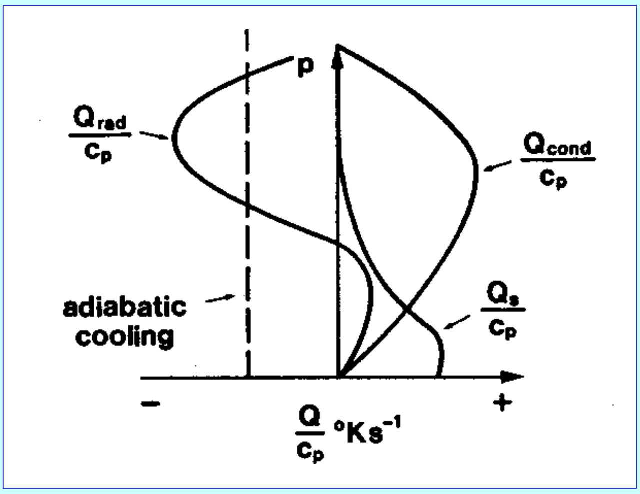
Write

$$Q_{total} = Q_{rad} + Q_{cond} + Q_{sen}$$

total heating	radiative heating	condensational heating	sensible heating

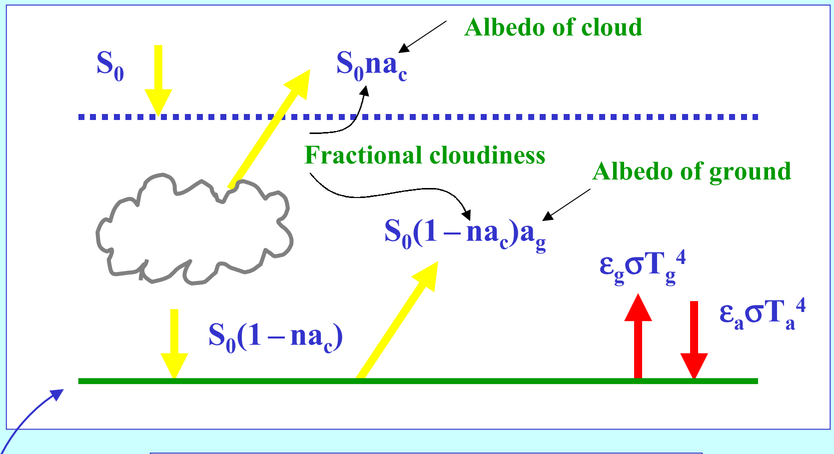
- While diabatic processes drive atmospheric motions, the contributions Q_{rad}, Q_{cond}, Q_{sen} are not pure external functions - they are strongly coupled to the flow configuration that they produce.
- This interdependency reflects a redistribution of the only pure external heating function; the solar energy which impinges on the atmosphere from space (S_0).



Vertical distribution of radiative, condensational and sensible heating.

Redistribution of solar energy

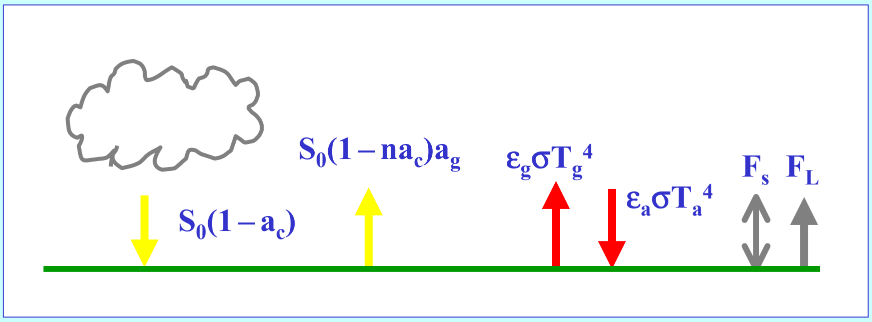
- To understand the full relevance of diabatic process and how the drive atmospheric motions, it is necessary to understand the manner in which S_0 is redistributed.
- If we assume that the atmosphere is in radiative equilibrium with outer space and note that the earth is a sphere, it is clear that considerably more energy (heat) must be transferred polewards if there is to be an approximate steady state.
- The question arises, how is the energy S_0 redistributed in the vertical?
- We consider first the effects of radiation alone.



A highly simplified radiation model

Radiative equilibrium: $S_0\left(1-na_c\right)\left(1-a_g\right)=\varepsilon_g\sigma T_g{}^4-\varepsilon_a\sigma T_a{}^4$

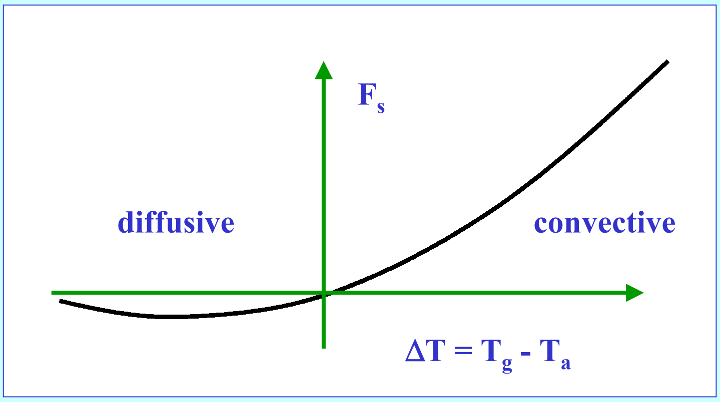
Incoming **Outgoing**



Energy balance at the earth´s surface.

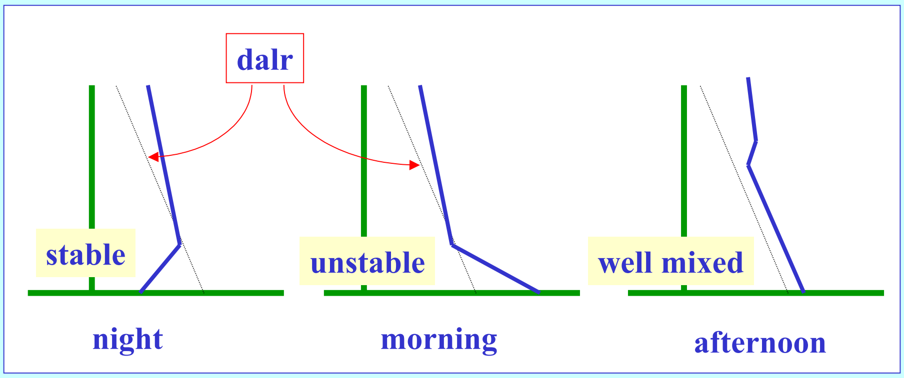
$$S_0\left(1-na\right)\left(1-a_g\right)=\varepsilon_g\,\sigma T_g{}^4-\varepsilon_a\sigma T_a{}^4+F_S+F_L$$

Sensible heat flux
Latent heat flux



Sensible heat flux, F_s, as a function of $\Delta T = T_g - T_a$.

Atmospheric conditions influencing F_s.



$F_s < 0$ $F_s > 0$ $F_s > 0$

Representations of the functions F_S and F_L

The functions F_S and F_L can be parameterized as

$$F_S = \rho C_S |\mathbf{V}| \left(T_g - T_a\right)$$
$$F_L = \rho C_E |\mathbf{V}| \left(q_g - q_a\right)$$

V = wind speed near the surface

T_a and q_a = temperature and specific humidity of the air near the surface

T_g and q_g are the sea surface temperature (SST) and saturation specific humidity at the SST

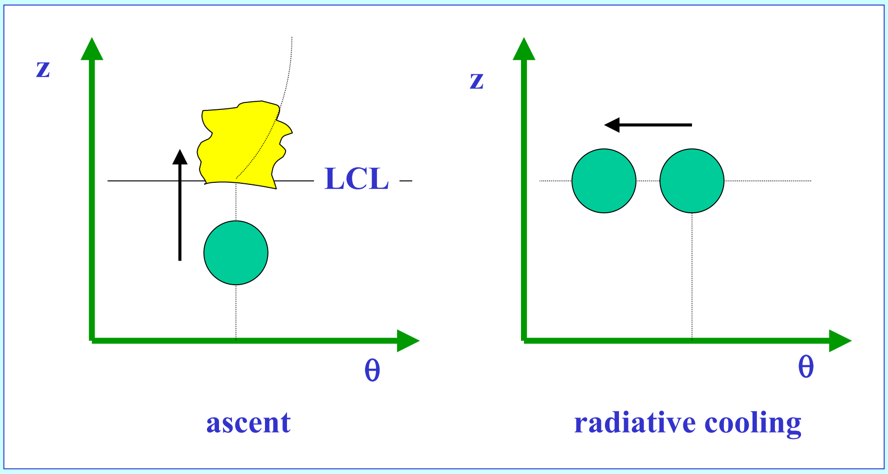
C_S, C_E are empirical coefficients (these depends on wind speed)

C_S is called the heat transfer coefficient

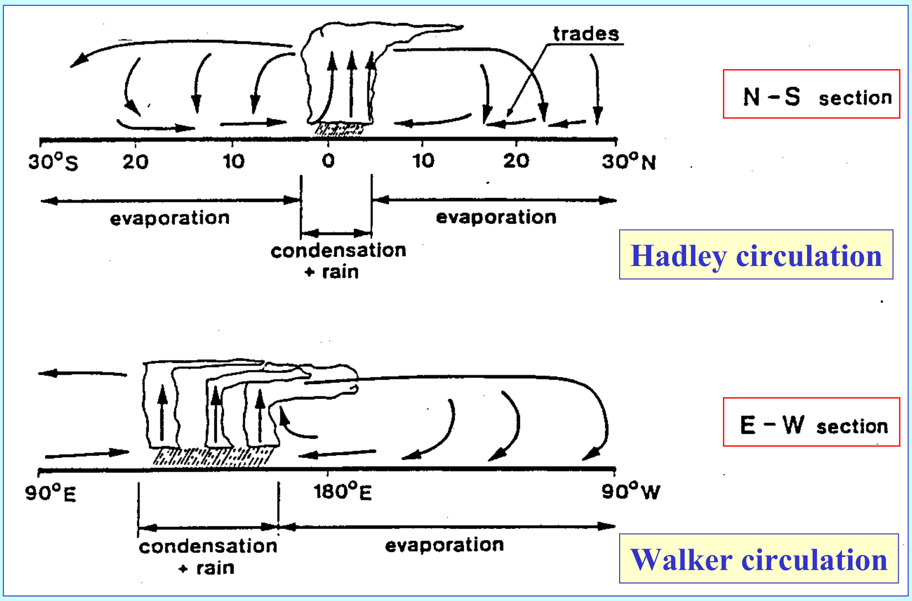
C_E is called the moisture transfer coefficient

Latent and sensible heating

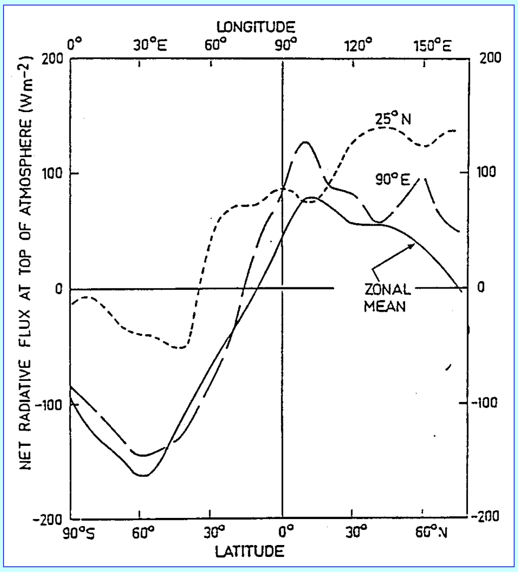
- The sensible heating Q_{sen} tends to be confined to the lowest 1-2 km, except over dry continental surfaces where it may be as high as 4 km.
- Also it represents an immediate acquisition by the column.
- The latent heating Q_{cond} is not immediate, but requires saturation in order to accomplish the heat release.
- This is a process that is highly dependent on the dynamics.
- There are two main ways of producing condensation:
  - ascent
  - radiative cooling



Processes leading to condensation.

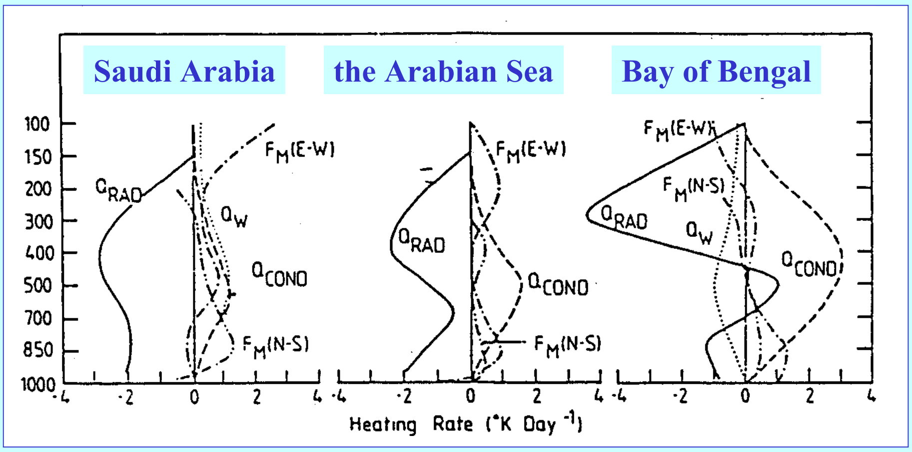


The moisture cycle in the tropics



The distribution of the net radiative flux at the top of the atmosphere inferred from NIMBUS 3.

(From Webster & Stephens, 1979)



The vertical distribution of the heating components in the atmospheric column above above the regions shown.

Q_{RAD}, Q_{COND}, F_M (E – W), F_M (N – S), refer to heating due to radiation, condensation and heat flux convergence due to mean zonal (E - W) and meridional (N - S) motion.

The End