Single Column Model CAM5 Simulations Of RACORO Cumulus Clouds

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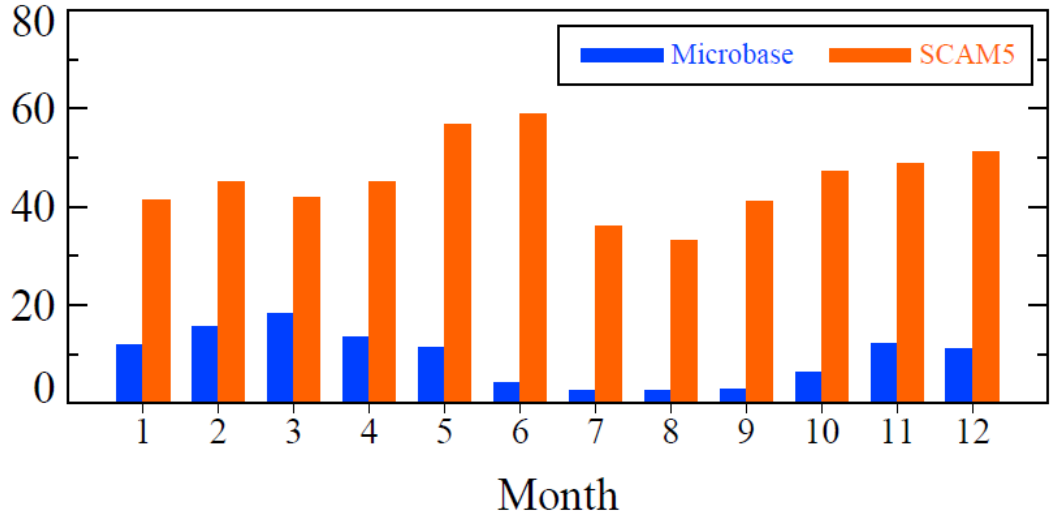
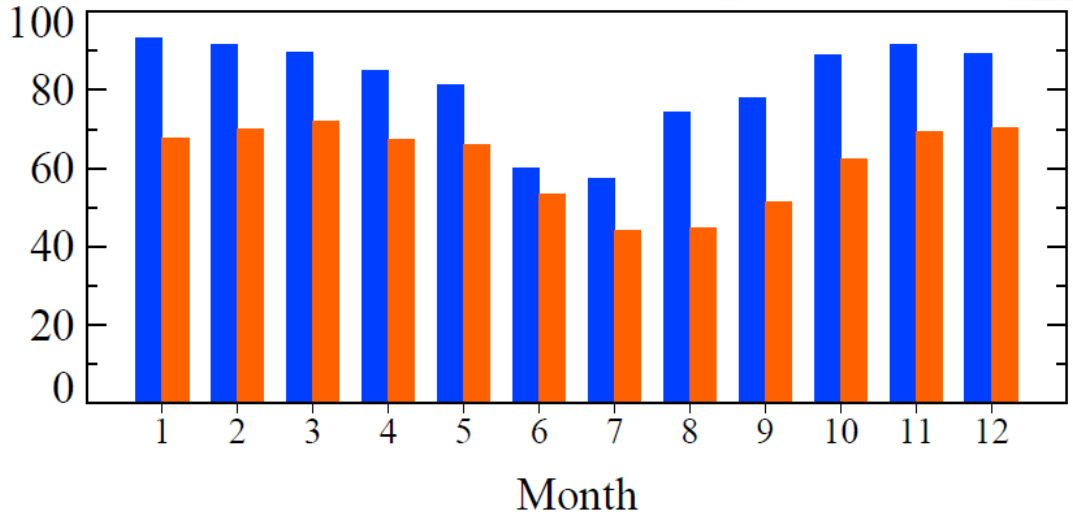
Climate Perspective: ISCCP & RACORO-like Clouds

Low-cloud Frequency

$CF_{low} > 10\%$
$CF_{mid} + CF_{high} < 10\%$



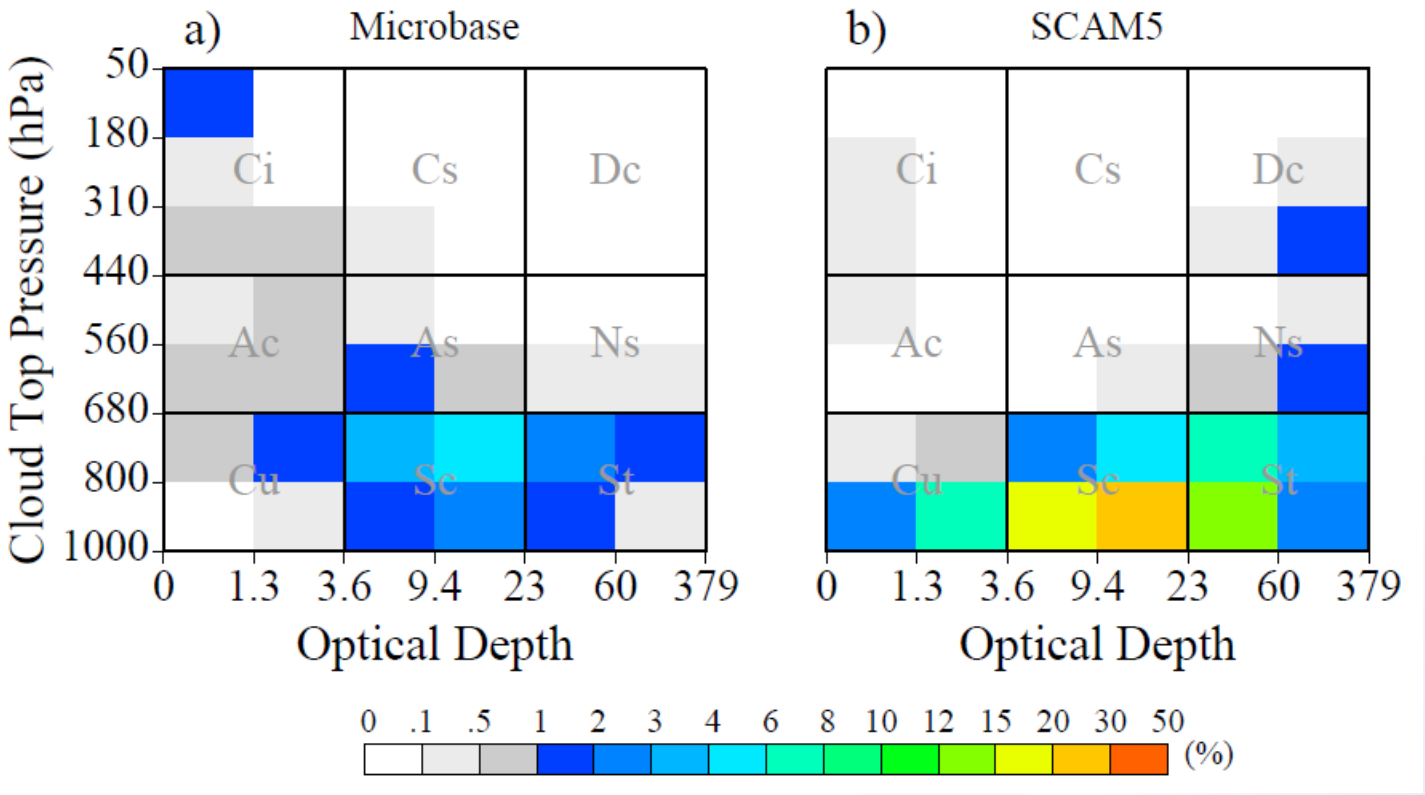
Low-cloud Intensity (%)



1999-2010 Climatology

ARM forcing (Xie et al. 2004) + ISCCP simulator (Klein and Jakob 1999)

Model RACORO-like Clouds Are Systematically Different



Warm season relative occurrence frequency of each cloud type regardless of its cloud amount.

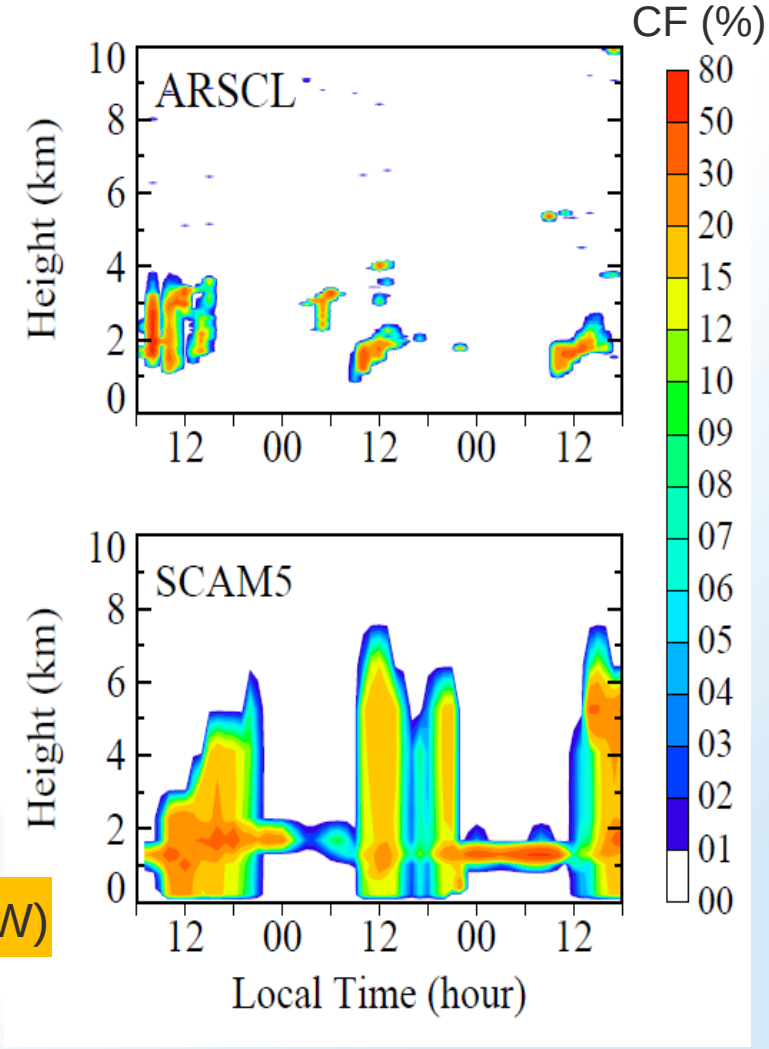
Single-Column Model CAM5 Investigation of RACORO Case 1

SCAM5 standard configuration driven by ARM forcing for reduced SGP domain (Δs=150 km, Δp=10 mb):

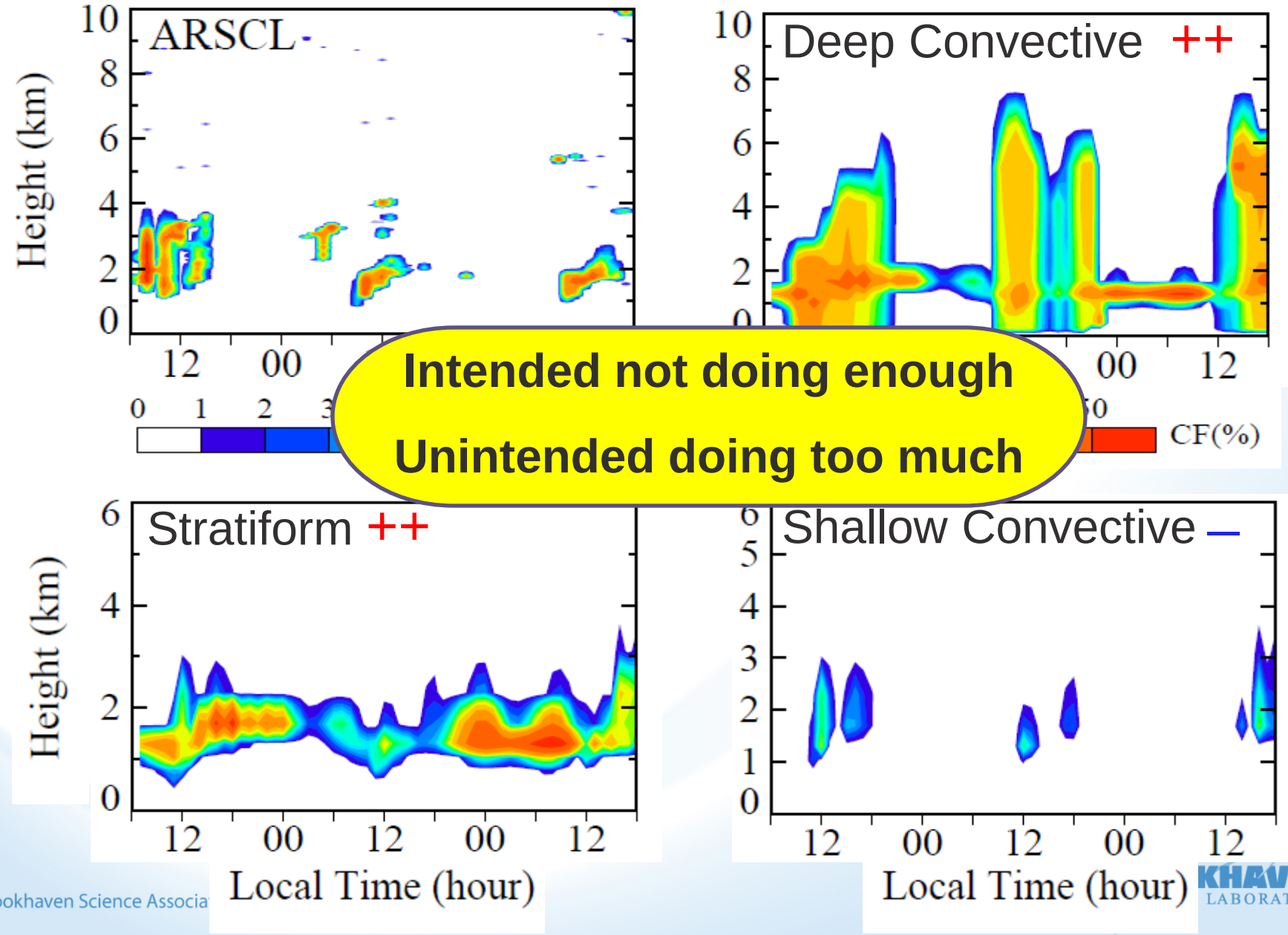
- Over-triggering of deep convection.
- Persistent night time PBL clouds (from stratiform cloud scheme)

Cloud producing model physics:

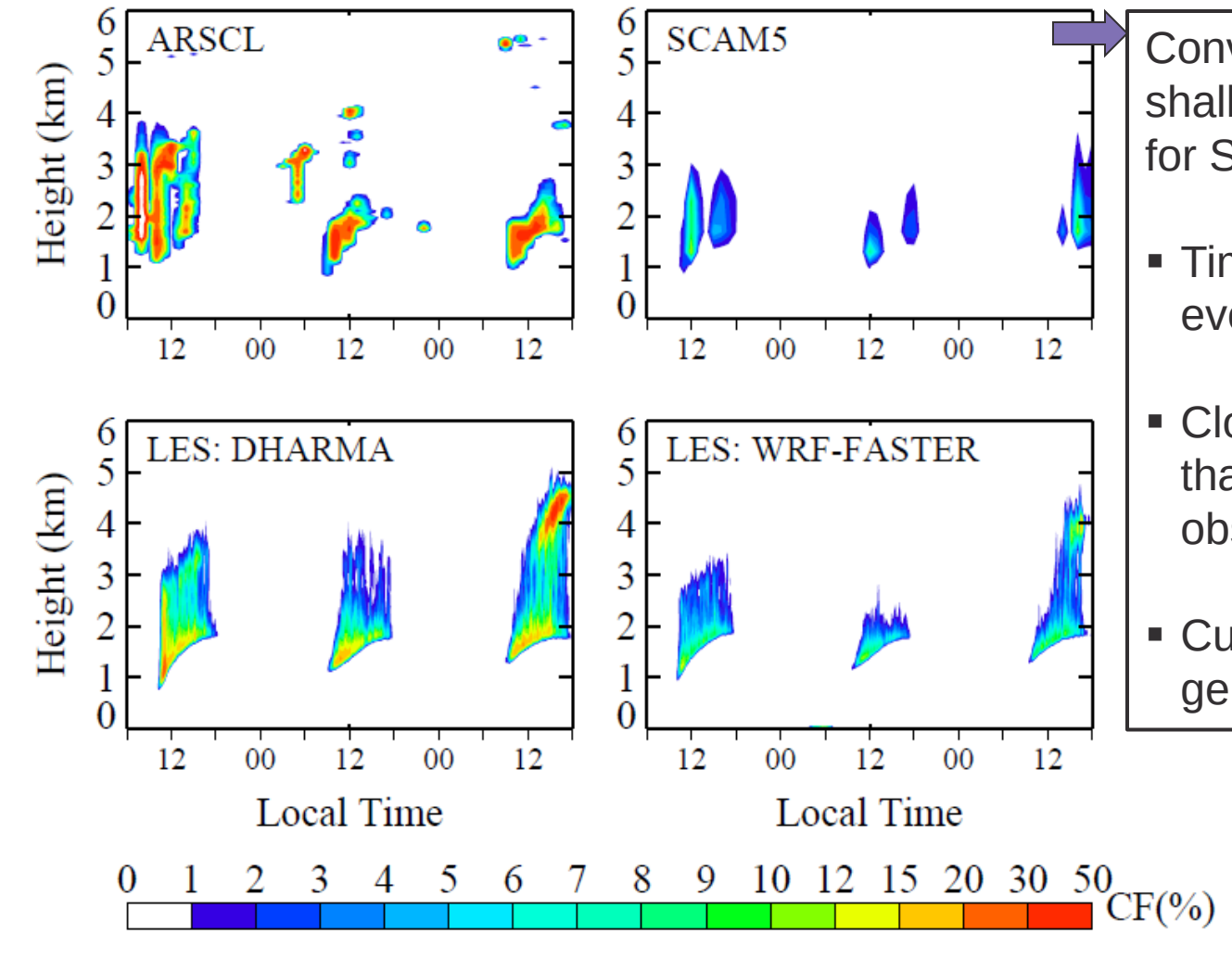
- Deep convection
- Stratiform (micro- & macro-physics)
- Shallow Convection + Moist Turbulence (UW)



SCAM5 Physics and Cloud Production



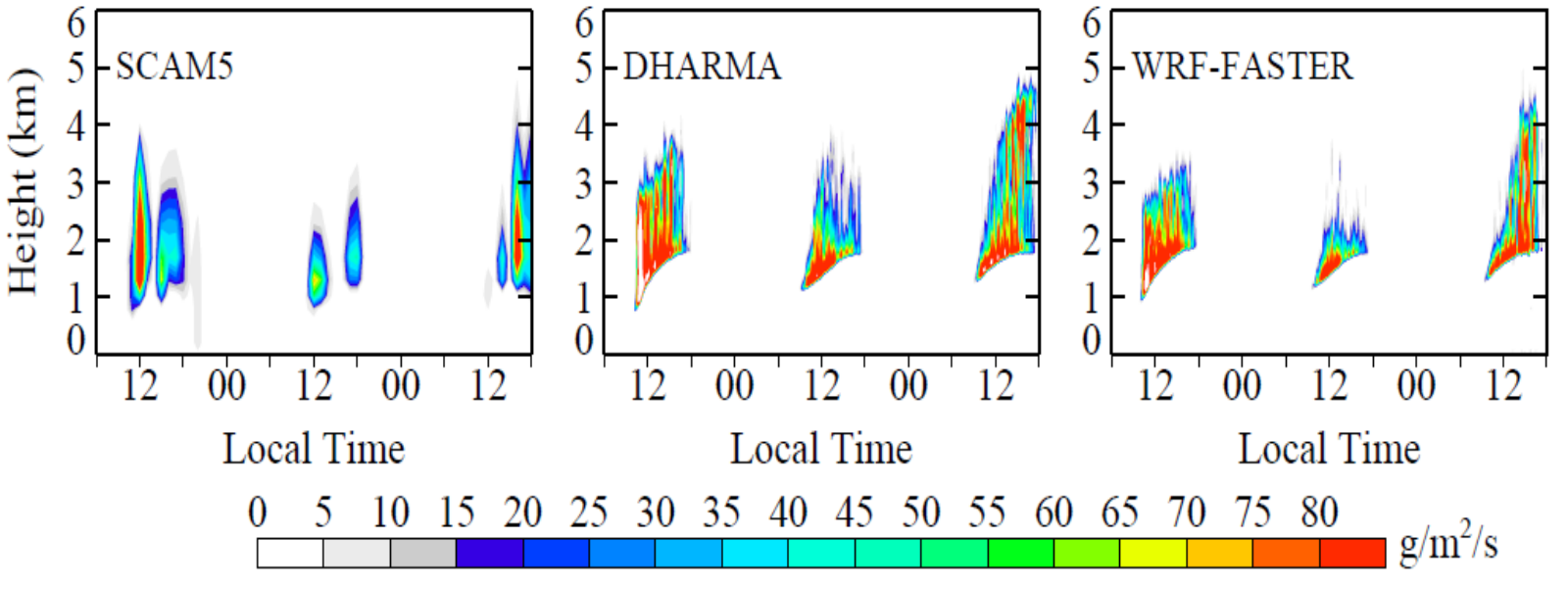
Comparison of shallow cumulus cloud production



Convective clouds by UW shallow cumulus scheme for SCAM5

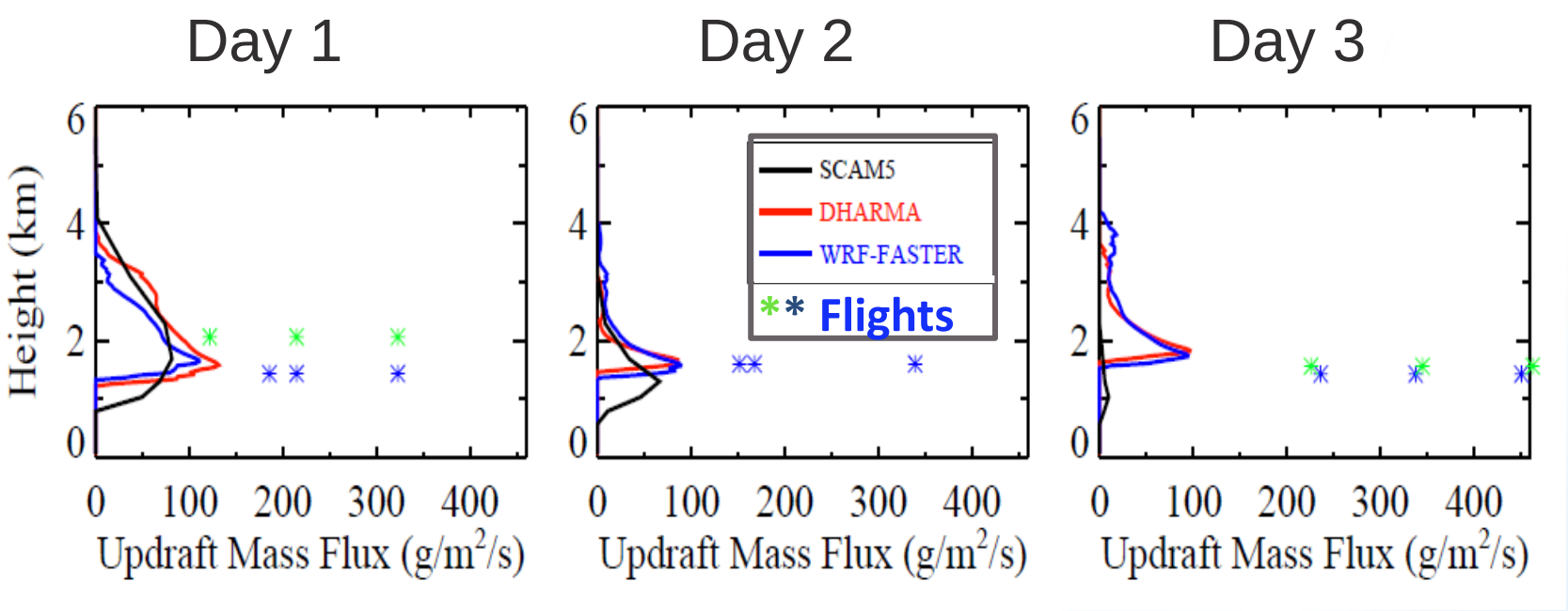
- Timing and temporal evolution reasonable.
- Cloud amount much less than LES simulations or observations.
- Cumulus cloud depth generally thinner.

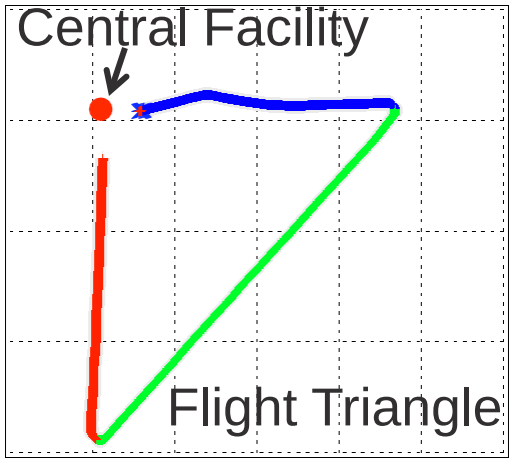
Cumulus mass fluxes from SCAM5 and LES



Cumulus activity in SCAM5 is much weaker than what the LES simulations consistently suggest.

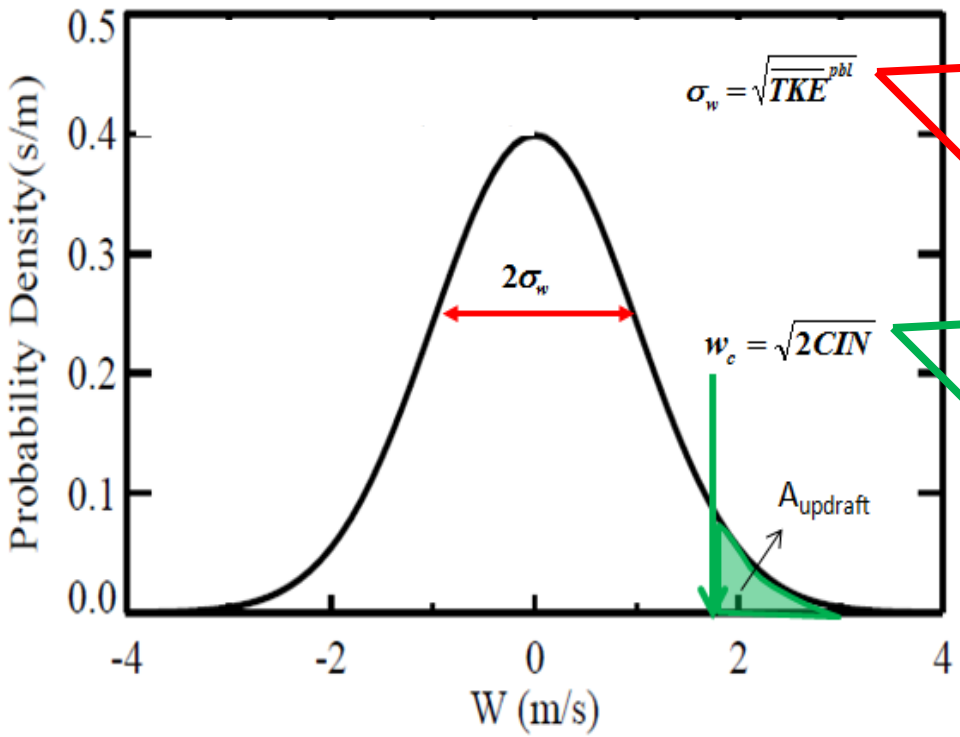
Cumulus Mass Fluxes from SCAM5, LES & Flights





Mean cumulus updraft mass flux between 11:30 AM and 1 PM local time.

UW Shallow Cumulus Scheme
Determination of convective updraft area at cloud base



PBL Mean TKE

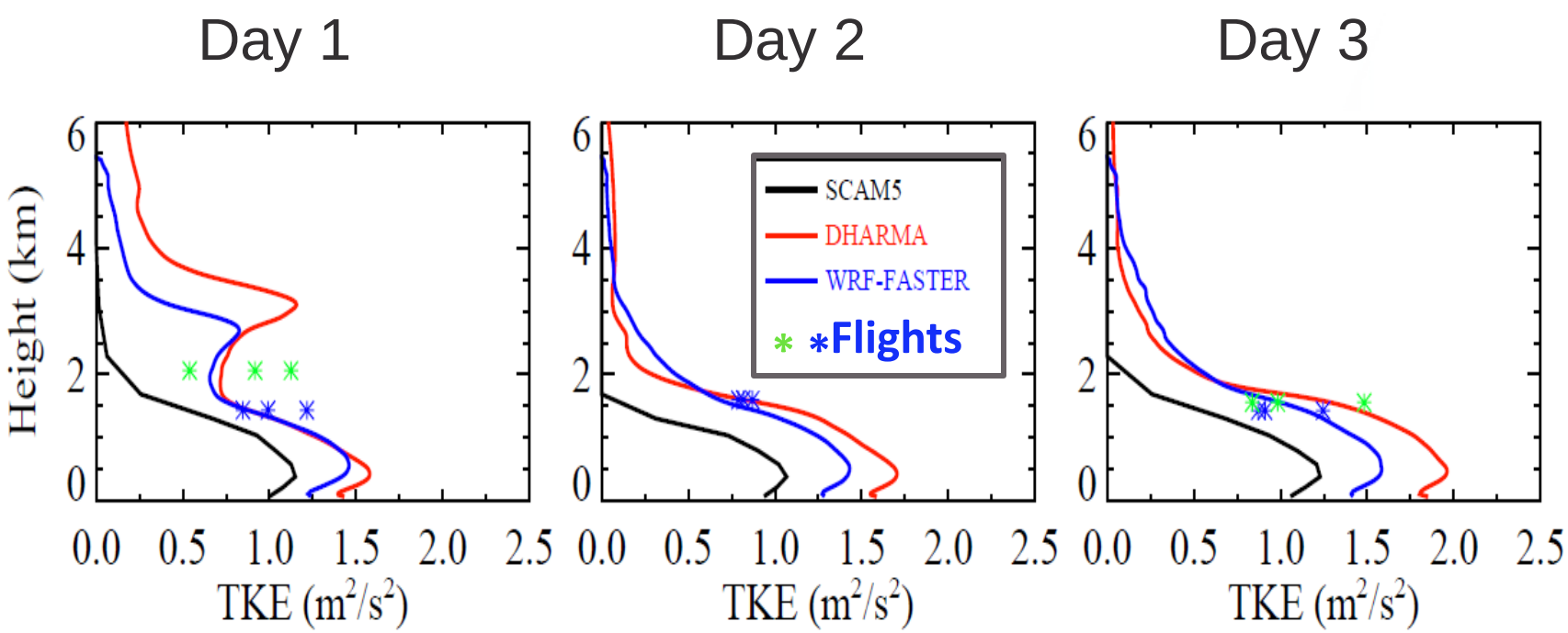
Width of w-pdf (Gaussian)

Convective Updraft Area

Weaker TKE → smaller updraft area, if all else being equal.

Relationship between PBL TKE, w-pdf, CIN, and convective updraft area in UWshcu.

Deficiency in SCAM5 PBL Turbulence & Impacts



TKE –

Cumulus activity –

P B L height –

Cu Ventilation –

Moisture trapped +

PBL Stratiform Clouds +

Summary of Error Attribution Guided by LES & Obs

Other than spurious deep convection

Weaker Turbulence & shallower PBL

↓

Narrower w-pdf

↓

Smaller Convective Updraft Area

↓

Weaker Cumulus convection *

↓

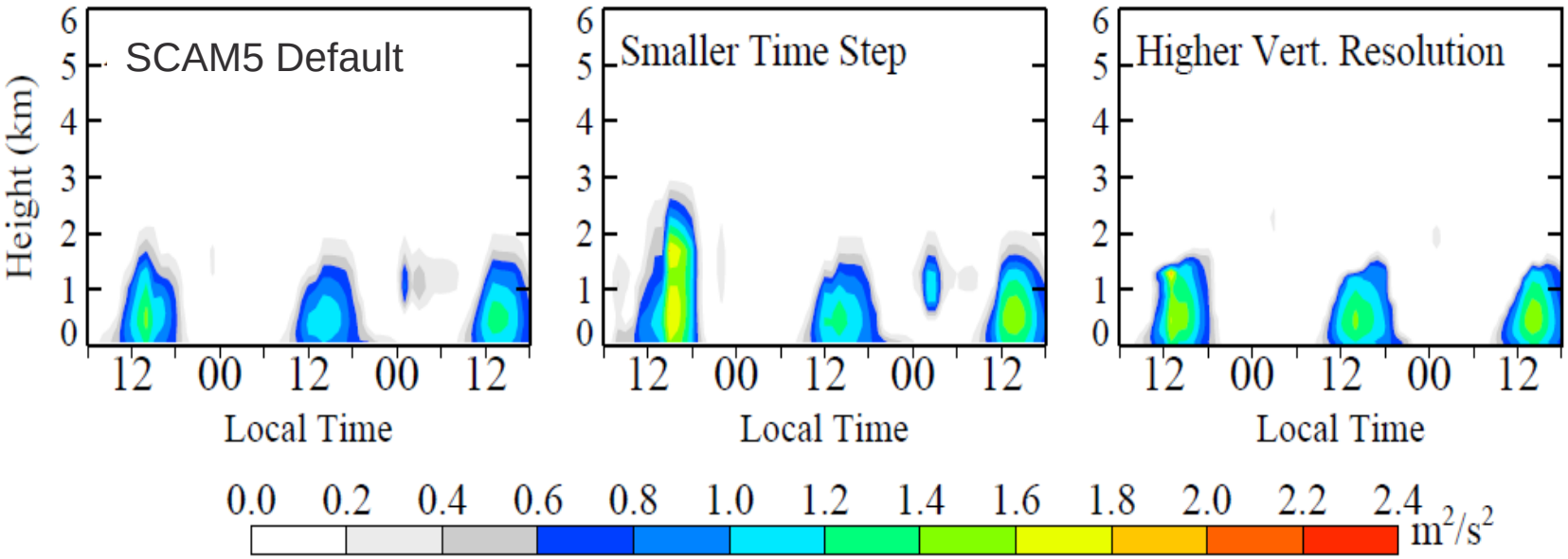
Weaker PBL ventilation

↓

More stratiform clouds (both day & night time)

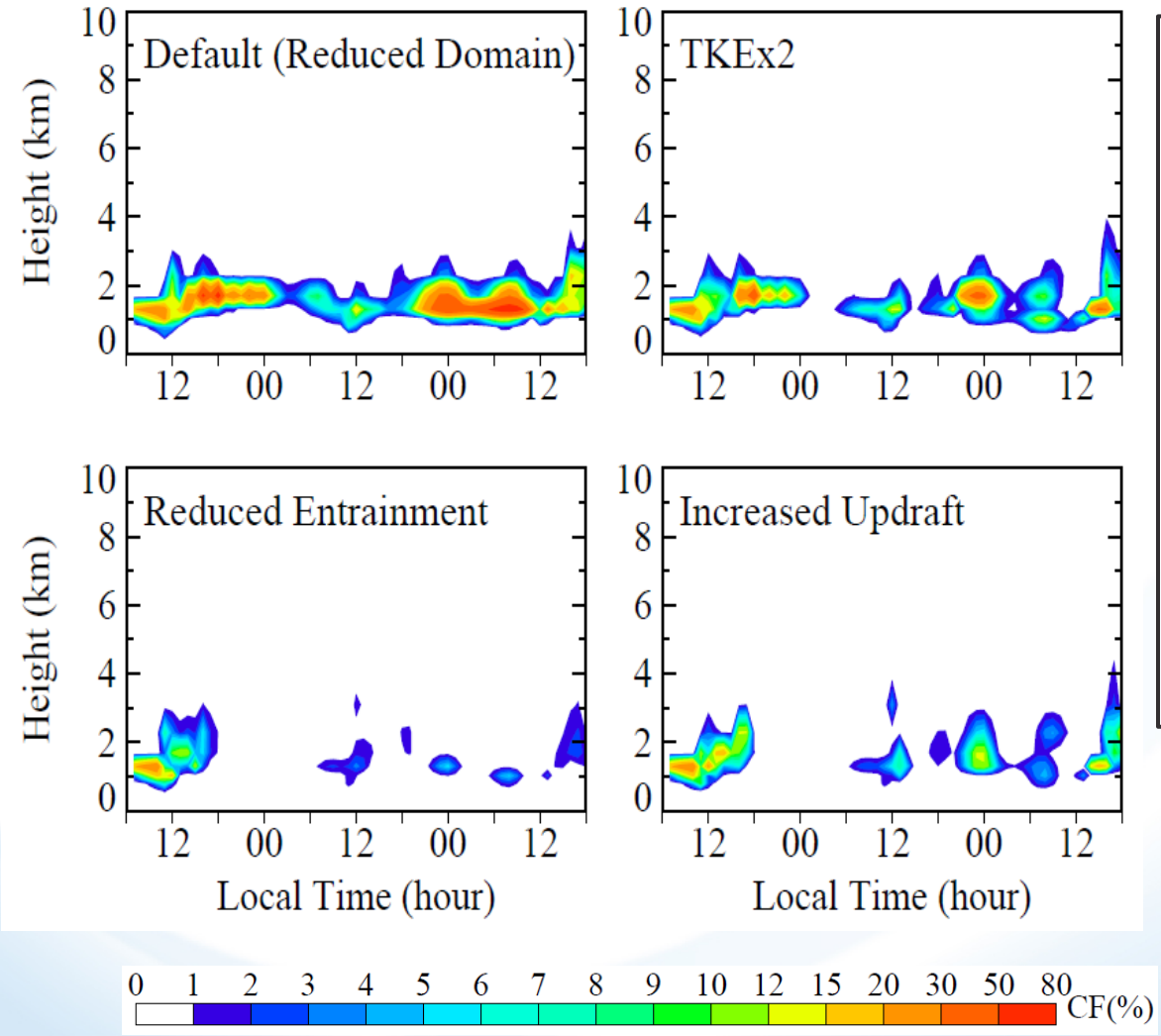
** Other factors, such as entrainment and max allowed updraft area in the UWshcu scheme also contribute to weaker cumulus activity*

Ways to improve the Simulations of PBL TKE



The existing PBL scheme in SCAM5 deliver improved results at higher horizontal and/or vertical resolutions (*e.g. application in* ***future models***).

Sensitivity experiments with the cumulus scheme and the impact of cumulus activity on PBL clouds



Overall model PBL clouds highly sensitive to shallow cumulus activities.

Sensitivity exps. suggest in SCAM5:

- Entrainment too strong.
- Updraft area too small