The RACORO-FASTER Project

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Andy Vogelmann, Tami Toto, Yangang Liu, Minghua Zhang

Poster #s

106 Yangang Liu et al.:
Development of Integrative LES-CRM-SCM-NWP Evaluation Framework and Demonstration with RACORO Case

107 Andy Vogelmann et al.:
1. RACORO-FASTER: Case Study Generation

108 Satoshi Endo et al.:
2. RACORO-FASTER: Large Eddy Simulations

109 Wuyin Lin et al.:
3. RACORO-FASTER: Climate Significance and SCM Simulations

110 Zhijin Li et al.:
Aerosol Reanalysis Using a Multiscale Aerosol Data Assimilation System for the FASTER Project

FASTER RACORO: Selection and Observational Constraints

A multi-pronged observation-LES-SCM approach selected three 3-day periods

Case 1: Cumulus with Variable Aerosol

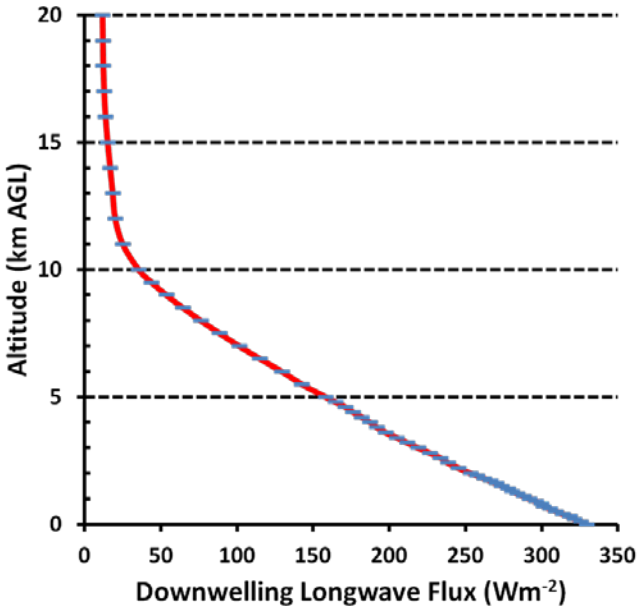
Case 2: Cumulus and Drizzling Stratus

Case 3: Variable Cloud Types

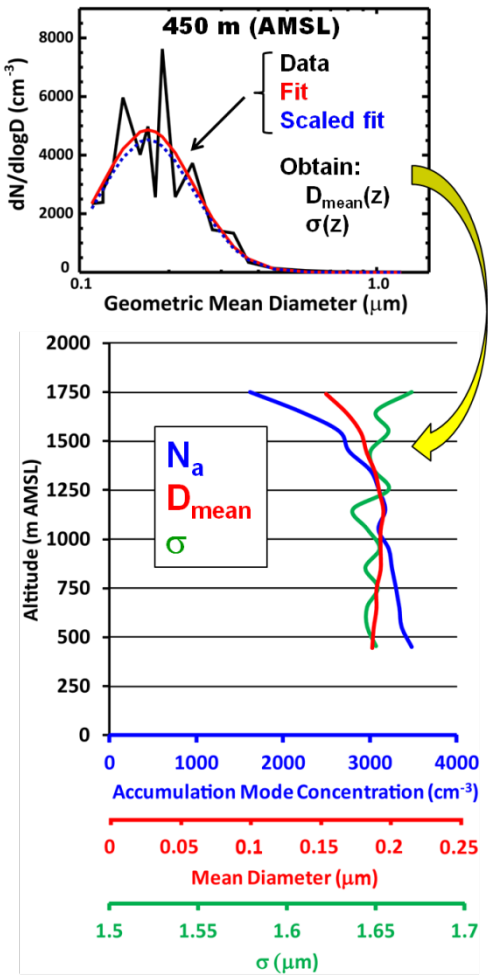
Observational Constraints:

LW & Aerosol Profiles

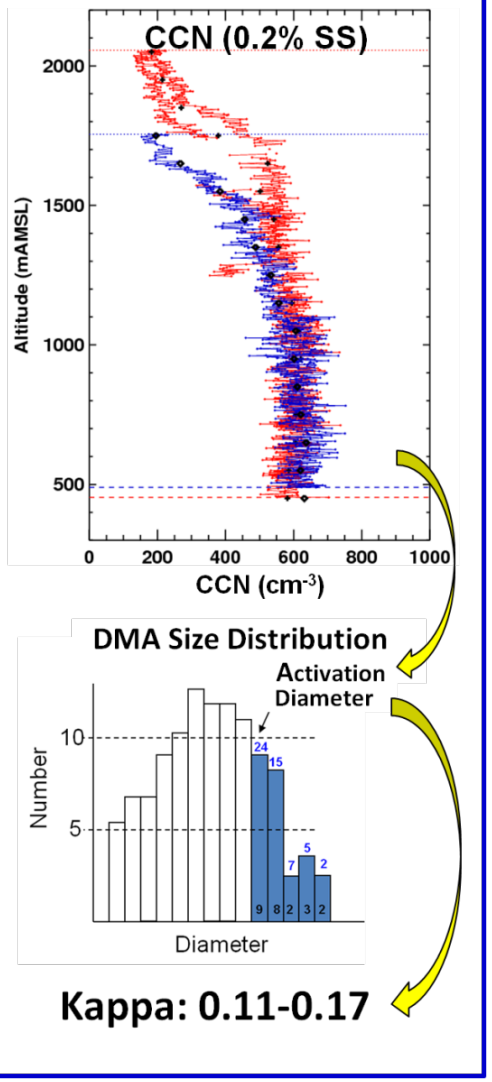
Longwave Flux Calculations



Aerosol Accumulation Mode Fits



Aerosol Hygroscopicity (Kappa)



FASTER RACORO LES update

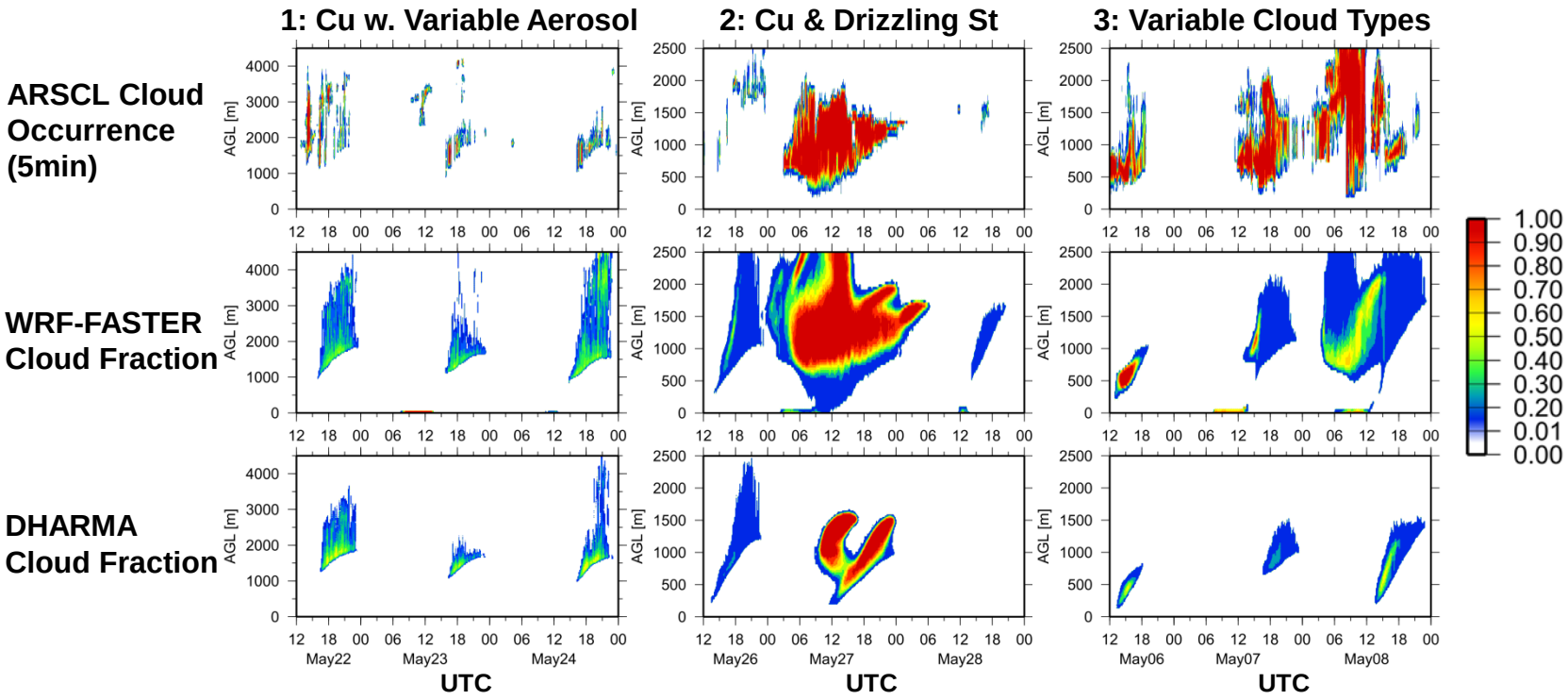
A new set of "realistic" runs by DHARMA and WRF-FASTER are under examination.

New Since Telecon

- **3-h relaxation** for temperature/water vapor
- Using the **same grid spacing** in low levels
- **Radiation ON**
- **Aerosol effect** in DHARMA (to be included in WRF)

No Change

- Three 60-h runs initialized by sounding just after sunrise
- Driven by surface and large-scale forcings from the ARM VARANAL product
- 1-h relaxation for horizontal wind components



We plan more examination in model configuration (e.g., relaxation time scale), comparison with observation, and idealization for target processes/periods.

FASTER RACORO LES update

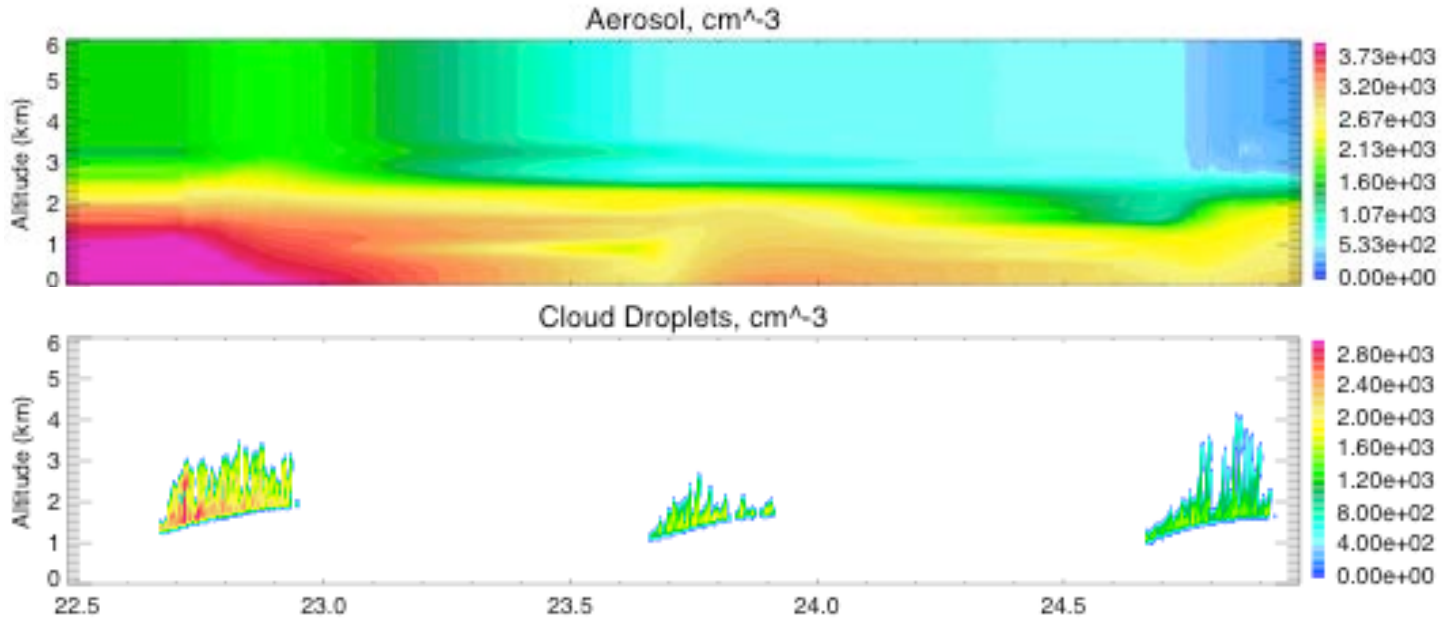
Test of aerosol representation in DHARMA with Morrison two-moment microphysics.

Aerosol-Cloud Interactions

- Idealized, observation-based, **time-varying aerosol number size distribution profile**
- Observation-based composition (**κ=0.12**)
- **Aerosol loss** via local coll-coal
- **Relax to background** (advection/sources)

Next Steps

- Use **RACORO in situ cloud obs** to evaluate DHARMA, WRF-FASTER, SAM results
- **Document case studies**: description, intercomparison of LES/SCM/obs, and climatological/radiative context



CASE 1: Background aerosol and predicted cloud droplet number concentrations varying on consecutive days of cumulus

FASTER-assisted ModelE development

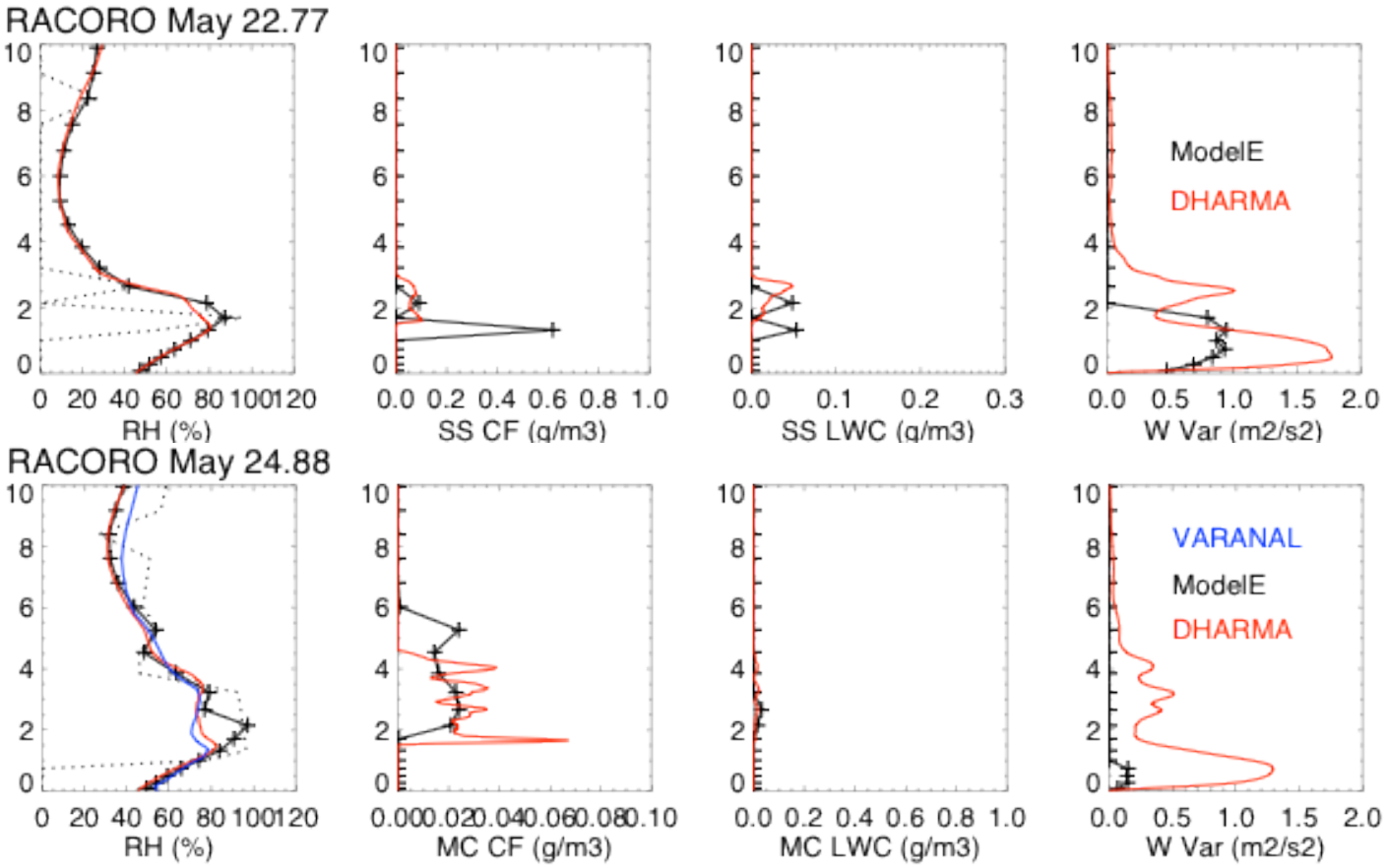
Implementation of Morrison and Gettelman (2008) two-moment microphysics in ModelE.

RACORO/CAP-MBL GISS Posters

- **56**—DHARMA/ModelE SCM—Ackerman
- **57**—CAP-MBL/ISCCP/ModelE—Tselioudis
- **58**—CAP-MBL cloud/drizzle obs—Rémillard
- **Suite of continental and oceanic shallow cloud case studies** (observationally rich)

Other FASTER/RACORO Posters

- **106**—FASTER methodology overview—Liu
- **107**—RACORO obs to cases—Vogelmann
- **108**—RACORO LES comparison—Endo
- **109**—RACORO SCM/climatology—Lin
- **110**—RACORO WRF-Chem—Li

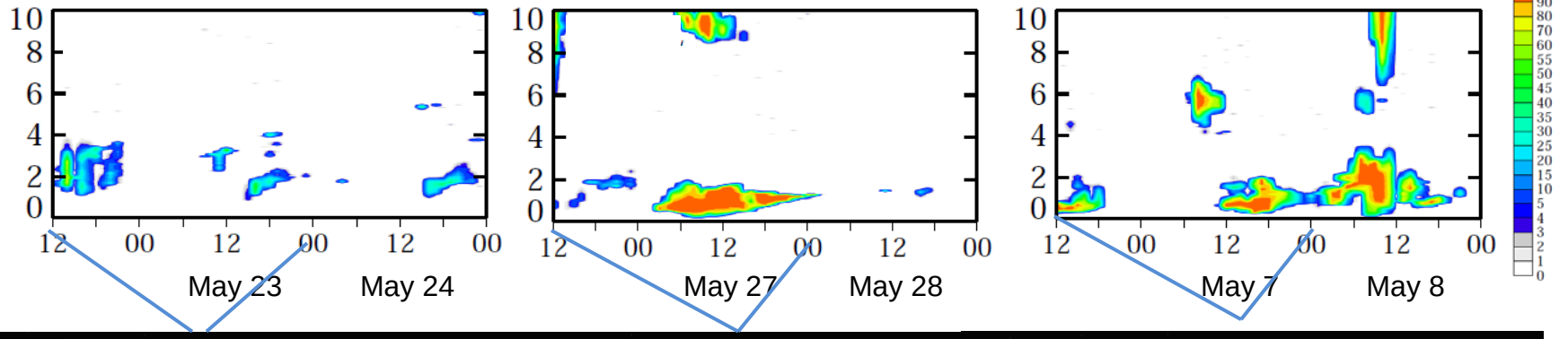


FASTER-RACORO SCM/Climatology update

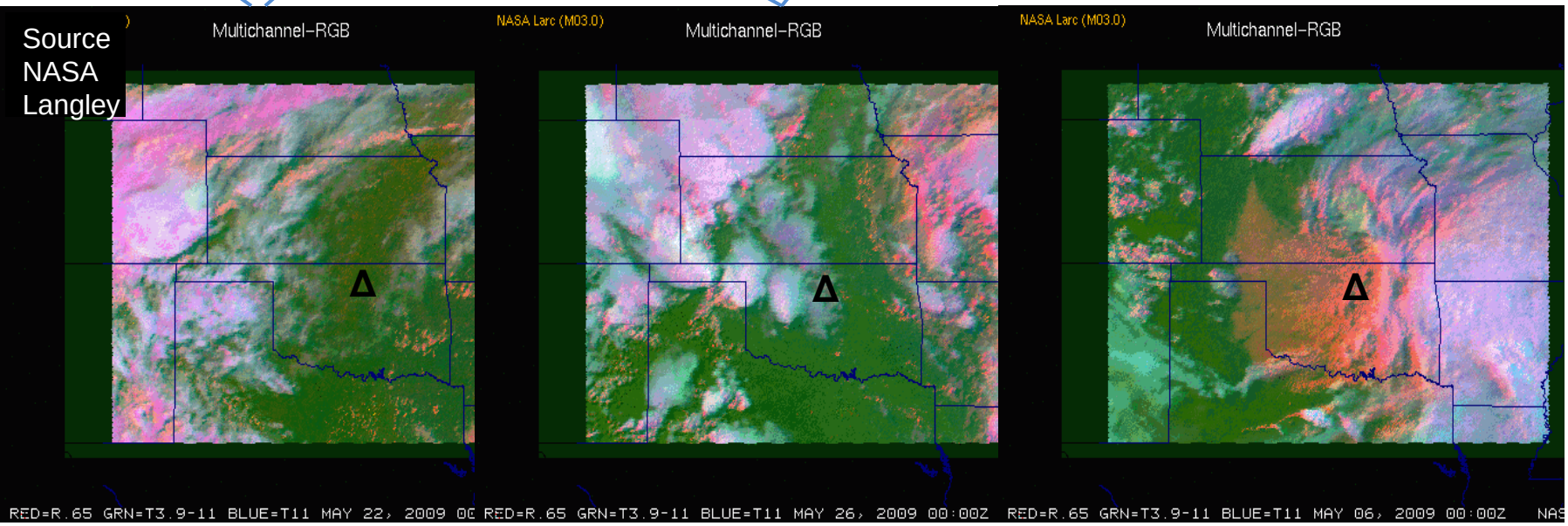
Larger-scale cloud environment of the three cases

1: Cu. w/ variable aerosols **2: Cu & Drizzling stratus** **3: Variable cloud types**

ARSCL



Source NASA Langley



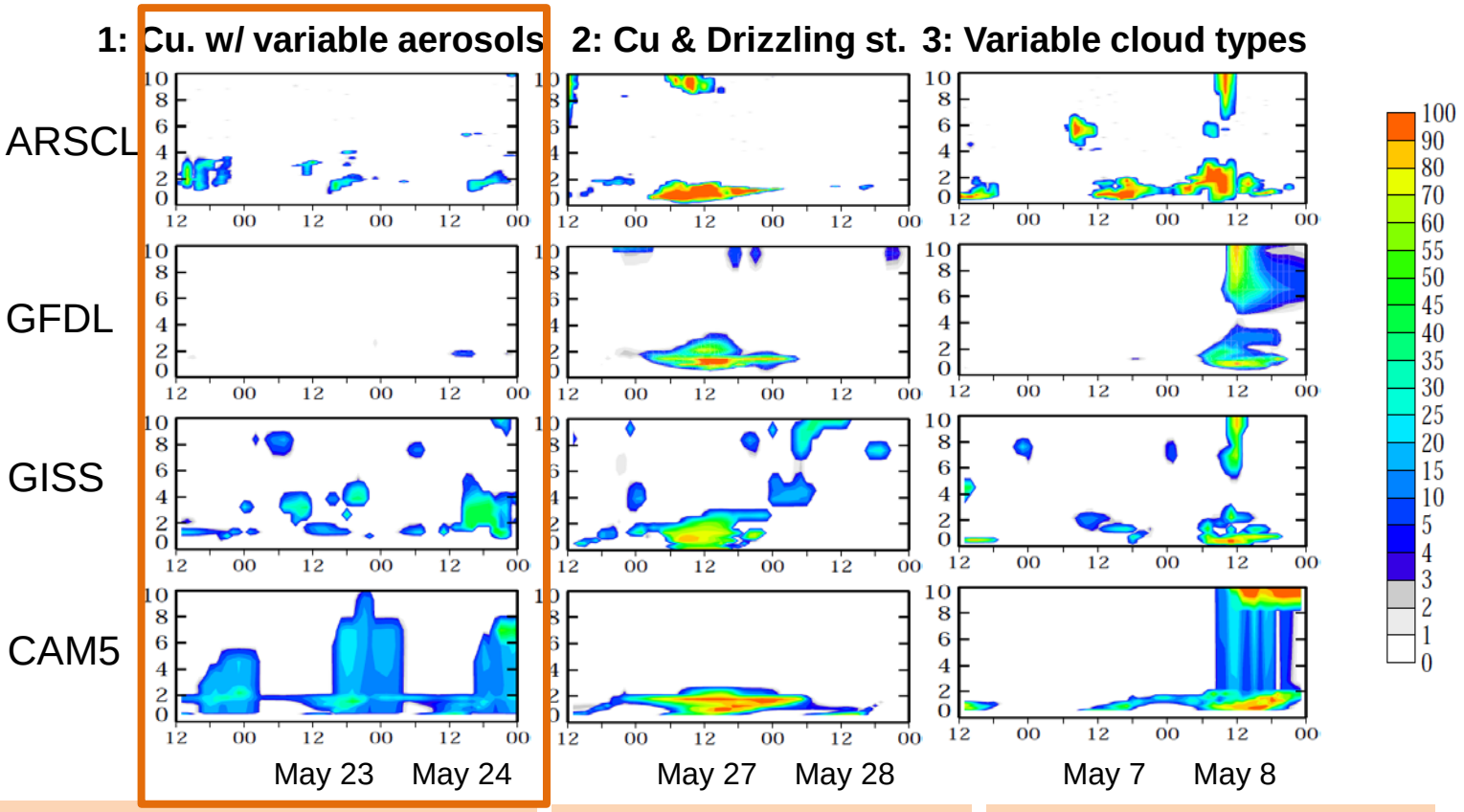
Short lived
Locally developed
Scattered cumulus

1st daytime Cu, locally developed; 2nd day, cloud structures (N & S) merged, evolved then moved out

Migrating cloud fields, daytime clouds mostly locally developed then moved out

FASTER-RACORO SCM/Climatology update

Overview of the simulated clouds by GFDL AM3, GISS modelE, and CAM5 SCMs



GFDL: very few clouds
GISS: well simulated.
scattered, recurrence, vertical extent
CAM5: penetrate too high
not dissipated night time

2nd day St: all well reproduce clouds, esp. temporal evolution.
1st day cumulus:
GFDL: missed
GISS and CAM5: OK

GISS and CAM5:
some thin stratus, day 1 & day 2.
GFDL: very few clouds
(all 3 cases missed locally driven clouds)

FASTER-RACORO SCM/Climatology update

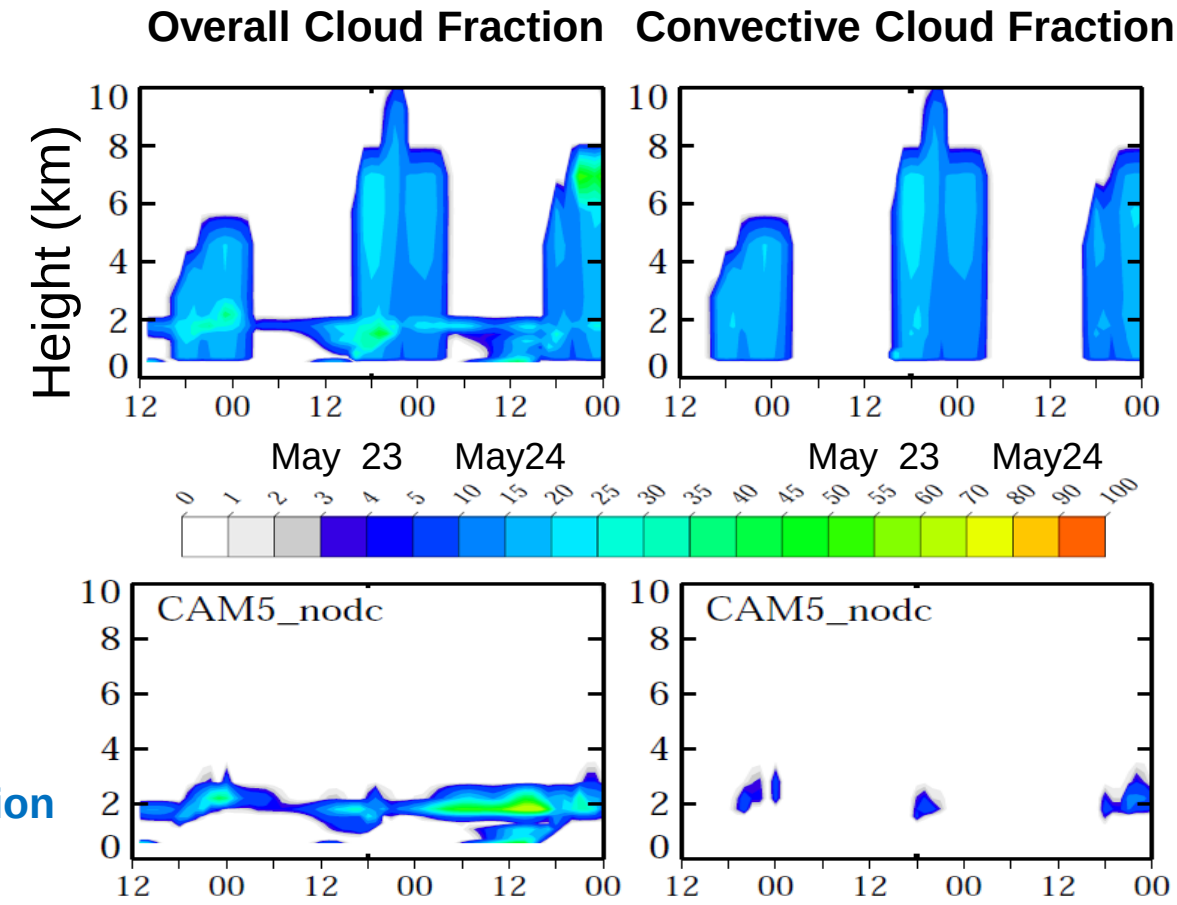
Do the convection schemes rule concerning cloud proudction?

YES and NO

Both unfavorable to the problem

Standard CAM5

Turn off Deep convection

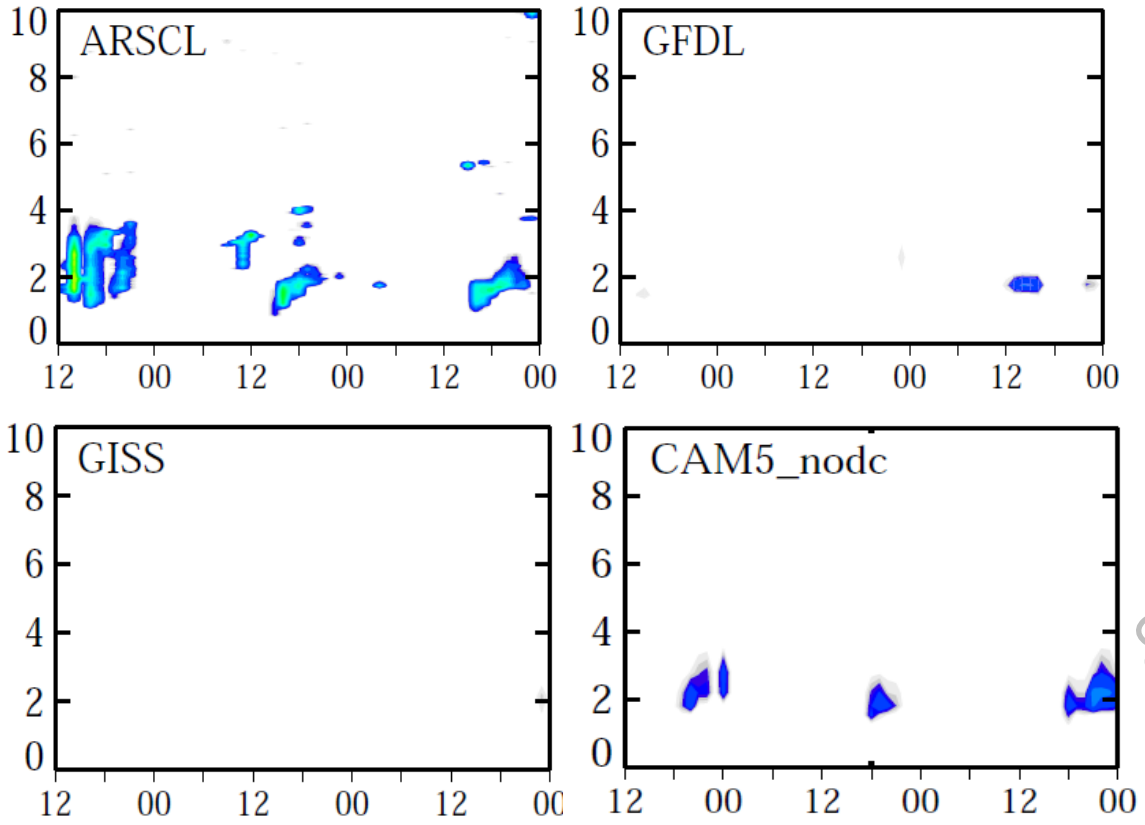


Confined w/i lower-troposphere. Insufficient vert. extent. Not dissipated night time.	Good timing of Cu occurrence But Cu clouds under-produced

FASTER-RACORO SCM/Climatology update

Cloud production by shallow cumulus in SCMs:

Very little direct cloud production by (shallow) cumulus scheme !



Shallow Cu., more physically based

Stratiform RH-dep.

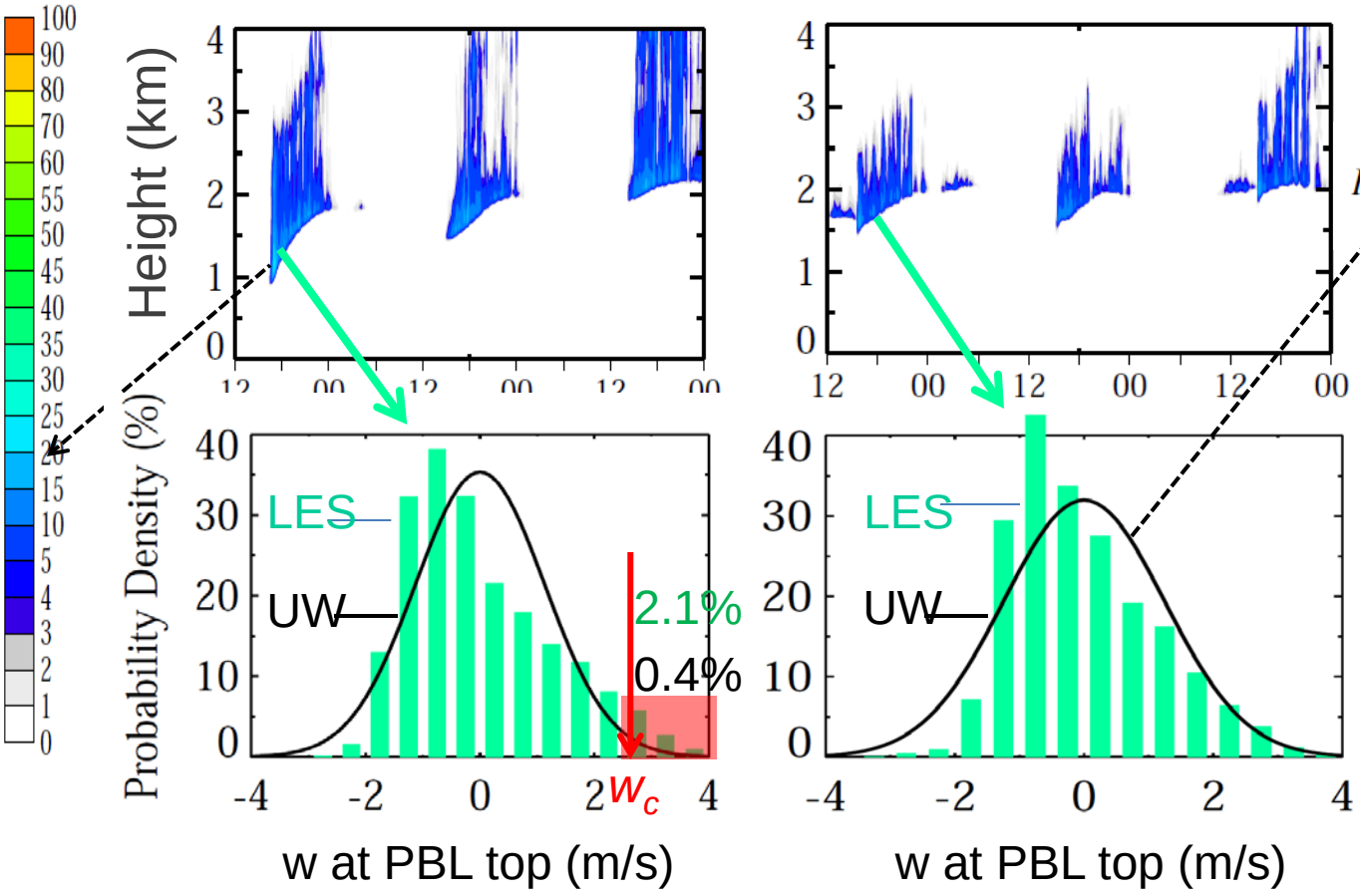
FASTER RACORO SCM/Climatology update

What can LES simulations inform us about the working of UW shallow Cu. scheme?

Shallow Cu scheme tends to underestimate cloud amount at cloud base ! ?

DHARMA

WRF-FASTER



convective updraft area at cloud base

$w > w_c = \sqrt{2CIN}$, convect

$$P(w) = \frac{1}{\sigma_w \cdot \sqrt{2 \cdot \pi}} \cdot \exp\left(-\frac{w^2}{2 \cdot \sigma_w^2}\right)$$

$$\sigma_w \propto \left(\overline{TKE}^{PBL}\right)^{0.5}$$

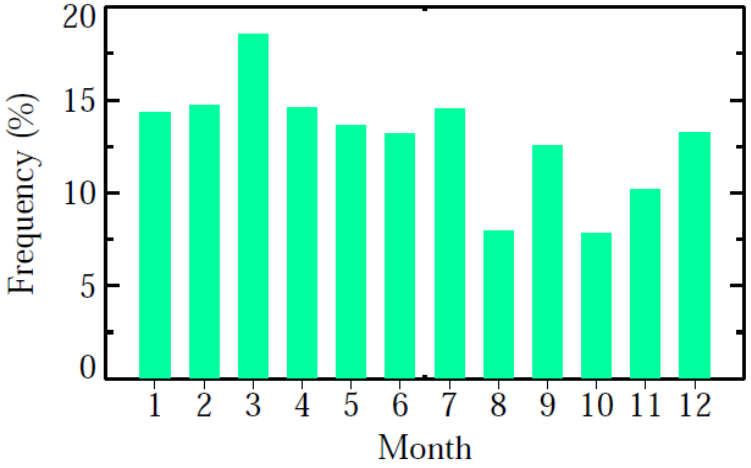
pdf-width: TKE

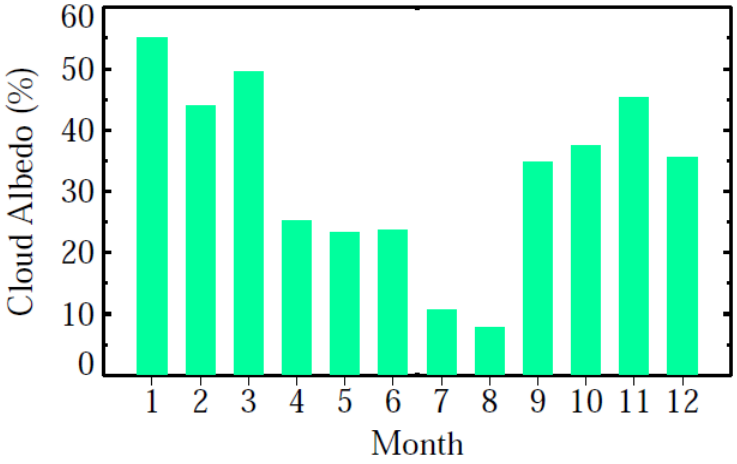
***AM3 vs CAM5**

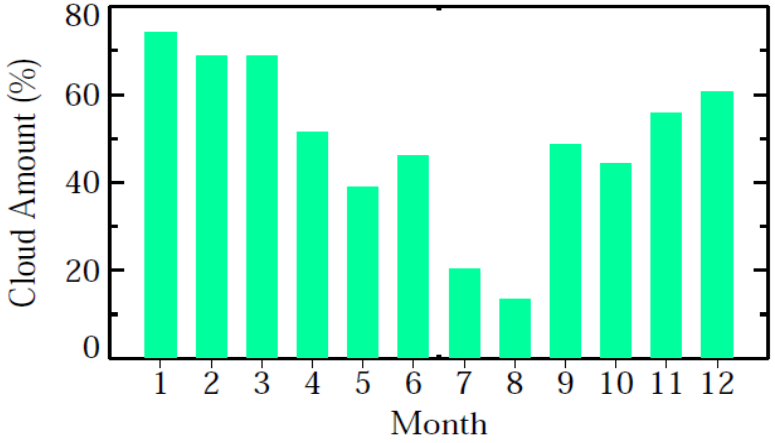
w_c : updraft properties launching level sounding

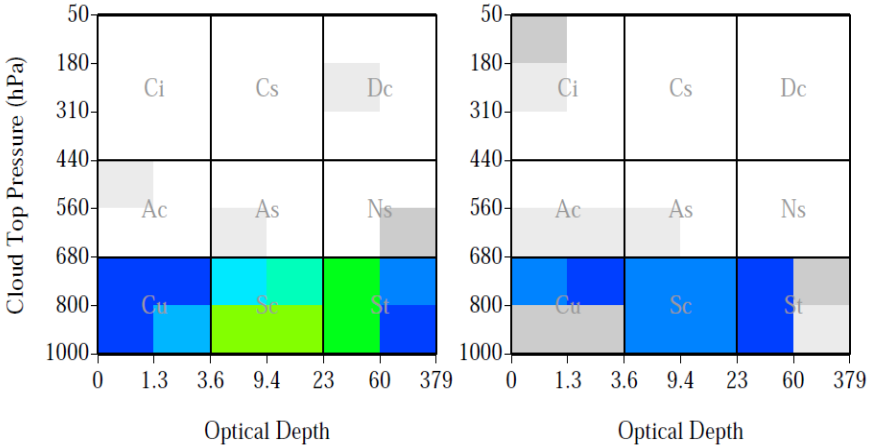
FASTER-RACORO SCM/Climatology update

Multi-year statistics of low-level clouds over the SGP site (poster # 109 by Lin et al.)

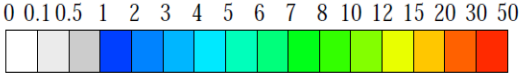






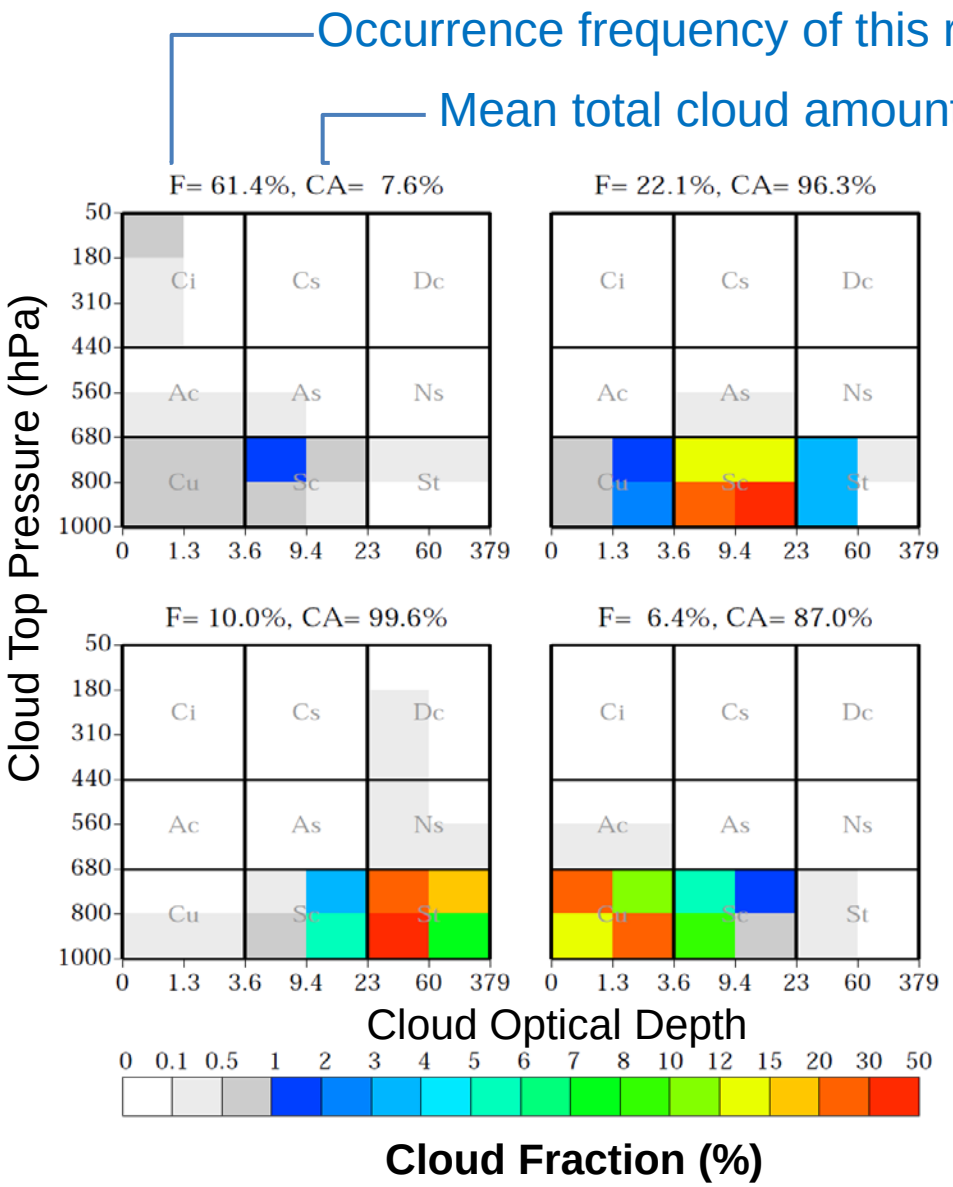


Screening criteria: presence of low-level clouds with very little overlying clouds.



FASTER-RACORO SCM/Climatology update

Low-level cloud regimes over the SGP site

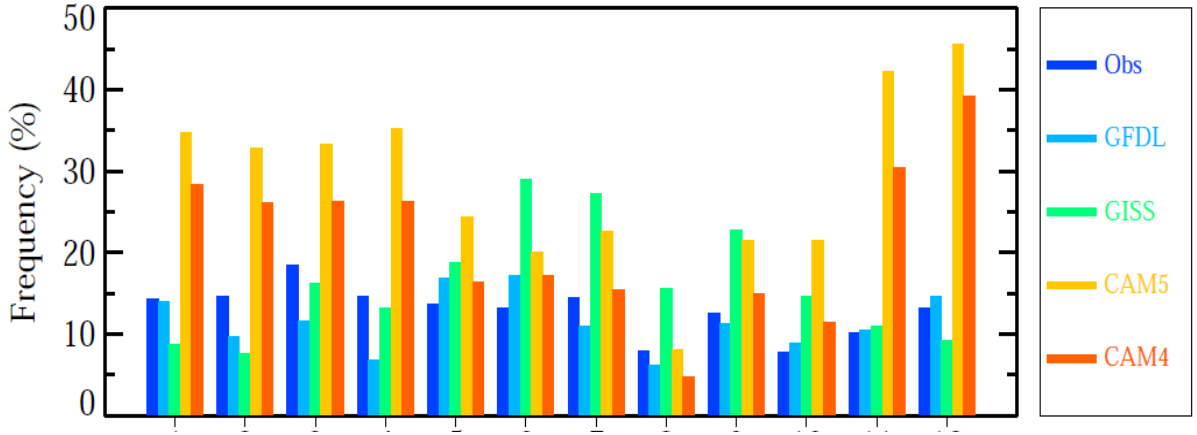


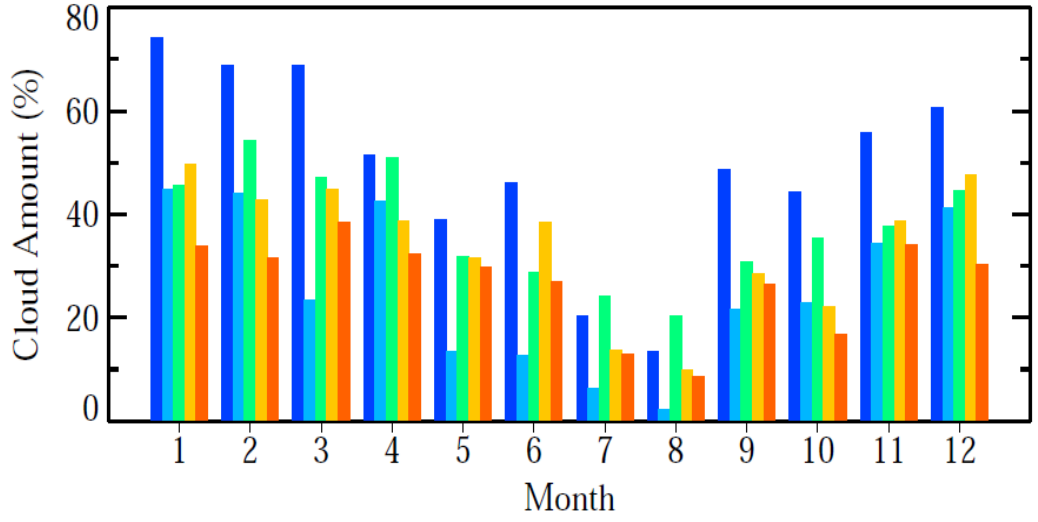
1. Scattered shallow cumulus
2. Stratocumulus
3. Thick Stratus
   (weather influence)
4. Thin Stratus

FASTER-RACORO SCM/Climatology update

What do long-term SCM simulations get?

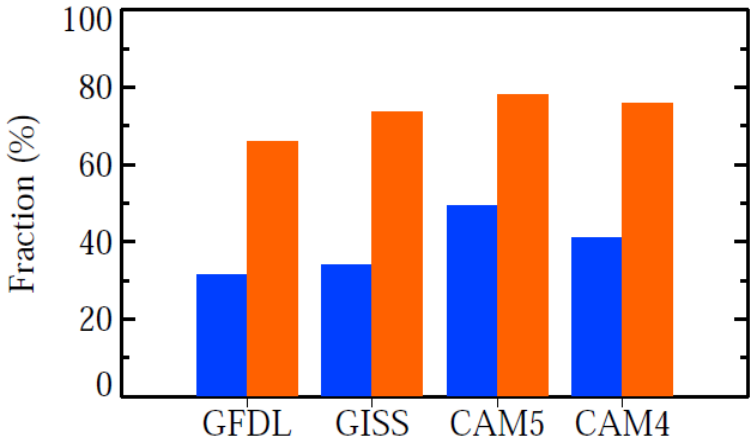
More often than not, SCMs fail to respond correctly to ENV in producing low-level clouds!



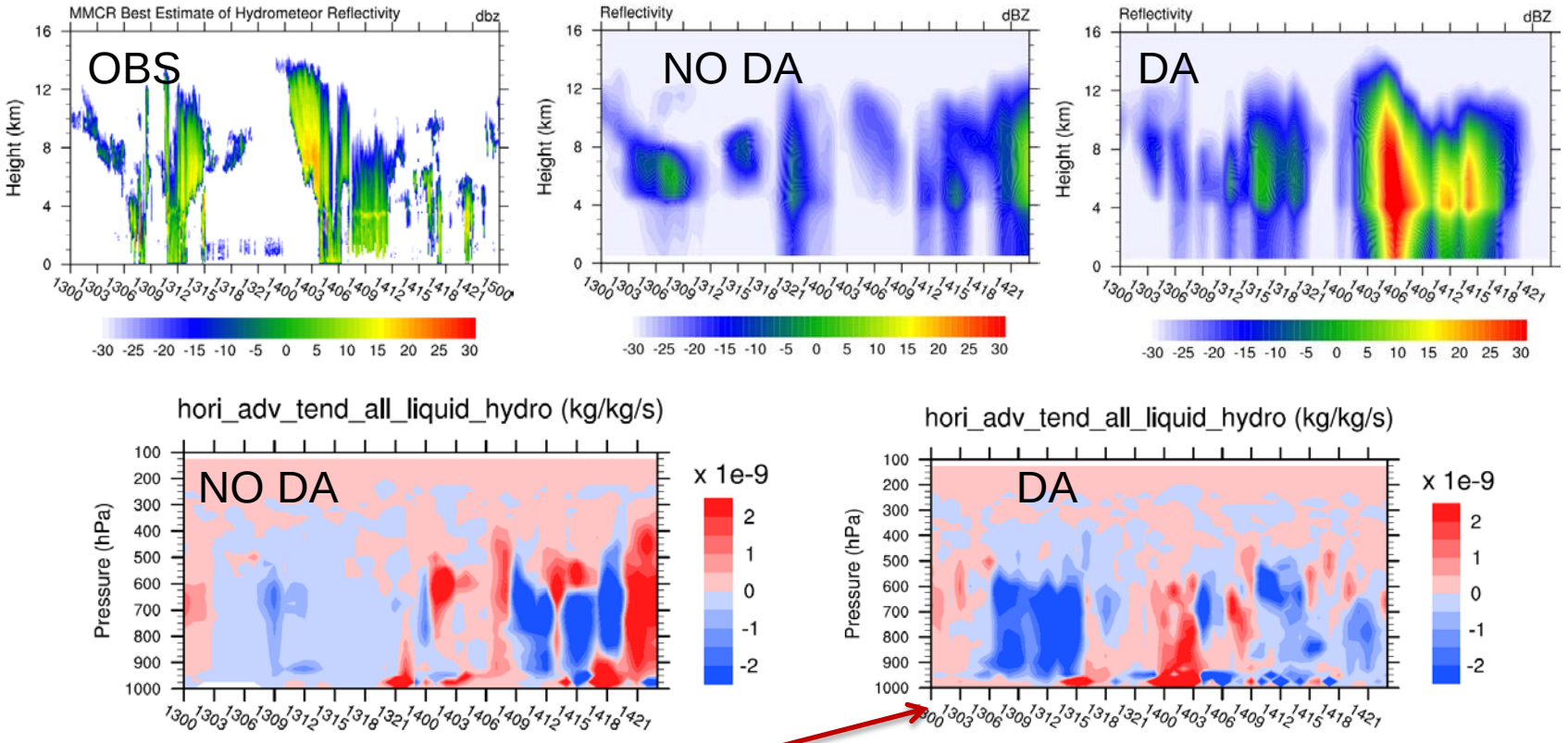


% hits

% false alarms



Data Assimilation for Improved Hydrometeor Forcing



$$\overline{-\vec{v}\cdot\nabla q_w} = -\overline{\vec{v}}\cdot\nabla\overline{q}_w - \overline{\vec{v}'\cdot\nabla q'_w}$$

(Advection of liquid water)

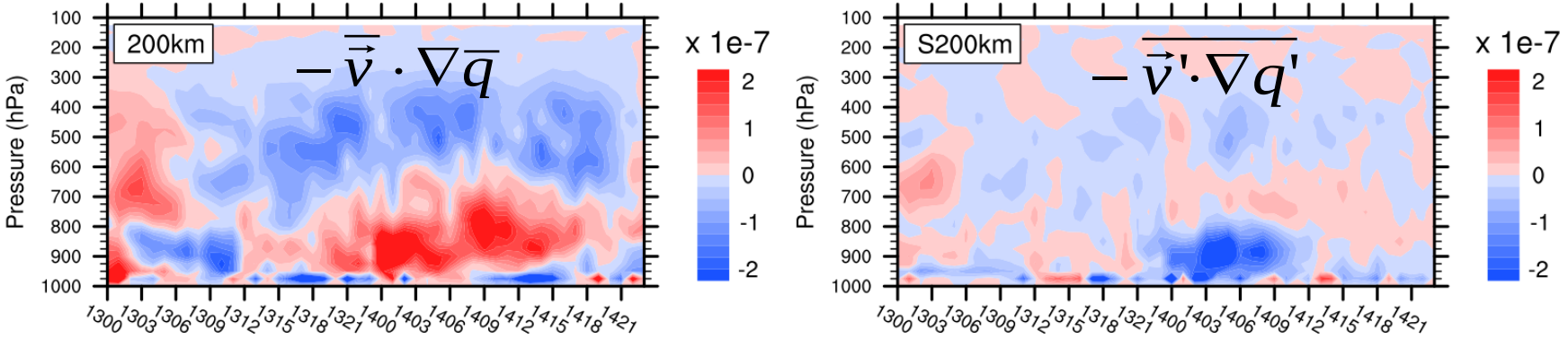
(Average over 300x300 km^2)

Large-Scale and Multi-Scale Forcing

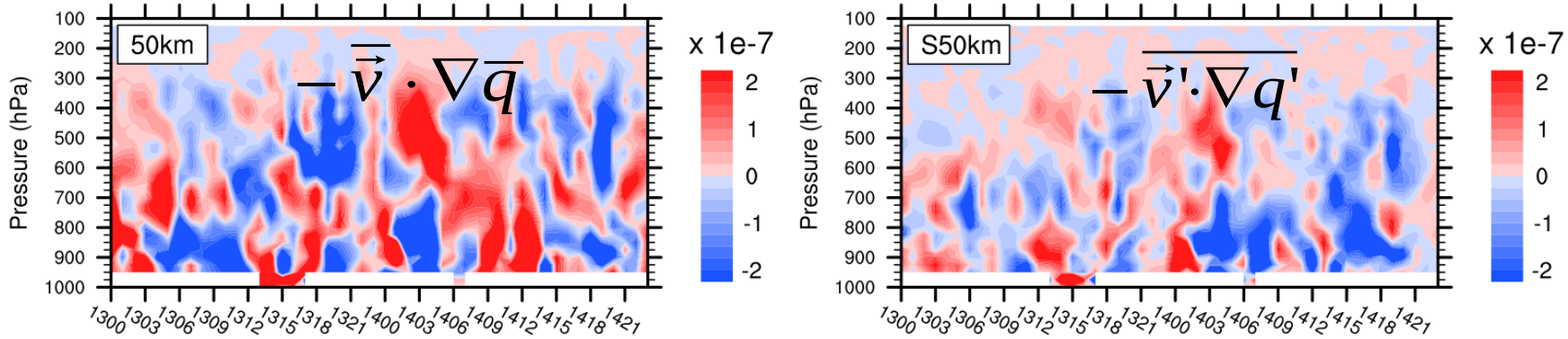
$$\overline{-\vec{v}\cdot\nabla q} = -\overline{\vec{v}}\cdot\nabla\overline{q} - \overline{\vec{v}'\cdot\nabla q'}$$

Large-scale

Subgrid-scale

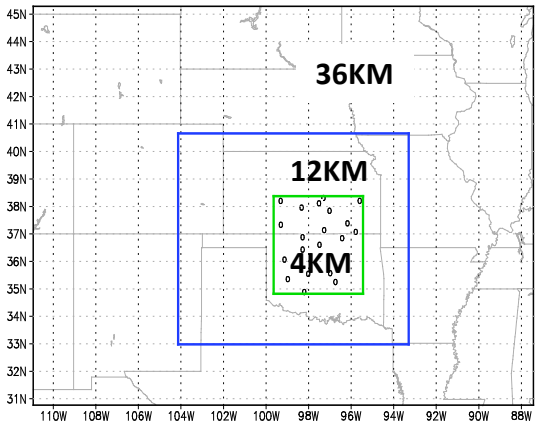


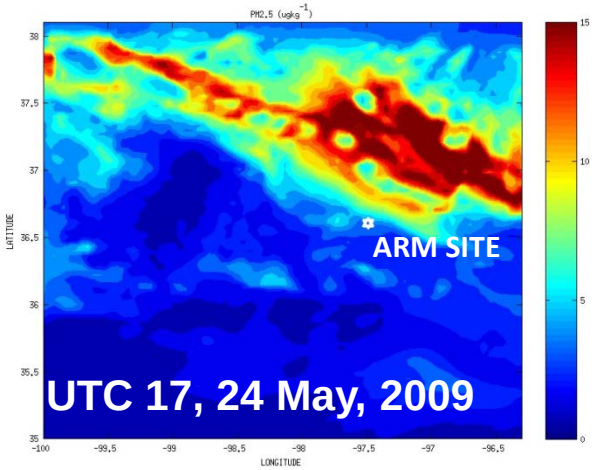
- **The subgrid component of moisture forcing is significant with a grid-size of 200 km**

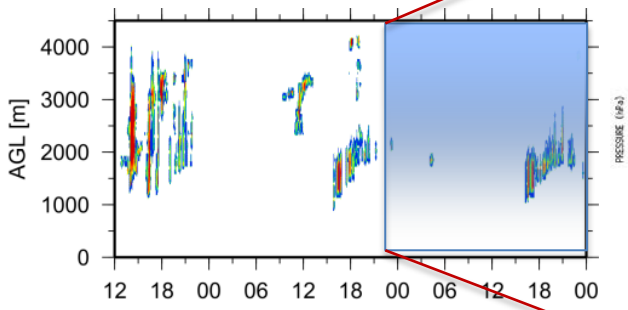


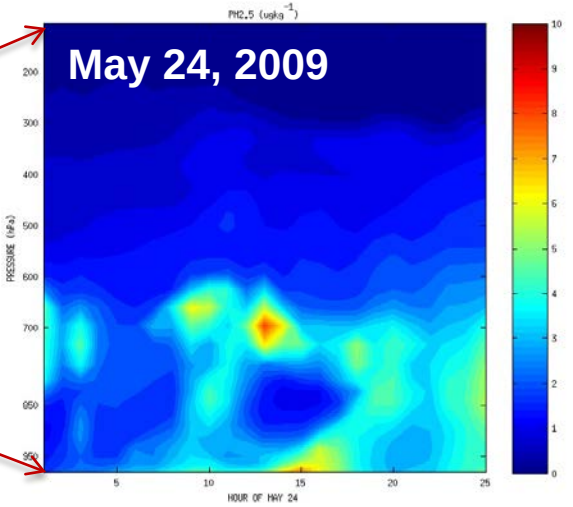
- **The significance of the subgrid component of moisture forcing increases with a smaller**

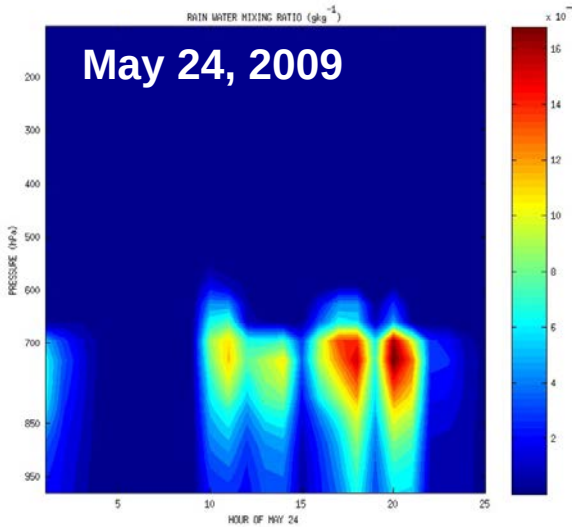
WRF/Chem Aerosol Simulation and Data Assimilation











High concentrations and complex spatial and temporal changes suggest a requirement on aerosol initialization and forcing

Impact of Hydrometeor Advection on CAM5-SCMs

With

Without

Difference