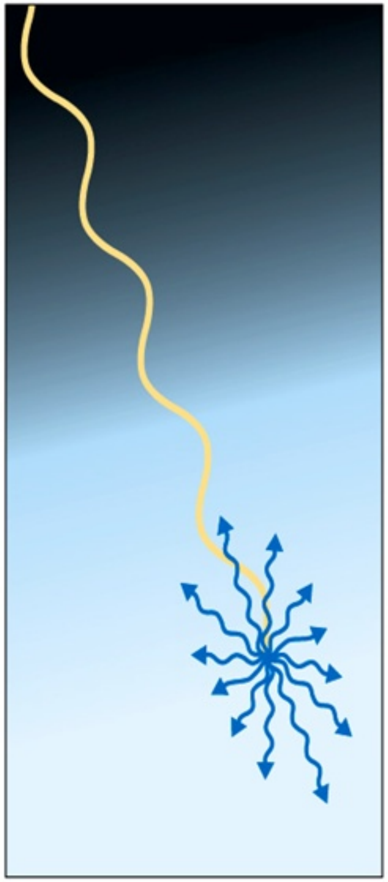
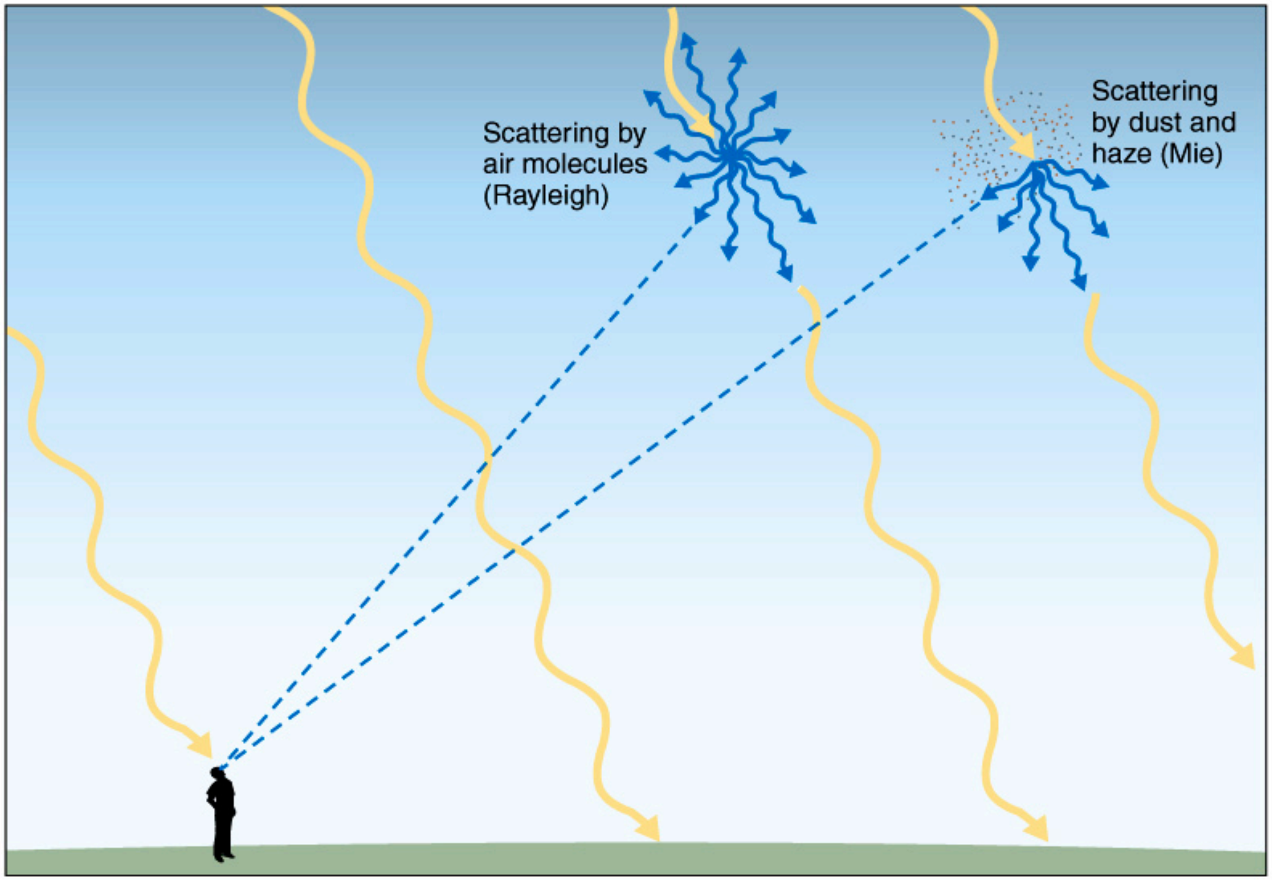
Scattering- Selective scattering

- Selective scattering of incoming solar radiation causes reflectance in portion of the electromagnetic spectrum that correspond with the colors our eyes detect.

- Rayleigh Scattering
  - Scattering agent (individual gas molecules) < 1/10 of the wavelength of incoming radiation
  - Effective for visible light, and disperses radiation forward and backward.
  - Blue sky on clear day. Redness of sunsets and sunrises.
- Mie Scattering
  - Larger scattering agents (aerosols)
  - Interacts with wavelengths across visible spectrum
    - Hazy, grayish skies
    - Sunrise/sunset color enhancement

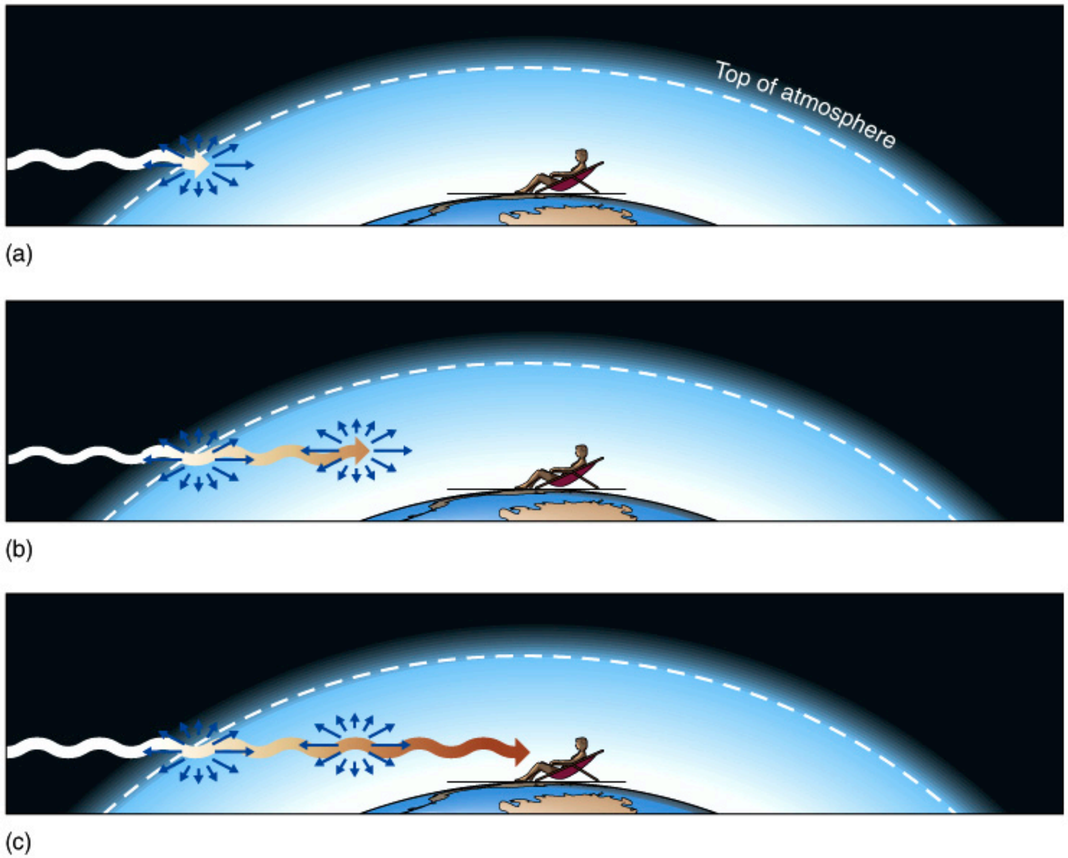


Scattering-Selective scattering



The sky appears blue because the gases and particles in the atmosphere scatter some of the incoming solar radiation in all directions. Air molecules scatter short wavelengths most effectively. Someone at the surface looking skyward perceives blue light.

Scattering- Selective scattering



Sunrises and sunsets appear red because sunlight travels a longer path through the atmosphere. This causes a high amount of scattering to remove shorter wavelengths from the incoming beam radiation. The result is sunlight consisting almost entirely of longer wavelengths.

Raleigh scattering and Mie scattering

https://www.ali-nsa.net/user/Article.aspx?Lang=1&SNo=05003785

https://www.scientificamerican.com/article/fact-or-fiction-smog-creates-beautiful-sunsets/

Scattering-Nonselective Scattering

- Nonselective Scattering
  - Very large scattering agents (water)
  - Scatter across the visible spectrum
    - White or gray appearance
  - Scattering by clouds: clouds reflect all wavelengths of incoming radiation about equally → nonselective

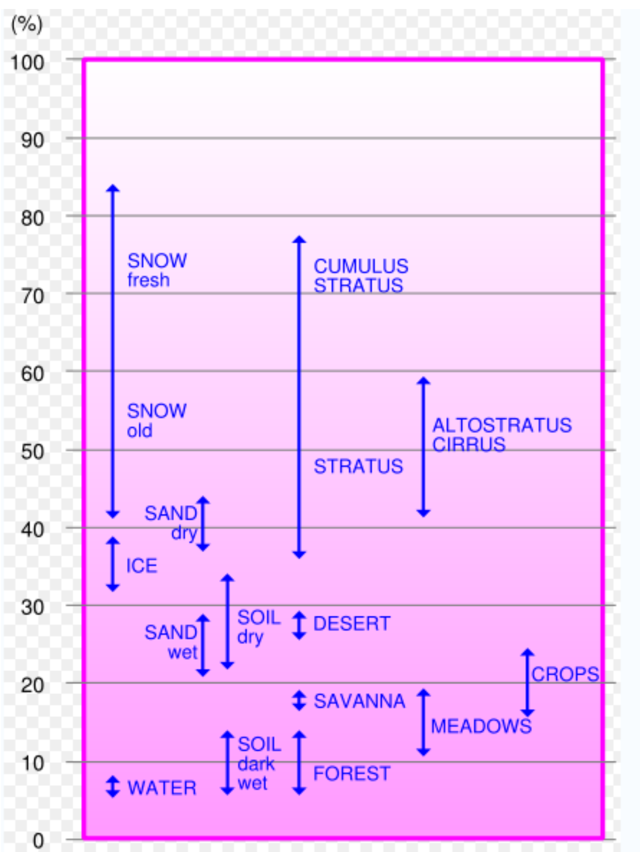
Albedo and Emissivity

- Surface albedo

$$= \frac{SW}{SW}$$

Emissivity

$$LW = \quad T^4$$



32 3 Radiation Balance Near the Surface

Table 3.1 Radiative properties of natural surfaces.

Surface type	Other specifications	Albedo (a)	Emissivity (ε)
Water	Small zenith angle	0.03–0.10	0.92–0.97
	Large zenith angle	0.10–1.00	0.92–0.97
Snow	Old	0.40–0.70	0.82–0.89
	Fresh	0.45–0.95	0.90–0.99
Ice	Sea	0.30–0.45	0.92–0.97
	Glacier	0.20–0.40	
Bare sand	Dry	0.35–0.45	0.84–0.90
	Wet	0.20–0.30	0.91–0.95
Bare soil	Dry clay	0.20–0.40	0.95
	Moist clay	0.10–0.20	0.97
	Wet fallow field	0.05–0.07	
Paved	Concrete	0.17–0.27	0.71–0.88
	Black gravel road	0.05–0.10	0.88–0.95
Grass	Long (1 m)	0.16	0.90
	Short (0.02 m)	0.26	0.95
Agricultural	Wheat, rice, etc.	0.18–0.25	0.90–0.99
	Orchards	0.15–0.20	0.90–0.95
Forests	Deciduous	0.10–0.20	0.97–0.98
	Coniferous	0.05–0.15	0.97–0.99

Compiled from Sellers (1965), Kondratyev (1969), and Oke (1987).

參考資料：Diffuse and beam SW

- The incoming shortwave radiation received by the surface is composed of two portions: (direct) beam S_{b0} and diffuse S_{d0} components.

$$K_a = \frac{S_p}{S_{p0}} = \frac{S_0}{S_{ET}\ \sin} = \frac{S_0}{S_{ET}\ \cos}$$

  - K_a: atmospheric transmissivity (clearness index)
  - S_p or S_0: measured incident radiation on the surface (perpendicular to the surface)
  - S_{p0} : measured radiation outside the atmosphere (perpendicular to the surface)
  - S_{ET}: solar radiative flux density outside the atmosphere (extraterrestrial radiation)
  - β: solar angle
  - Ψ: zenith angle

參考資料：Diffuse and beam SW

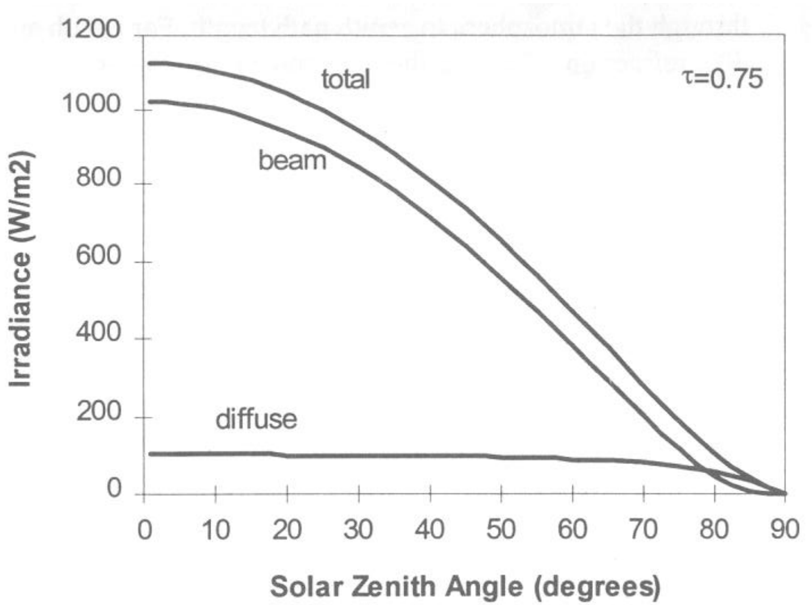


FIGURE 11.2. Beam (S_b), diffuse (S_d), and total solar radiation (S_t) as a function of zenith angle for a very clear sky.

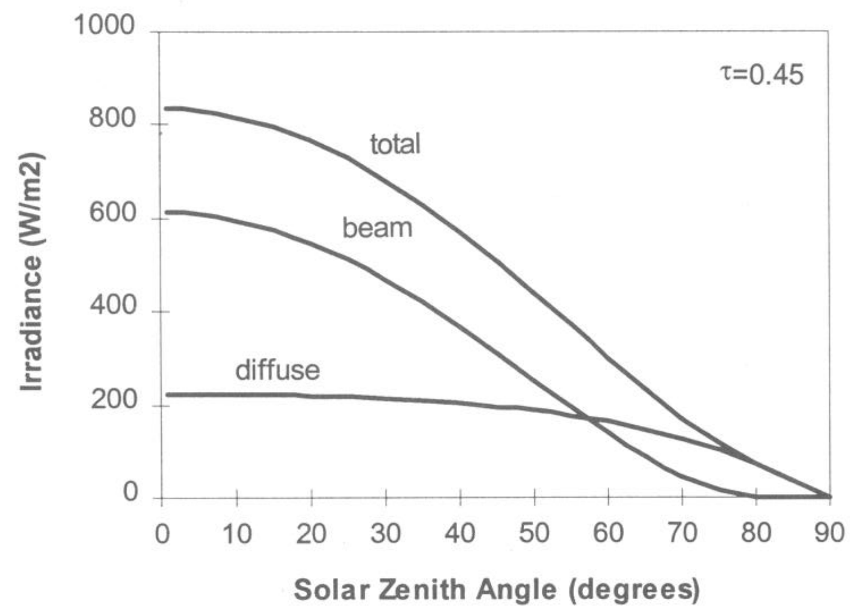


FIGURE 11.3. Similar to Fig. 11.2, but for turbid or polluted air.

補充資料(03/12) Incoming shortwave

- Partitioning of incoming shortwave radiation
  - The incoming shortwave radiation received by the surface is composed of two portions: (direct) beam S_b and diffuse components S_d.

$$K_a = \frac{S_t}{S_{t0}} = \frac{S_p \cos}{S_{p0} \cos} = \frac{S_t}{S_{p0} \cos}$$

- K_a: atmospheric transmissivity (clearness index)
- S_t measured incident radiation on the surface (perpendicular to the surface)
- S_{t0} : measured radiation outside the atmosphere (perpendicular to the surface)
- S_{p0}: solar radiative flux density outside the atmosphere (extraterrestrial radiation)→solar constant

$$S_{p0} = 1367 \quad 0 + 0.033 \cos \ 2 \quad \frac{J \quad 10}{365}$$

- Ψ: zenith angle

補充資料：Incoming shortwave

- Partitioning of incoming shortwave radiation
  - the fraction of the beam and diffuse components

$$S_b = S_t \quad (1 \quad f_d)$$
$$S_d = S_t \quad f_d$$

  - The quantity of f_d (Erbs et al. ,1982):

$$
\begin{array}{ll}
f_{\mathrm{d}} = 1.0 \quad 0.09K_{\mathrm{a}} & \text{if } K_{\mathrm{a}} \quad 0.22 \\
f_{\mathrm{d}} = 0.95 \quad 0.16K_{\mathrm{a}} + 4.38K_{\mathrm{a}}^{2} \quad 16.63K_{\mathrm{a}}^{3} + 12.33K_{\mathrm{a}}^{4} & \text{if } 0.22 < K_{\mathrm{a}} \quad 0.8 \\
f_{\mathrm{d}} = 0.16 & \text{if } K_{\mathrm{a}} > 0.8
\end{array}
$$