Tracing the origins of tropical SST biases in CESM through a hindcast approach

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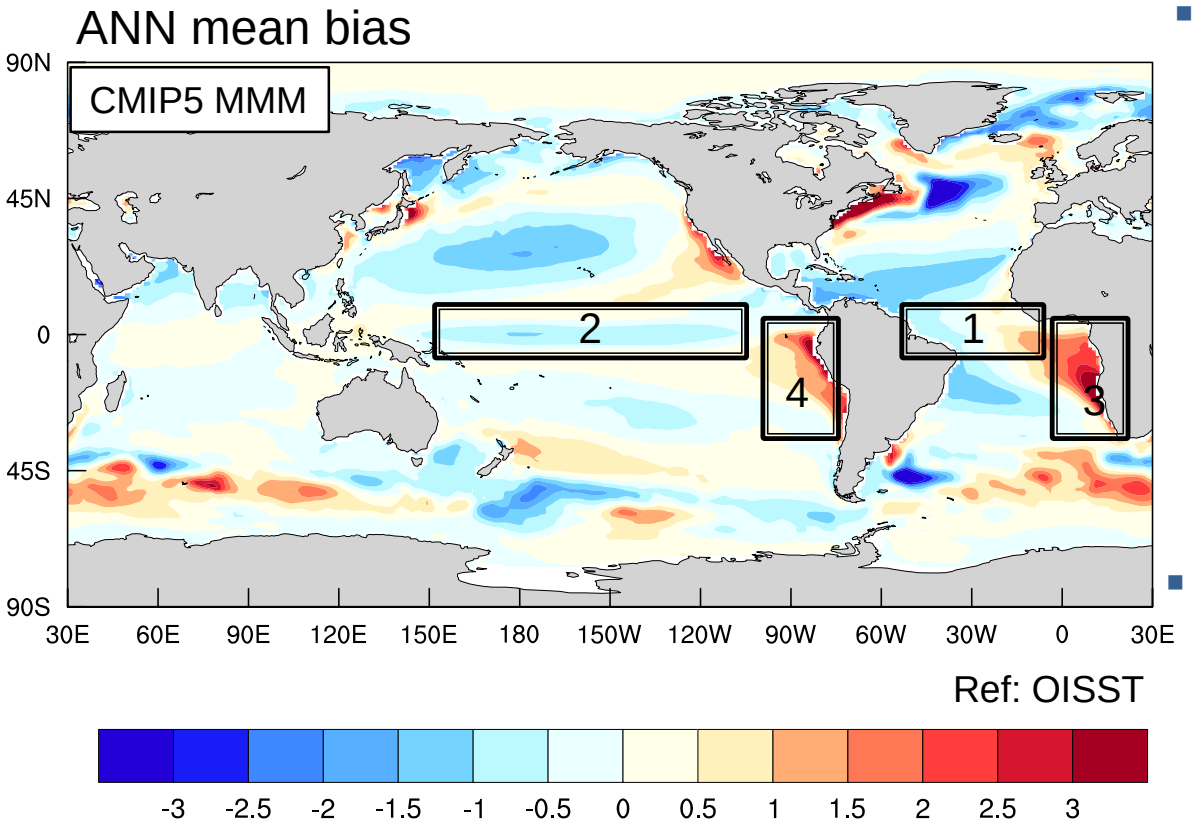
Mean SST biases in CMIP5 models



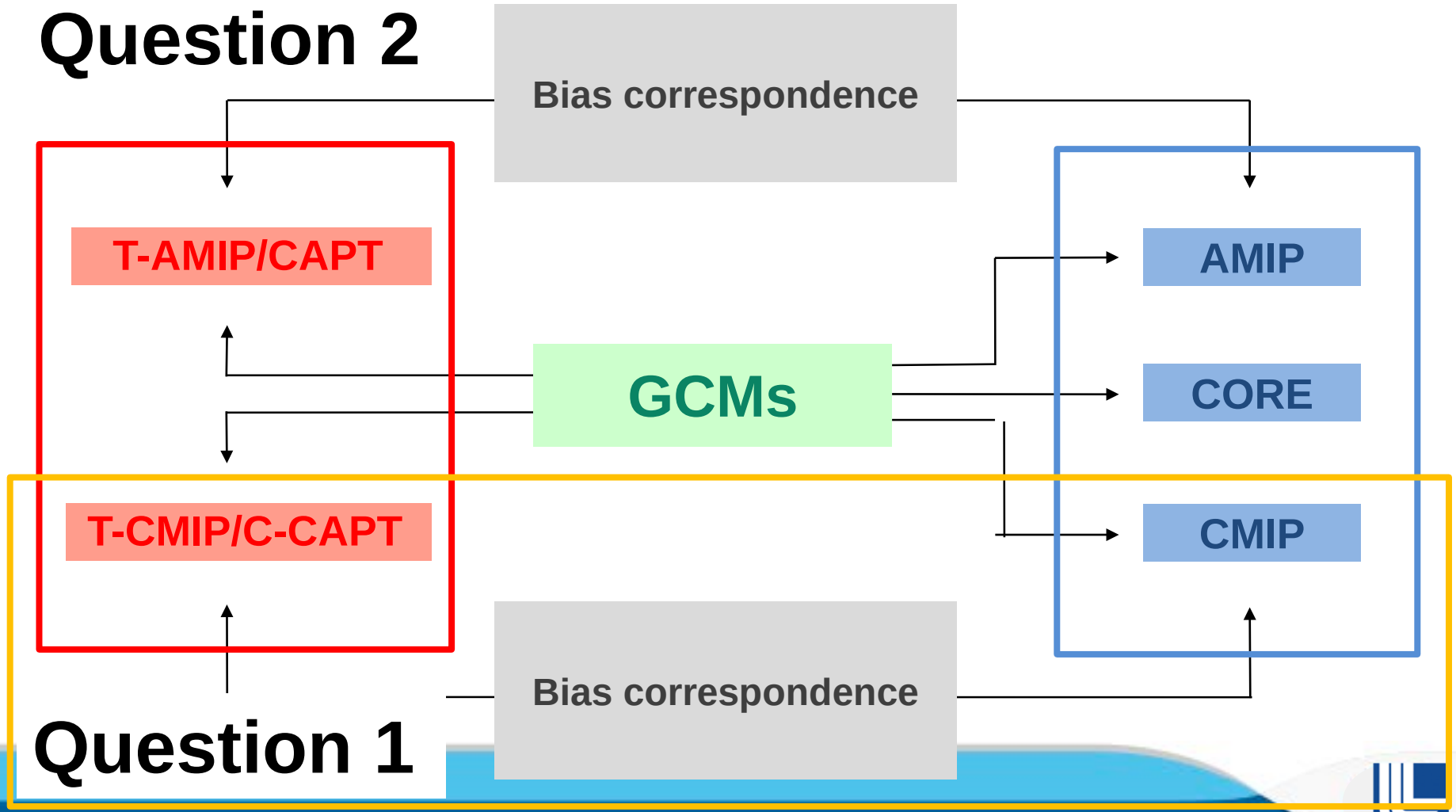
- CMIP5 models suffer from biases in SST over the tropics such as:
  1. reversed SST gradient in the equatorial Atlantic
  2. too cold equatorial Pacific SST
  3. anomalous warm SST at southeastern Atlantic and
  4. Pacific coasts
- **Hypothesis:** Biases in SST represent the average effects of biases in fast processes (e.g. clouds, precipitation, wind stress) and are visible within simulations of a few months.

Research Questions

Question 1: Is there a correspondence between short and long-term tropical SST errors?

Question 2: What are the relative contributions of the atmospheric and oceanic component of the model to the SST biases?

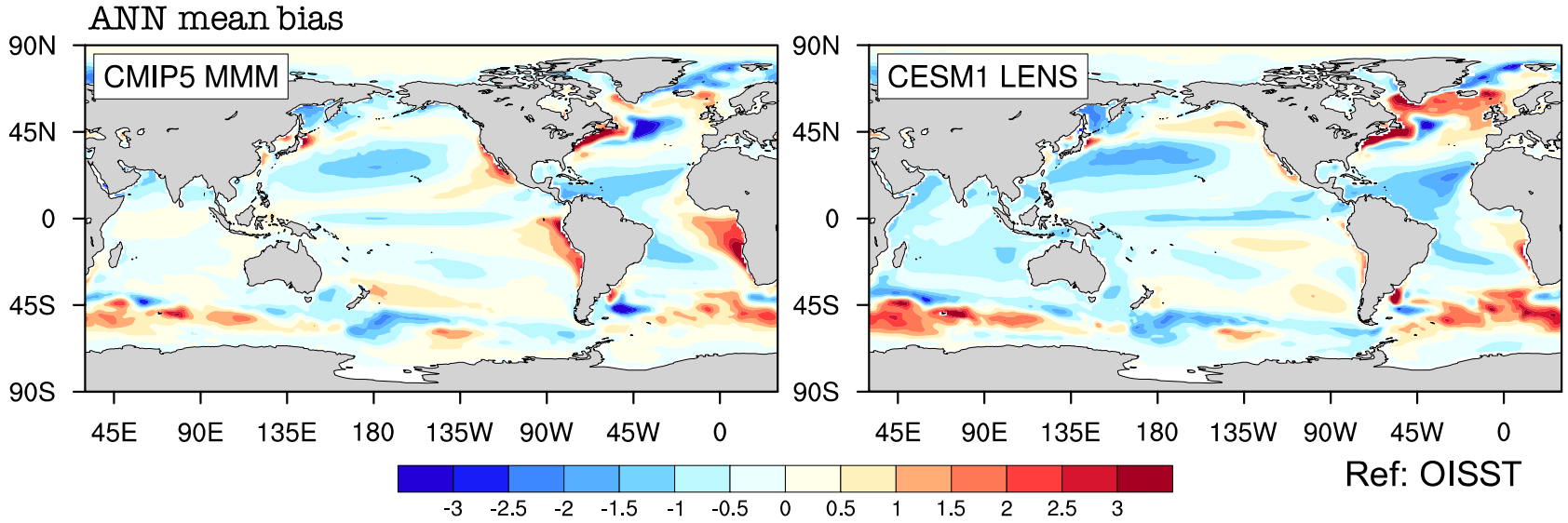
Modeling Evaluation Framework



Datasets

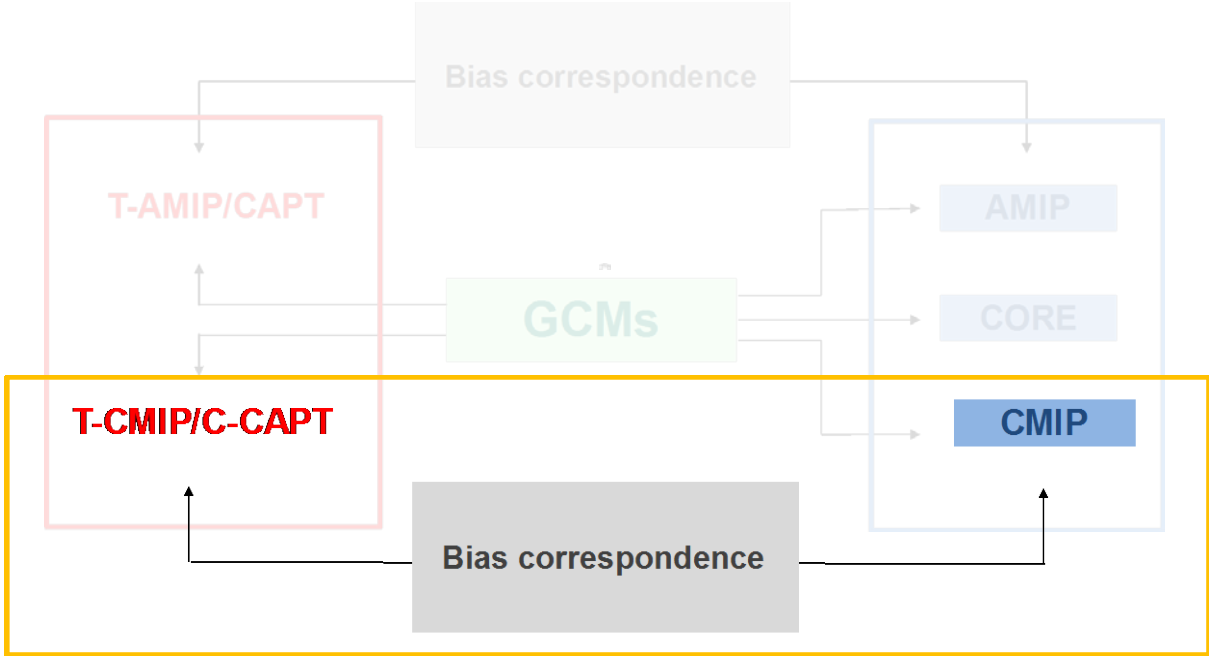
- **CESM1 LENS** Historical simulation ensemble mean (1980-2005)
- **2005 CCAPT** CESM run in 6-month long hindcast mode for 2005
- **AMIP CAM5.1** Simulations with prescribed SSTs (1997-2012)
- **Long-term AMIP CAPT CAM 5.1** run in 3-day long hindcast mode (1997-2012)

Does CESM have similar mean SST biases to the CMIP5 MMM?

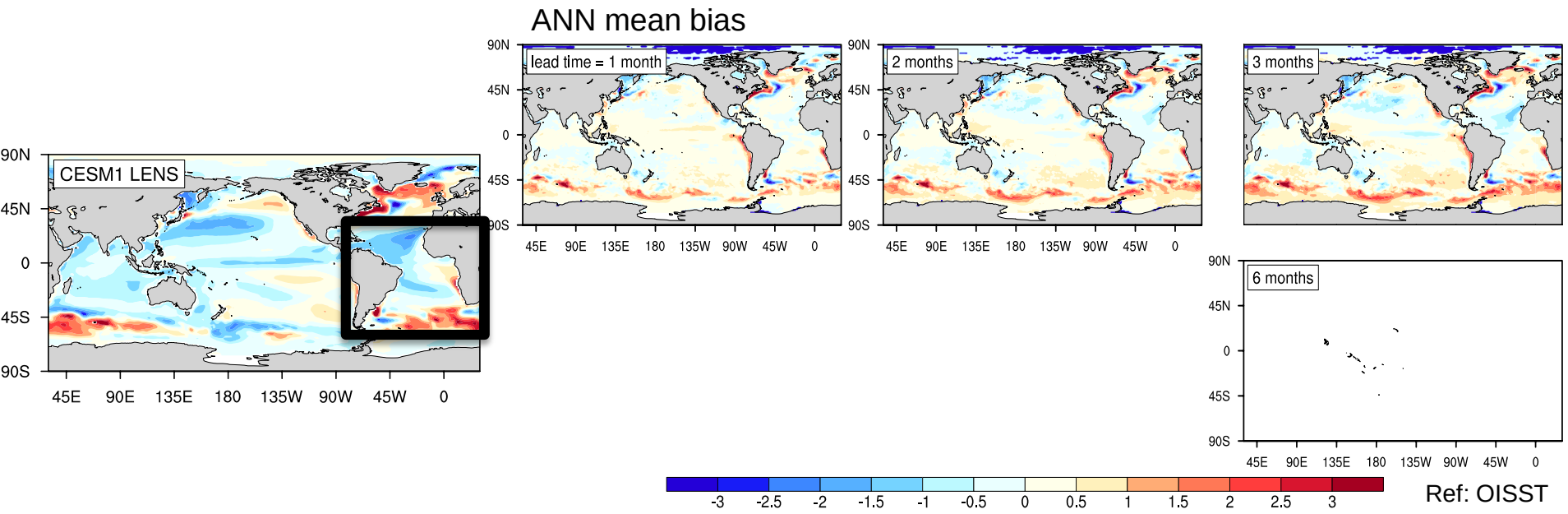


- CESM1 (LENS) shows similar tropical SST bias patterns, although weaker in magnitude

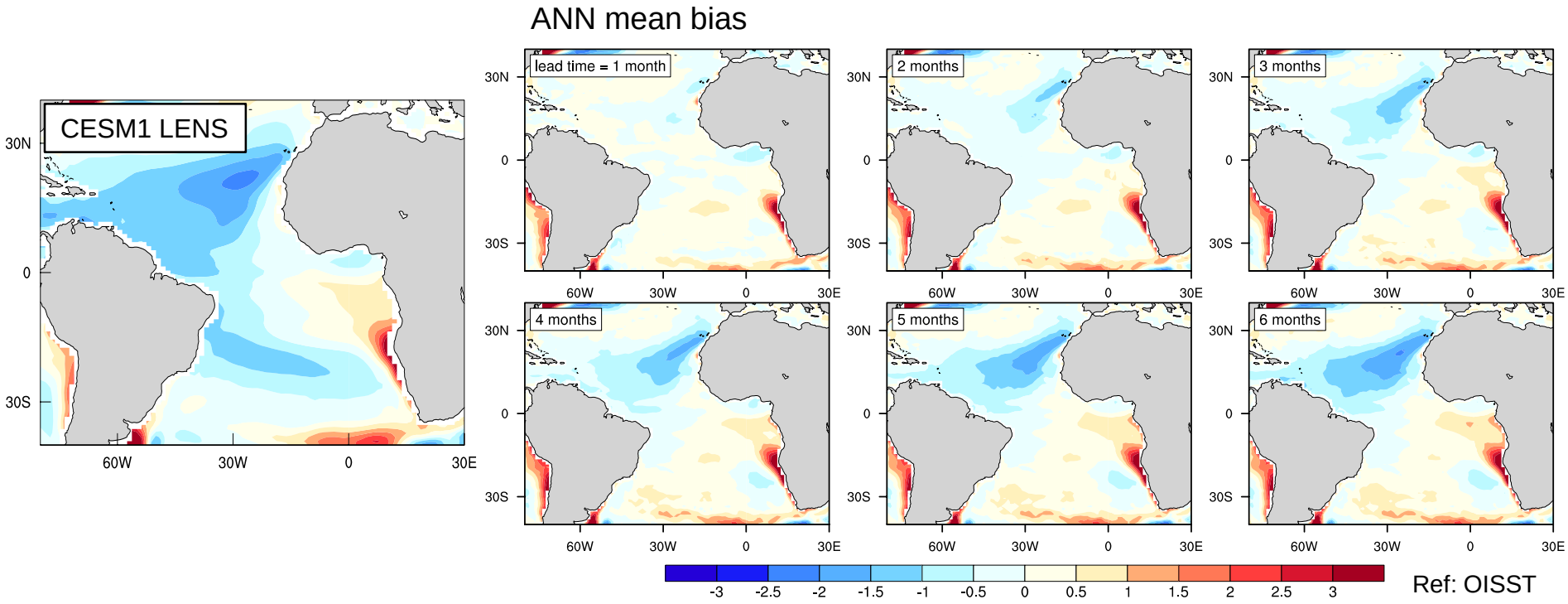
Question 1: What is the correspondence of short and long-term tropical SST errors?



SST bias growth through 1-6 months hindcast lead time

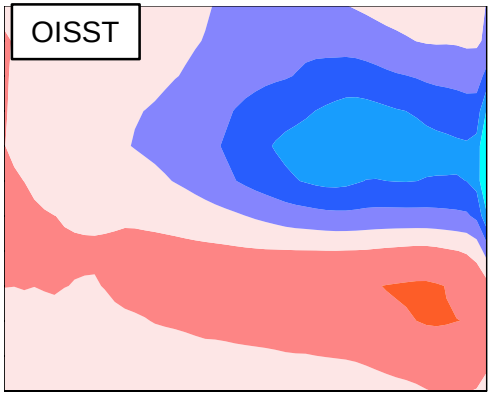


SST bias growth: case of the tropical Atlantic

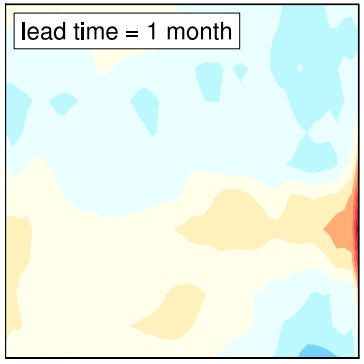


Annual cycle of the equatorial Atlantic (5°S-5°N) SST bias

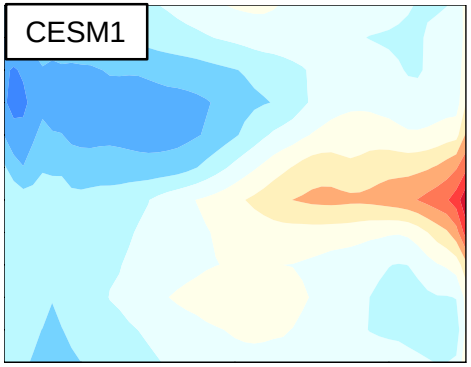
OBS monthly climatology

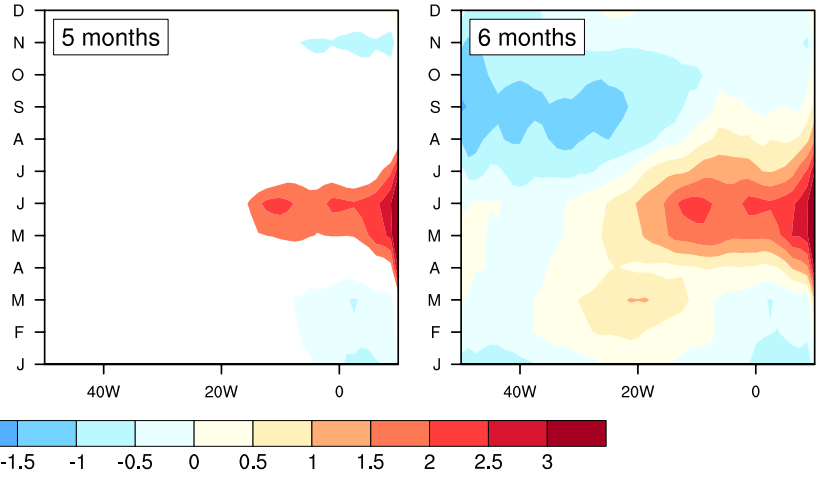


MON mean bias



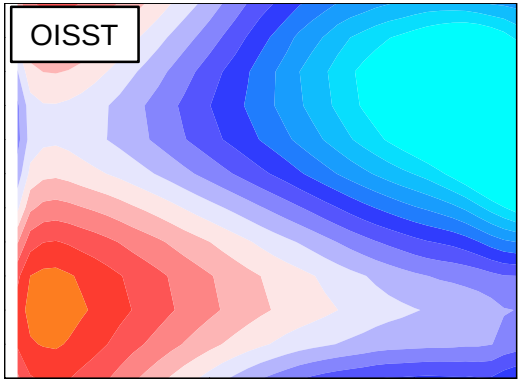
MON mean bias



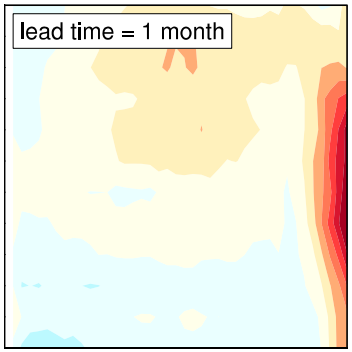


Annual cycle of the southeastern tropical Atlantic (10°S-20°S) SST bias

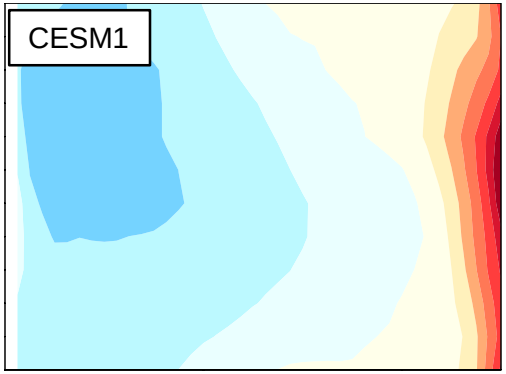
OBS monthly climatology

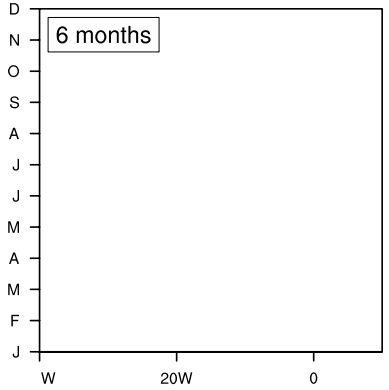


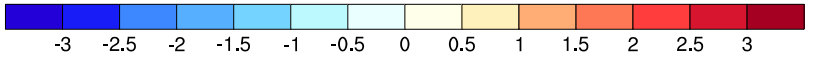
MON mean bias



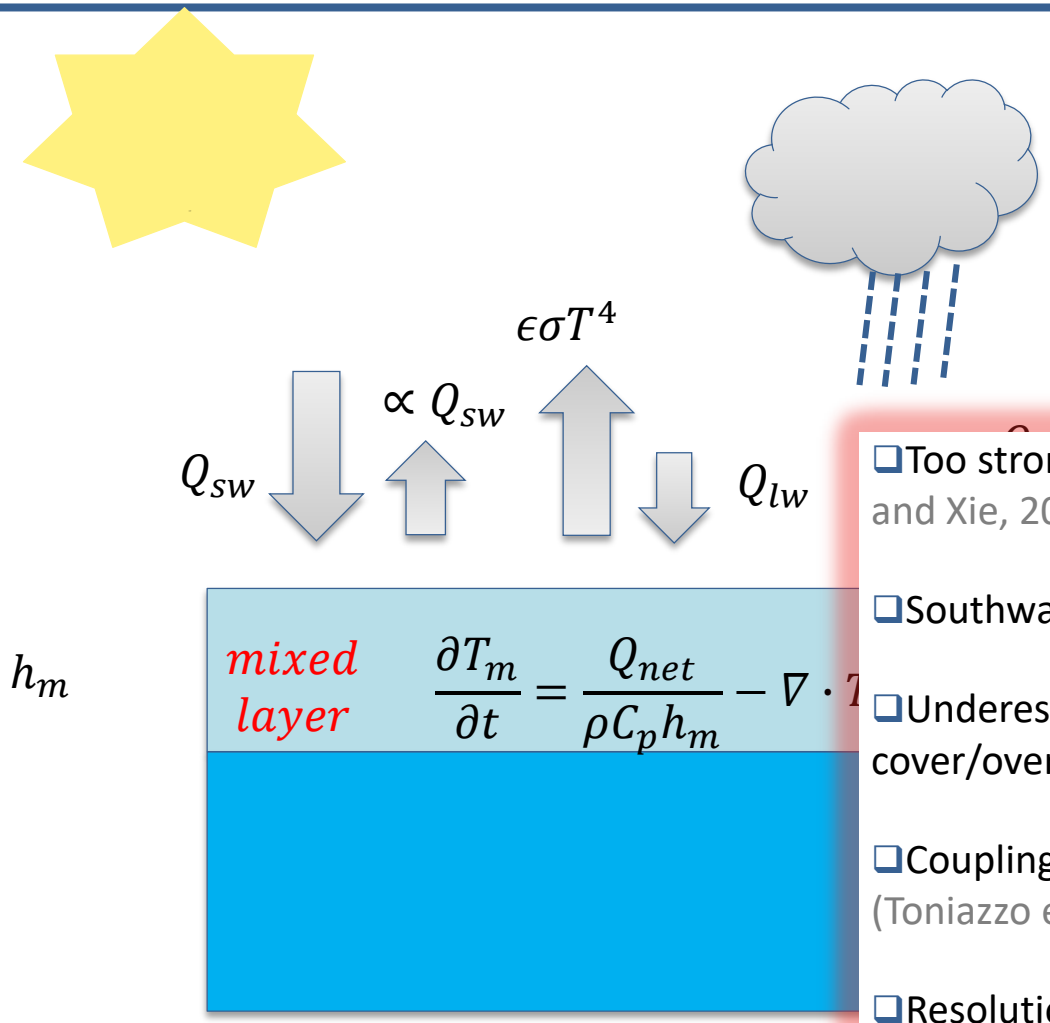
MON mean bias





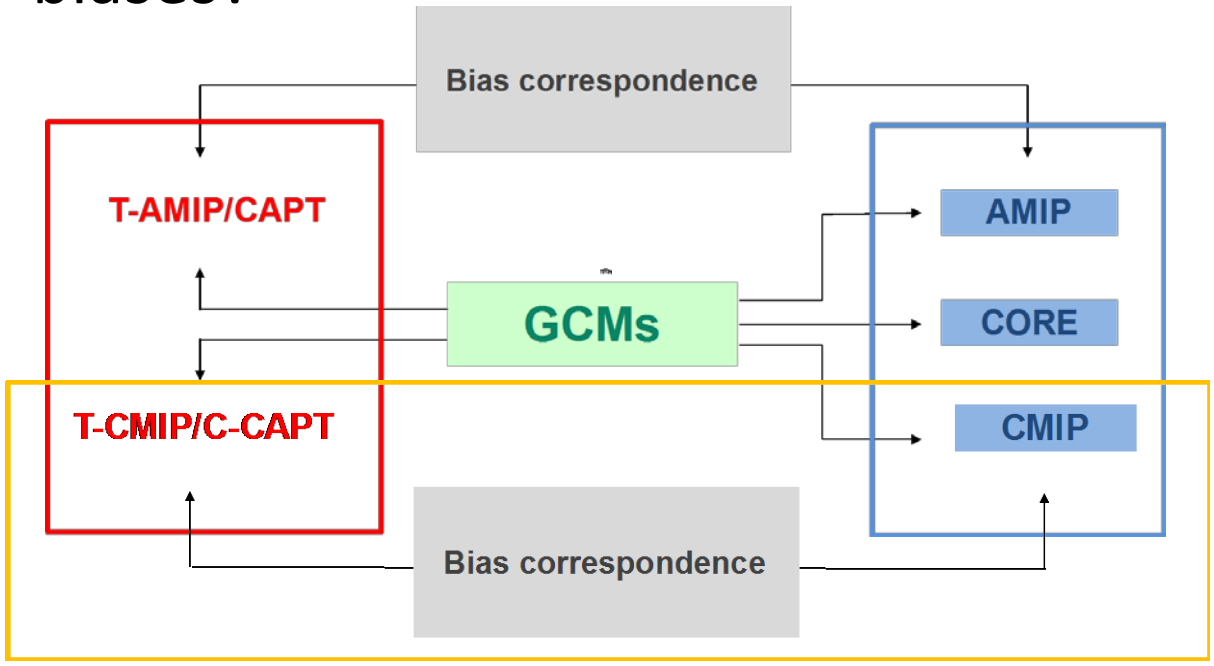


Possible reasons for the SST biases

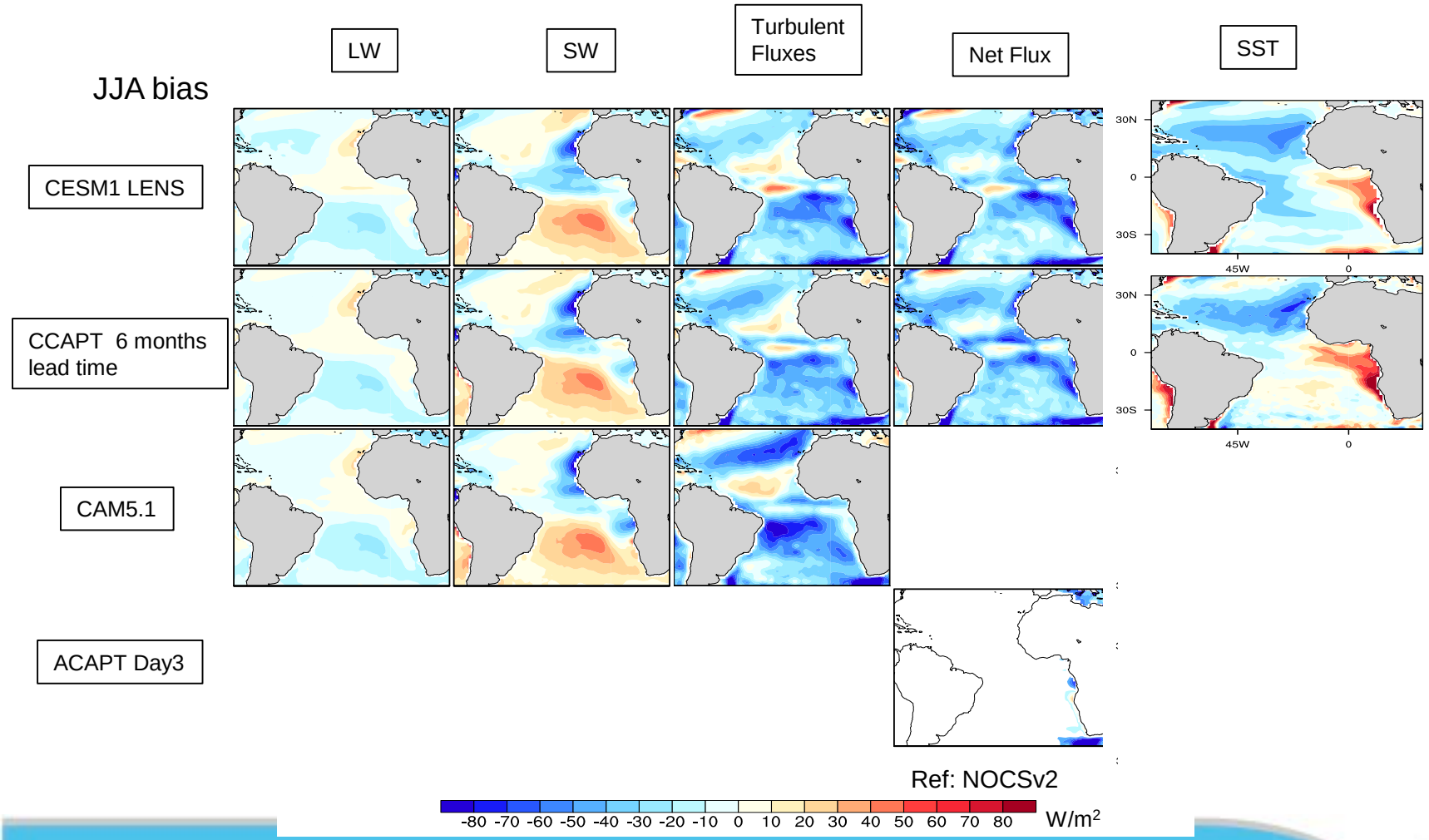


- ❑Too strong westerly winds (Chang, 2007; Richter and Xie, 2008)
- ❑Southward Atlantic ITCZ (Richter et al, 2013)
- ❑Underestimated stratus cloud cover/overestimated SW flux (Huang, 2007)
- ❑Coupling with the equatorial Atlantic bias (Toniazzo et al, 2013)a
- ❑Resolution of topography (Milinksi, 2016)

Question 2: What are the relative contributions of the atmospheric and oceanic component of the model to the SST biases?



Biases in surface radiative and turbulent fluxes



Summary and Outlook

- The coupled CAPT framework is used to diagnose the sources of tropical SST biases in CESM
- Preliminary analysis of the coupled CAPT runs indicate that SST biases along the southeastern tropical Atlantic emerge within 1 month lead time, and after 1 month lead time for the equatorial Atlantic
- The CCAPT framework will be used together with AMIP/ACAPT and CORE analysis to identify the atmospheric and oceanic contributions
- Next steps: sea surface/mixed-layer heat budget analysis of CCAPT