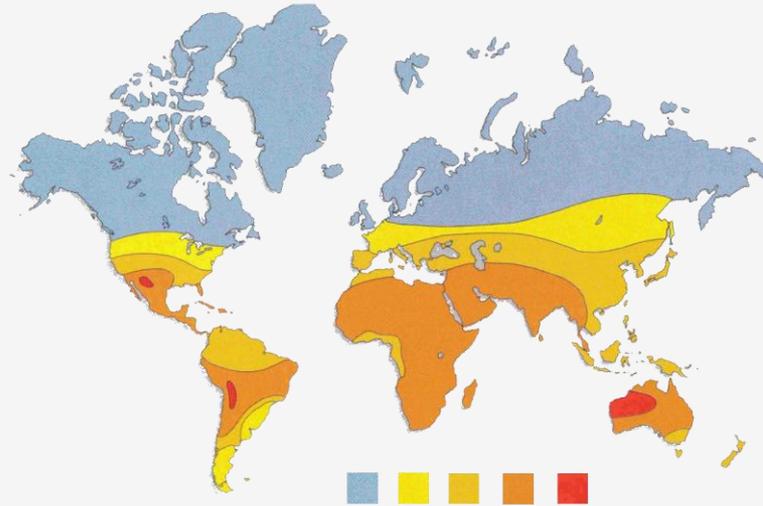
Nominal power Module $100 W_p$
(power generated under $1000 W/m^2$, AM1.5)

Solar irradiation on Earth



The Netherlands: 2.7 sun hours/day/year

Solar irradiation on Earth



Output per day:

$100 W_p \times 2.7 \text{ sunhours} = 270 \text{ Wh}$ Per year: 98.6 kWh

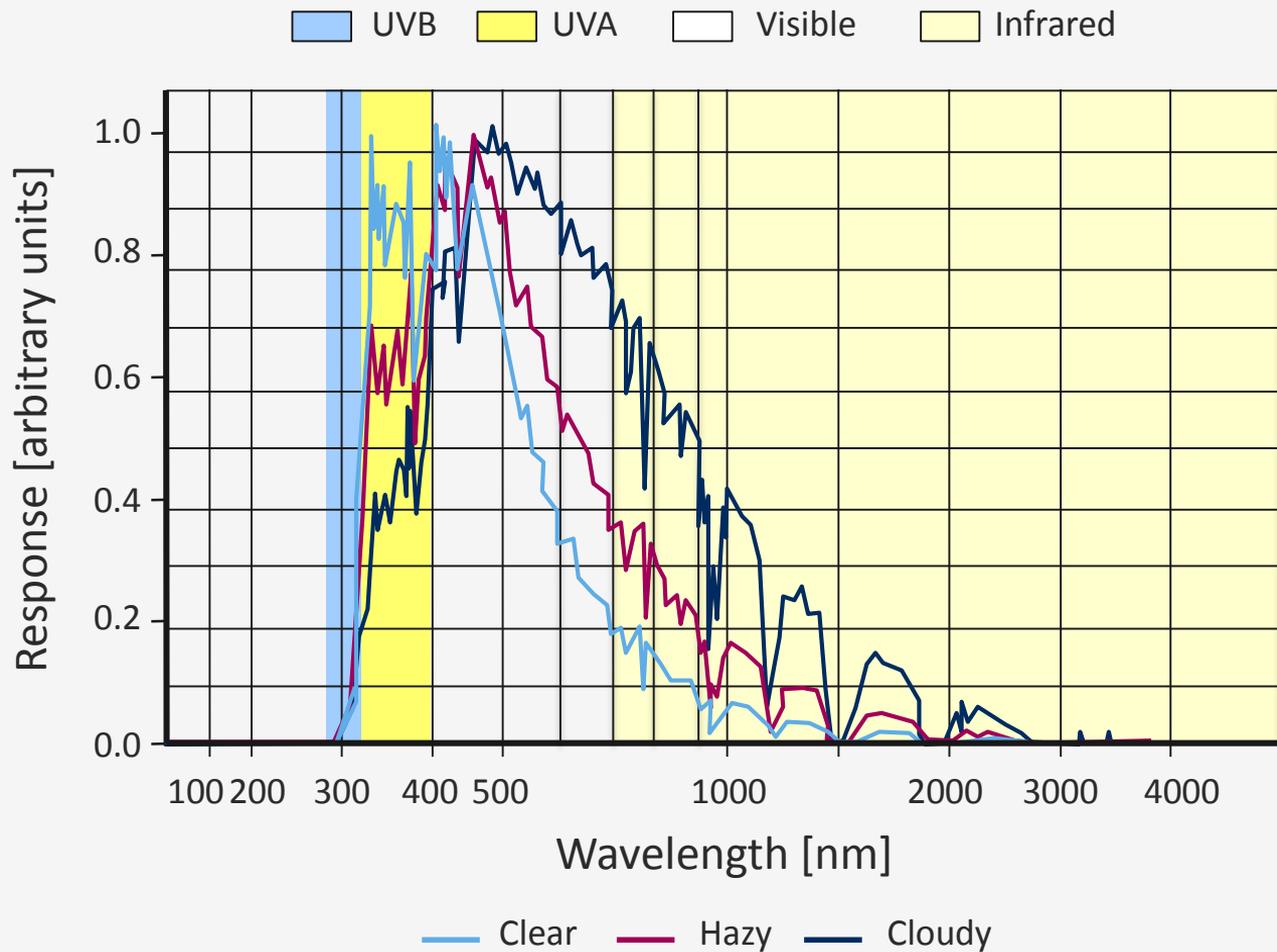
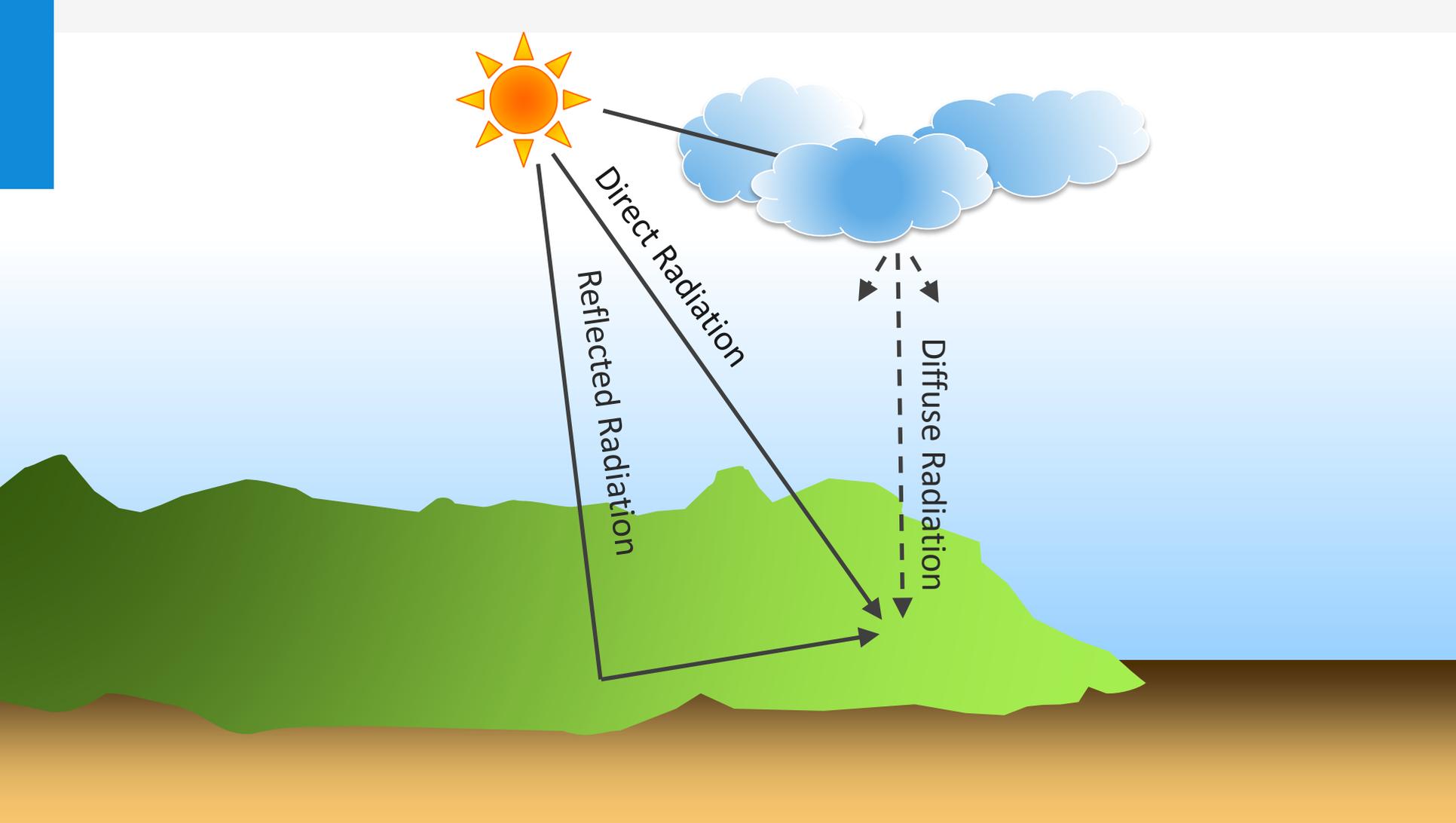
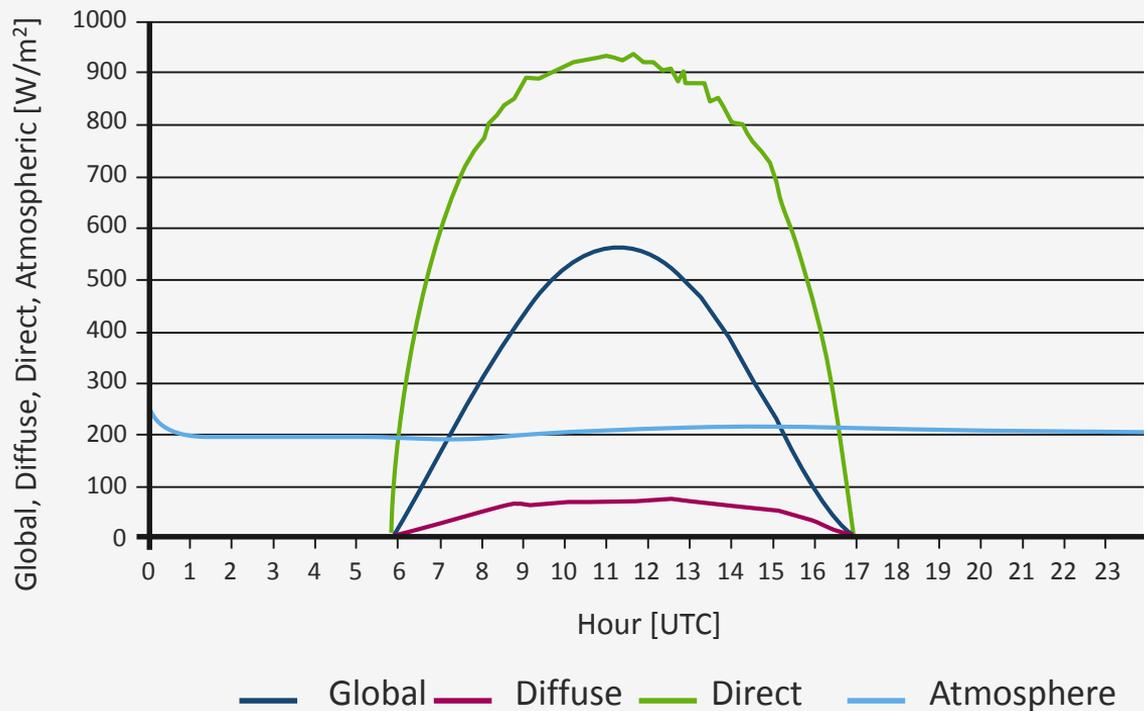


figure 3: spectral shift in diffuse irradiance with sky type

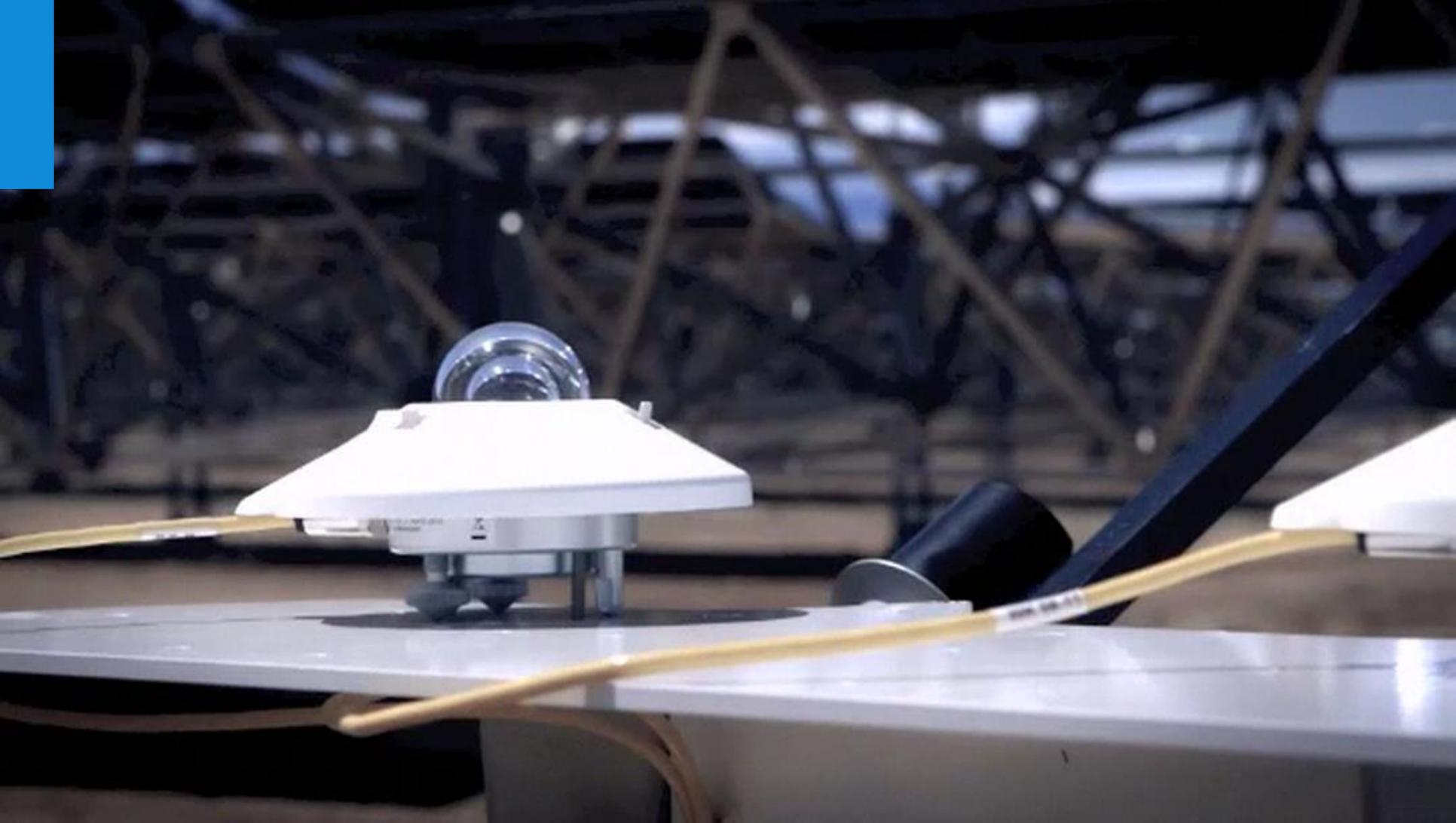


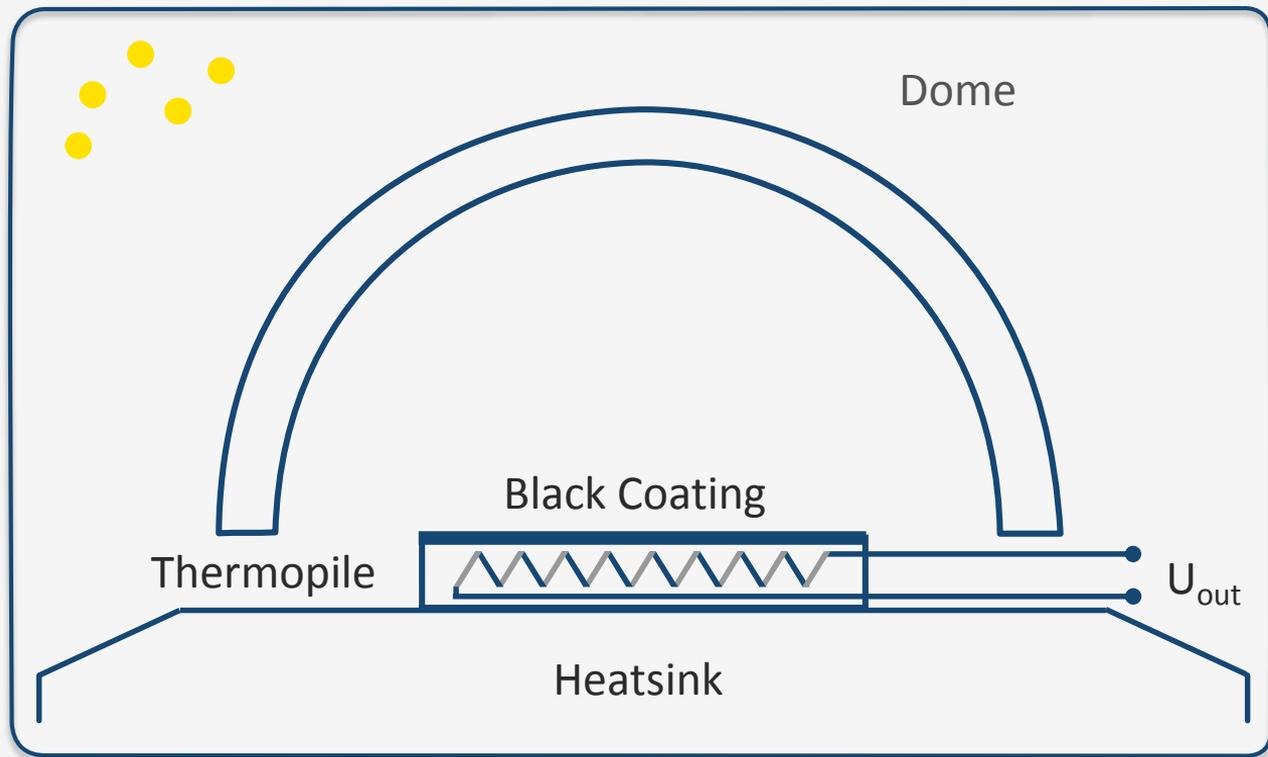
BSRN-Station Lindenberg, 05-03-2004



Source: DWD, Meteorologisches Observatorium Lindenberg

diurnal variation of irradiance on 05-03-2004



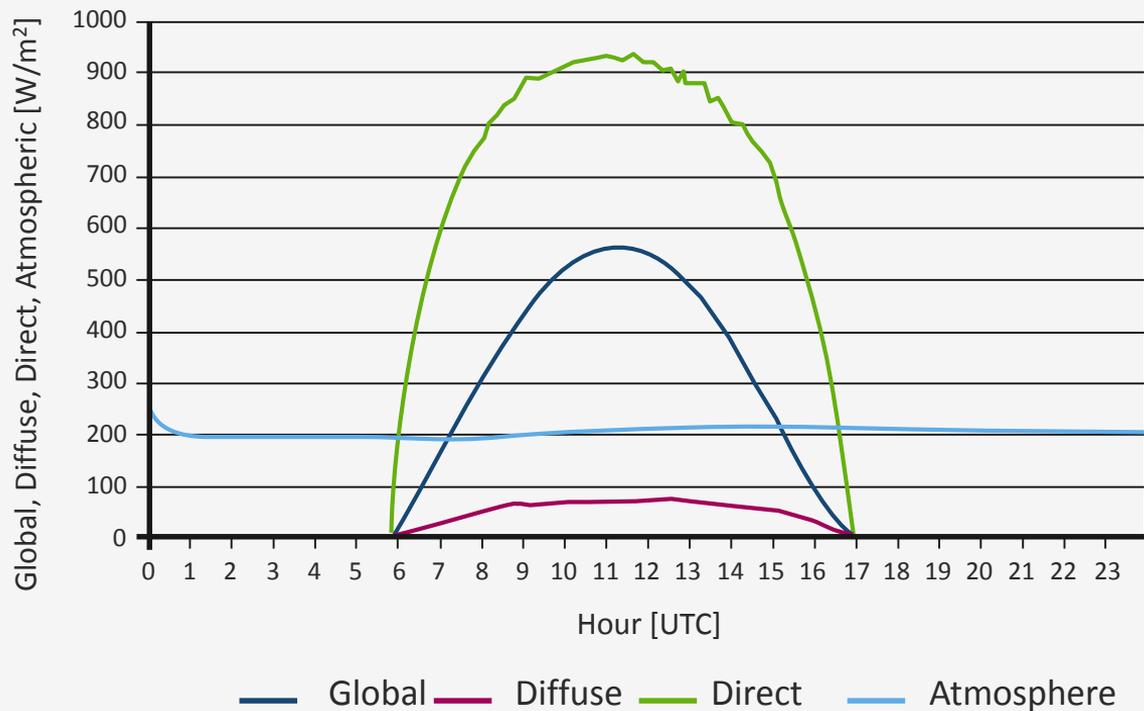




acciona Energy S.A. - Spain



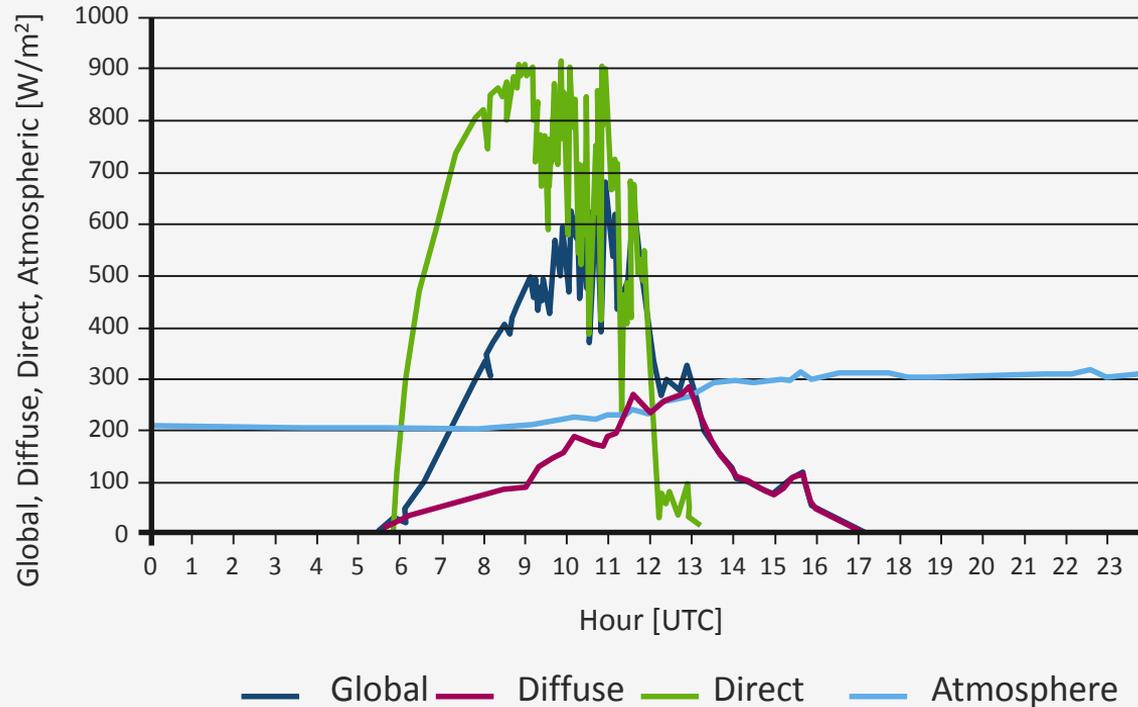
BSRN-Station Lindenberg, 05-03-2004



Source: DWD, Meteorologisches Observatorium Lindenberg

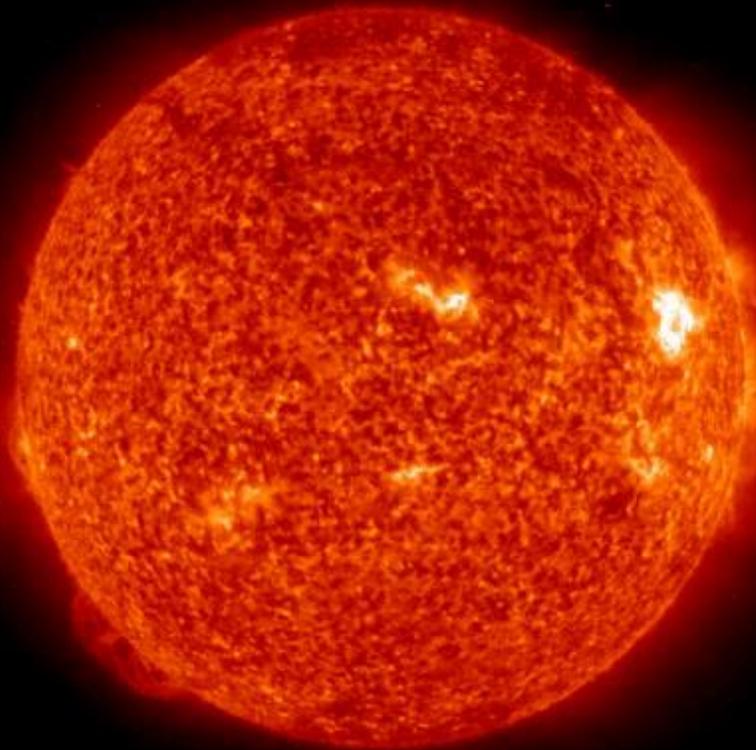
diurnal variation of irradiance on 05-03-2004

BSRN-Station Lindenberg, 06-03-2004



Source: DWD, Meteorologisches Observatorium Lindenberg

diurnal variation of irradiance on 06-03-2004



(Source: NASA)