UNIT 3: Atmospheric Interaction

- Extinction Processes: Absorption, Scattering
- Spectral Effects

Extraterrestrial Solar Irradiance
Solar Spectral Irradiance at Sea Level

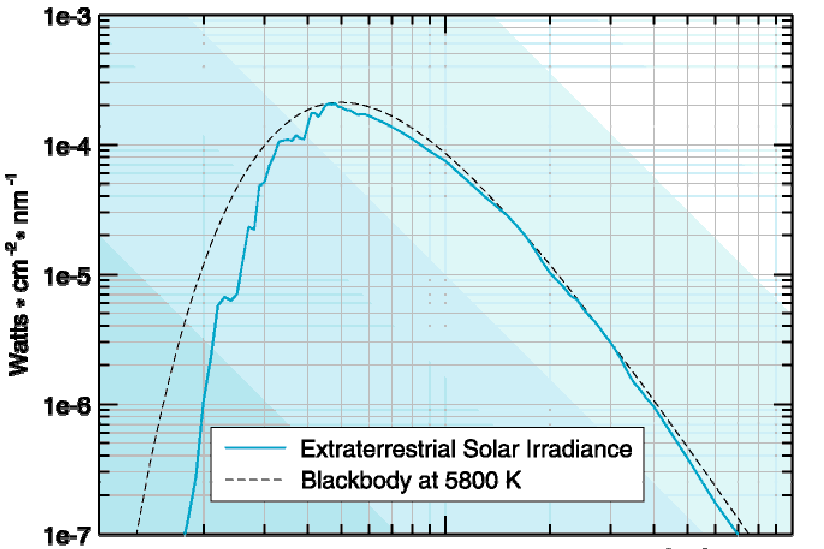


Fig. 5.7 Extraterrestrial solar irradiance compared to a blackbody.

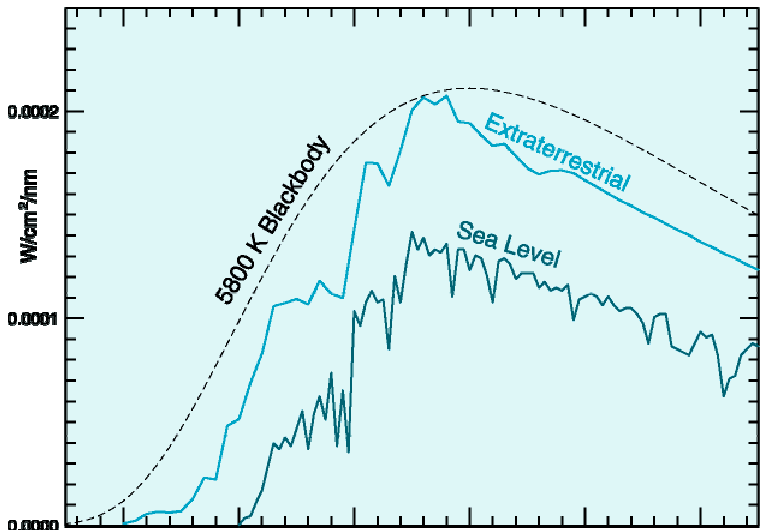
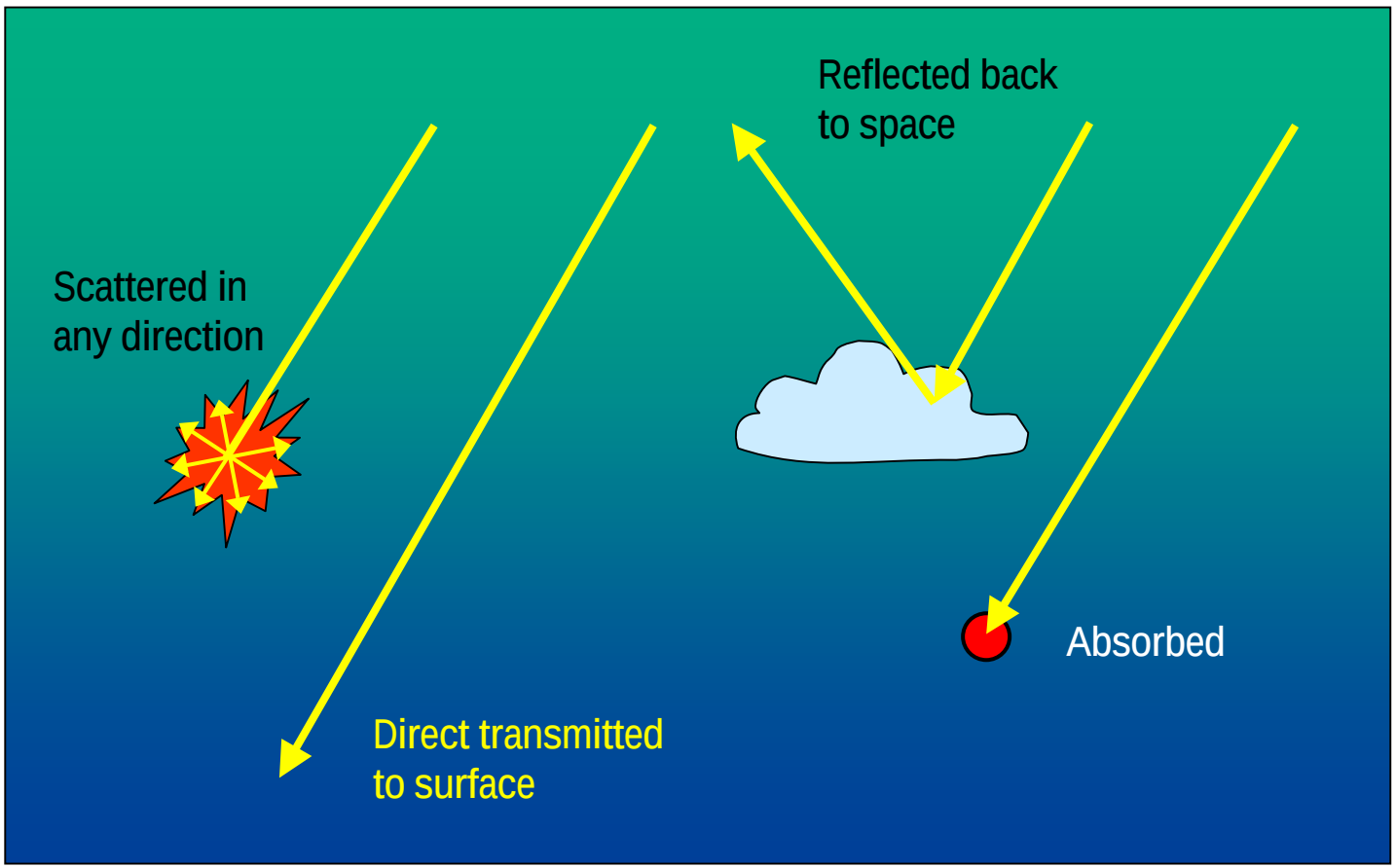


Fig. 5.8 Solar irradiance at sea level.

Atmospheric Extinction Processes



Composition of the Atmosphere

Nitrogen	N_2	78.08 %
Oxygen	O_2	20.95 %
Argon	Ar	0.93 %

= 99.96 % of dry atmosphere

Nitrous Oxide	N_2O		0.3 ppm
Carbon Monoxide	CO		0.1 ppm

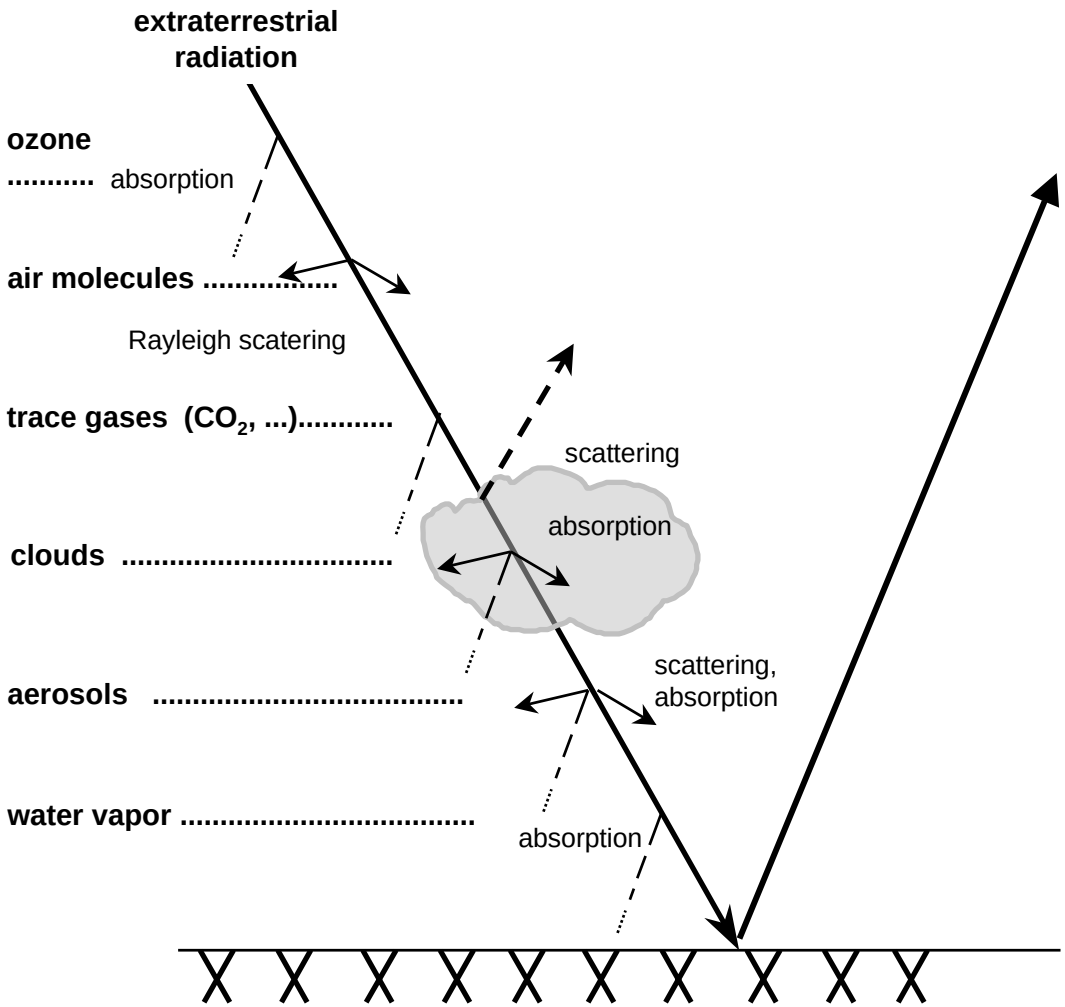
concentrated near the surface

Carbon Dioxide	CO_2	✸	360 ppm
Neon	Ne		18 ppm
Helium	He		5 ppm
Methane	CH_4	✸	1.8 ppm
Krypton	Kr		1 ppm
Hydrogen	H_2		0.6 ppm
Xenon	Xe		0.1 ppm

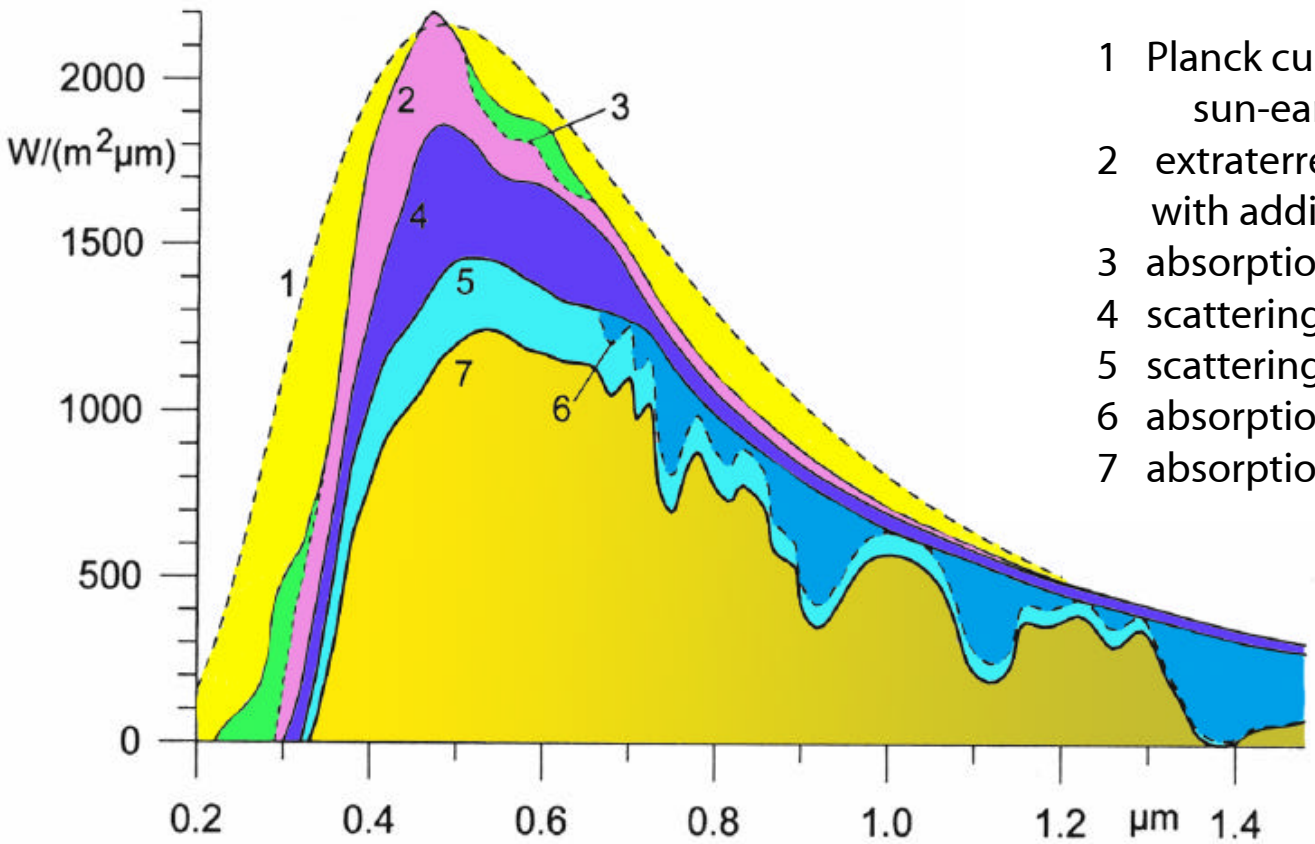
Ozone	O_3	troposphere	< 0.05 ppm
		stratosphere	5 - 10 ppm
Water Vapor	H_2O		1-4 %

variable in space and time

Atmospheric Extinction Processes



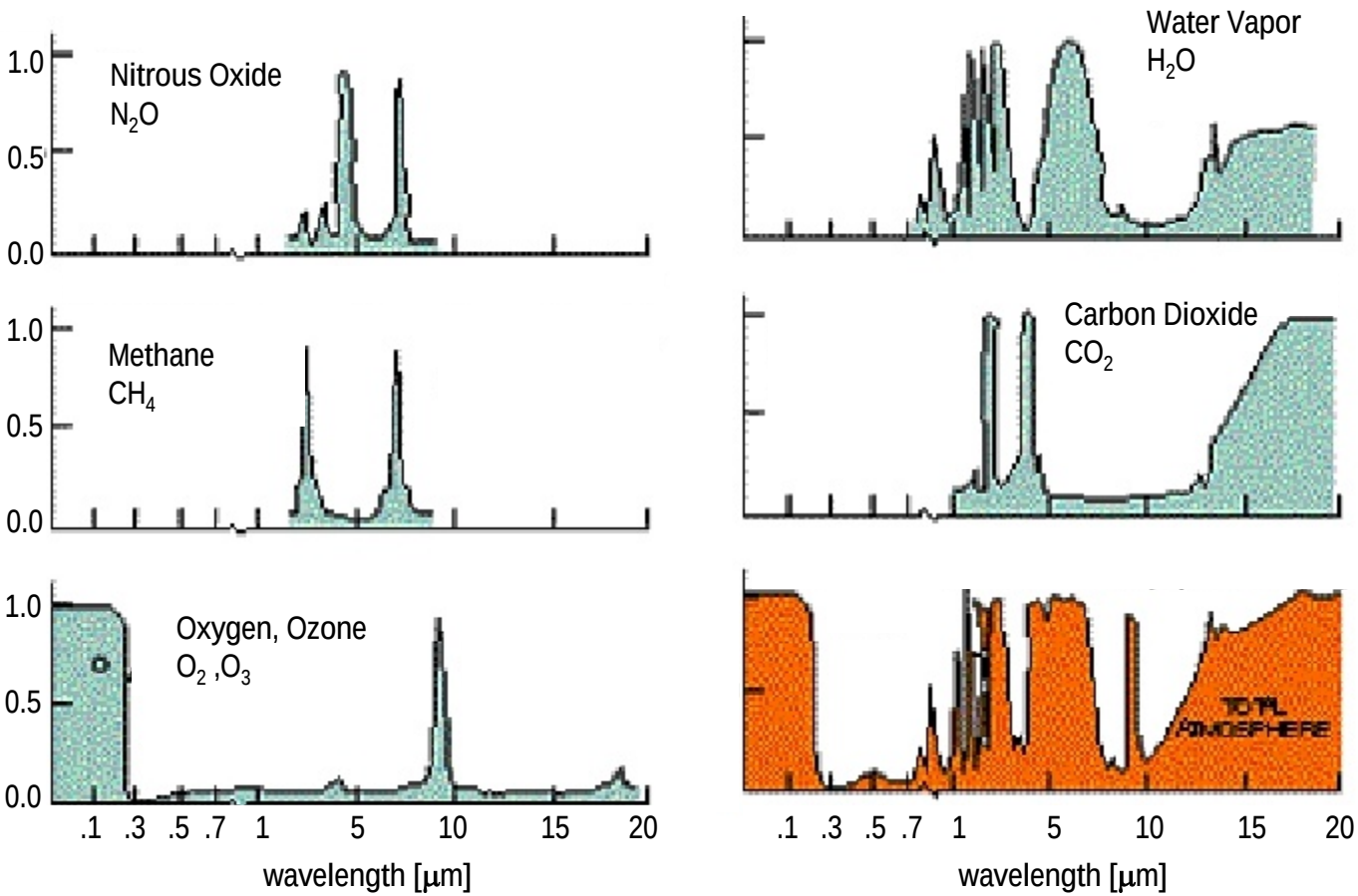
Spectral Solar Radiant Flux Density



1 Planck curve T=5780 K at mean sun-earth distance
2 extraterrestrial solar spectrum with additional
3 absorption by 0_3
4 scattering by 0_2 und N
5 scattering by aerosols
6 absorption by H_2O vapor
7 absorption by aerosols

Source: Vogt

Selective Absortion in the Atmosphere



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Atmospheric Scattering

Rayleigh scattering

particle size << wavelength

$\sim \lambda^{-4}$

directionality: $(1 + \cos^2 \alpha)$

Mie scattering

particle size ≥ wavelength

$\sim \lambda^{-1.3}$

directionality: very strong foreward scattering

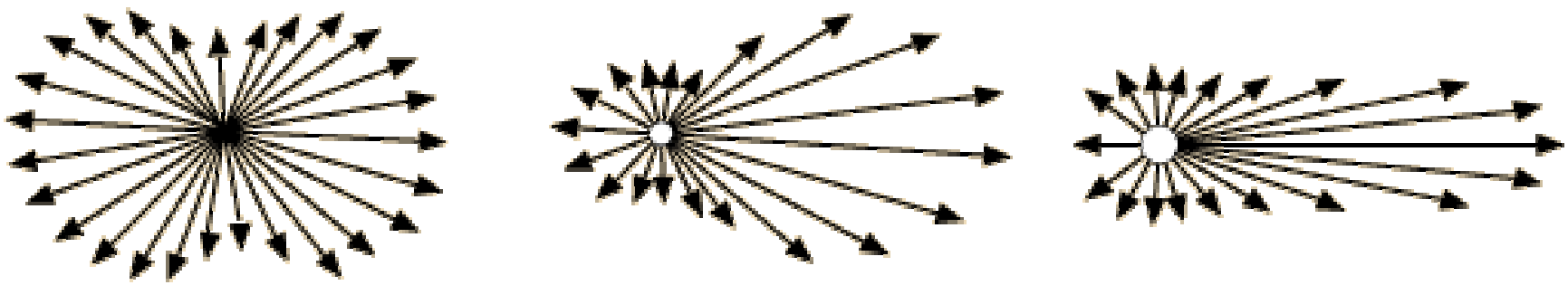
large variability by non-uniform particles (aerosols!)

Atmospheric Scattering

Rayleigh scattering

Mie scttering

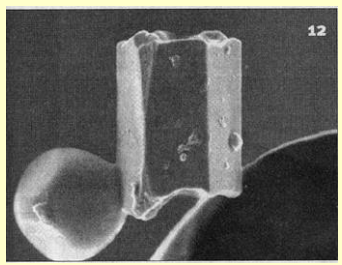
Mie Scattering, larger particles



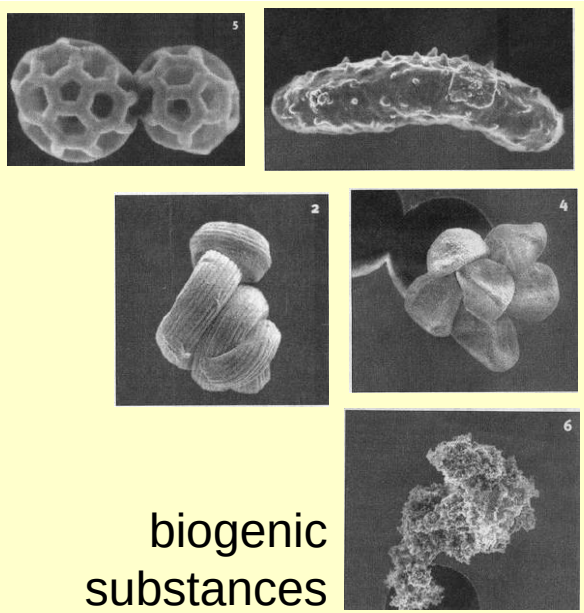
Direction of incident light

Aerosols

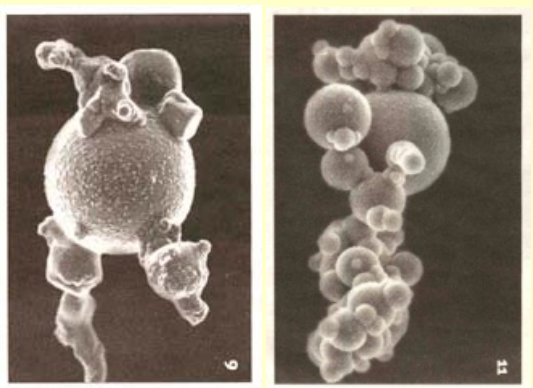
- Solid and liquid particles in air
- Size: 10 nm - some μm



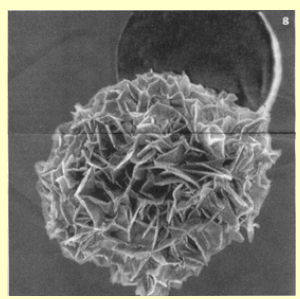
salt crystals



biogenic substances



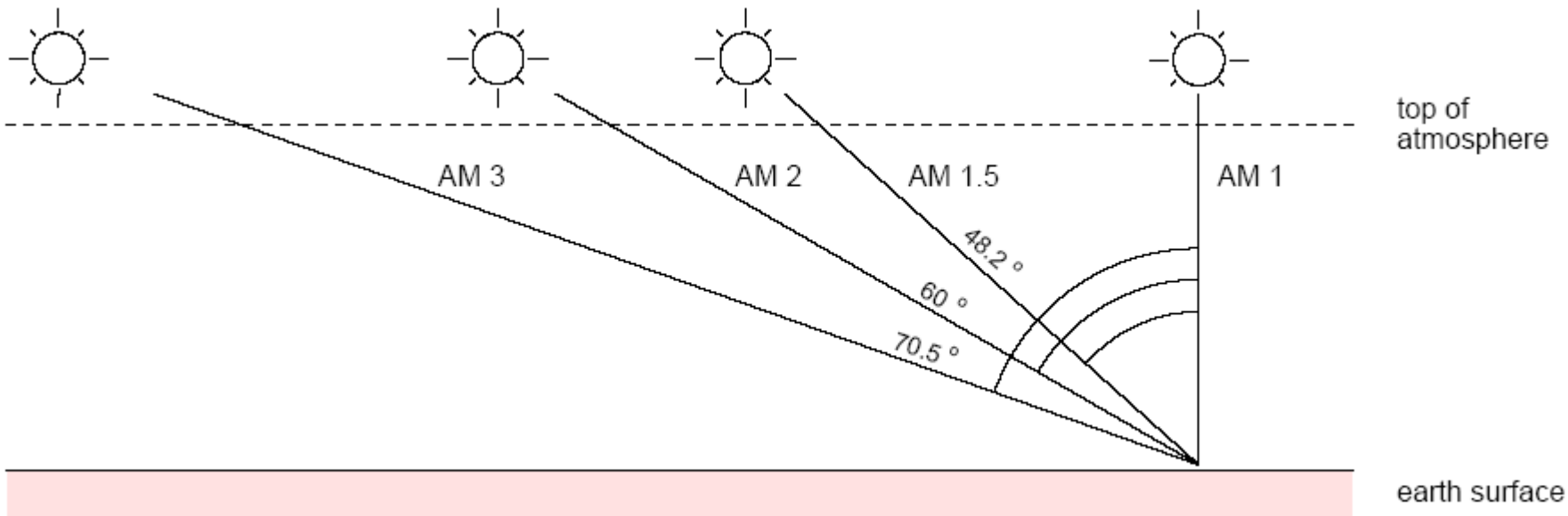
soot particles



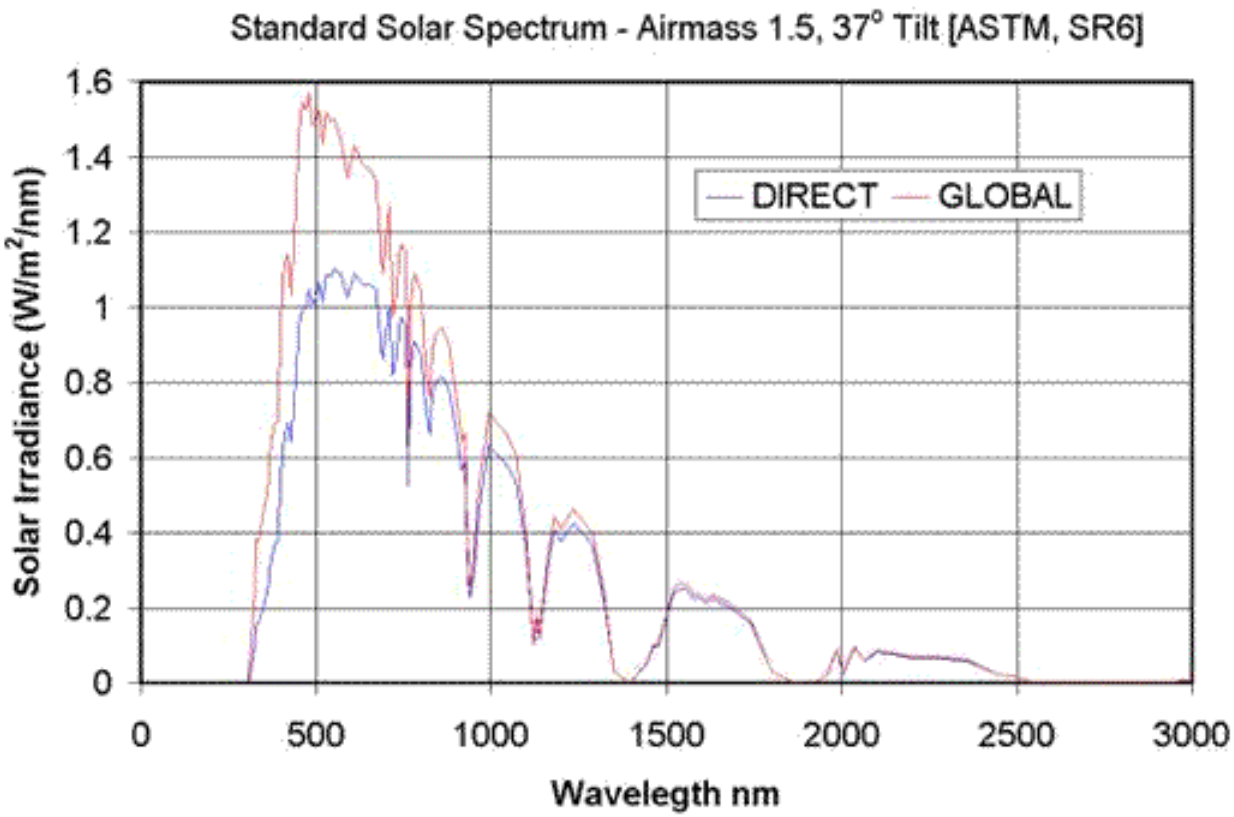
desert dust

Source::General-Anzeiger, 8./9.6.2002

Air Mass



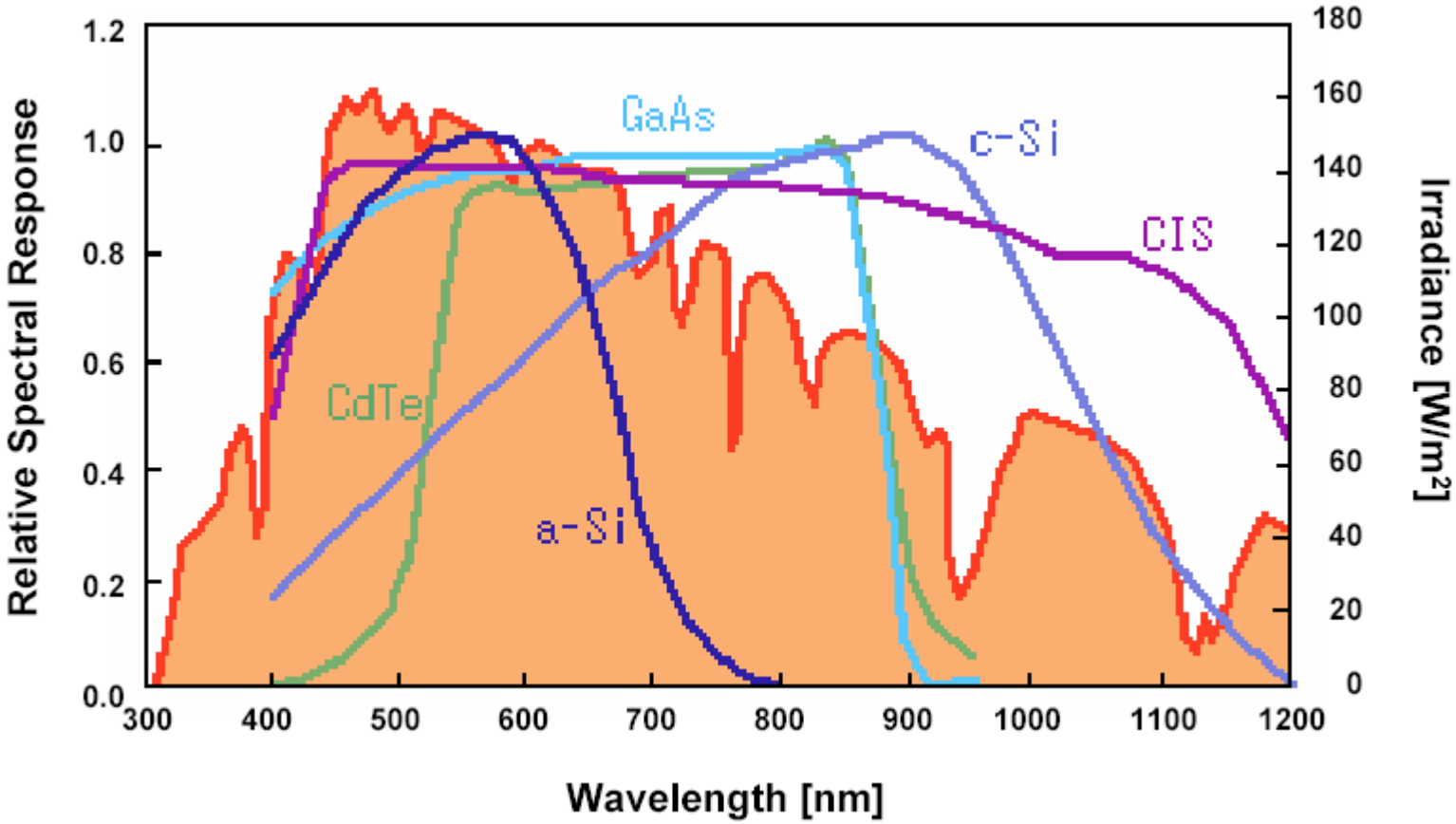
Standard Solar Spectrum



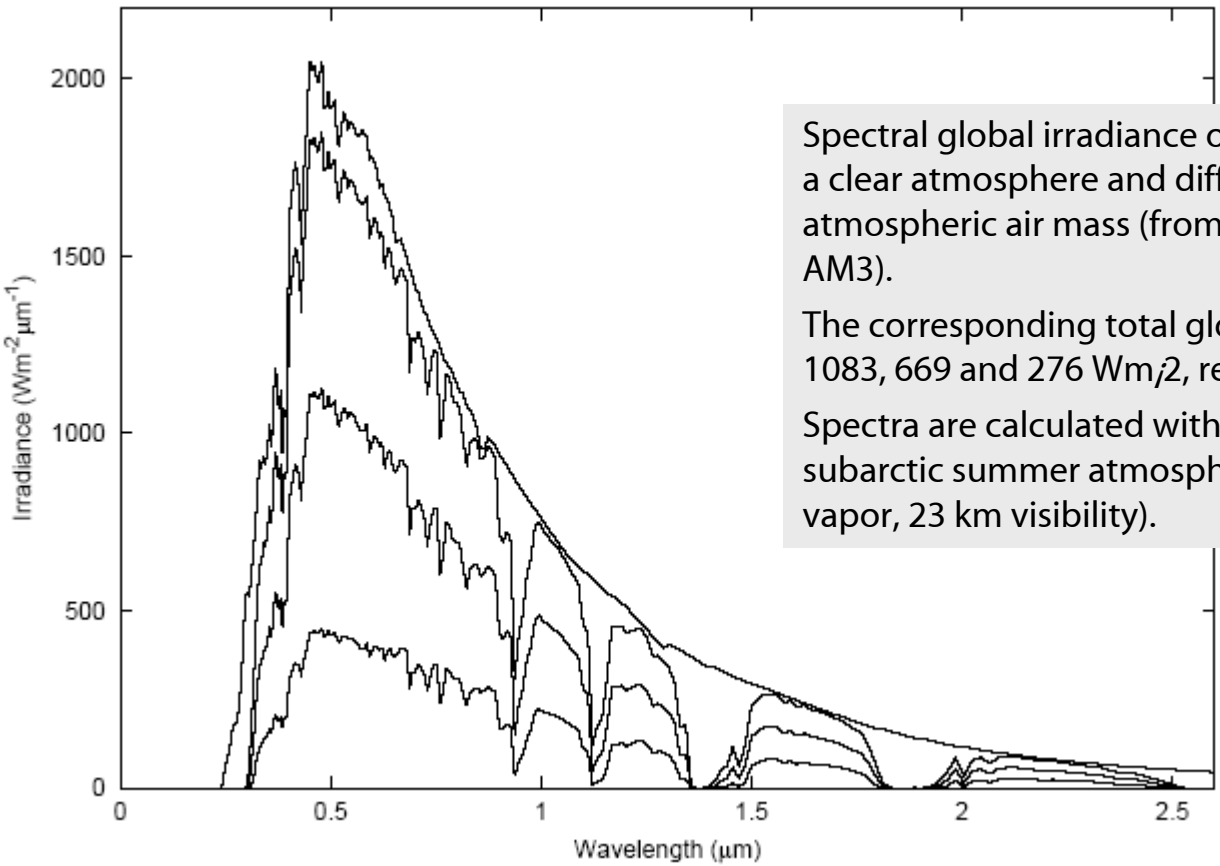
AM 1.5, 37° tilt

ASTM Standards
(E-891) and (E-892)

Spectral Response of Solar Cells



Spectral Irradiance depending on Air Mass



Spectral global irradiance on a horizontal surface for a clear atmosphere and different values of the atmospheric air mass (from top: AM0, AM1, AM1.5, AM3).

The corresponding total global irradiances are 1367, 1083, 669 and 276 Wm¡2, respectively.

Spectra are calculated with SBDART using a subarctic summer atmosphere (1.42 gm¡3 water vapor, 23 km visibility).