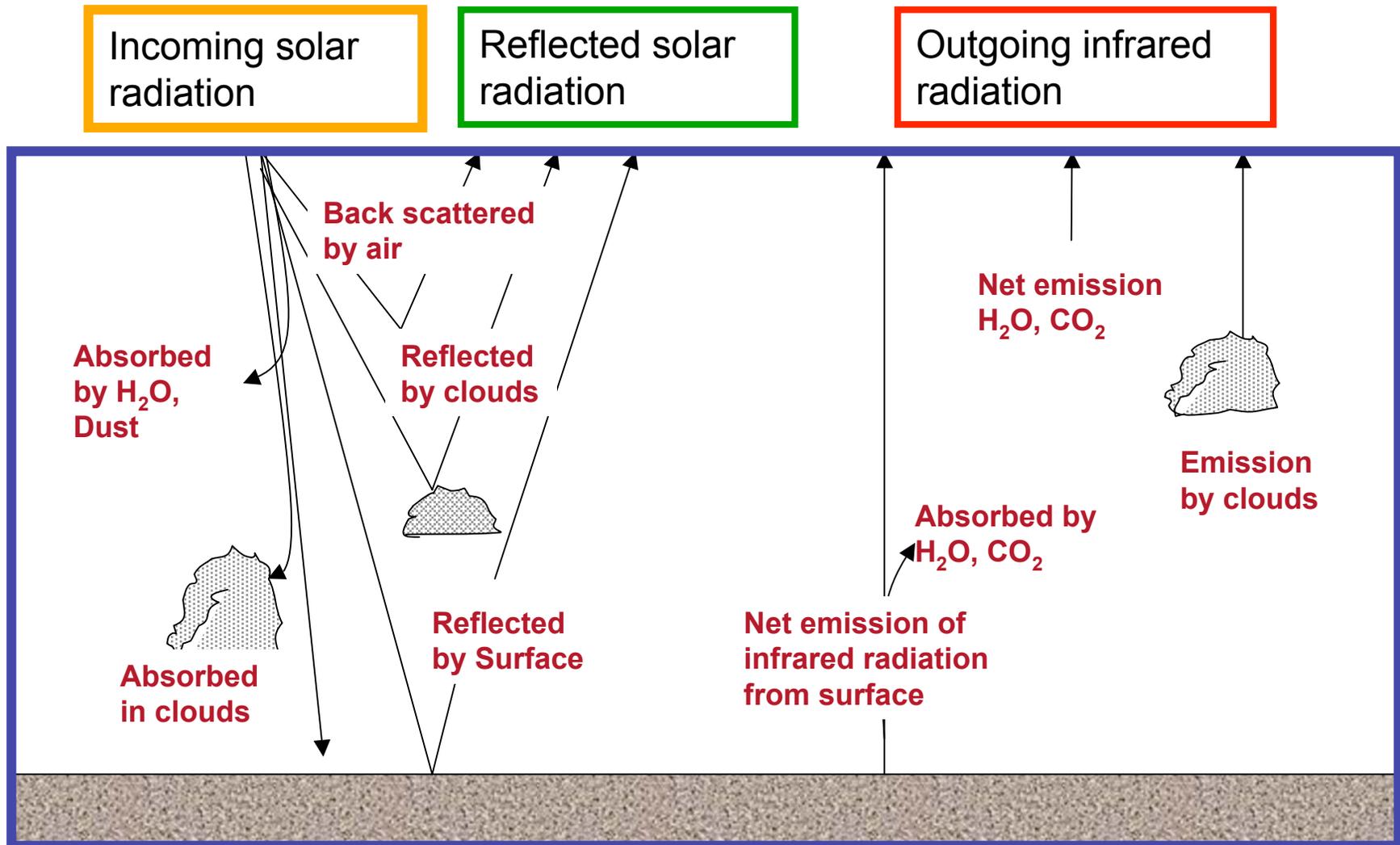


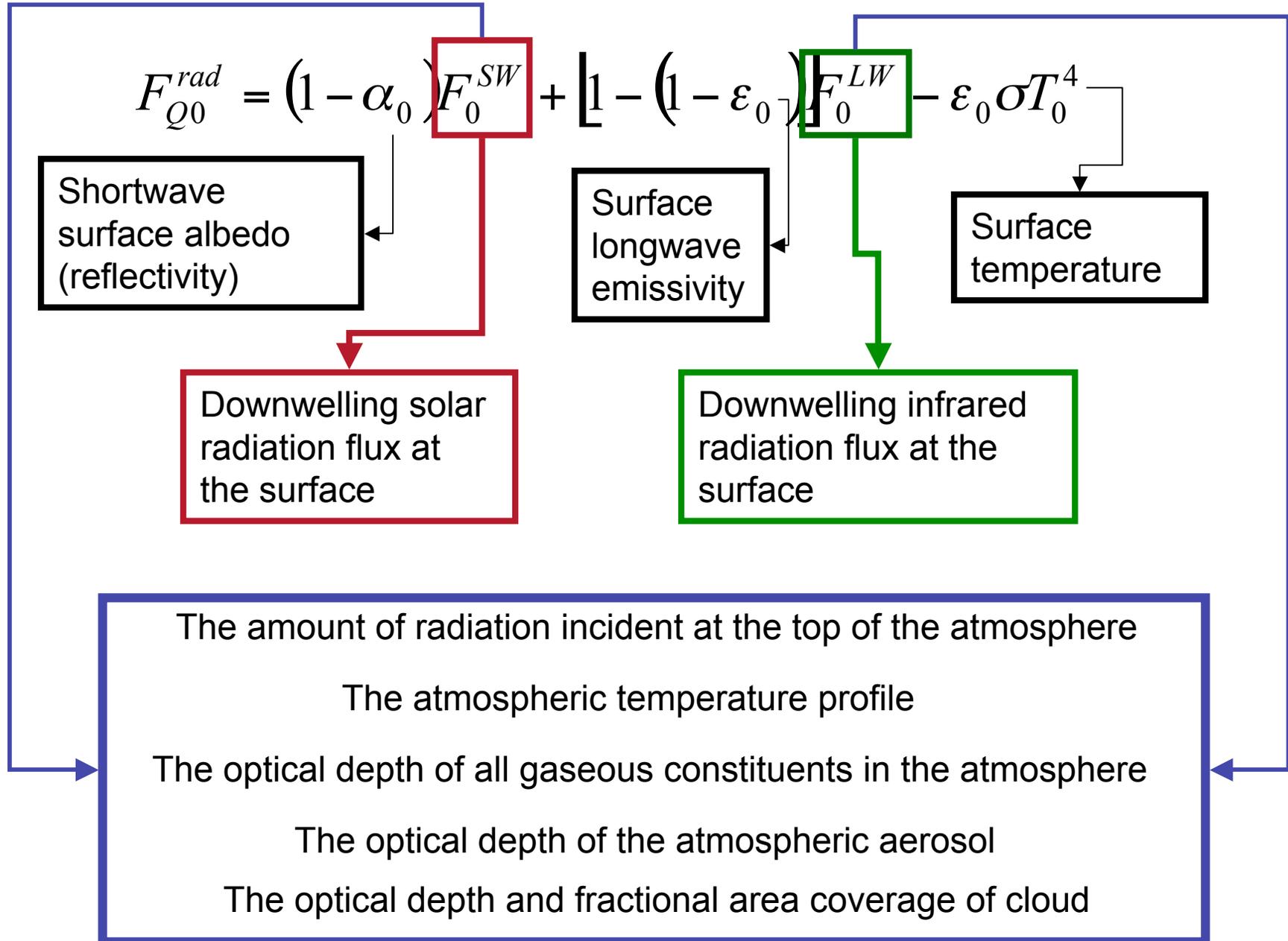
9.1.1, 11.1, 12.1

Net surface radiation flux



Sum of the net solar and longwave fluxes at the surface

Net surface radiation flux



Empirical formulations

Available conventional surface observations

Fractional cloud cover

Surface air temperature

Downwelling solar shortwave radiation flux

Cloudless conditions

Varies with the amount of radiation received at the top of the atmosphere

Variations in aerosol and water vapor content

$$F_0^{sw,clr} = S \cos^2 Z [1.085 \cos Z + (2.7 + \cos Z) e_a + 0.01]^1$$

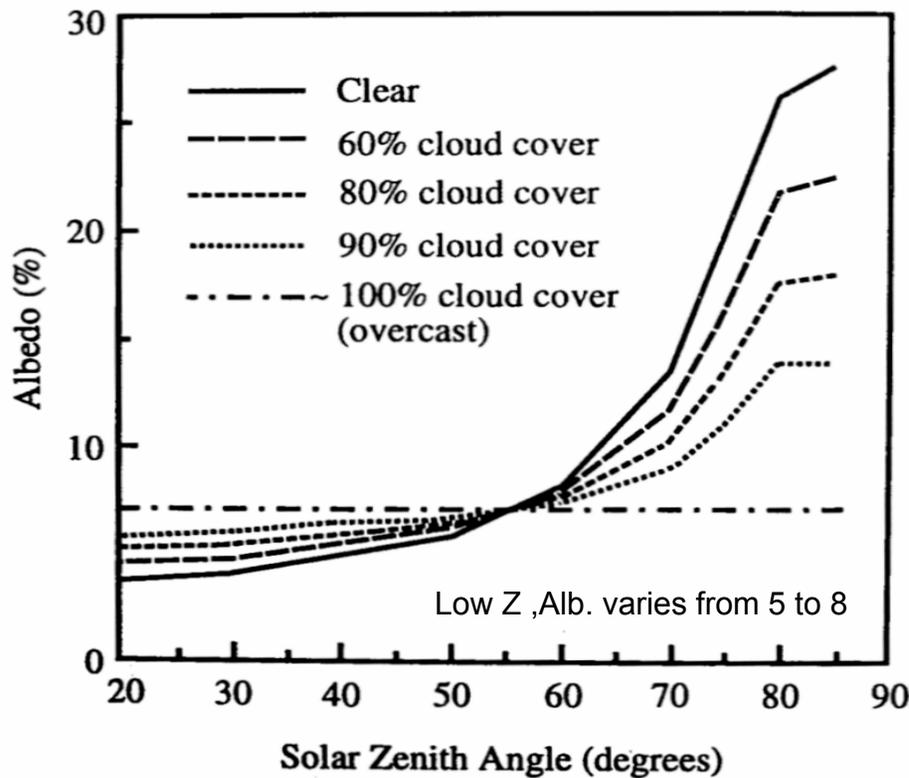
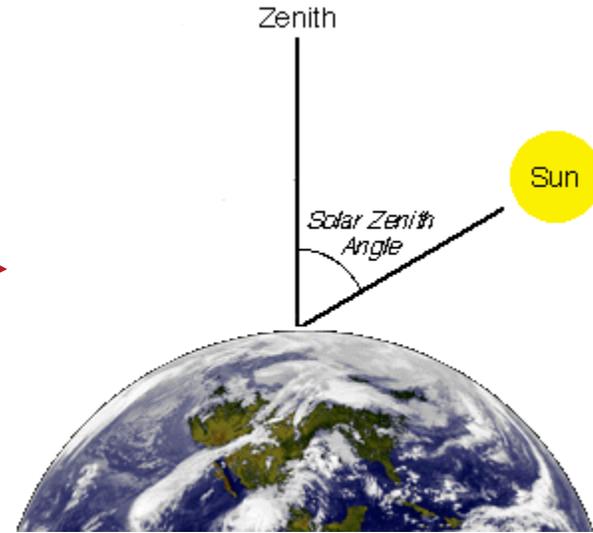
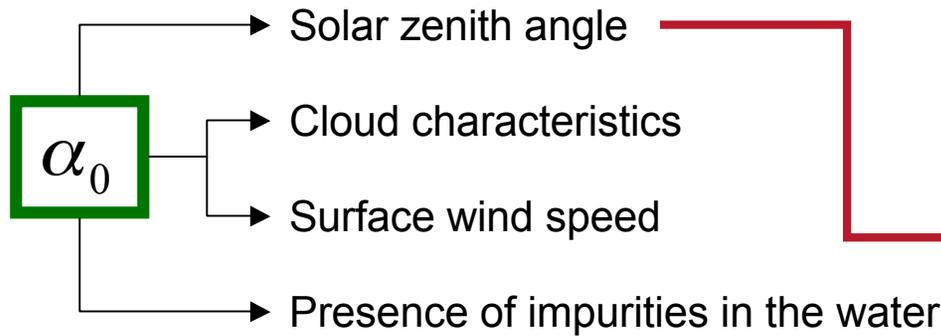
Cloudy conditions

$$F_0^{sw} = F_0^{sw,clr} [1 + 0.0019(90 - Z) - 0.62 A_c]$$

A_c Fractional area of the sky cover by clouds

Portion of radiation that reaches sea surface is reflected back into the atmosphere

Surface albedo over ocean (Ice free)



Clouds scatter very effectively

Radiation very diffuse: surface albedo insensitive to angle

Albedo of Water varies spectrally

Higher for visible

Downwelling infrared radiation

Cloudless conditions

$$F_0^{Lw,clr} = \sigma T_a^4 \left(1 - 9.365 \times 10^{-6} T_a \right)$$

Cloudy conditions

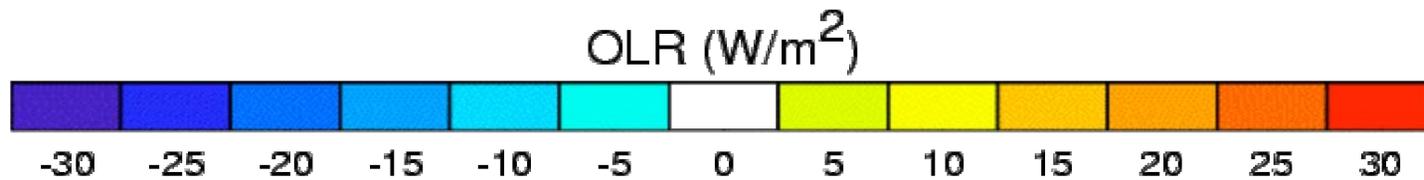
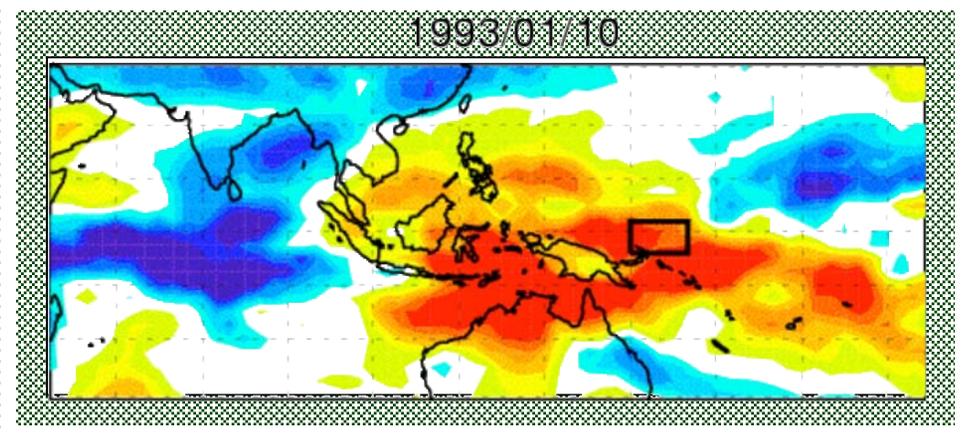
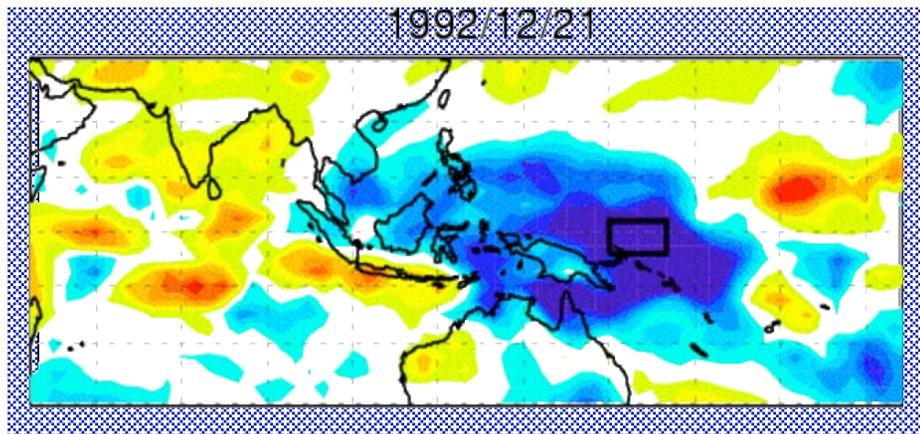
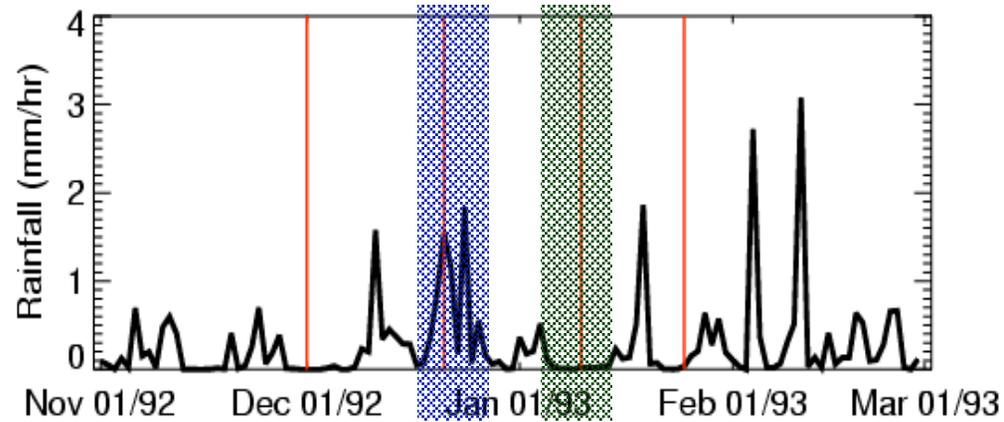
$$F_0^{Lw} = F_0^{Lw,clr} + 0.96 A_c \sigma T_a^4 \left(1 - 9.2 \times 10^{-6} T_a^2 \right)$$

larger values under cloudy conditions

Longwave radiation is absorbed and emitted in the top 1mm of the ocean.

The ocean surface emits nearly as a black body with a surface emissivity of 0.97

Outgoing long wave radiation



Usually more than 90% of the solar radiation incident in the ocean is absorbed

Extinction of solar radiation in the ocean

Beer's law

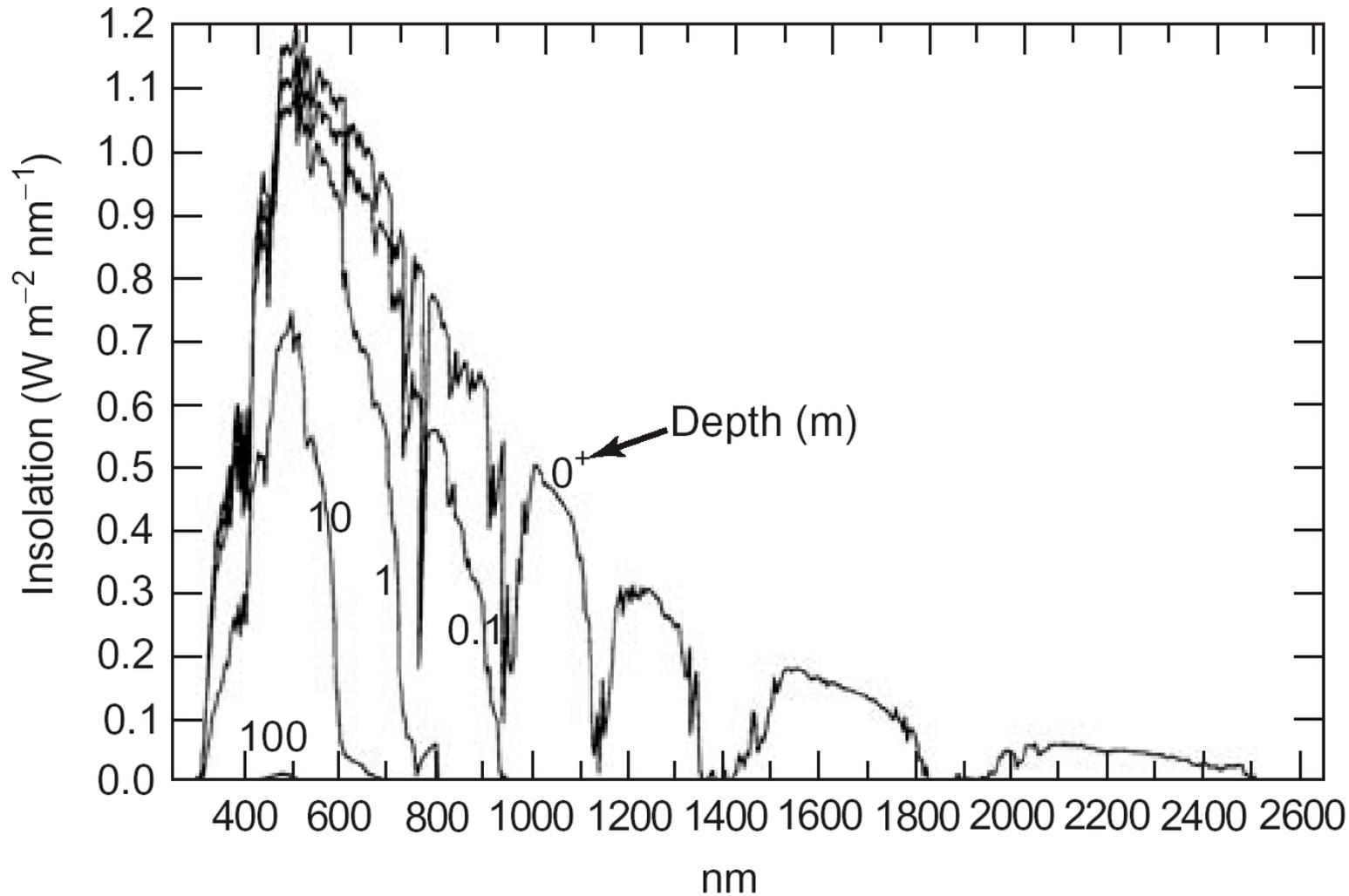
$$F_{\lambda}(z) = F_{\lambda}(0)(1 - \alpha_{\lambda 0}) \exp(-k_{\lambda}z)$$

Shortwave radiation
incident at the surface

Volume shortwave
extinction coefficient
of the ocean

Absorption at the near infrared wavelengths is insensitive to turbidity, while absorption in the visible depends crucially on the chlorophyll content

Solar insolation at the ocean surface and below.



Note the rapid attenuation of non-visible components with depth. Only the visible part remains below about 10 m.

Multi-Annual Radiation budget

