

Understanding CMIP5 Systematic Model Biases in Surface Temperature, Cloud, Precipitation and Radiation through the Hindcast Approach

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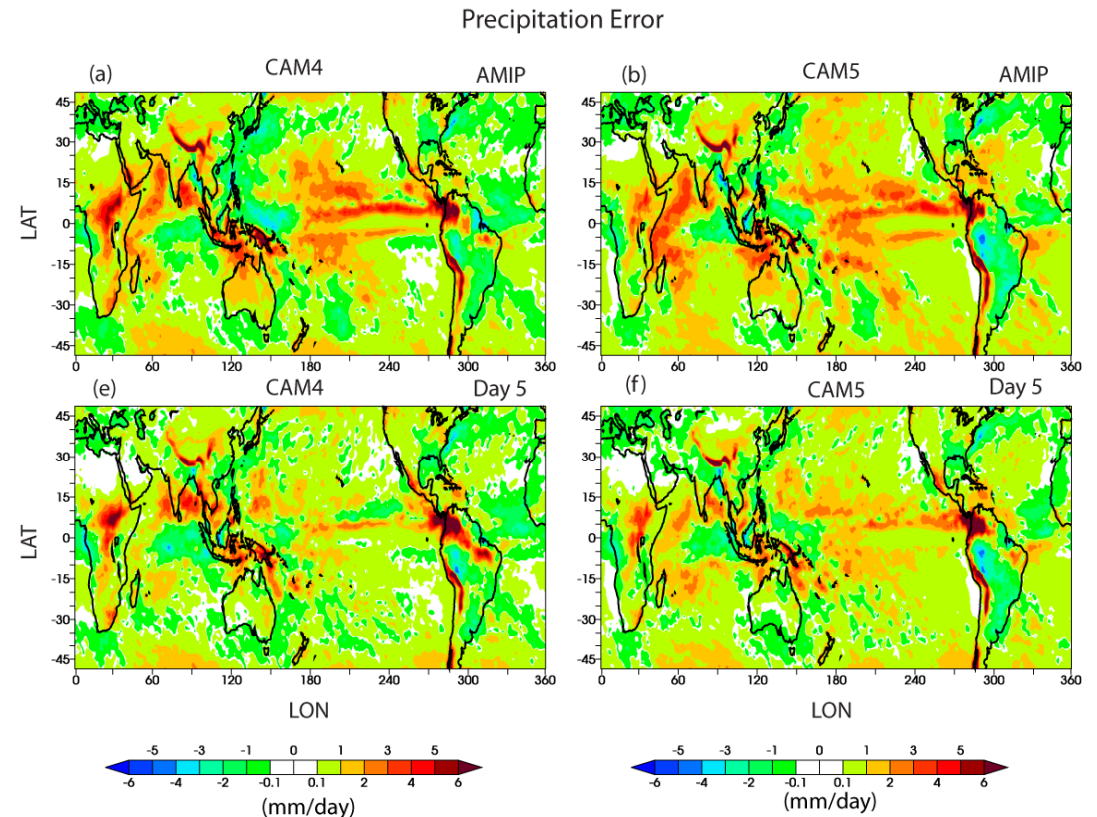


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Background and motivation:

- Large systematic errors still present in the latest version of climate models
- Recent studies with CAM5 showed that **many systematic climate biases are present in just a few days of hindcasts (fast processes)**
- Is this **correspondence** robust in other CMIP5 climate models? What can we learn from this?

CAM ANN Precipitation Errors



Xie, Ma, Bolye, Klein, Zhang (2012) J Climate

Model experiments:

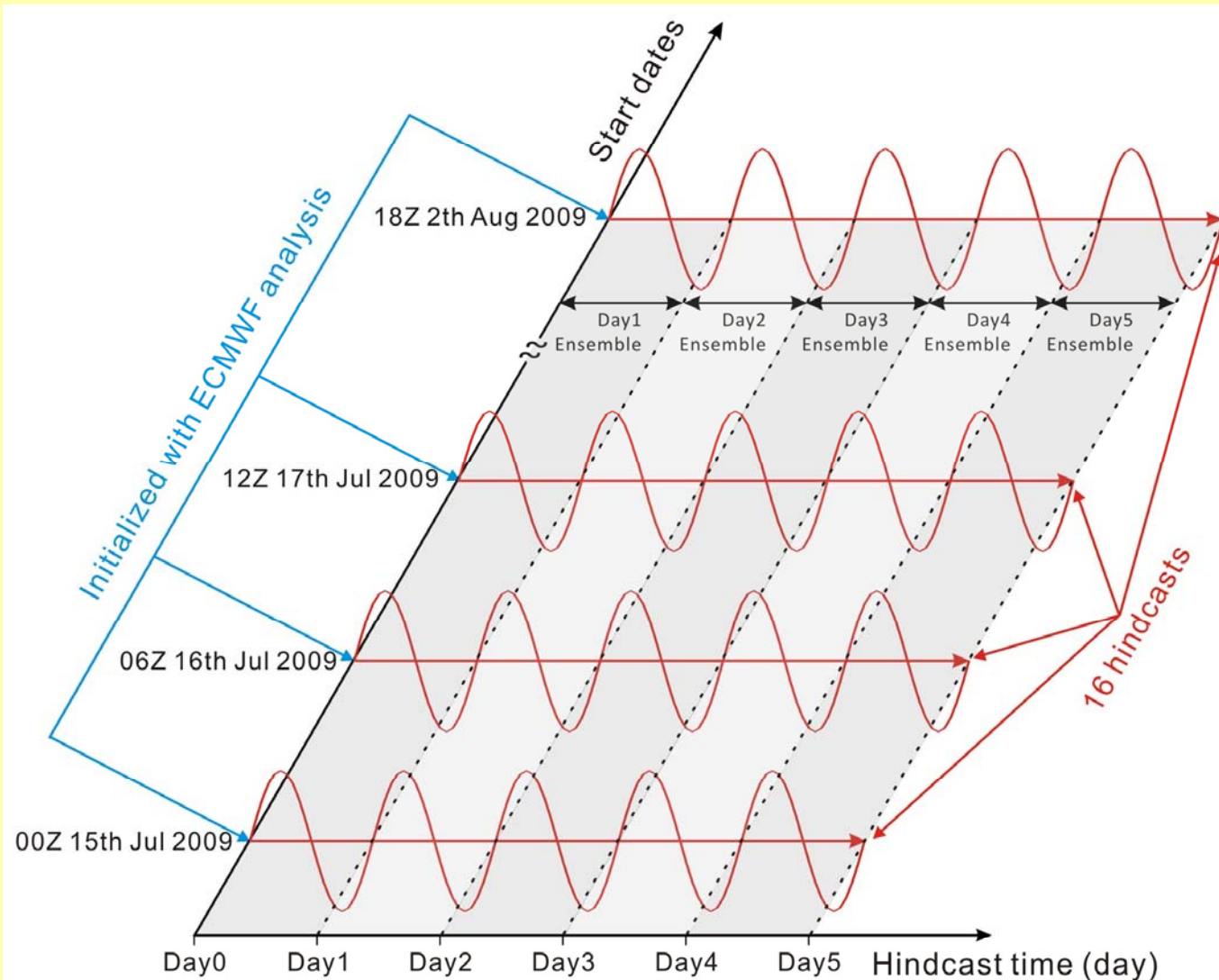
- **Short-term hindcasts: *Transpose-AMIP II***
 - Jul. 2009 (tamip200907 experiments, 16 hindcasts)
- **Long-term climate simulations: *CMIP5-AMIP***
 - CMIP5-AMIP simulations (JJA of 1979-2008)
- The analysis is focused on typical model errors in ***precipitation, clouds and radiation*** from five climate models.

T-AMIP II (hindcast) approach

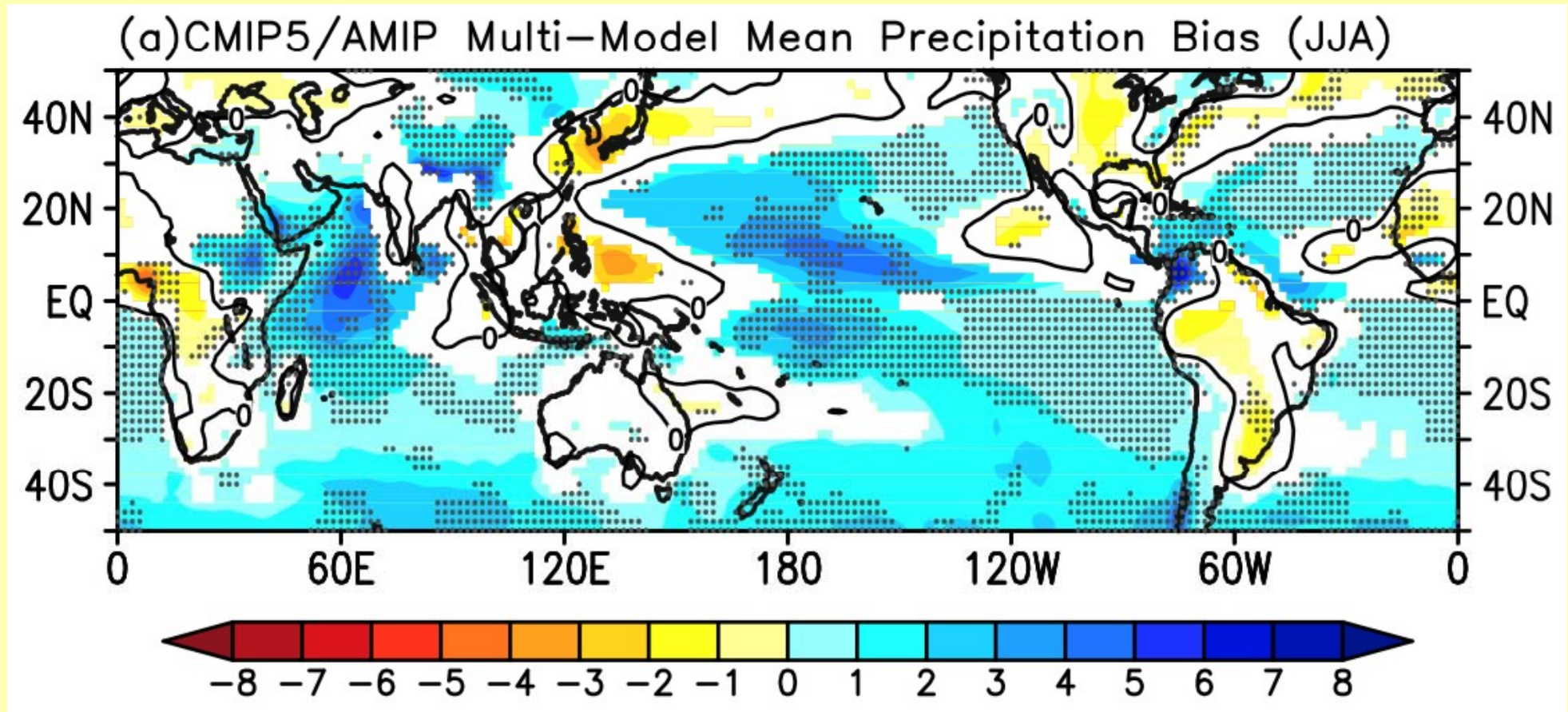
Initial Conditions:
ECMWF analysis

CMIP5 Models

5 days hindcast



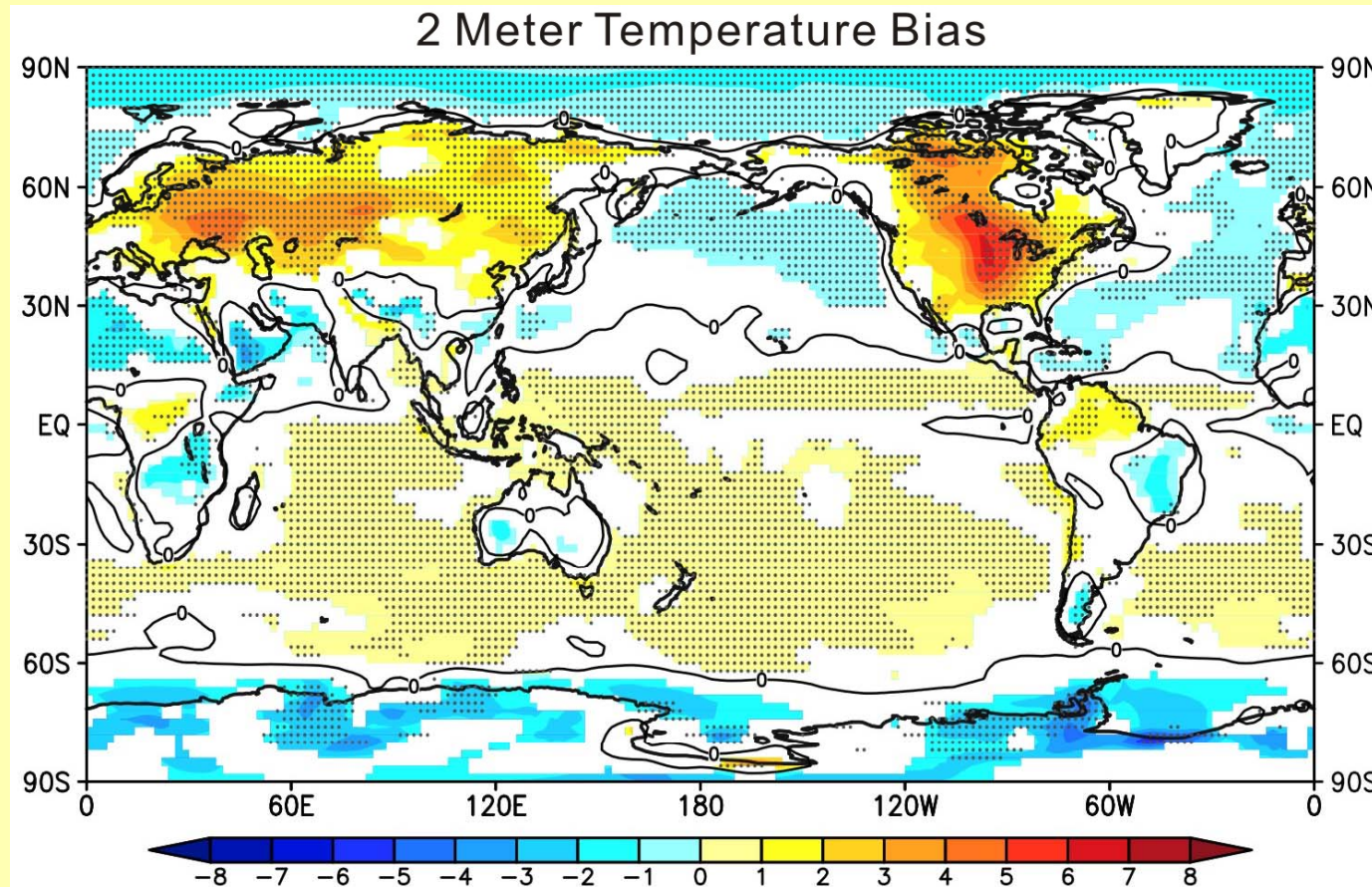
Systematic climate errors in precipitation



- Most systematic errors (color) in climate models appear by Day 5 (stippling indicates the regions where this occurs)

Ma et al. (2014) J Climate

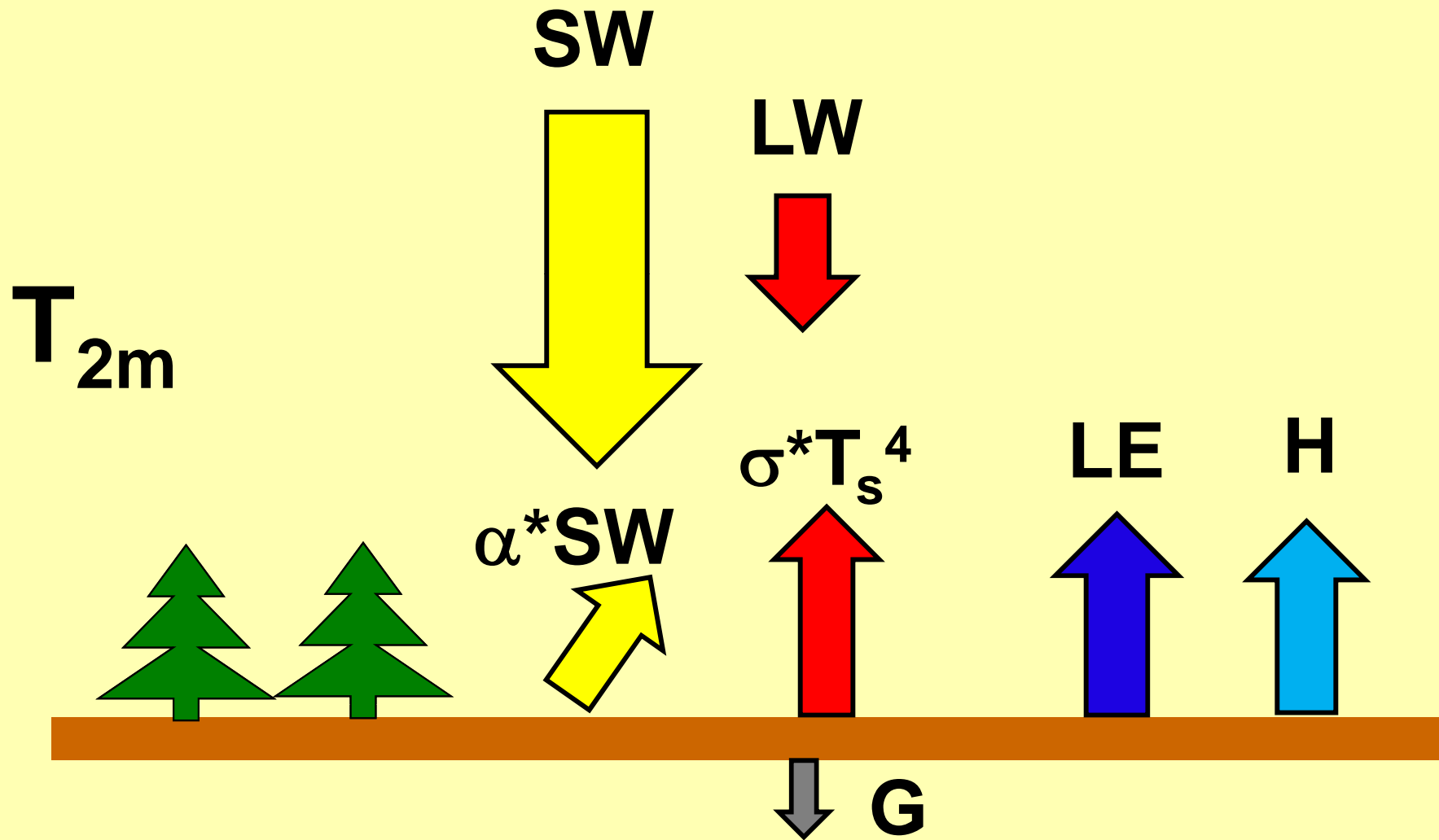
Large summertime near surface warm bias over mid-latitude continents



- Initial biases in the precipitation (less) or clouds (less) can affect the surface energy budget (more SWAbs) and in turn modify the 2 meter temperature
- Biases in the initial conditions for land surface models

Ma et al. (2014) J Climate

Surface air temperature (T_{2m}) and energy budget



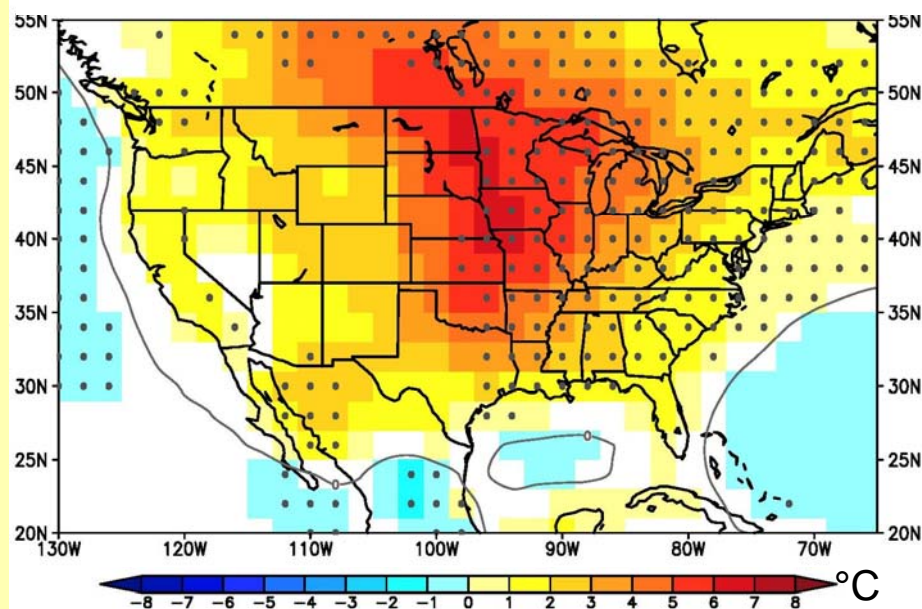
Clouds Above the United States and Errors at the Surface (CAUSES)

Purpose

A joint GASS-RGCM-ASR model intercomparison project aiming to determine the role of radiation and precipitation errors in temperature biases in climate models



Summertime 2 meter temperature bias in climate models



Research Foci

1. Radiation errors – particularly due to clouds
Led by Met Office: Cyril Morcrette and Jon Petch
2. Precipitation and surface energy budget errors
Led by LLNL: Hsi-Yen Ma, Steve Klein, Shaocheng Xie

Methods

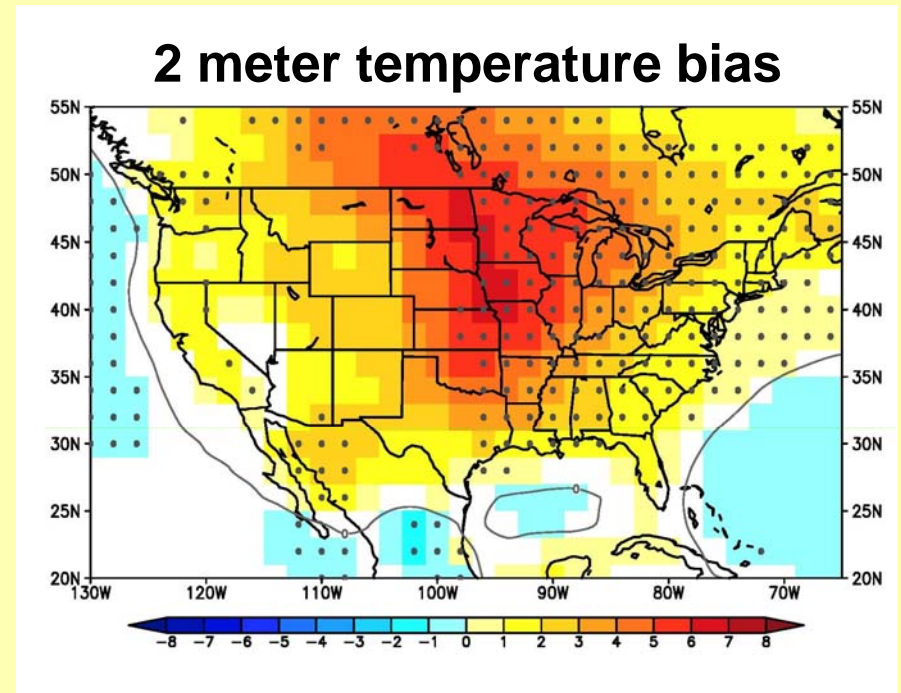
Error growth will be diagnosed in hindcast simulations from a variety of 1-10 km resolution limited area models and 10–100 km resolution global climate models

Scientific Questions?

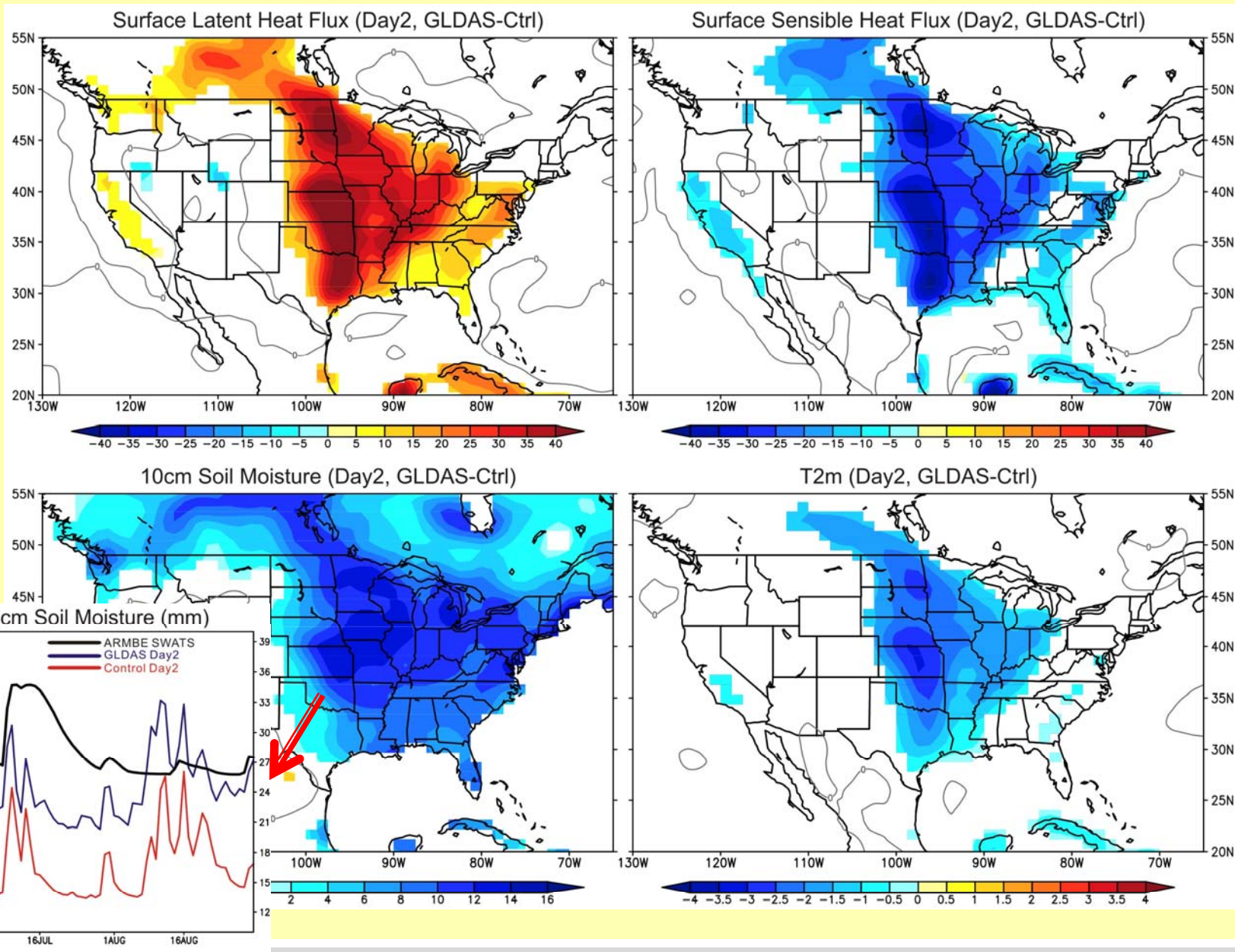
- What is the relative contribution of precipitation errors to the temperature errors?
- Which type of precipitating convection systems dominate the errors in the surface precipitation?
- Does this atmosphere provide the correct amount of precipitation for the soil?
- Does the surface energy balance reveal signs that evaporation is underestimated due to the lack of soil moisture?

Model experiments

- CAM5 FV (0.9x1.25L30)
- Two sets of 2-day hindcasts
 - June-August of 2008
 - Same CAM initial conditions from YOTC analysis
 - Different CLM initial conditions (Control/GLDAS)
- The analysis will focus on Day 2 ensembles (24-48 hrs) of US summer time warm bias

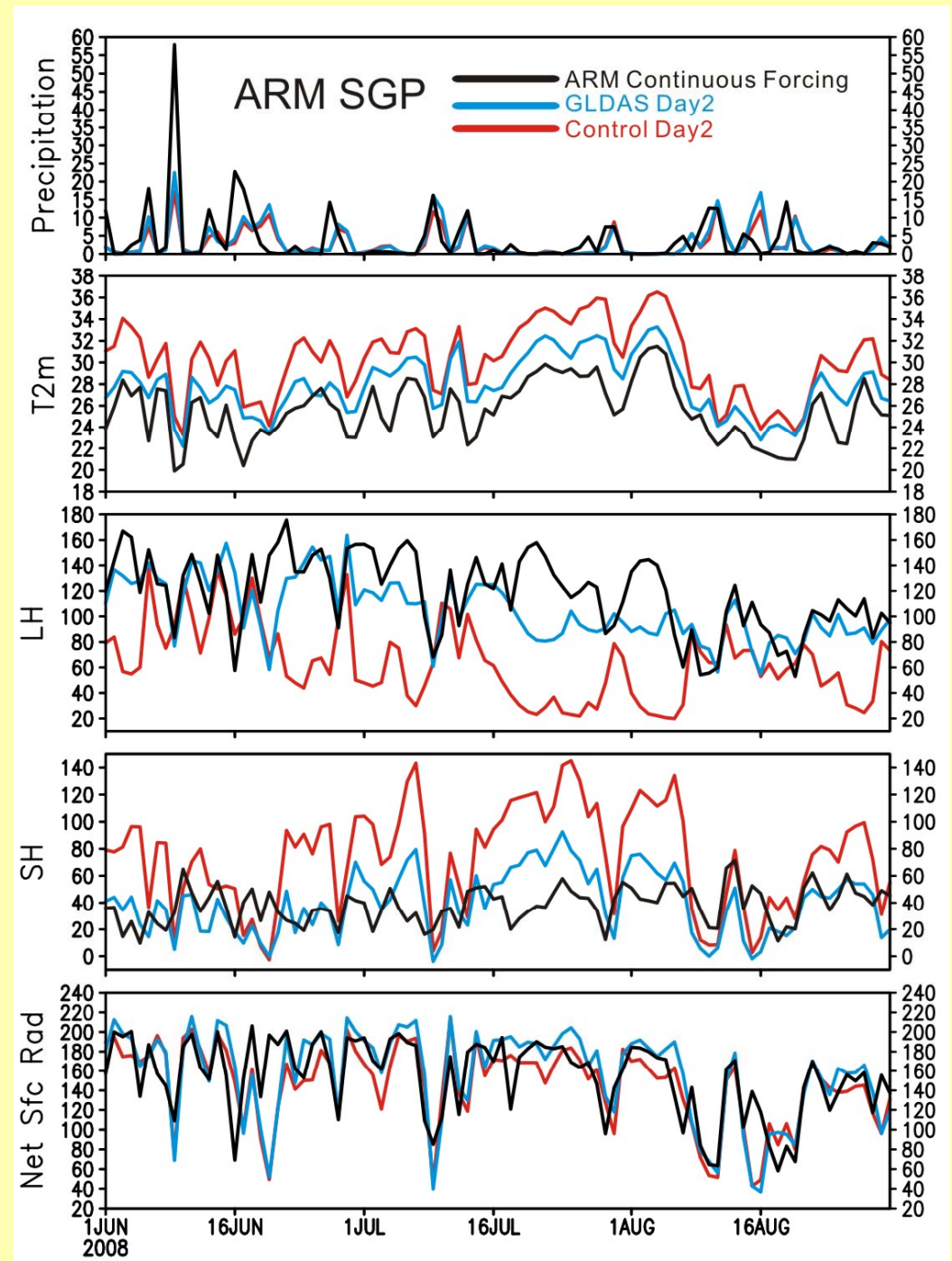


Surface Fluxes vs T_{2m} (Day 2, JJA)

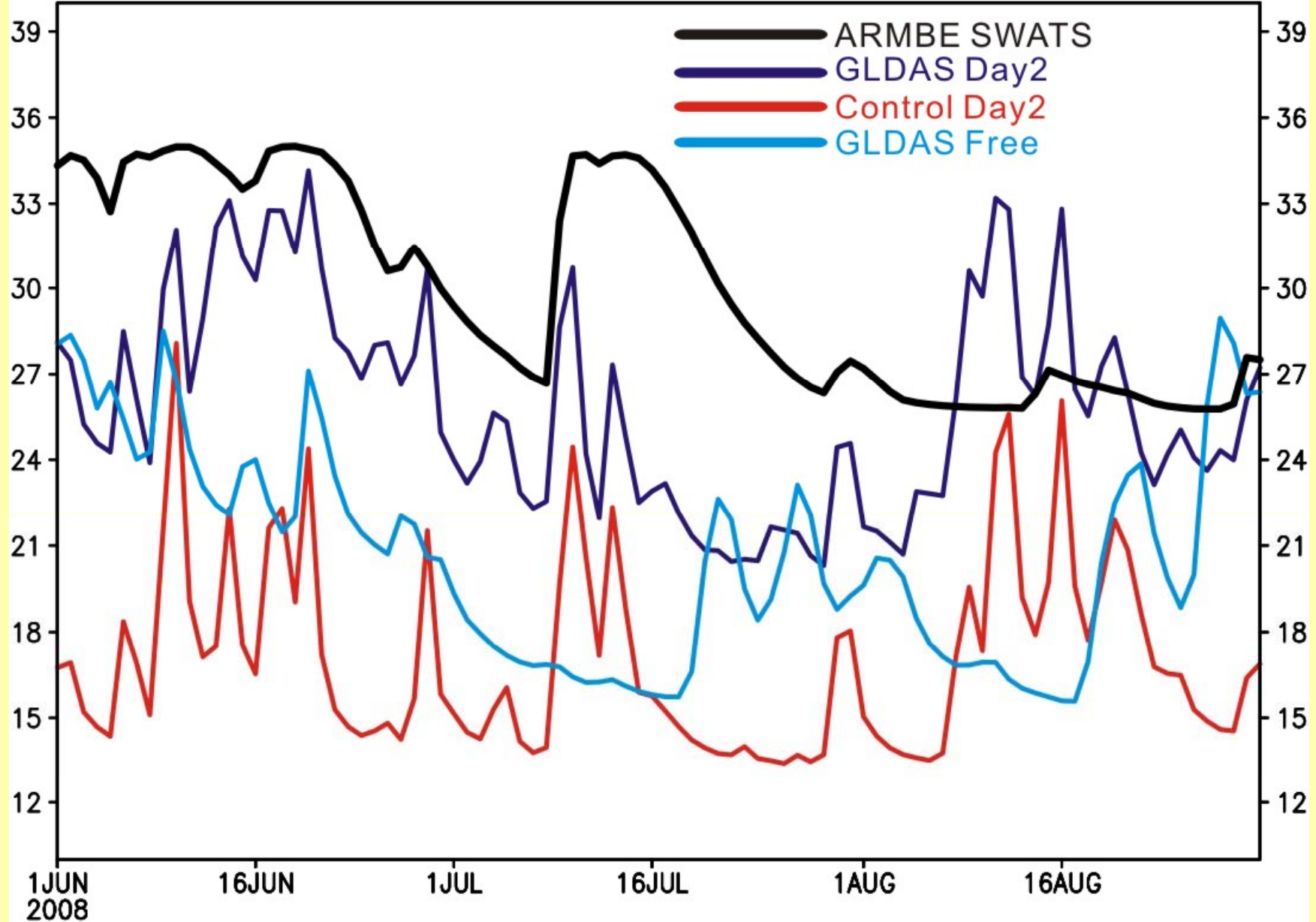


Model hindcasts examined by ARM observations at SGP

Larger Bowen ratio \rightarrow
Warm T2m



ARM SGP 10cm Soil Moisture (mm)



Summary and Future Plan:

- The analysis from the Transpose-AMIP II and CMIP5 models indicate many systematic climate errors, particular those associated with moist processes, are present in just a few days of hindcasts (“fast processes”). These errors in the hindcasts are likely due to model parameterizations.
- For the CAUSES project, the low soil moisture in the land model is likely the cause of surface warm temperature biases. The biased low precipitation is likely one of the key factors.
- Additional sensitivity experiments will be carried out to identify the relative bias contribution from the atmospheric component, land component or atmosphere-land interactions.
- Analyze multi-model hindcasts for the intercomparison project.

Thank you and questions?