"Evaluating aspects of existing shallow cumulus cloudiness and mass flux parameterizations using MC3E observations"

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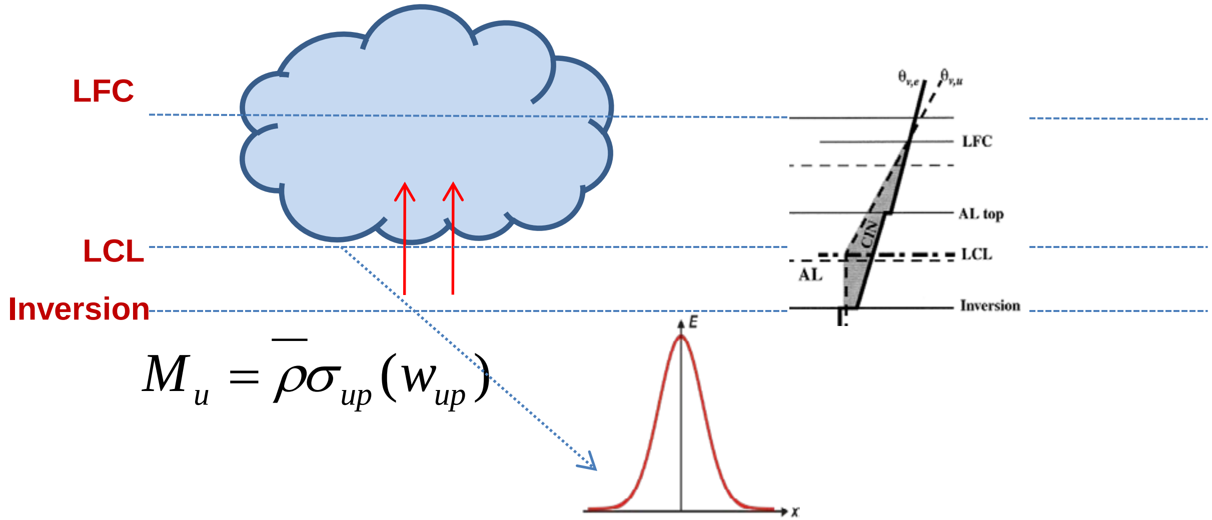
Cloud-base mass flux



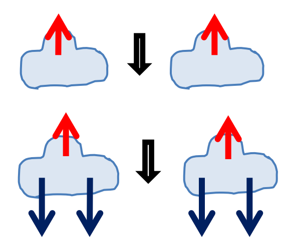
$$M_u = \overline{\rho}\sigma_{up}(w_{up})$$

Assuming Gaussian vertical velocity distribution at Cbase

M_u = Updraft mass flux
σ_{up} = fractional updraft area
W_{up} = bulk updraft velocity
ρ= Air density
CF: Cloud Fraction

σ_{up} = CF*α

- ***1.0 100 % goes up***
- ***0.5 50 % goes up***



Parameterization of **σ_{up} and W_{up}**

Mass-Flux and Bulk upward velocity

(Grant 2001)

$$m_b = 0.03 w_*$$

$$m_b = \frac{M}{\rho}, ms^{-1}$$

$$w_* = convective\_velocity\_scale = \left((\frac{g}{\overline{\theta_v}}) \overline{w'\theta_{v0}} z_i \right)^{\frac{1}{3}}$$

0.03=Constant based on LES studies over Ocean

g=acceleration due to gravity

θ_V=virtual potential temperature

$\overline{w'\theta_{v0}}$ =Surface Buoyancy Flux

z_i=mixed layer depth

(Fletcher and Bretherton 2010; Bretherton et al., 2004)

Gaussian form for vertical velocity: (2 variables)

$$w_c = \sqrt{2a(CIN)}$$

a=1;massflux coefficient

$$\text{variance} = \overline{w'^2} = k_f e_{avg}$$

$$e_{avg} = \tfrac{1}{2}(\overline{u'^2} + \overline{v'^2} + \overline{w'^2})$$

Avg. TKE in the SCL

k_f=0.5; TKE partitioning between horizontal and vertical motions

Active Cloud Fraction at inversion

$$CF_{active,inv} = \int_{w_c}^{\infty} f(w)dw = \frac{1}{2} erfc(\frac{w_c}{2k_f e_{avg}})$$

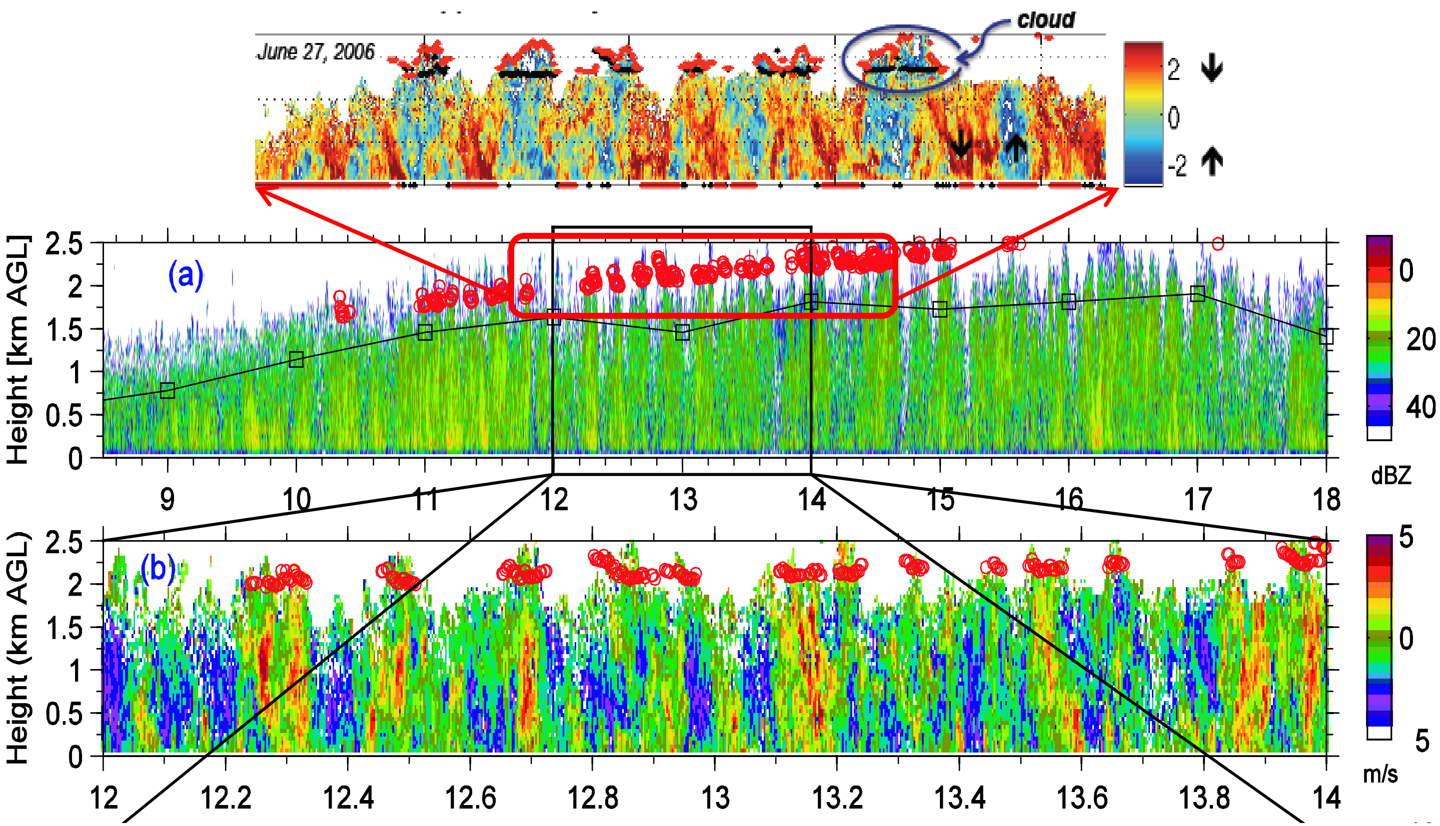
Active Upward mass flux at inversion

$$M_{u,inv} = \overline{\rho}_{inv} \int_{w_c}^{\infty} wf(w)dw = \overline{\rho}_{inv} \sqrt{\frac{k_f e_{avg}}{2\pi}} \exp(\frac{-w^2}{2k_f e_{avg}})$$

Assuming $M_{u,LCL}=M_{u,inv}$

- **Gaussian vertical velocity distribution**
- **Can not resolve inversion layer**
- **CIN values are very small and calculations are very sensitive**

Cloud radar measurements



Chandra et al., 2010

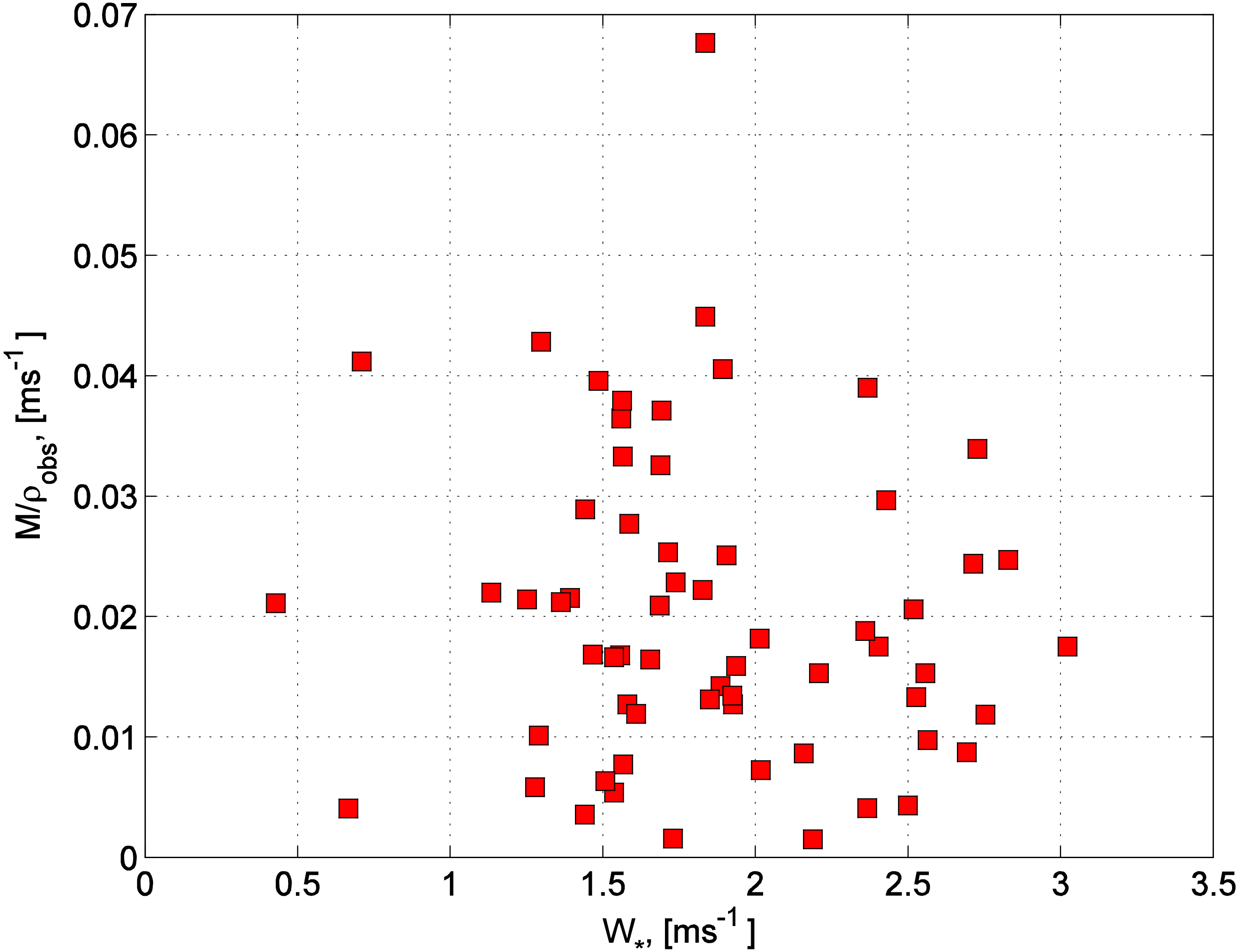
Vertically pointing
35 GHz, 8.66 mm
Res: 45m, 2 sec

Note: Sensitive to the cloud droplets and insects in the boundary layer

Insect echoes from a cloud radar (35 GHz)

- ***Corrected insect velocities: To study the turbulent structure of the Convective Boundary Layer from surface up to the cloud base***

- ***Doppler velocities inside clouds: To study in-cloud turbulent structure during non-precipitating conditions (assuming cloud droplets as passive tracers of air motion)***

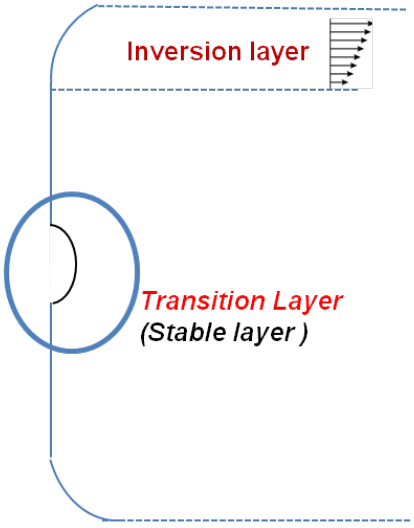


Is mass flux controlled by other factors ??

Possible factors

Active + Passive clouds

- **Cloud Life Cycle (Active/Passive)**
- **Effect of transition layer (stable layer) ??**
- **Inversion layer (wind shear, etc) ??**

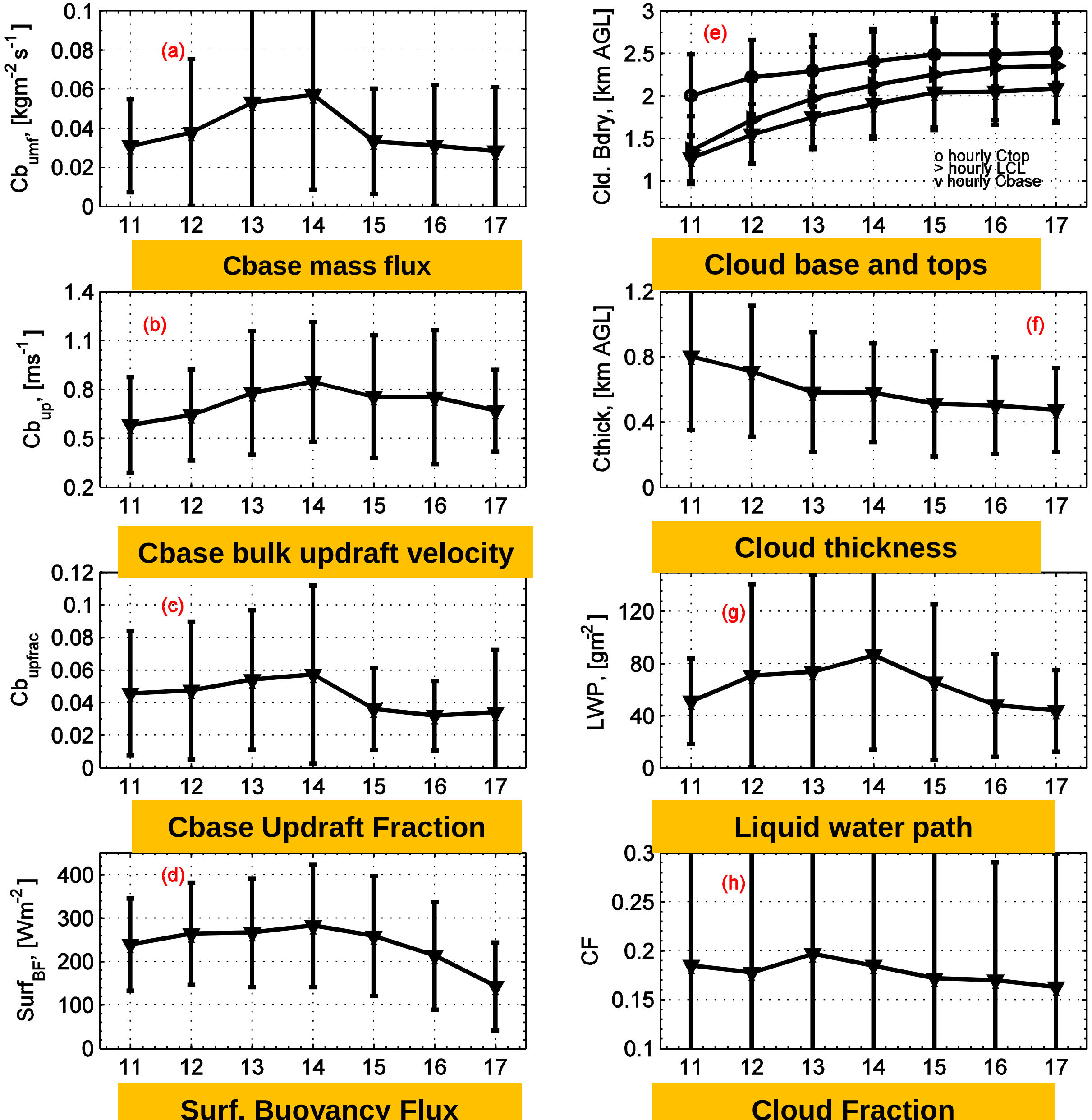


e.g. Yin and Albrecht 2000

- *Some of the above issues (e.g., diurnal cycle, mass-flux characterization) are addressed partly using long-term cloud radar observations (Please see the poster)*

- *Other issues are addressed using intensive MC3E dataset*

Composite diurnal variation of surface and shallow cumulus properties at SGP



Data period

13 years of summer months

(840 Hours of Shallow cumulus)

In preparation

MC3E (Mid-latitude Continental Convective Clouds Experiment) Campaign and New Instruments

Site: ARM Central Facility, Oklahoma (May-July 2011)

Science Focus: *To understand different components of convective simulation*

SWACR

Scanning WACR: 3d statistics of the cloud field, life cycle and LWC (liquid water content) measurements

Doppler LIDAR: Simultaneous vertical air velocity measurements from the surface up to the cloud base simultaeously

Doppler lidar

AERI (Atmospheric Emitted Radiance Interferometer) measurements: Detailed measurements of water vapor plumes in the Convective Boundary Layer

Radio-sonde: 8 soundings per day at 6 near locations

Science added value of MC3E dataset v/s Long-term (13 years) dataset

Doppler lidar data

- *Verification of CBL turbulent statistics calculated from the Insect velocities*
- *Verification of the aspects of mass-flux parameterization (kf : empirical parameter (tke), gaussian velocity distribution)*
- *Subcloud-cloud coupling: mass flux, water vapour flux transport combined with AERI water vapor data.*

SWACR data

Detailed analysis of the in-cloud mass flux profiles and turbulent structure

Cloud-clear air interactions at cloud edges along with Doppler lidar data

Sounding data

Better characterization of diurnal evolution of the convective boundary layer (Daytime variation of transition layers, CIN daytime evolution,etc)

Thank you !!

Questions & Suggestions ??

Scanning Strategy