Ground-based Retrieval of Entrainment Rates in Stratocumulus-topped Boundary Layers

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Wang-Albrecht Flux-Jump Relation

When $A = l$, cloud water mixing ratio, we obtain

$$w_e = \left((F_l)_B + \frac{\alpha}{L} \frac{\Delta F_R}{\rho} \right) \left(\frac{\alpha}{L} \Delta h - \Delta(q + l) \right)^{-1}.$$

where

$$(F_l)_B = (\overline{w'l'})_B - P_B,$$

- $\overline{w'l'}$ is the **turbulent liquid water flux**,
- P is the **precipitation flux** (including cloud droplet sedimentation flux),
- $\Delta(q + l)$, Δh, and ΔF_R are the jumps in **total water** (vapor plus liquid) **mixing ratio**, **moist static energy**, and **net upward radiative flux** across the STBL top, respectively
- α is a thermodynamic parameter.

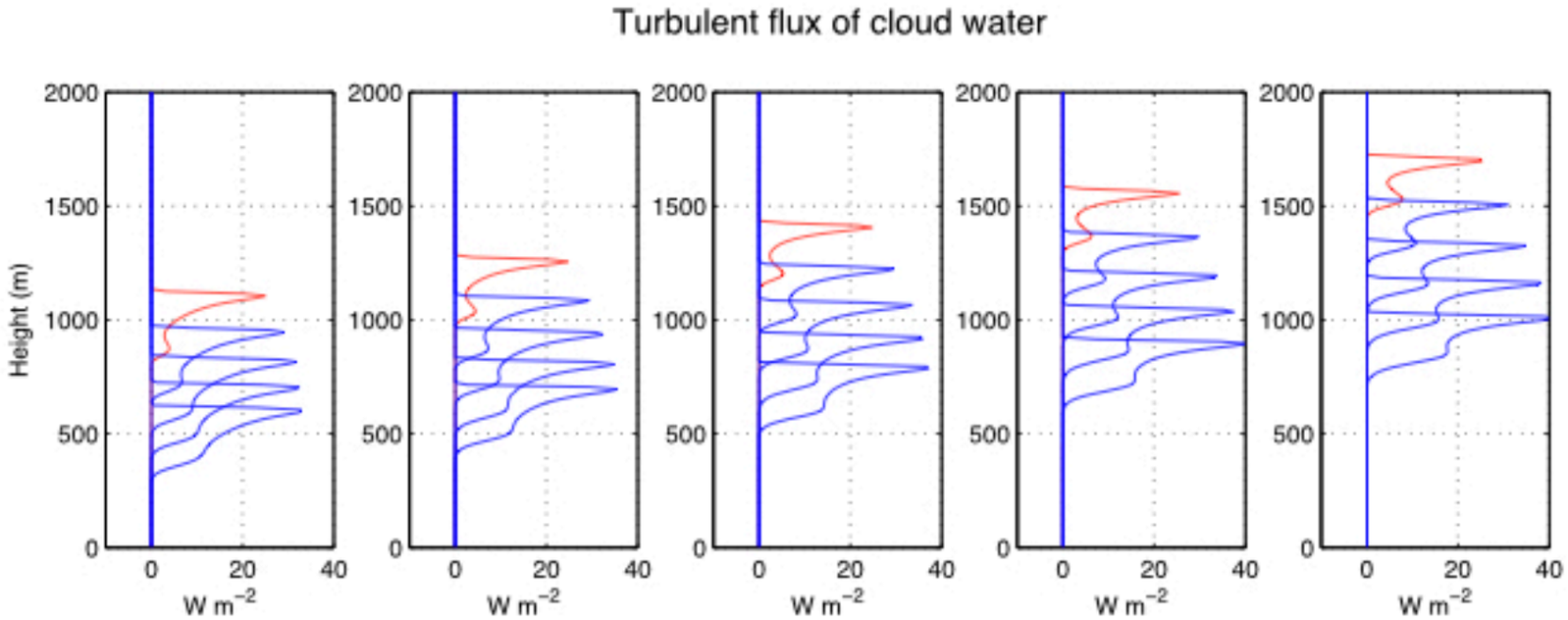
This is a generalization of the flux-jump relationship derived by Wang and Albrecht (1986).

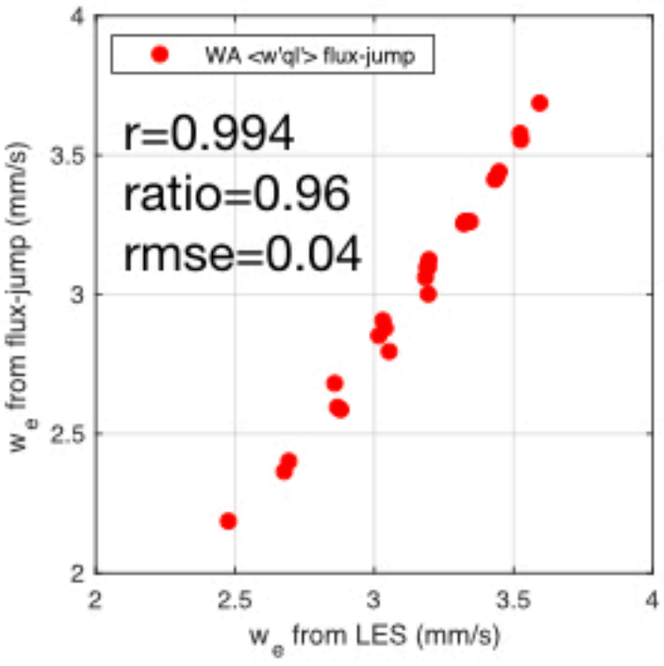
This form has not been previously used because the liquid water flux is difficult to measure.

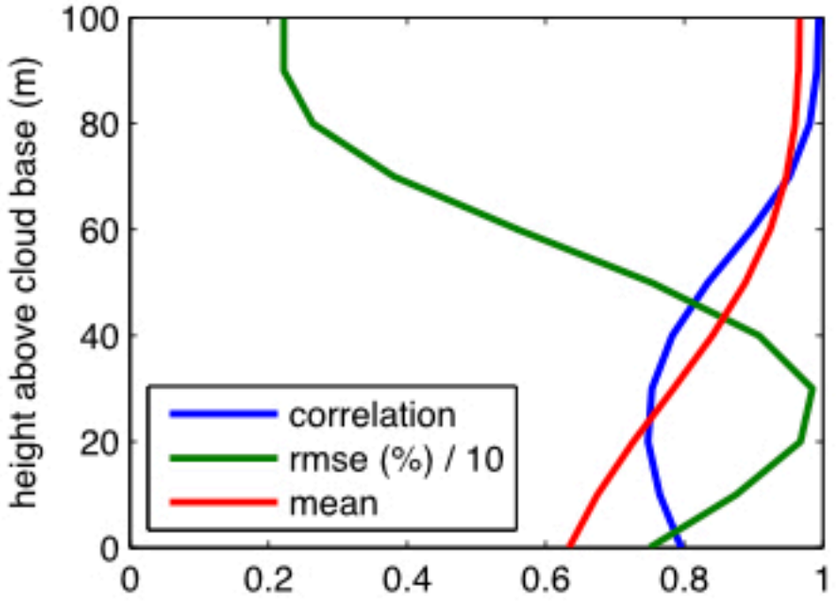
Evaluate using a set of stratocumulus LESs

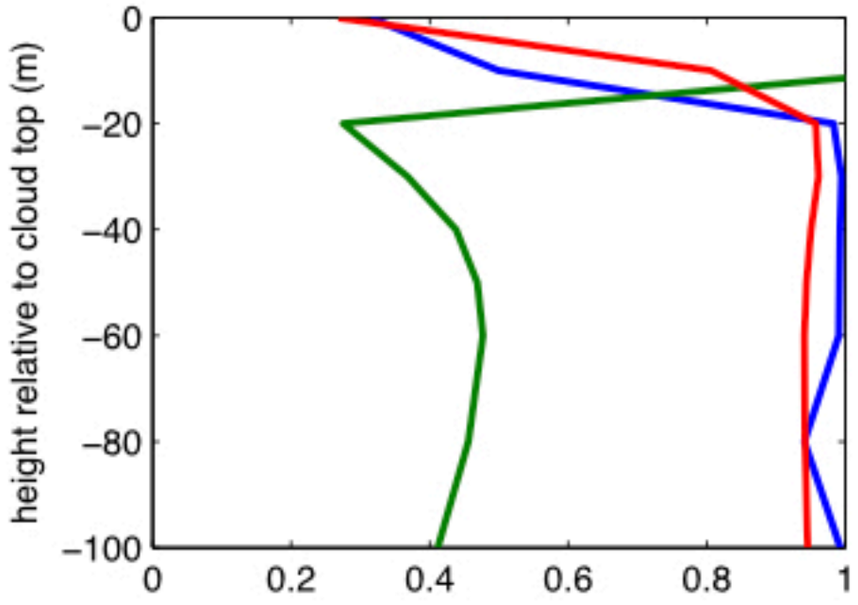
van der Dussen et al. (2015)

- Model: DALES
- 25 simulations with different jumps
- Configuration:
  - Δx = 50 m, Δz = 10 m
  - Domain: 6 km x 6 km x 3 km
  - 10-day duration
  - Diurnally averaged radiation
  - Drizzle allowed but negligible
  - Cloud water sedimentation allowed





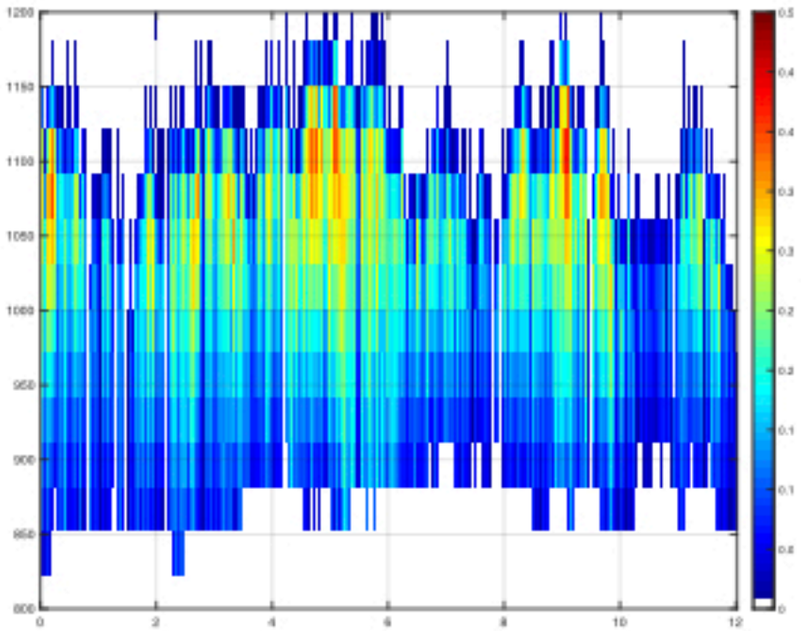




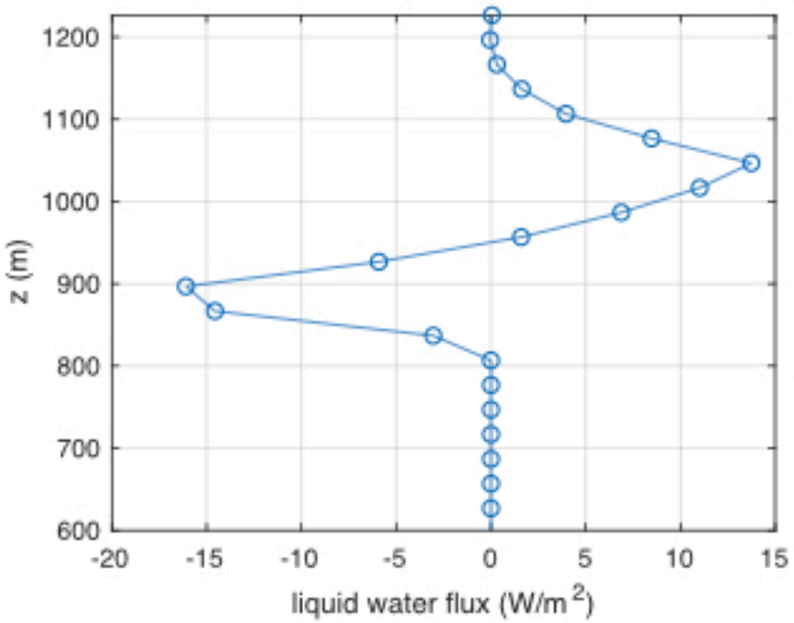
Correlation of retrieved w_e with actual w_e, normalized rmse of retrieved w_e (percent of mean), and mean of retrieved w_e relative to actual w_e. Left: For levels above cloud base, right: levels below cloud top.

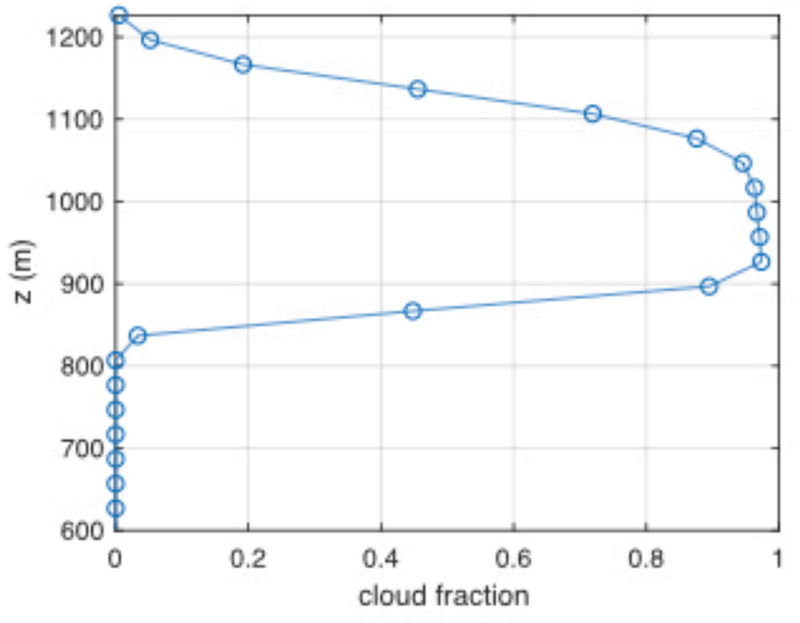
First results from Kollias retrievals

LWC



0-12 h





Vertical velocity