

Identifying and Improving Key Physical Processes Critical to Precipitation Biases - **Field Observations and Hierarchy Modeling**

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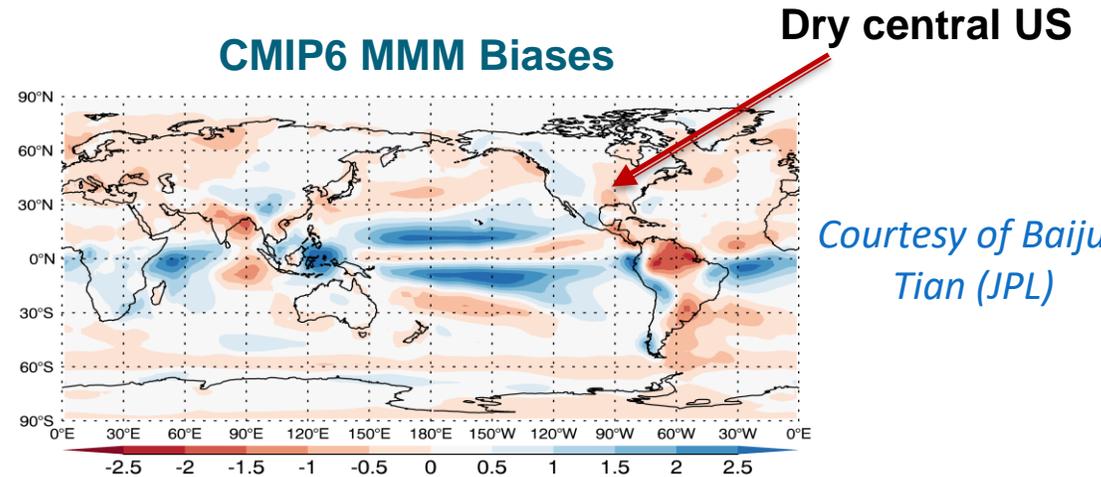
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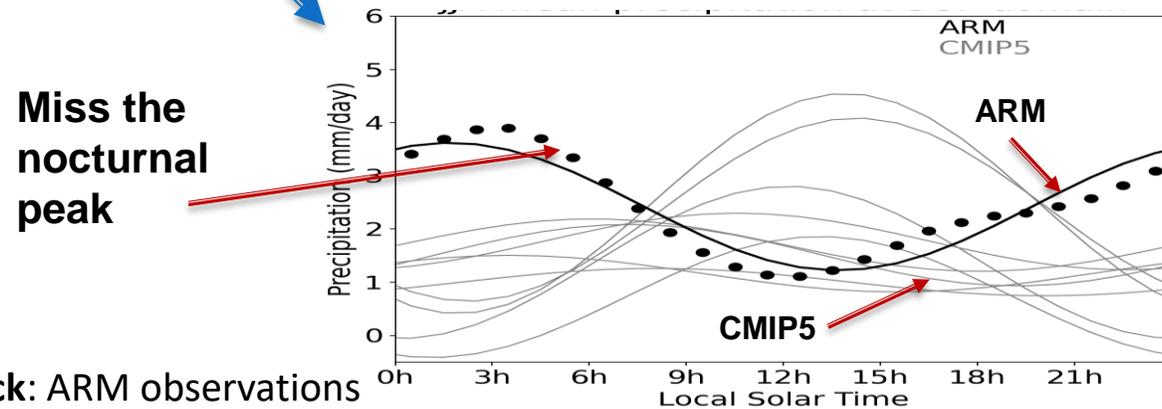


Common Model Errors in Precipitation over US

- Dry bias over central US
- Weaker MCS precipitation
- Wrong diurnal cycle



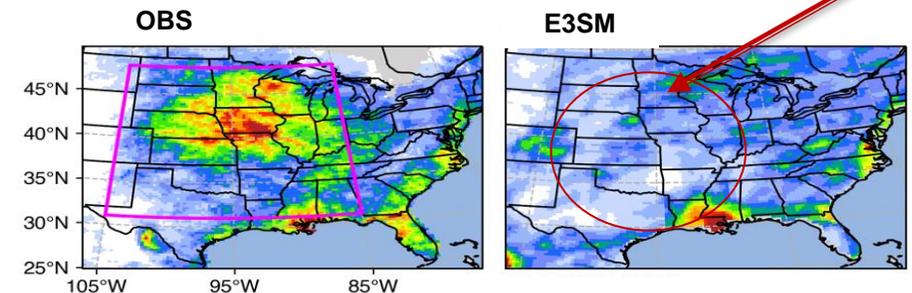
JJA Diurnal Cycle of Precipitation in CMIP5 at ARM SGP Site



Black: ARM observations
Grey lines: CMIP5 model results,

Zhang, Xie et al. (2020) BAMS

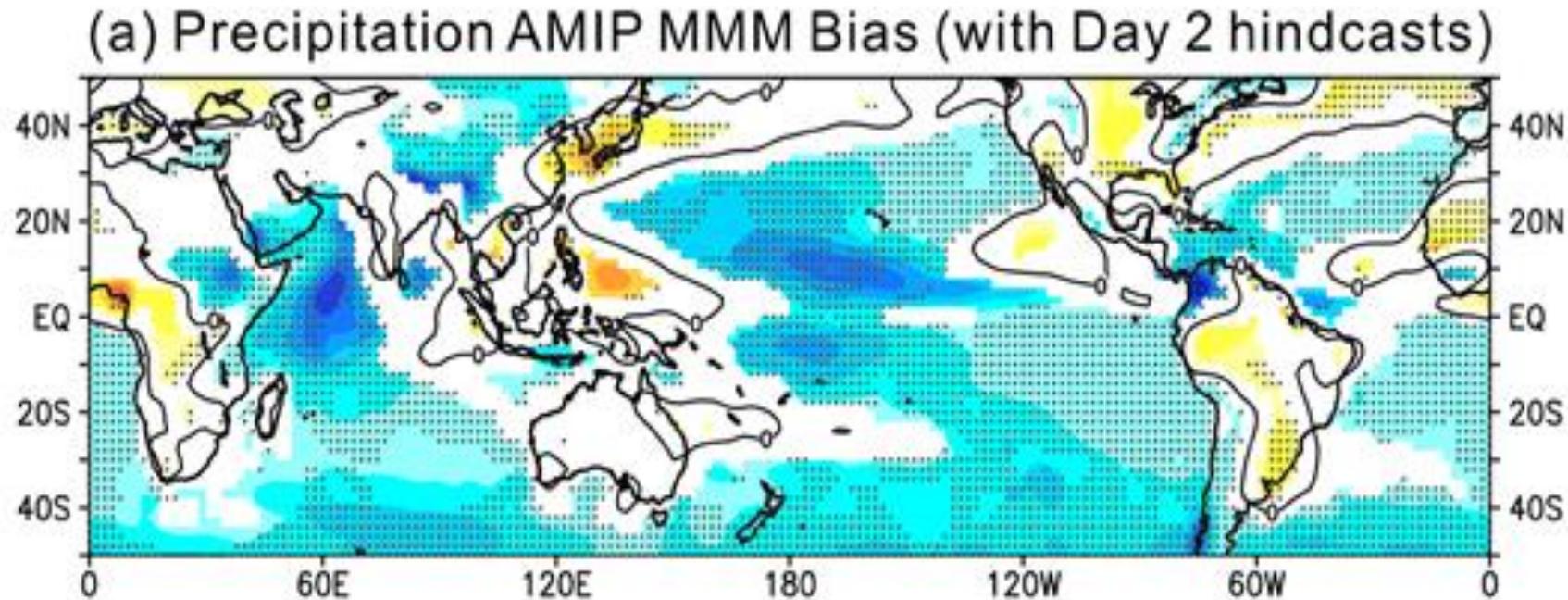
JJA MCS Precipitation in E3SM



Xie, Leung et al. (2020) DOE Q4 Metric Report

Good Correspondence between Forecast Errors and Climate Errors in Precipitation

Xie et al. (2012); Ma et al. (2014), J. Climate

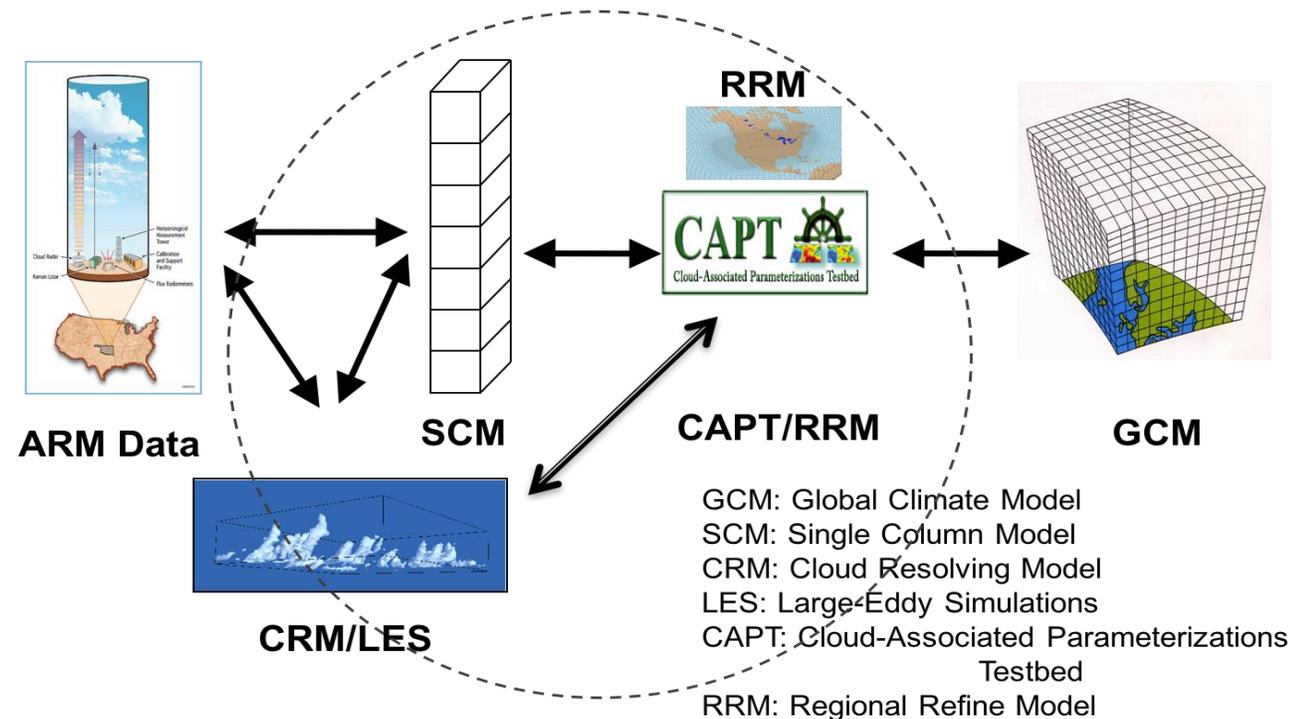


The stippled regions are where day 2 hindcasts with the same models used in CMIP5 show the same sign of biases as CMIP5 simulations

Field Observations and Hierarchy Modeling for Process Studies

- Detailed field observations like ARM data are extremely useful in process studies
 - Understanding key physical processes critical to precipitation
 - Guiding physical parameterization developments
 - Testing assumptions with process models for specific cases or through statistical studies.
- Hierarchy modeling
 - A modeling framework with different levels of complexities
 - Provide a direct link to field data
 - Identify and improve key physical processes to precipitation biases at process level

A hierarchy modeling framework supported by DOE

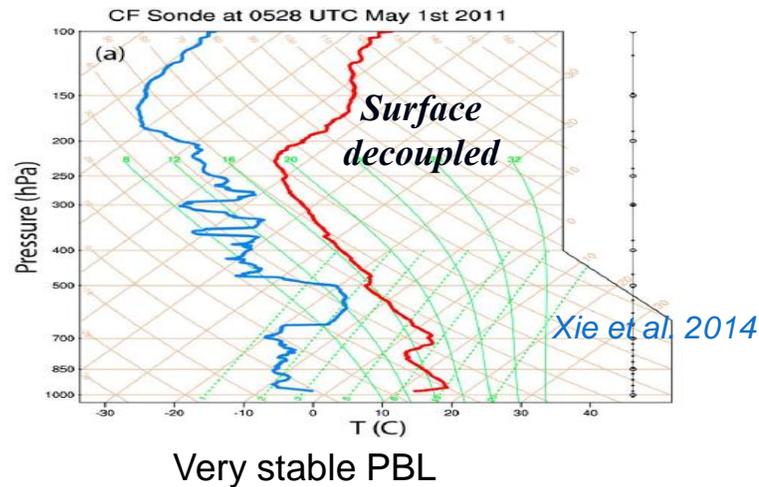


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A hierarchy modeling framework jointly supported by DOE ARM, ASR, RGMA, and ESMD programs

Processes Critical to Nocturnal Precipitation over SGP

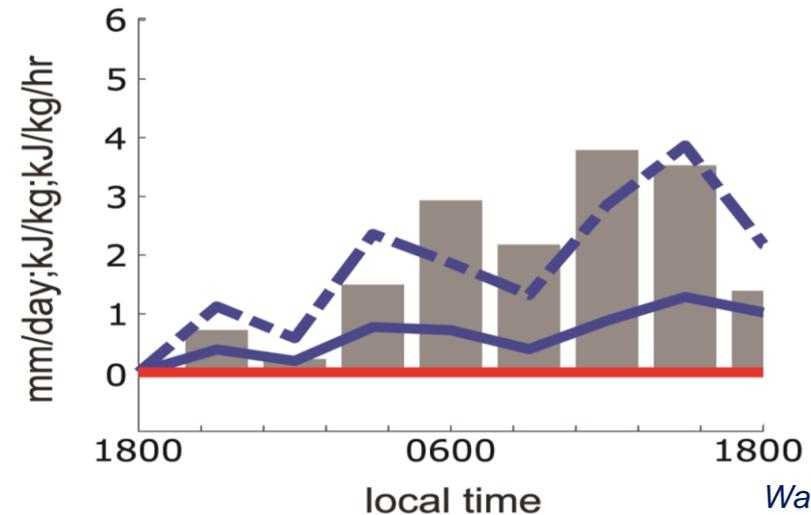
- Nocturnal precipitation over SGP primarily results from nocturnal elevated convection associated with the eastward propagating MCSs originated over the Rocky Mountains and low-level jet activities

A Selected Elevated Nocturnal Convection Case from ARM MC3E



Most convection schemes assume convection with its root within PBL

Event of 2011-04-24



■ 0.1*rain(mm/day)
 — CAPE (kJ/kg) - - - 10*dCAPE (kJ/kg/hr)
 — CAPE* (kJ/kg) - - - 10*dCAPE* (kJ/kg/hr)

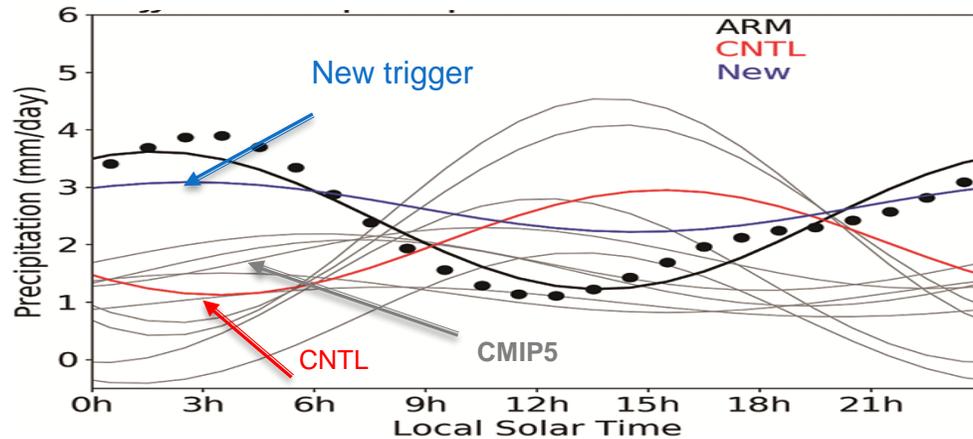
CAPE* calculated with air parcel launched from surface are marked as **red**

Allowing Convection Triggered above PBL is the Key to Capture the Nocturnal Peak

A new trigger in Xie et al. (2019):

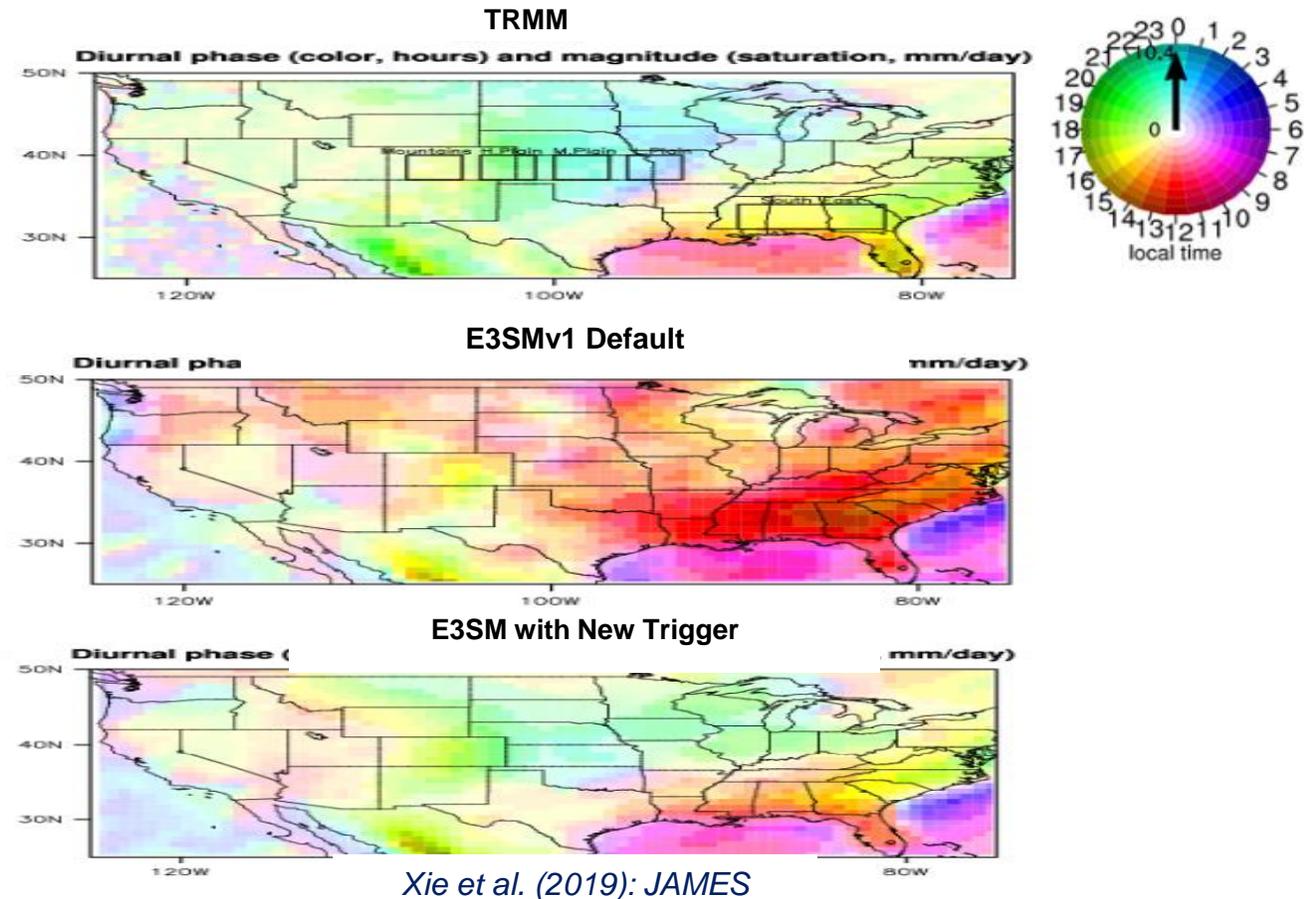
- (1) Add an empirical dynamic constraint (dCAPE) to suppress overactive daytime convection;
- (2) allow air parcel launching above PBL to capture elevated nocturnal precipitation (ULL)

JJA Diurnal Cycle of Precip at SGP



Zhang et al. (2020): BAMS

Summertime Diurnal Cycle of Precipitation



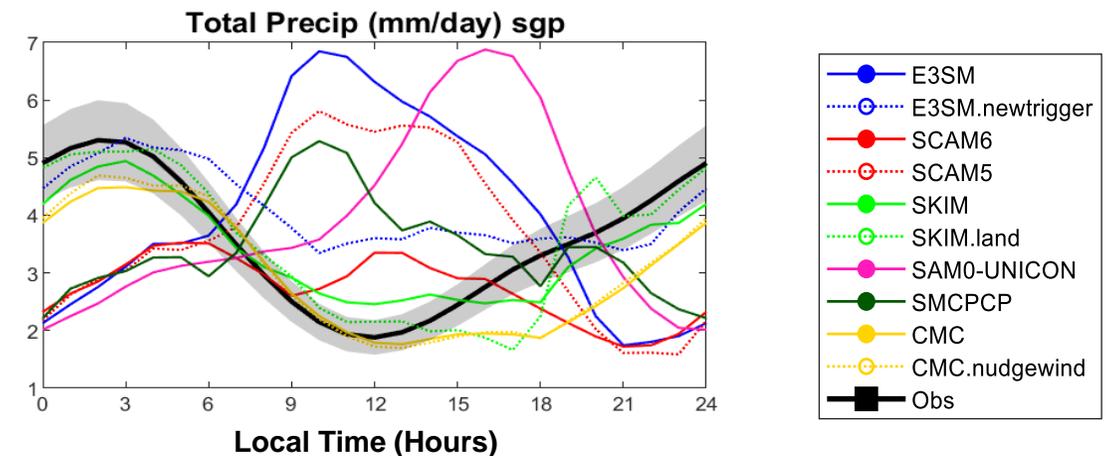
Summary

- Detailed field observations are critical for improving our understanding of precipitation-associated processes
- A hierarchy modeling framework acts to bridge the gap between field data and model developments
- Critical data and tools need to be developed to support such as a model framework

Improving the Diurnal Cycle of Precipitation through A Hierarchy Modeling Approach – A GASS Multi-Model Intercomparison Study Project

Co-Chairs: Shaocheng Xie (LLNL), Peter Bechtold (ECMWF), David Neelin (UCLA), and Hsi-Yen Ma (LLNL)

Long-term SCM runs driven by the ARM SGP Cont. Forcing from 2004 to 2015



Tang, Xie, et al. (2020) in preparation