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Land-atmosphere coupling strength for locally generated convection regimes at the ARM SGP site

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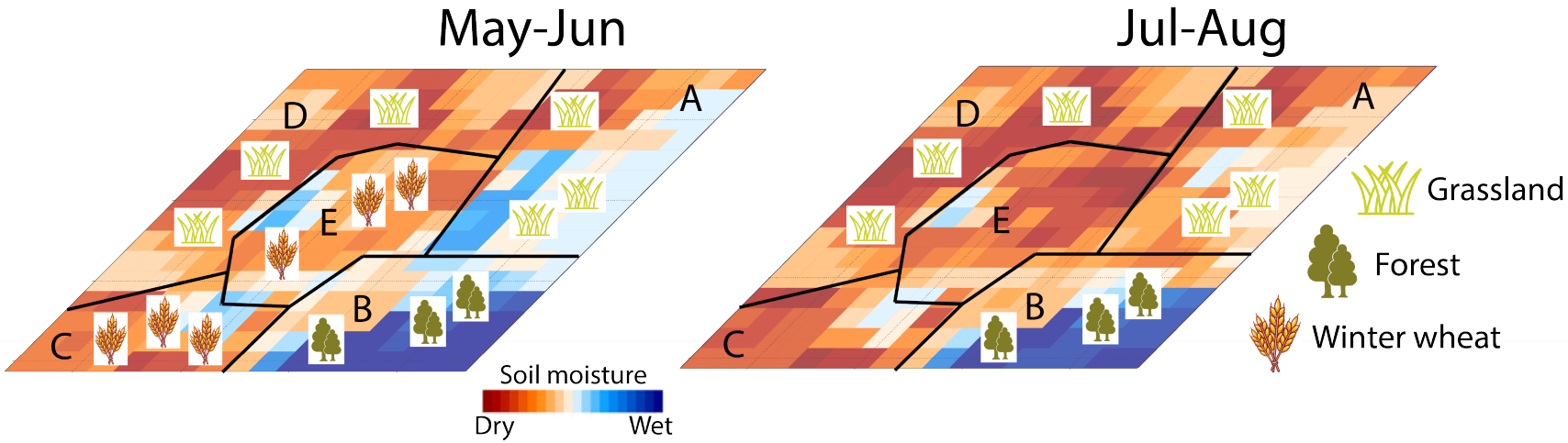
Introduction

- A discrepancy exists between models and observations on the strength of L-A coupling at the ARM SGP site.
- Using 10-yr warm season observational data, we found that:
  - ✓ Surface evaporation is relatively more important than moisture flux convergence (MFC) on local convective events.
  - ✓ For clear-sky regime, the control of land surface on the evolution of PBL is dependent on the vegetation leaf area index (LAI).
  - ✓ With similar soil conditions, the forest region shows a much higher cloud fraction on fair-weather shallow cumulus days than grassland region.



Tao et al. (2019) under revision in JGR-Atmosphere

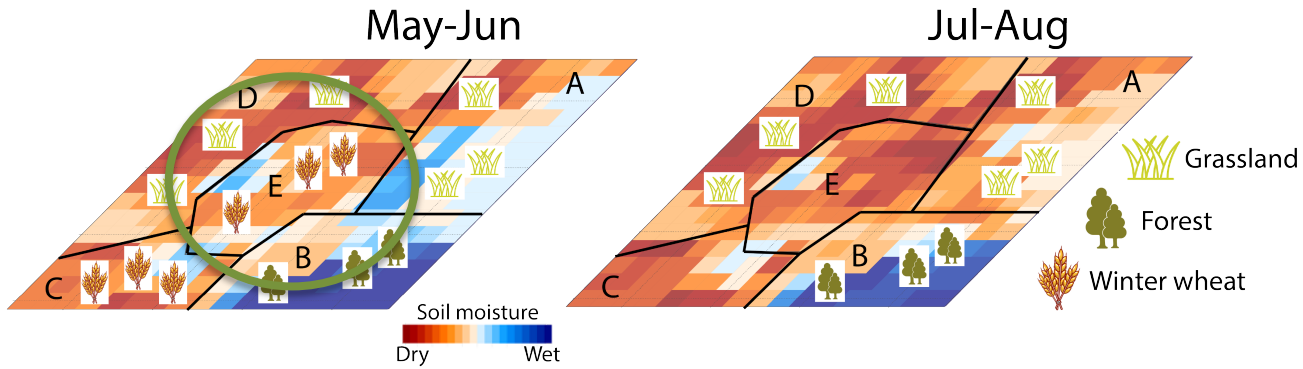
Introduction (cont.)

- ***Objective:*** *To make diagnosis on model deficiencies and to attribute model biases to parameterized processes.*
- Dataset:

Observations at the ARM SGP site
- ARM continuous forcing data (VARANAL)
- ARM Best Estimate (ARMBE)
- 915-MHz Radar Wind Profiler (RWP)
- Balloon-Borne Sounding System (SONDE)

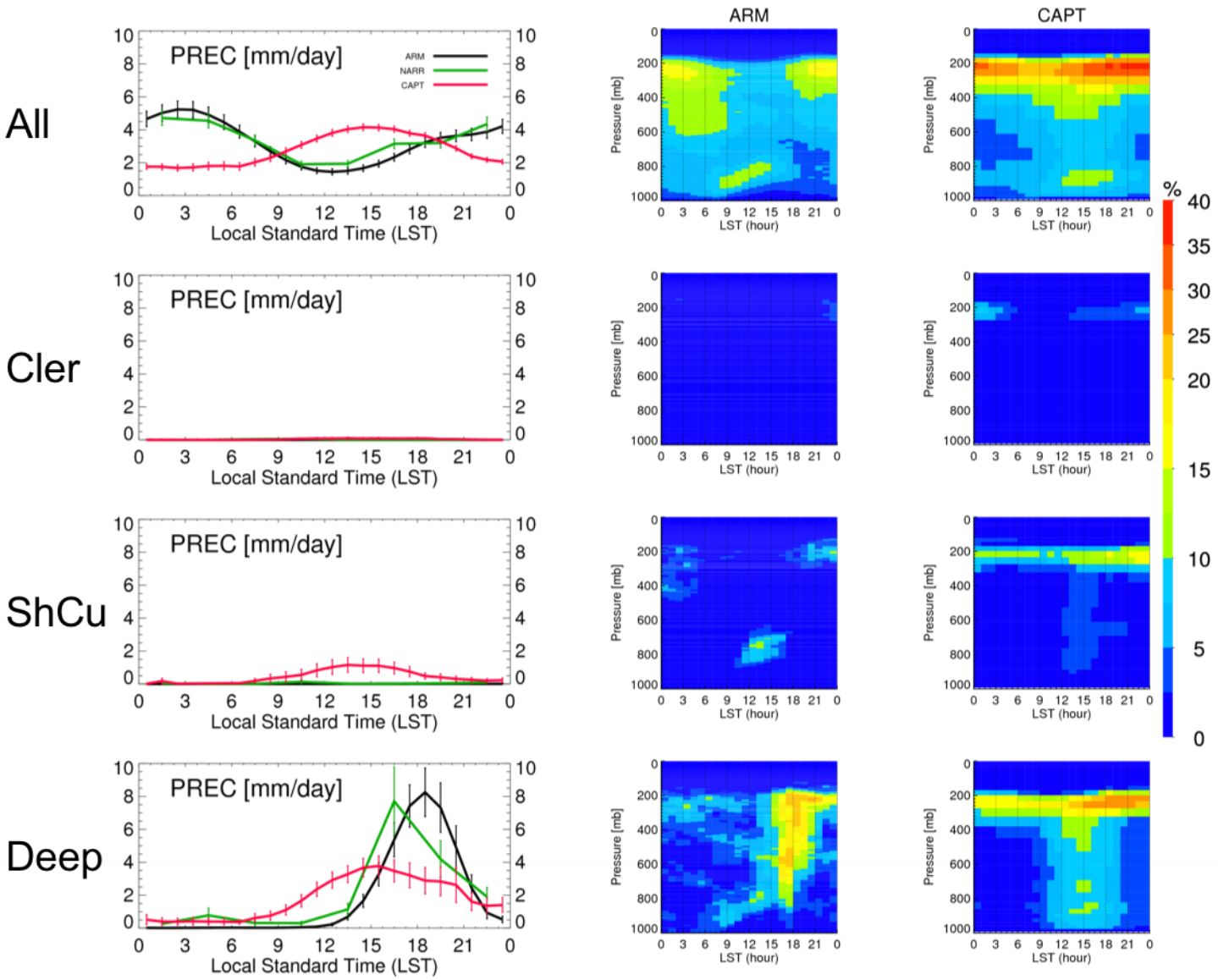
NARR (North American Regional Reanalysis)
- 3-h temporal and 32-km horizontal resolution
- Developed with Eta model (2003 version) and 3DVAR technique
- With precipitation data assimilated

CAPT (Cloud-Associated Parameterizations Testbed)
- A technique to diagnose the contribution of fast physical processes in the atmosphere to long-term errors in climate simulations
- CAM5.1/CLM4 coupled system run in a controlled hindcast configuration
- The 3D fields of atmospheric prognostic dynamic and thermodynamic state variables from ERA-Interim Reanalysis were initialized at the beginning of each simulation day.



CAPT model simulations (CAM5.1)
- Radiative transfer scheme
- Shallow convective parameterizations (Park and Bretherton, 2009)
- Deep convective parameterizations (Zhang and McFarlane, 1995)
- PBL and associated moist turbulence scheme (Bretherton and Park, 2009)
- Cloud physics and microphysics schemes (Morrison and Gettelman, 2008)
- Prognostic aerosol scheme (Liu et al. 2012)

Diurnal cycle of domain-average precipitation and cloud fraction



All (warm-season, MJJA)

- Diurnal precipitation peaks around noon
- Greater high-level clouds

Clear-sky regime

- Overall performance is pretty good

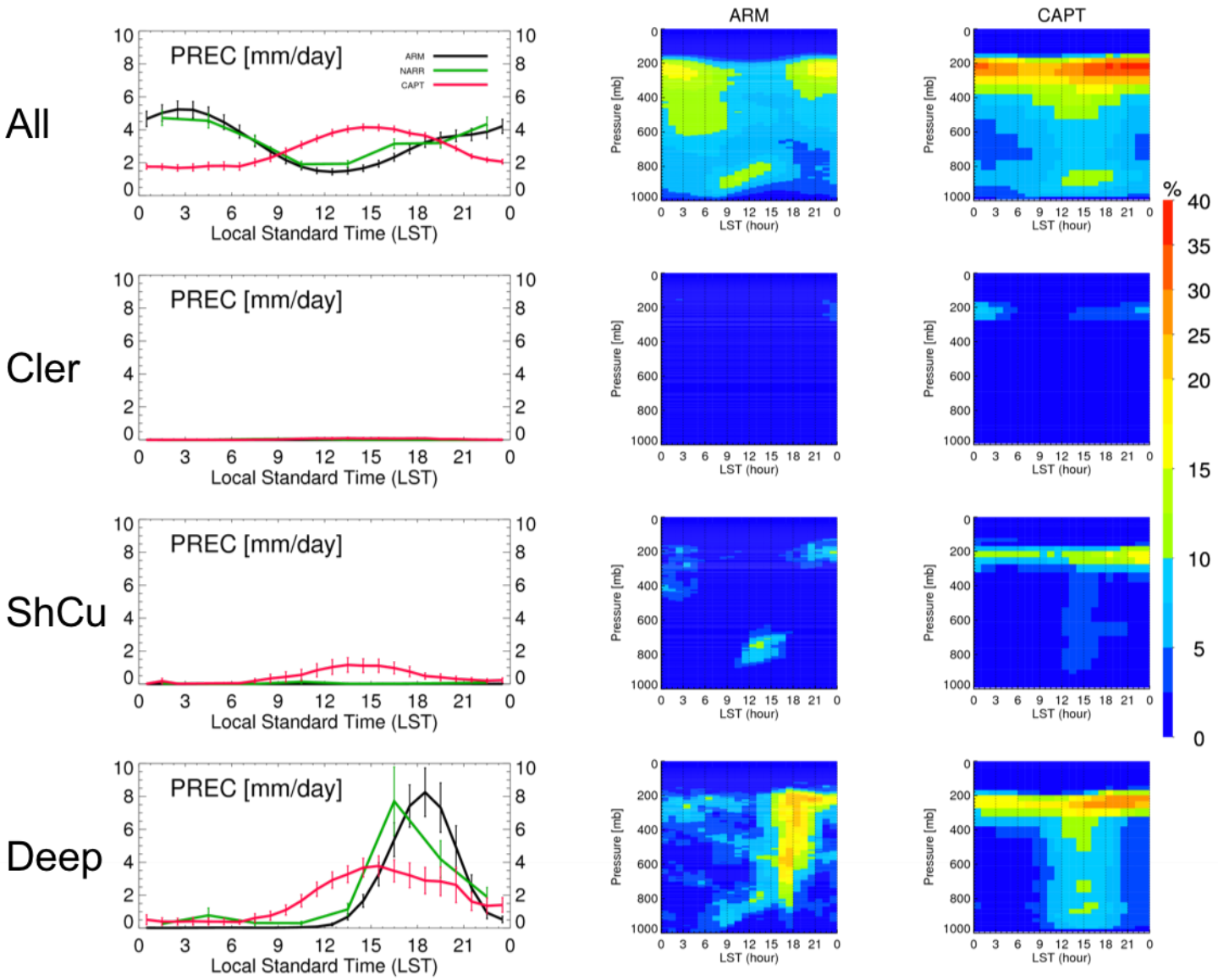
ShCu regime

- Precipitation peaks ~ 1 mm/day
- Less low-level clouds, but more high-level clouds

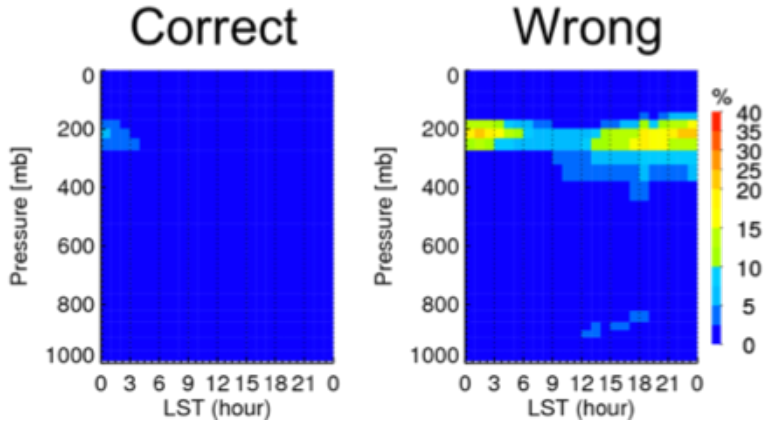
Late-afternoon deep convection regime

- Precipitation starts earlier, but with a lower maximum rain rate
- No shallow-to-deep transition

Diurnal cycle of domain-average precipitation and cloud fraction



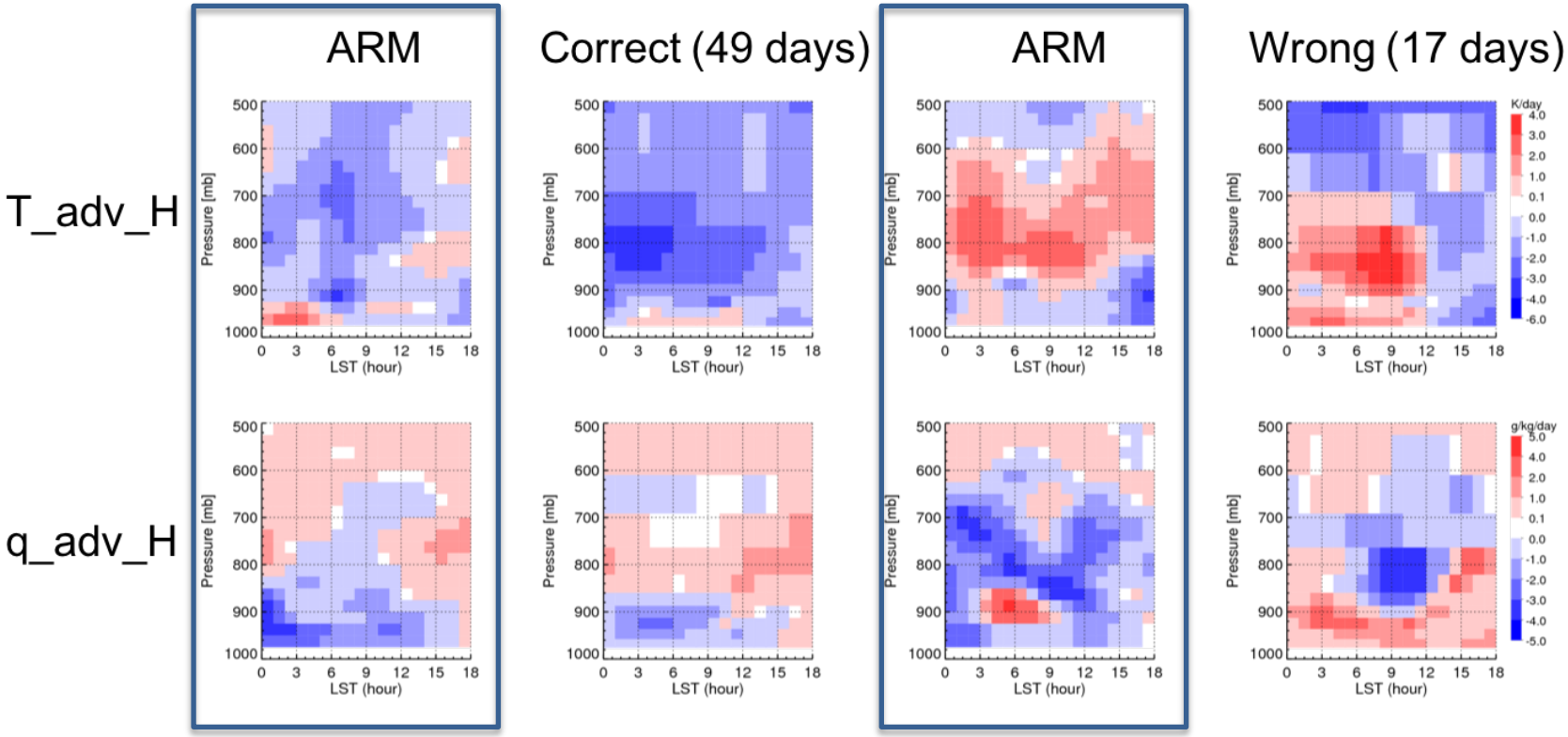
CAPT: classification of “correct” and “wrong”

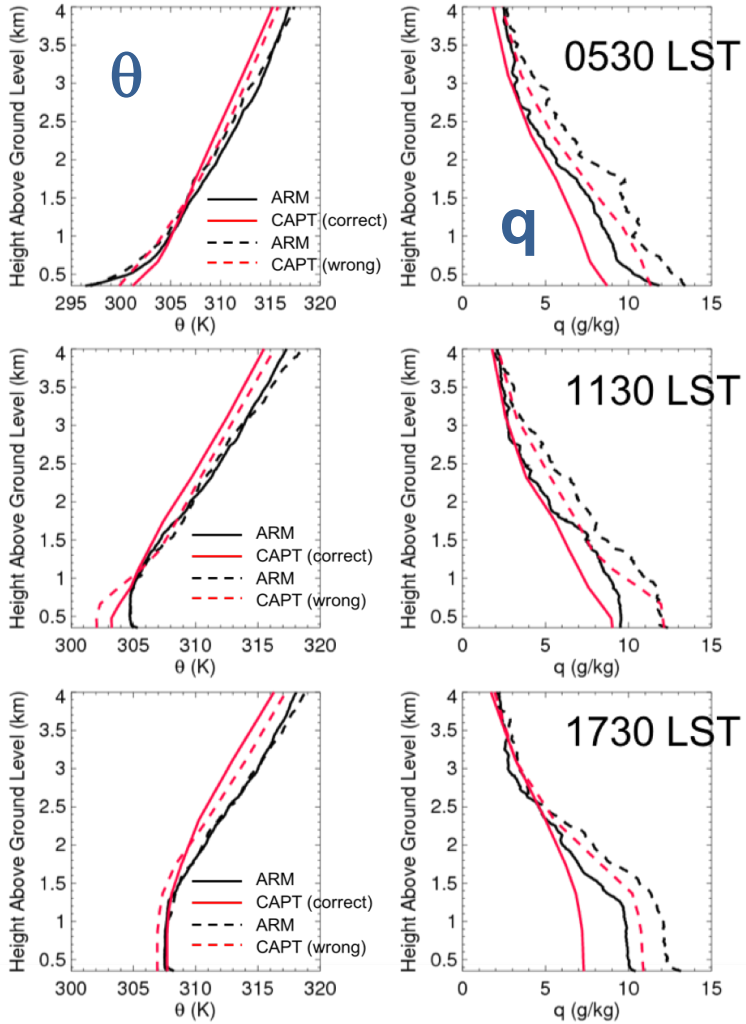


Clear-sky regime:

- 49/66 days (74%) are identified as clear-sky regime in CAPT
- “Wrong” cases are mainly attributed to days with precipitation, where the ZM-scheme is triggered

CAPT clear-sky regime: “wrong” cases



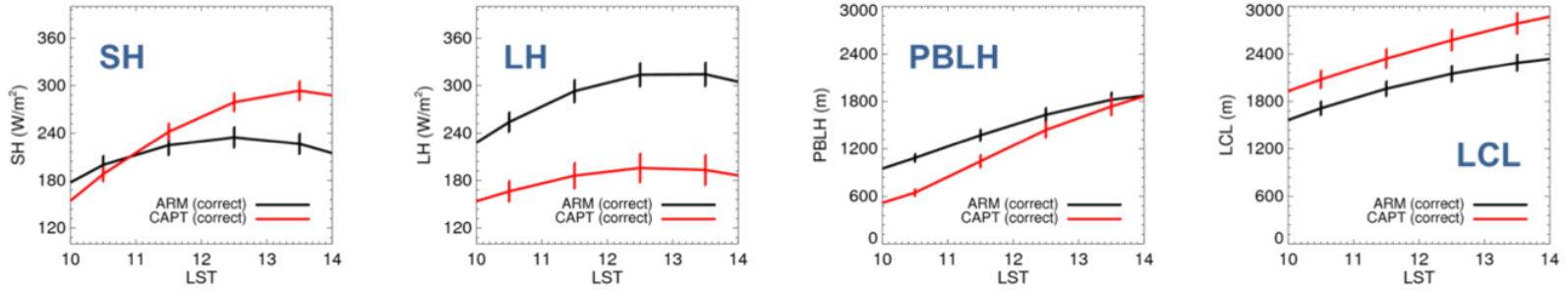


“Wrong” cases in CAPT

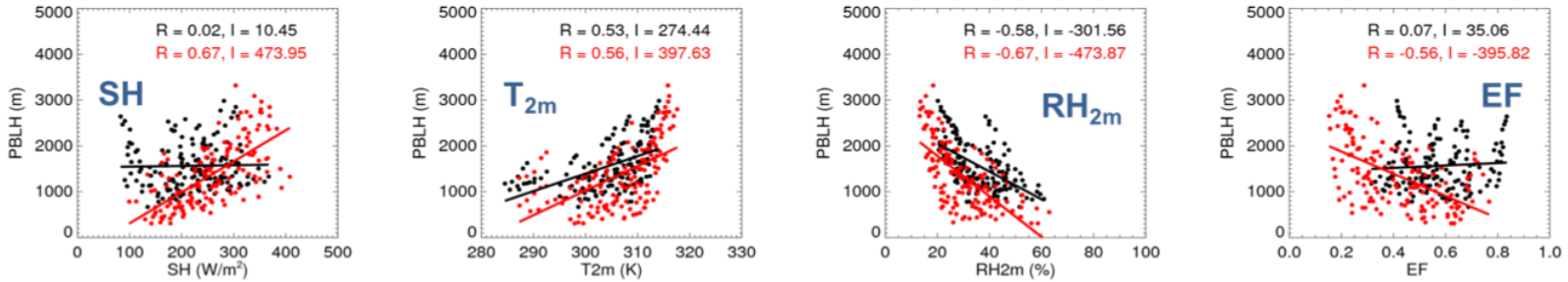
- Tend to occur on days when there is a warming and moistening in the early morning
- Exhibit more moisture at the near surface

CAPT clear-sky regime: “correct” cases

Variation of SH, LH, PBLH and LCL from 10 to 14 LST

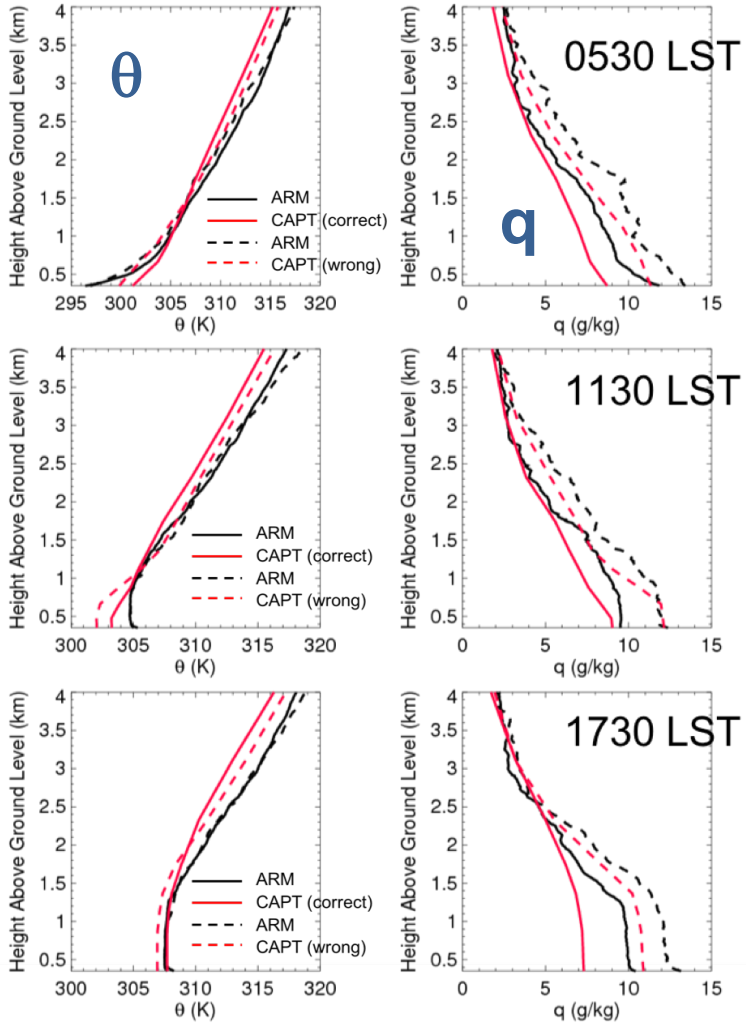


Scatterplot of PBLH vs. SH, T_{2m}, RH_{2m} and EF



“Correct” cases in CAPT

- A well-mixed layer at 1130 LST, but is much lower than that from observations.
- The mixed layer has deepened, warmed and dried by 1730 LST.
- A much stronger L-A coupling strength



Summary and future work

CAPT model simulation

"Correct" cases of clear-sky regime

- A much lower PBLH at 1130 LST → the growth of PBLH is slower
- PBLH is correlated with surface sensible heat flux and evaporative fraction → a much stronger L-A coupling strength

"Wrong" cases of clear-sky regime

- 13 out of 66 clear-sky days in CAPT simulations have daytime precipitation, where the ZM-scheme is triggered.
- A warming and moistening in the early morning is noted in these days, accompanied with a much larger relative humidity profile.

Ongoing work

- L-A coupling in local convection regimes will also be evaluated in the E3SM regional refined model (RRM, with 25 km space resolution).

POSTER: Section B1, Wednesday 3:30-5:00, Number 25