Impact of Sea Surface Temperature Biases on Tropical Cyclone Simulations

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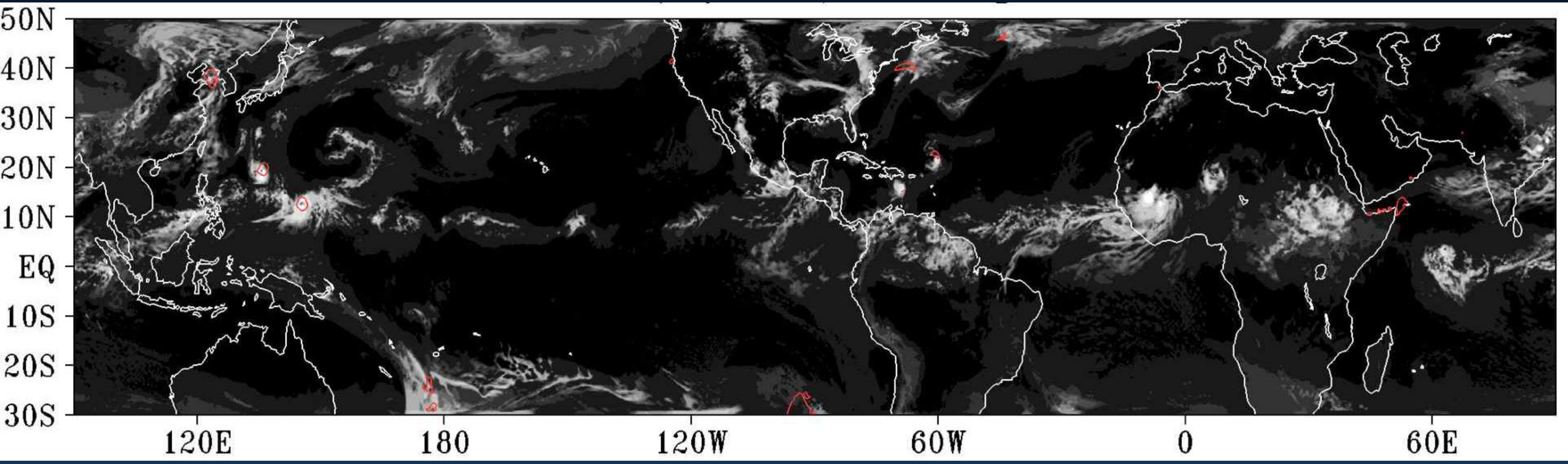
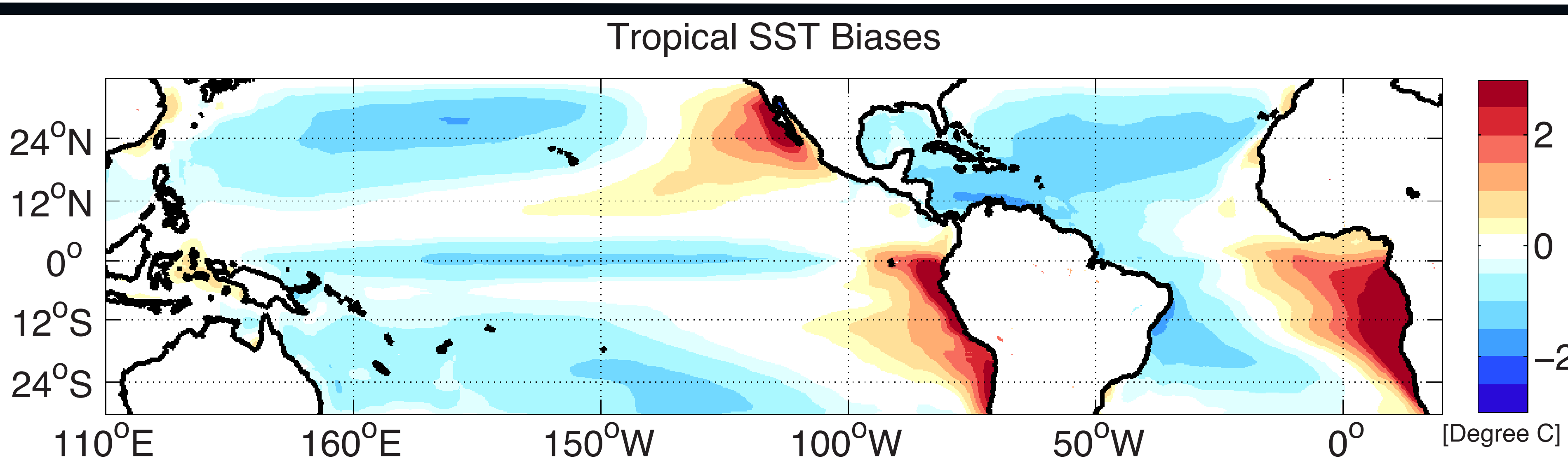
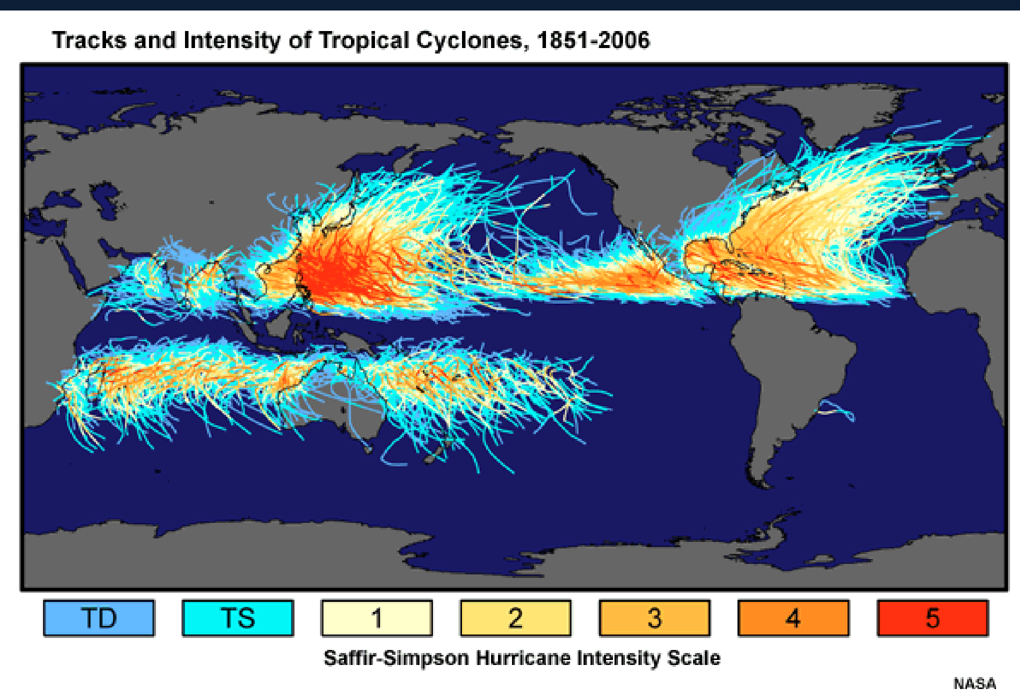


Tropical Atlantic Conference and PREFACE General Assembly
Paris, France, Nov. 28-Dec. 2, 2016

CMIP5 Model SST Bias

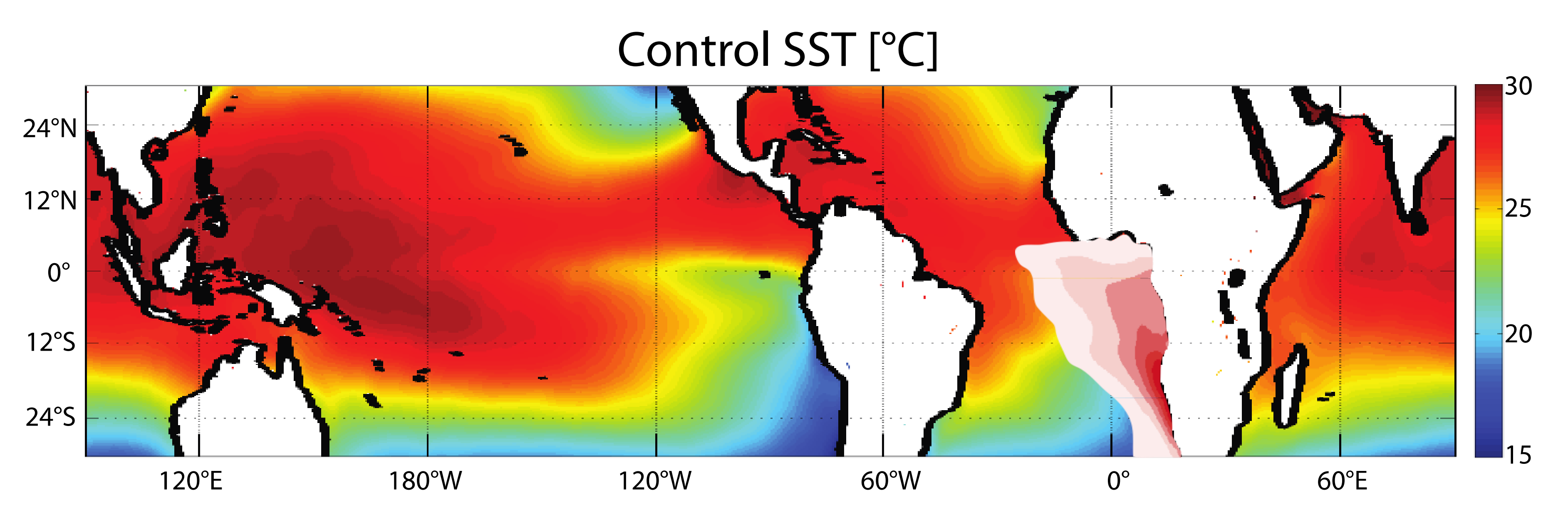




Questions:

- Can SST biases have an impact on TC simulations and predictability?
- Which biases are most detrimental to TC simulations?
- Can biases in one basin influence TC simulations in other basins?
- What are the underlying mechanisms governing biases' influence on TC simulation?

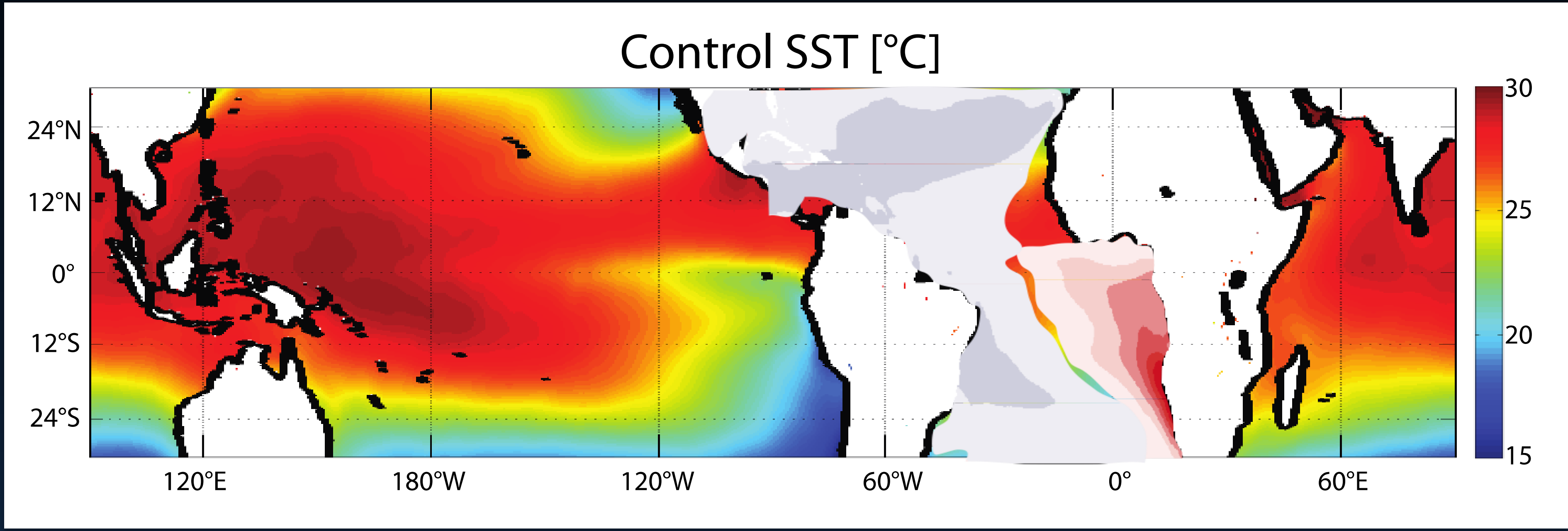
Modeling Approach



Ensembles of 27 km WRF Tropical Channel Model Simulations (Each of 16 Runs):

- <u>CTRL:</u> Observed climatological SST
- <u>AtlWB:</u> Atlantic warm SST bias + Observed SST

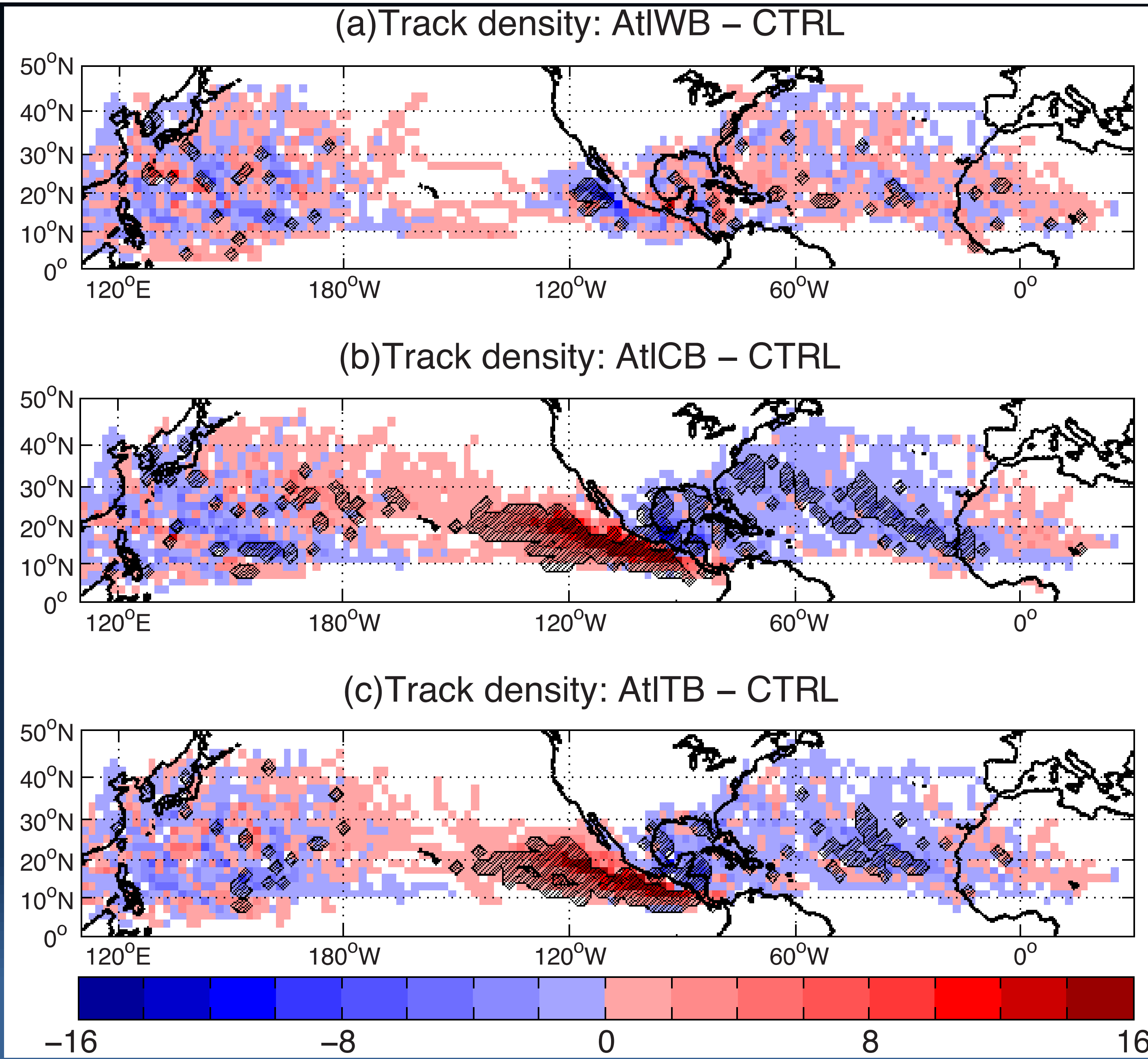
Modeling Approach



Ensembles of 27 km WRF Tropical Channel Model Simulations (Each of 16 Runs):

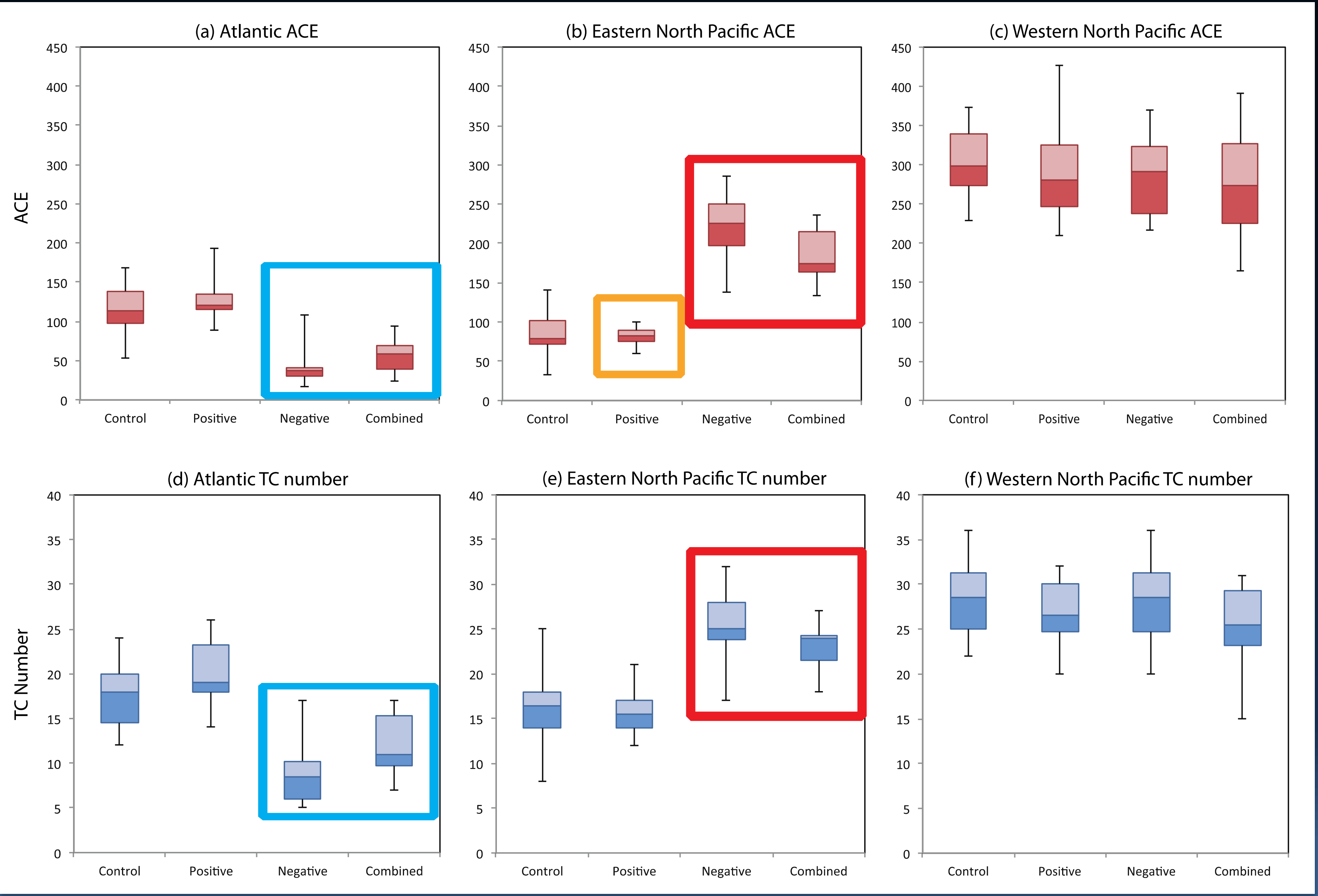
- <u>CTRL:</u> Observed climatological SST
- <u>AtlWB:</u> Atlantic warm SST bias + Observed SST
- <u>AtlCB:</u> Atlantic cold SST bias + Observed SST
- <u>AtlTB:</u> Atlantic warm and cold SST biases + Observed SST
- <u>PacWB:</u> Same as AtlWB except Pacific warm SST bias
- <u>PacCB:</u> Same as AtlCB except Pacific cold SST bias
- <u>PacTB:</u> Same as AtlTB except Pacific warm and cold SST biases
- <u>GloTB:</u> Same as PacTB except also including Atlantic SST biases

Impact of Atlantic Biases on TCs



TCs/day in 16 seasons

Accumulated Cyclone Energy and TC Numbers



Genesis Potential Index (GPI)

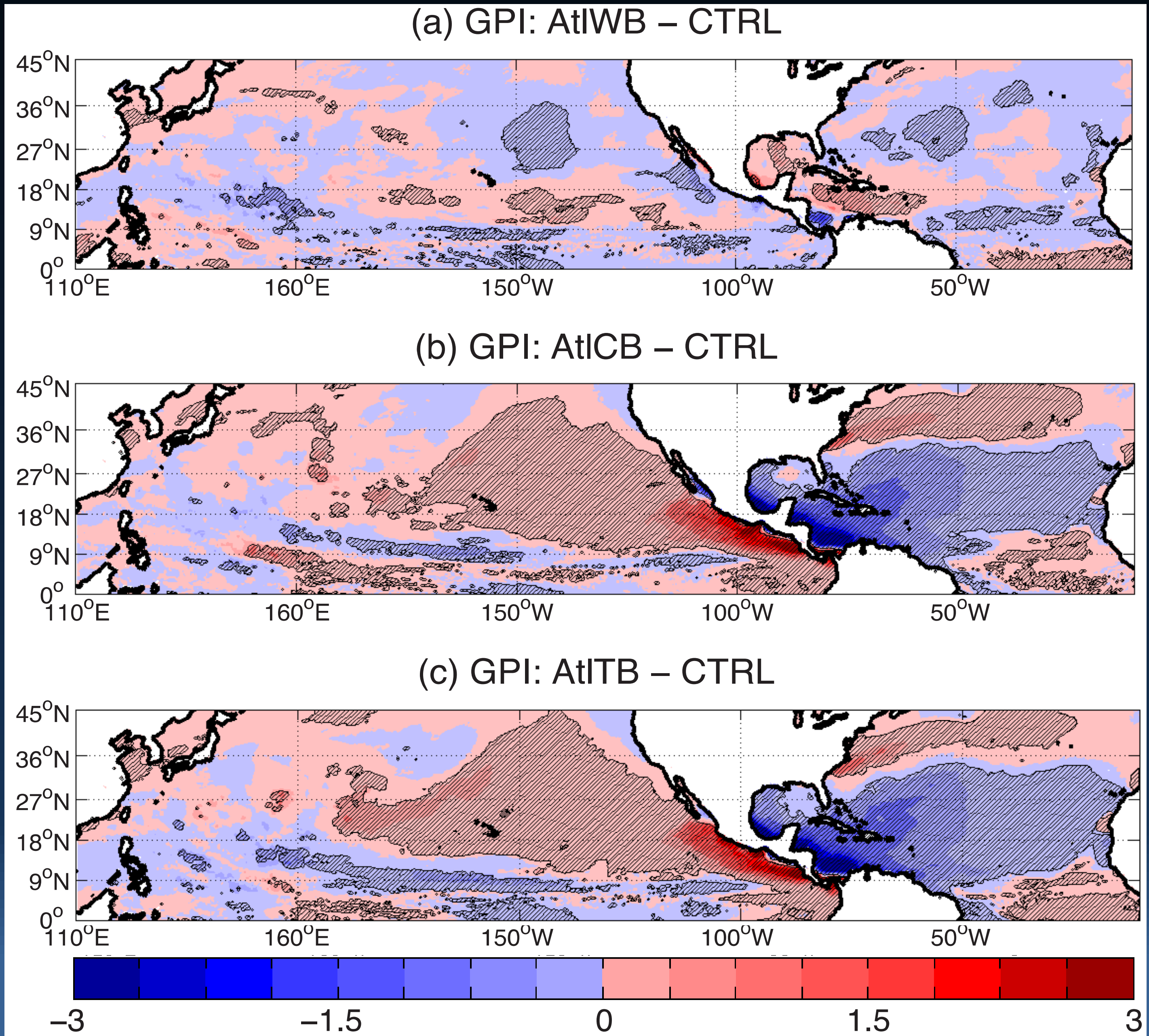
$$GPI = \left|10^5 \eta\right|^{3/2} \left(\frac{H}{50}\right)^3 \left(\frac{V_{pot}}{70}\right)^3 \left(1 + 0.1 V_{shear}\right)^{-2}$$

Vorticity — Humidity — Potential Intensity — Wind Shear

(Emanuel and Nolan, 2004)

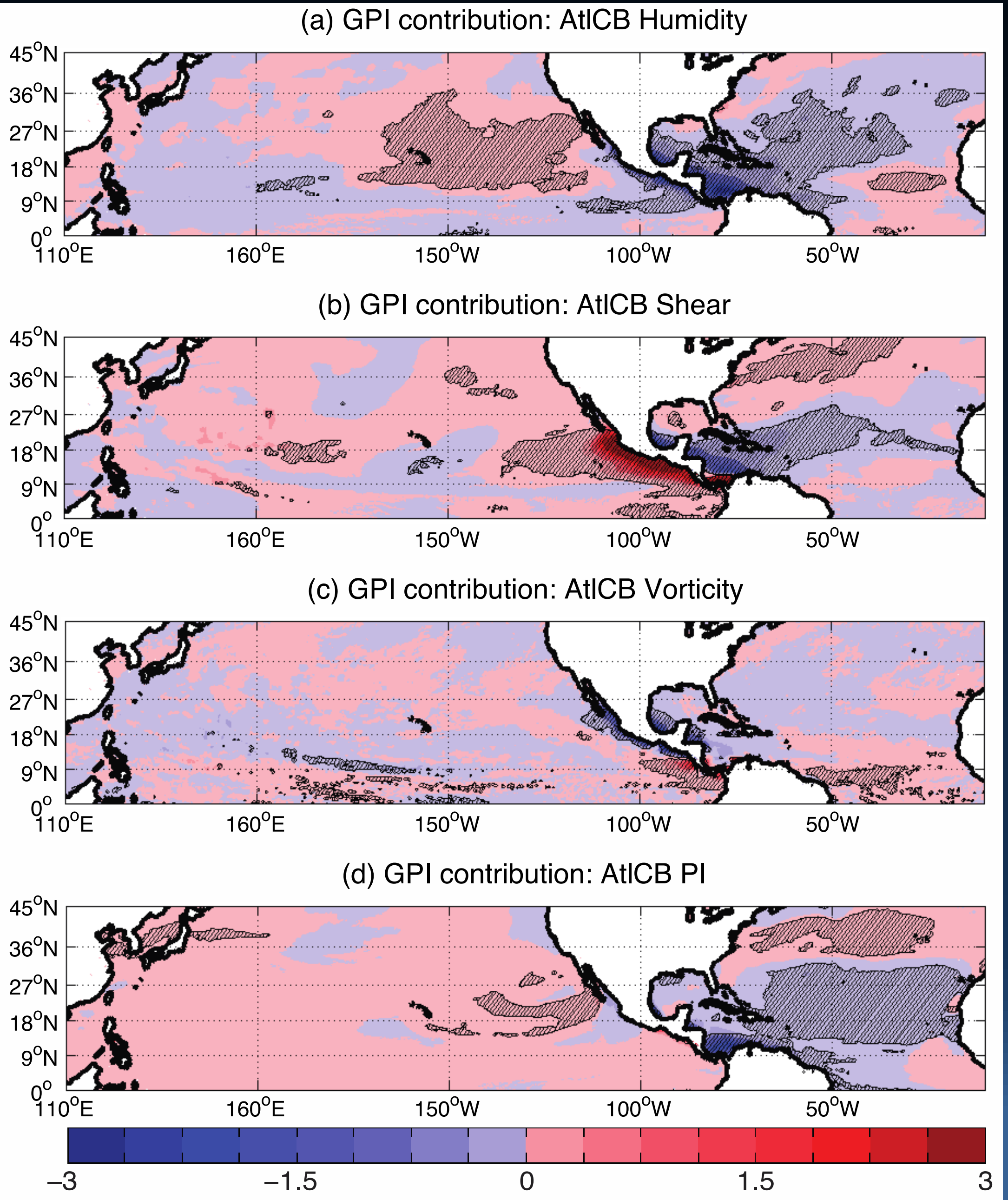
η = absolute vorticity at 850 hPa
H = relative humidity at 600 hPa
V_{shear} = vertical wind shear between 850 hPa and 200 hPa
V_{pot} = potential intensity (function of SST and vertical profiles of atmospheric temperature and moisture)

SST Bias Induced GPI Changes

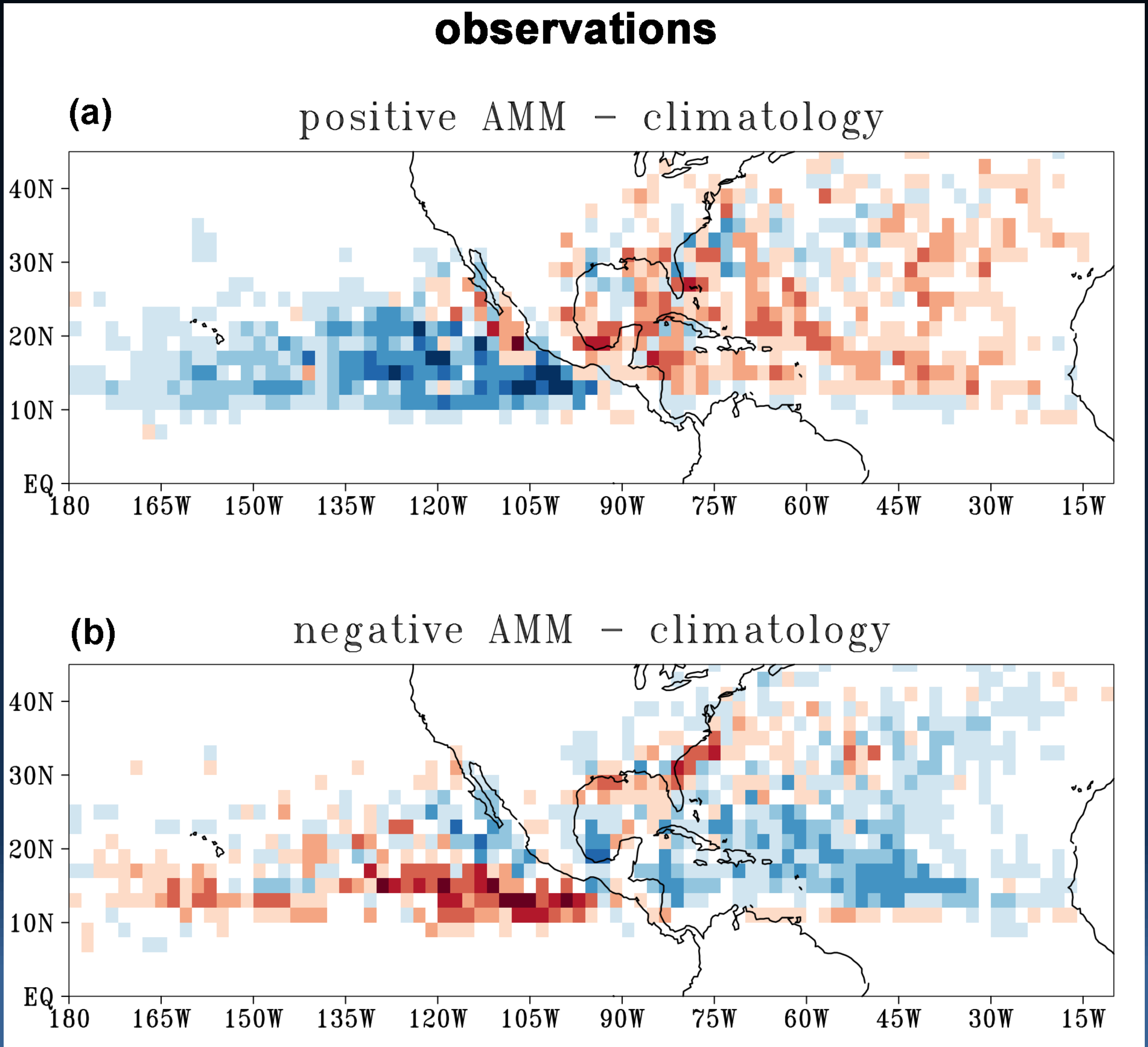


Decomposing GPI Changes

- Decreases in humidity and potential intensity and increase in vertical wind shear caused by cold SST bias all contribute to decrease in GPI in the North Tropical Atlantic
- Increase in GPI in the North Tropical Pacific primarily comes from decrease in vertical wind shear due to remote influence of cold SST bias



Observed Remote Influence of AMM on Northeastern Pacific TCs

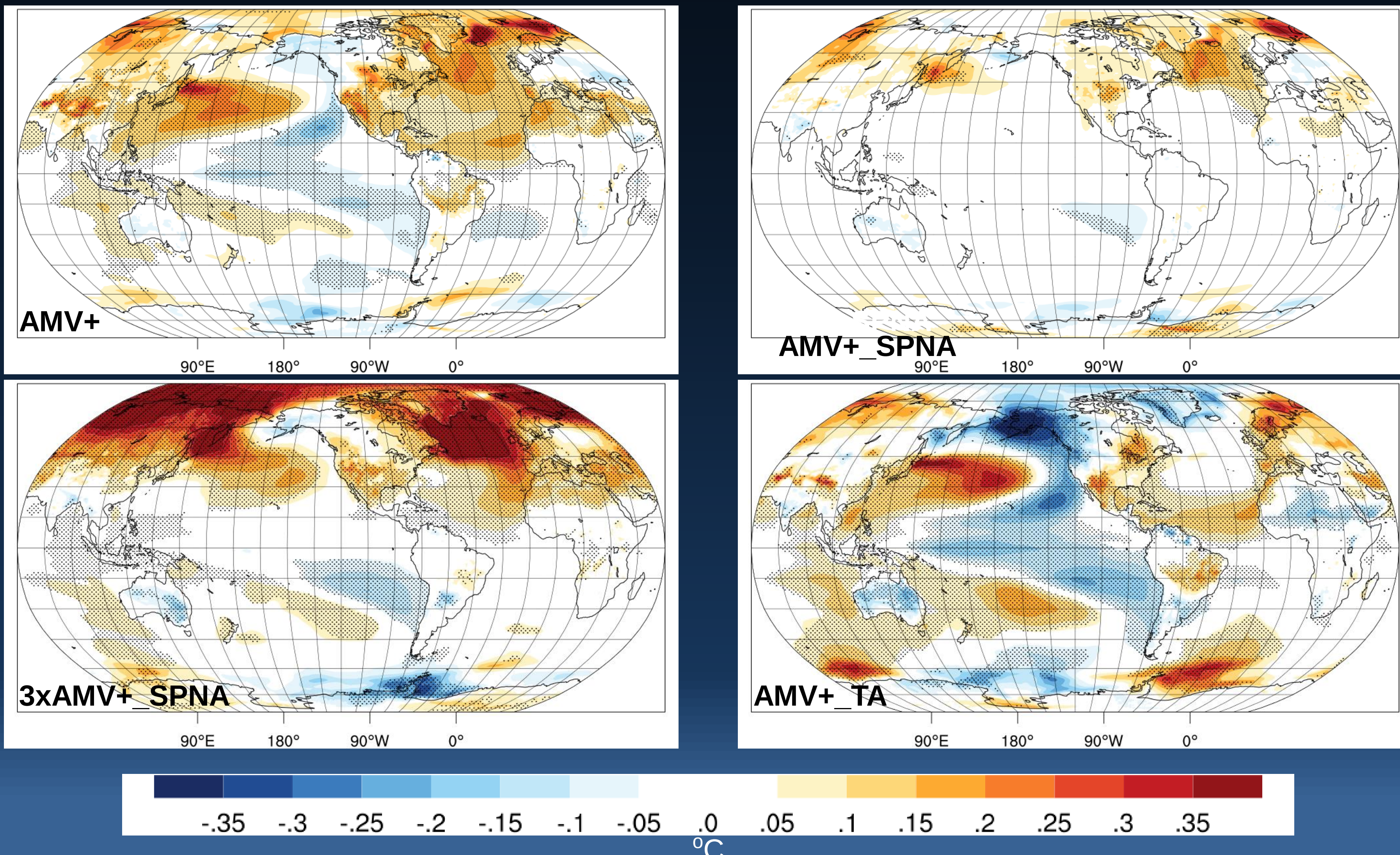


Patricola et al. (2016)

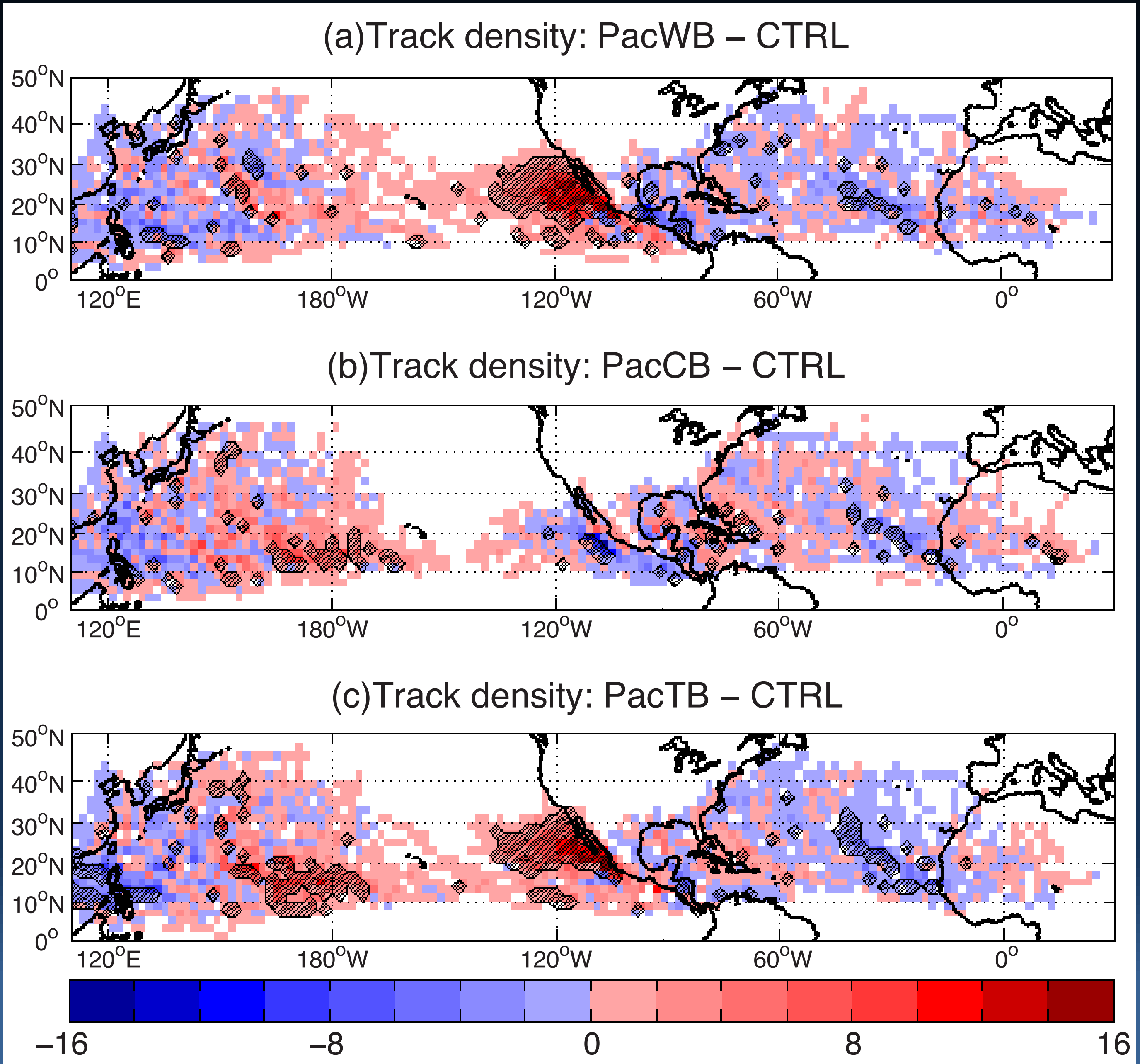
GFDL and NCAR Coordinated AMV Climate Impacts Experiments
Surface Air Temperature

Frederic Castruccio, Yohan Ruprich-Robert, et al.

10-year climatological composite (30 members)



Pacific SST Biases on TCs



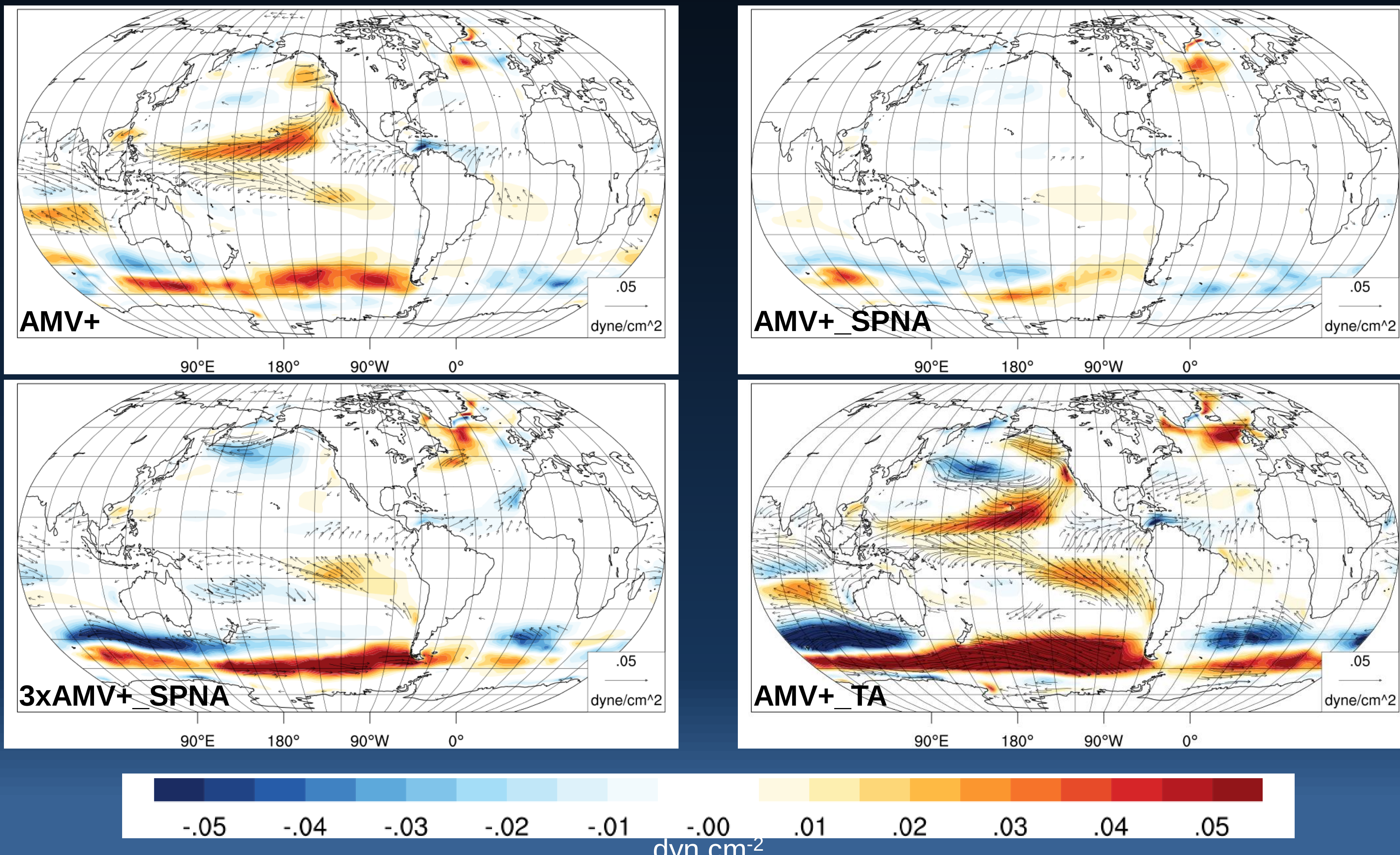
Summary

Large ensembles of TC-permitting tropical-channel WRF simulations show that tropical SST biases in CMIP5 models can have a significant impact on TC simulations, predictions and projections:

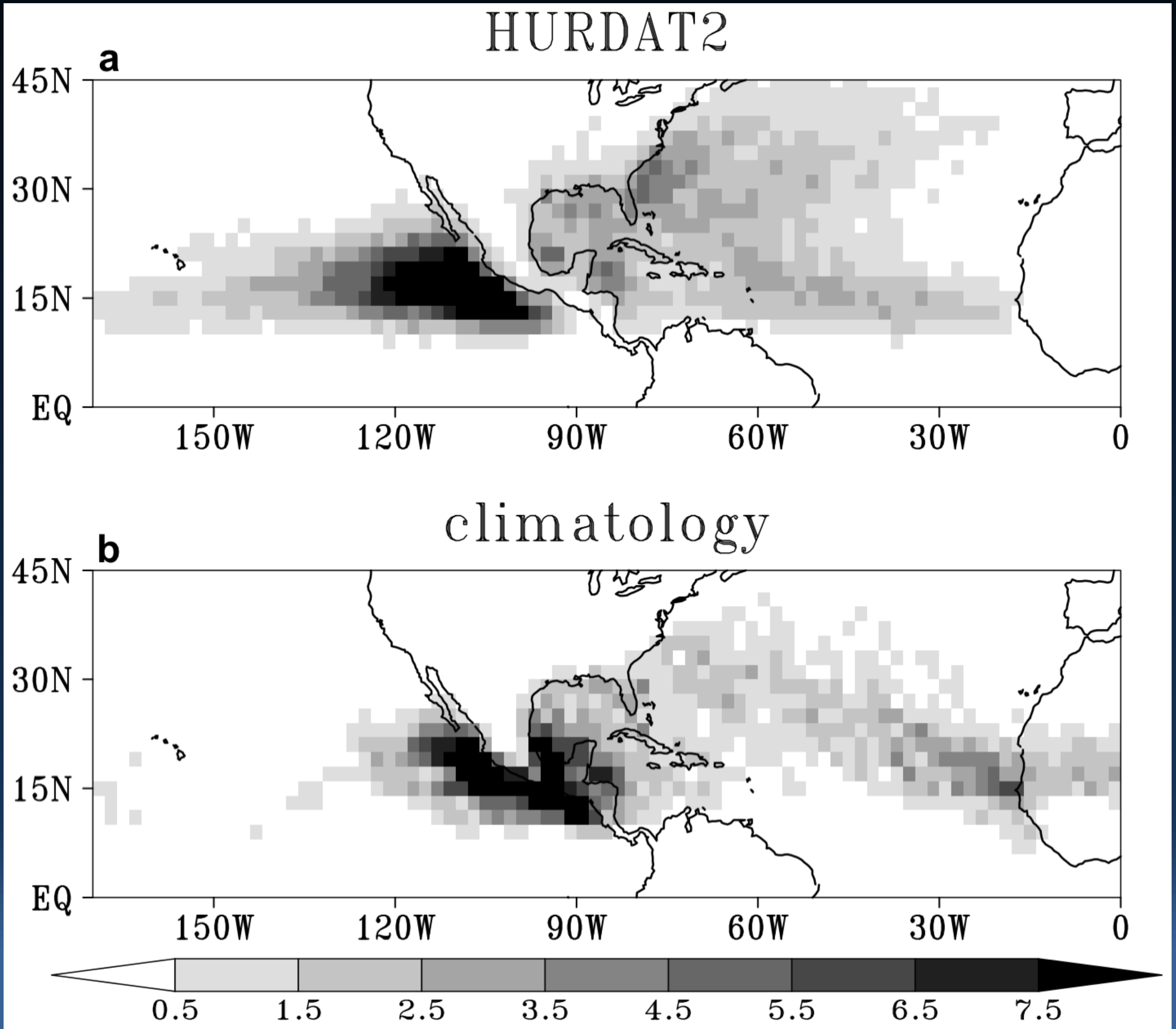
- North Tropical Atlantic cold SST bias, albeit much weaker than its counterpart in the South Tropical Atlantic, is most detrimental to TC simulations.
- Atlantic SST biases, mostly the cold SST bias in the North Tropical Atlantic, lead to a significant underestimate of Atlantic TCs. This impact on TC simulations is through a combined effect of decrease in local relative humidity and potential intensity, as well as increase in local vertical wind shear.
- Atlantic SST biases can have a significant remote influence on Eastern North Pacific TCs, causing a significant increase in TC activity in the region. This remote impact appears to be mainly through vertical wind shear changes.
- The remote influence of Atlantic SST is supported by observational analysis that shows an increase (decrease) in Eastern North Pacific TCs during cold (warm) AMM phase
- In comparison, Pacific SST biases do not exhibit a clear remote influence on Atlantic TCs, although the warm SST bias off the west coast of Mexico has a significant impact on Eastern North Pacific TCs.

AMV climate impacts
Preliminary results: surface wind stress

10-year climatological composite (30 members)



Observed and WRF Simulated TC Track Density



Atlantic TC ACE and Number

	CTRL	AtlWB	AtlCB	AtlTB
Atlantic ACE	116	128	42 [-64%]	57 [-51%]
ENP ACE	87	81	220 [153%]	185 [113%]
WNP ACE	302	295	285	278
Atlantic number of TCs	18	20	9 [-50%]	12 [-33%]
ENP number of TCs	16	16	26 [63%]	23 [44%]
WNP number of TCs	28	27	28	25

Pacific TC ACE and Number

	CTRL	PacWB	PacCB	PacTB
Atlantic ACE	116	92 [-21%]	125	100
ENP ACE	87	181 [108%]	75	166 [91%]
WNP ACE	302	292	314	317
Atlantic number of TCs	18	15	18	17
ENP number of TCs	16	25 [56%]	16	25 [56%]
WNP number of TCs	28	27	31	31