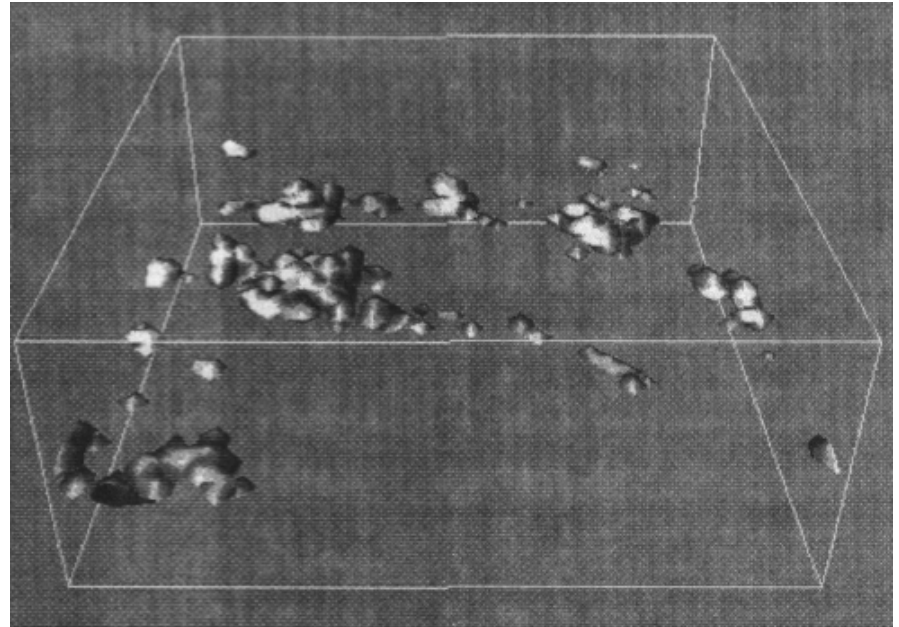


Shallow trade cumulus: BOMEX

Barbados Oceanographic and Meteorological Experiment (1969)



LES of nonprecipitating BOMEX trade cumulus

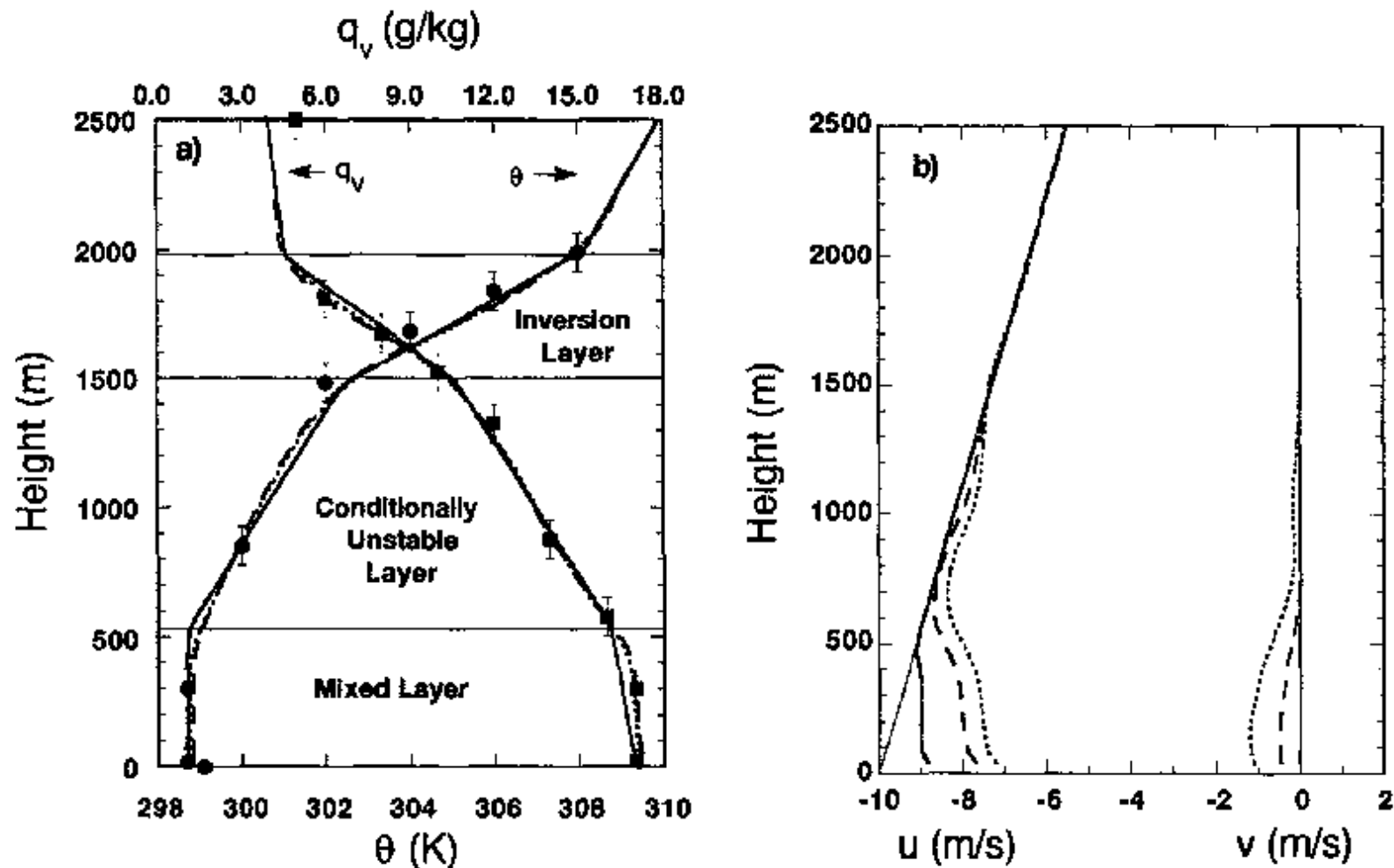
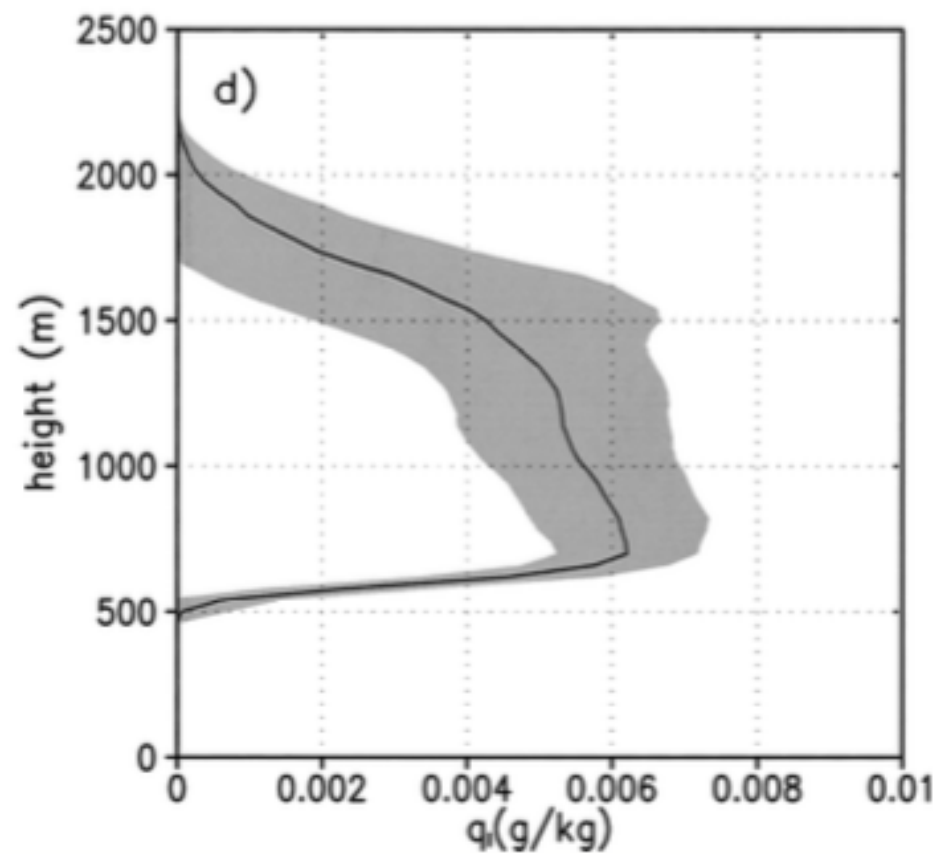
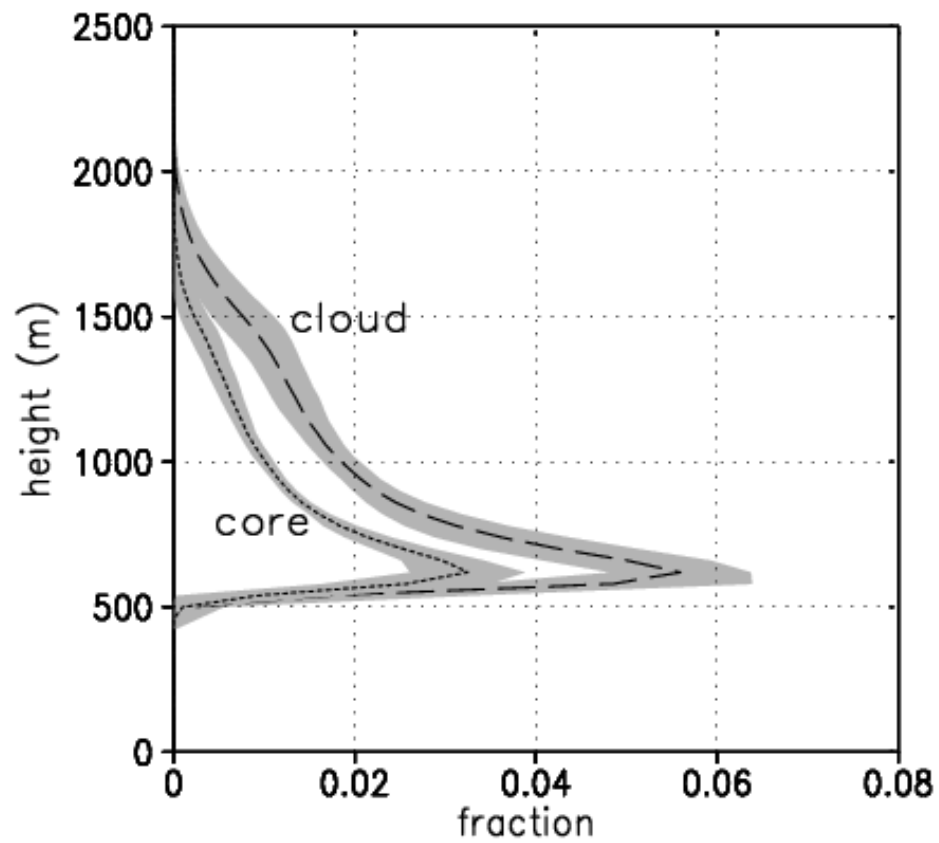
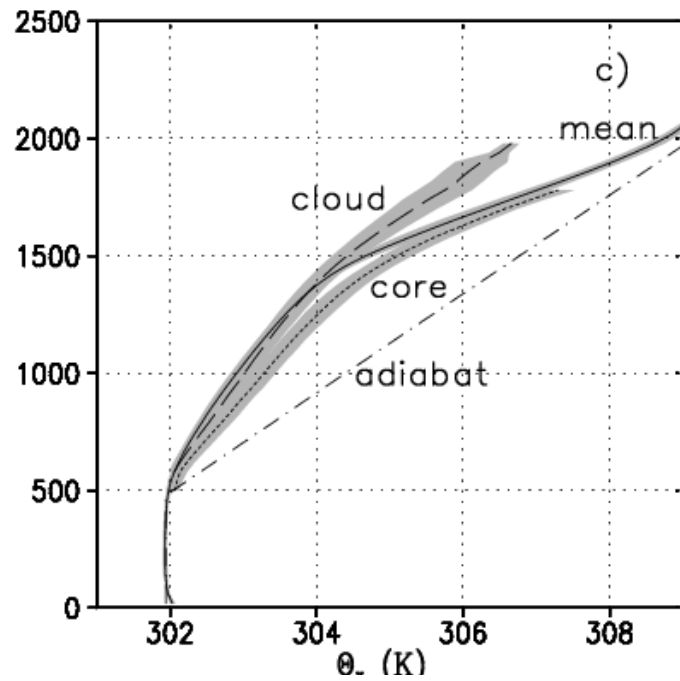


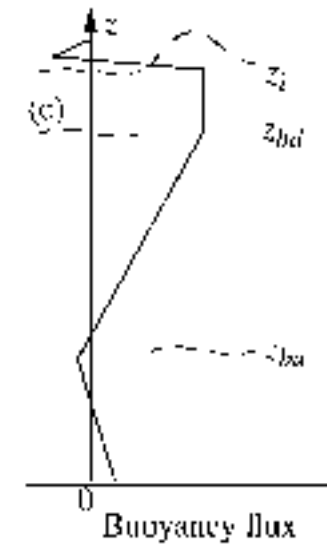
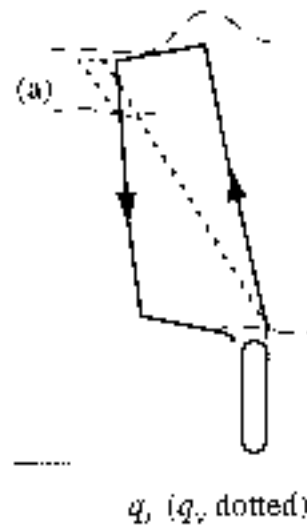
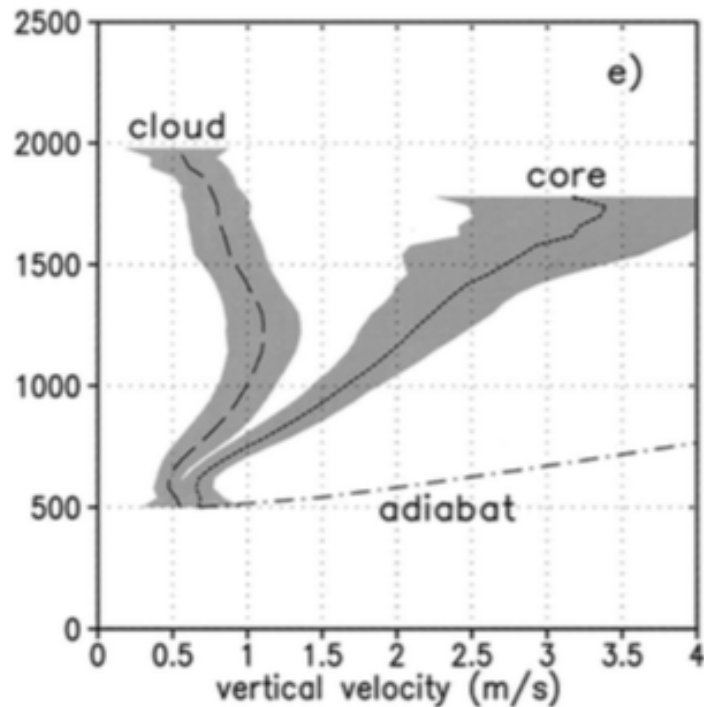
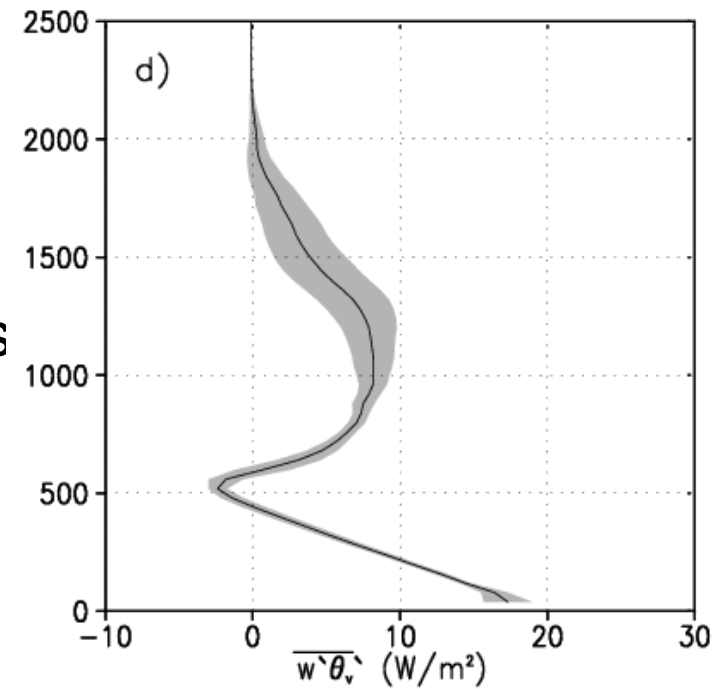
FIG. 1. Horizontally averaged vertical profiles of θ and q_v (a) and the u and v components of the velocity (b) at time $t = 0$ h (full lines), $t = 3$ h (dotted lines), and $t = 7$ h (dashed lines). The circles and squares are the observed values. The thin line in (b) is the prescribed geostrophic wind profile.

BOMEX LES profiles

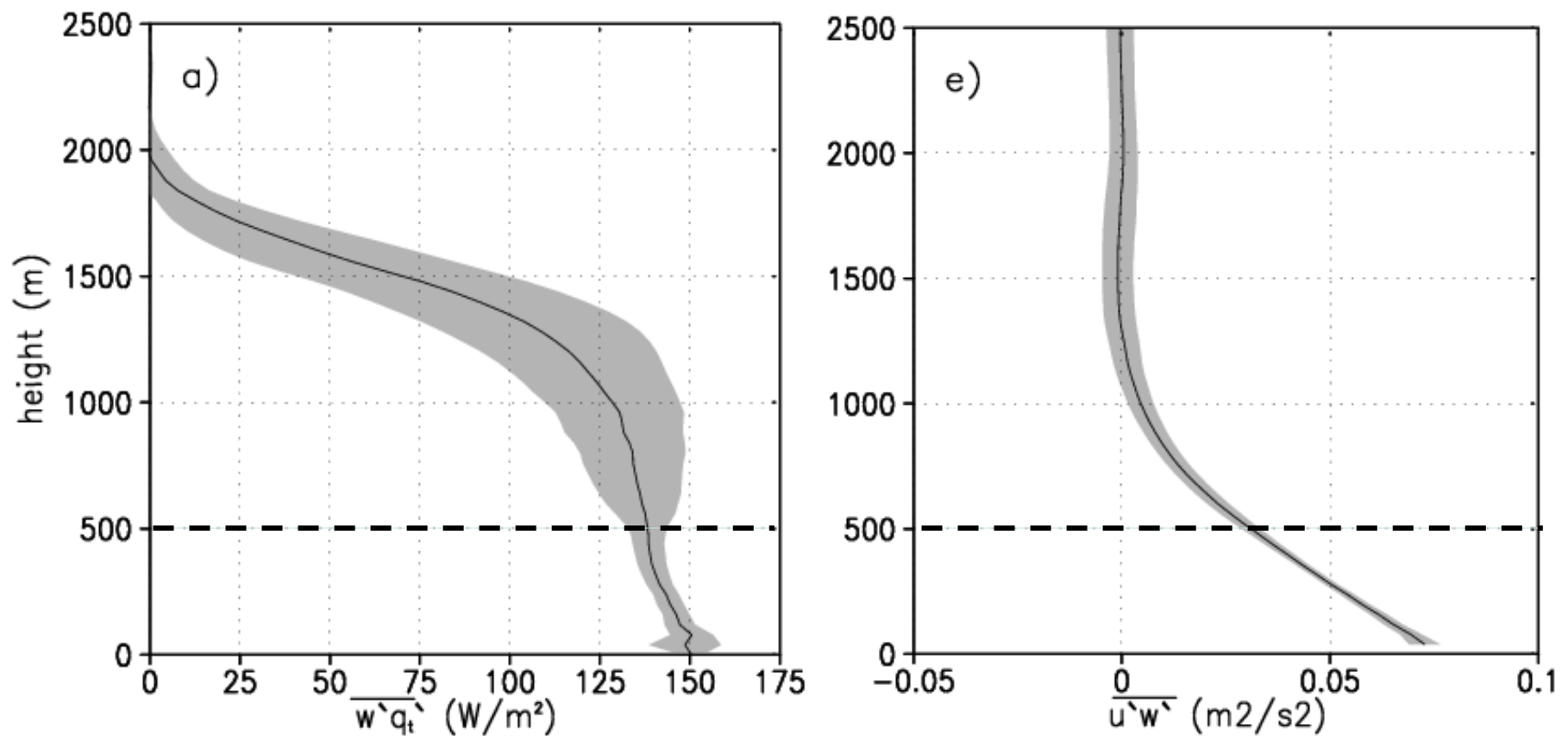




Shallow Cu
buoyancy/ flux:
entrainment
dilution reduces
 b' and w'

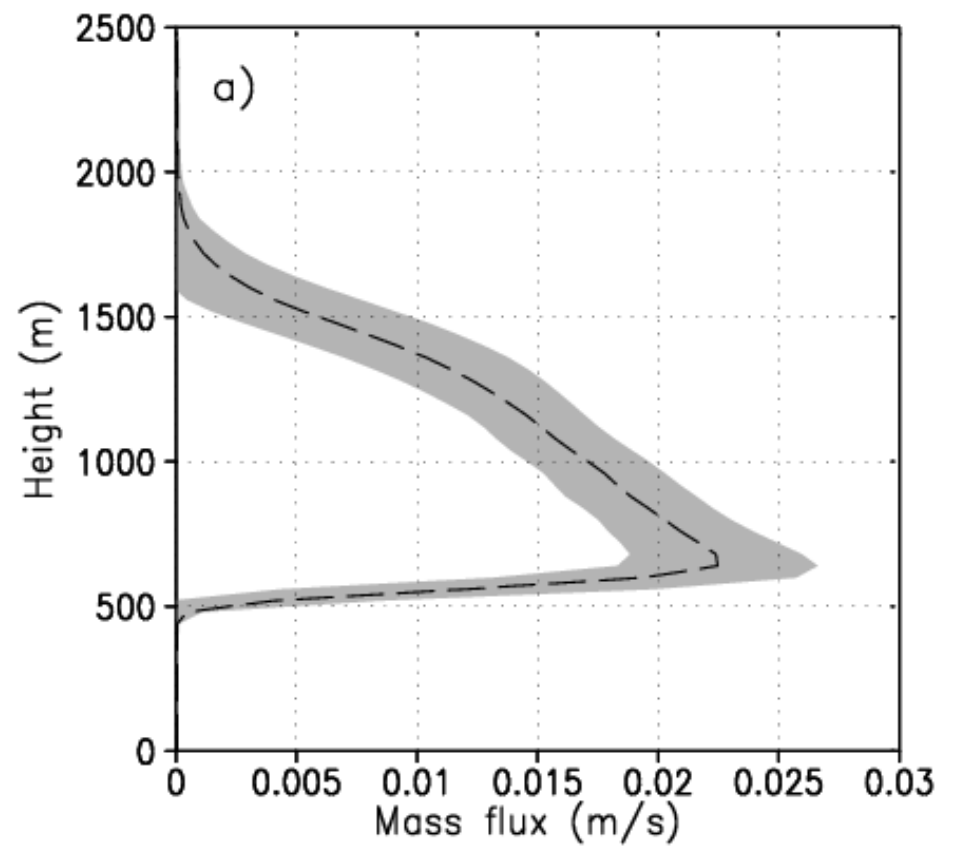
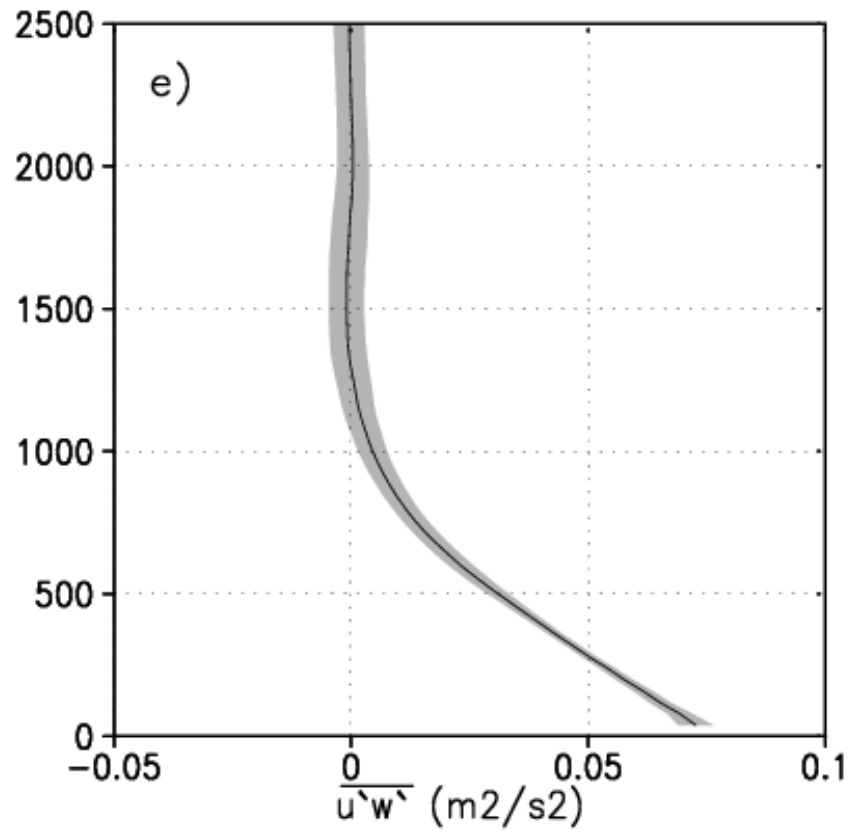


BOMEX LES profiles



- Humidity is fluxed up into the inversion where Cu mix with FT air
- Cu flux momentum downshear, but not as efficiently as dry convection.

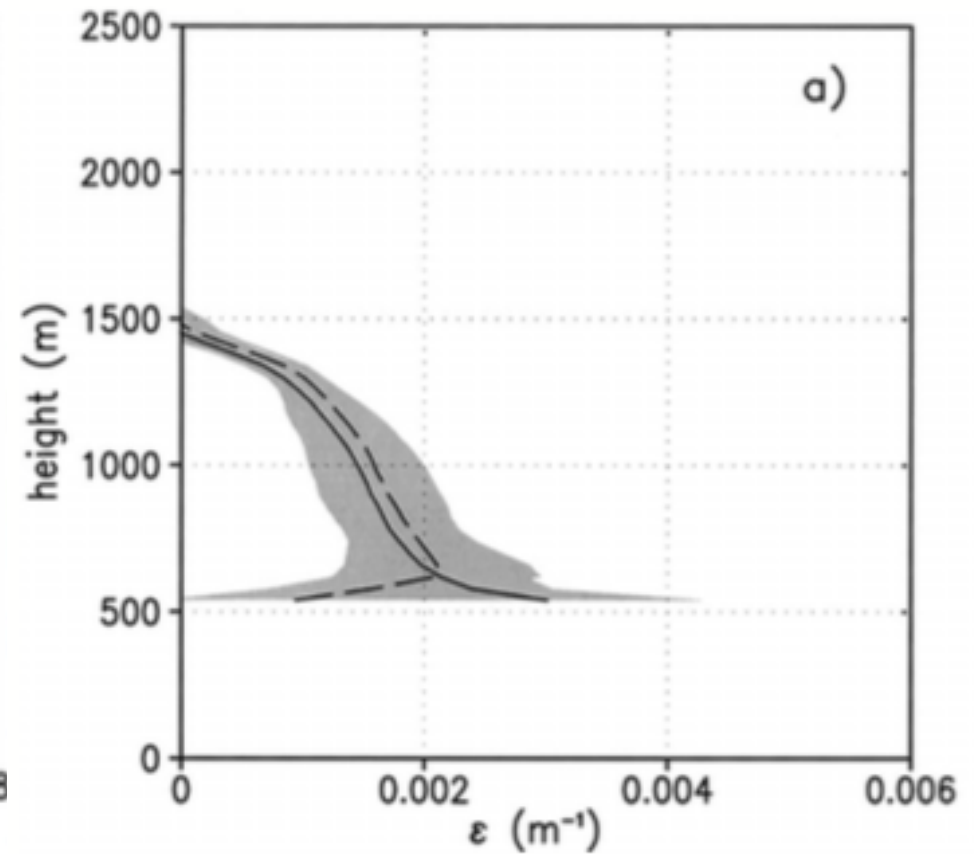
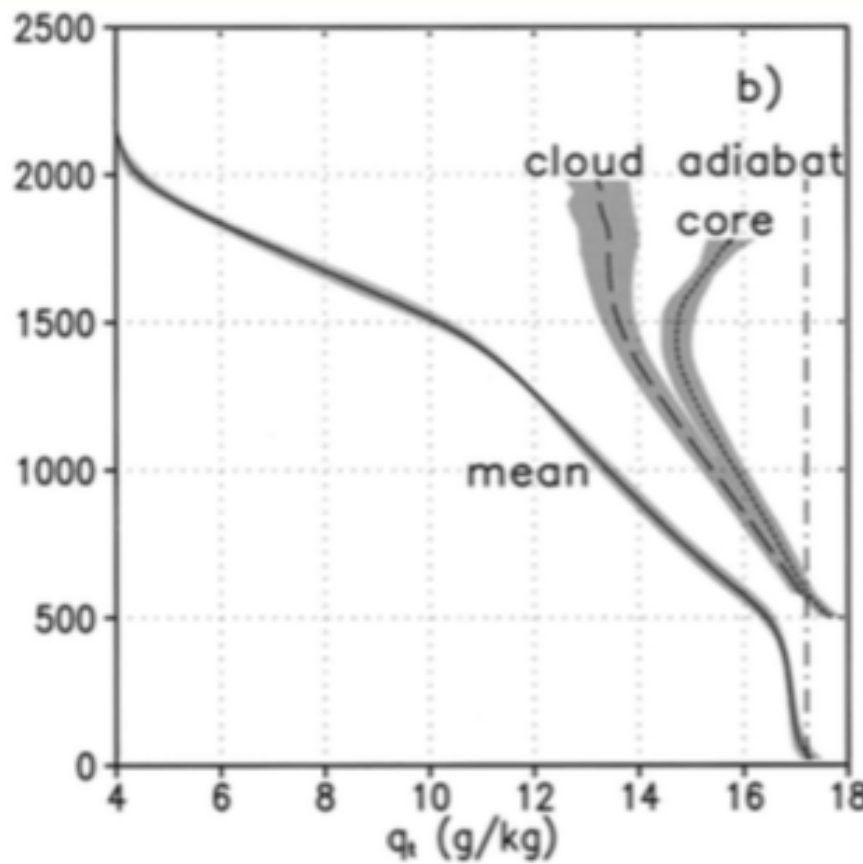
BOMEX LES profiles



Estimating Cu lateral entrainment rate

$$\varepsilon_q = \frac{-dq_{tu}/dz}{q_{tu} - \bar{q}_t}$$

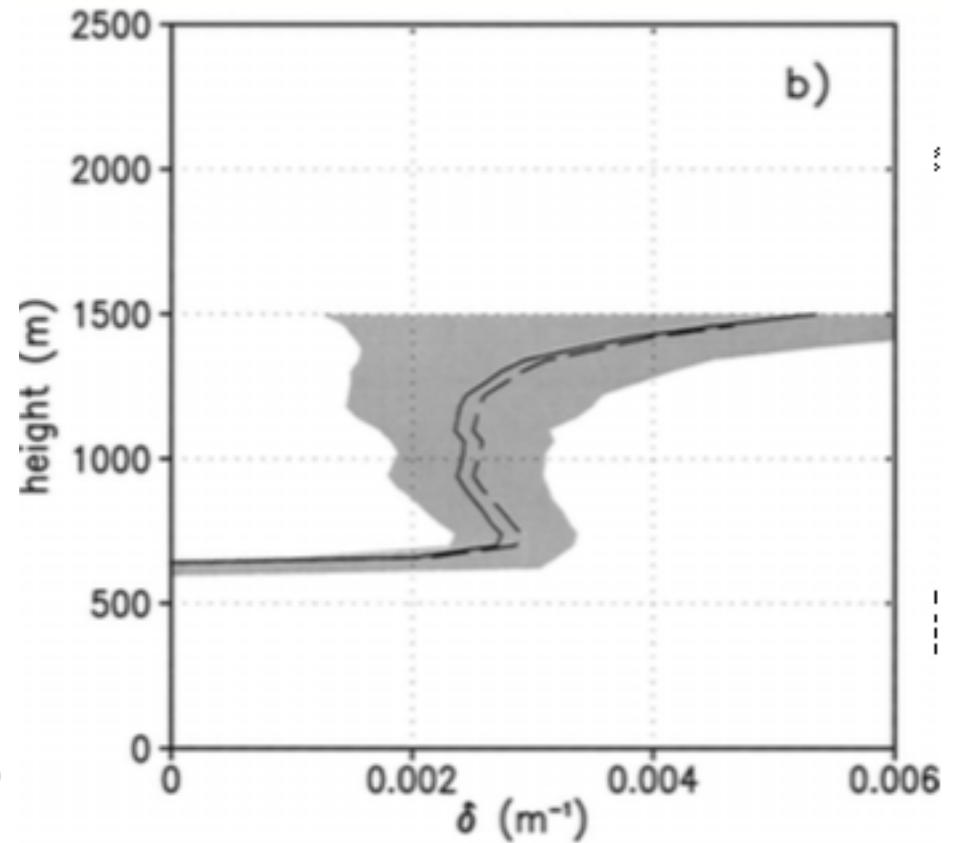
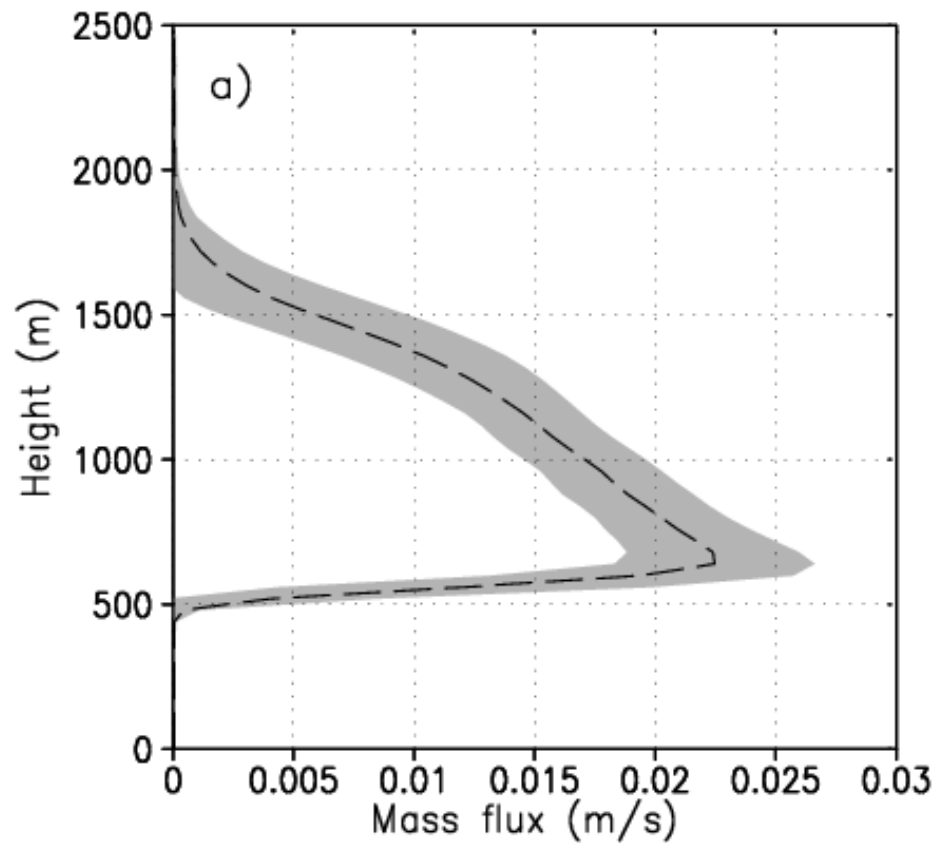
- Lots of entrainment dilution
- Shallow Cu updrafts are far from moist-adiabatic



Mass flux and detrainment rate

$$\frac{1}{M} \frac{dM}{dz} = \varepsilon - \delta$$

Many Cu don't ever reach the inversion



Sc to Cu transition

- A fundamental feature of the Hadley circulation.
- Important to global radiation balance
- A challenge for climate models, because it involves cloud-turbulence interaction that must be parameterized.

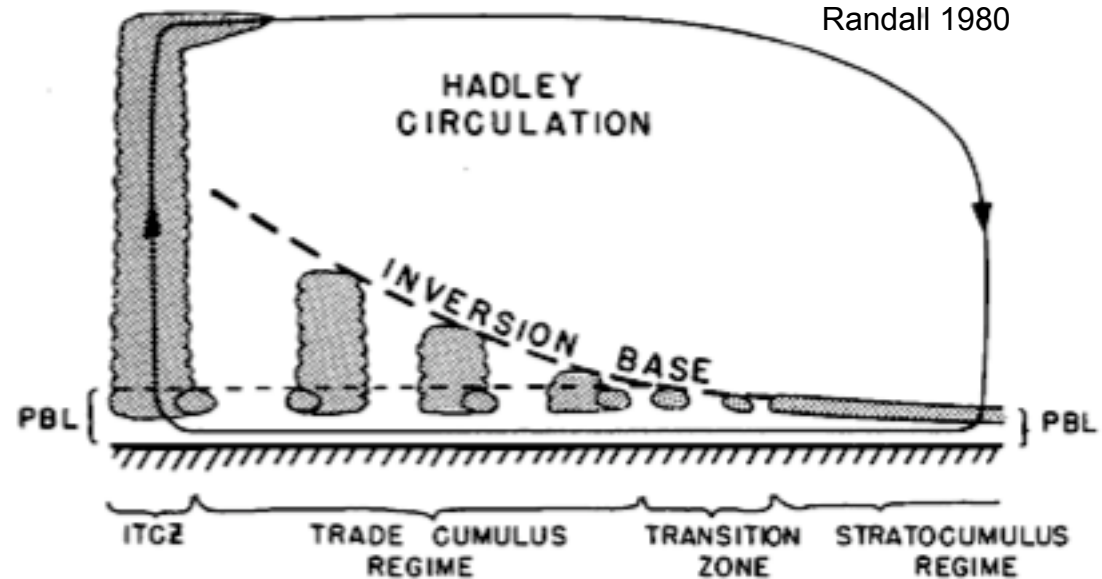
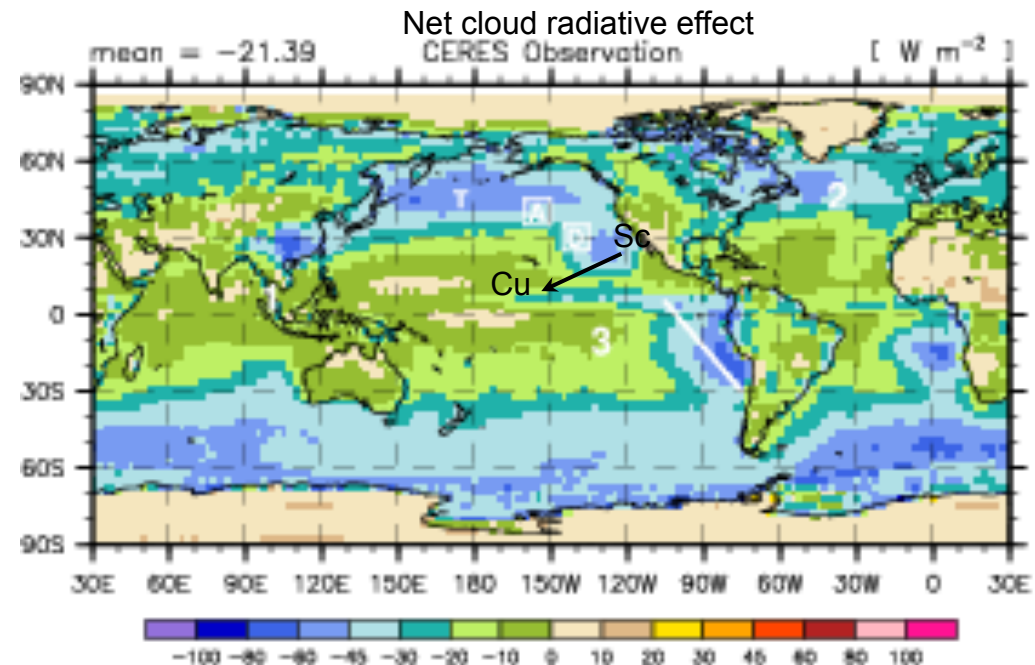
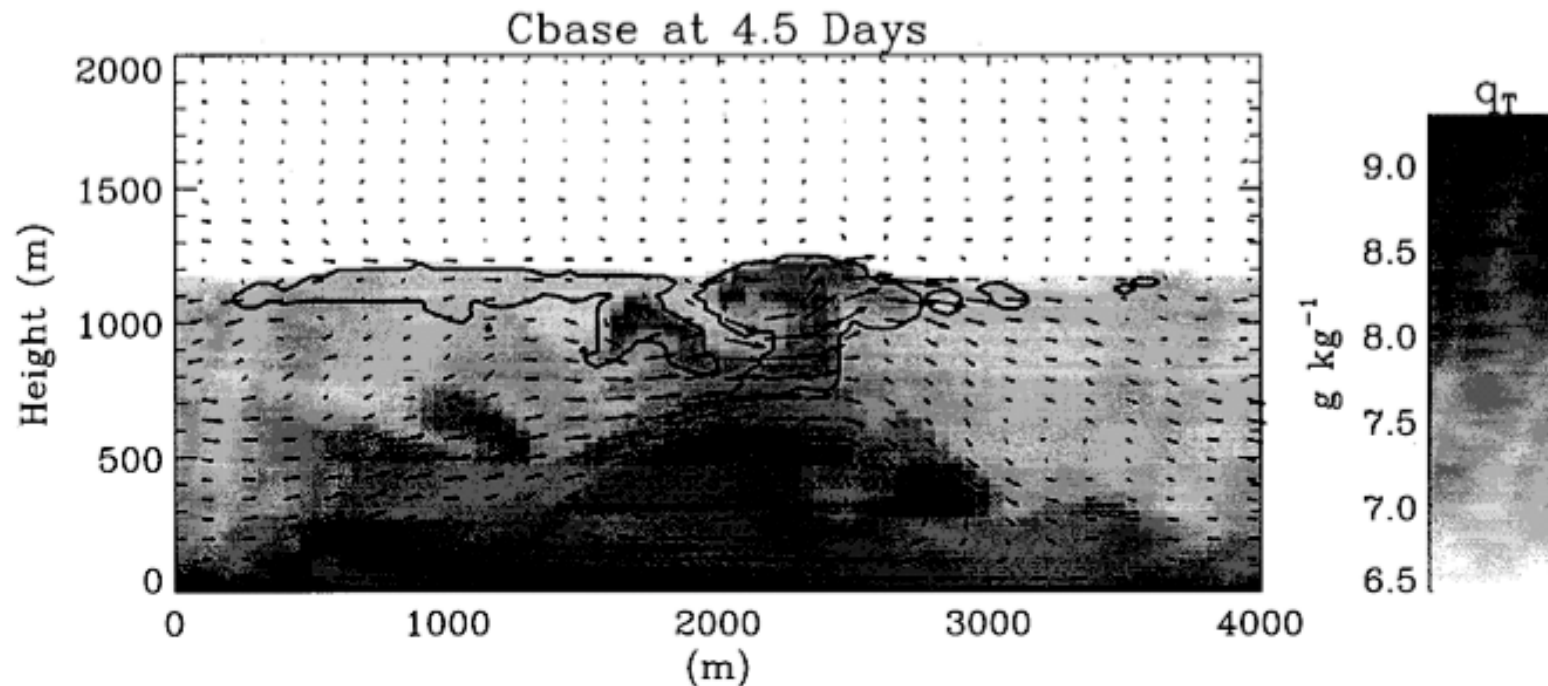


FIG. 5. A schematic illustration of the role of CIFKU in determining the tropical and subtropical distributions of cloudiness. Details are given in the text.



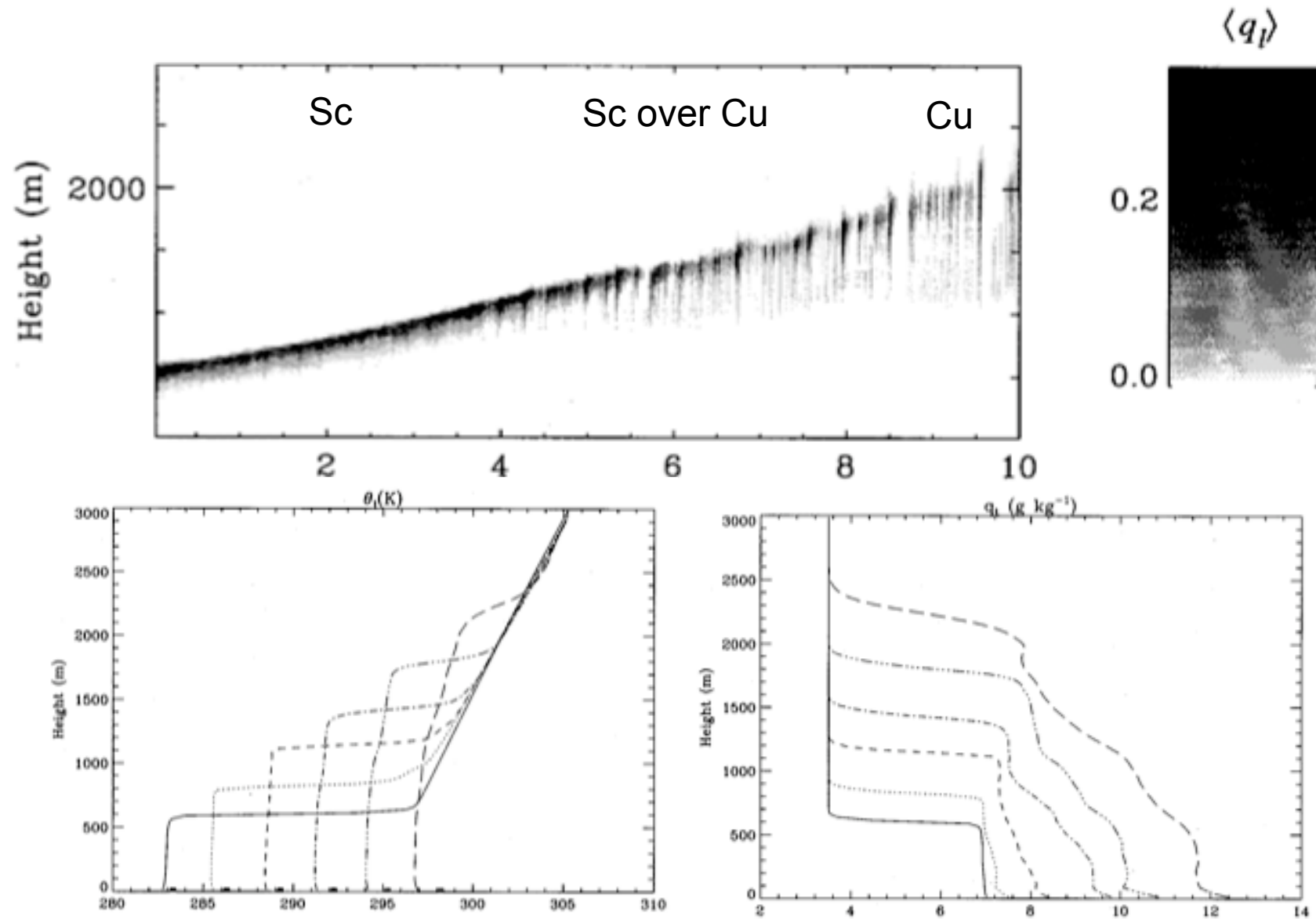
LES of Sc to Cu transition

- 2D, 4x3 km, $\Delta x = 50$ m, $\Delta z = 25$ m, 8 days
- SST = $285 + 1.5 \text{ K d}^{-1}$, $D = 3 \times 10^{-6} \text{ s}^{-1}$, $V_g = 7.1 \text{ ms}^{-1}$
- Diurnally-averaged insolation for 30 N.



Wyant et al. 1997

Horizontal-mean statistics



Sc breakup, decoupling and DIDEUCUPE

DIDEUCUPE = Deepening-Induced Decoupling and Cumulus Penetrative Entrainment (Wyant et al. 1997)

1. Deeper Sc-capped boundary layers with weaker inversions over warmer water favor persistent decoupling.
2. Decoupling leads to development of a Cu layer, which takes over the entrainment, mixing in enough dry air to evaporate the Sc below the inversion.

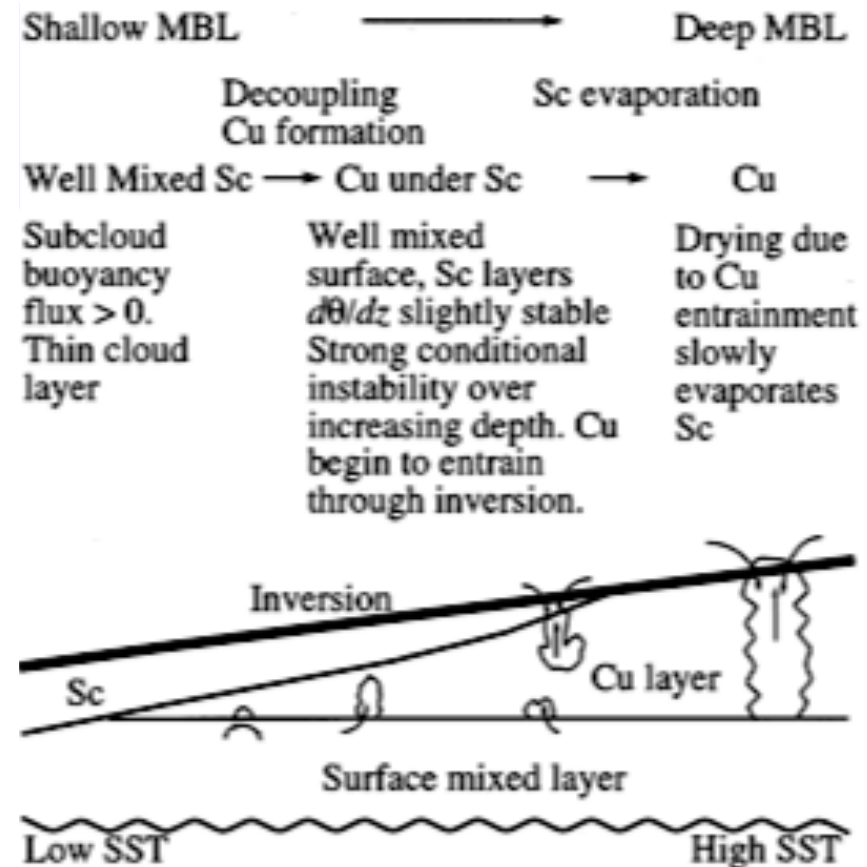


FIG. 10. A conceptual diagram of the STCT.

(Wyant et al. 1997)