Model biases in the Inter-American Seas

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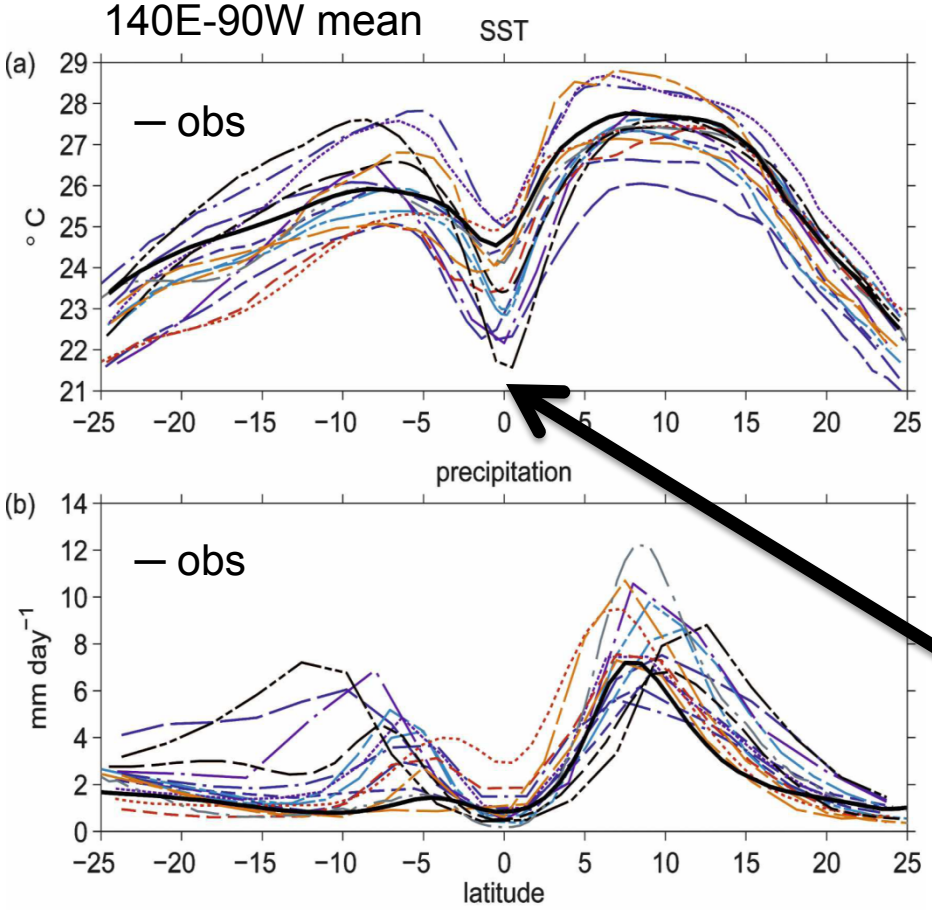
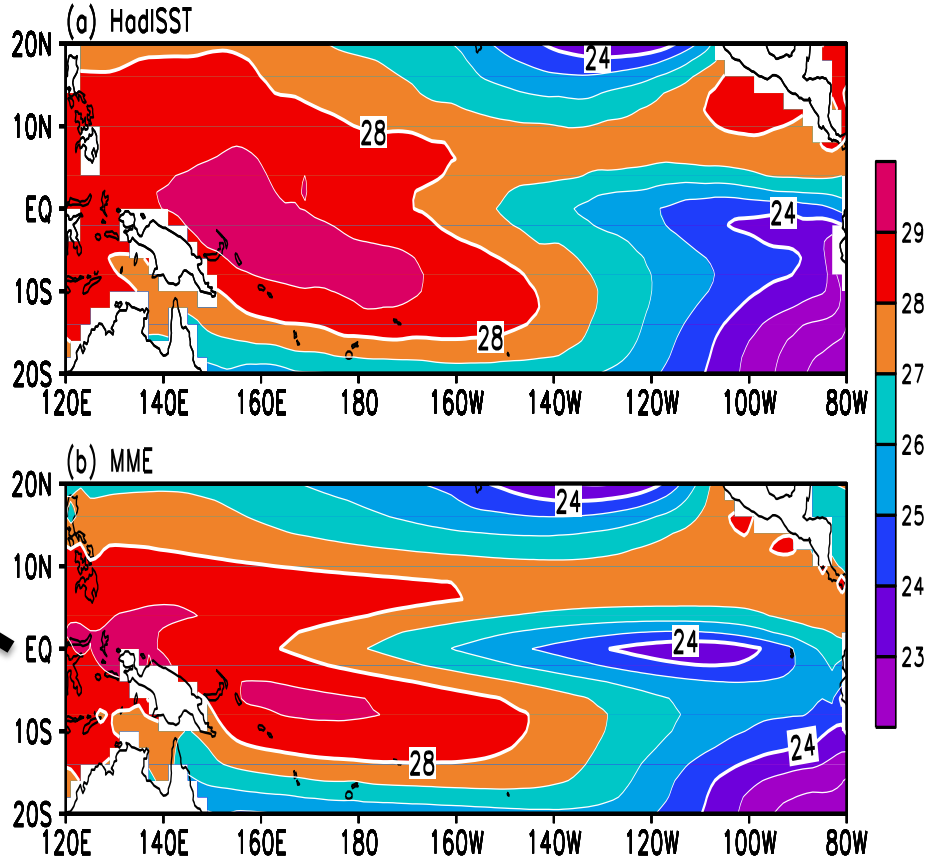
- Tropical Pacific
- Equatorial Atlantic
- Atlantic warm pool

Tropical Pacific biases in climate models





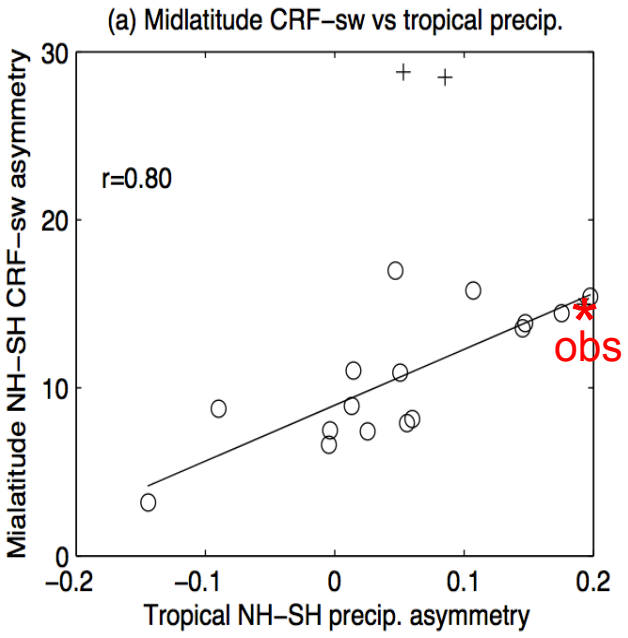
- Double ITCZ bias
- Excessive Eq. cold tongue bias

de Szoeke & Xie (2008, JC); Li & Xie (2014, JC)

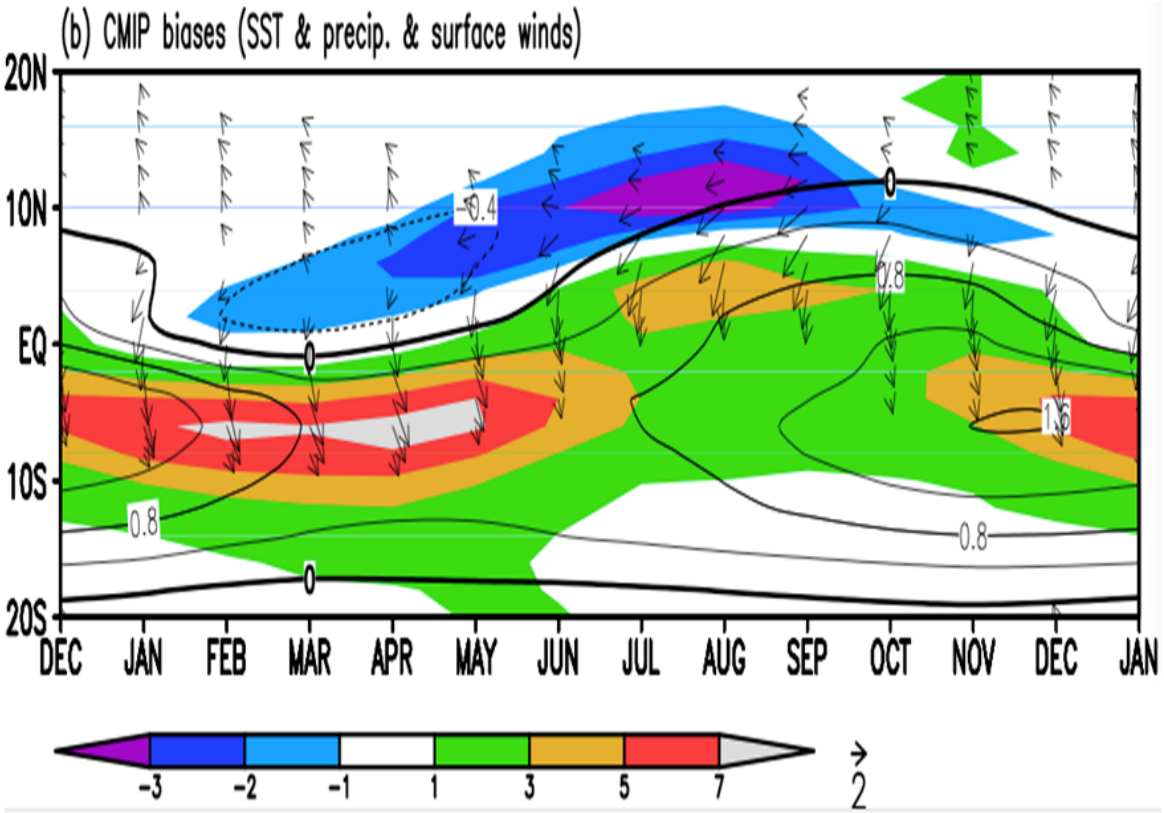
Extratropical forcing and the double ITCZ bias

Li & Xie (2014, JC); Hwang & Frierson (2013, PNAS)

Tackle the double ITCZ problem beyond the tropics: insufficient SH midlatitude clouds



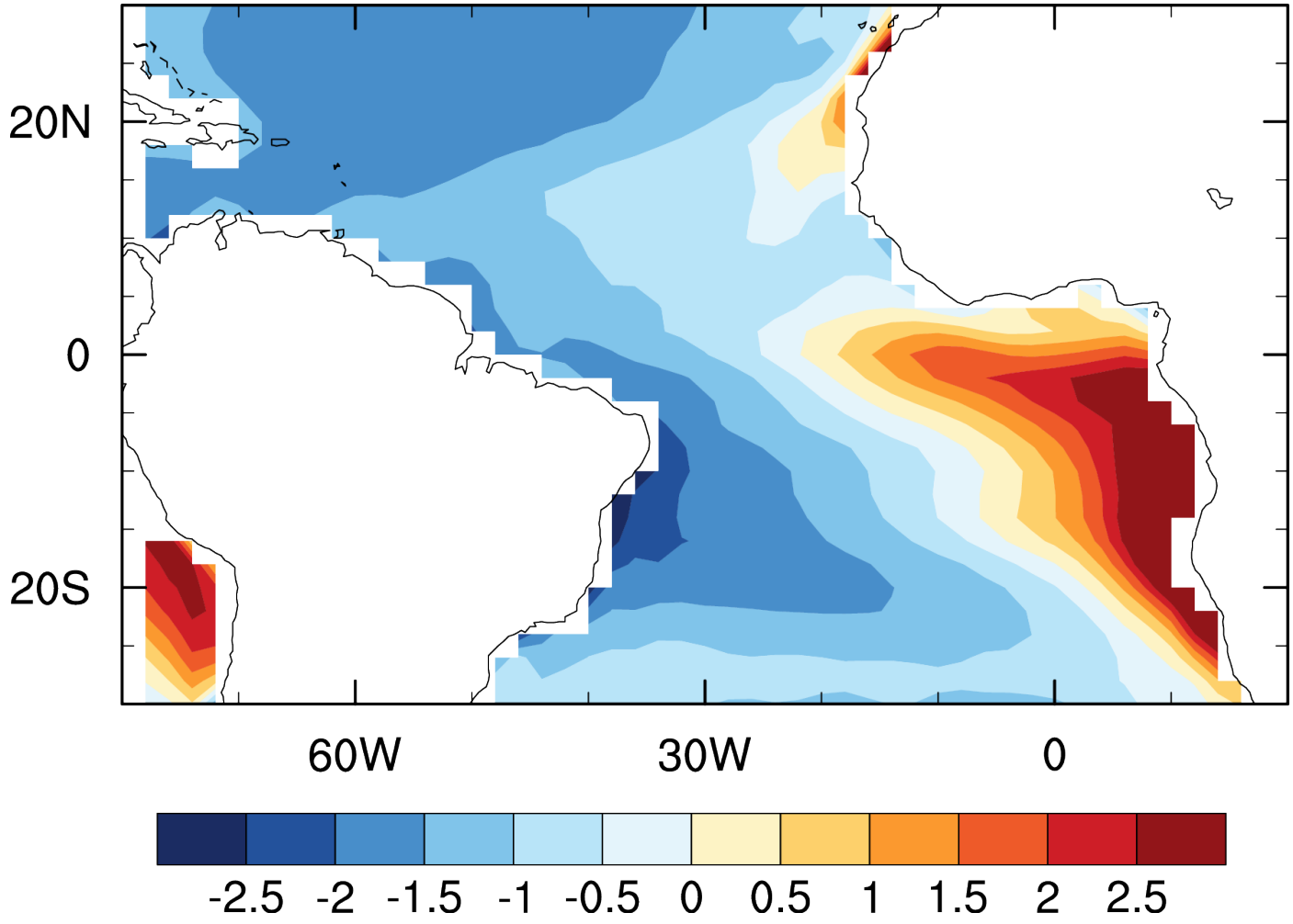
Inter-model spread in inter-hemispheric asymmetry b/w midlatitude CRF-sw & tropical rainfall



- Excessive solar radiation occurs in SH midlatitudes in Nov-Dec, while the ITCZ biases are most pronounced in Jan-May.
- Coupled biases are in WES feedback.

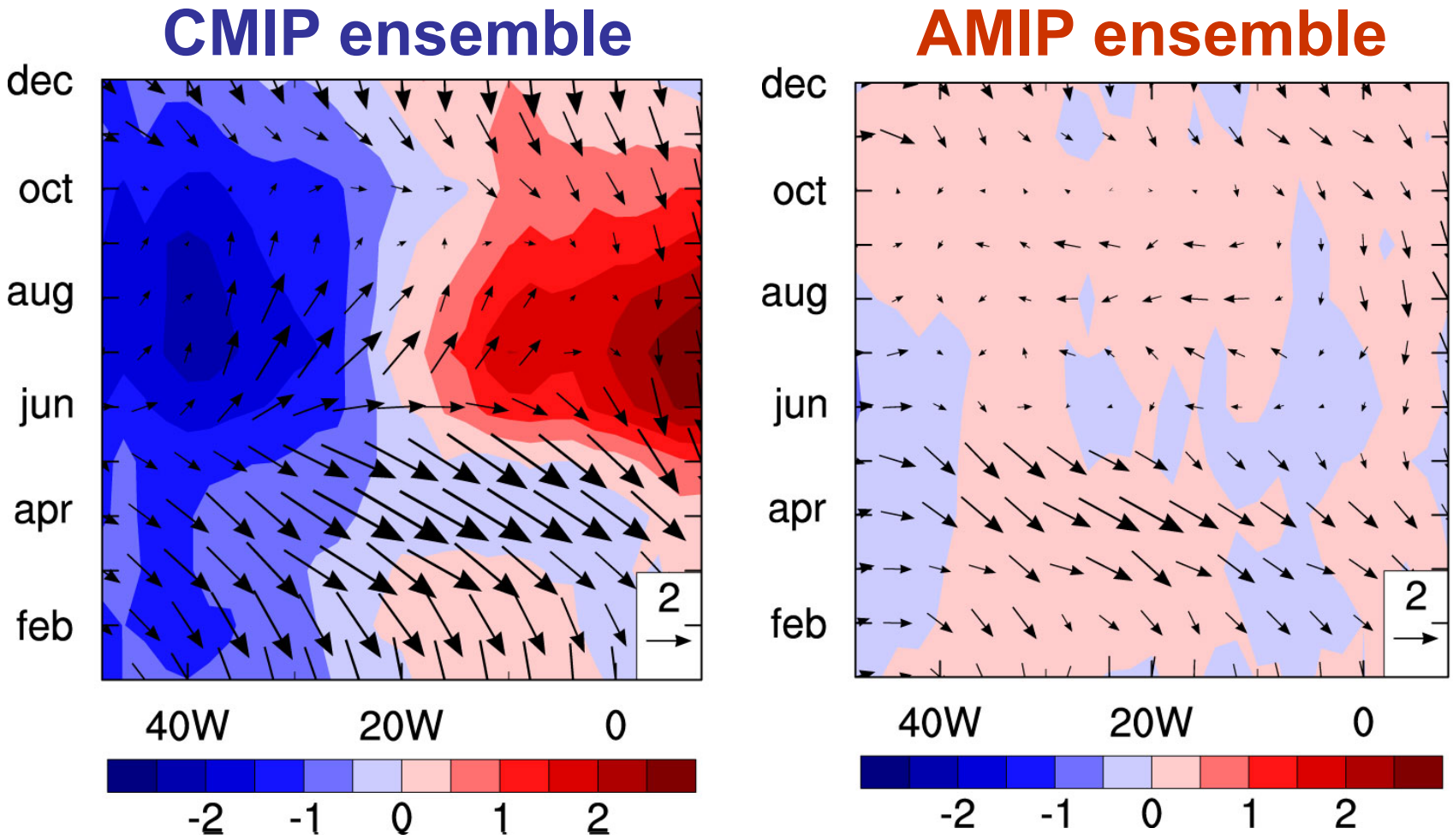
Trop Atlantic SST biases in JJA

CMIP5 ensemble mean



Seasonal evolution of biases

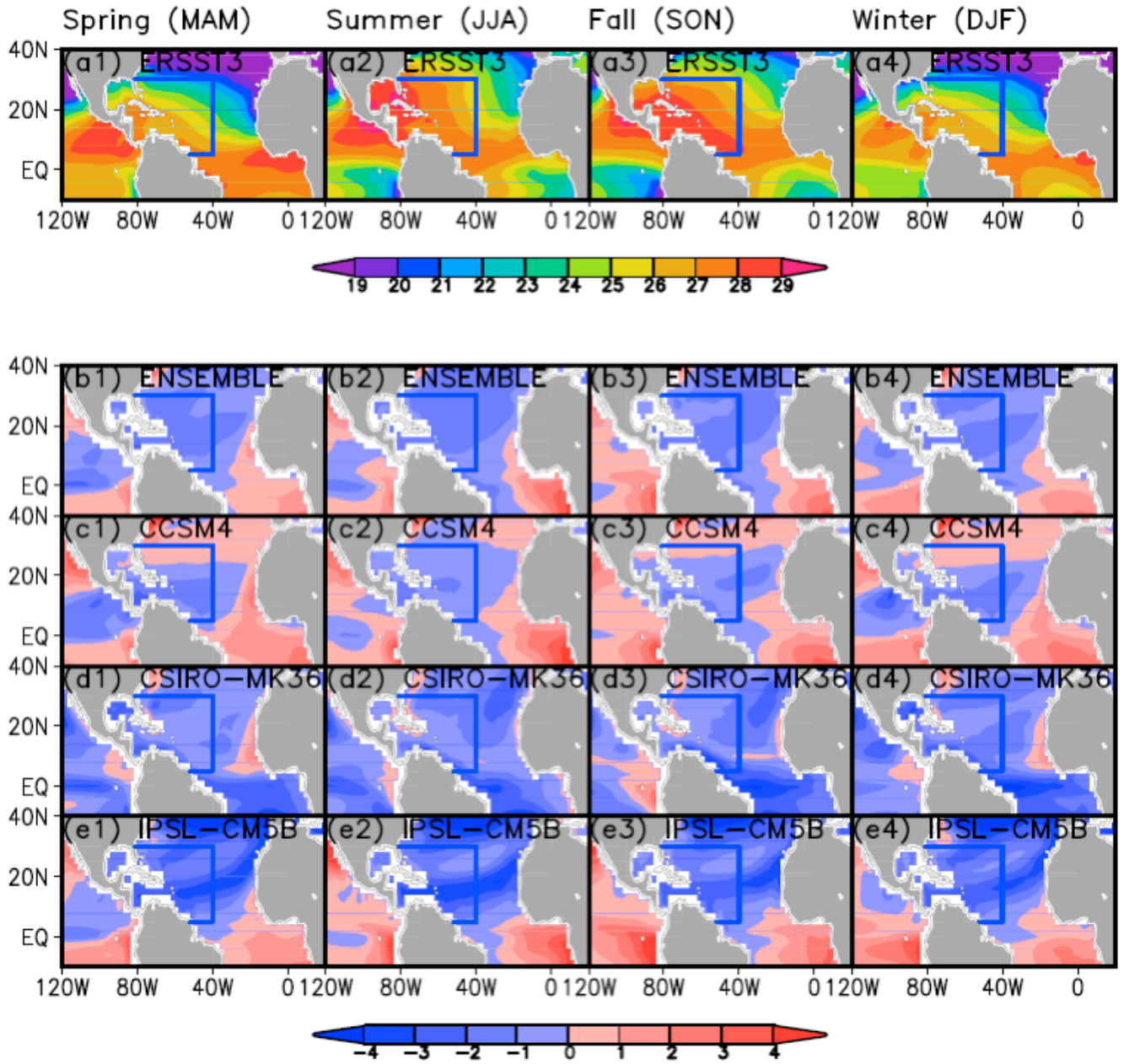
Longitude-time sections of equatorial SST bias and sfc winds



Richter and Xie (2008)

Atlantic warm pool in CMIP5 models: cold SST bias

Liu, Wang, Lee and Enfield (2013, JC)



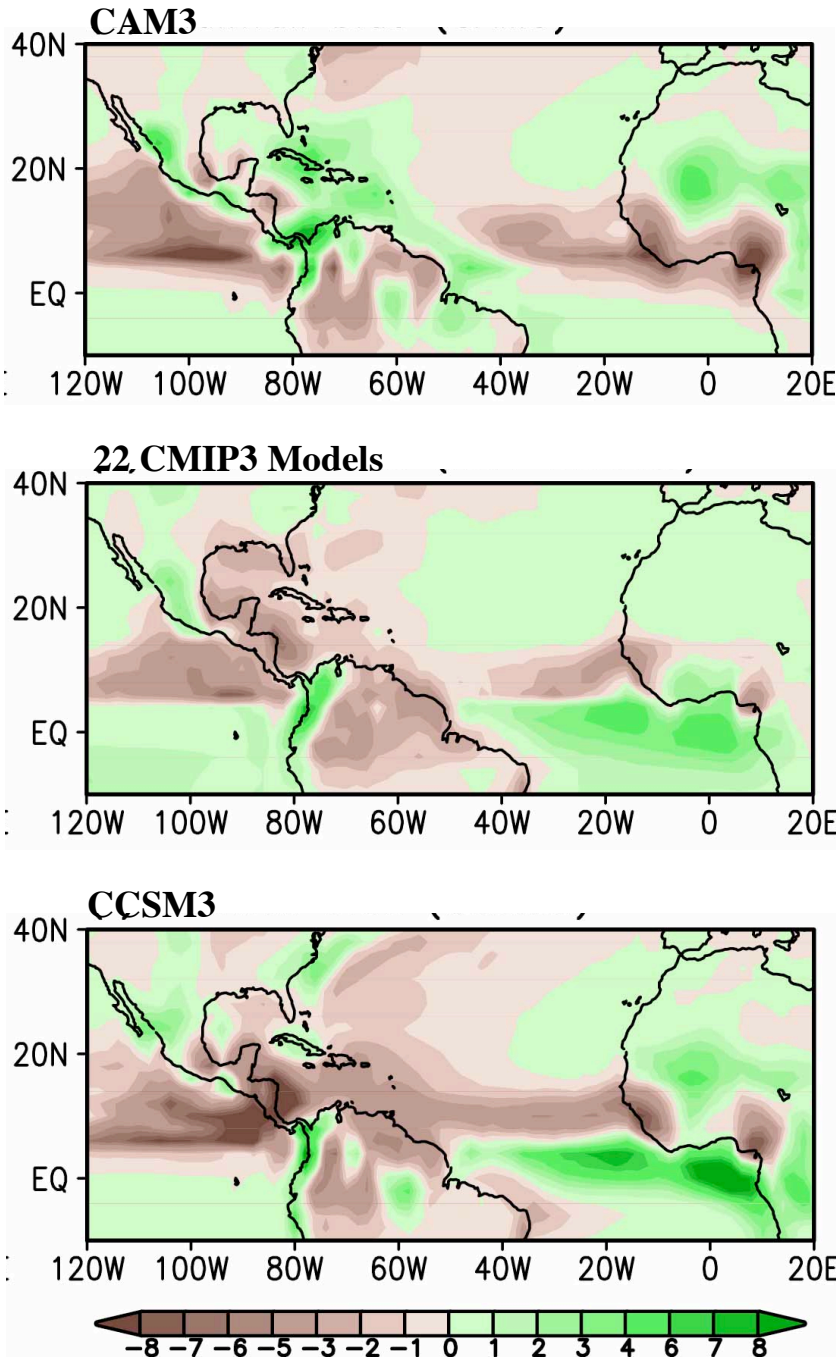
Observed SST

19 CMIP5 models

CCSM4

CSIRO

IPSL

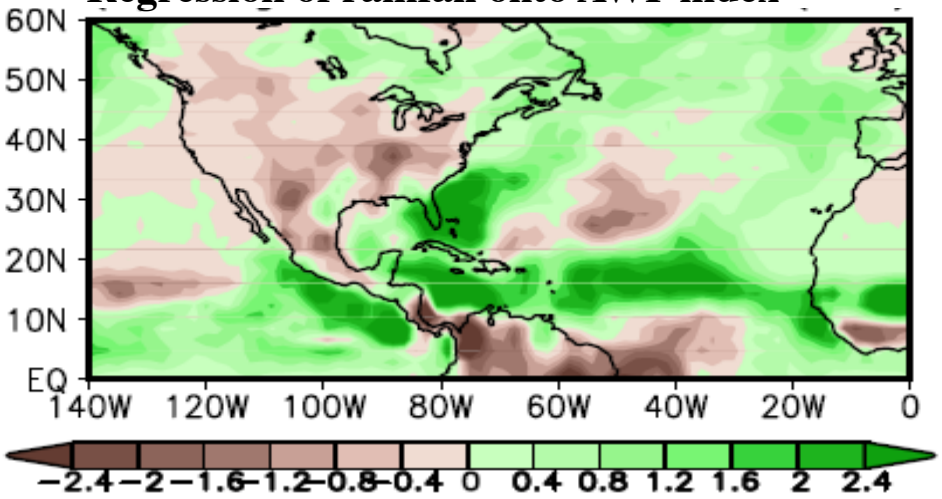


Model rainfall bias in the AWP region

- When an atmospheric GCM is forced by observed SST, there is an excessive precipitation over the AWP region during the summer (top panel).
- When the atmosphere and ocean are fully coupled, there is a dry bias in the AWP region (middle and low panels).
- Negative SST biases are suggested to cause the dry bias.

Impact of the AWP on United States Rainfall

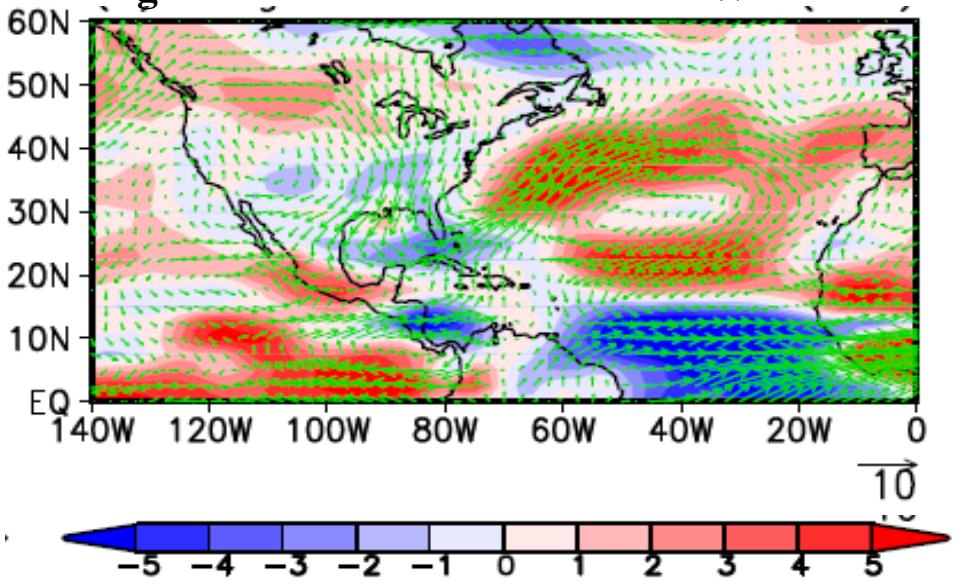
Regression of rainfall onto AWP index



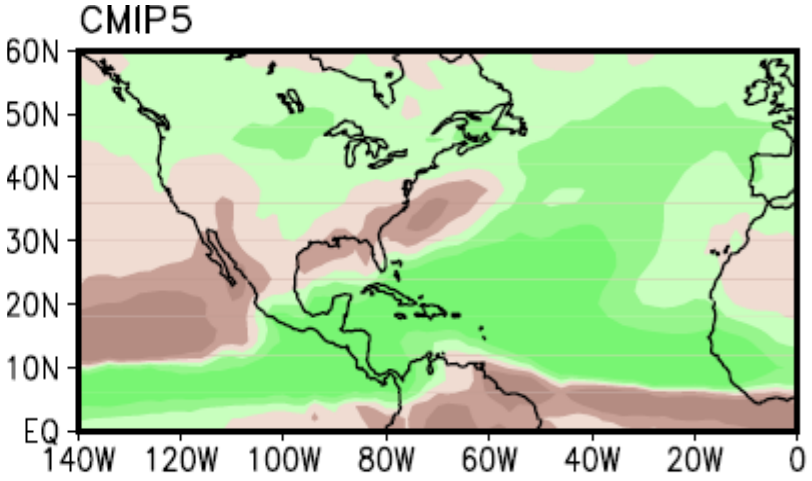
Liu, Wang, Lee, and Enfield (2015)

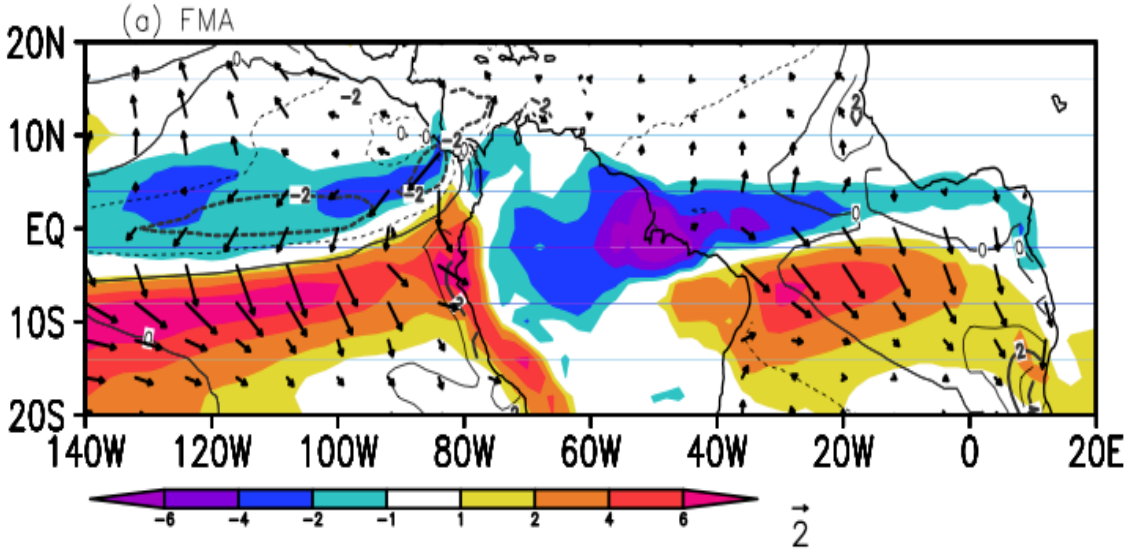
Large AWP is associated with reduced rainfall in the U.S. during summer and fall. High AWP temperature decreases the moisture transport to the U.S. from the Gulf of Mexico.

Regression of moisture flux onto AWP index



19 CMIP5 models fail to simulate the decreased rainfall in U.S.





Precip, wind & SST (blk contours)

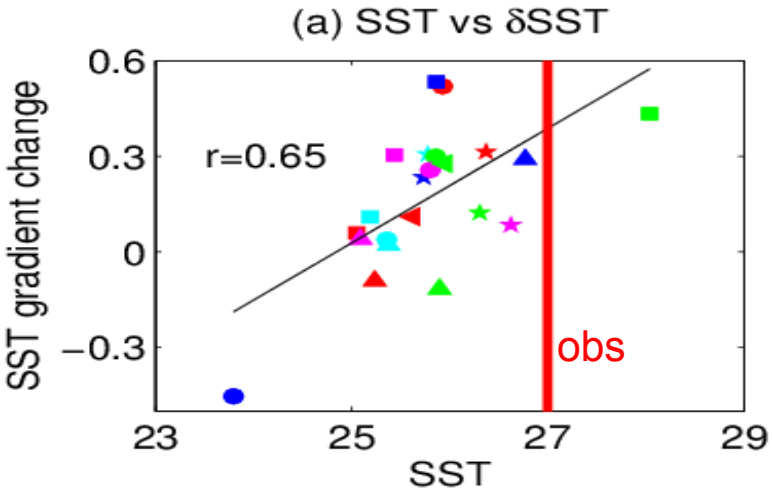
Major biases in the tropics

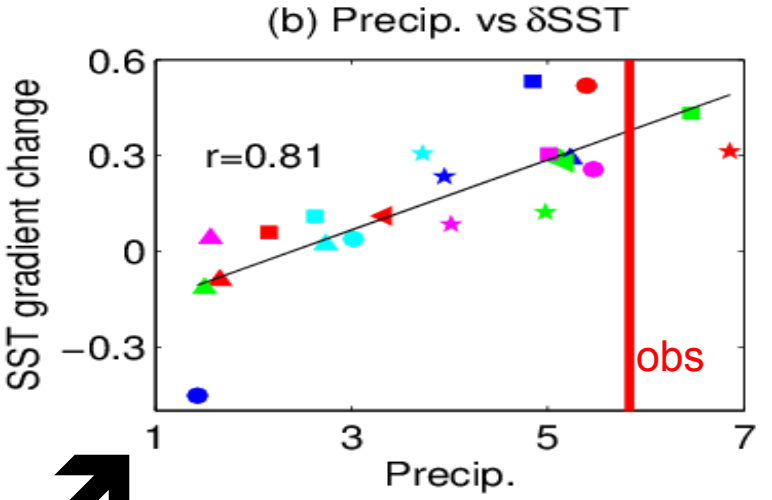
- Spurious southern ITCZ during FMA; WES feedback.
- Might be caused by extratropical biases (new global perspective).
- Pacific cold tongue extends too far westward.
- Atlantic cold tongue is too weak.
- Cold biases in the Atlantic warm pool ← AMOC biases?
- MJO, TCs

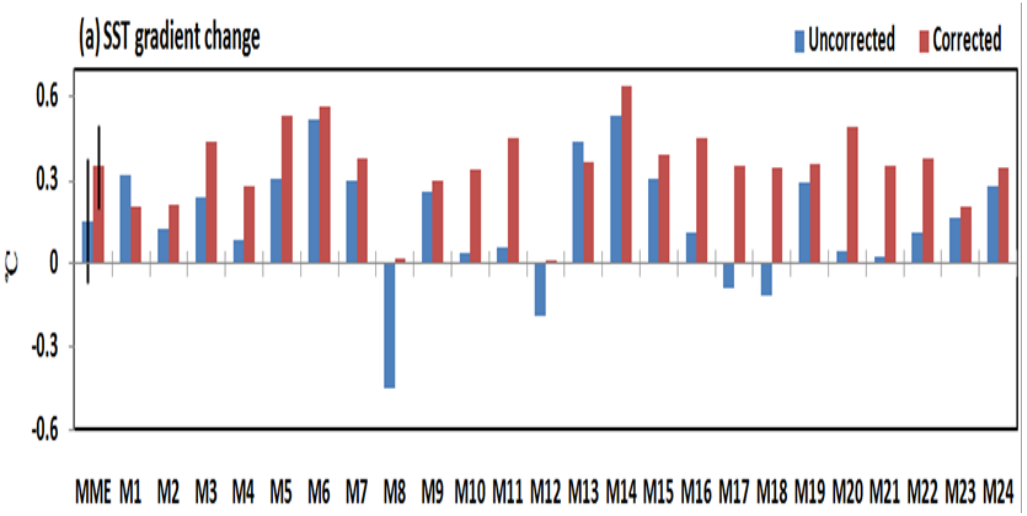
- ➢ Evaluate impacts on modes, seasonal prediction and future projection;
- ➢ Predictive understanding of the root cause;
- ➢ Improve models and reduce stubborn biases.

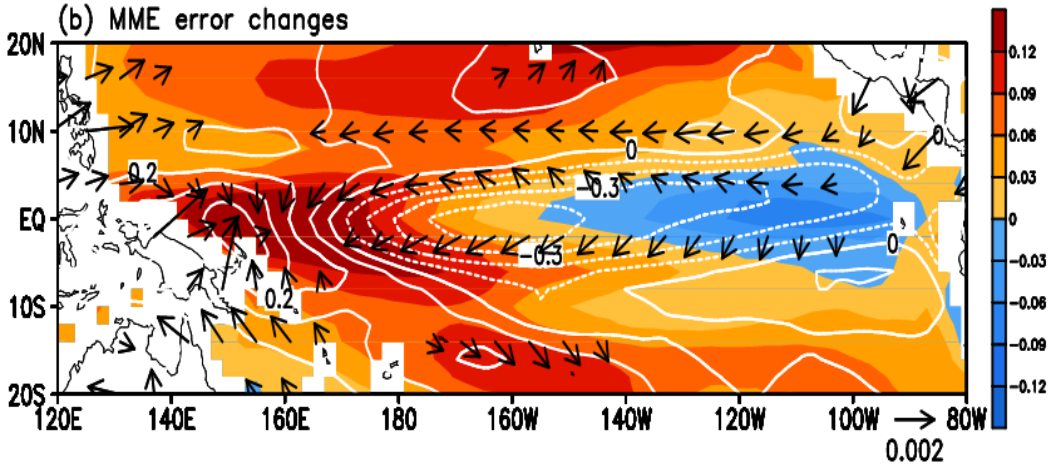
Cold tongue bias and the underestimated El Nino-like warming

Li et al. (2015, In preparation for CD)







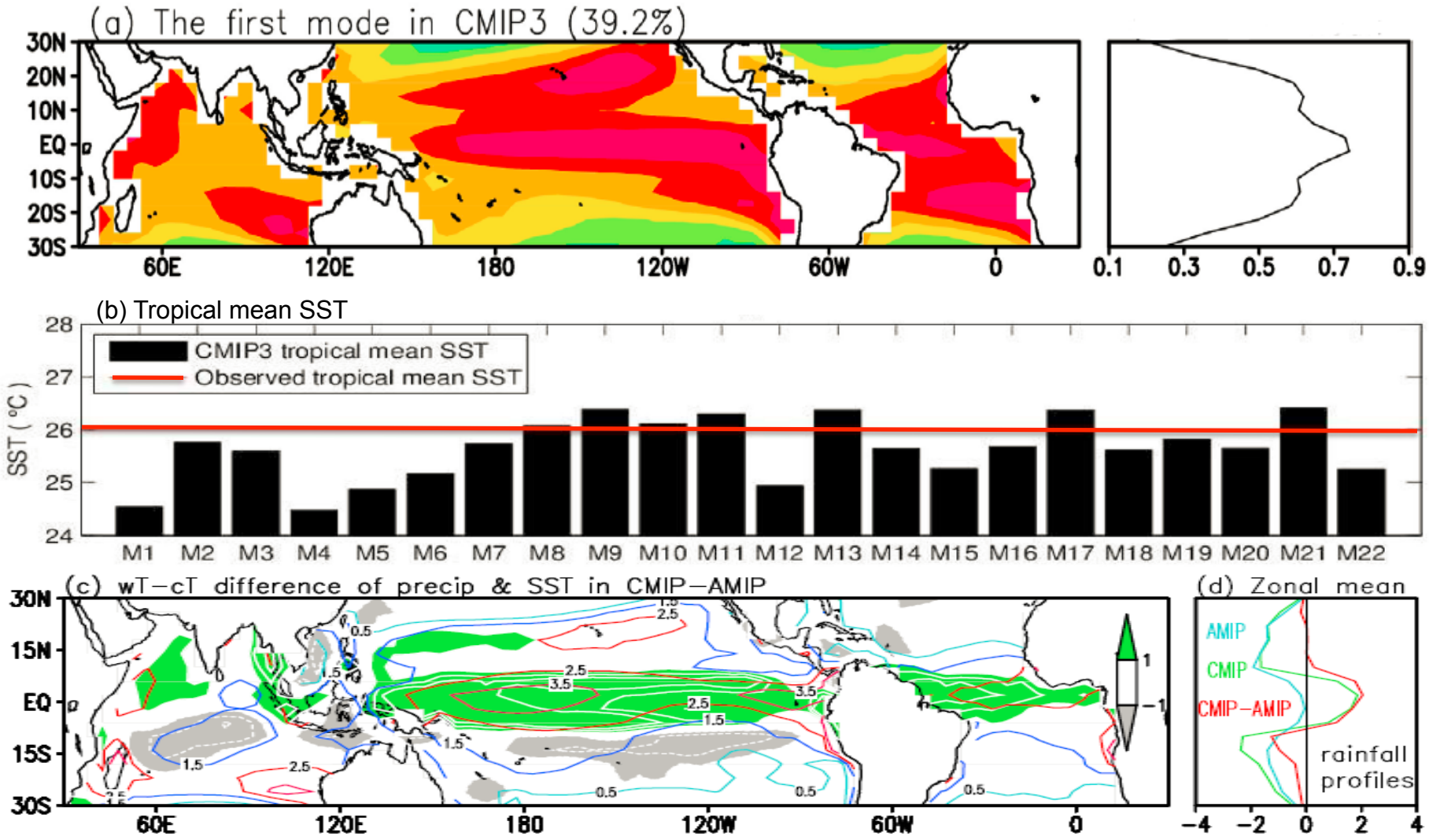


Correlation among CMIP5 models between cold tongue simulation bias and projected east-minus-west SST change in the Eq. Pacific

- Too cool Eq. cold tongue and deficient WP rainfall
- Too weak WP CRF feedback leads to a La Nina-like warming offsetting.

Tropical-wide SST offset error

Li & Xie (2012, GRL)

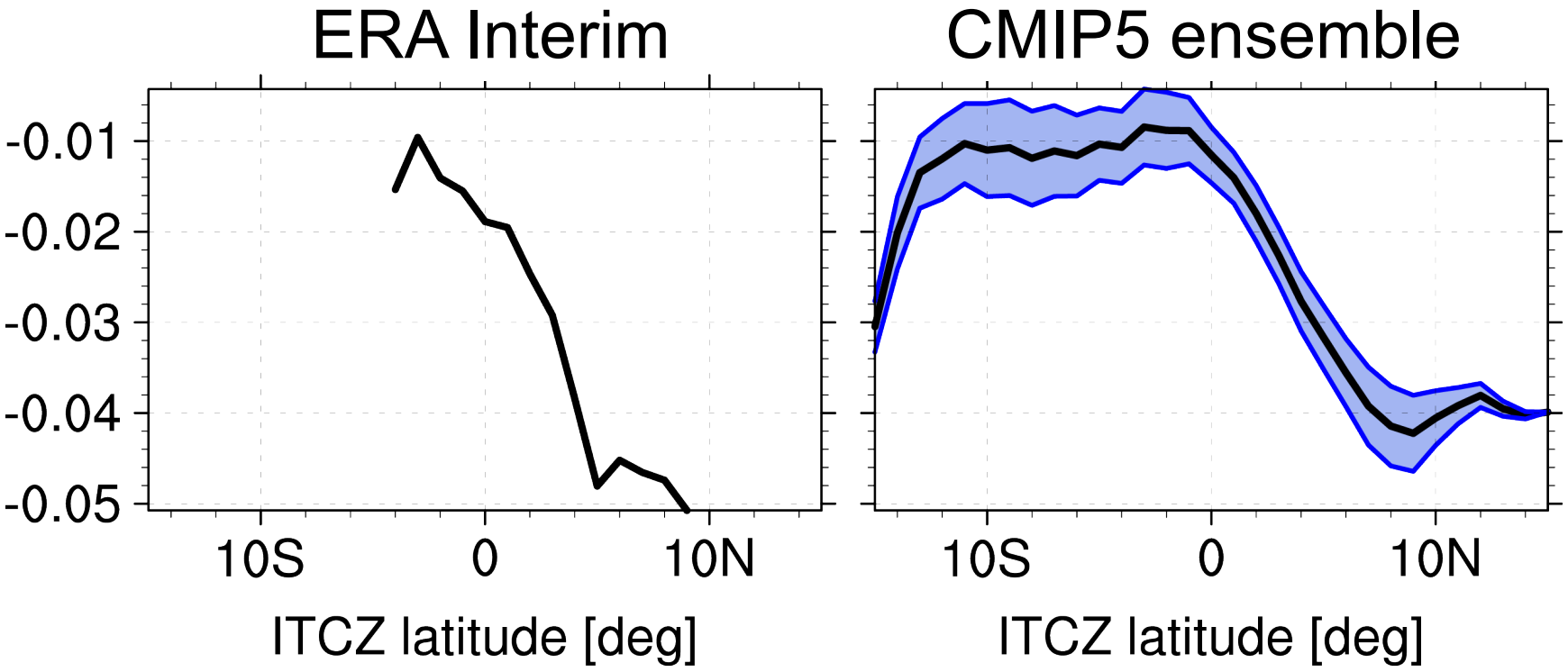


- Tropical-wide error originates excessive clouds, and affects the SST threshold for convection

τ_x as a function of Atlantic ITCZ latitude

based on monthly mean total fields

(ITCZ latitude determined using zonally averaged precip)



Richter et al. 2014, Clim. Dyn.

Potential root causes

- potential root causes for equatorial Atlantic biases: 1) errors in convection schemes; 2) insufficient vertical momentum transport in atmosphere; 3) diffuse oceanic thermocline
- likely root causes for southeast Atlantic biases: 1) weak along-shore winds (e.g. Small et al. 2015, JC, accepted); 2) insufficient stratocumulus cover; recent review by Richter et al. 2015
- results of Richter et al. (2014) suggests that despite severe biases some models are able to simulate zonal mode of variability
- impact of Atlantic biases on seasonal predictions and global change projections largely unexplored

Ways forward

- multi-model coordinated OMIP, AMIP, CMIP experiments: test the role of resolution, position of atmospheric coastal jet (e.g. CORE2 vs. QuikSCAT forcing), off-shore transport by ocean eddies
- develop convective parameterizations to further reduce south-equatorial ITCZ biases; test the impact of convective parameterization in (global) CRMs
- more observations needed to understand what it is that we are trying to model: lack of observations for Angola/Benguela coastal current structure and along-shore winds; ditto for vertical profile of equatorial winds