Correspondence between short and long timescale systematic errors in CAM4/CAM5 explored by YOTC data

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In collaboration with

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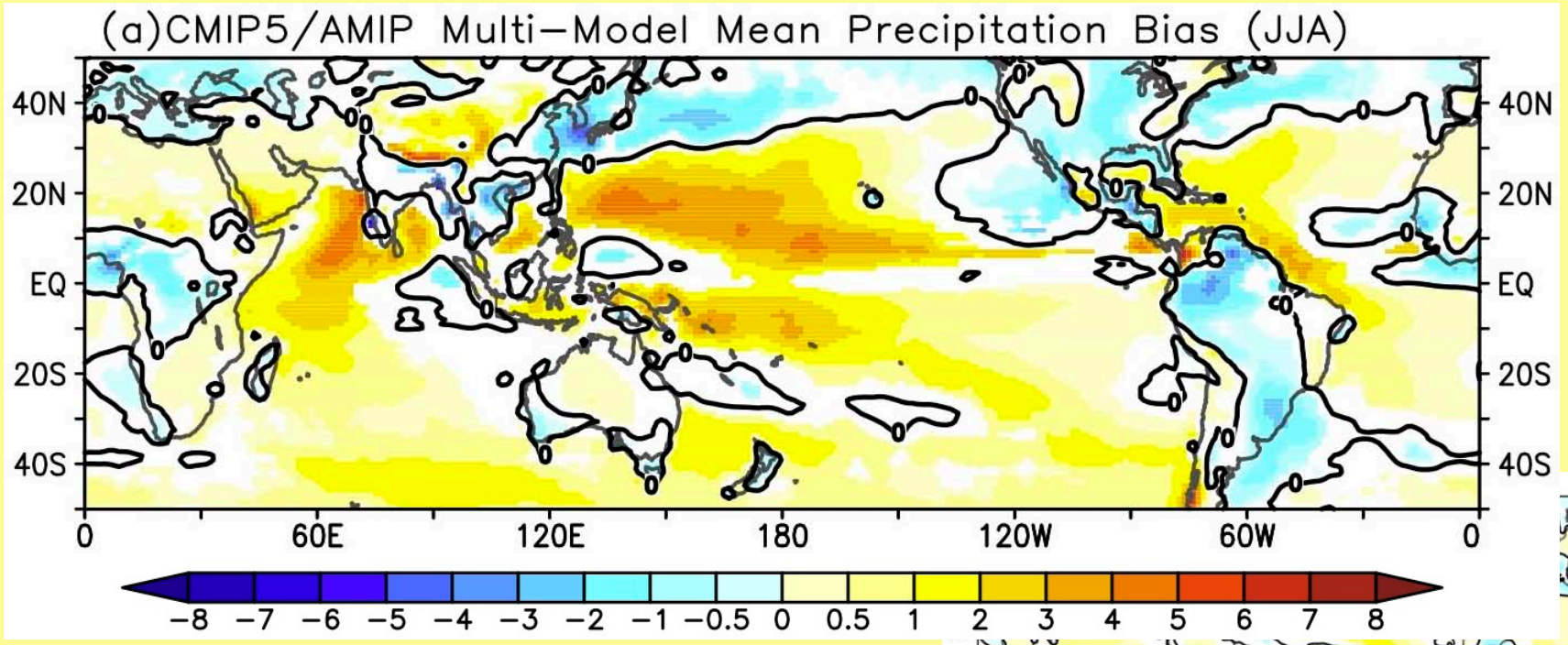
Motivation

- Climate model biases are examined through the Cloud-Associated Parameterizations Testbed (CAPT) approach: A numerical weather prediction technique to evaluate parameterizations of sub-grid scale processes in climate models: To determine their initial drift from the observations.

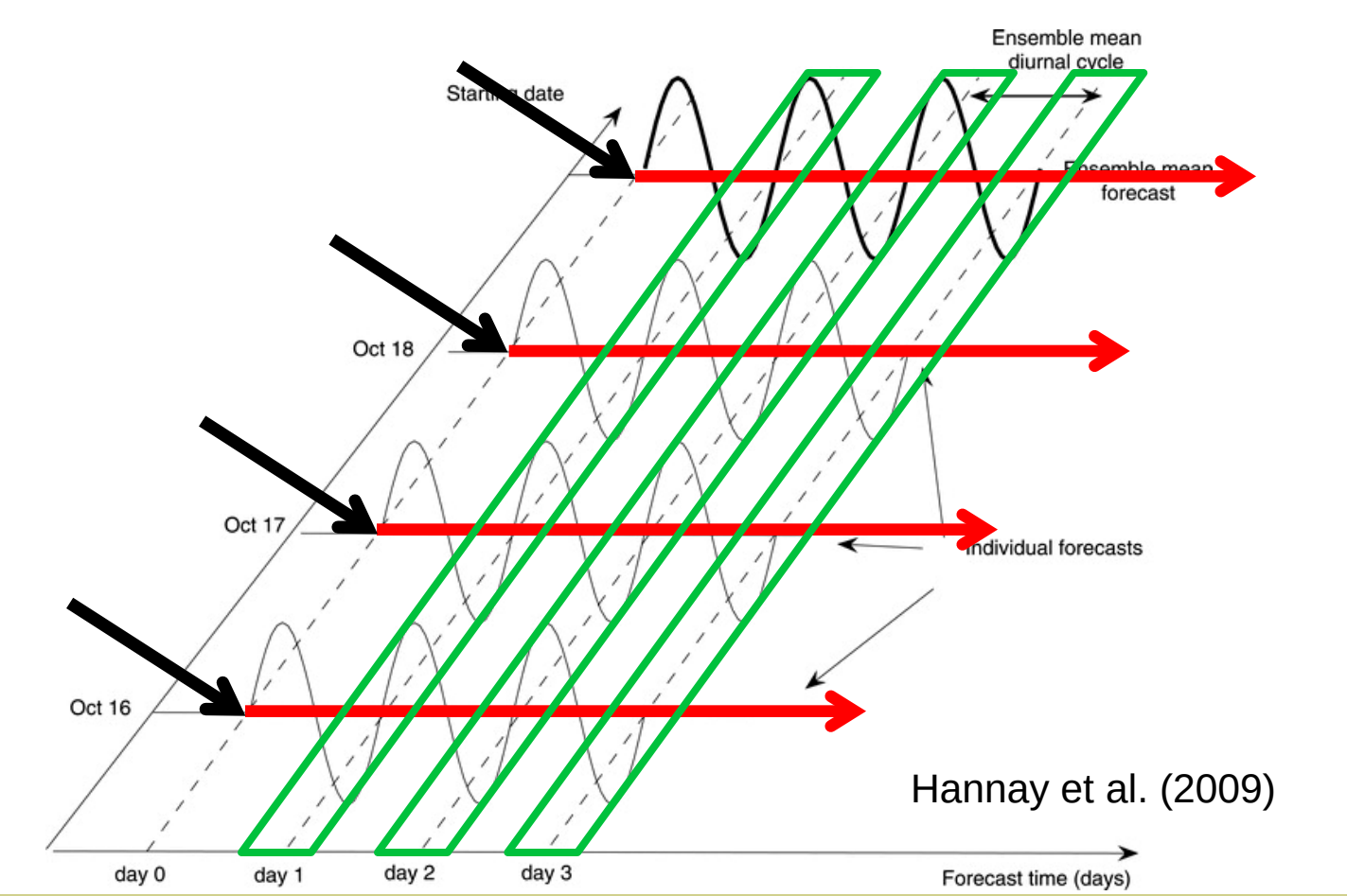


Experiments and Reference Data Sets

- Model:
  - NCAR Community Atmosphere Model, version 4 & 5
- Experiments:
  - Forecast runs (CAPT): Day 1 – Day 6 (during YOTC period)
    - Initialized with ECMWF analysis and prescribed with weekly observed SST
  - Climate run (AMIP): 2008 – 2010 with prescribed weekly SST
- Observational Data Sets:
  - TRMM & GPCP precipitation; CERES Radiation; CALIPSO cloud fractions (comparing with CAM CALIPSO simulator); ECMWF analysis data

CAPT Approach

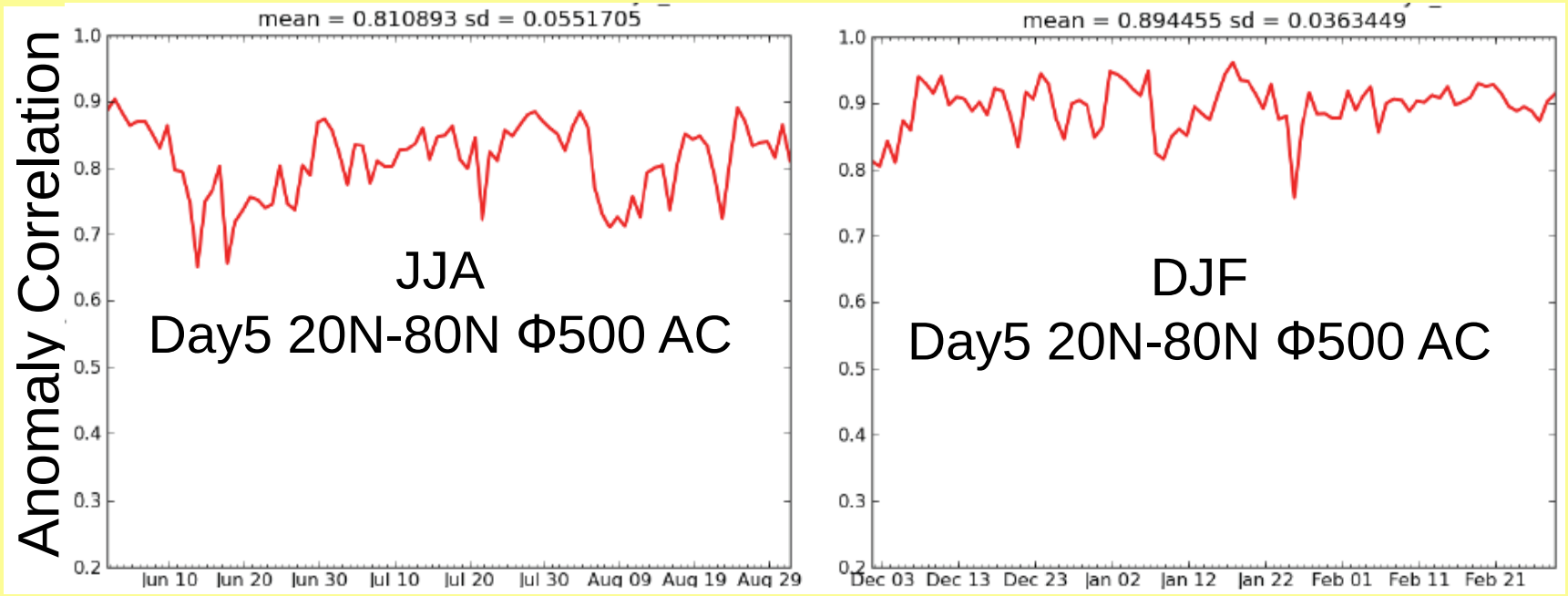
Initial Conditions: ECMWF Analysis → **NCAR Community Atmosphere Model** → **6 days forecast**

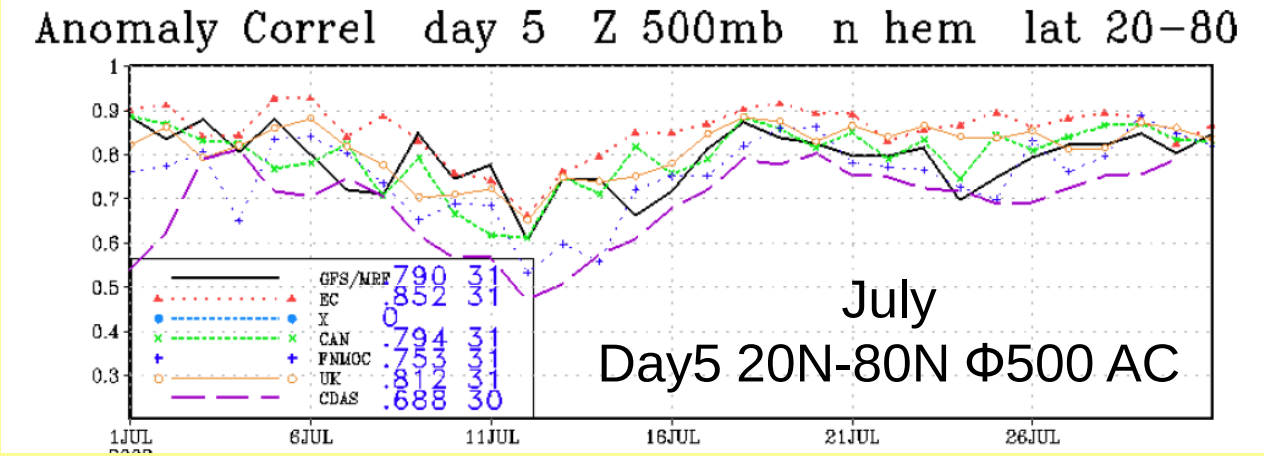


Hannay et al. (2009)

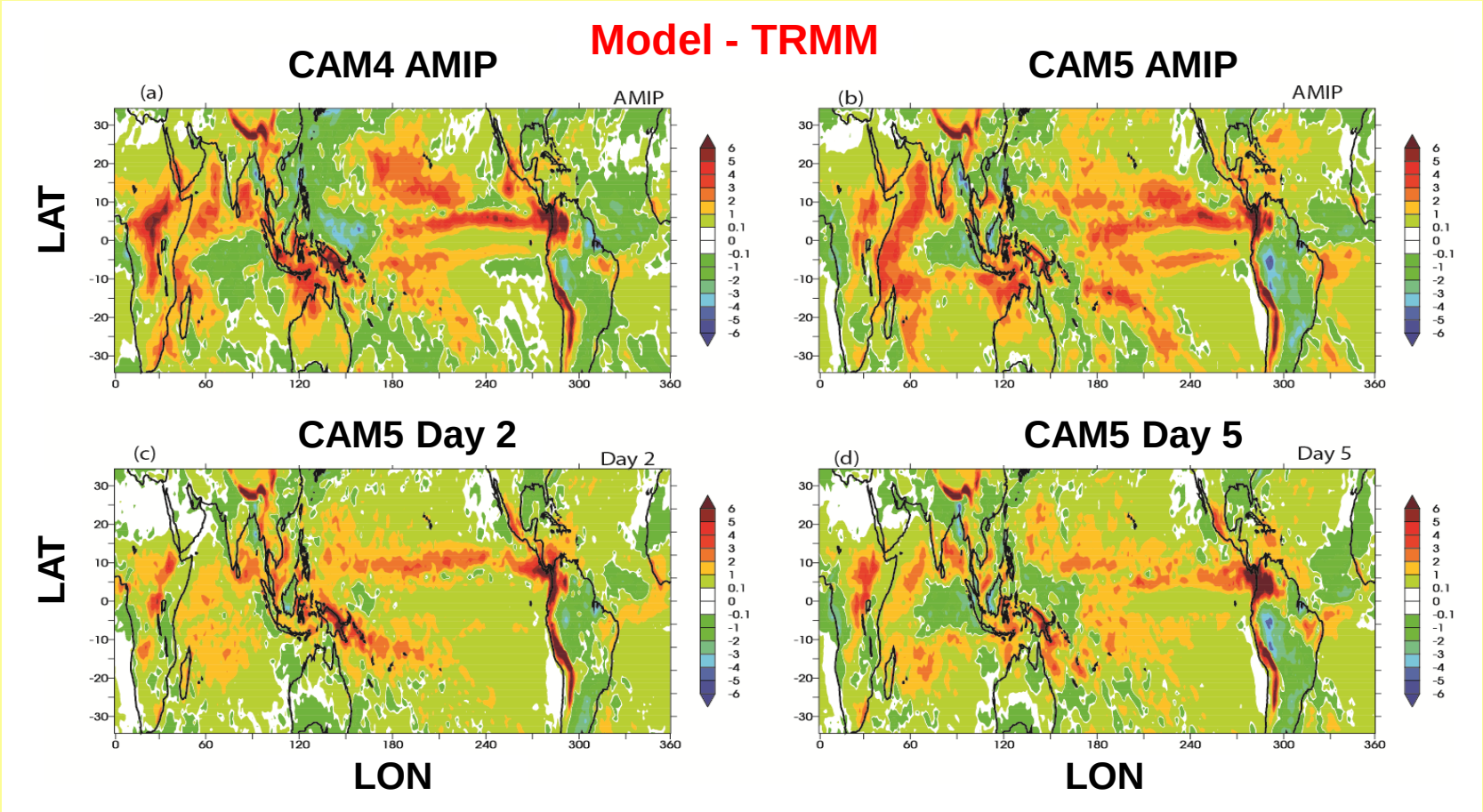
CAM5 Forecast Skill

The values are comparable to those achieved by the major forecast centers.





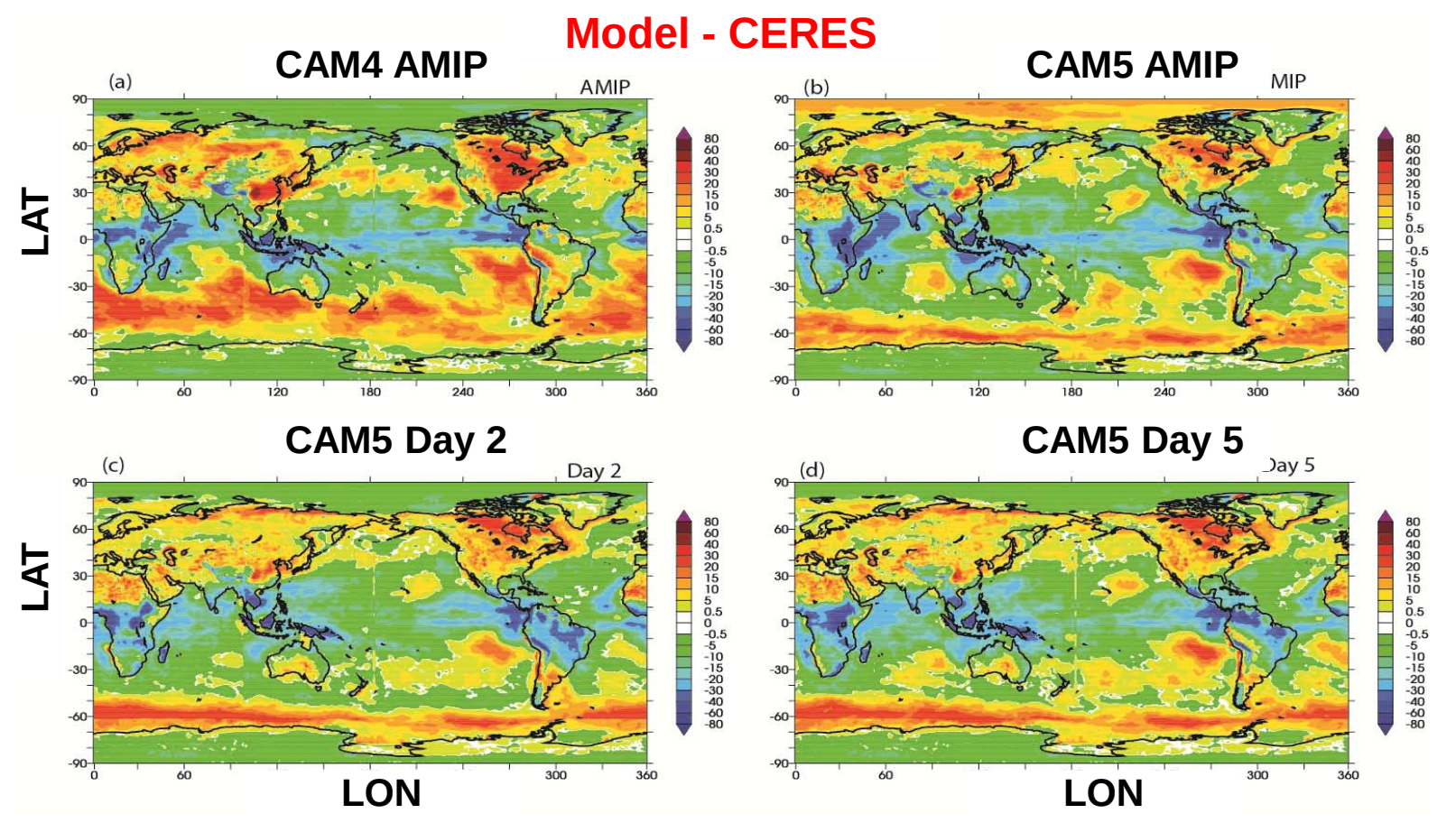
ANN Tropical Precipitation



- CAM5 vs. CAM4 → remarkably similar (bias is less stronger in CAM5)
  - Excessive Pr much of the Tropics; Double ITCZ / Less Pr over the joint area of Indian Ocean, marinetime continent, and western Pacific
- Climate vs. Forecast → less strong but most remarkably similar. Some errors are not clear in Day 2 forecasts (e.g., Double ITCZ)

Xie et al. (2012) in preparation

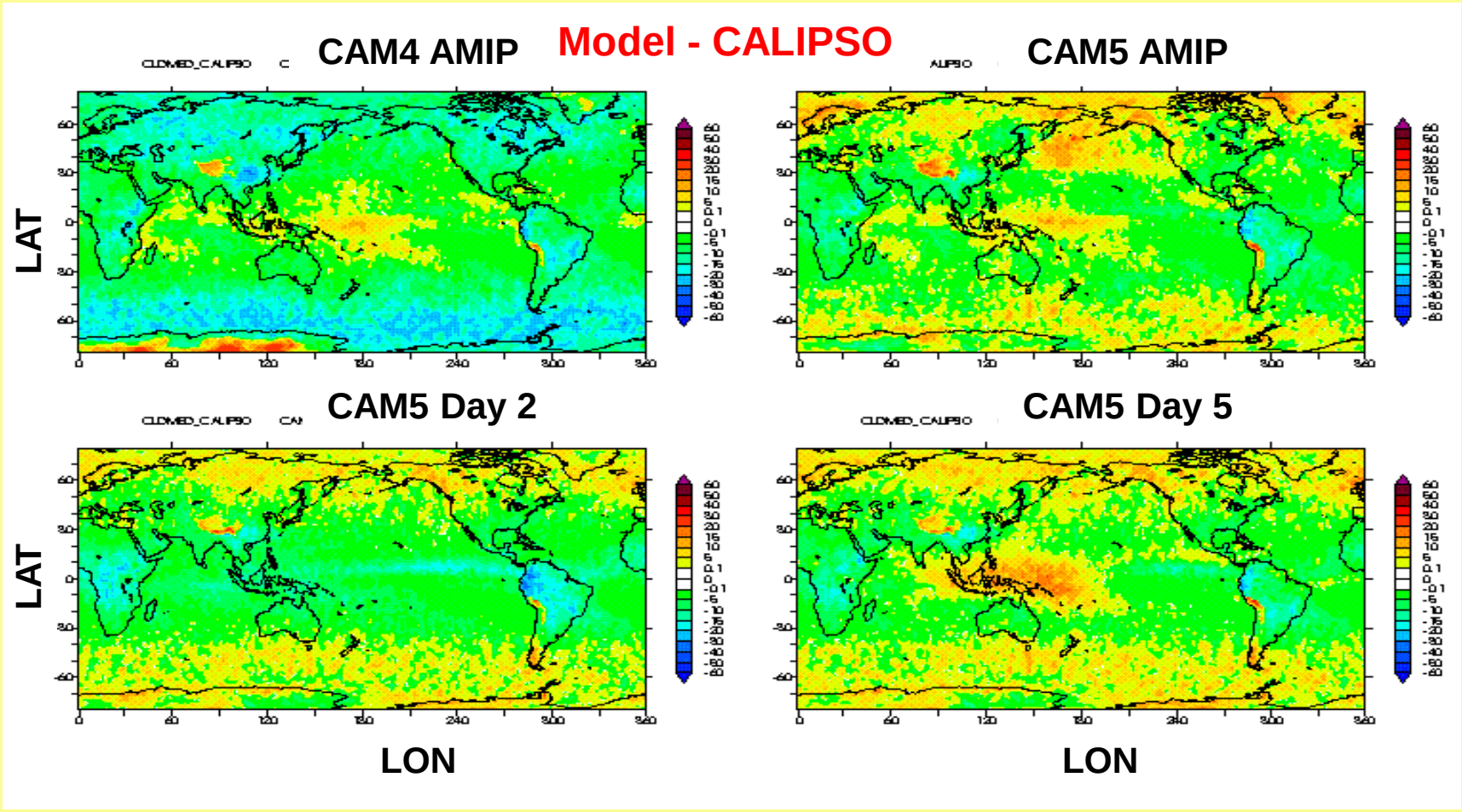
ANN Net Shortwave at TOA



- **CAM5 vs. CAM4 → Overestimation of Net Shortwave at TOA in the southern ocean near 60S. Considerable improvement in CAM5, mainly due to the increase of mid- and low clouds.**
- **Climate vs. Forecast → remarkably similar.**

Xie et al. (2012) in preparation

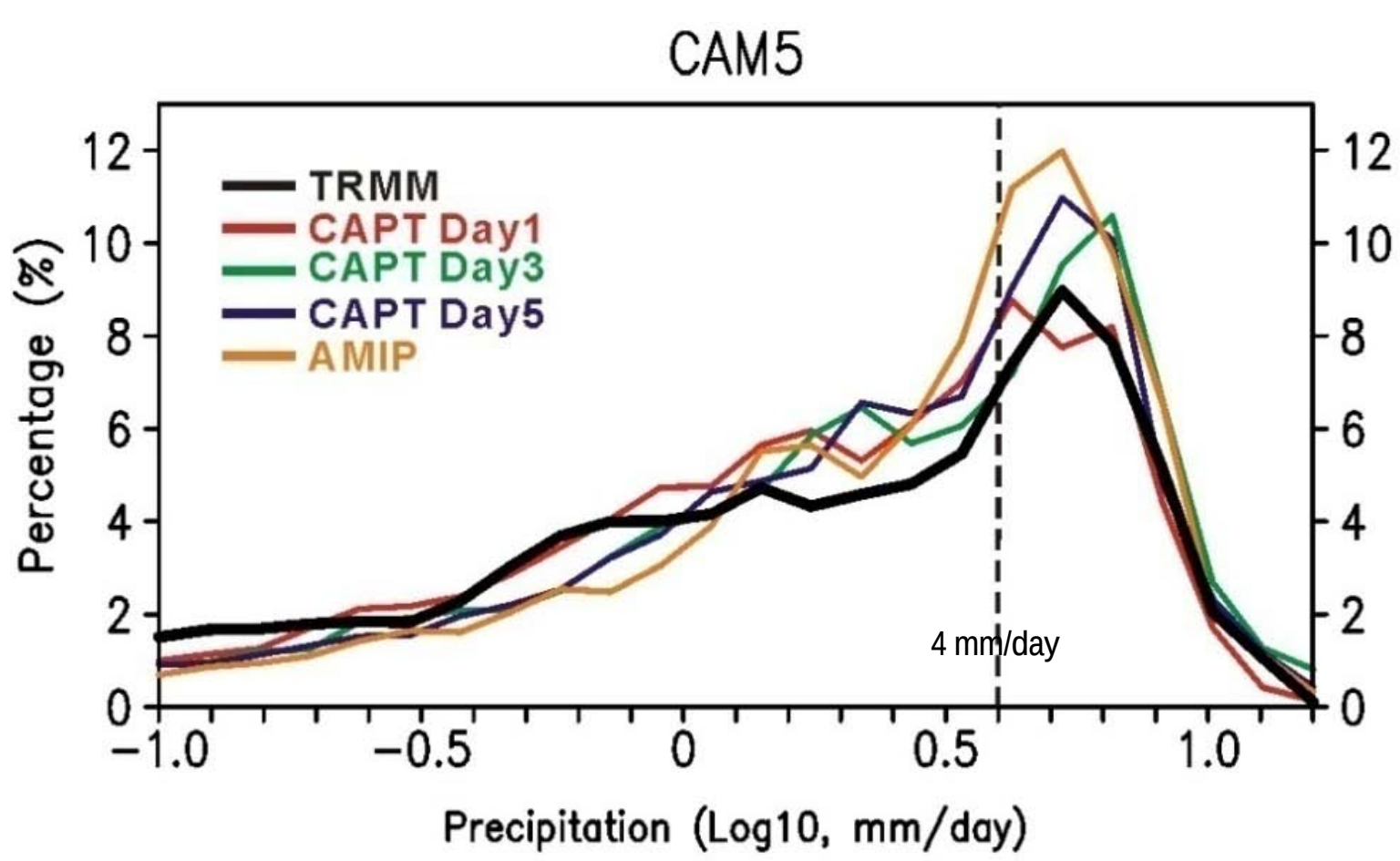
ANN Mid-level Clouds (CALIPSO simulator)



- CAM5 vs. CAM4 → Considerable improvement in CAM5
- Forecast vs. Climate → Less bias over the western Pacific warm pool (CAM5 Day2)

Xie et al. (2012) in preparation

June-August Mean Precipitation

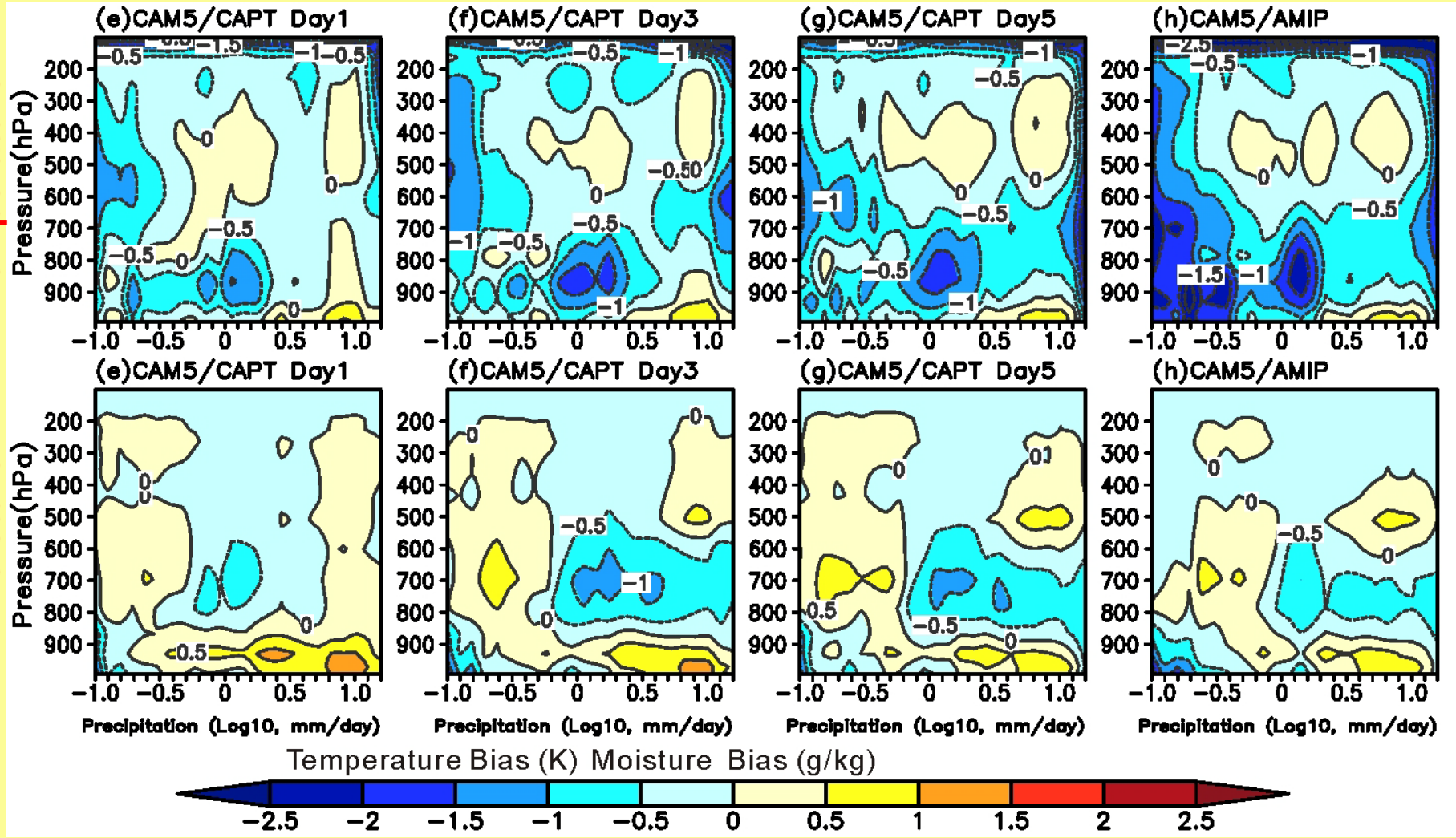


Too active deep convection over the tropical domain (0-360, 20S-20N)

-> positive bias in tropical mean precipitation

Ma et al. (2012) in preparation

Precipitation vs Temperature & Moisture



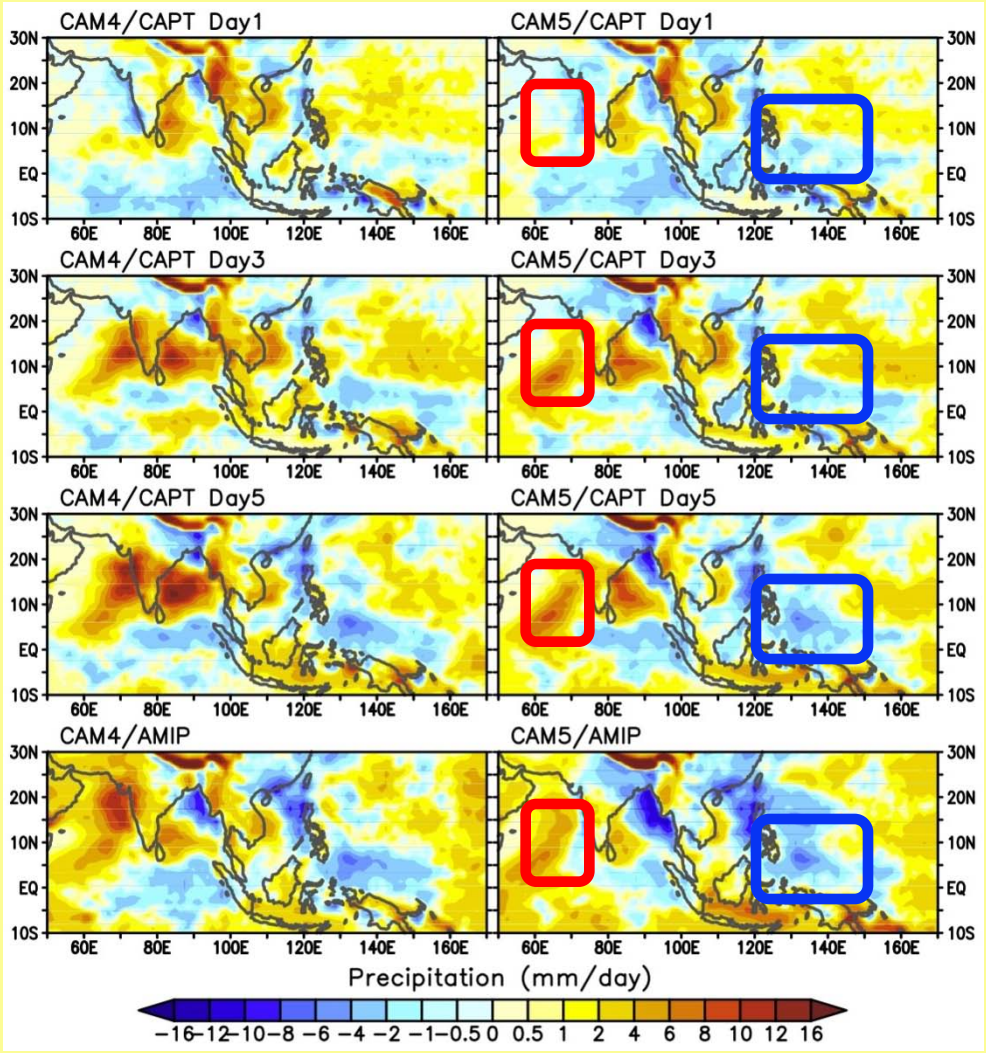
Cold bias in the middle- to lower (lower) troposphere

Wet and warm bias is present near the surface ➡ **Less stable atmosphere**

Ma et al. (2012) in preparation

In reference to ECMWF-YOTC analysis

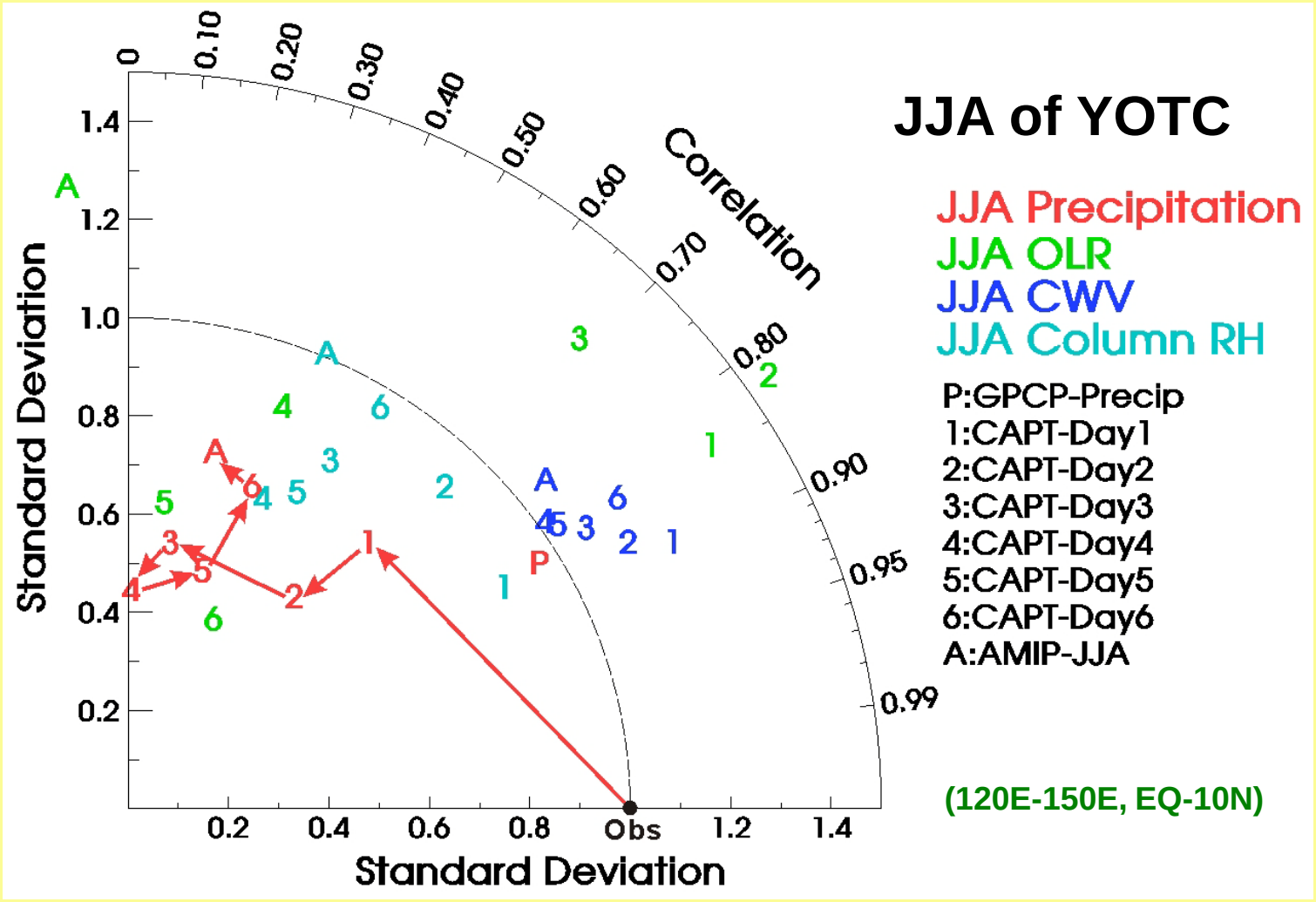
Regional analysis of precipitation bias and moist processes



- Dry bias tendency over **(120E-150E, EQ-10N)**
- Wet bias tendency over **(60E-75E, 5-20N)**

Ma et al. (2012) in preparation

Short-term Forecasts vs Long-term Climate



A Taylor diagram to summarize the performance of simulated fields.

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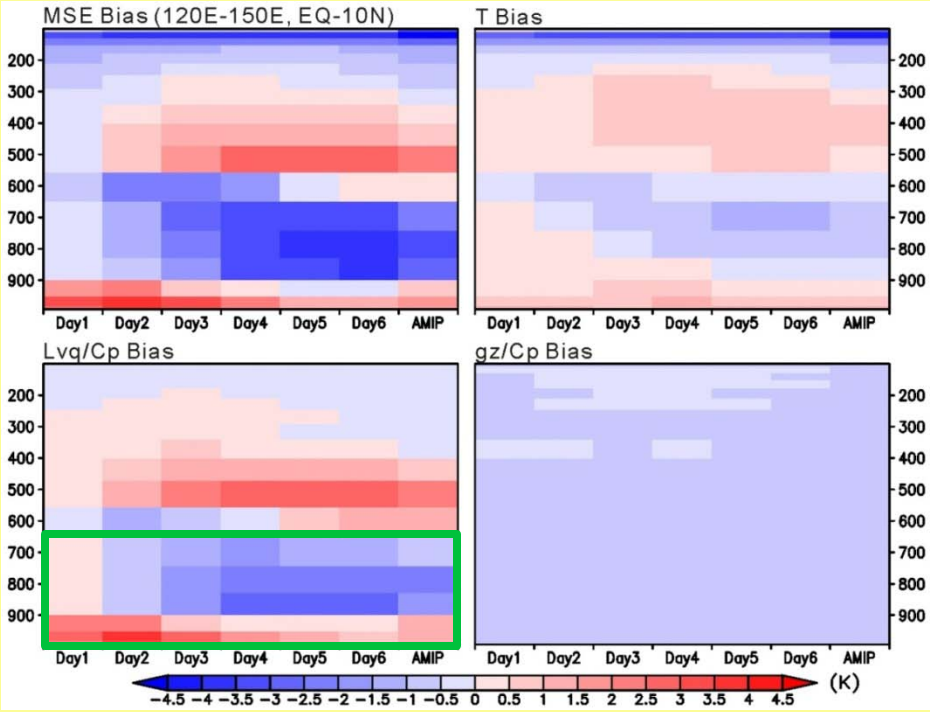
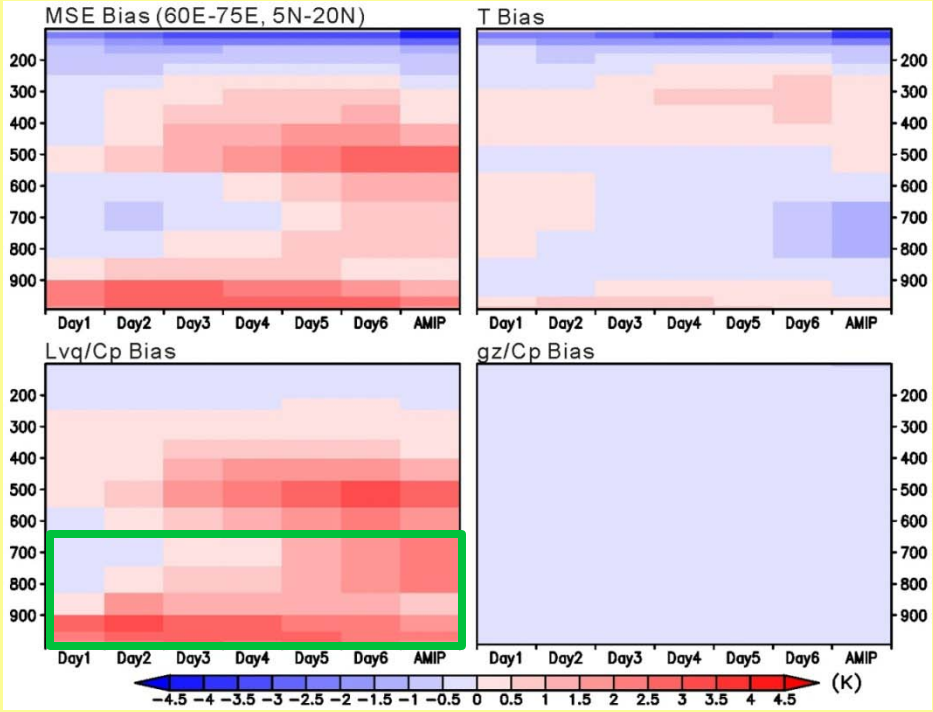
Moist Static Energy profiles

Dry Bias



Wet Bias



In reference to ECMWF-YOTC analysis

- Moisture bias is the main contributor to the MSE bias.
- Both regions show similar cold bias profiles.
- Dry (Wet) tendency between 600 – 900 hPa disfavors (favors) deep convection

Ma et al. (2012) in preparation

Summary & Future Work

- The CAPT approach demonstrates the benefit to identify climate model biases through numerical weather prediction technique: Initial drift in precipitation, clouds, temperature, and moisture fields could be identified through Day 1 to Day 3 forecasts. Beyond Day 3 forecasts, model performance converges to mean climate (AMIP) performance. (Similar Day 5 and AMIP error patterns).
- Global tropical analyses on the precipitation suggest that both CAM 4 & 5 tend to produce too much precipitation. This is consistent with higher near surface moisture and temperature, and colder mid-level temperature, especially for intense convective regions.
- Regional analyses on the precipitation over the northwestern Pacific Ocean and southwestern Indian Peninsula suggest that: Dry (Wet) bias of precipitation in the model is associated with anomalous drying (moistening) at lower troposphere. The reason for such drying (moistening) requires further studies.
- Includes high frequency (hourly to daily) and other source of data for analysis (e.g. ARM, Satellite retrievals).

Acknowledgements

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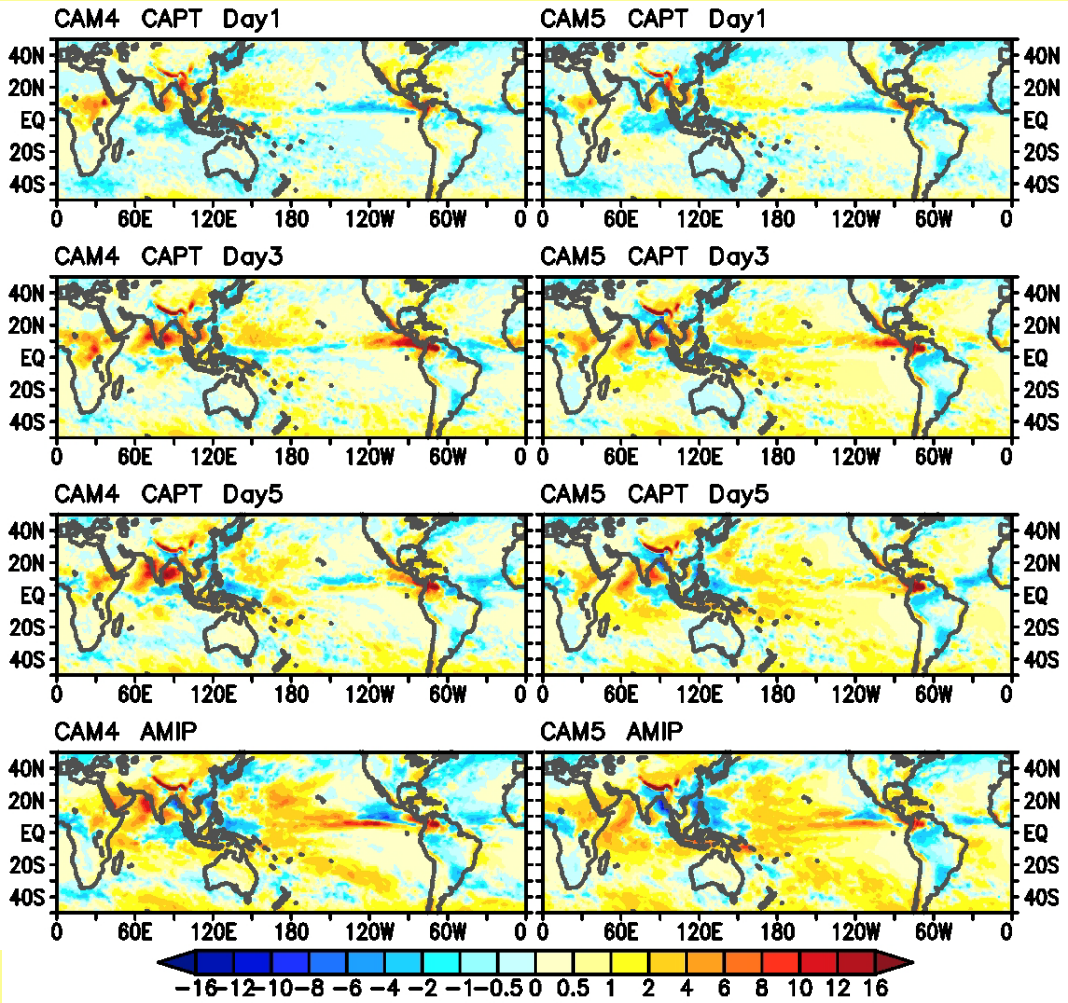
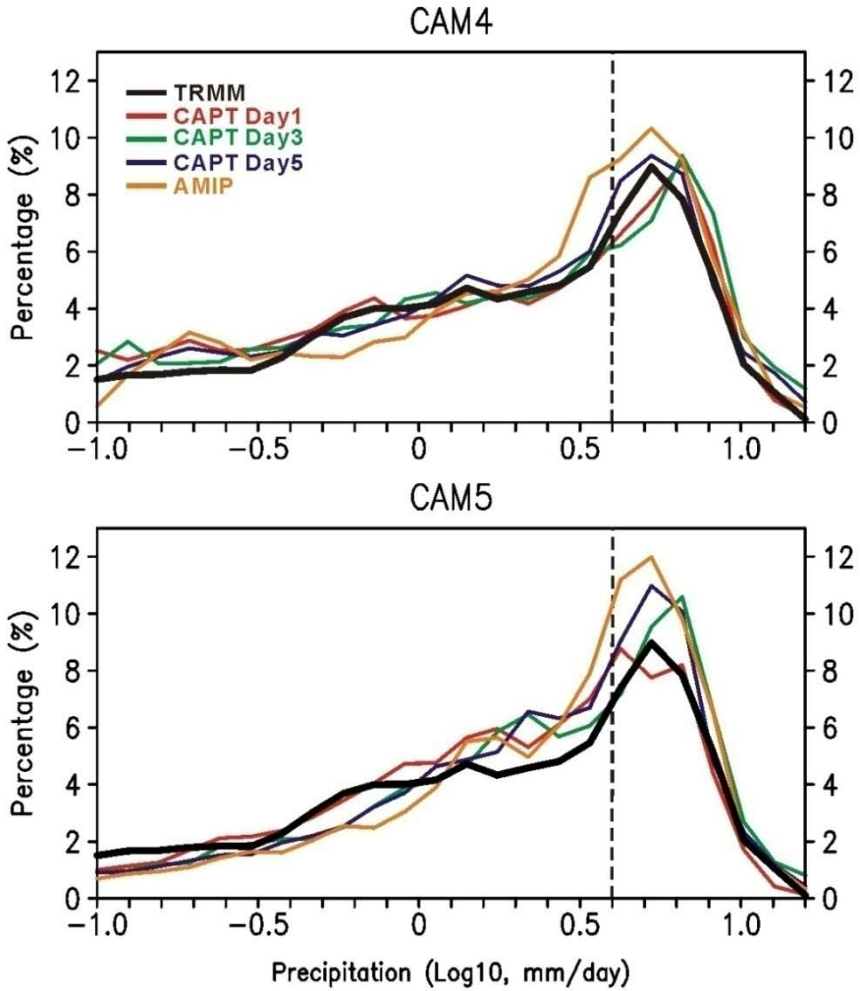
- We would also like to thank ECMWF for providing its operational analysis data to support YOTC studies.

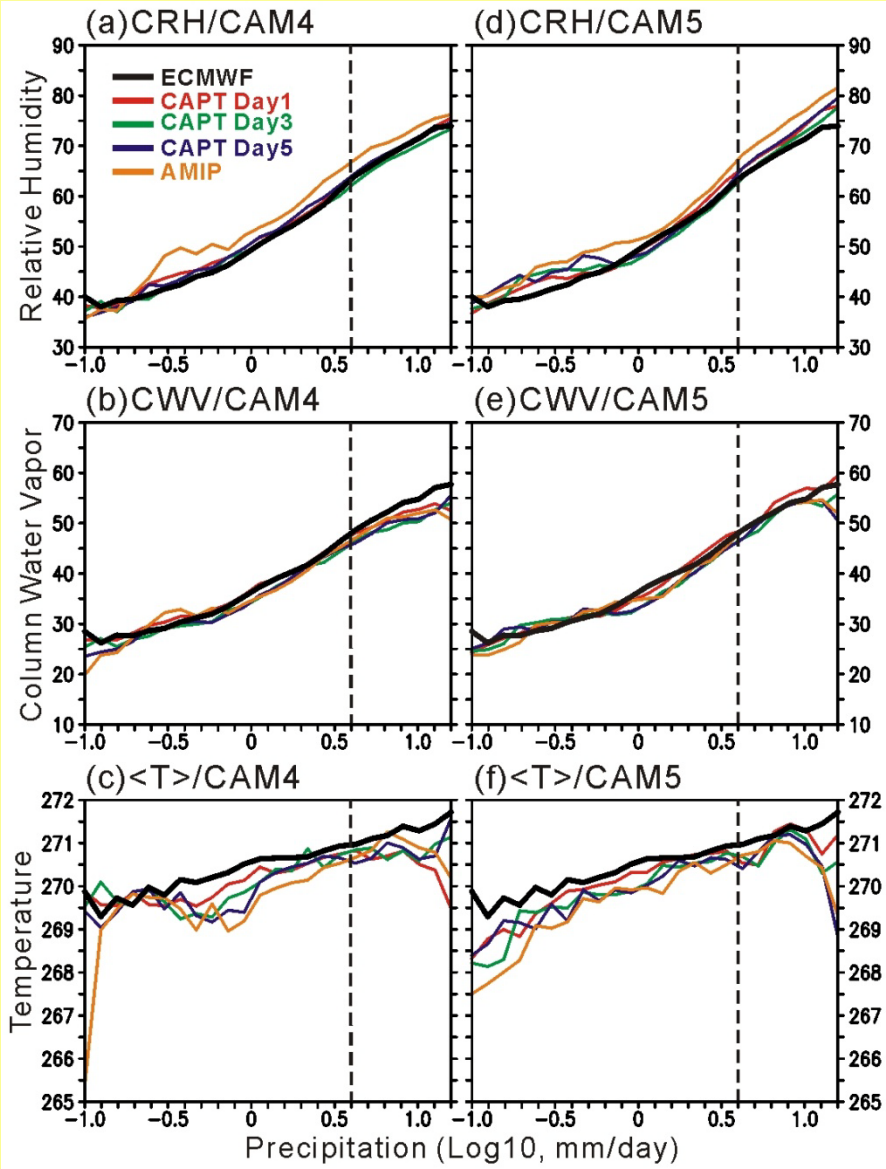

June – August Precipitation Biases



- Both CAM4 & CAM5 show similar bias patterns except bias is smaller in the forecasts
- The bias is enhanced with the forecast lead time.

Precipitation and Moist Processes



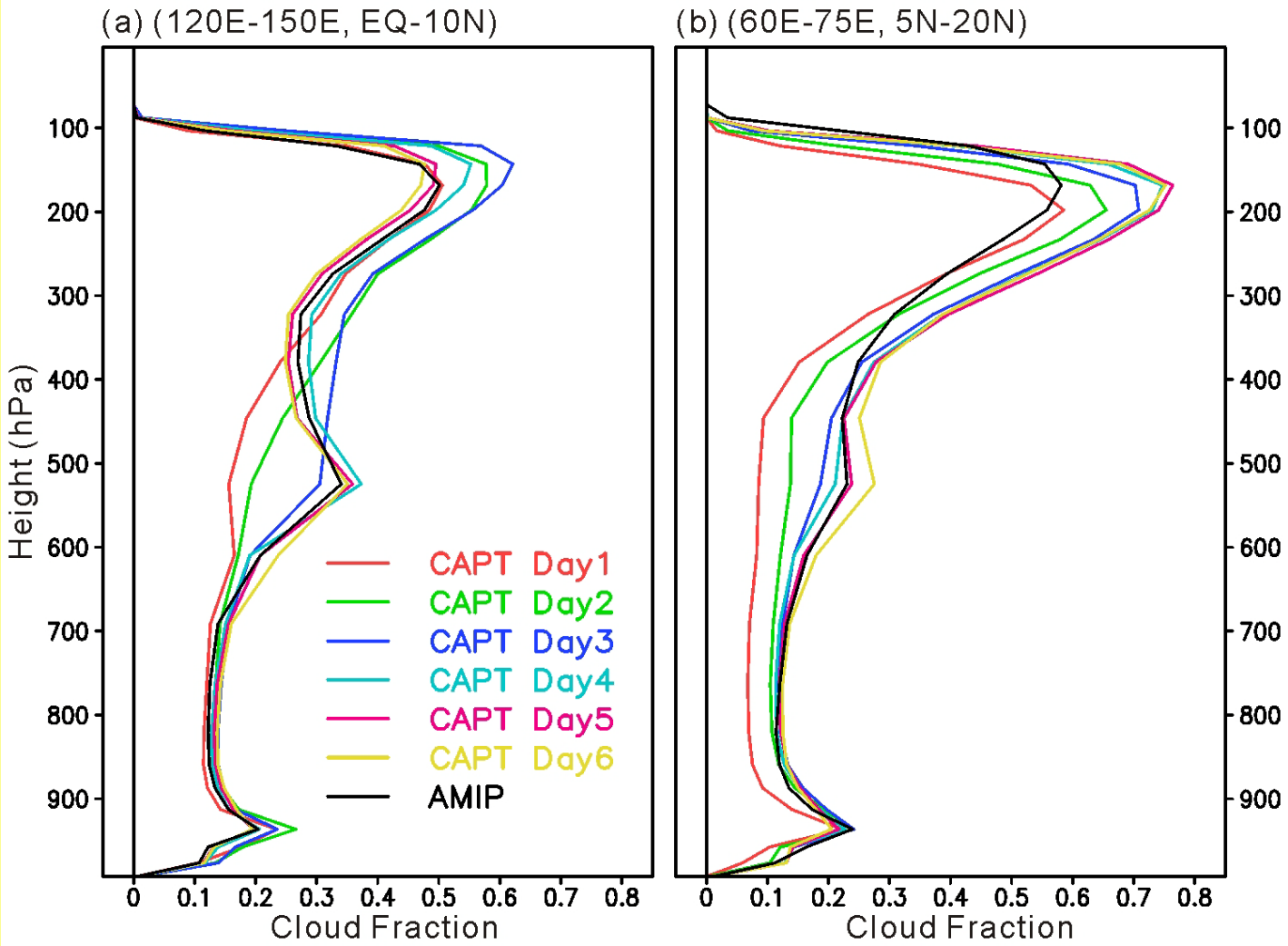


Too active deep convection over the tropical domain (20S-20N) -> positive bias in tropical mean precipitation

Cold bias over deep convective regions

Ma et al. (2012) in preparation

Vertical Profiles of Cloud Fraction



Ma et al. (2012) in preparation