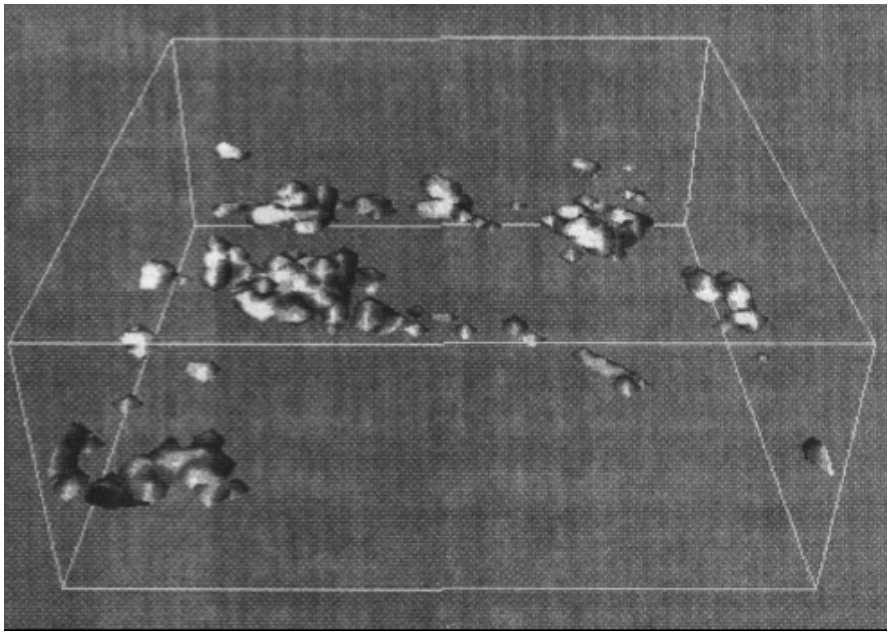
Shallow trade cumulus: BOMEX

Barbados Oceanographic and Meteorological Experiment (1969)



LES of nonprecipitating BOMEX trade cumulus

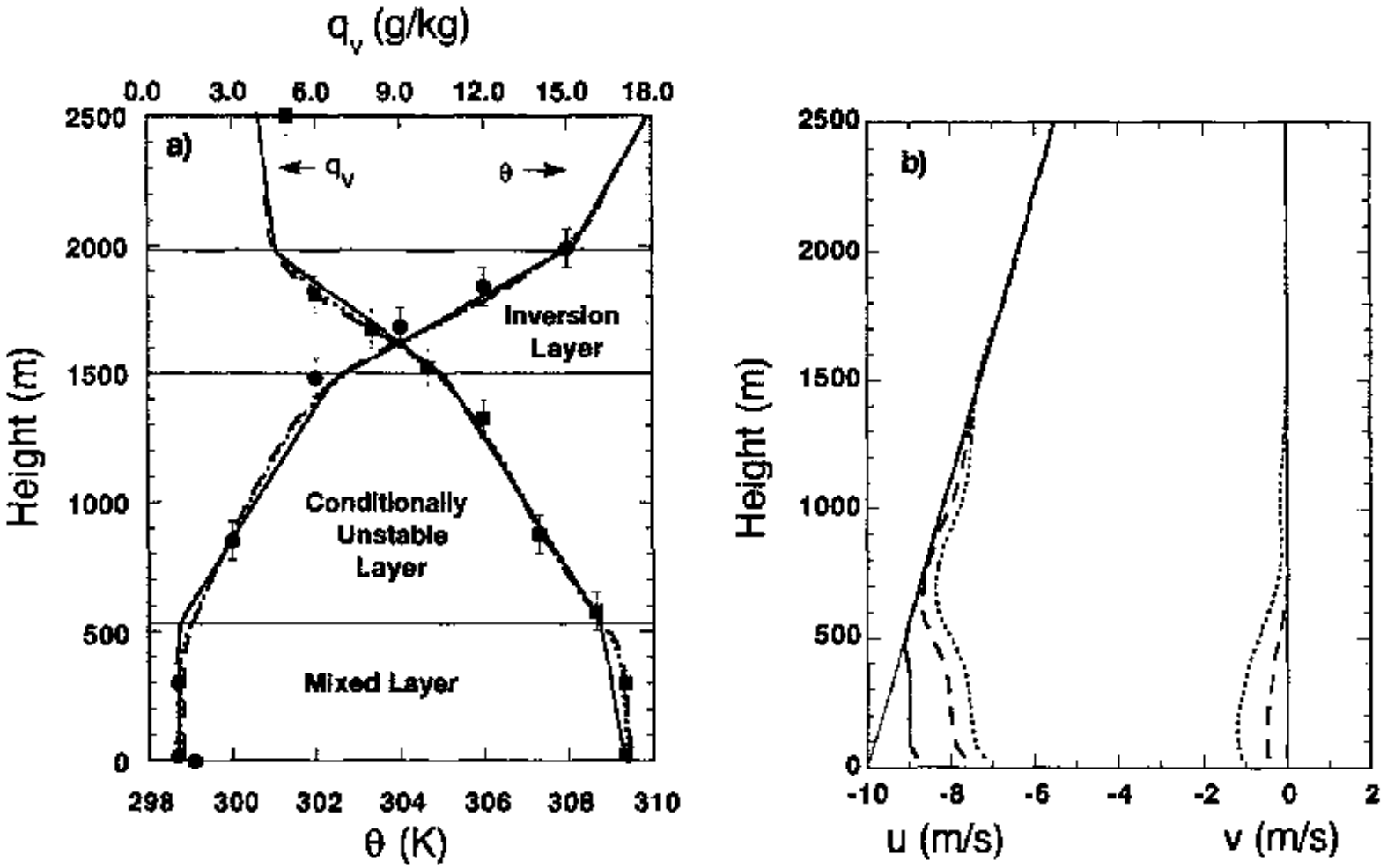
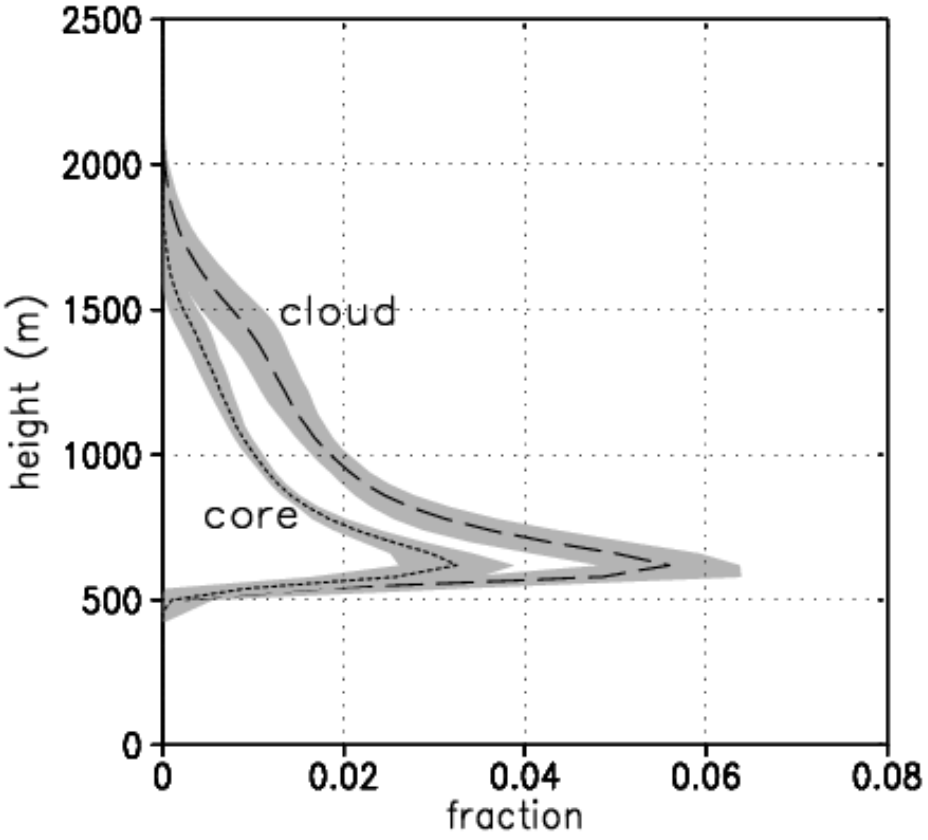
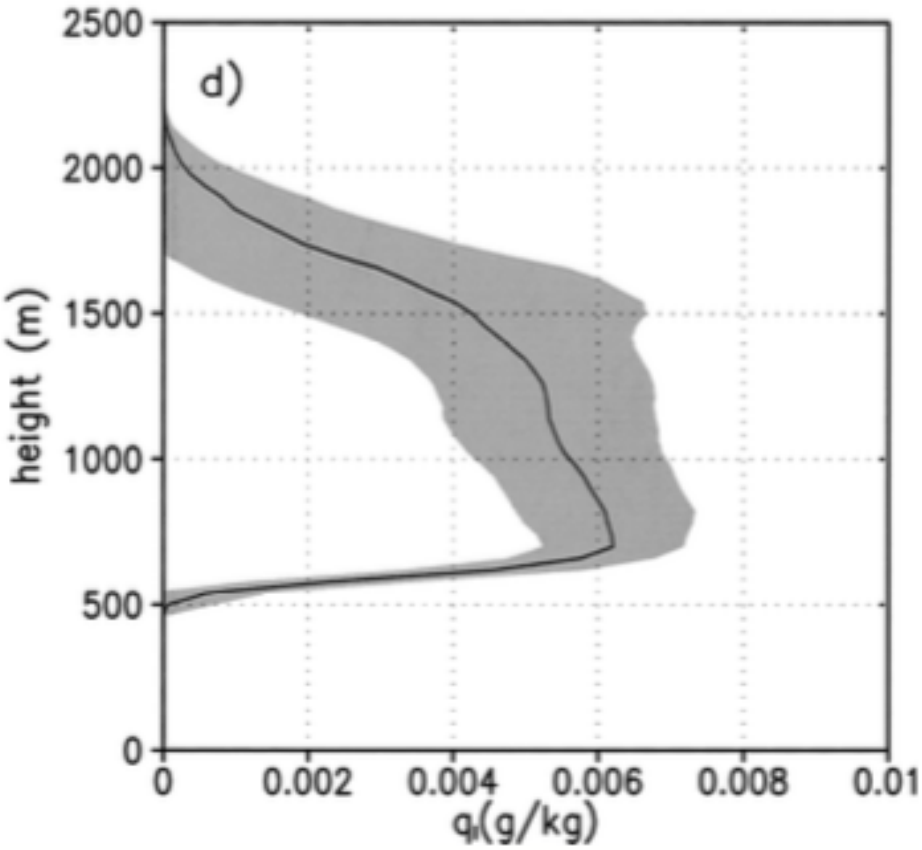


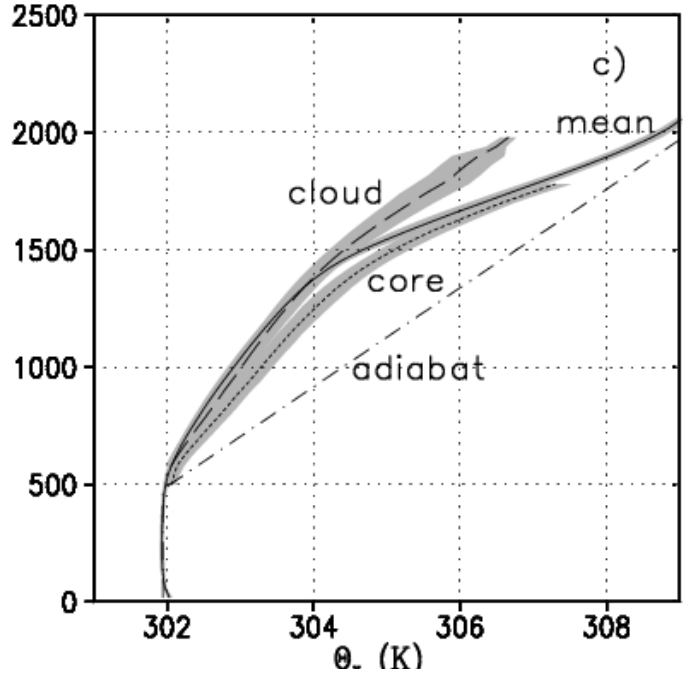
FIG. 1. Horizontally averaged vertical profiles of θ and q_v (a) and the u and v components of the velocity (b) at time $t = 0$ h (full lines), $t = 3$ h (dotted lines), and $t = 7$ h (dashed lines). The circles and squares are the observed values. The thin line in (b) is the prescribed geostrophic wind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

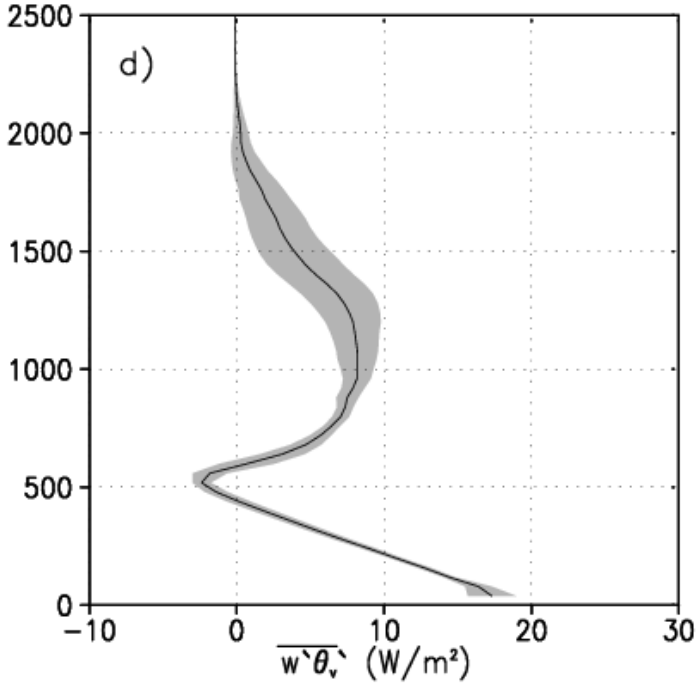
BOMEX LES profiles

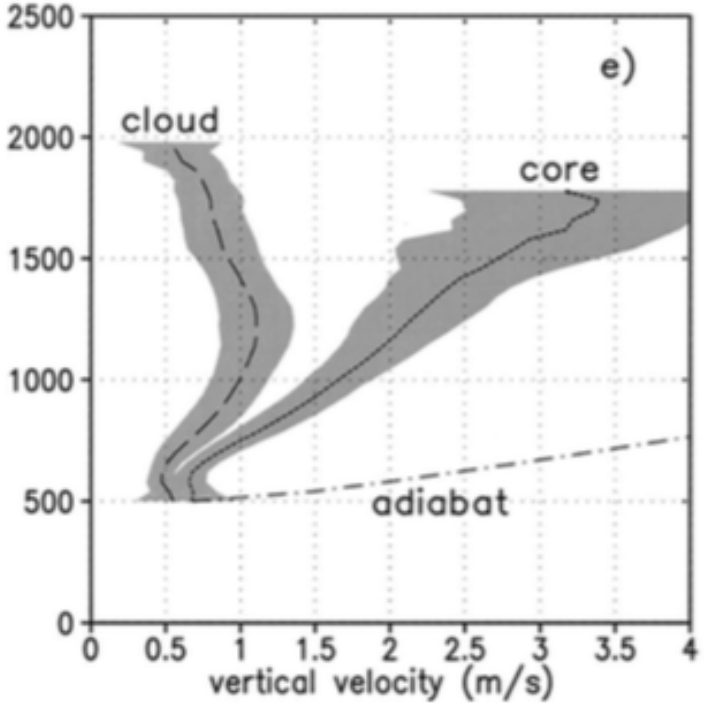


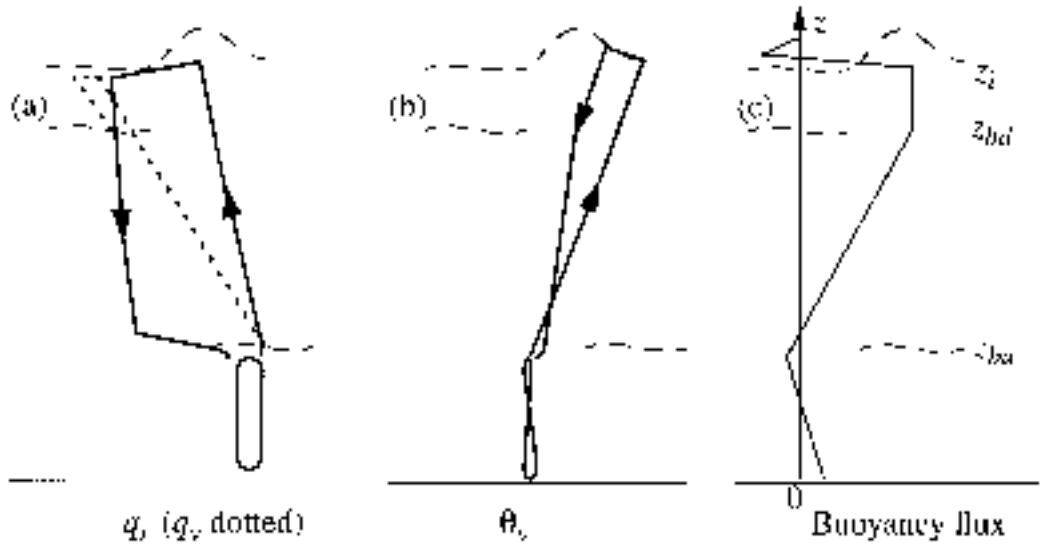


Shallow Cu buoyancy/ flux: entrainment dilution reduces b' and w'

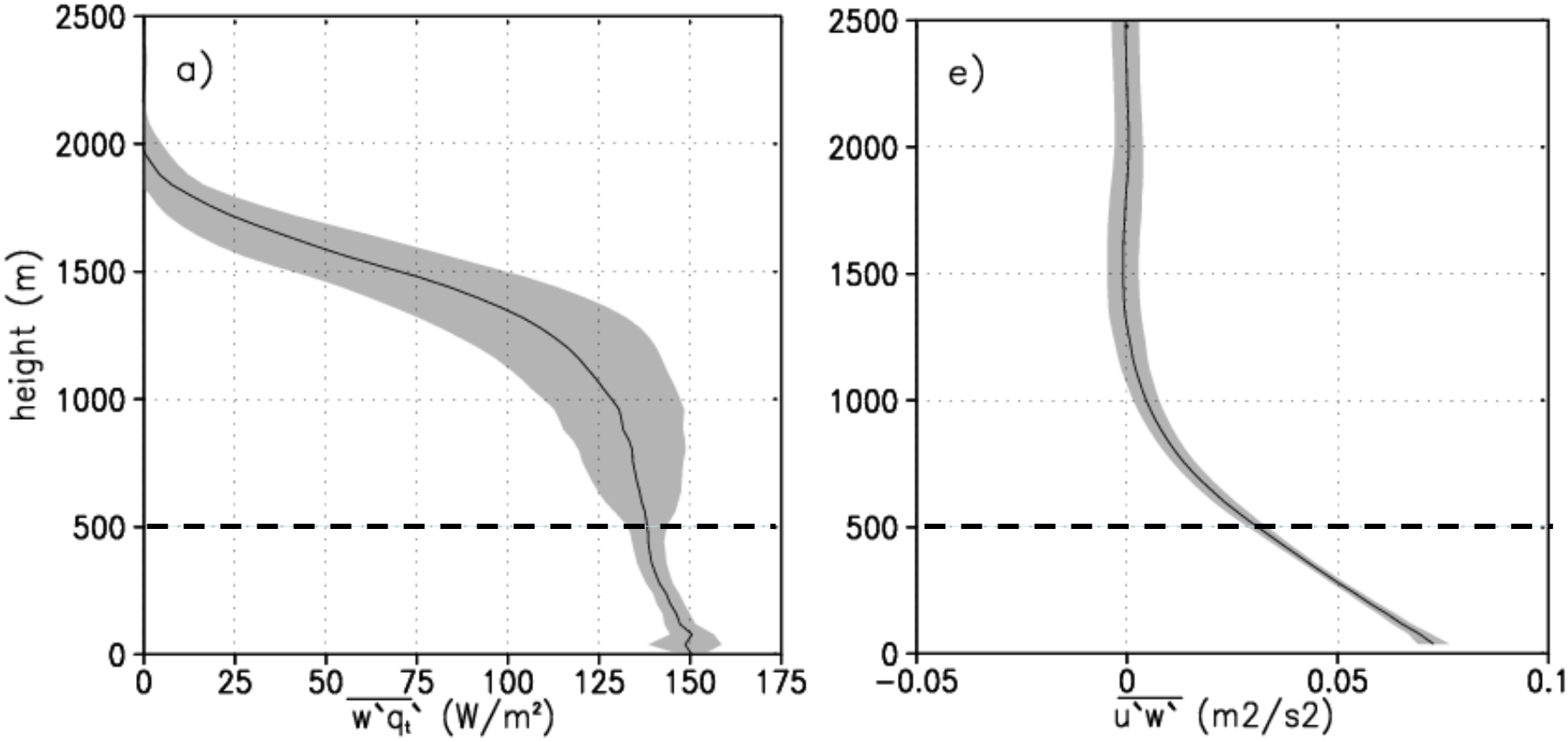






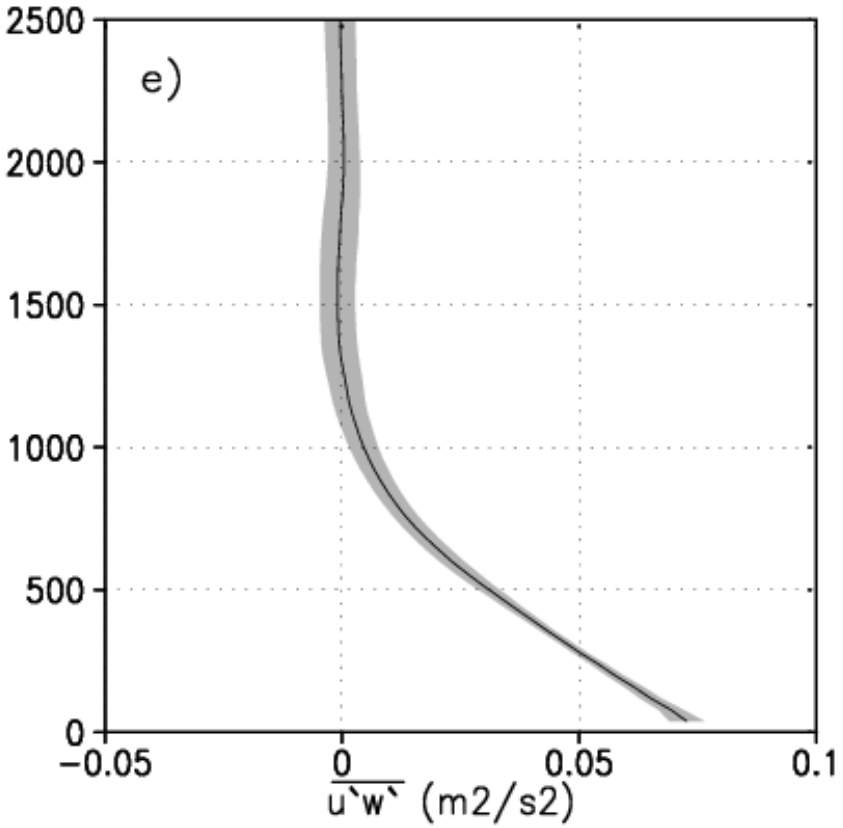


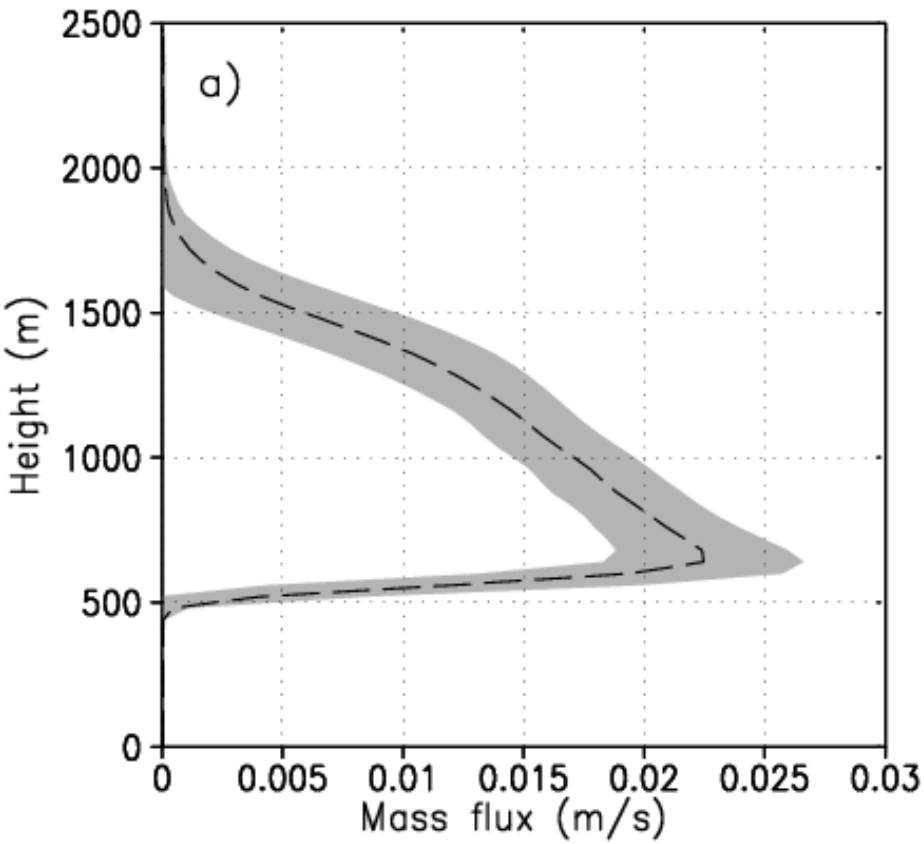
BOMEX LES profiles



- 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

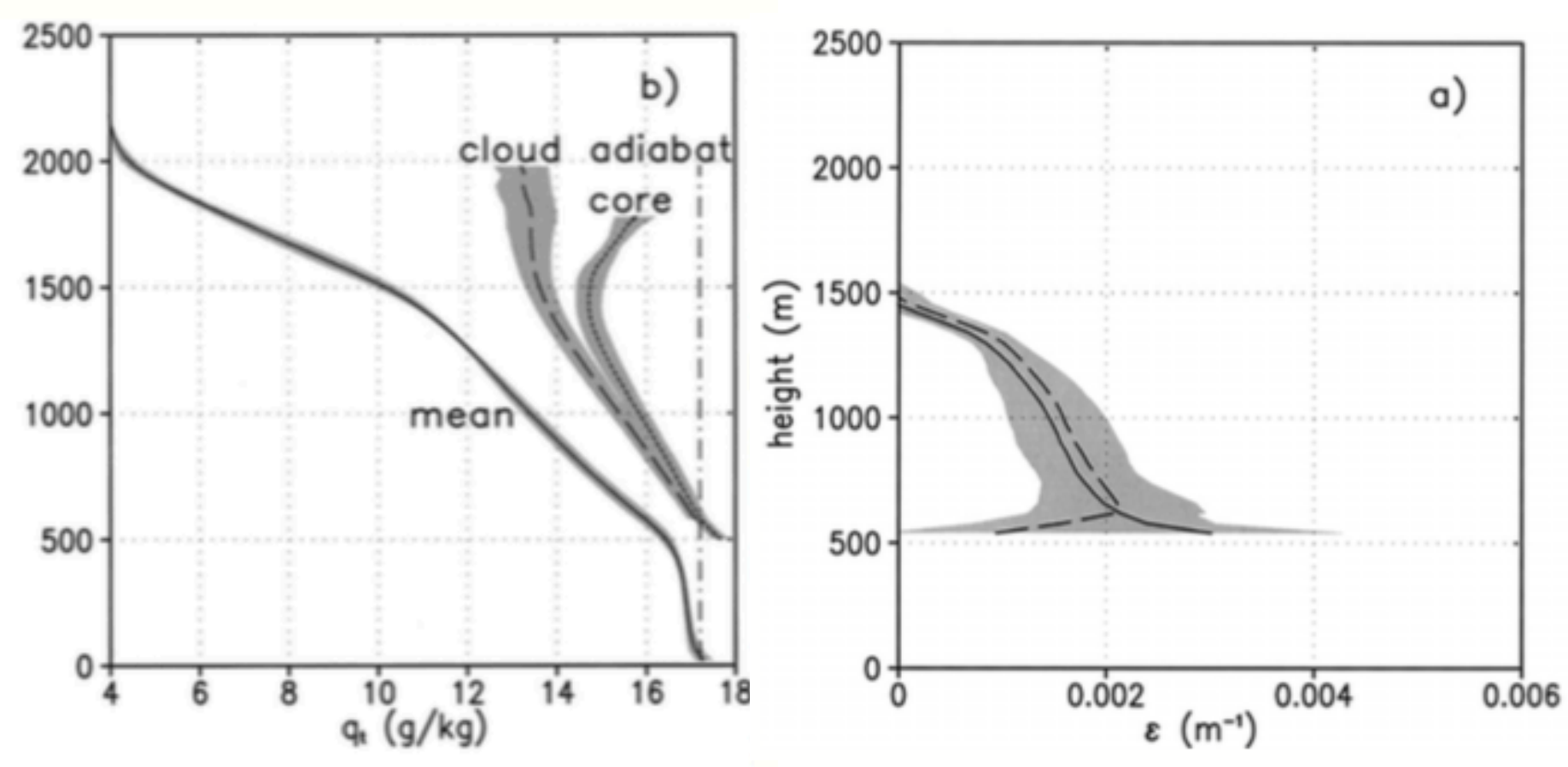




Estimating Cu lateral entrainment rate

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

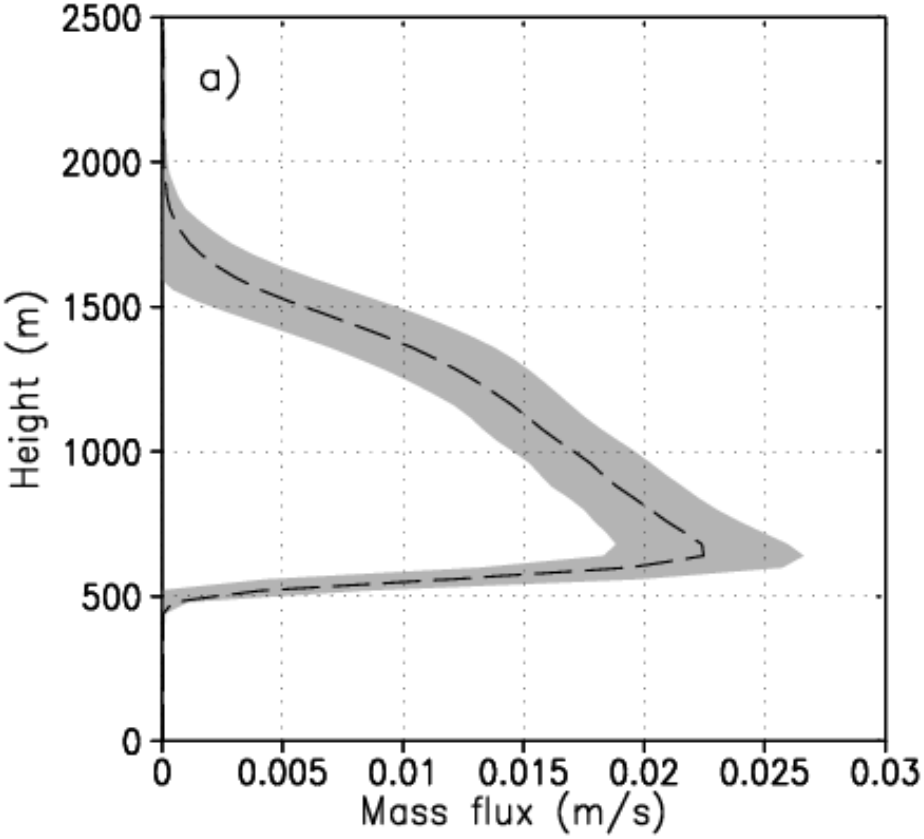
- Lots of entrainment dilution
- Shallow Cu updrafts are far from moist-adiabatic

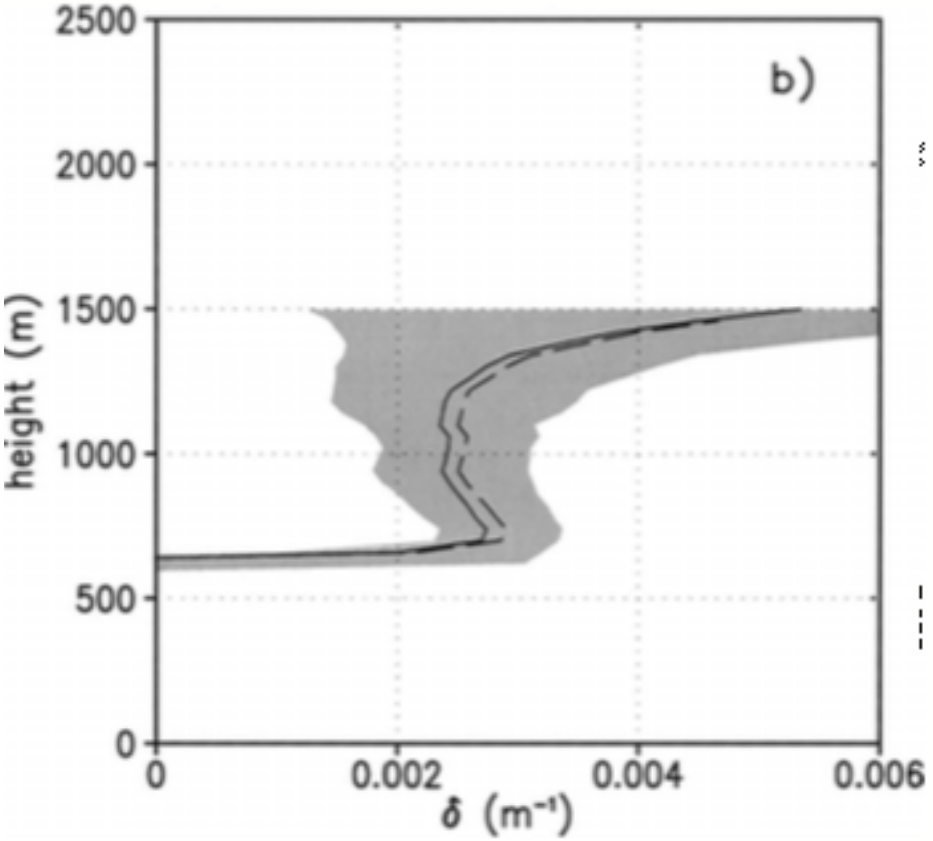


Mass flux and detrainment rate

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

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.

Randall 1980

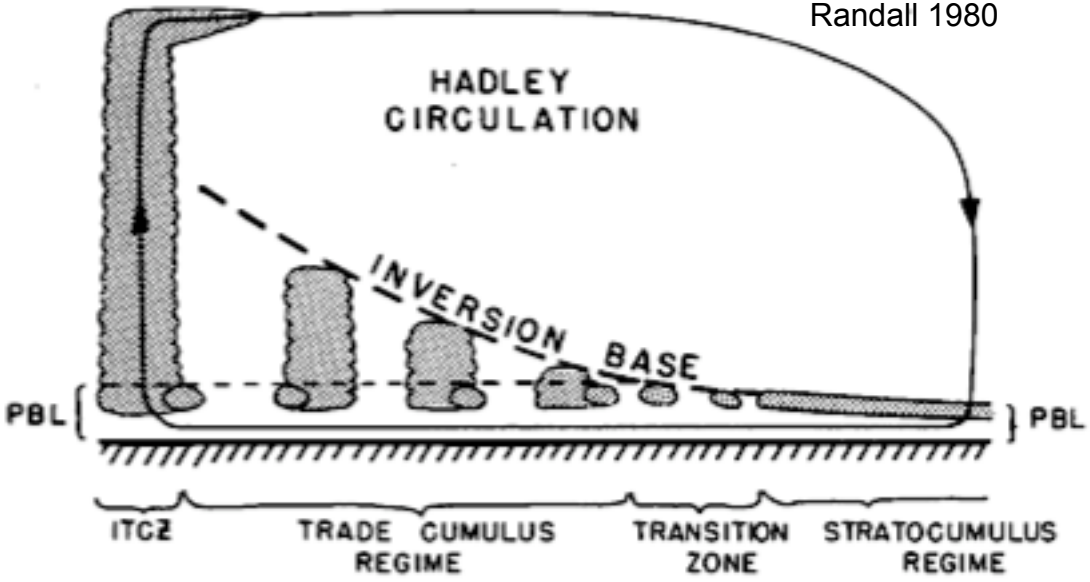
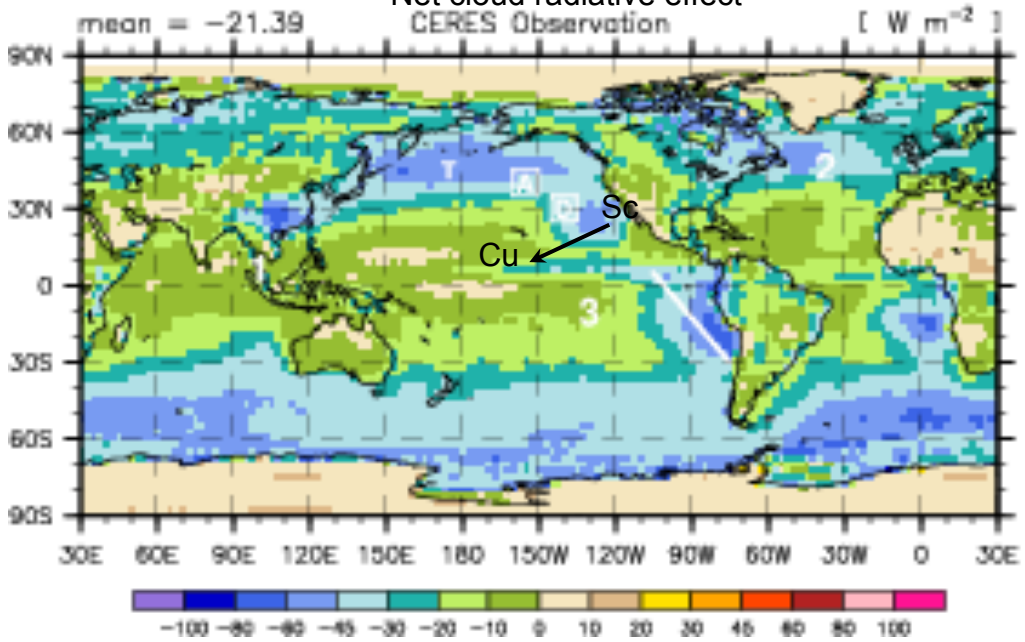


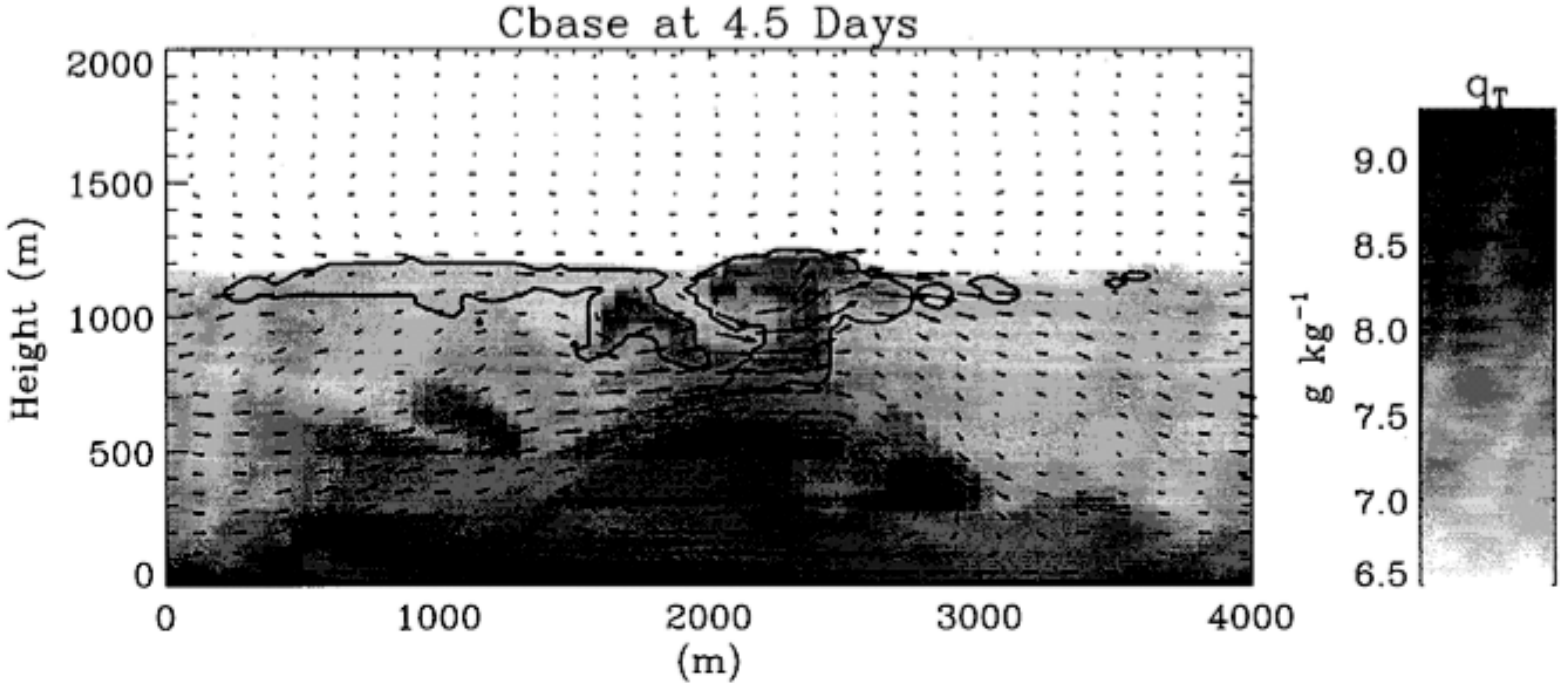
FIG. 5. A schematic illustration of the role of CIFKU in determining the tropical and subtropical distributions of cloudiness. Details are given in the text.

Net cloud radiative effect



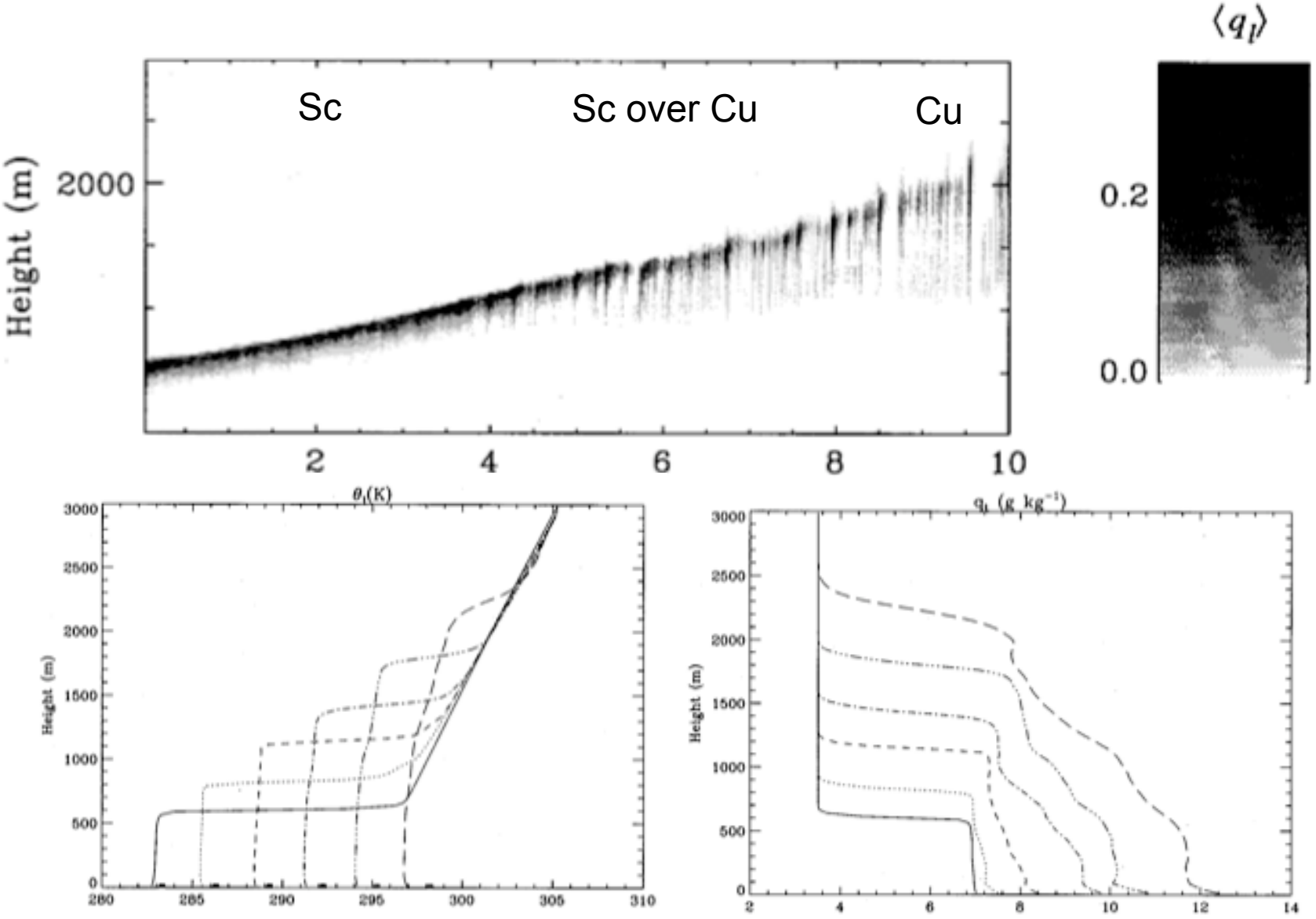
LES of Sc to Cu transition

- 2D, 4x3 km, Δx = 50 m, Δz = 25 m, 8 days
- SST = 285 + 1.5 K d^{-1}, D = 3×10^{-6} s^{-1}, Vg = 7.1 ms^{-1}
- Diurnally-averaged insolation for 30 N.



Wyant et al. 1997

Horizontal-mean statistics



Sc breakup, decoupling and DIDECUPE

DIDECUPE = 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.

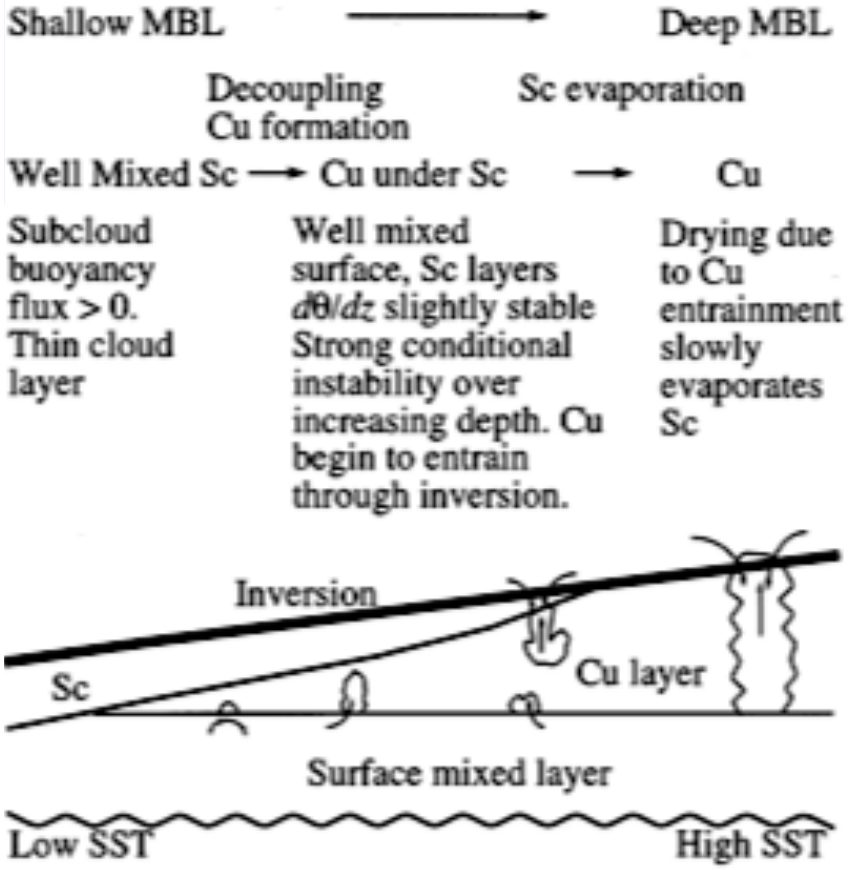


FIG. 10. A conceptual diagram of the STCT.

(Wyant et al. 1997)