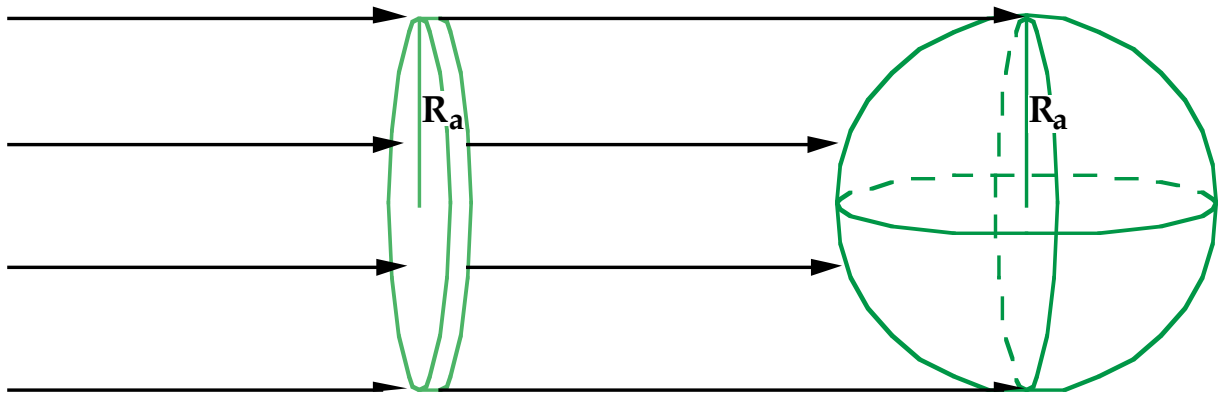
Lecture 3

Radiation and Climate

RADIATIVE EQUILIBRIUM

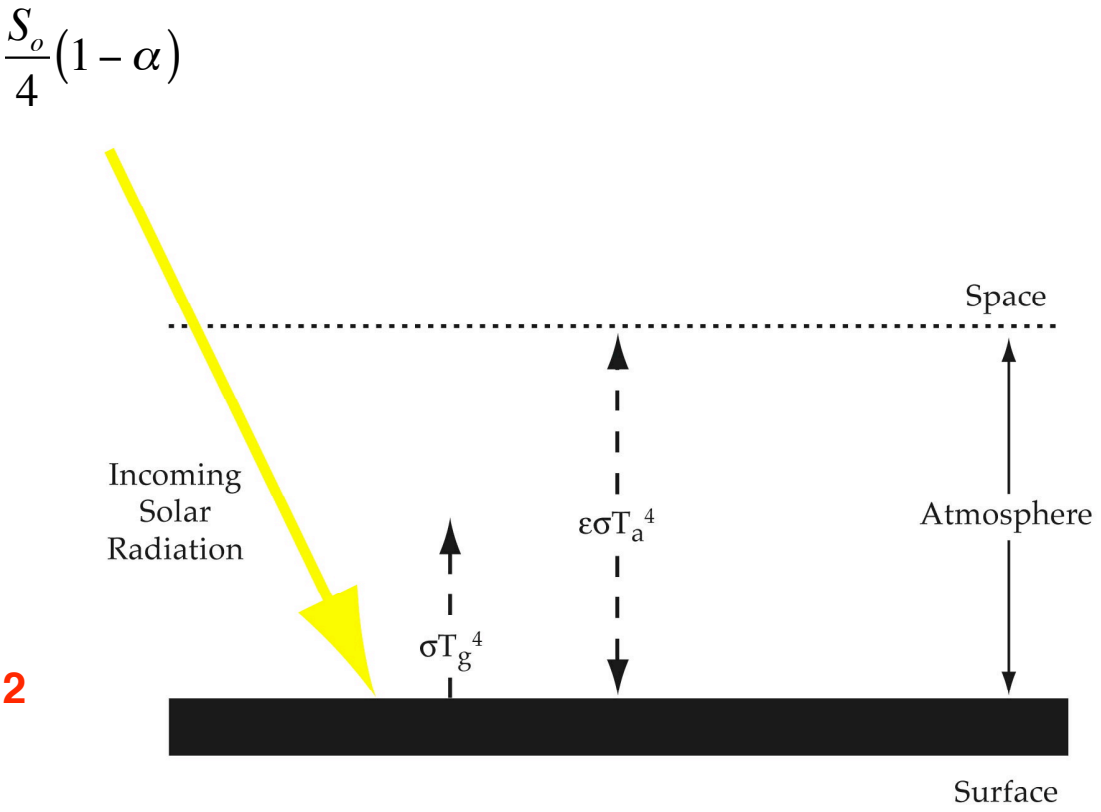
The disc (left) intercepts the same amount of radiation that reaches earth (right). Radius of earth = 6370 km.



$$S_o(1-\alpha)\pi R_a^2 = \sigma T_e^4 4\pi R_a^2$$

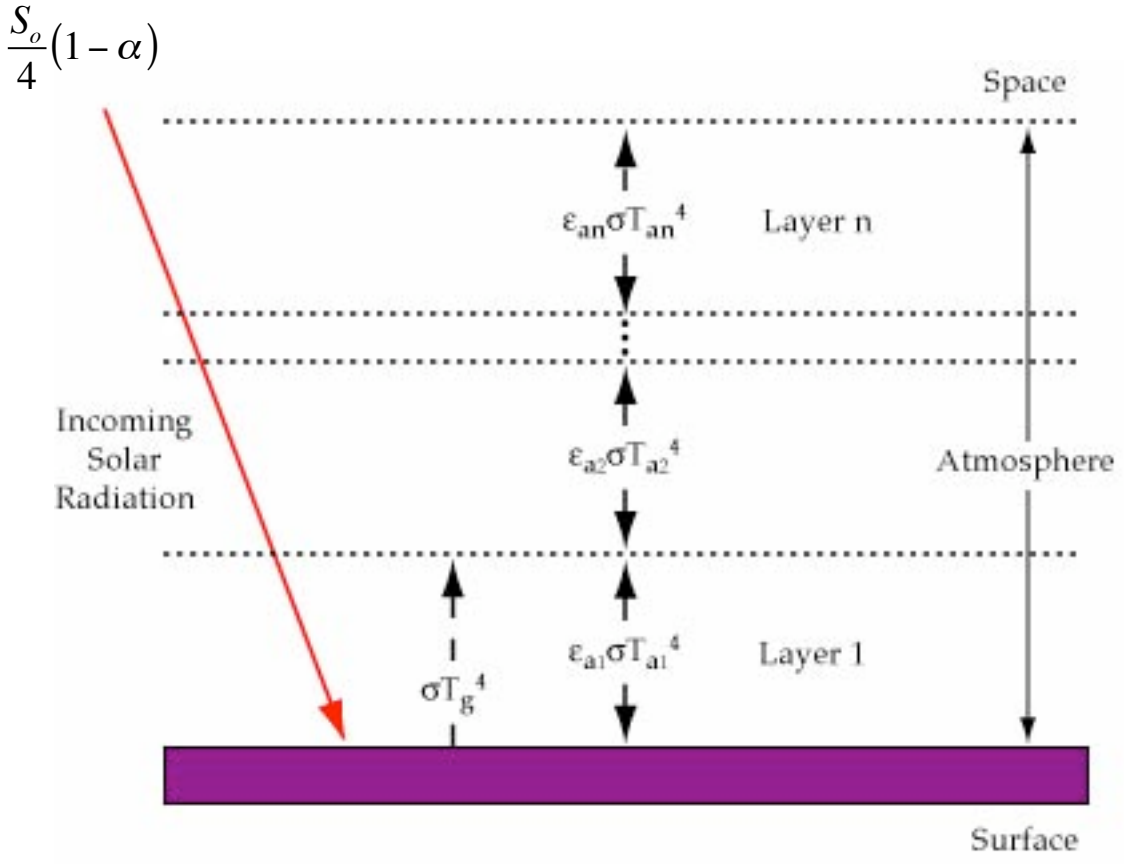
For Earth: $T_e = 255K = -18^\circ C$

Heuristic model of radiative equilibrium



S_o=1370 W/m^2
α=0.3
Let's solve for T_g and T_a…

Multi-layer radiative model depicting equilibrium for the atmosphere.



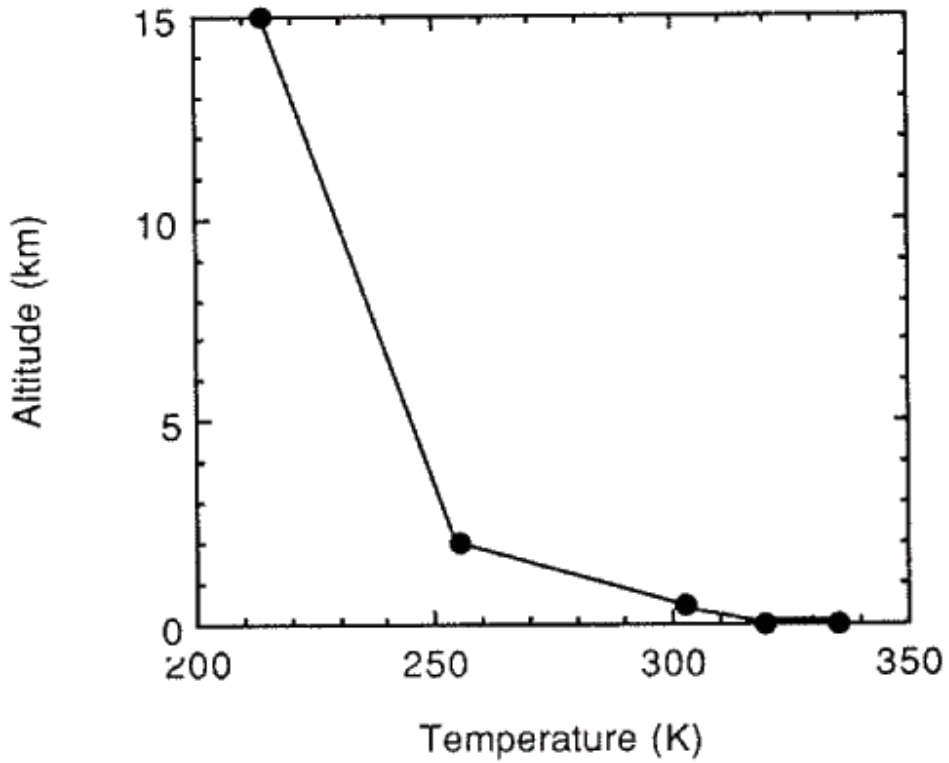


Fig. 3.11 Plot of temperature profile obtained from the simple two-level atmosphere radiative eq librium model.

(from Hartmann)

RADIATIVE-CONVECTIVE EQUILIBRIUM

Radiative-Convective Equilibrium Temperature Profiles

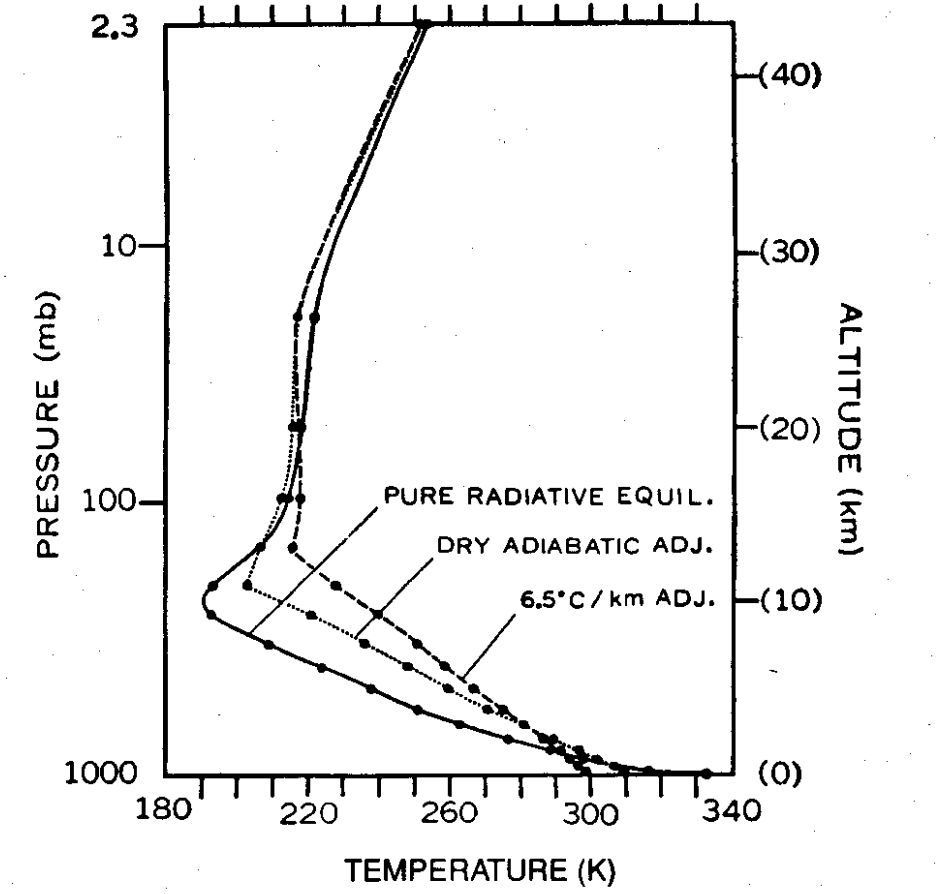


Fig. H3.16 Calculated temperature profiles for radiative equilibrium, and thermal equilibrium with lapse rates of 9.8 degrees C km^{-1} and 6.5 degrees C km^{-1}

Thermal Equilibrium Profiles

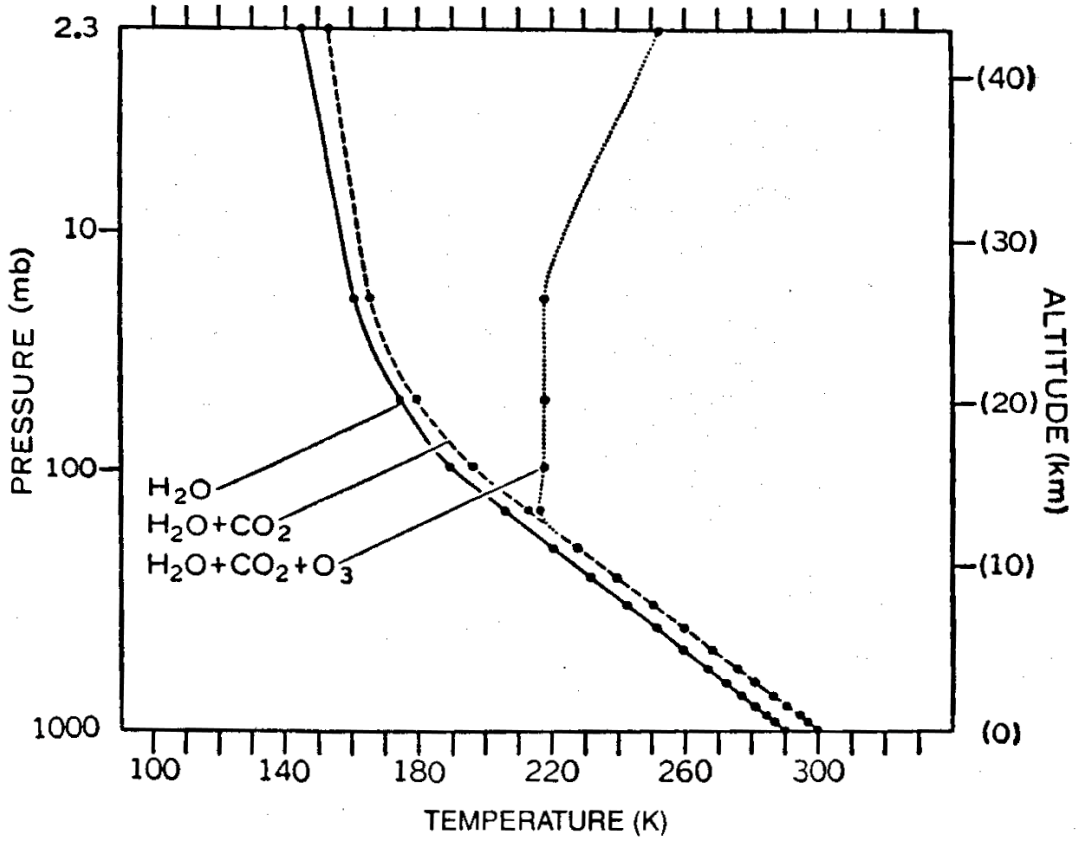


Fig. H3.17 Thermal equilibrium profiles for three cloudless atmospheres obtained with a critical lapse rate of 6.5 km-1. One atmosphere has water vapor only; one includes water vapor and carbon dioxide; and the third contains water vapor, carbon dioxide, and ozone.

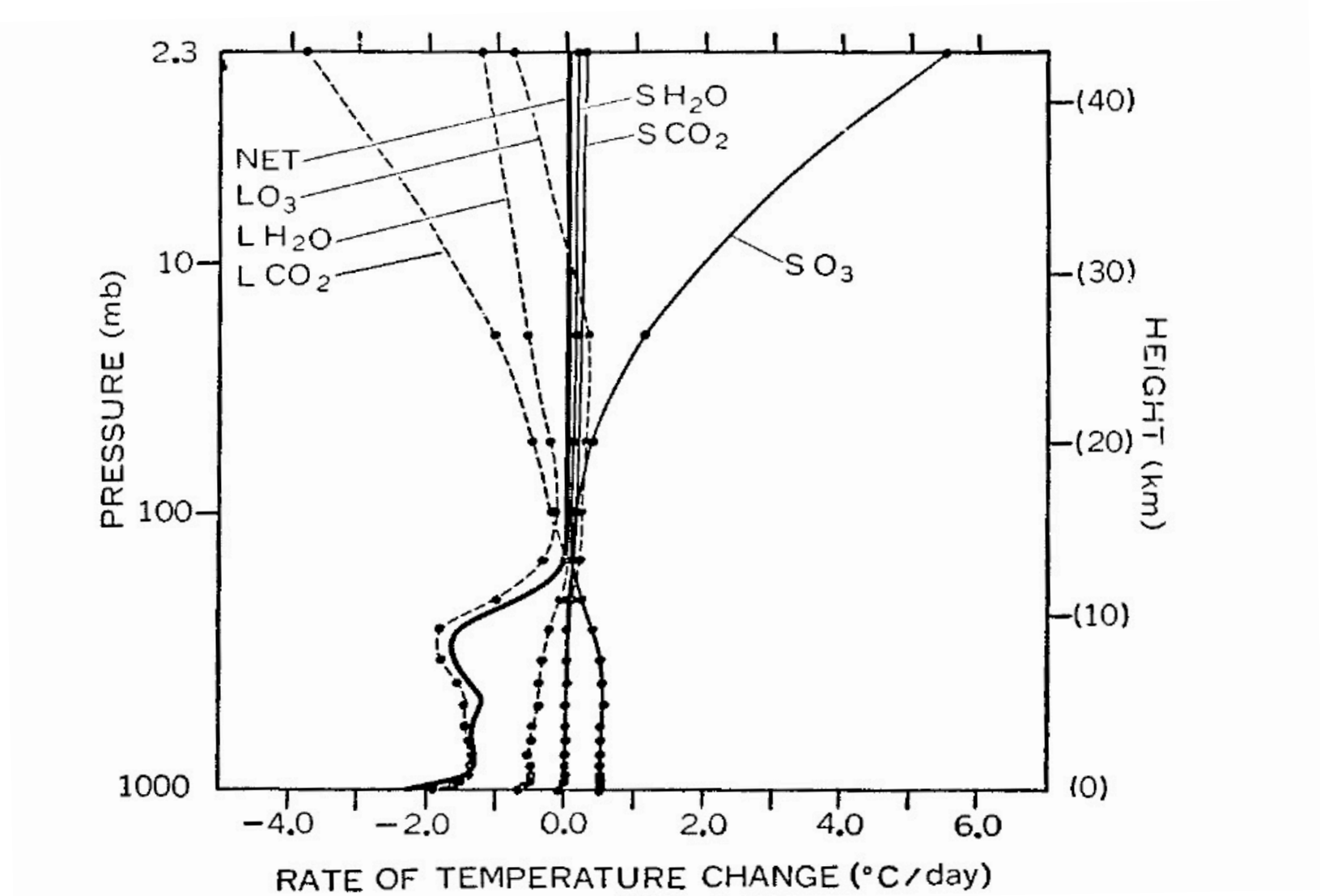


Fig. H3.18 Radiative heating rate profiles for a clear atmosphere. LH2O, LCO2, and LO3 show the heating rates associated with longwave cooling by water vapor, carbon dioxide, and ozone. The S prefix indicates heating rates associated with solar absorption. (From Manabe and Strickler, 1964)


The role of clouds
MODIS, SE Pacific

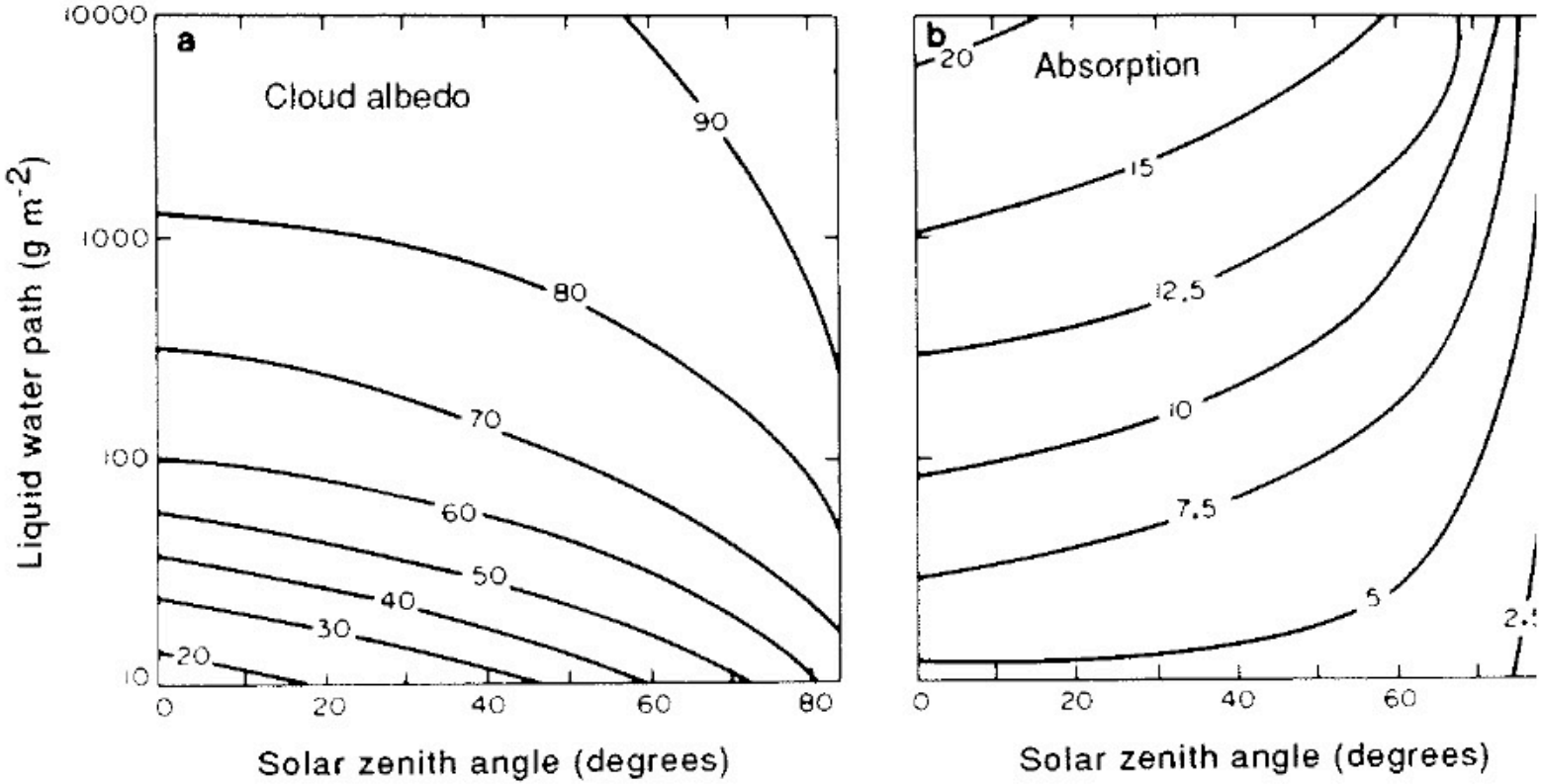
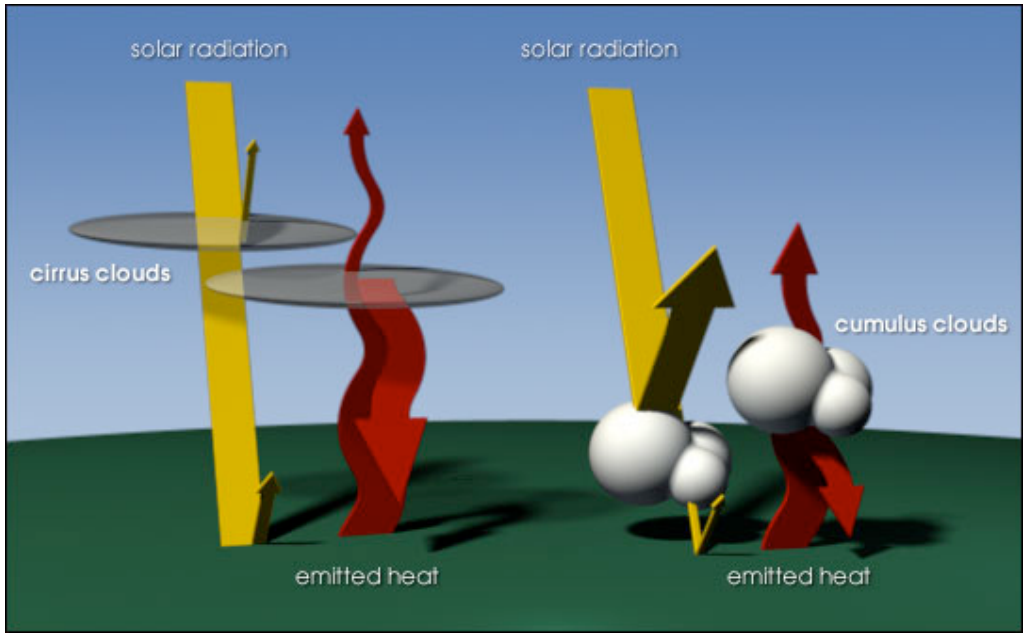
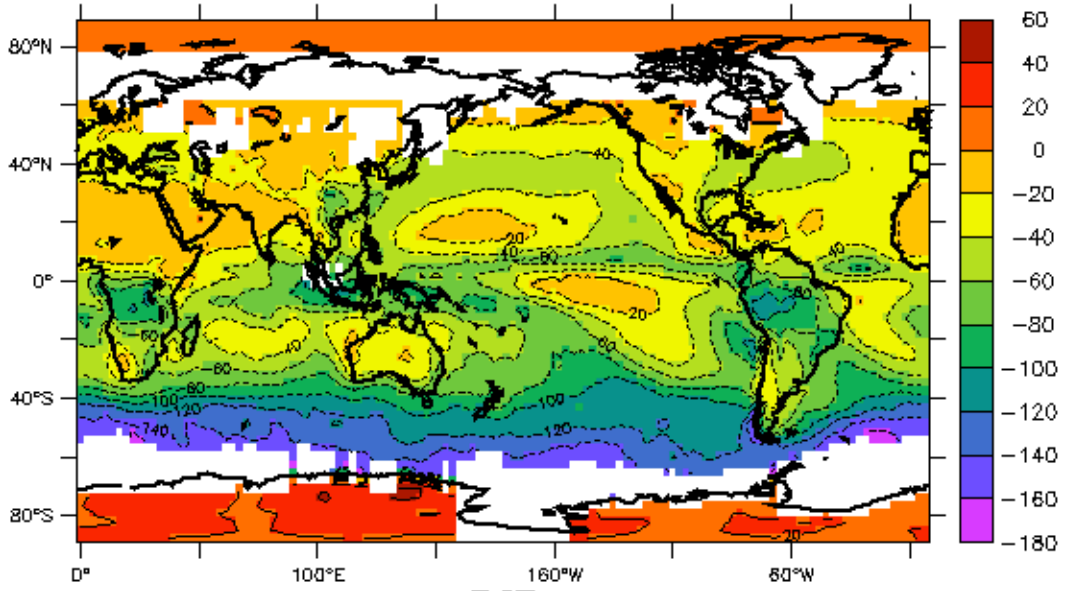


Fig. 3.13 The dependence of (a) cloud albedo and (b) cloud absorption on cloud liquid water and solar zenith angle. Values are given in percent. [From Stephens (1978). Reprinted with permis from the American Meteorological Society.]

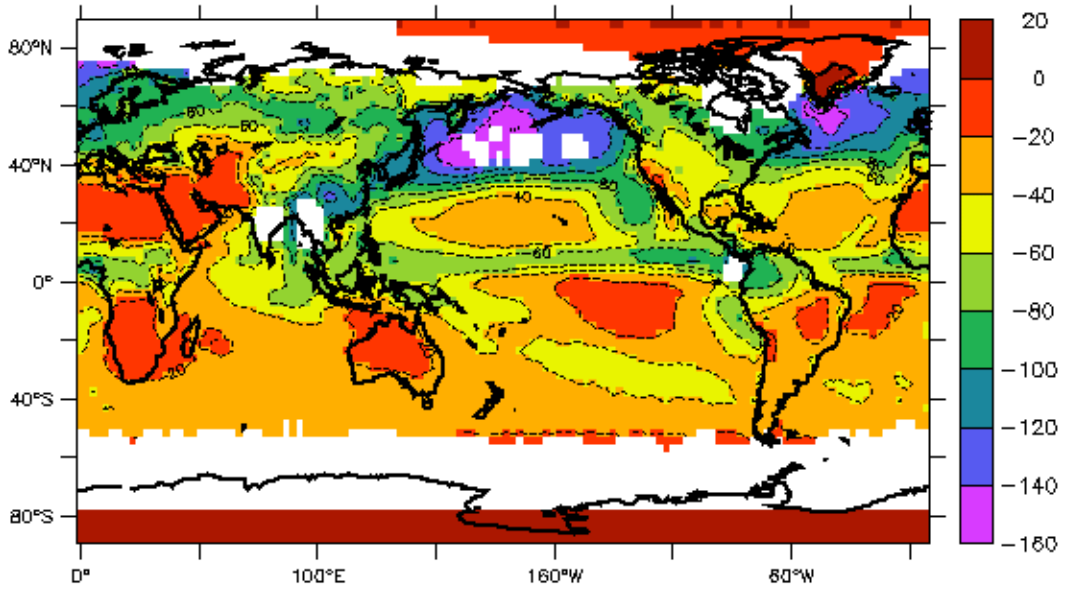


Clouds play an important role in regulating Earth's energy balance balance. Thin cirrus clouds permit sunlight to pass through them, while blocking a significant amount of the heat radiating from the surface. Thick cumulus clouds reflect most sunlight, and block the majority of heat radiating from the surface.
(Illustration by Robert Simmon, Earth Observatory)

ERBE SW Cloud Radiative Forcing



DJF



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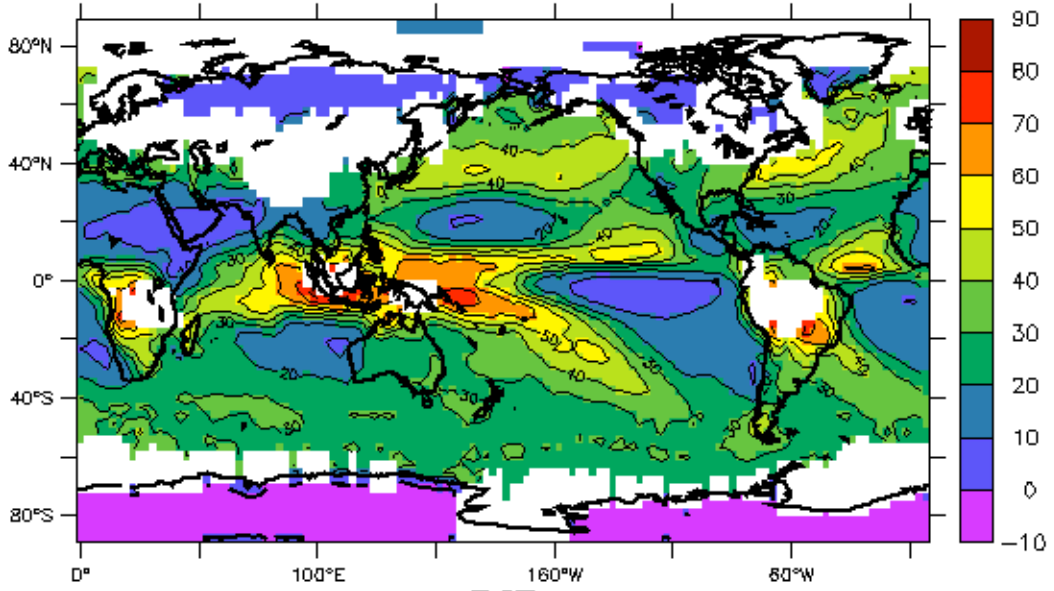
ERBE LW Cloud Radiative Forcing



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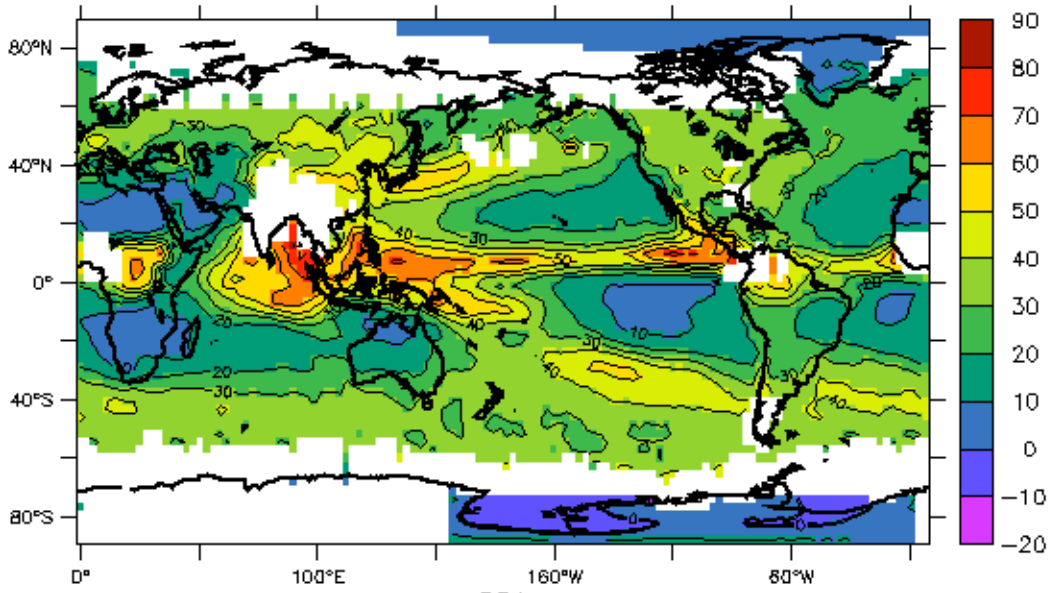

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