# Analyses of CAPT simulations with CAM5.3 and CLUBB-MG2 based on observations from the Azores

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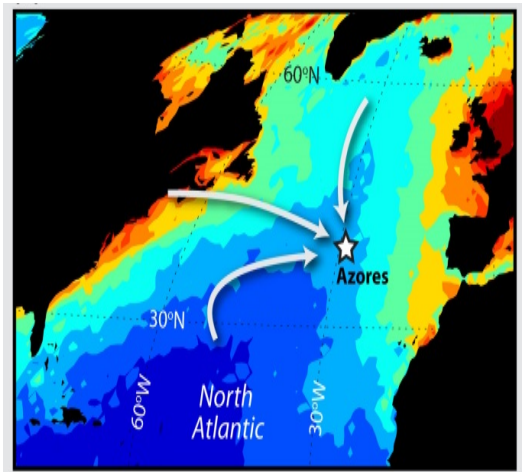
# Motivation

- The CAP-MBL ARM field campaign from Jun. 2009 to Dec. 2010
  - Unique resource targeting marine boundary layer (MBL) clouds

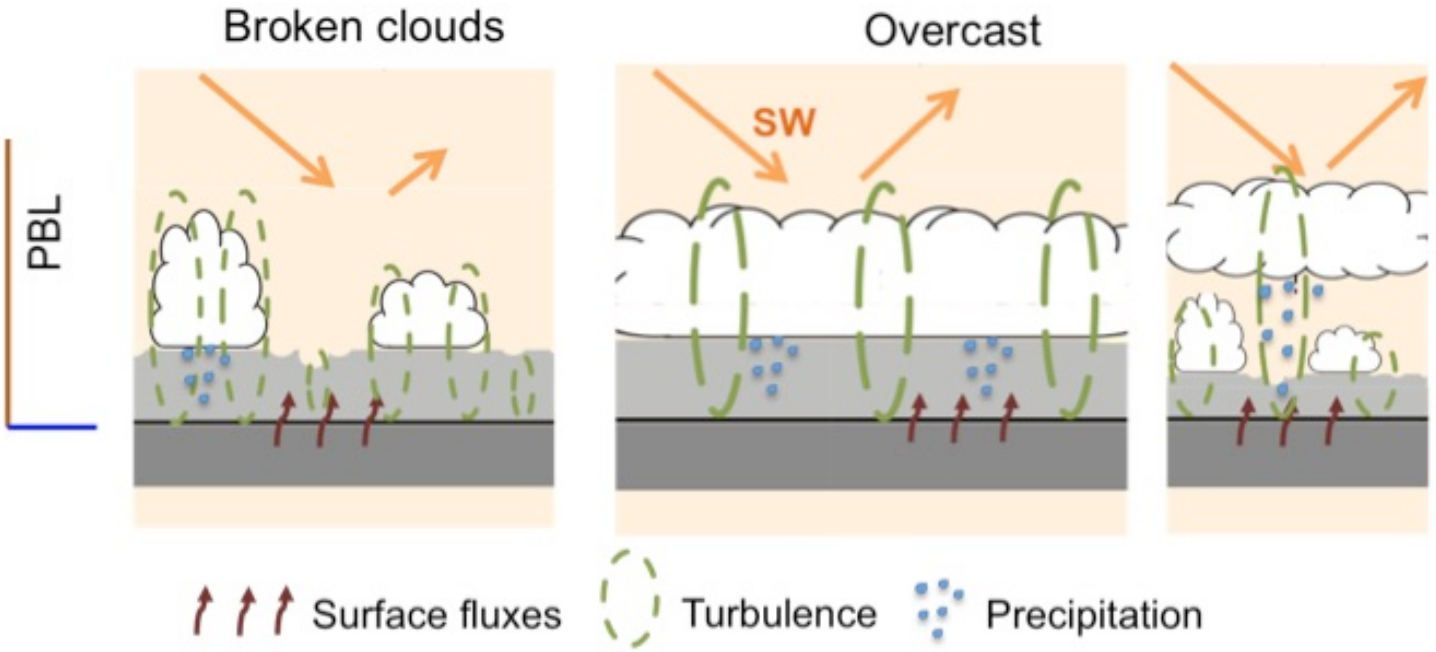



(Wood et al. 2014)

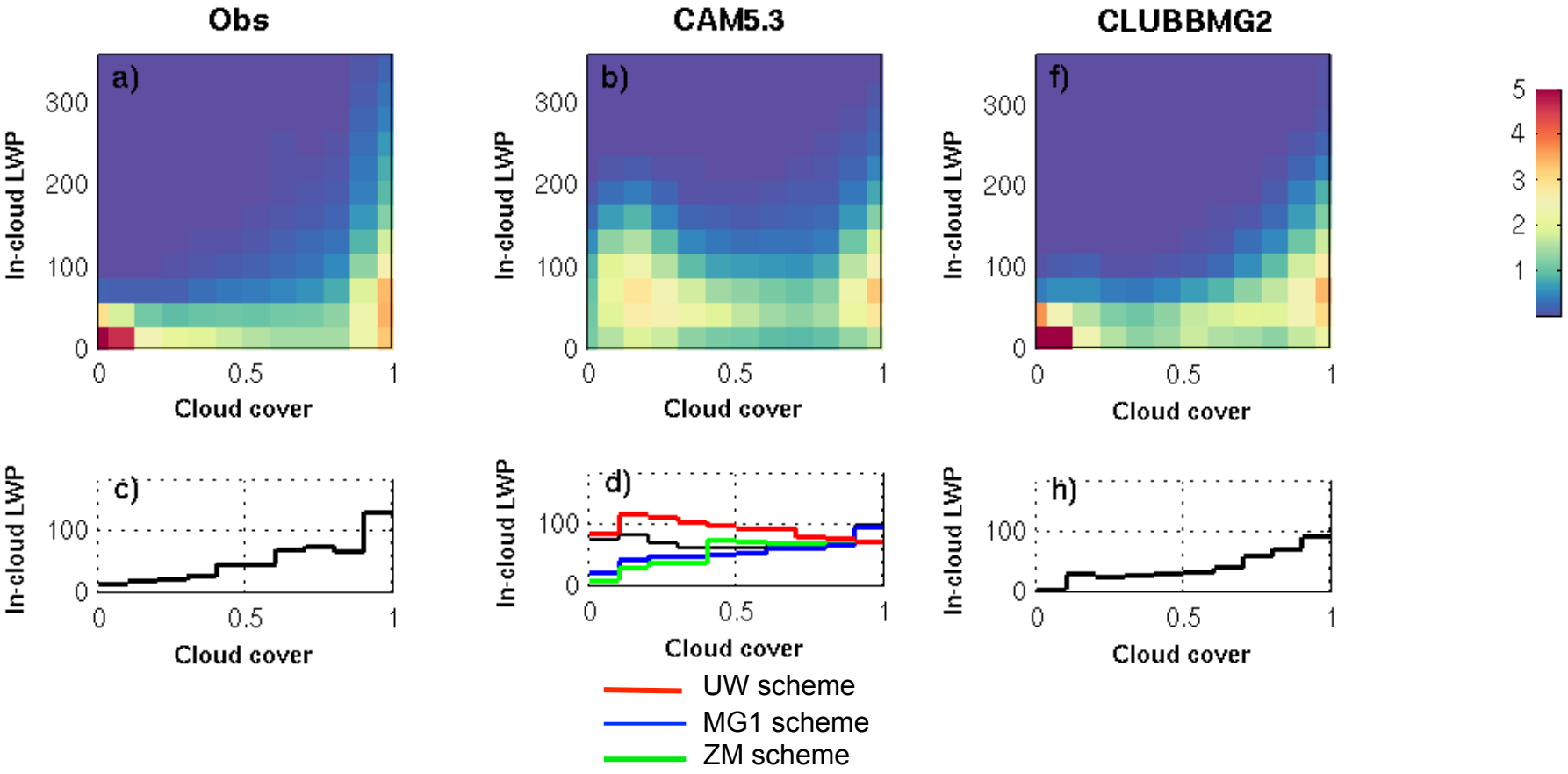
- Scientific Objective
  - To evaluate cloud parameterizations and identify deficiencies

# Methodology

- CAM5.3 control; CLUBB-MG2; CLUBB-MG1
  - From 05/31/2009 to 12/30/2010: Day 2 at one grid column (39.1N, 27.5W)

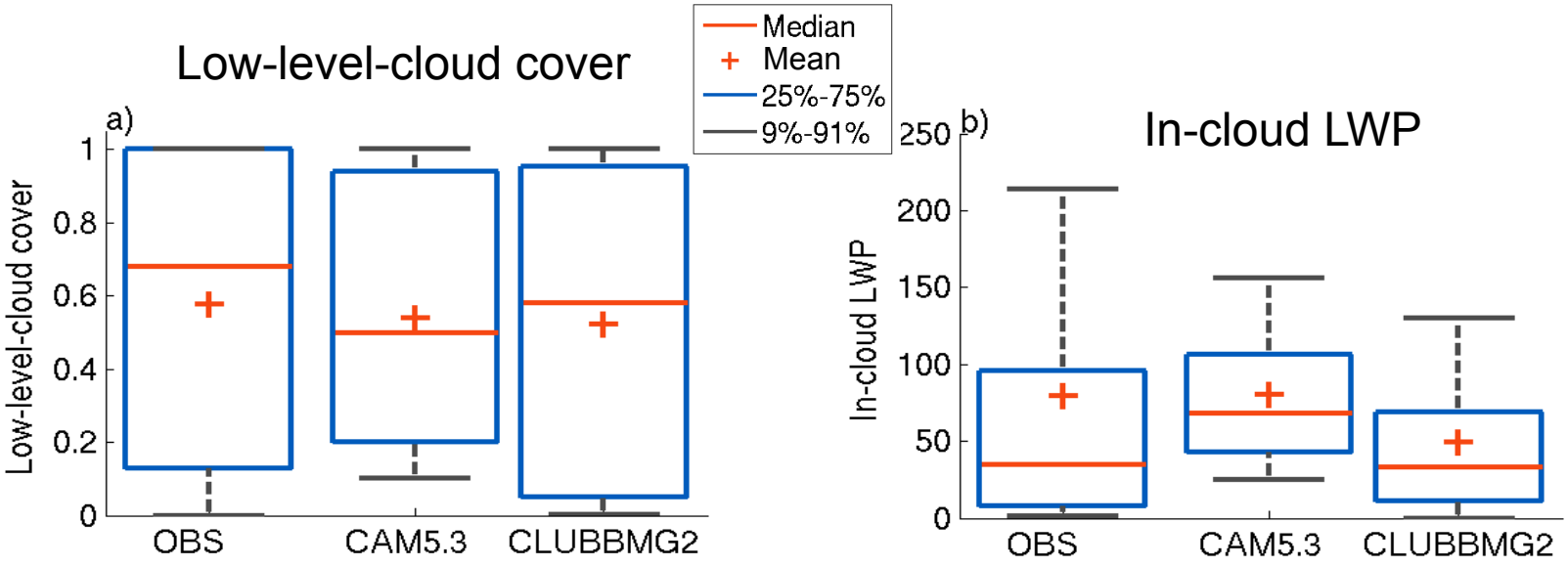


# Hourly cloud cover vs. in-cloud liquid water path



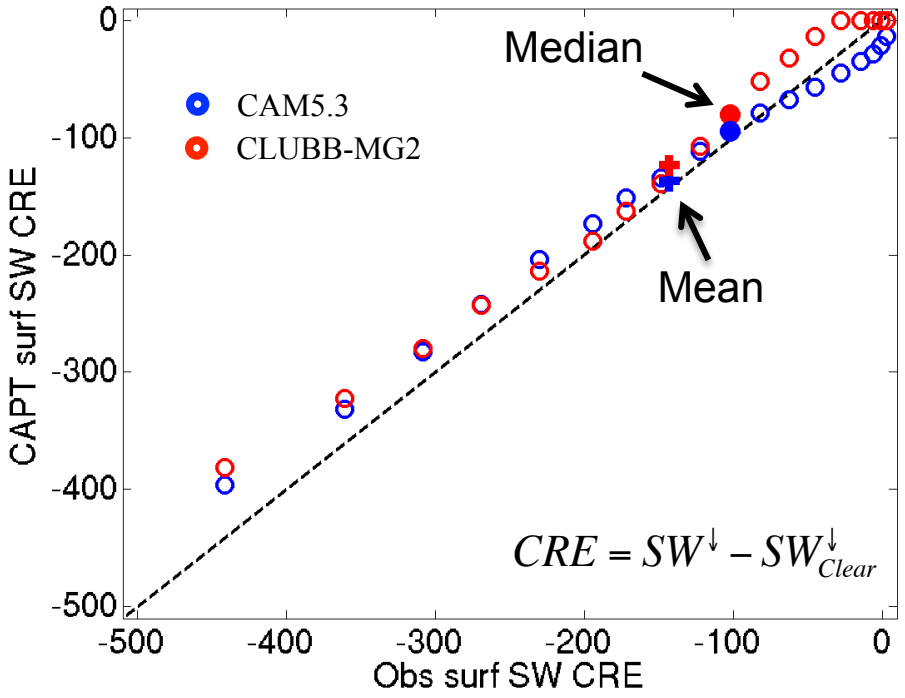

- Would this improvement impact on the cloud radiative effects?

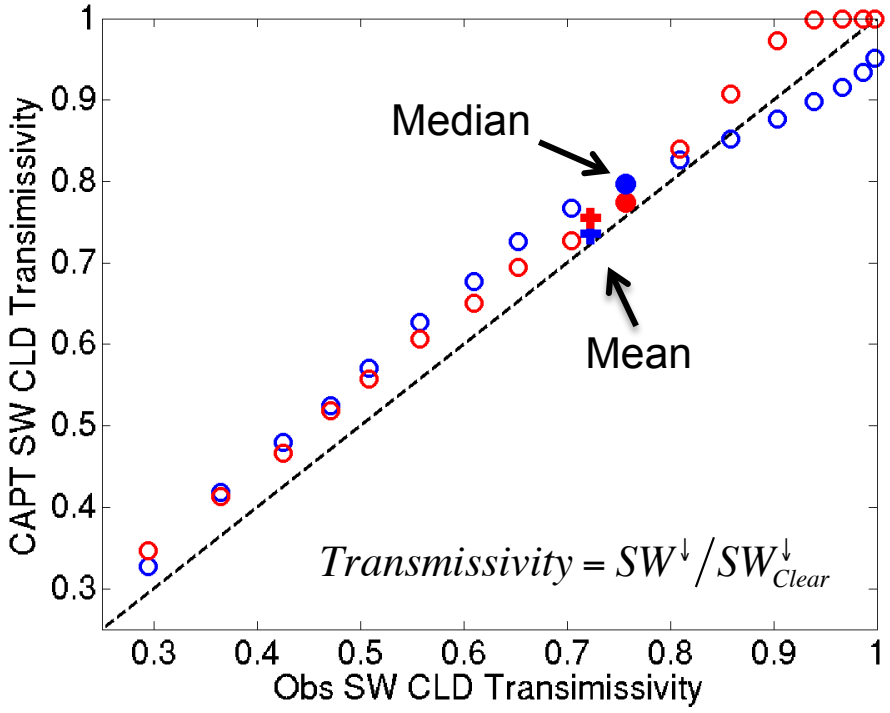
# Cloud statistics




- Negative cloud cover biases
- CLUBBMG2 has a larger variability in low-level-cloud cover
- Obs. in-cloud LWP has a positively skewed distribution

# Surface SW cloud radiative effect (CRE) and transmissivity

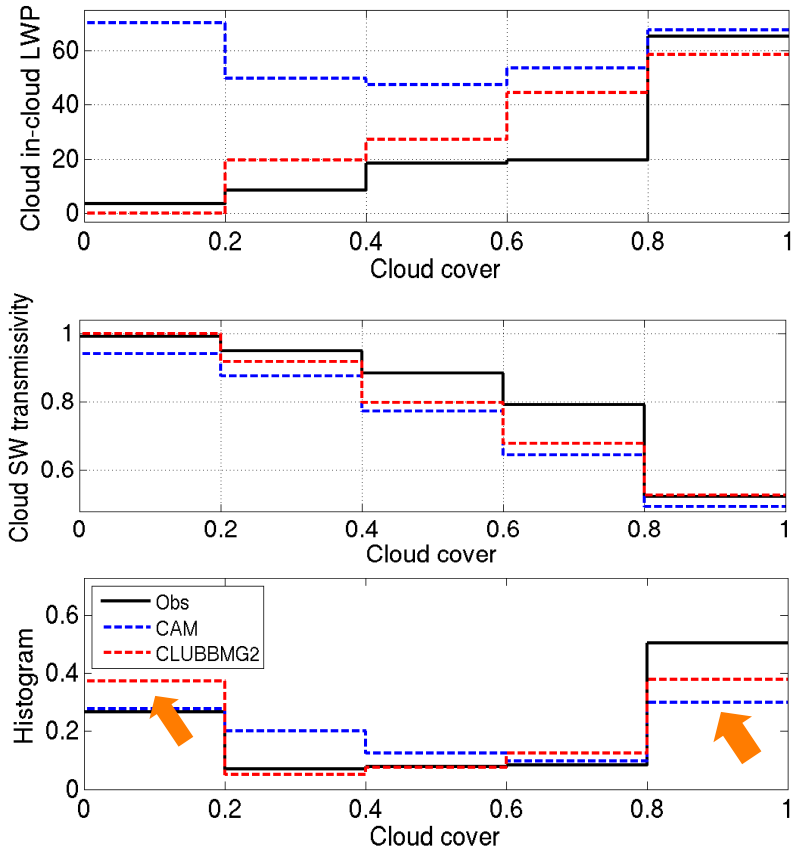



- Positive SW CRE/transmissivity biases in CAM5.3 and CLUBBMG2
- CLUBBMG2: larger positive biases in the mean values of CRE and cloud transmissivity.
  - Where do the biases come from?

# Cloud SW transmissivity vs. in-cloud LWP

Median values binned by cloud cover



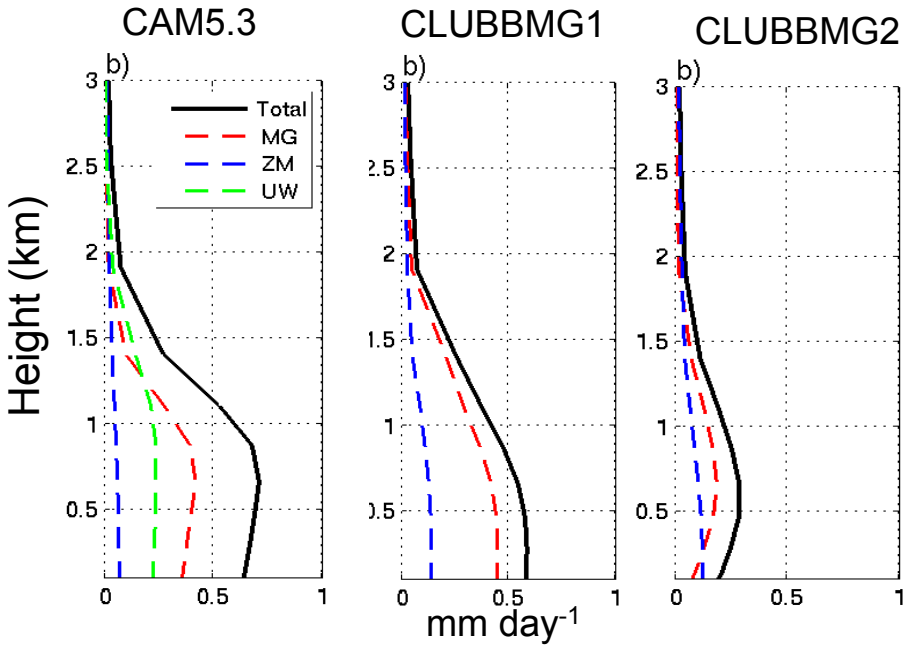

**CAM5.3**

The negative biases in the surface SW transmissivity for all cloud cover bins compensates the CAM5.3 cloud cover bias

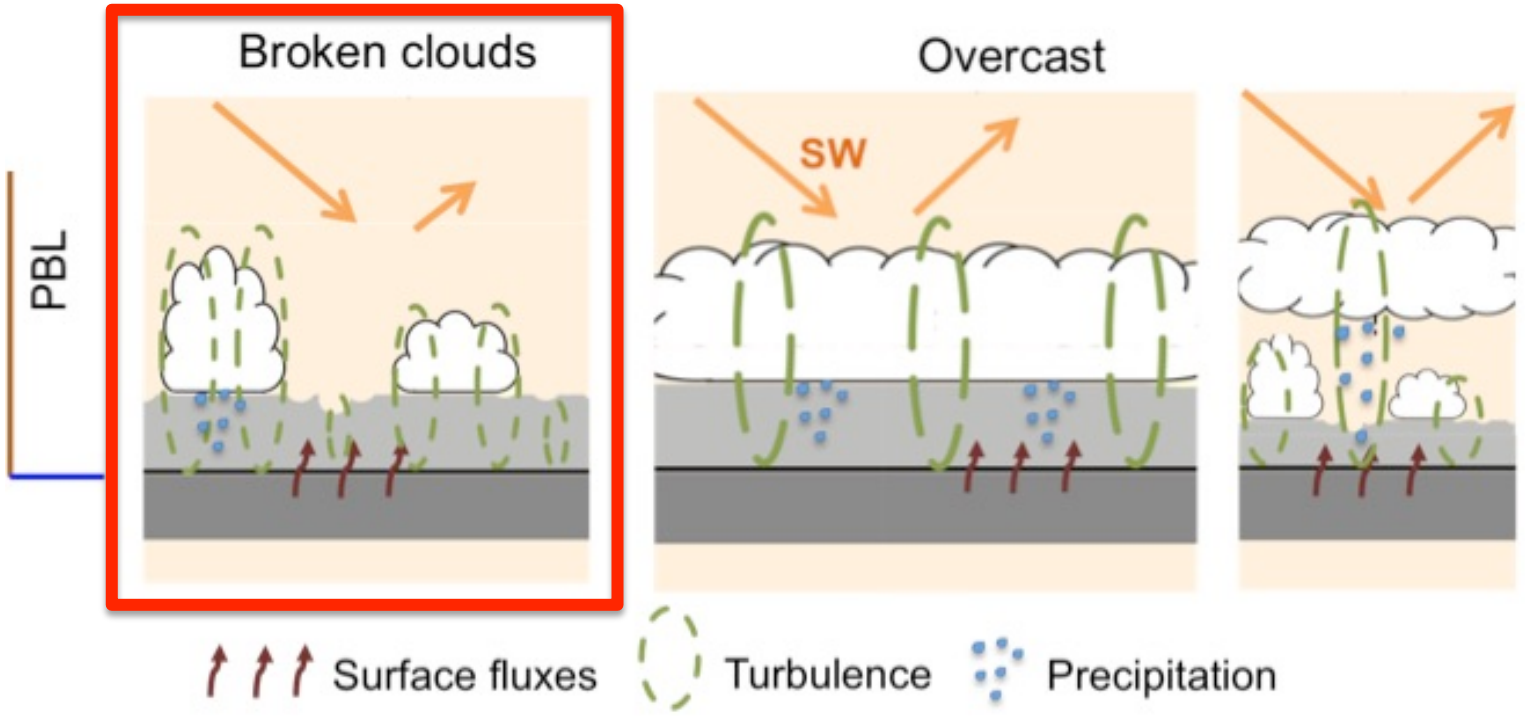
**CLUBB-MG2**

Not enough overcast cloud condition and too often clear-sky and broken cloud condition + the reduction of compensating errors in CWP results in a higher cloud SW transimissivity bias.

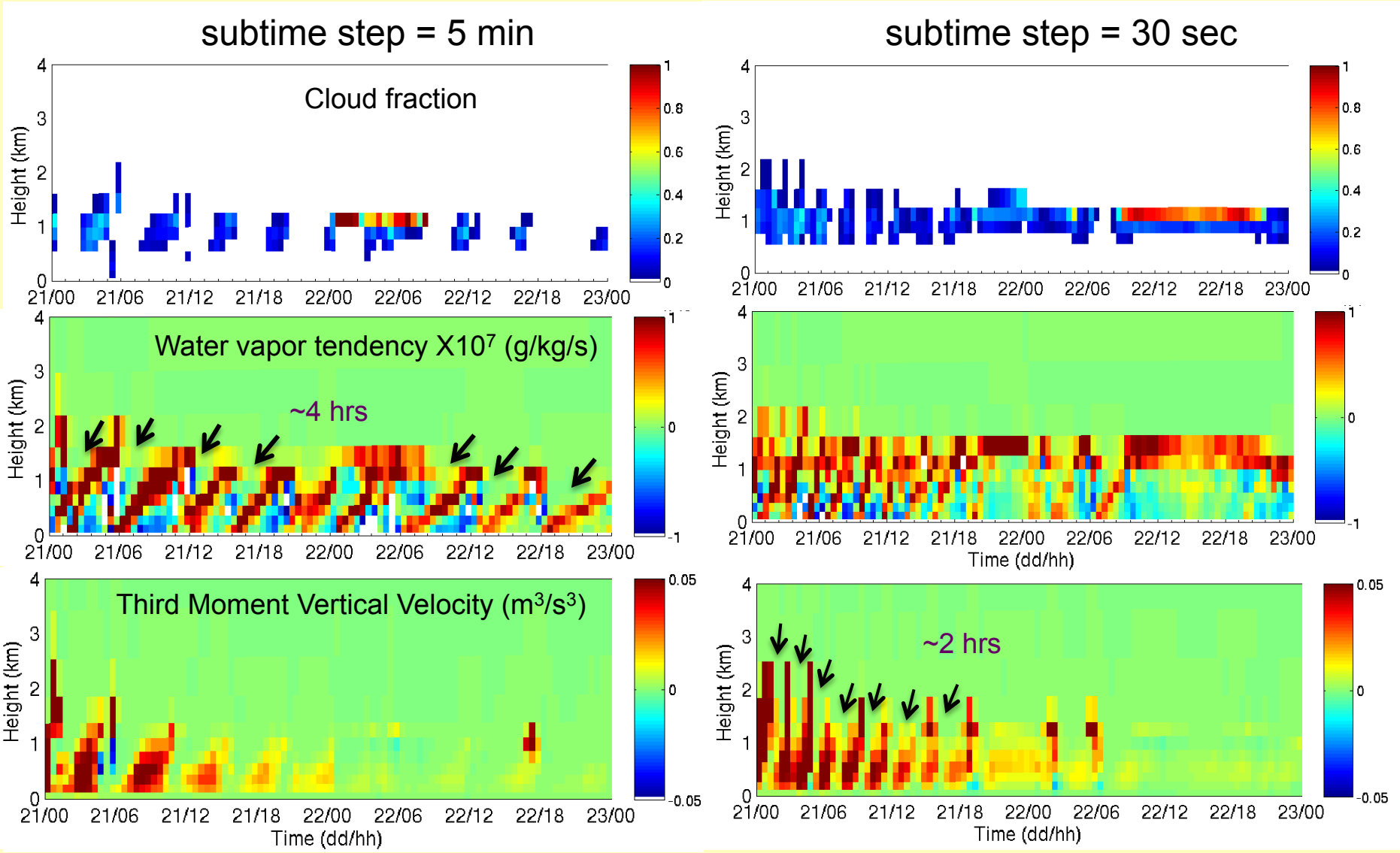
# Precipitation flux



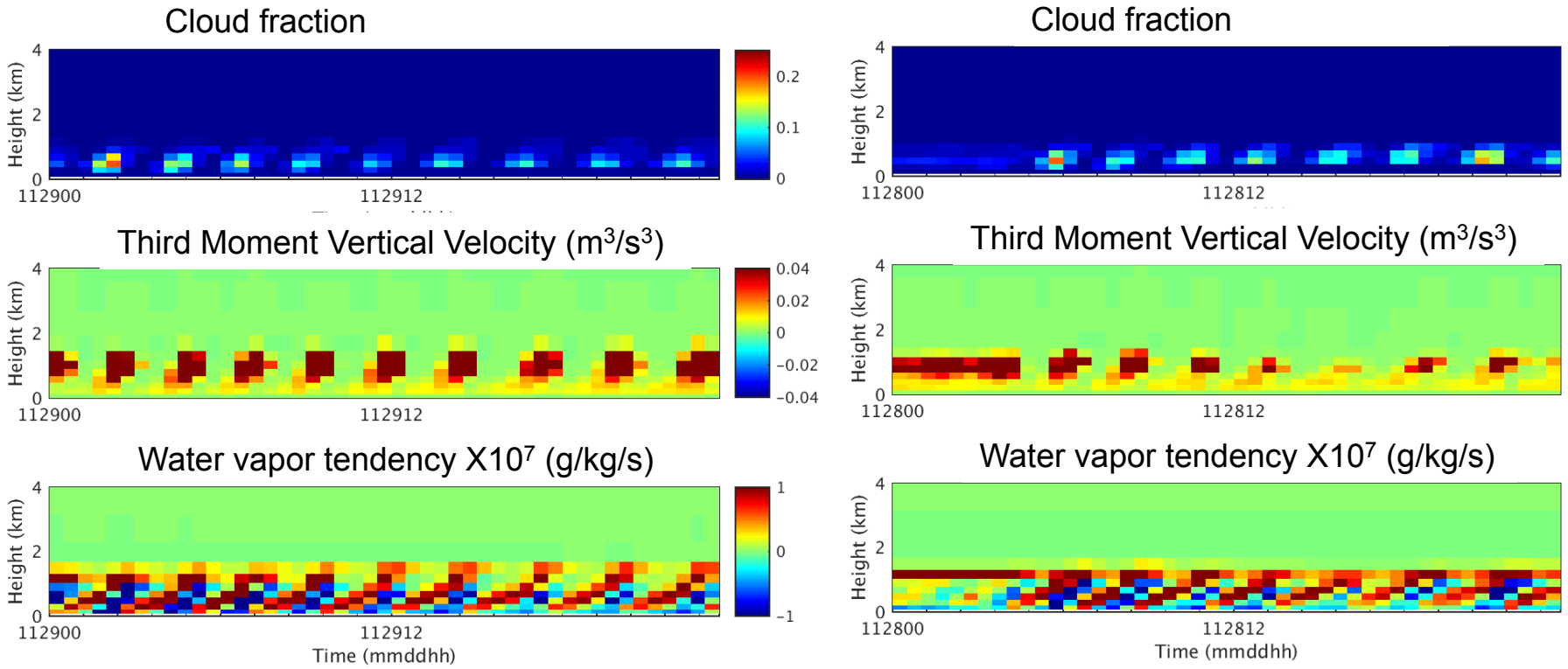

- Precipitation flux decreases in CLUBBMG2 compared with CAM5.3 and CLUBBMG1.
- Deep convection scheme is active during 34 days in CAM5.3, 56 days in CLUBBMG1 and 55 days in CLUBBMG2.


Broken clouds
Overcast
SW
PBL
Surface fluxes
Turbulence
Precipitation

# Cloud/BL oscillation in CLUBBMG2

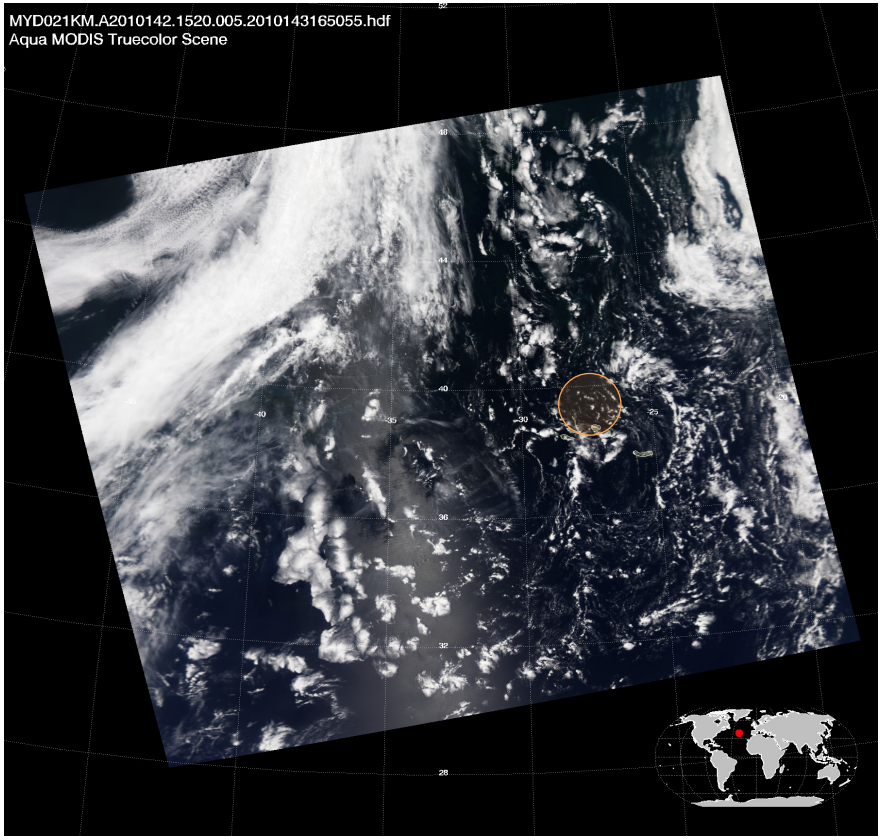


# Oscillation frequency becomes higher in CLUBB-MG2 (clubb_rainevap_turb = .false.)

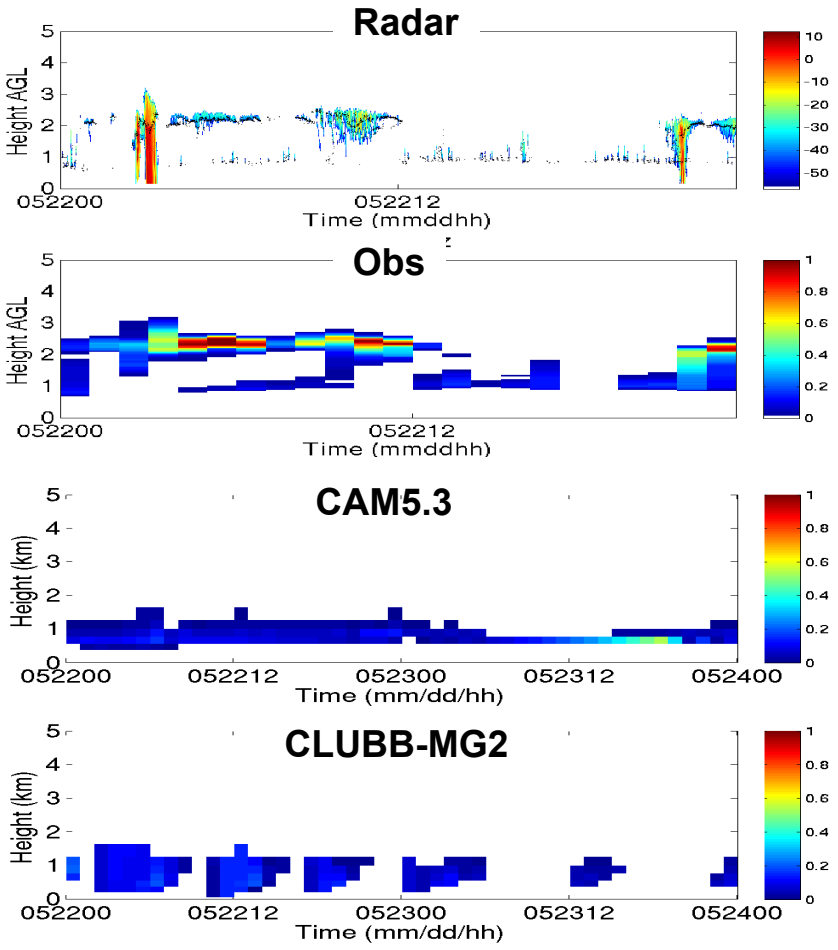



(22.5 º S, 17.5 º W)

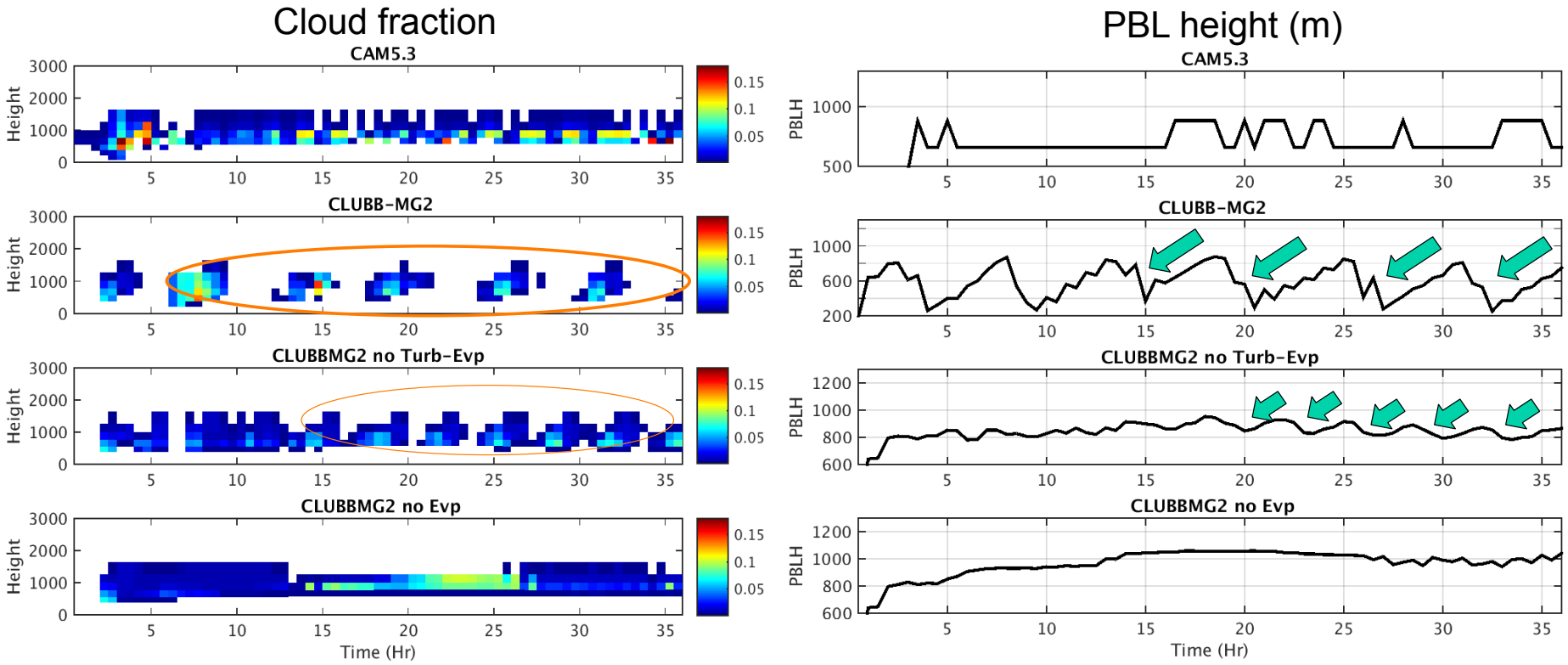
# A precipitating cumulus cloud case




05/22/2010



# Single-column simulations



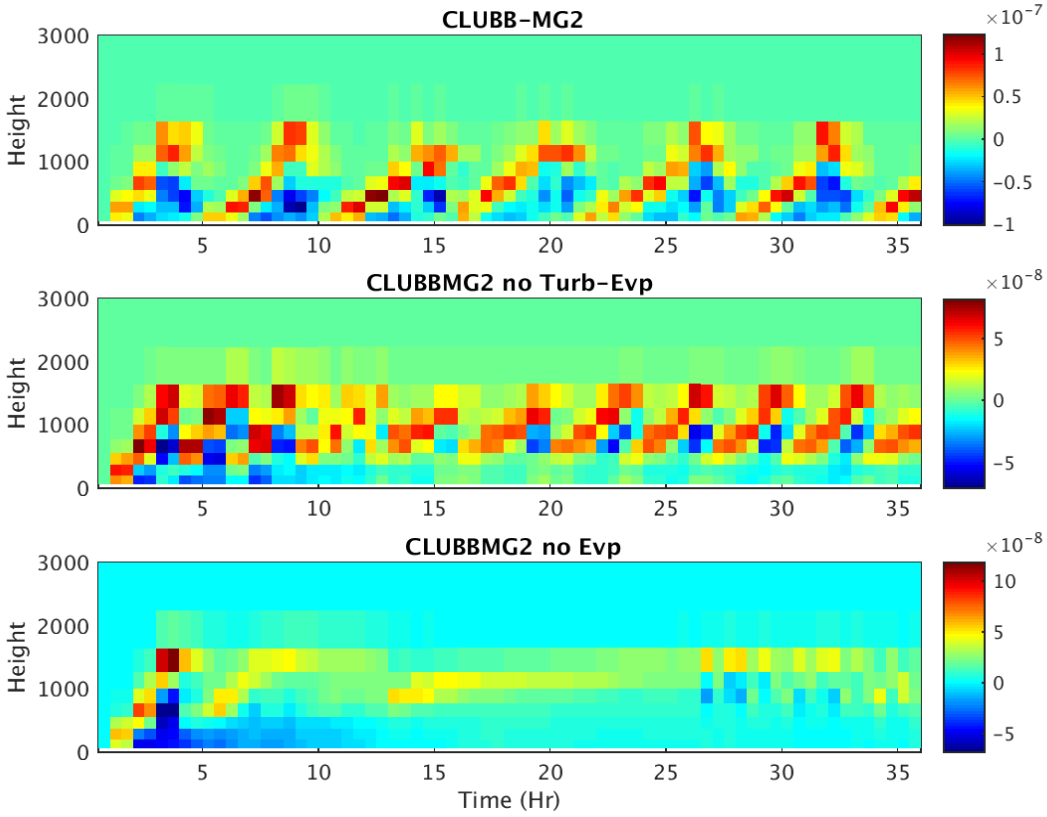

A lower-freq and stronger oscillation occurs in CLUBB-MG2.

A higher-freq and weaker oscillation occurs in CLUBB-MG2 no Turb-Evp.

No oscillation in CLUBB-MG2 without precipitation evaporation

# Cloud/PBL life cycles

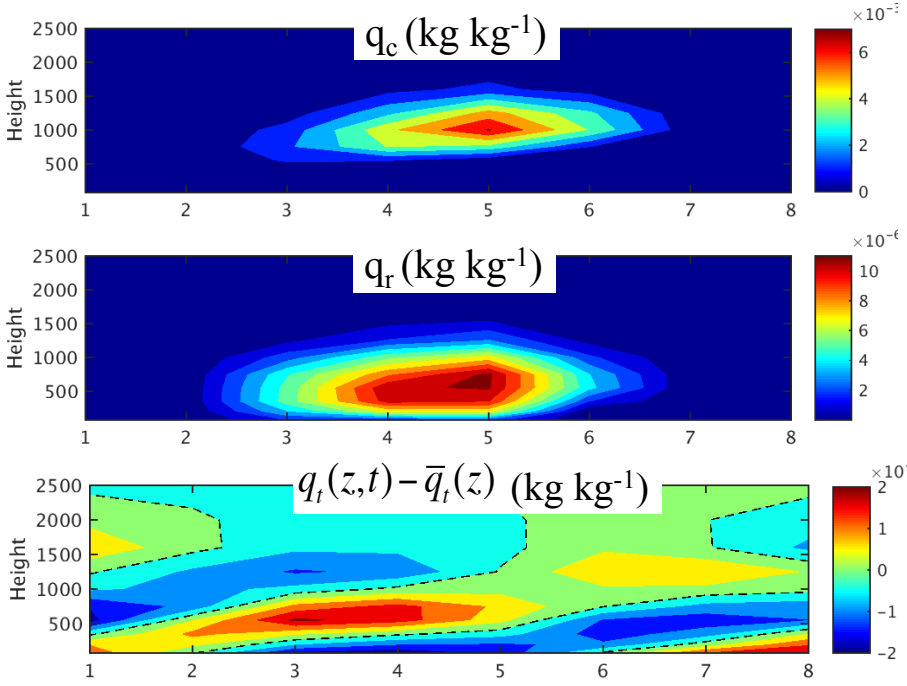
Water vapor tendency from CLUBB (g $kg^{-1}$ $s^{-1}$)




***We composite the life cycle of the boundary layer evolution***

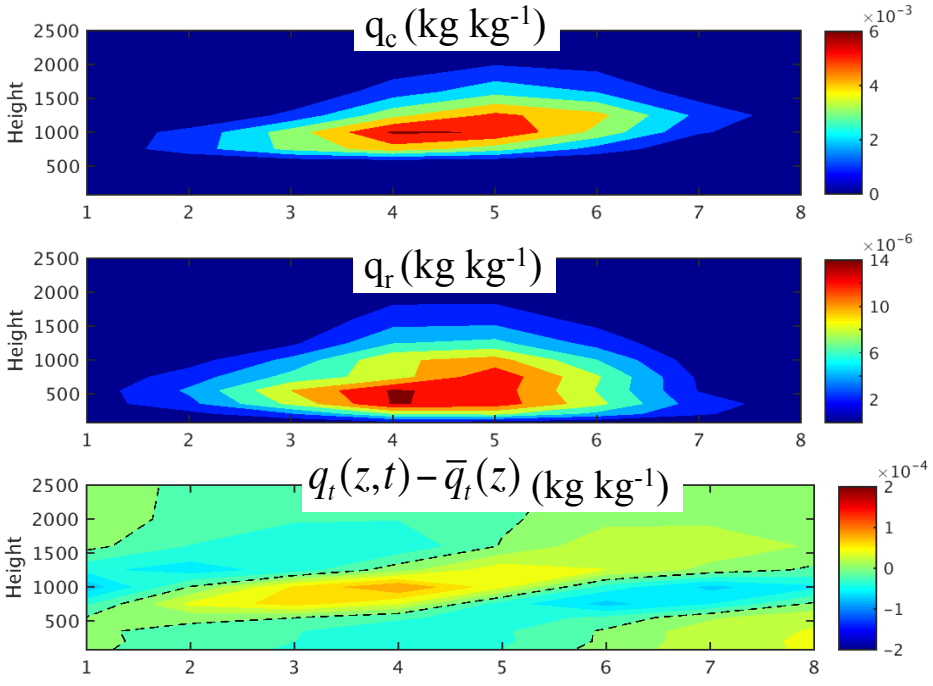
# The composite life cycle of BL and cloud

## CLUBB-MG2




Cloud/PBL life cycle

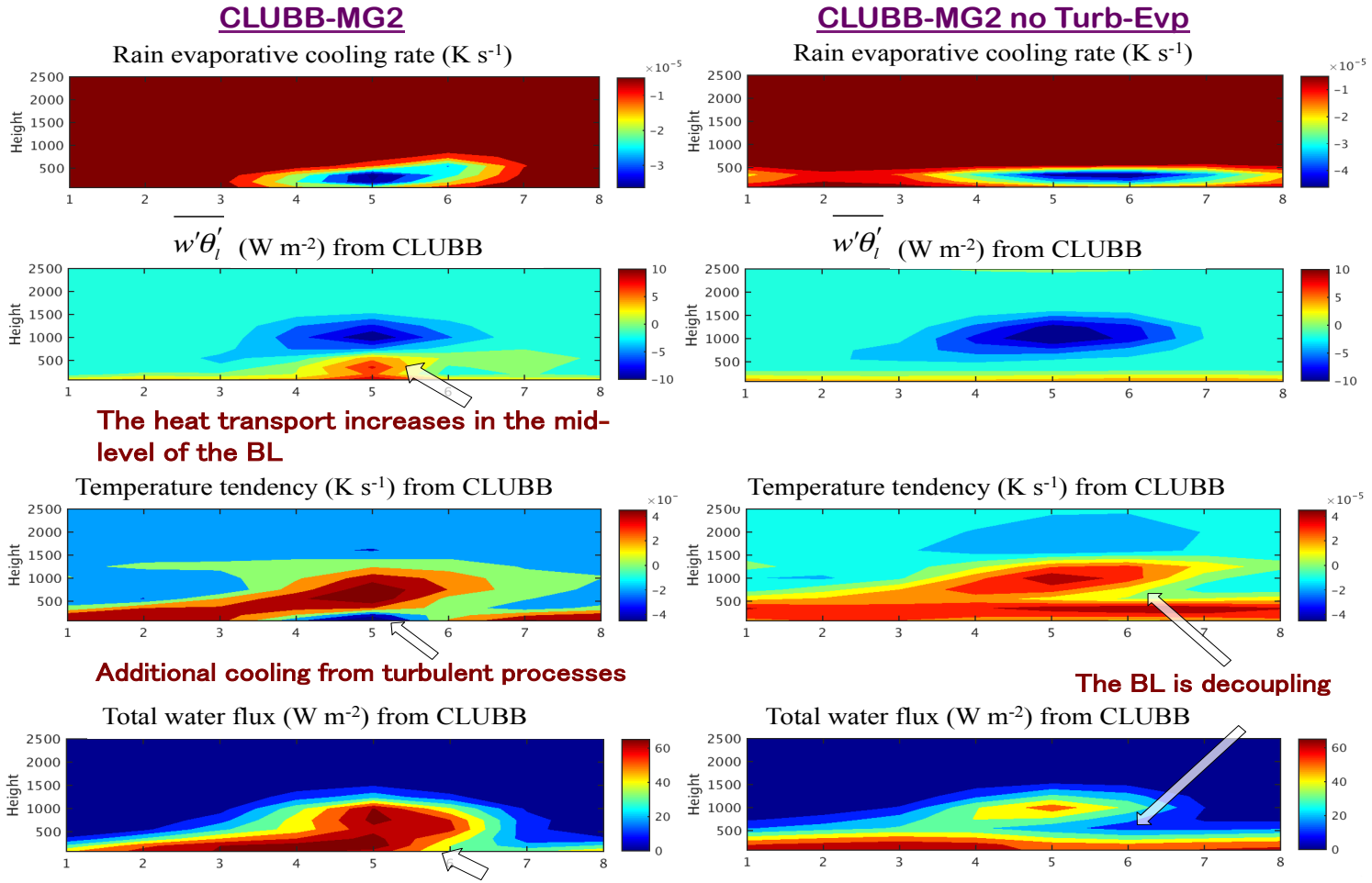
## CLUBB-MG2 no Turb-Evp




Cloud/PBL life cycle

The cloud and precipitation vary closely with the PBL life cycle.

# The impact of the rain evaporation




Cumulus clouds in CLUBB are sensitive to the evaporative cooling induced boundary layer decoupling.

# Summary

- CLUBB-MG2 simulates a more realistic cloud variation from broken thin clouds to thick solid clouds.
- CAM5.3 produces stronger negative surface SW CRE by excessive in-cloud LWP.
- Due to the reduction of compensating errors in LWP, the lack of overcast cloud conditions results in larger bias of SW cloud transmissivity in CLUBB-MG2 than that in CAM5.3.
- A single-column modeling study demonstrates that cumulus clouds in CLUBB are sensitive to the evaporative cooling induced boundary layer decoupling.

# Thanks!