radiative transfer: some general features about our radiative climate.

Fig. 10.4. "radiative-conv. equilibrium"

helps explain how greenhouse gases warm: in pure conv. equil. no warming.

Fig. 10.5. $\cos D_2 = \sin \phi \sin \delta + \cos \phi \cos \delta \cosh.$

Kirkwood's law.

Note: radiative $T_{\text{surface}} \gg$ actual $T_{\text{surface}}$. 11 & layer atm.

radiative $T$ profile: fig 4.9 radiative balance. A lot of $E$.

$T_s = 289 K.$

2 layer atmosphere: transparent to solar, opaque to IR.

$T_e = 4\sqrt{n+1}$ $T_e = 9\sqrt{3}$ $T_s = 335 K.$

Fig. 6.2 Petty: $a_w = 0.1; a_{nw} = 0.8$ more accurate.

$T_s = \left[ \frac{S_e}{4\pi} \left( \frac{2-a_{ew}}{a_{ew}} \right) \right]^{1/4} = \left[ \frac{S_e}{4\pi} \frac{1.99}{1.2} \right]^{1/4}$

~1.66 as opposed to 2. So $T_s$ is reduced.

back to fig 4.29.

$\int_0^T \frac{dT}{dt} = -\frac{dF(z)}{dz}$ atmosphere-averaged.

atmospheric mass $\frac{dT}{dt} = \epsilon \sigma T^4 \approx 240 W/m^2$

downward solar and near in JUP.

downward thermal variations small, 0.1 K.
up to now everything a global mean:
seasonal dependence: fig 10.5

direction angle between tilt in earth's axis & sun's rays.

dehikel cirque: 90° s, eq to horizon.
currently we are closer to the sun during summer or winter?

paradoxically, it receives more sun than at averaged over the year.

note how much θ - to - eq gradient var w/ the season.

now: the new RT.

differential form:

\[
\frac{dI(\omega)}{d\omega} = I(\omega) - (1 - \omega) \beta - \frac{I^2}{\pi} + p(\omega', \omega) I(\omega) d\omega
\]

transmission, thermal emission, sub/saturation

go through the terms.

3 radiative parameters: ε, β, γ.

transmission: sec. 4.4.

\[
\frac{dI(\omega)}{d\omega} = I(\omega)
\]

mass abs. coeff., \(\frac{m^2}{kg}\).

ε: \[\int \beta \; ds\\ or \\int k \; N ds\\ or \\int p \; r \; k_a \; ds\\\]

volume eff. \(\frac{1}{m}\\ extr. \# of particles / cm^3\\ extr. efficiency\\ extr. cross section\\ extr. m \]

\(k_a\) eff. m

sec. 4.5.

Beer's law I(\omega) = I(0) e^{-\alpha} \rightarrow e^{-\alpha} = T

\(A + T + R T = I(0)\\ dom., fr.\\ or \\frac{dT}{T} = - \beta ds\)
used to determine solar spectrum \( \rho \), as a calibration technique, and to determine aerosol optical depth (sun photometers).

Sec. 4.52 describes \( \omega, \theta \)

\[
\frac{\text{scale}}{\text{scale} + \text{abs}} = \frac{1}{2} \int \rho(\cos \theta) \cos \theta d\theta
\]

assumes plane parallel, azimuthally symmetric scattering.

\(-1 \leq g \leq 1 \quad \text{(in my notation: } g = \frac{1}{4\pi} \int \rho(\cos \theta) \cos \theta d\theta \text{)}\)

now including the thermal absorption in RT / no re-scattering

\[
\frac{dI(\omega)}{d\epsilon} = \frac{1}{1 - \omega} B, \quad \propto \int \frac{e^{-\epsilon}}{\epsilon} \frac{e^{-\epsilon}}{\epsilon} d\epsilon
\]

Schwarzschild's eqn:

- multiply by integrating factor \( e^\epsilon \) and integrate

\[
\text{rule: } \frac{dI}{ds} = e^{-\epsilon} \rightarrow \text{weighting function.}
\]