

Projected Changes in the Seasonal Cycle of Tropical Cyclones

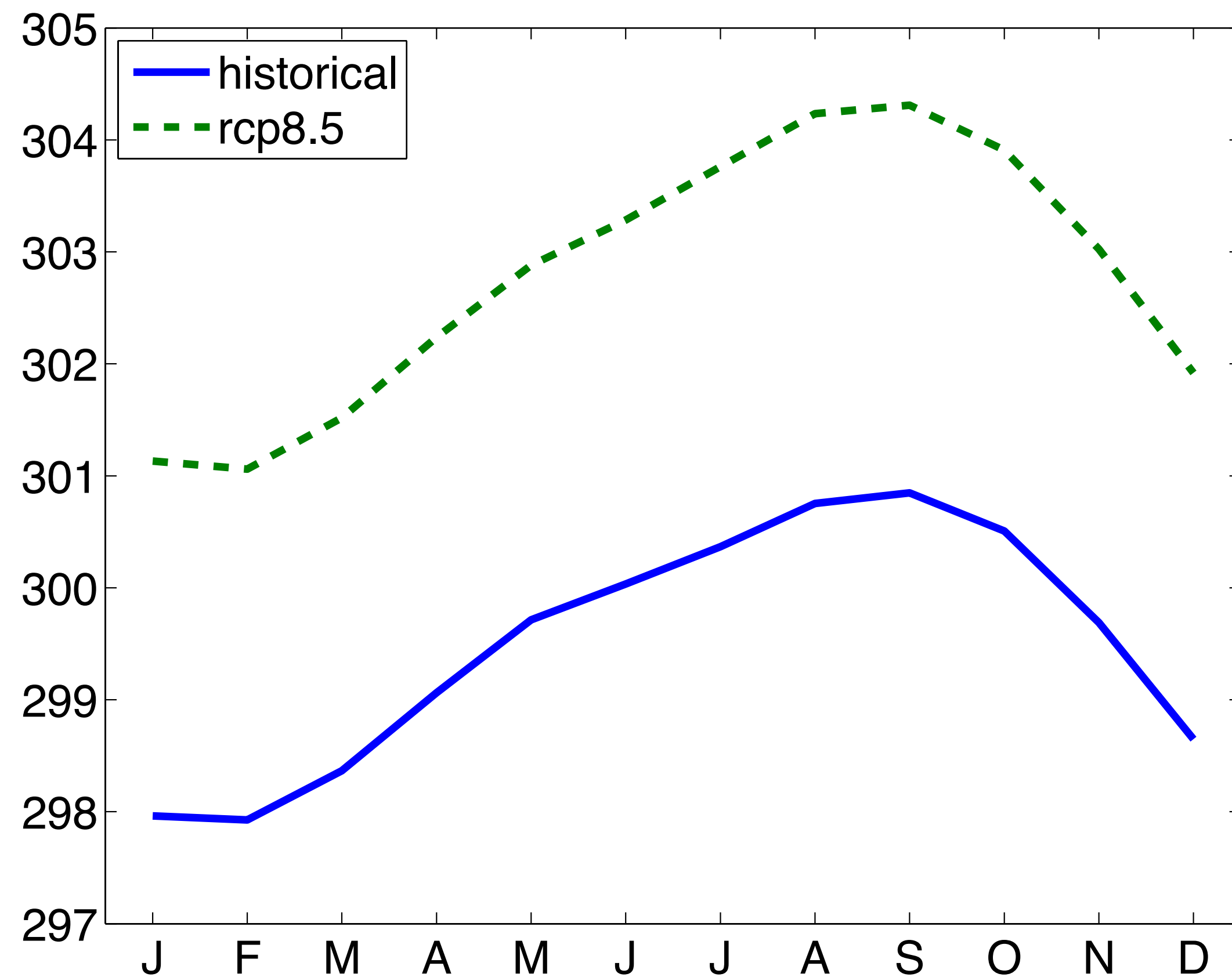
John G. Dwyer, Suzana J. Camargo, Adam H. Sobel, Michela Biasutti,
Kerry A. Emanuel, Gabriel A. Vecchi, and Ming Zhao

U.S. CLIVAR Hurricane Workshop 2013

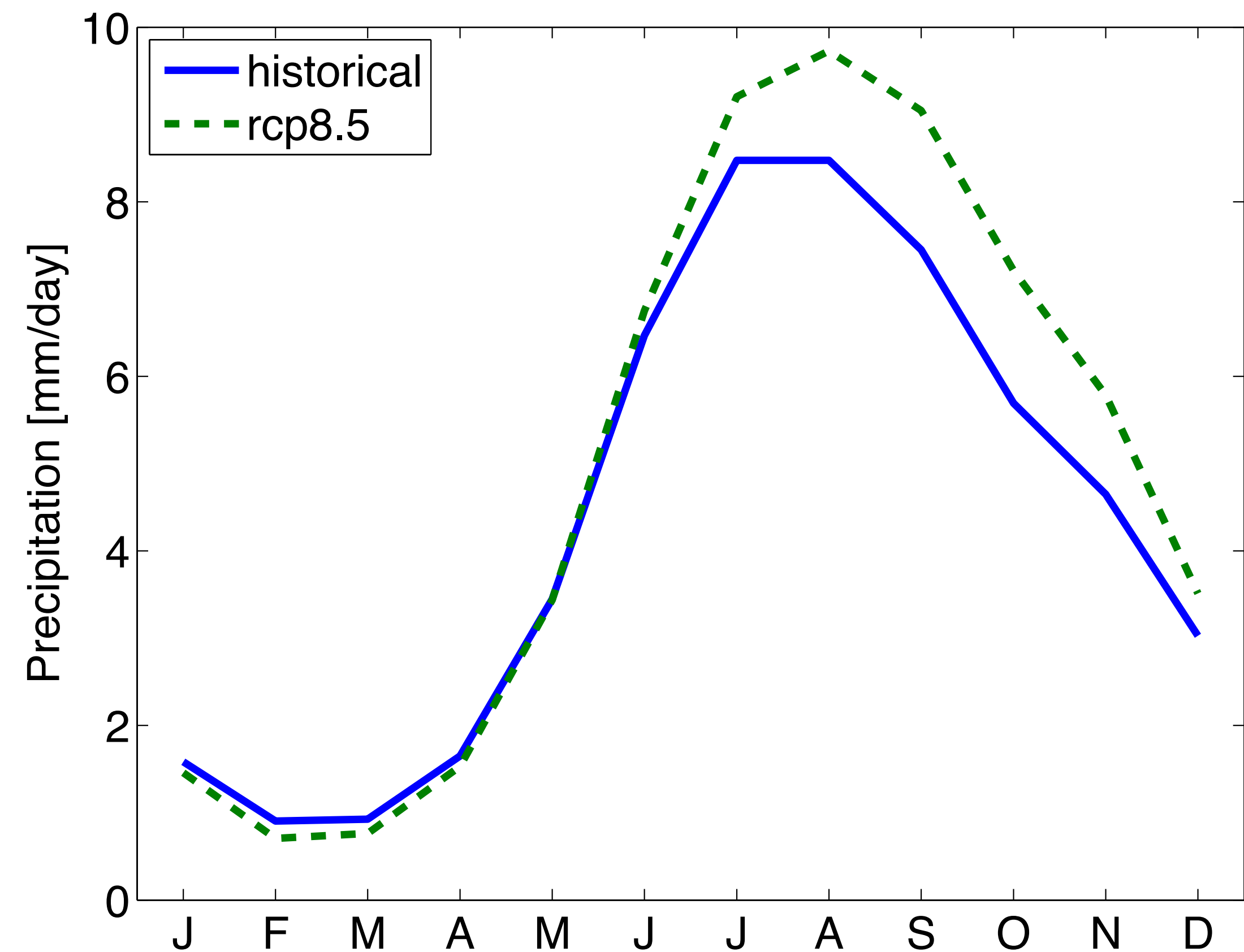
CMIP3 & CMIP5 models project changes to the seasonality of tropical precipitation and SST due to increased greenhouse gases

Two examples:

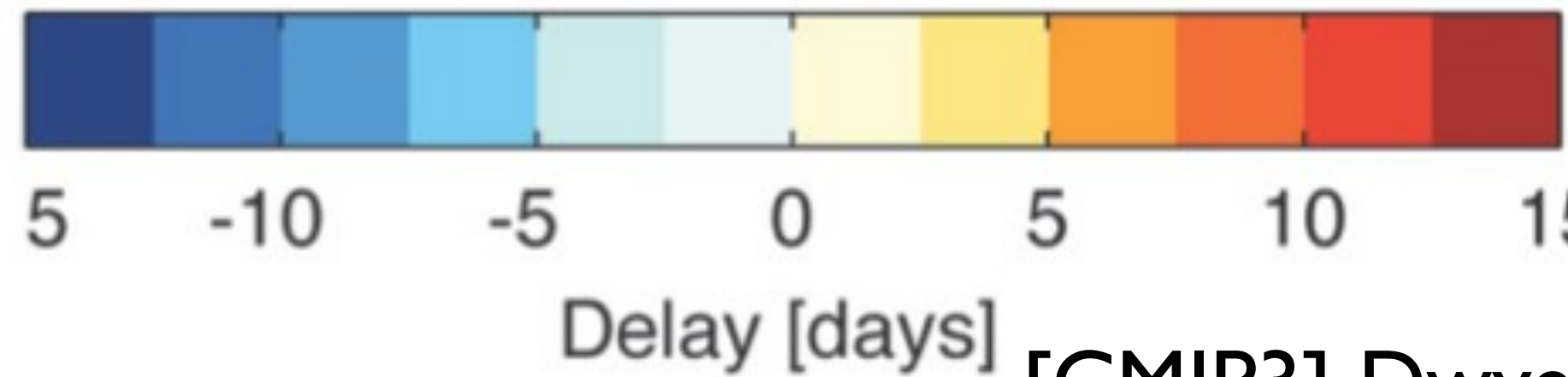
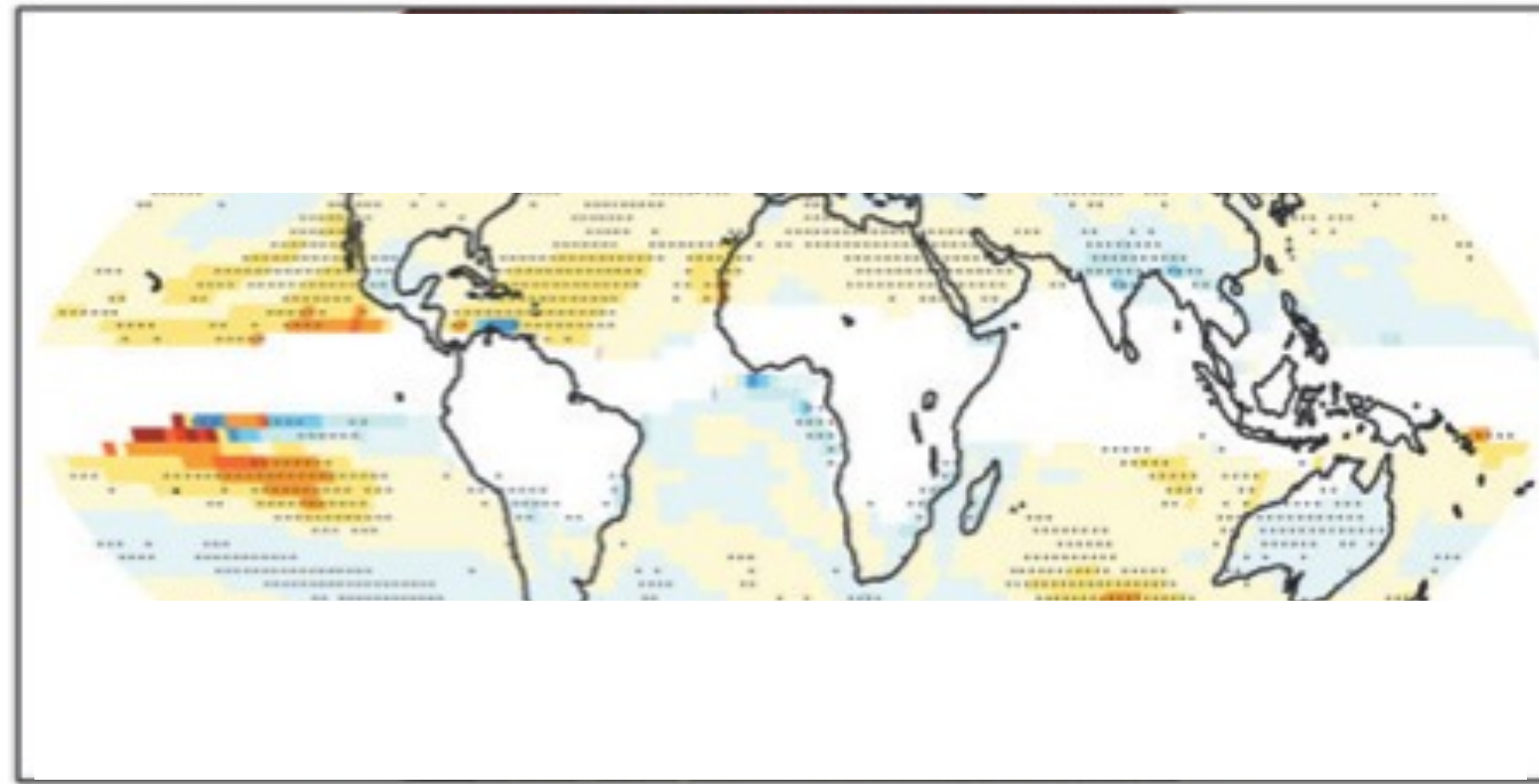
NH E. Pac. and Carib. SST



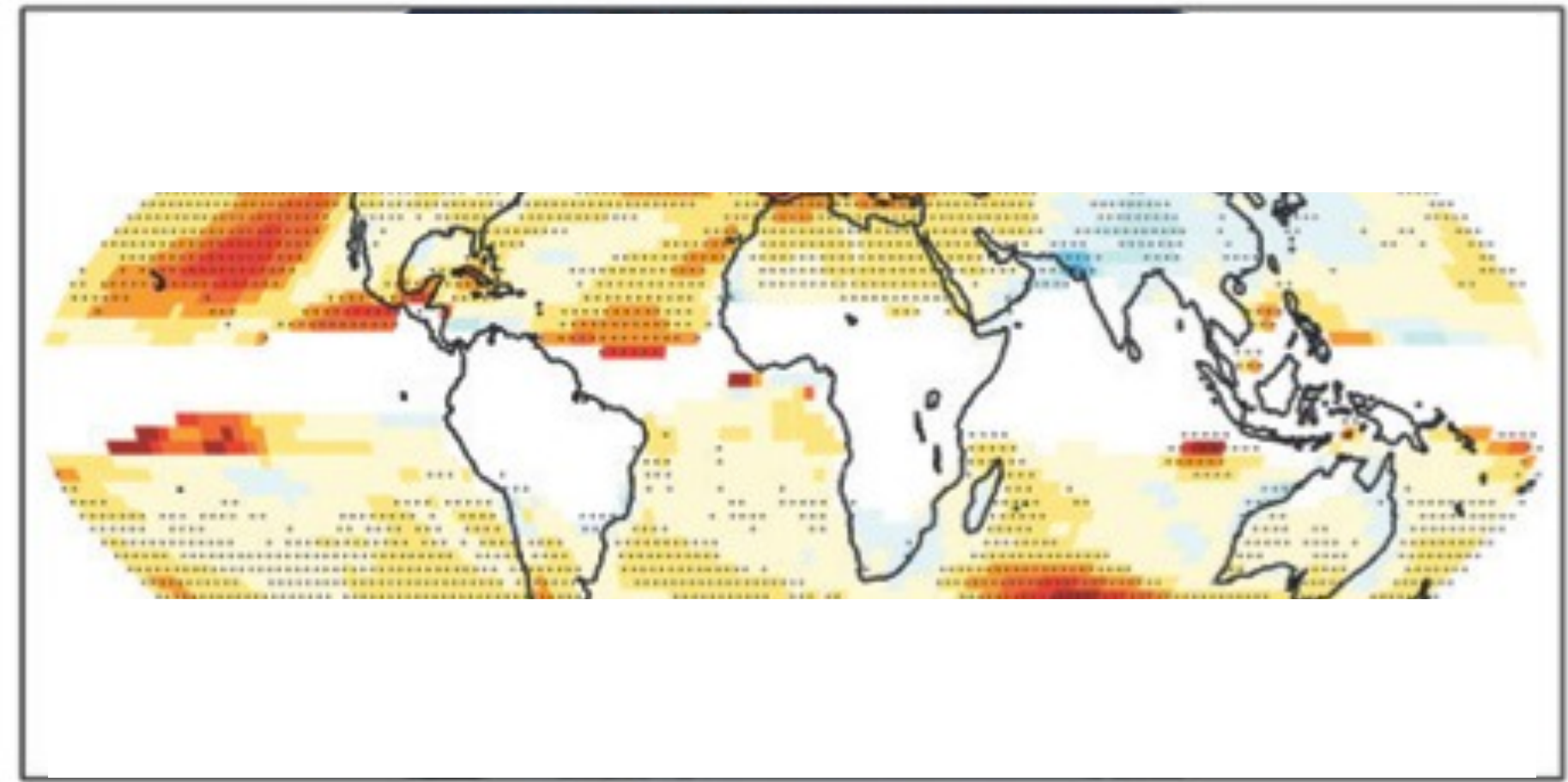
NH Indian Ocean Rainfall



(a) Temperature Phase Change

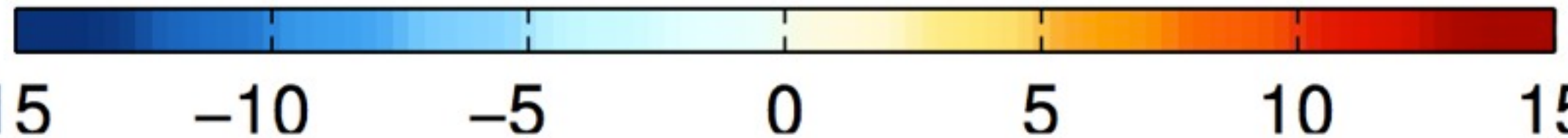
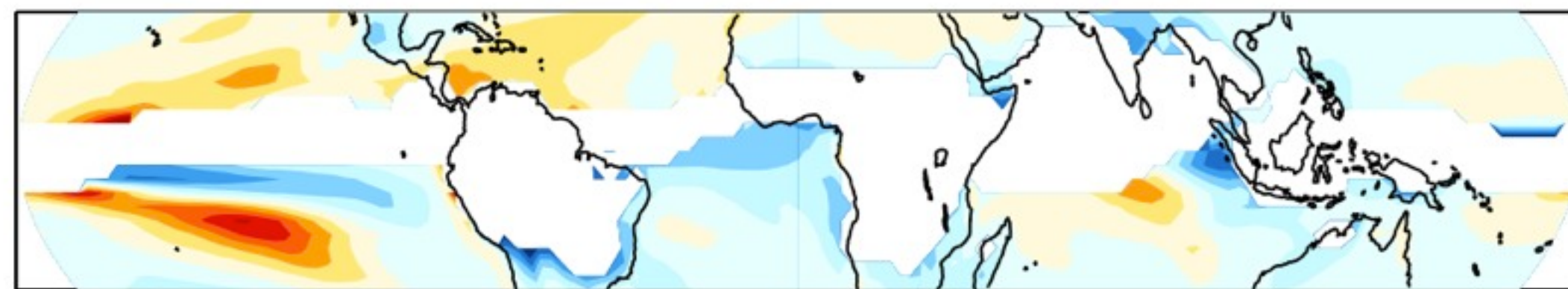


(b) Temperature Amp. Change

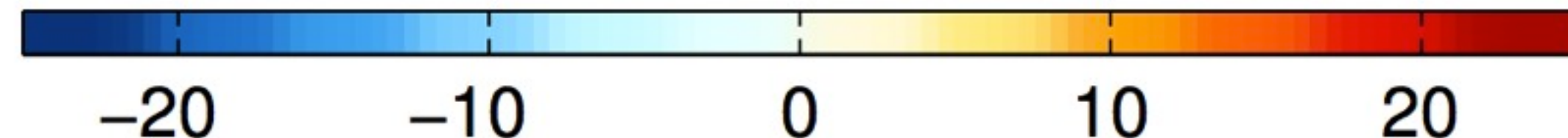
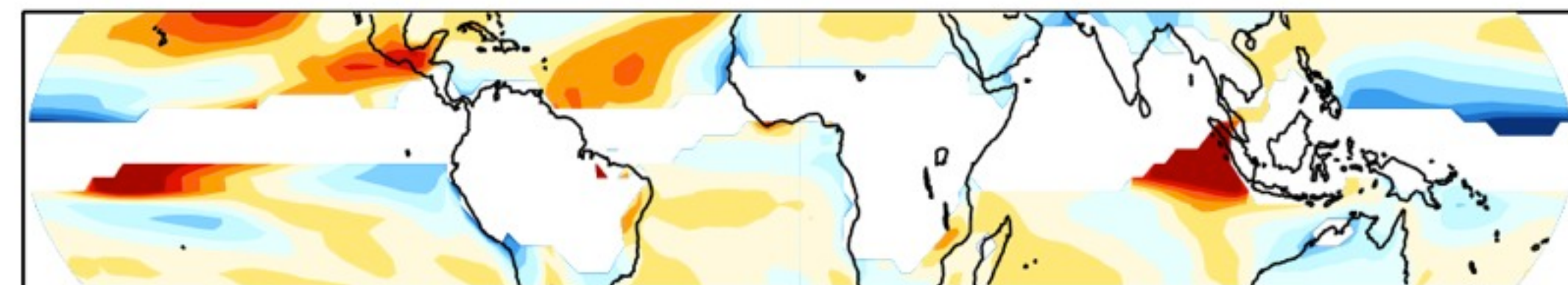


[CMIP3] Dwyer et al. (2012)

(e) Phase Delay of Surface Temperature [days]

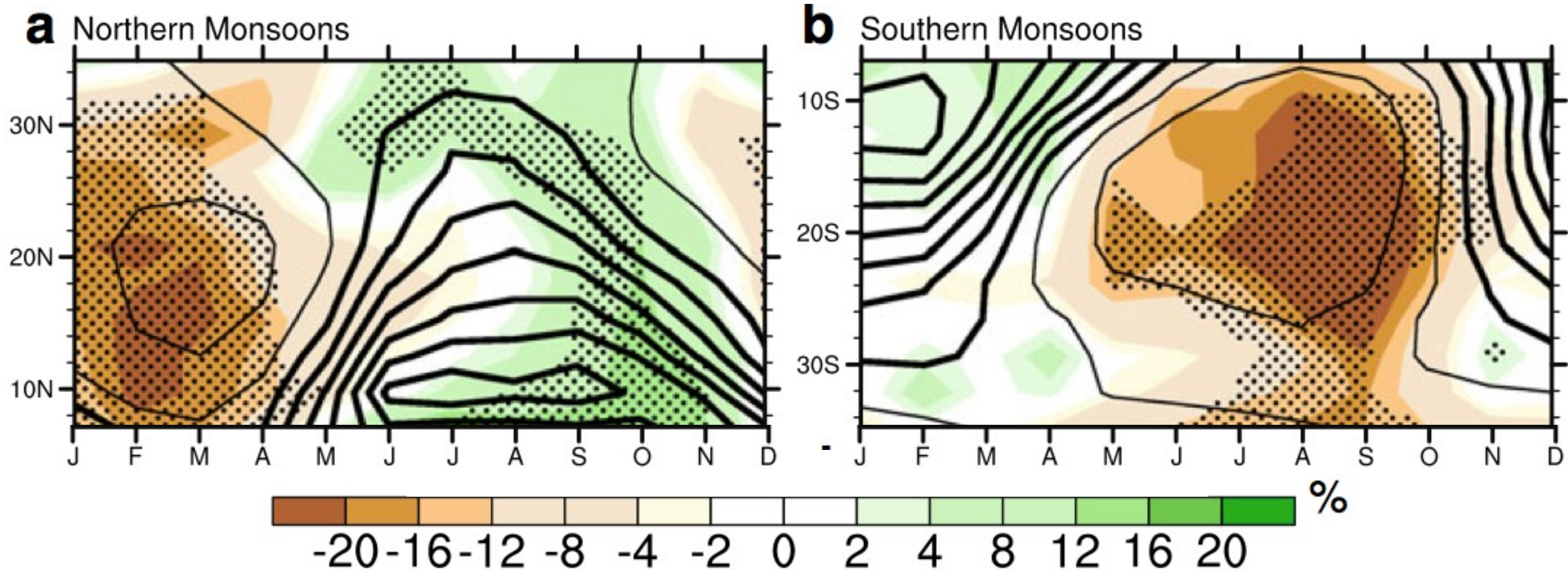


(c) Amplitude Change of Surface Temperature [%]



[CMIP5] Dwyer et al. (2013)

Projected Precipitation Changes



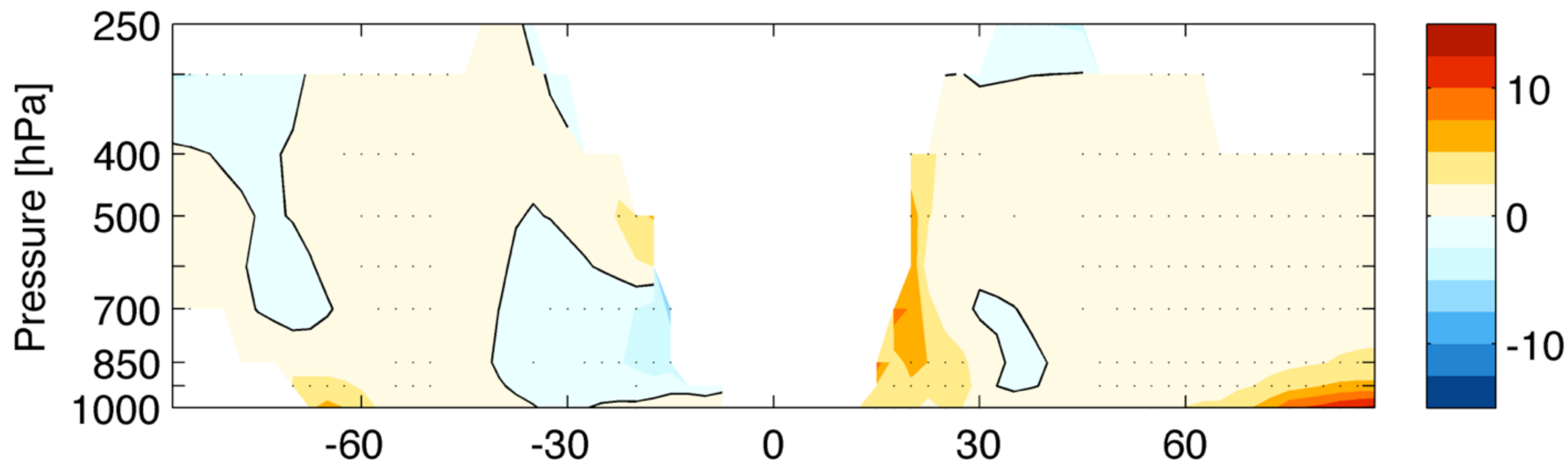
Seth et al. (2011)

Projected Precipitation Changes

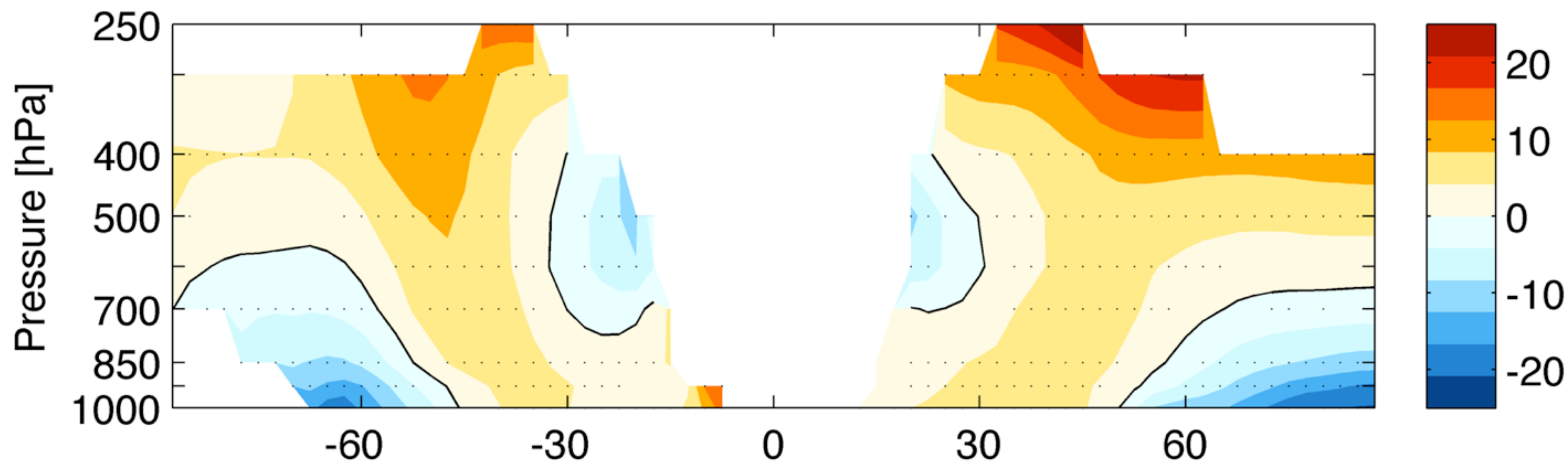
	SST		Ocean Precip.		Land Precip.	
Δ Annual Mean	2.9 K	(35)	0.2 mm day ⁻¹	(35)	0.1 mm day ⁻¹	(27)
Δ Amplitude	4.2%	(33)	15.5%	(34)	8.2%	(35)
Δ Phase	1.1 days	(29)	2.7 days	(27)	3.5 days	(34)

TABLE 2. Multi-model mean changes in the annual mean, phase, and amplitude over ocean and land in the tropics (25°S–25°N) for the CMIP5 models between 2080–2099 relative to 1980–1999. Seasonal changes were calculated using EOF analysis. Numbers in parentheses indicate the number of models projecting changes of the same sign as the mean for each quantity out of a total of 35 models.

(a) Temperature Phase Change [days]



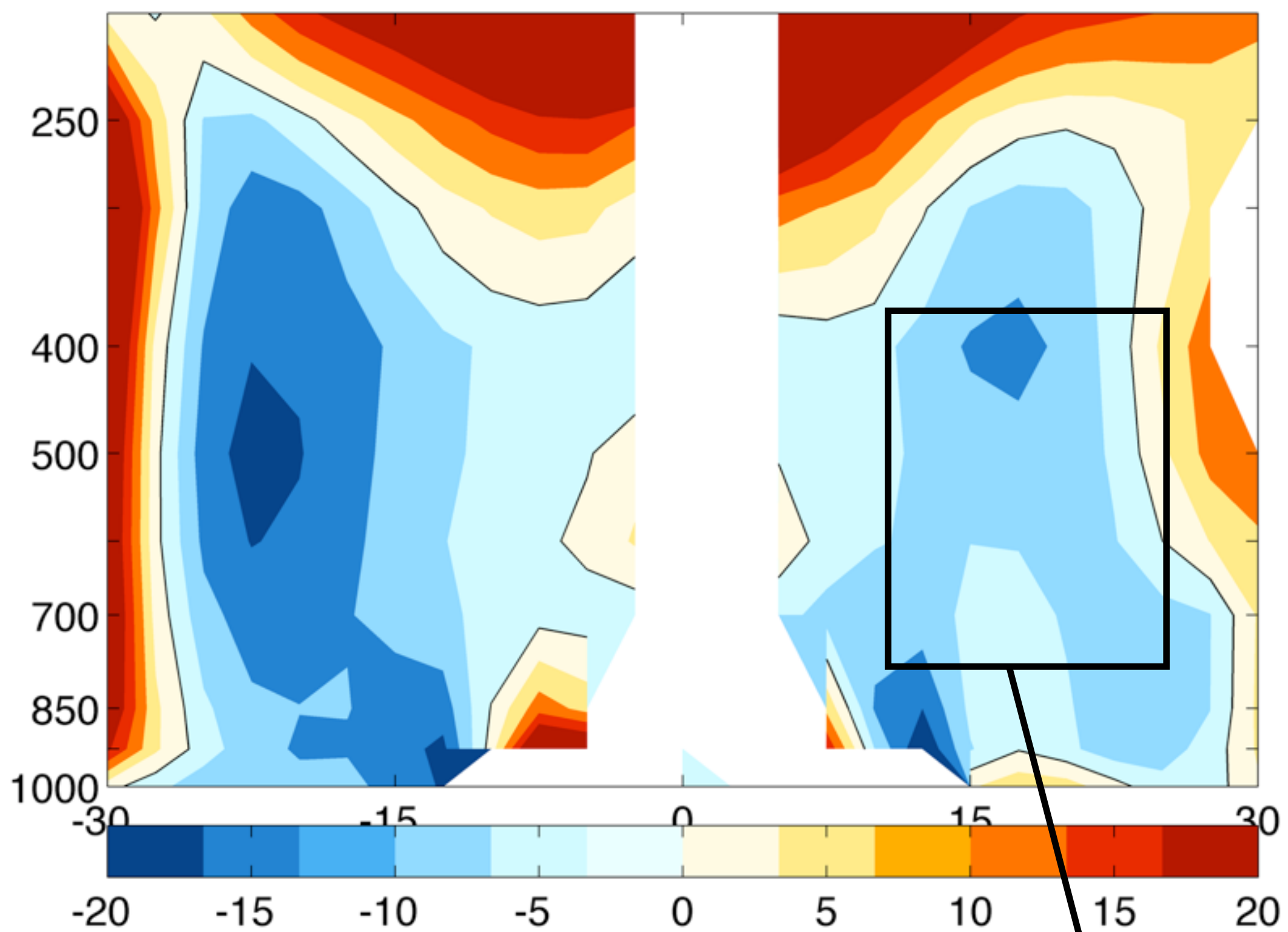
(b) Temperature Amplitude Change [%]



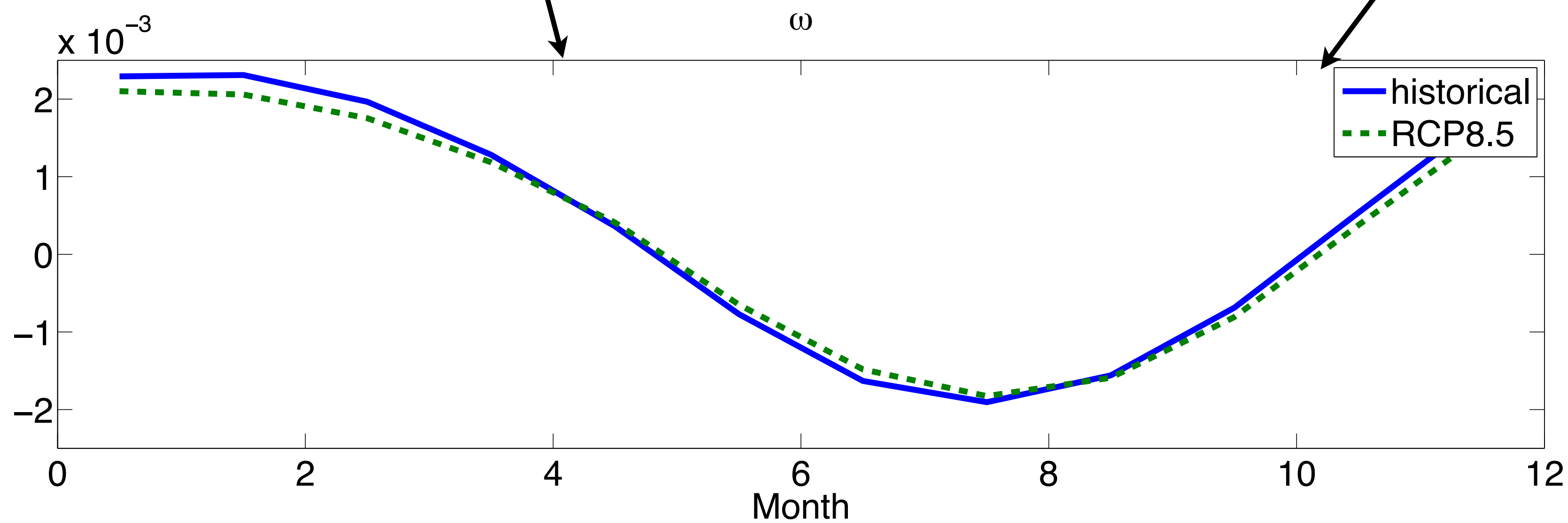
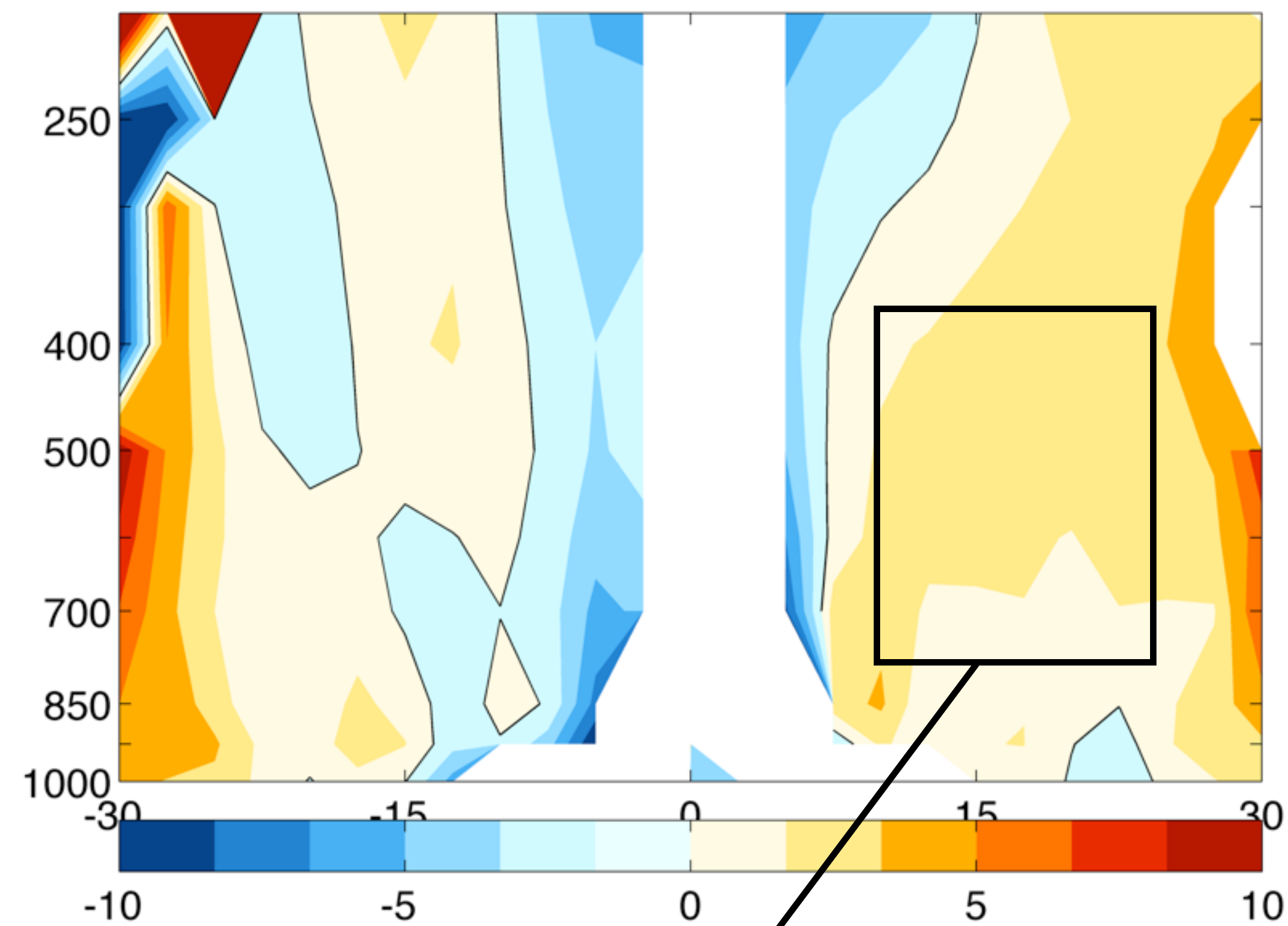
Latitude

Dwyer et al. (2012)

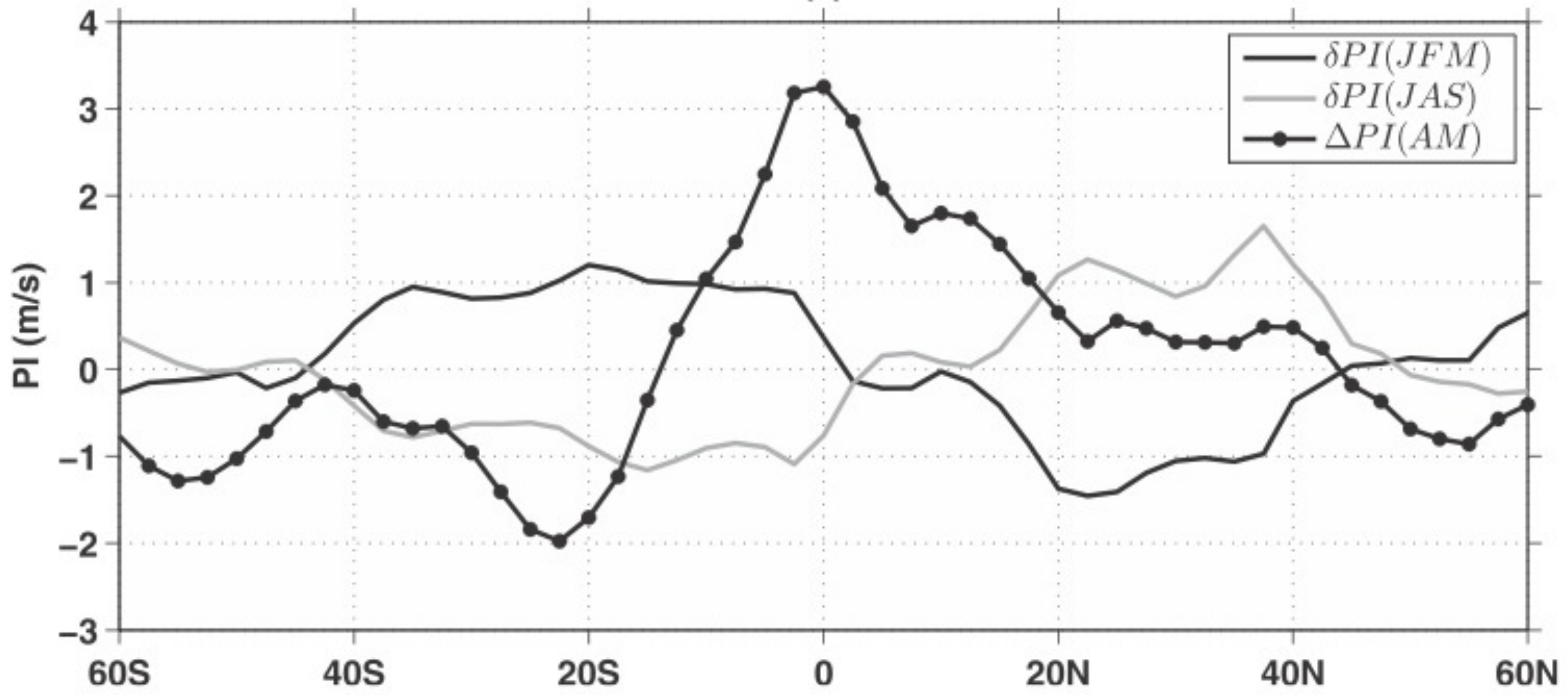
Δ Zonal Mean OMEGA Amplitude [%]



Δ Zonal Mean OMEGA Phase [days]



(c)



Sobel & Camargo (2011)

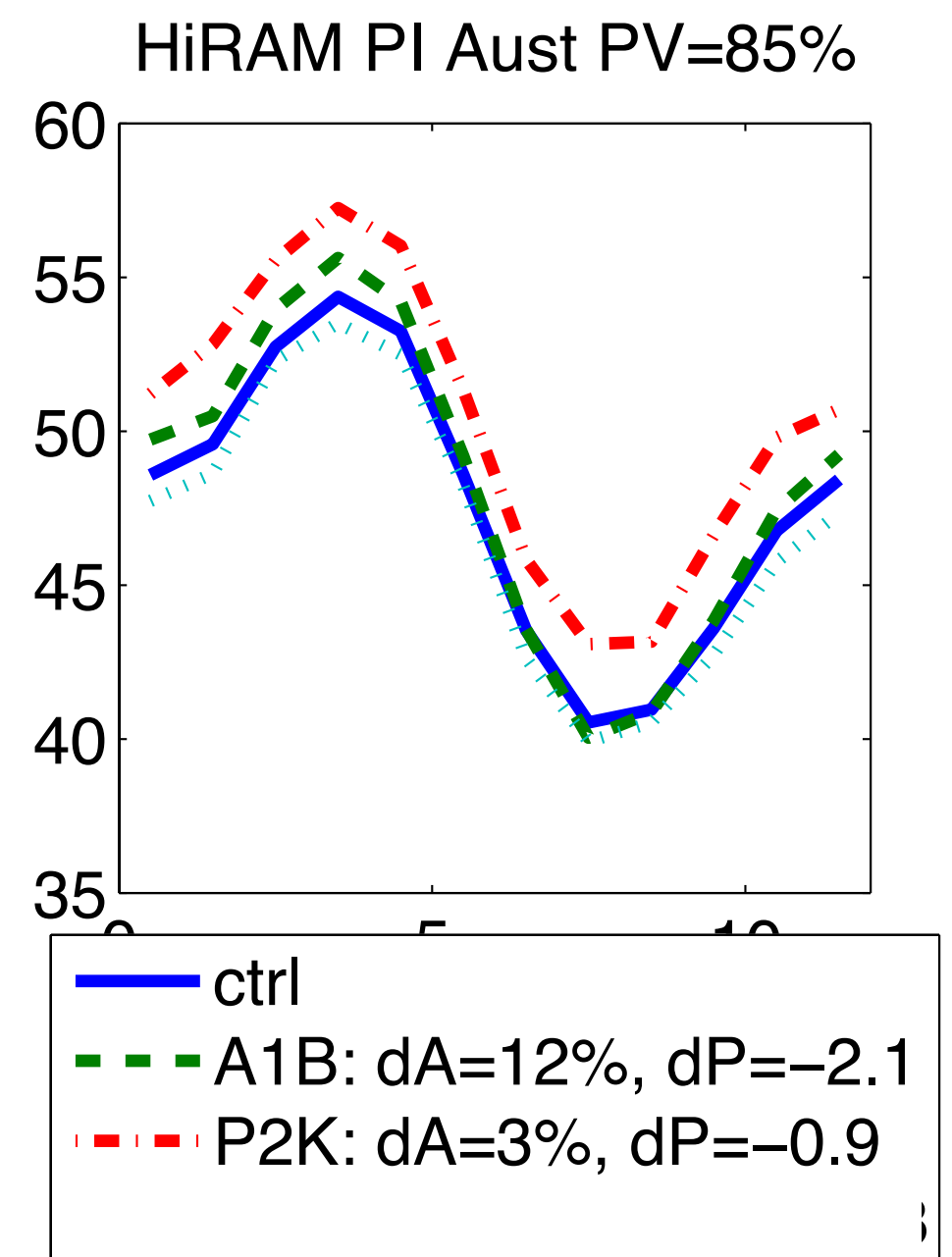
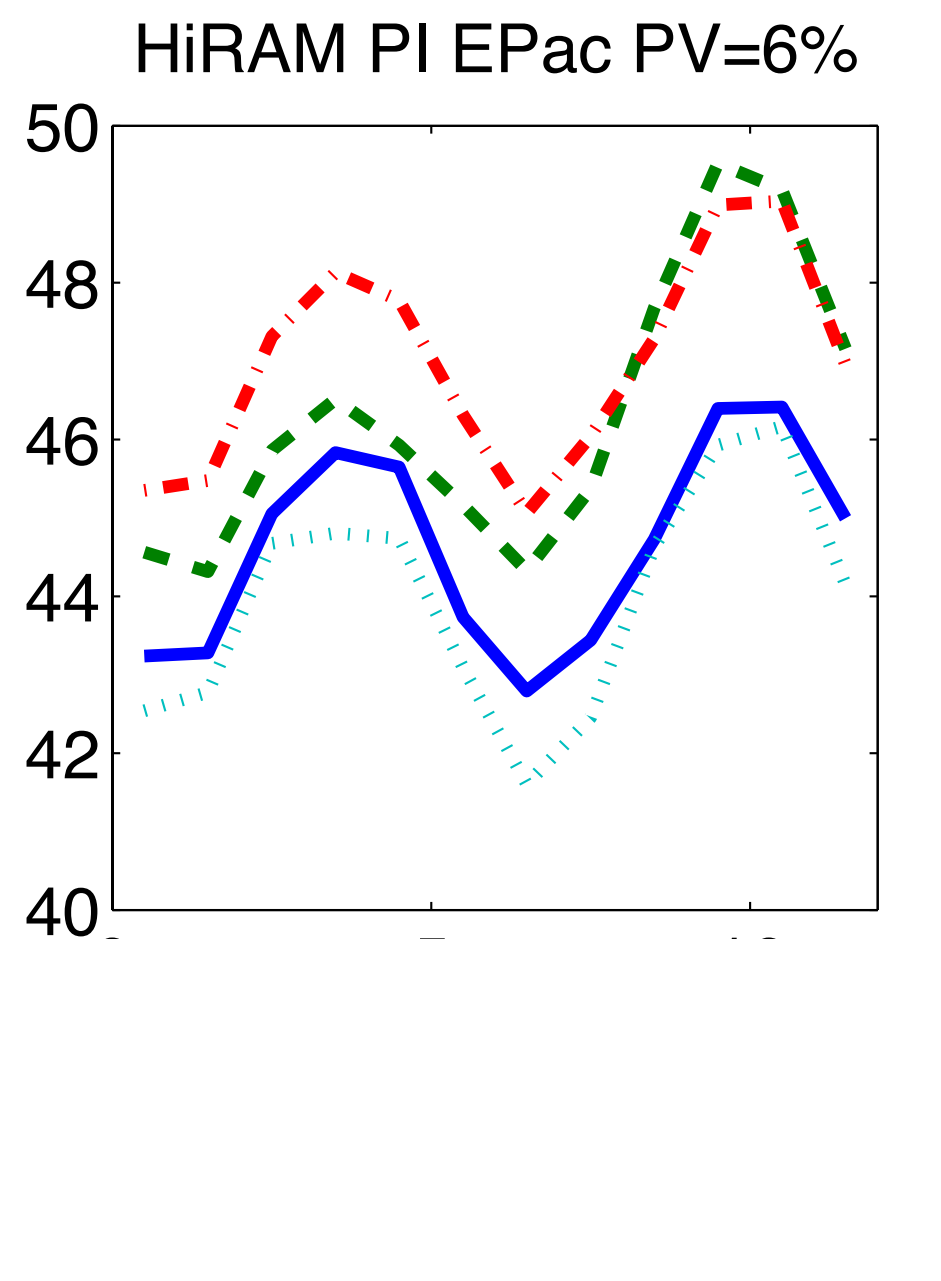
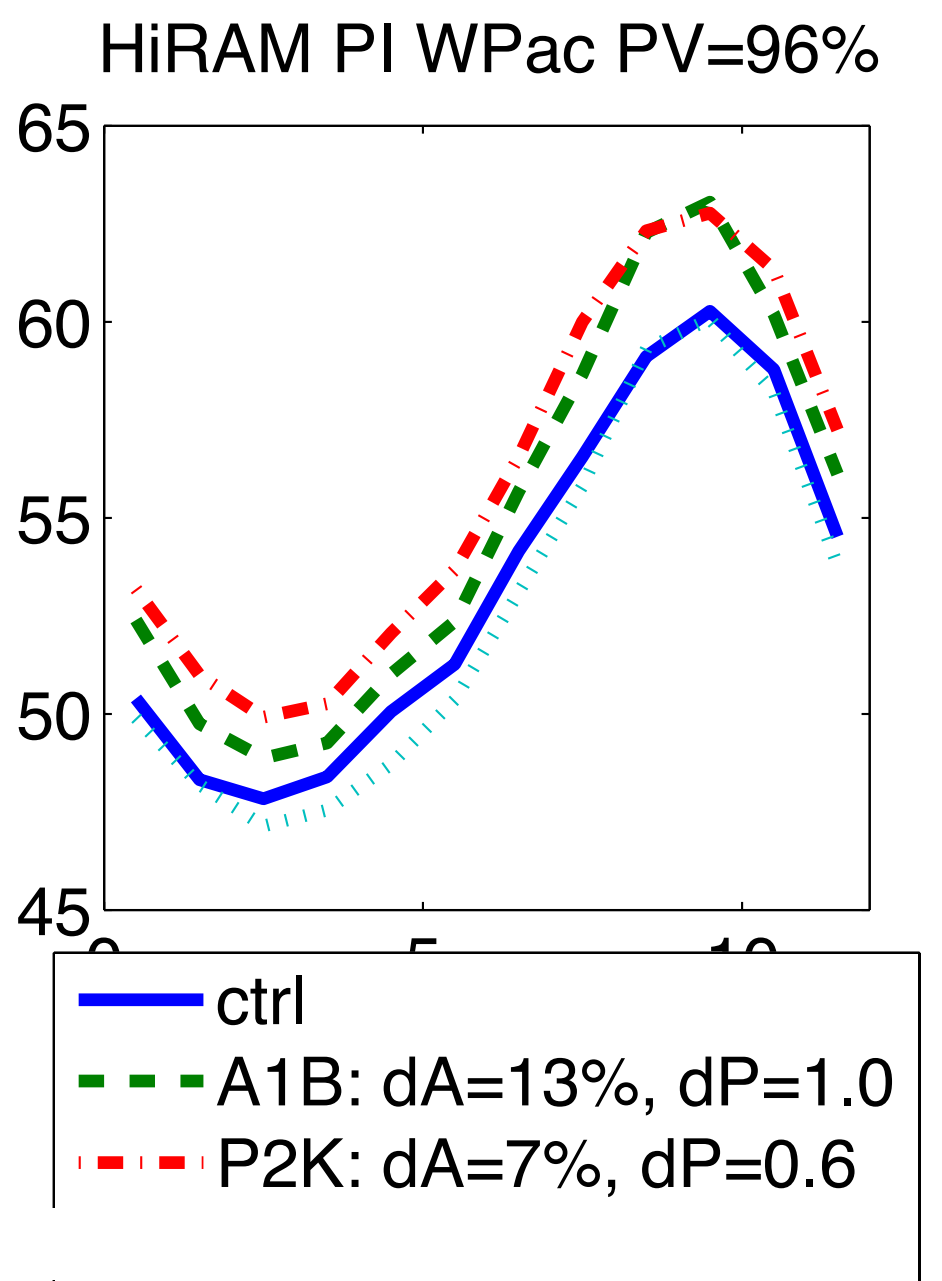
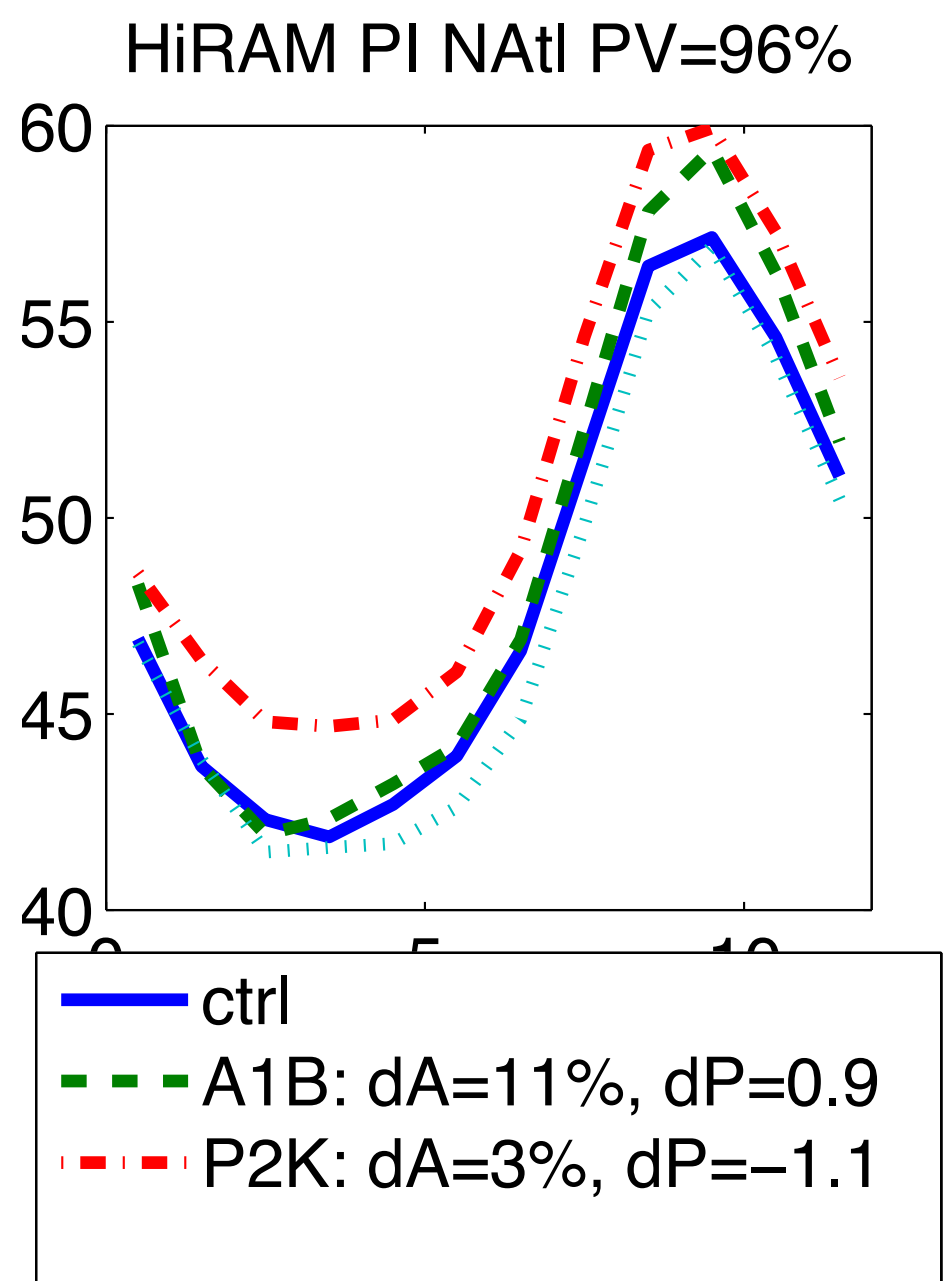
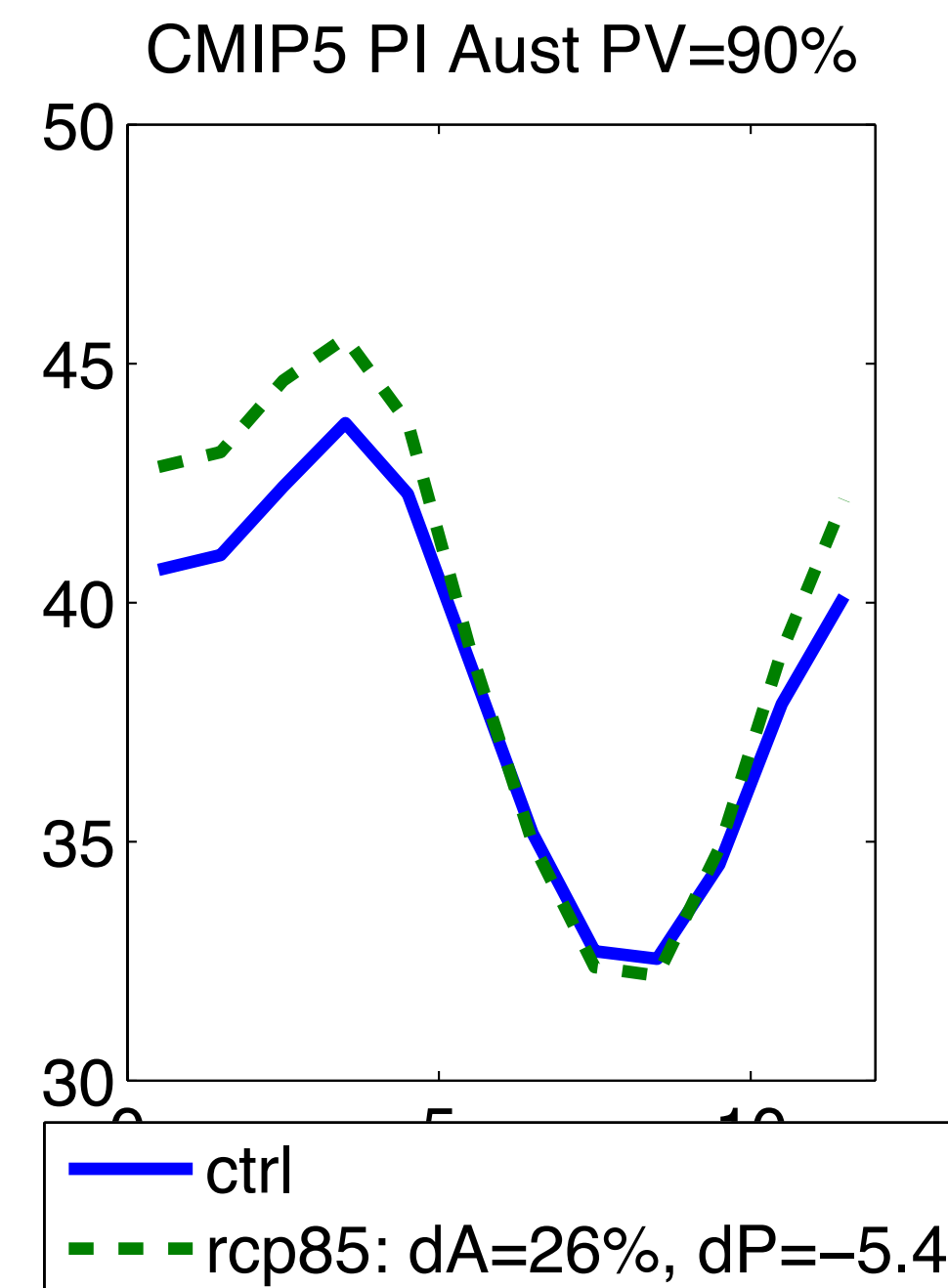
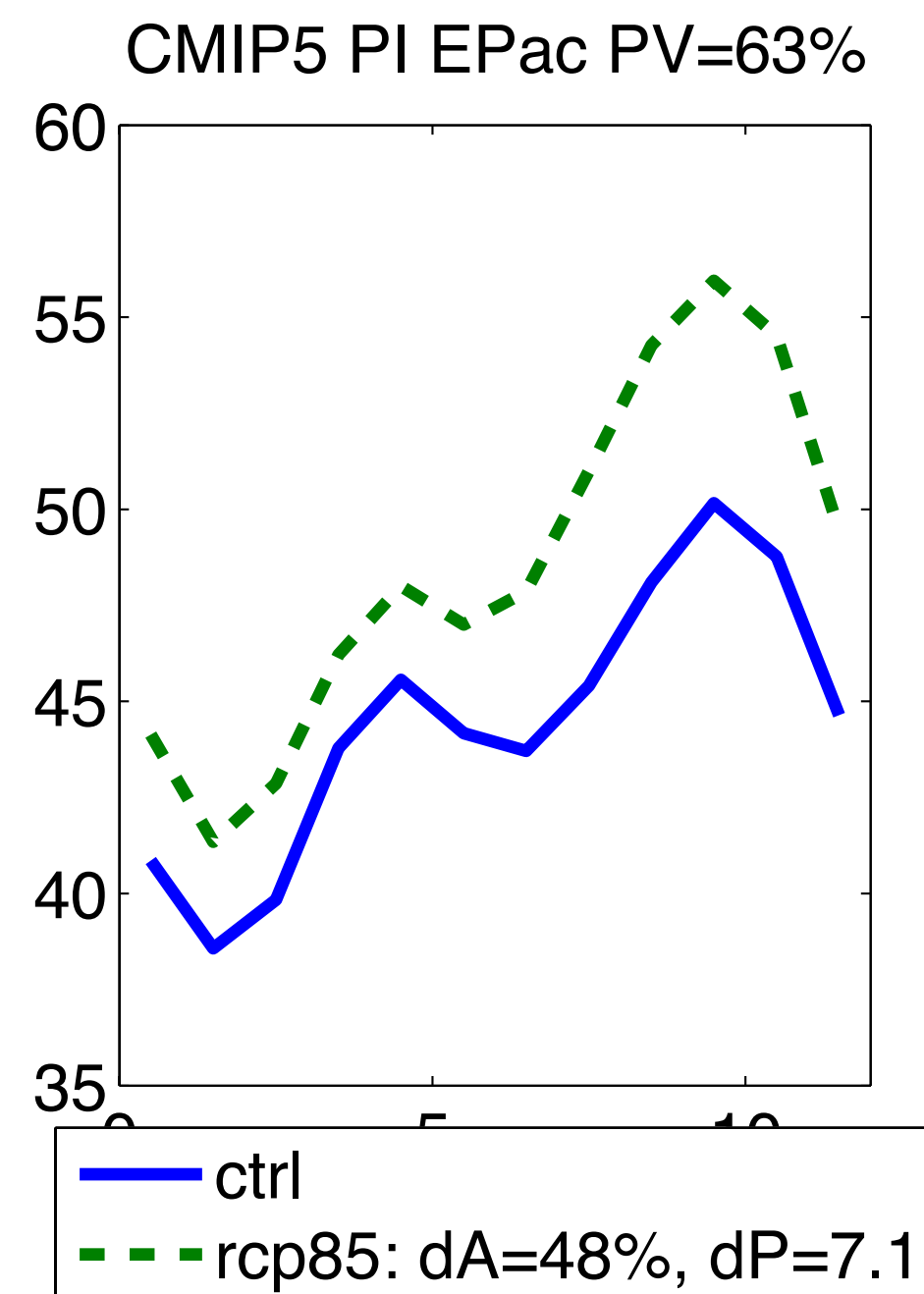
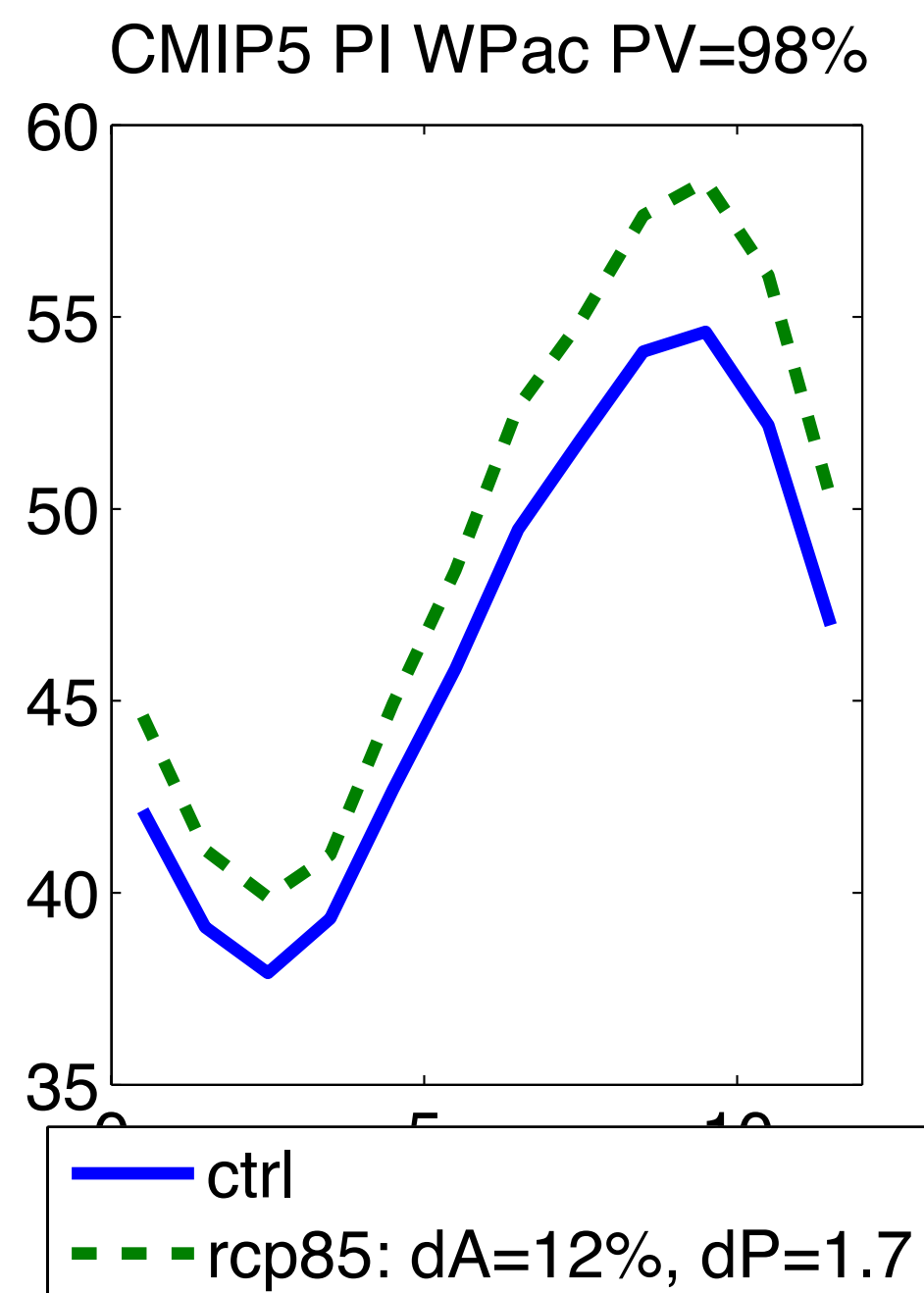
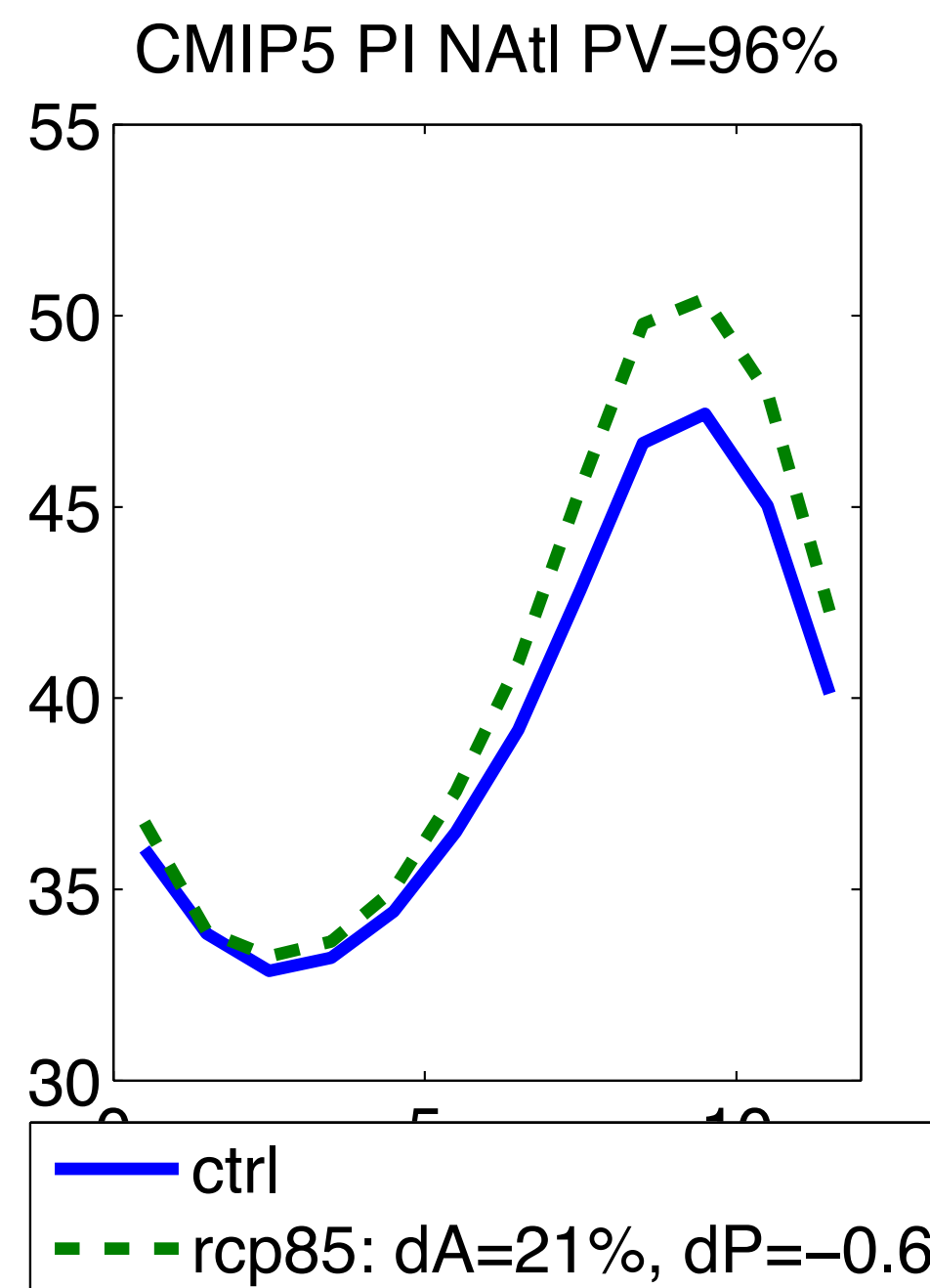
Questions

- Motivated by these projected changes in SST and precipitation, does the timing of tropical storms and their environmental conditions change due to greenhouse gases in the latest models?
- If so, how important is the spatial pattern of SST for these changes?

Data

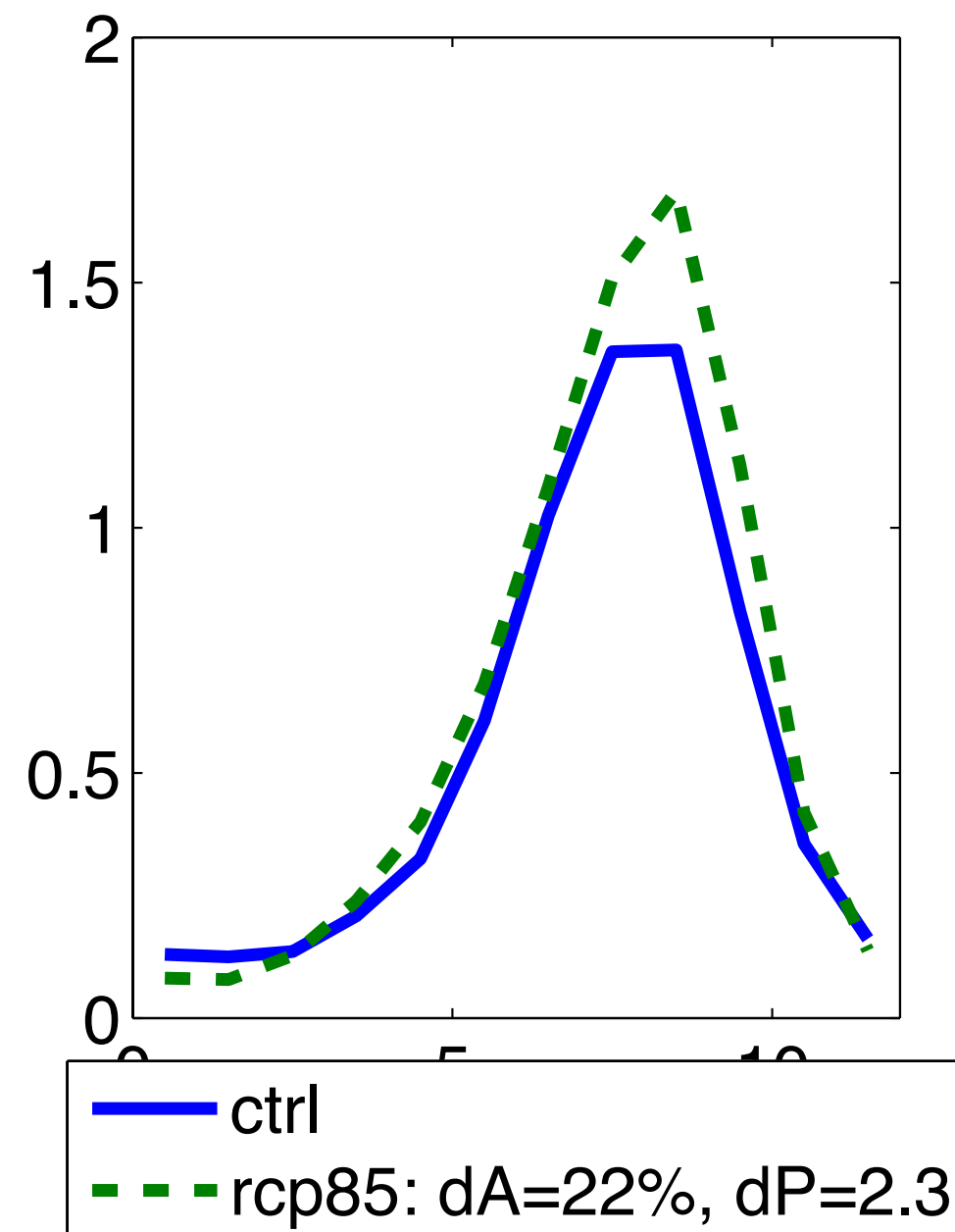
- CMIP5 (Taylor et al., 2011) & Downscaled TC tracks (Emanuel et al., 2008)
 - Downscaling based on CMIP5 results from various models
- HiRAM (Zhao et al., 2009)
 - 50km resolution
 - Forced by observed SST and CMIP3 projections of SST changes

PI

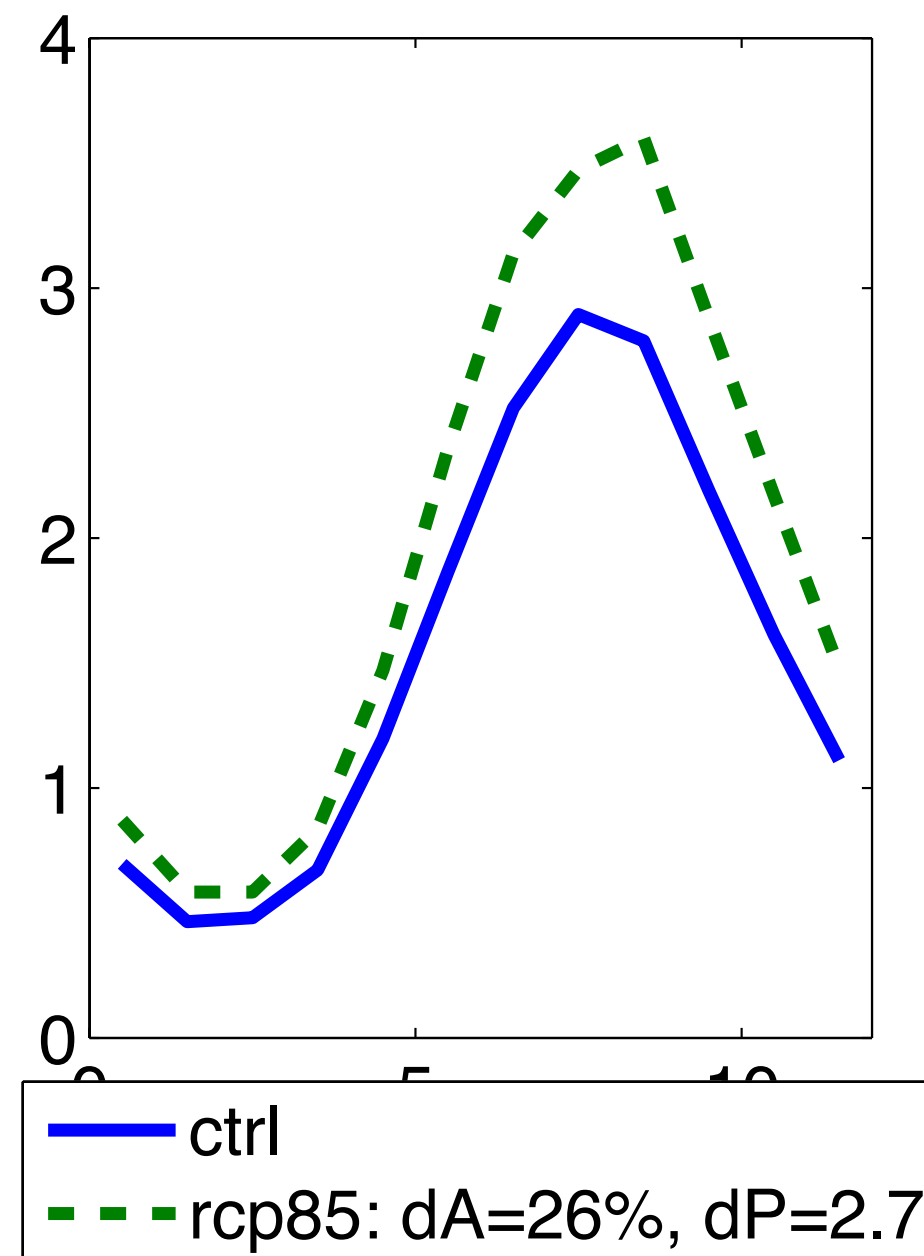


GPI

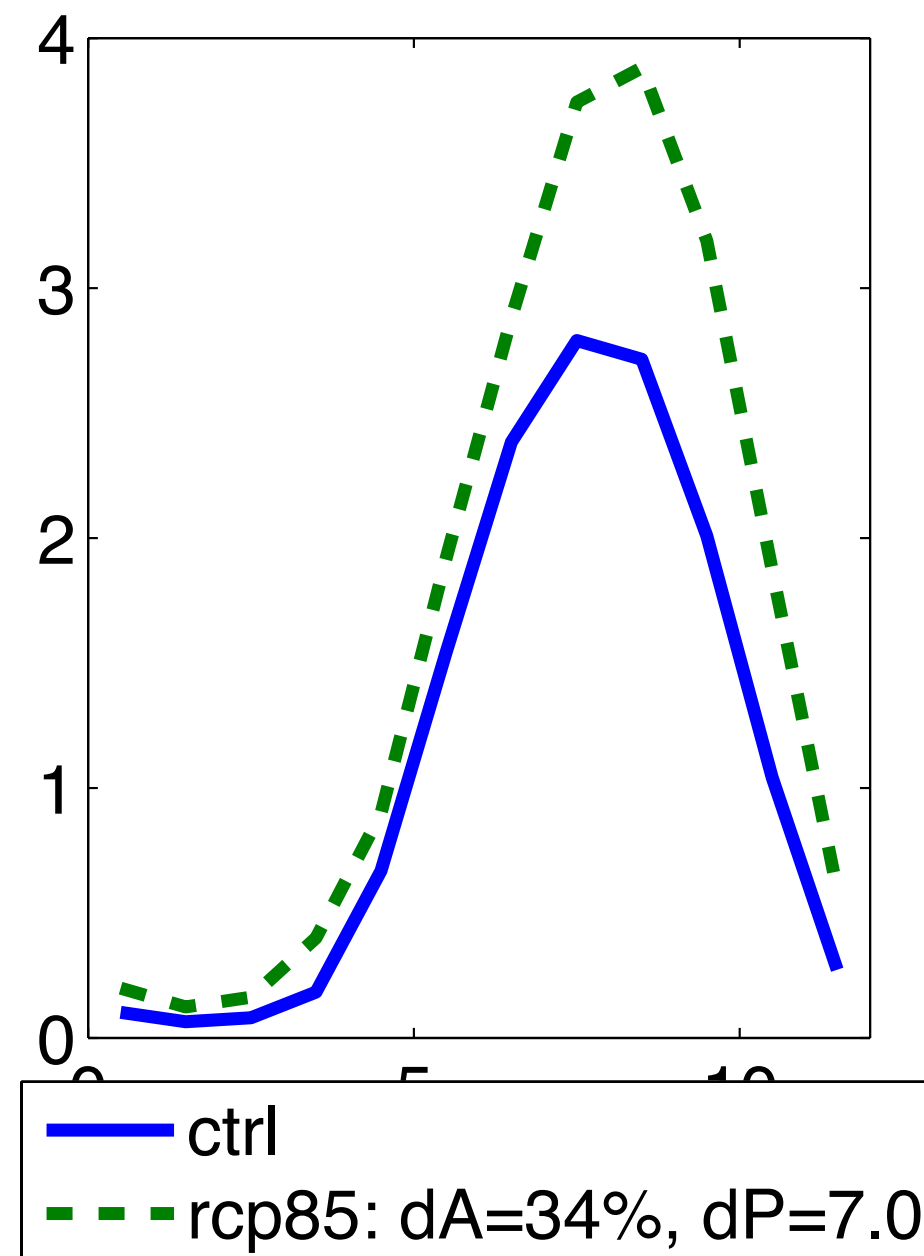
CMIP5 GPI NATl PV=87%



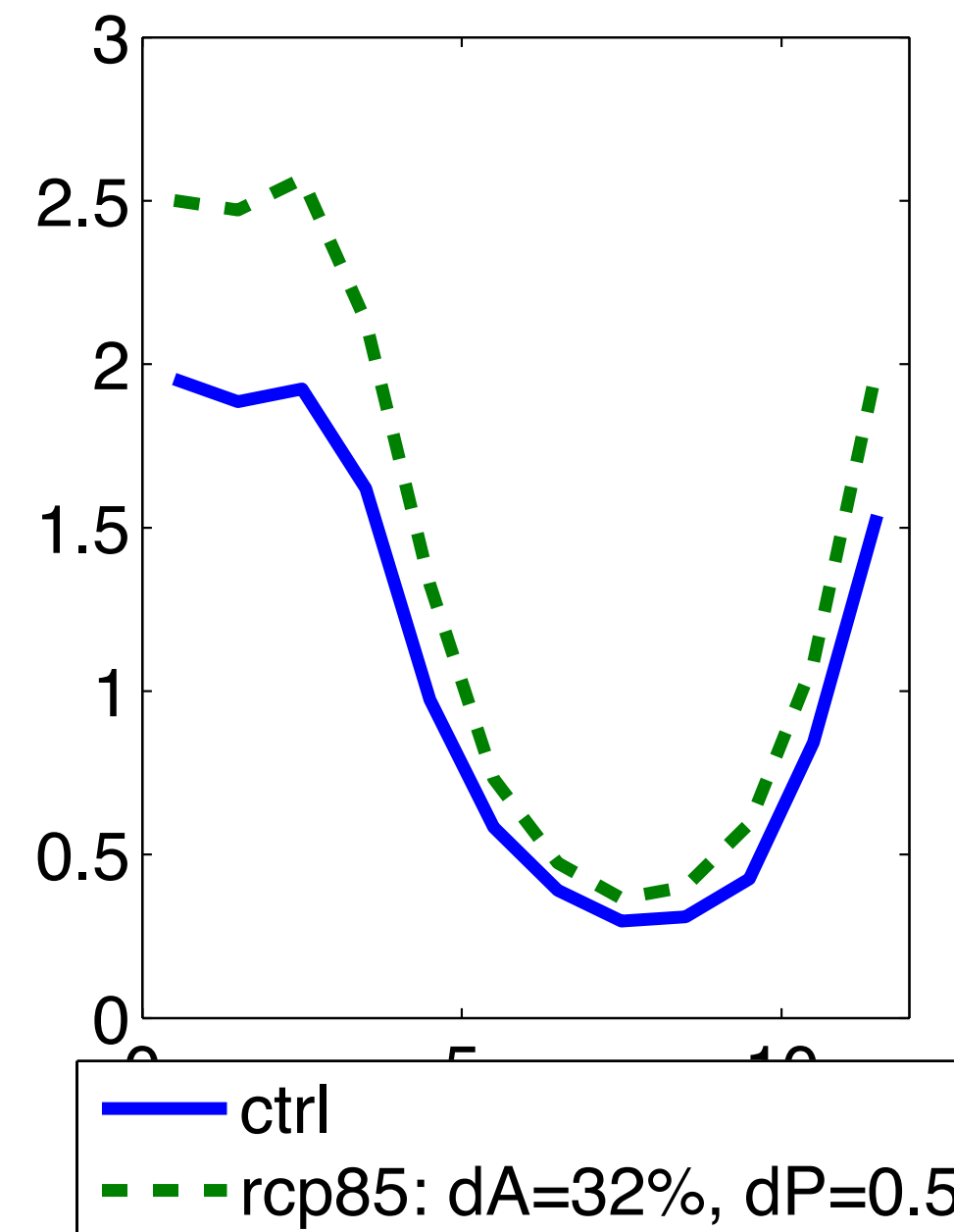
CMIP5 GPI WPac PV=98%



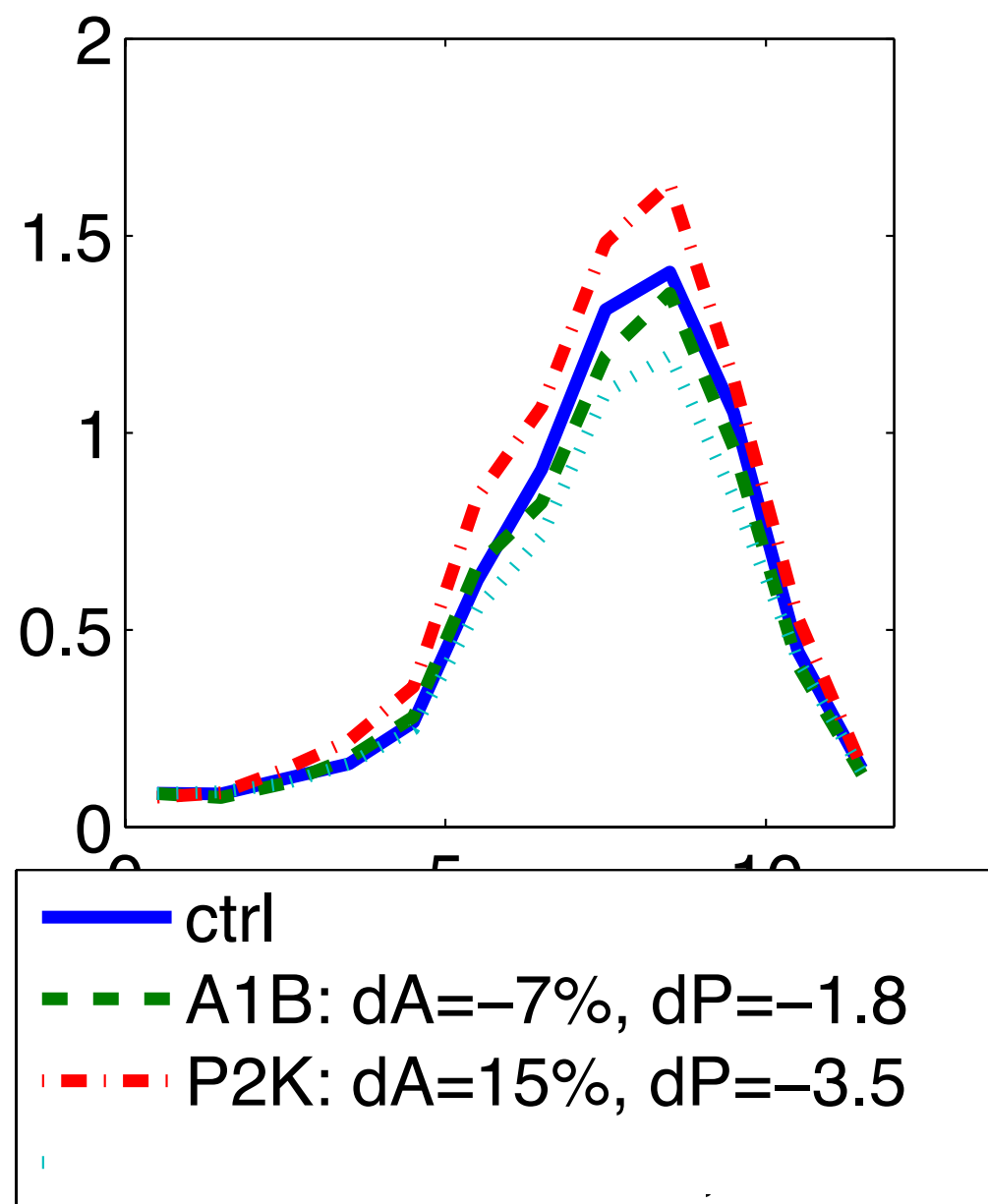
CMIP5 GPI EPac PV=95%



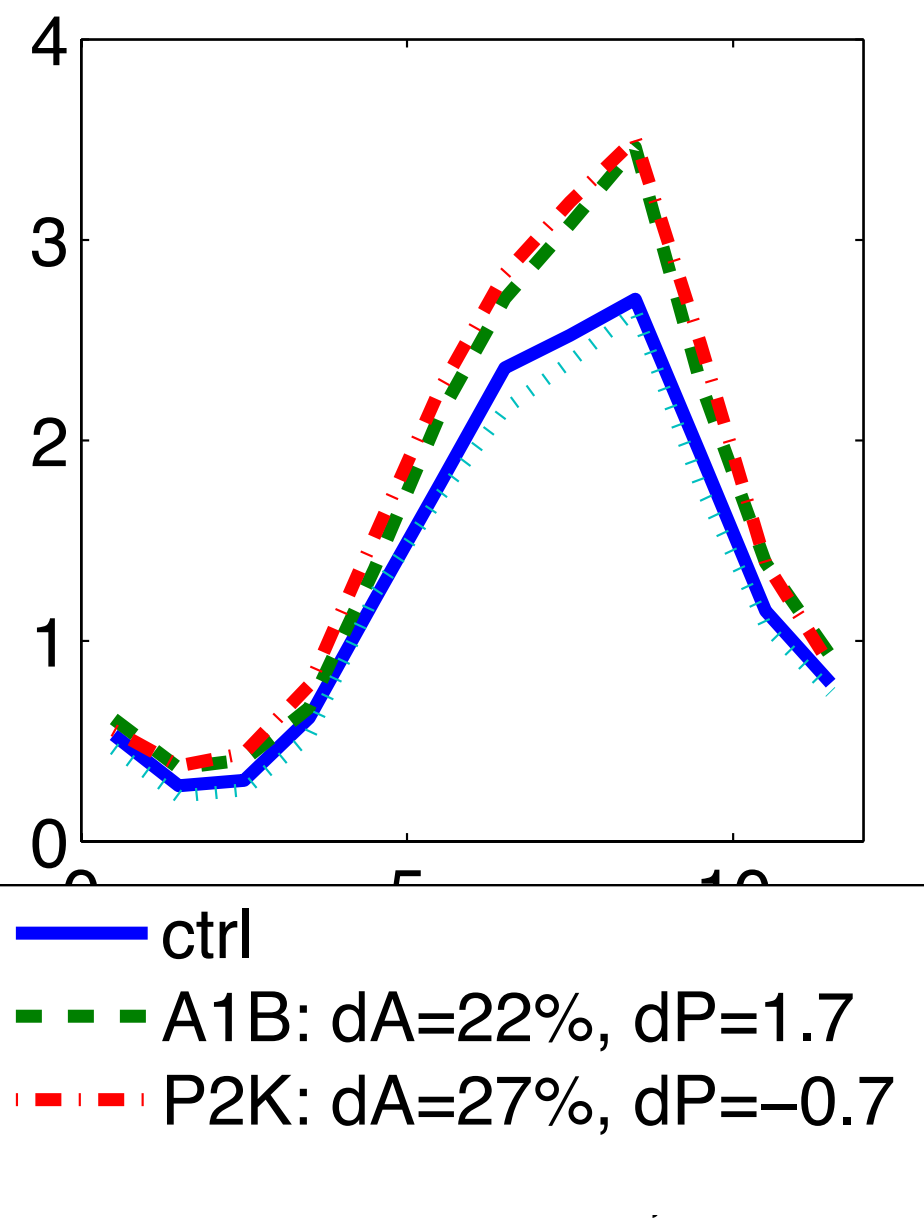
CMIP5 GPI Aust PV=97%



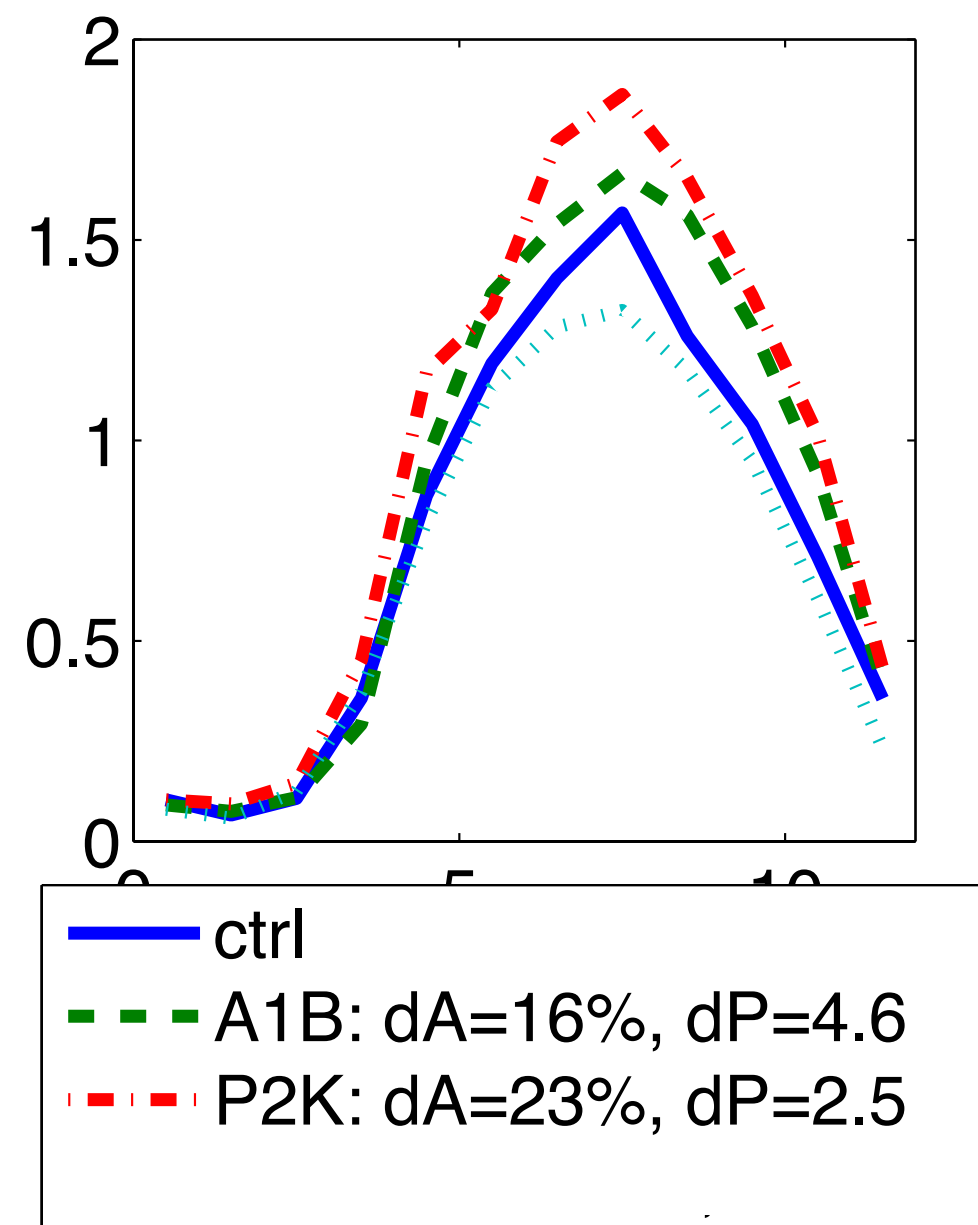
HiRAM GPI NATl PV=89%



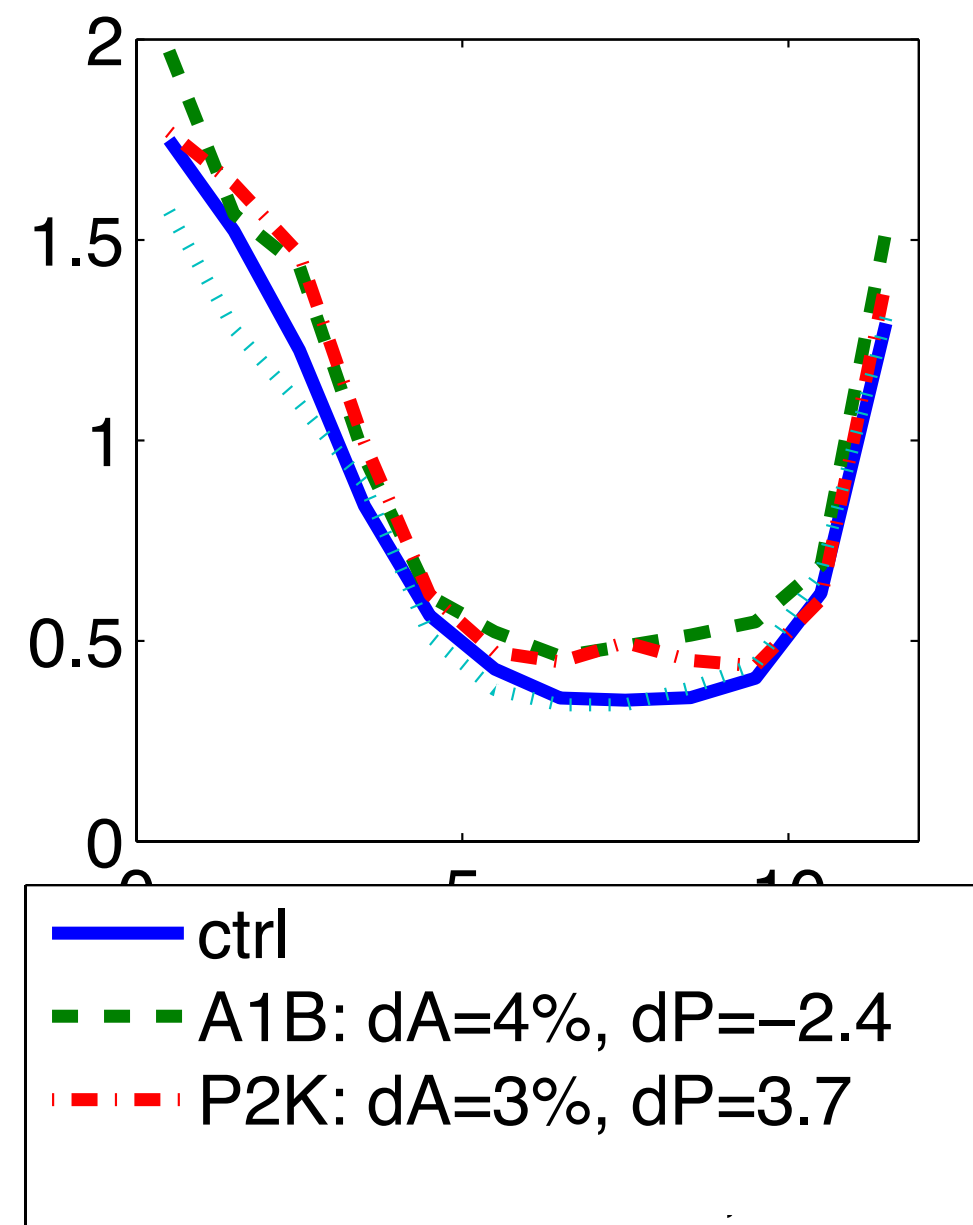
HiRAM GPI WPac PV=97%



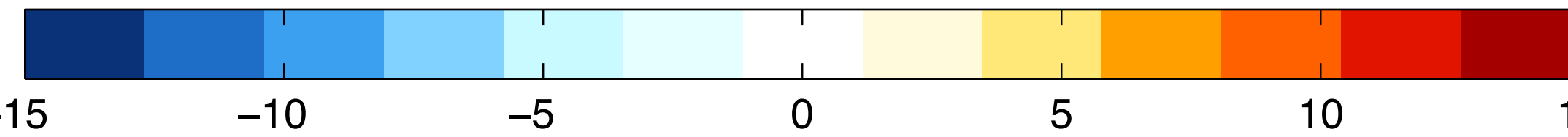
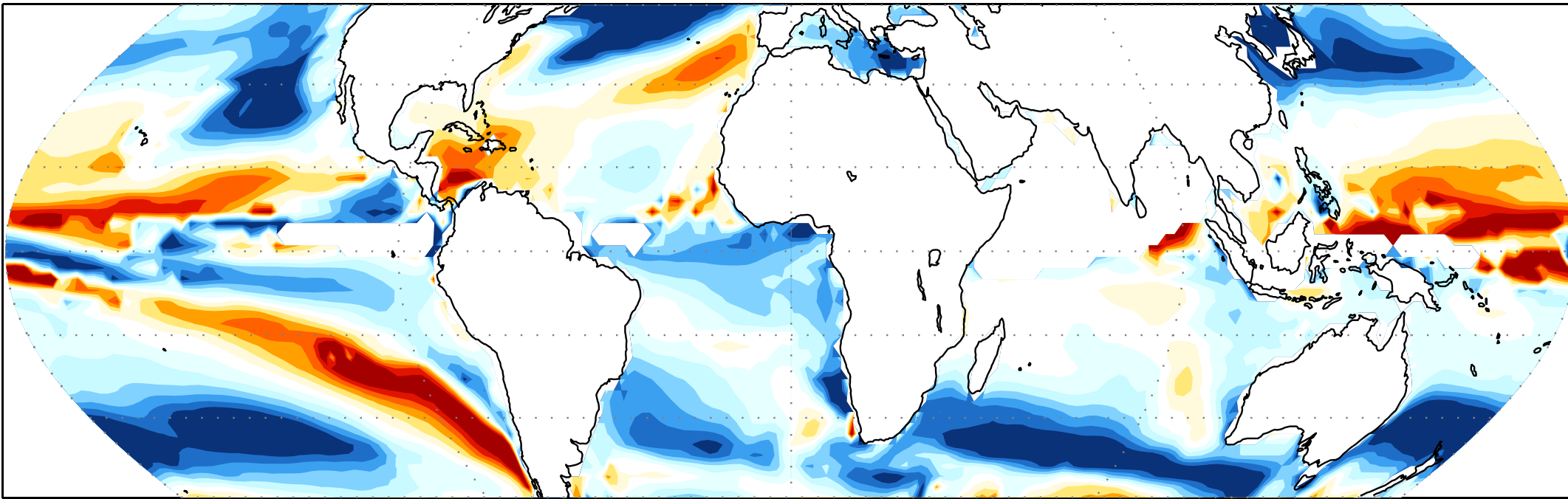
HiRAM GPI EPac PV=99%



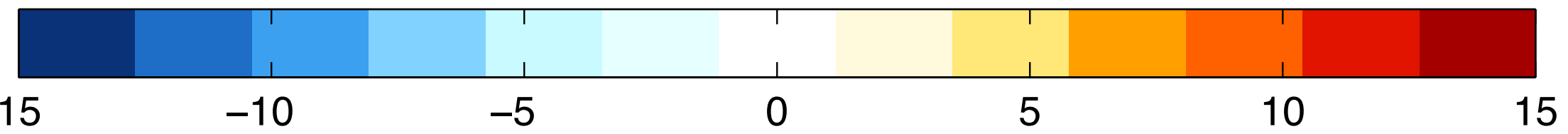
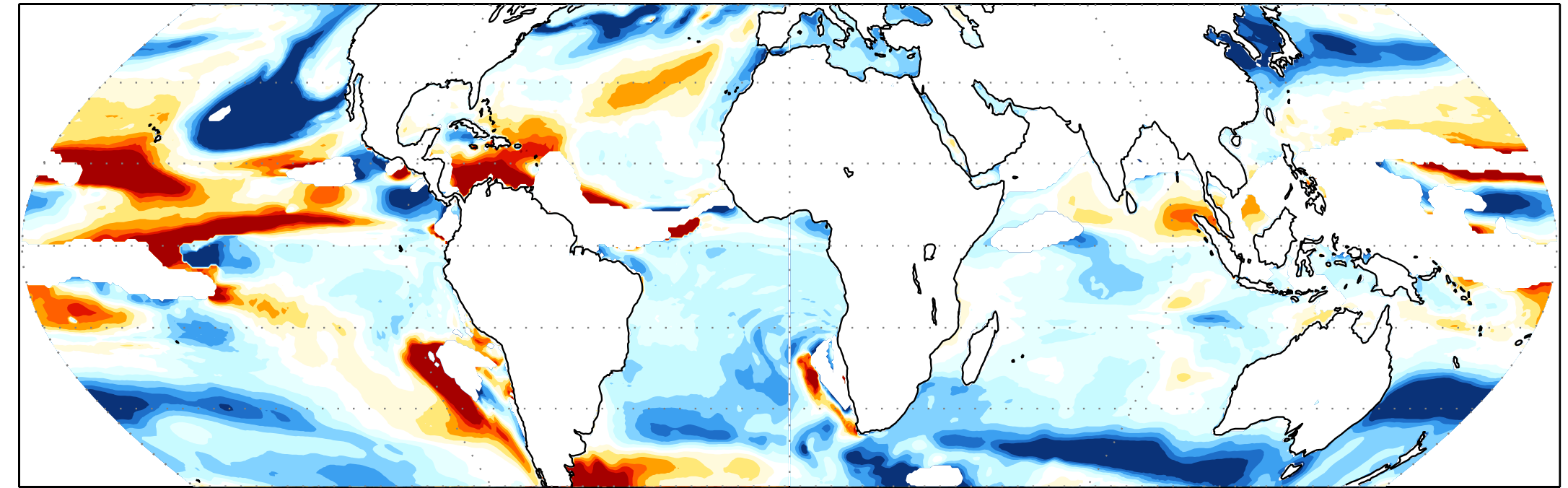
HiRAM GPI Aust PV=87%



CMIP5 MMM PI Δ Phase [days]

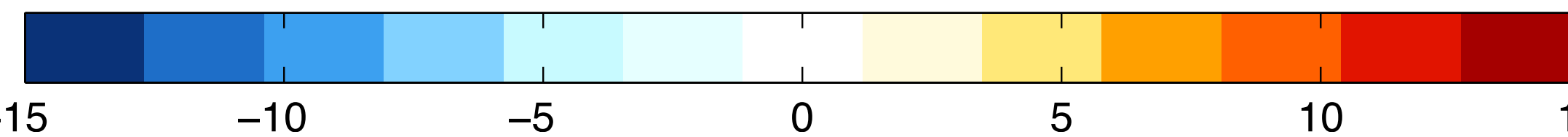
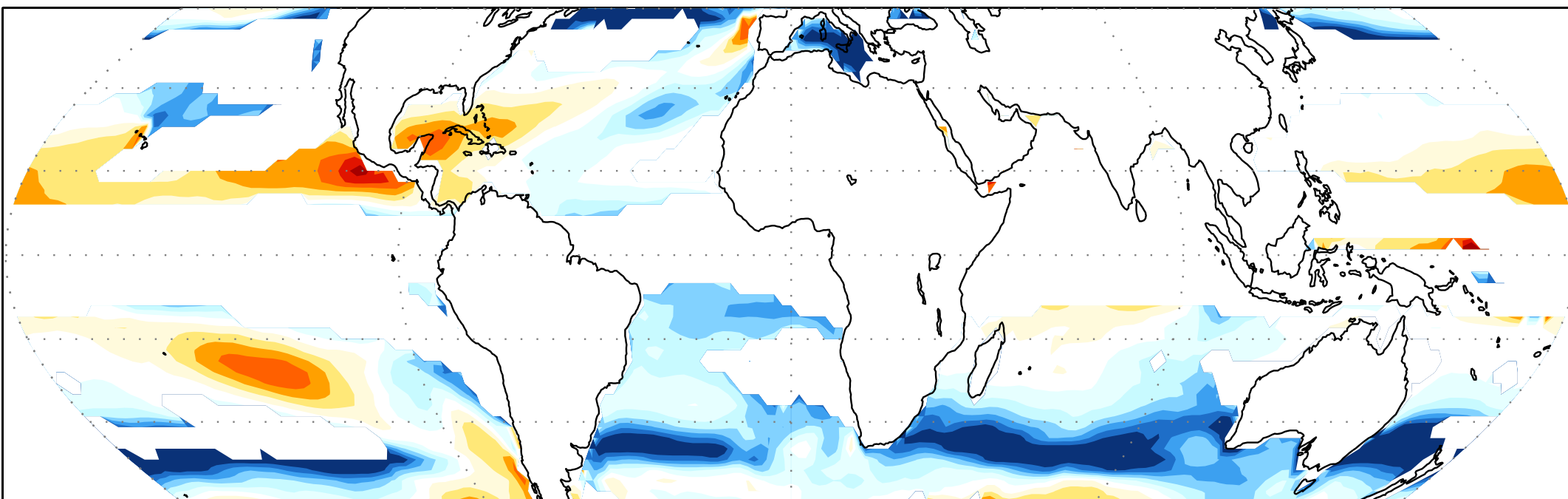


HiRAM MMM PI Δ Phase [days]

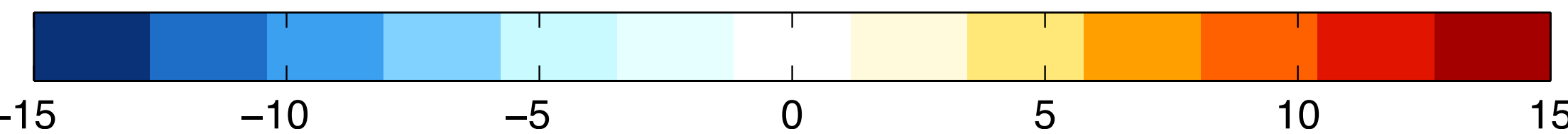
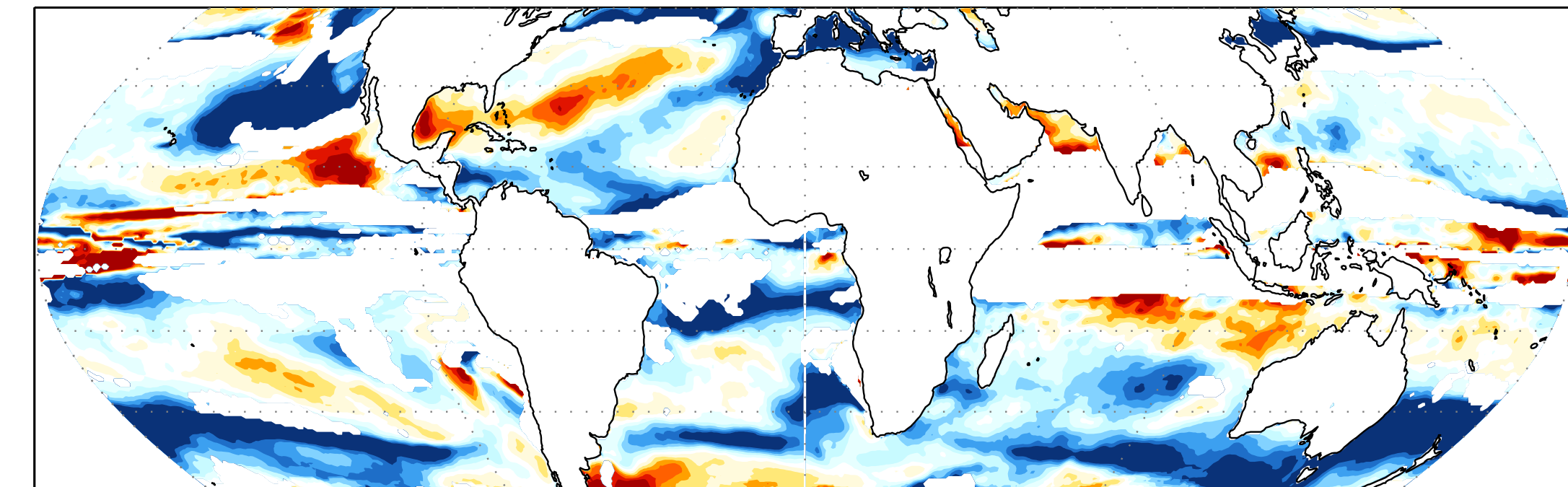


Genesis Potential Index

CMIP5 MMM GPI Δ Phase [days]

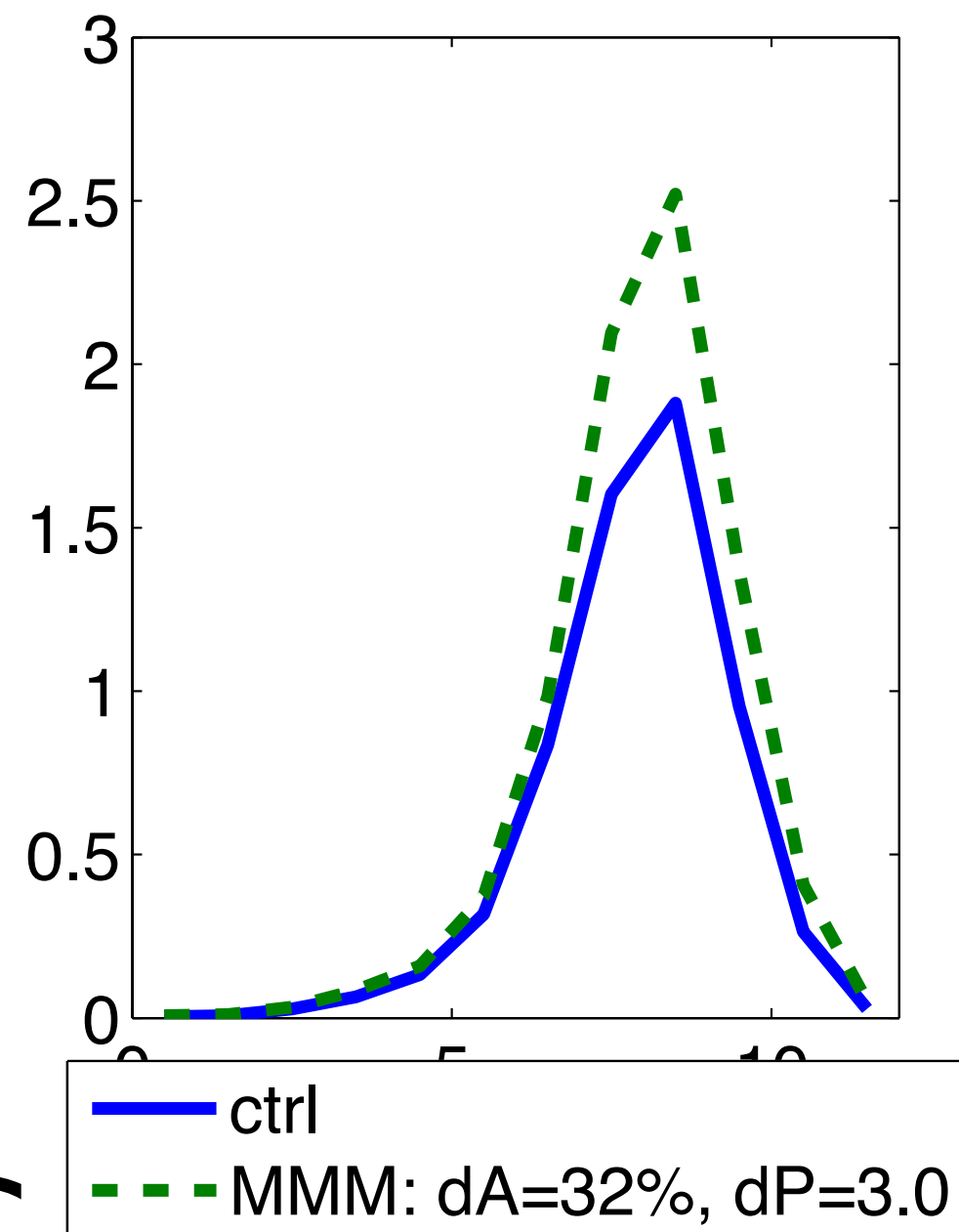


HiRAM MMM GPI Δ Phase [days]

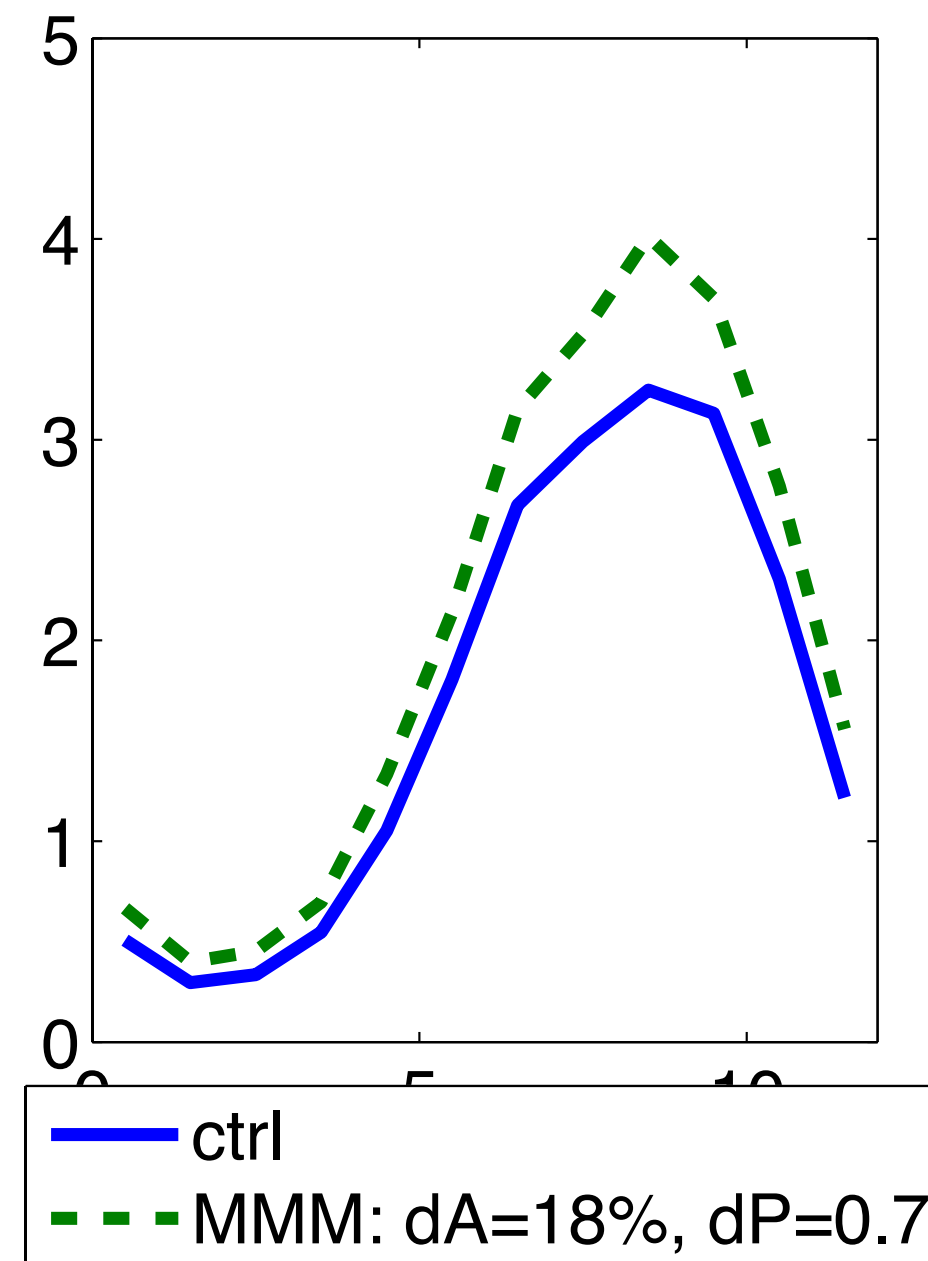


NTC

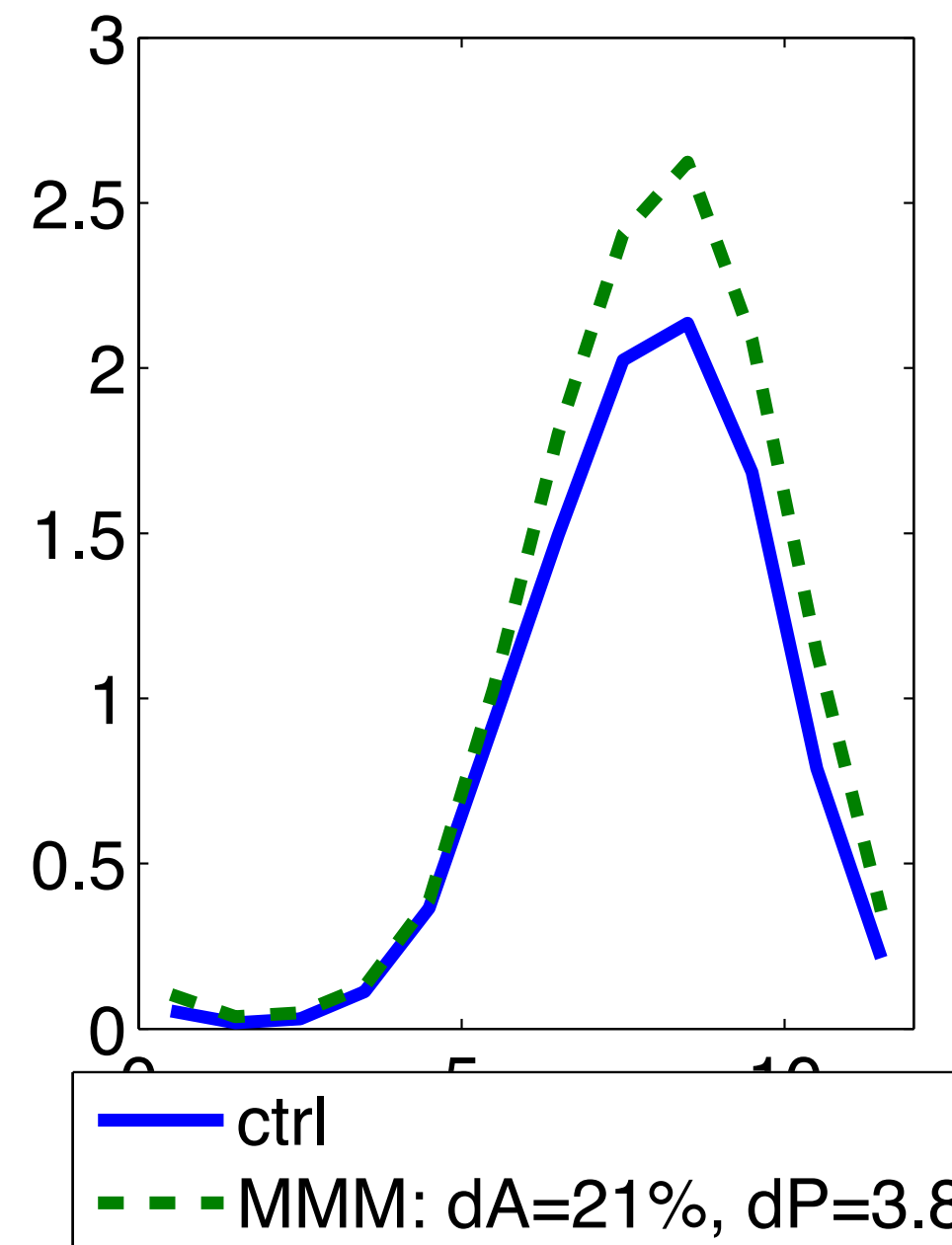
Dwnscl. ntc NATl PV=62%



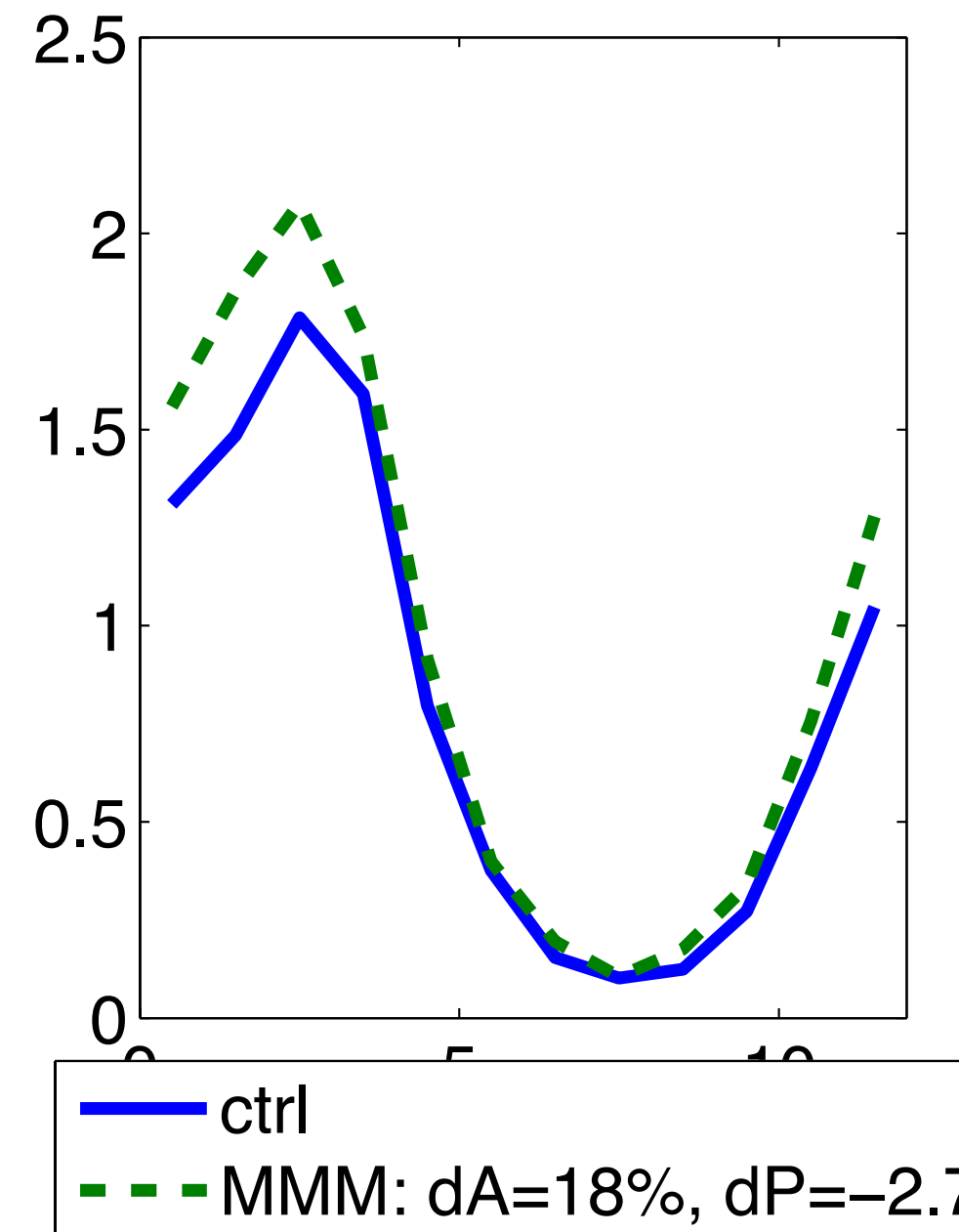
Dwnscl. ntc WPac PV=98%



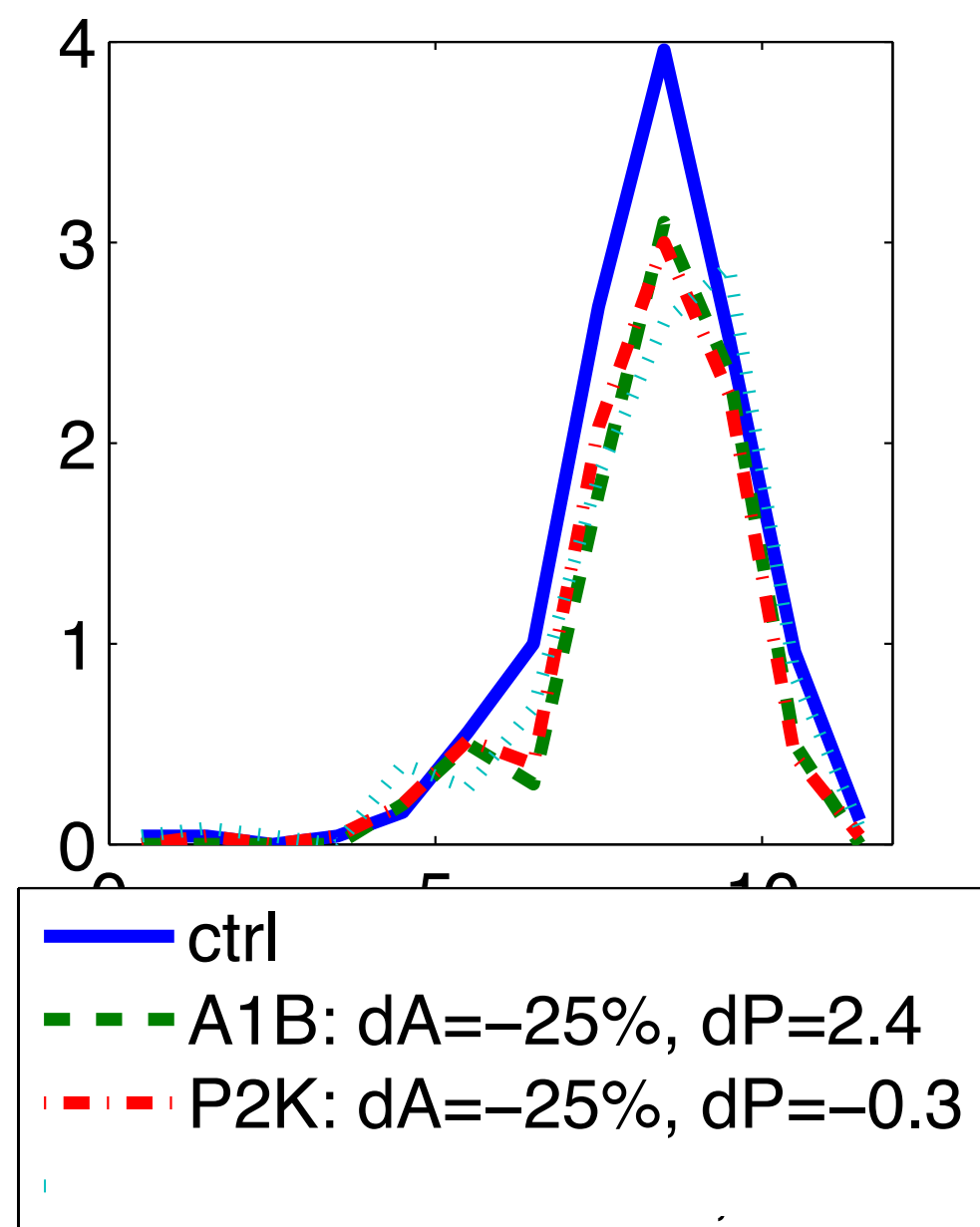
Dwnscl. ntc EPac PV=84%



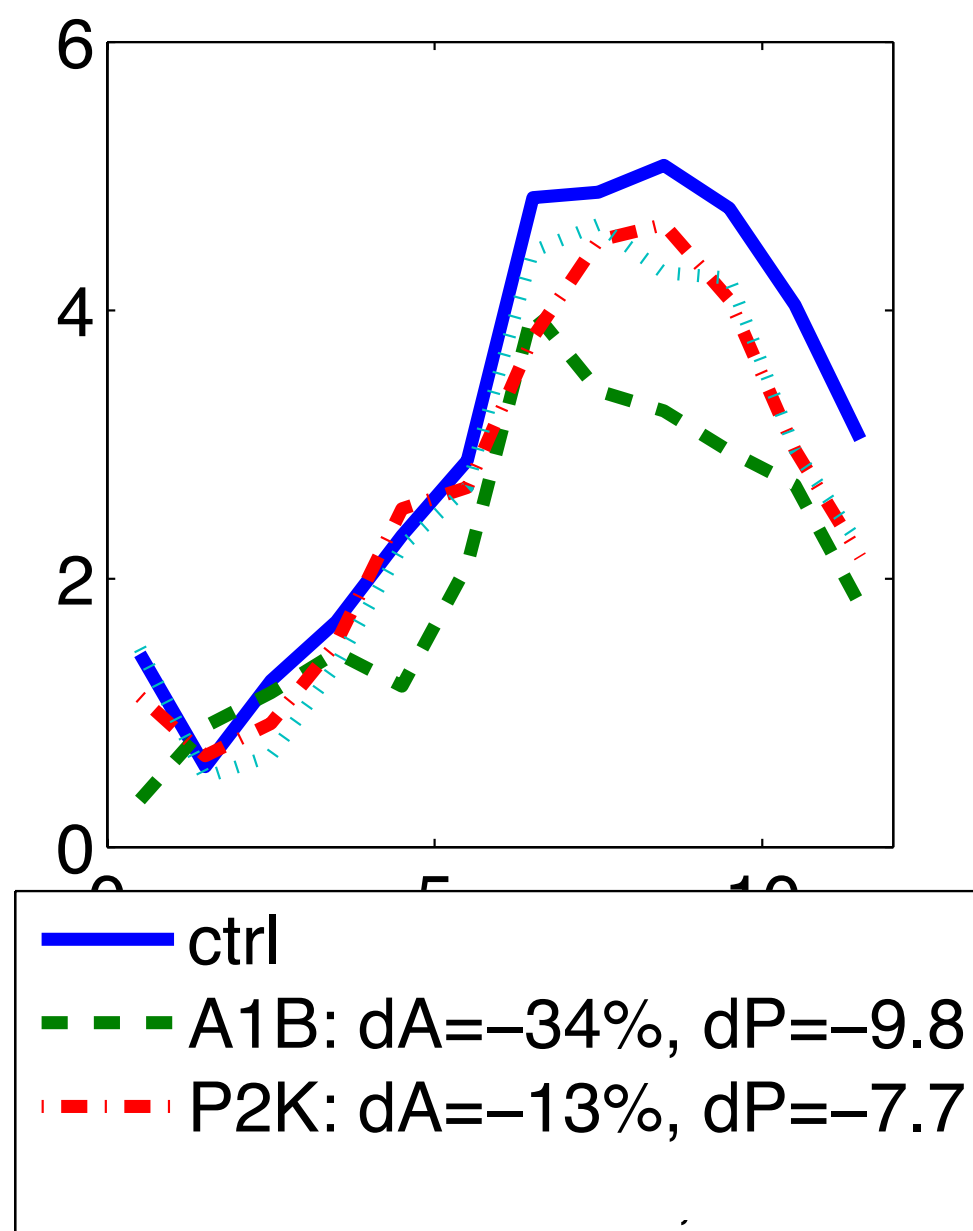
Dwnscl. ntc Aust PV=95%



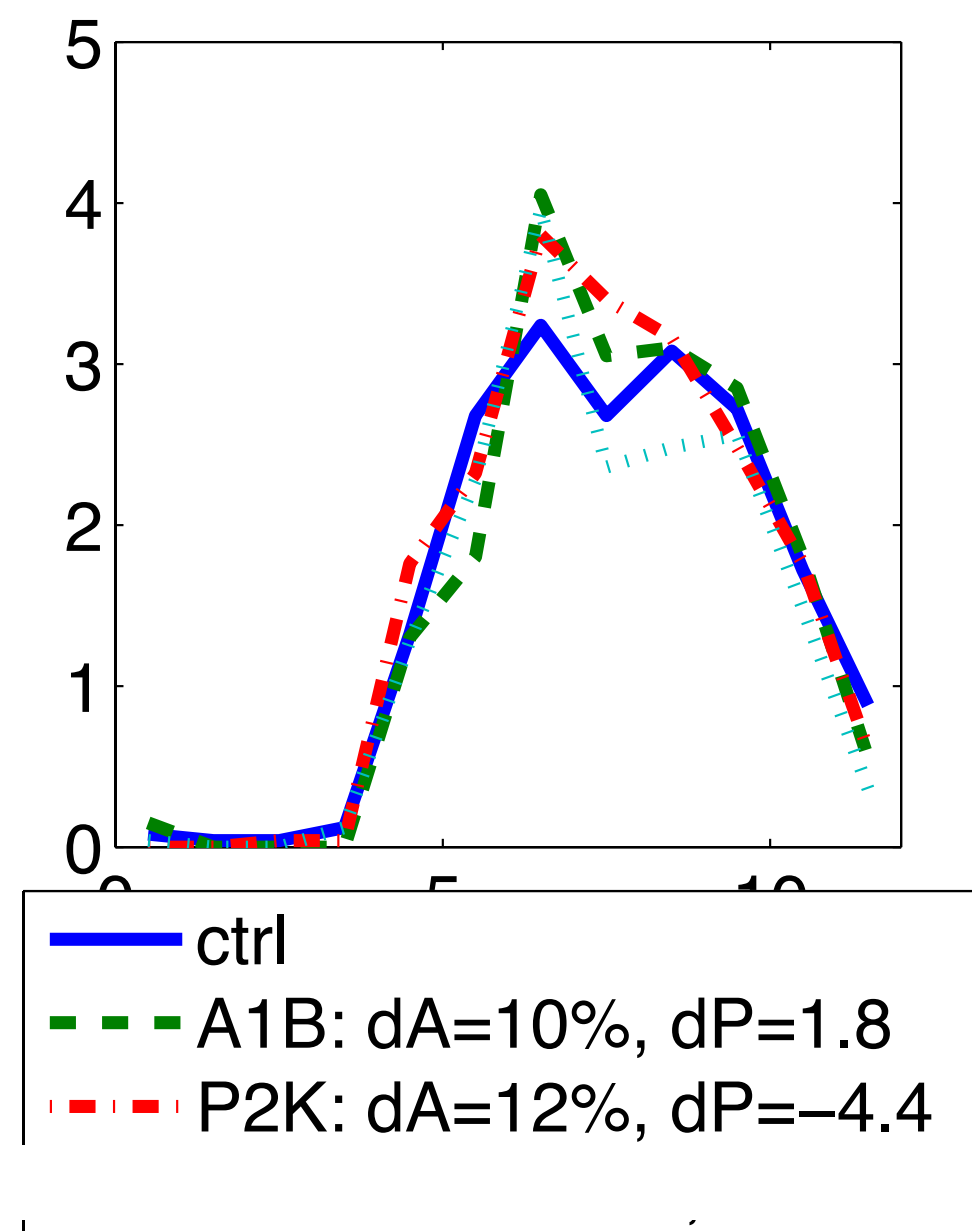
HiRAM NTC NATl PV=75%



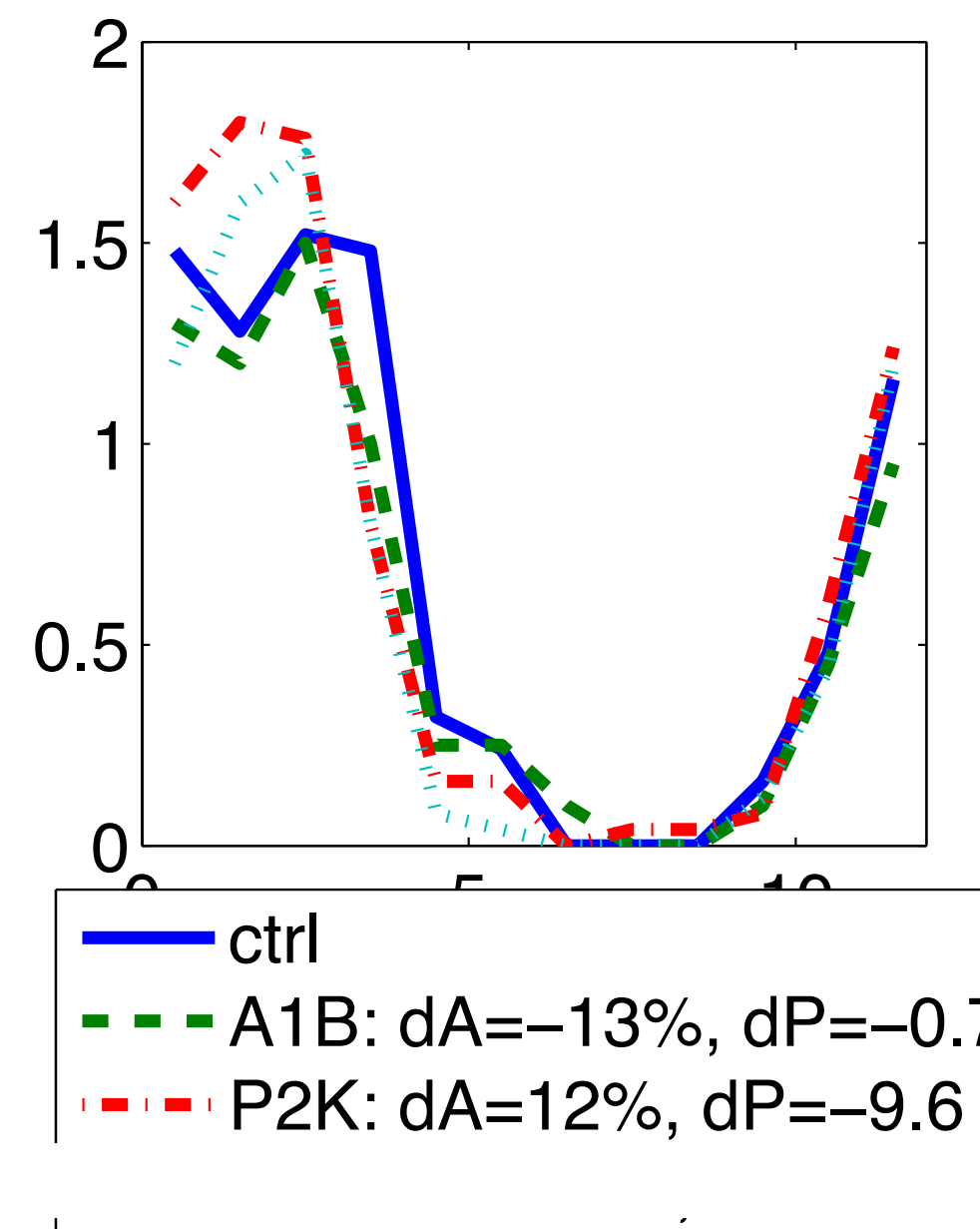
HiRAM NTC WPac PV=96%



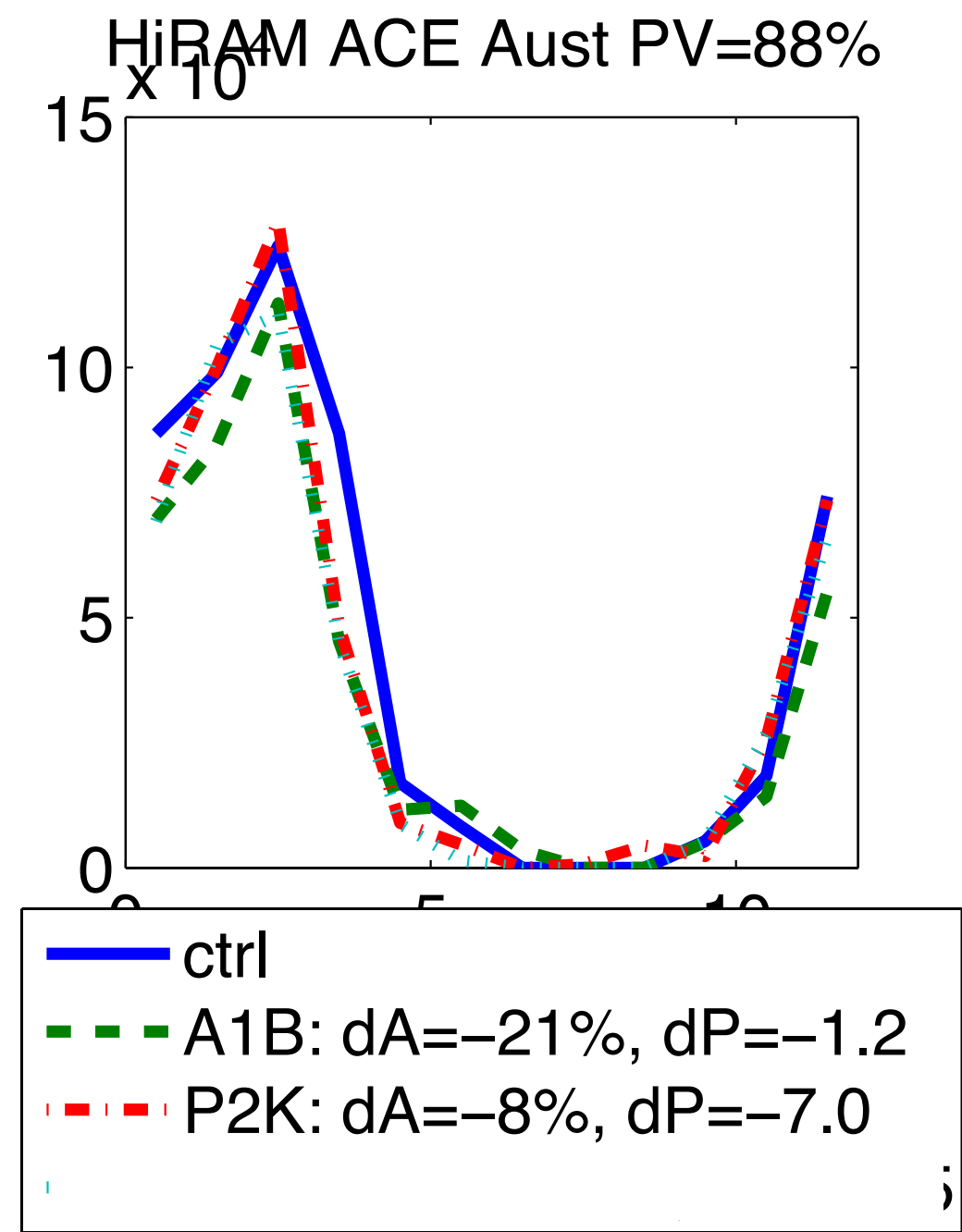
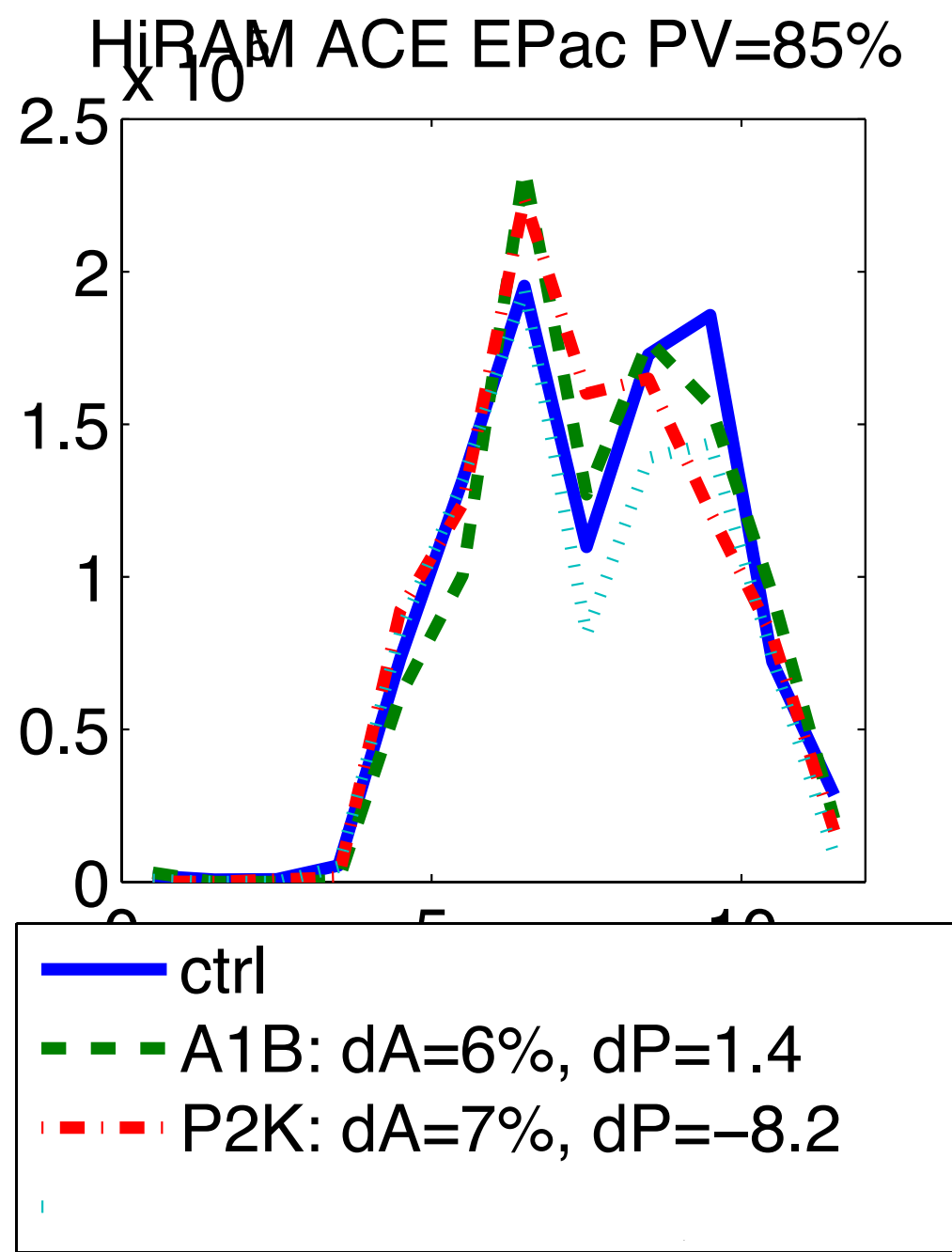
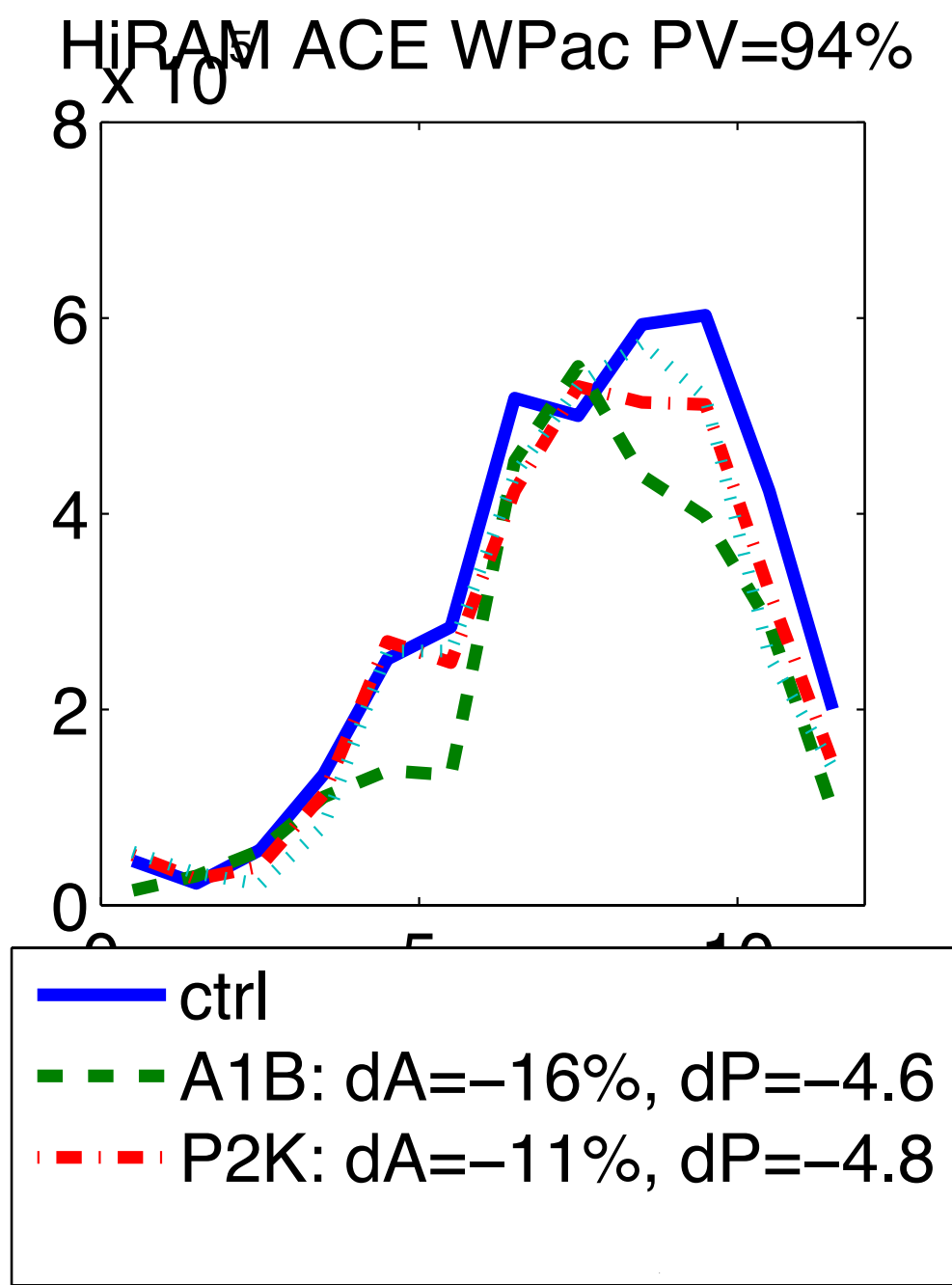
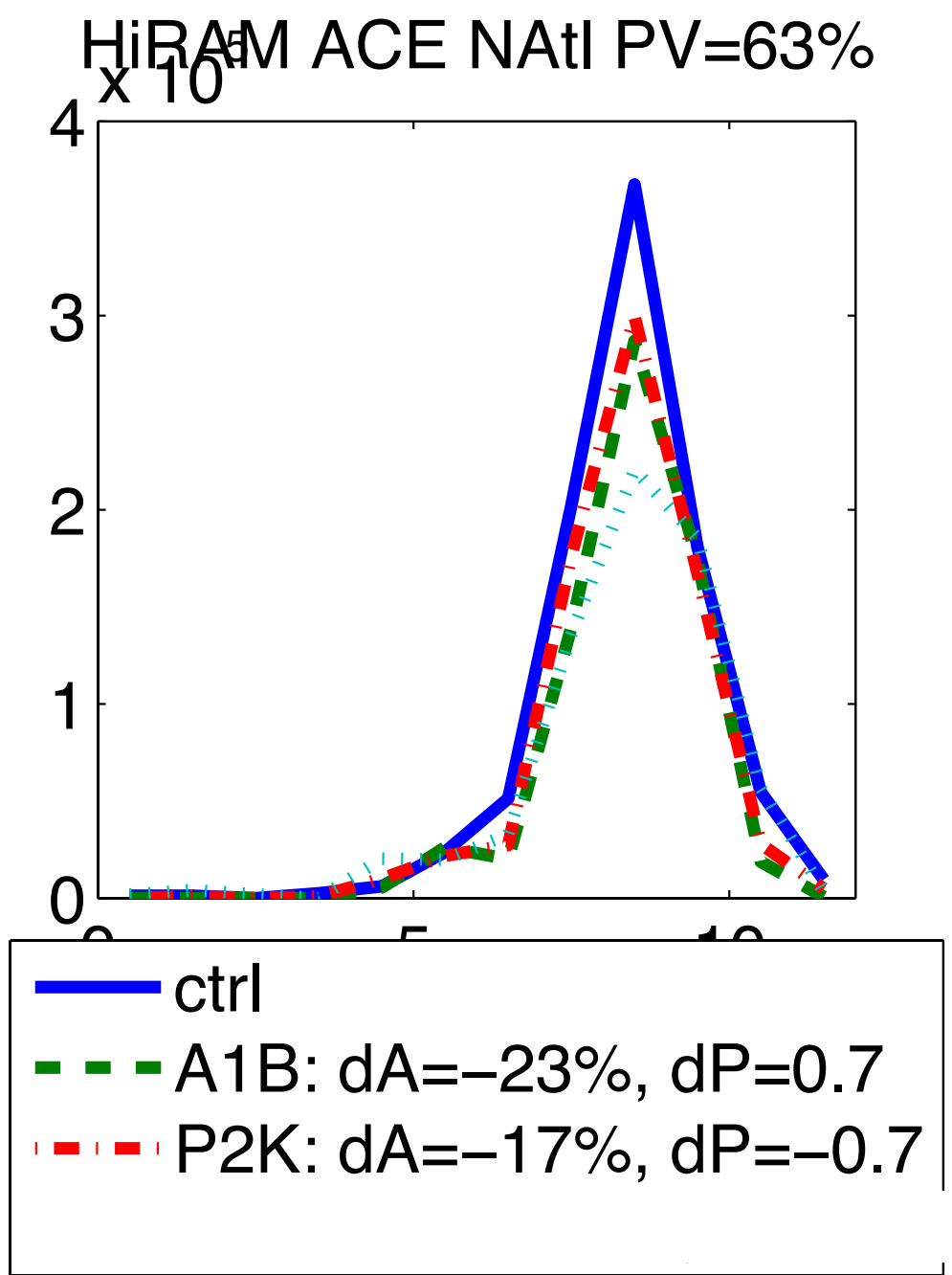
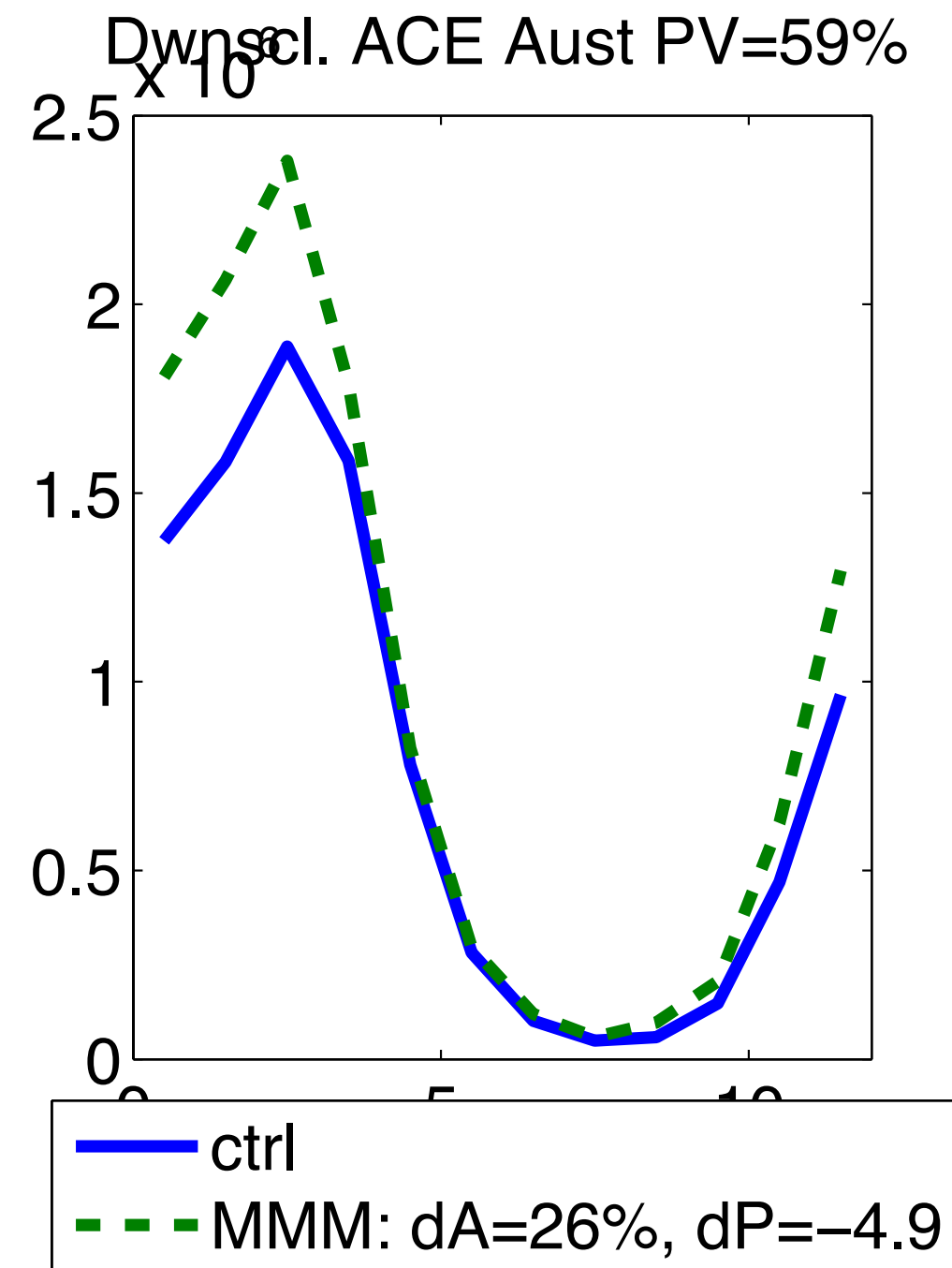
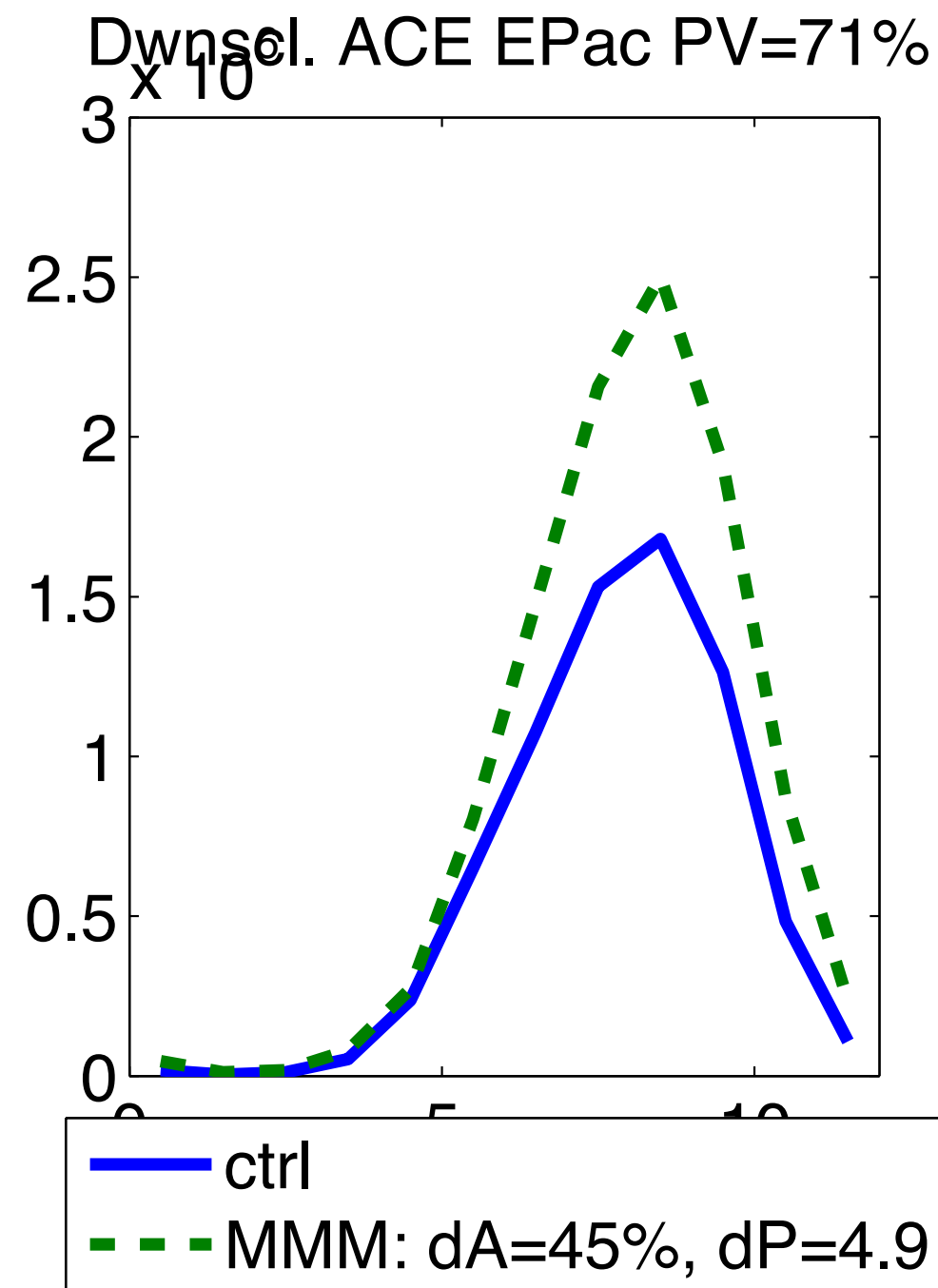
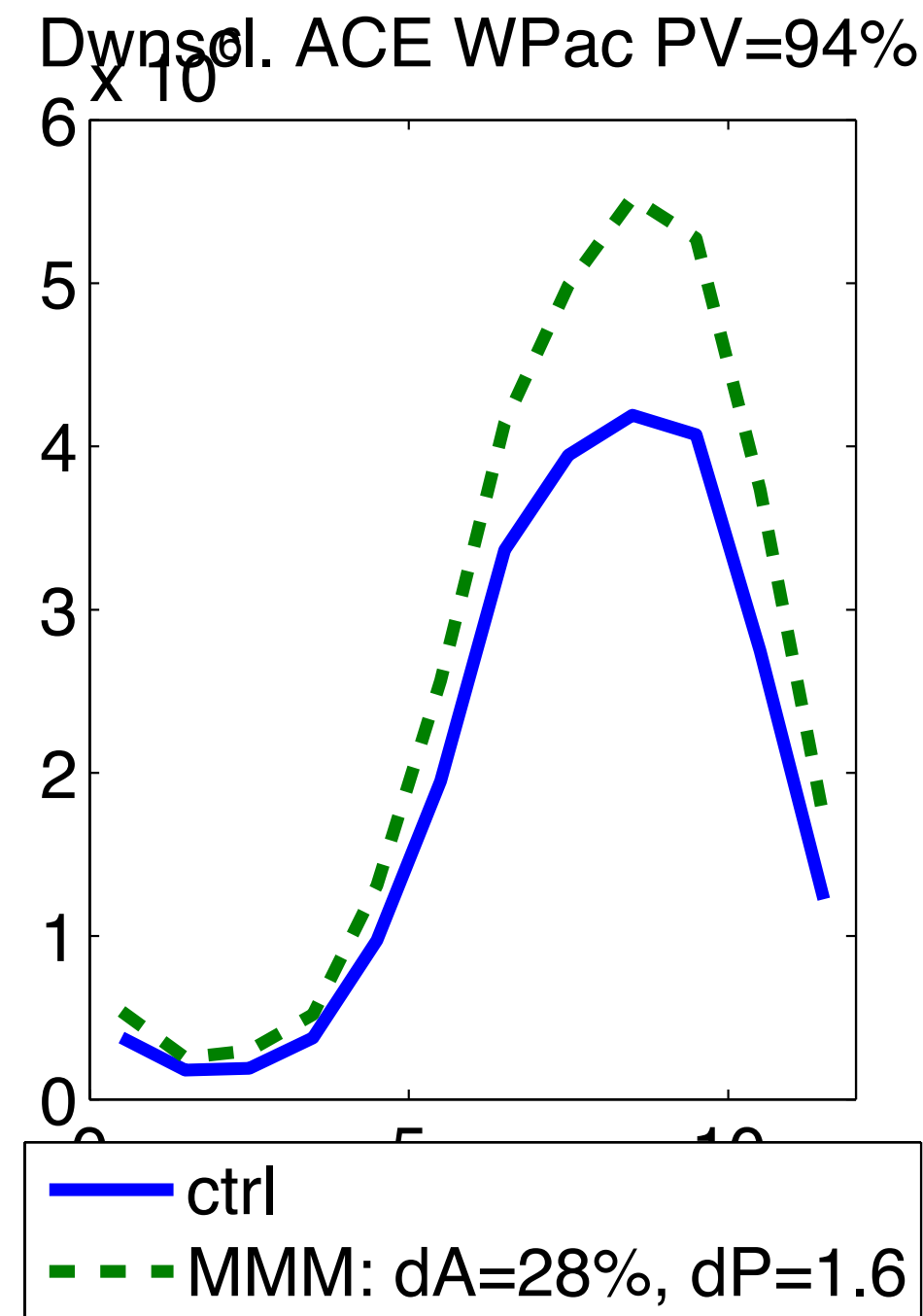
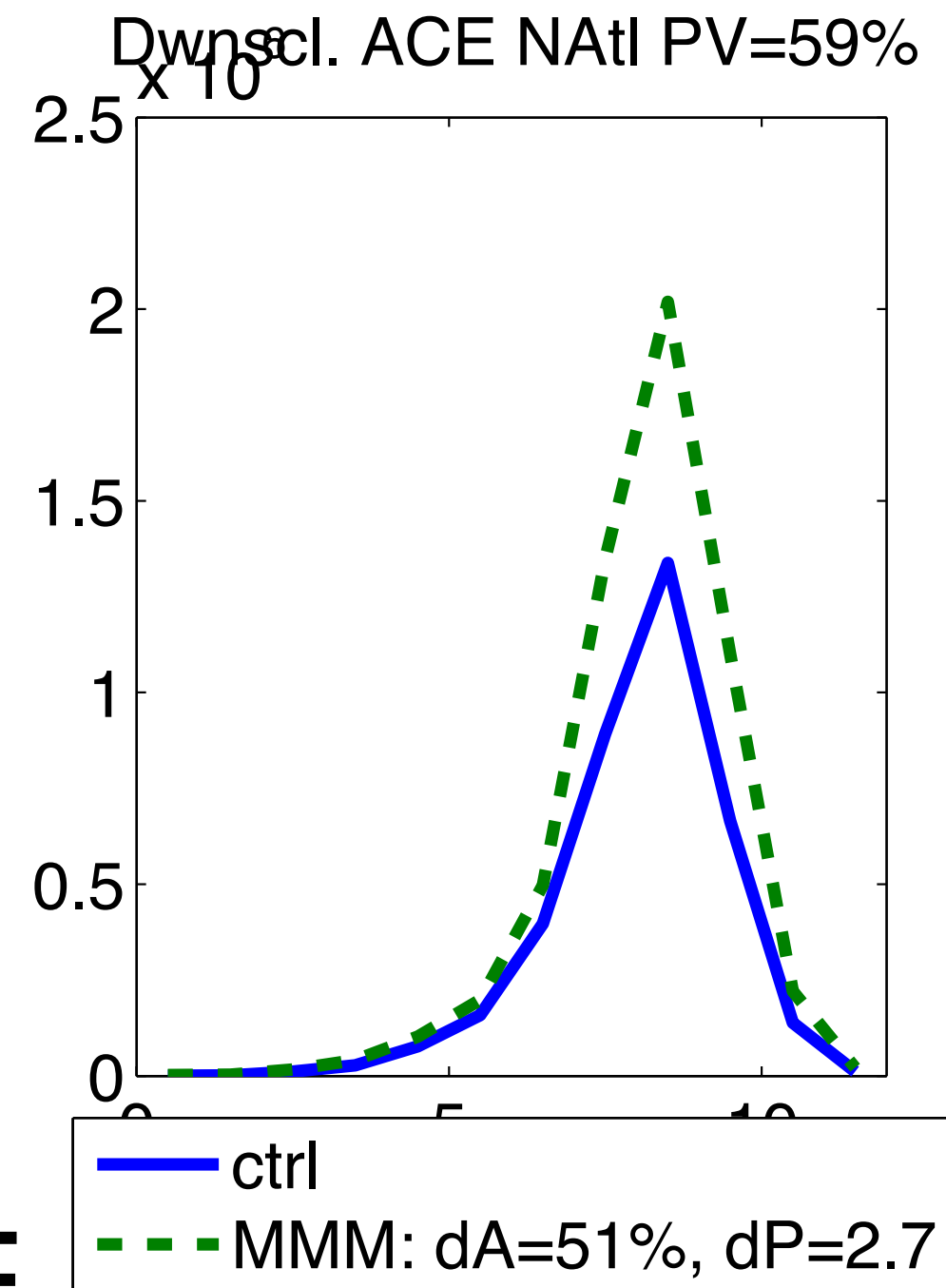
HiRAM NTC EPac PV=95%

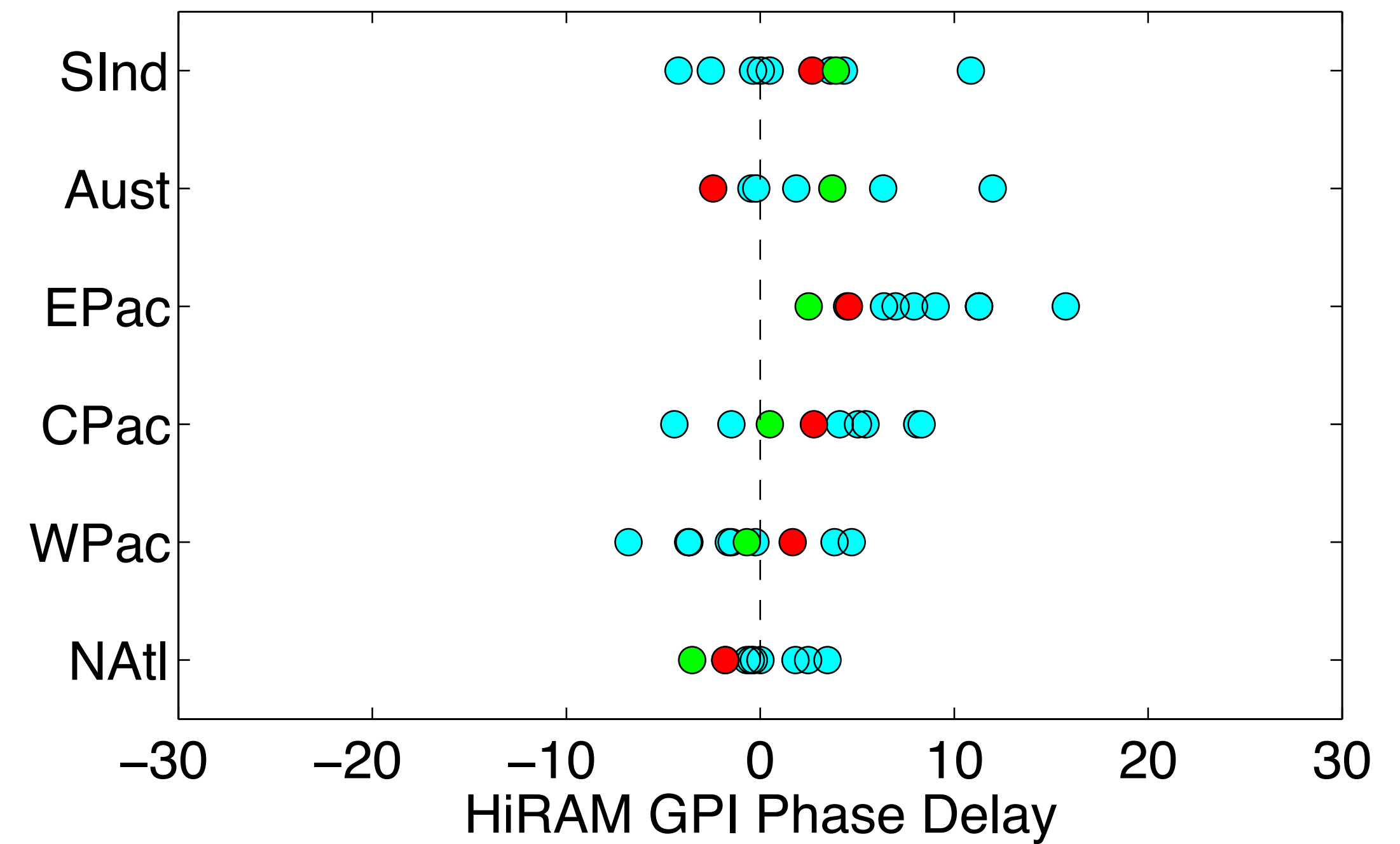
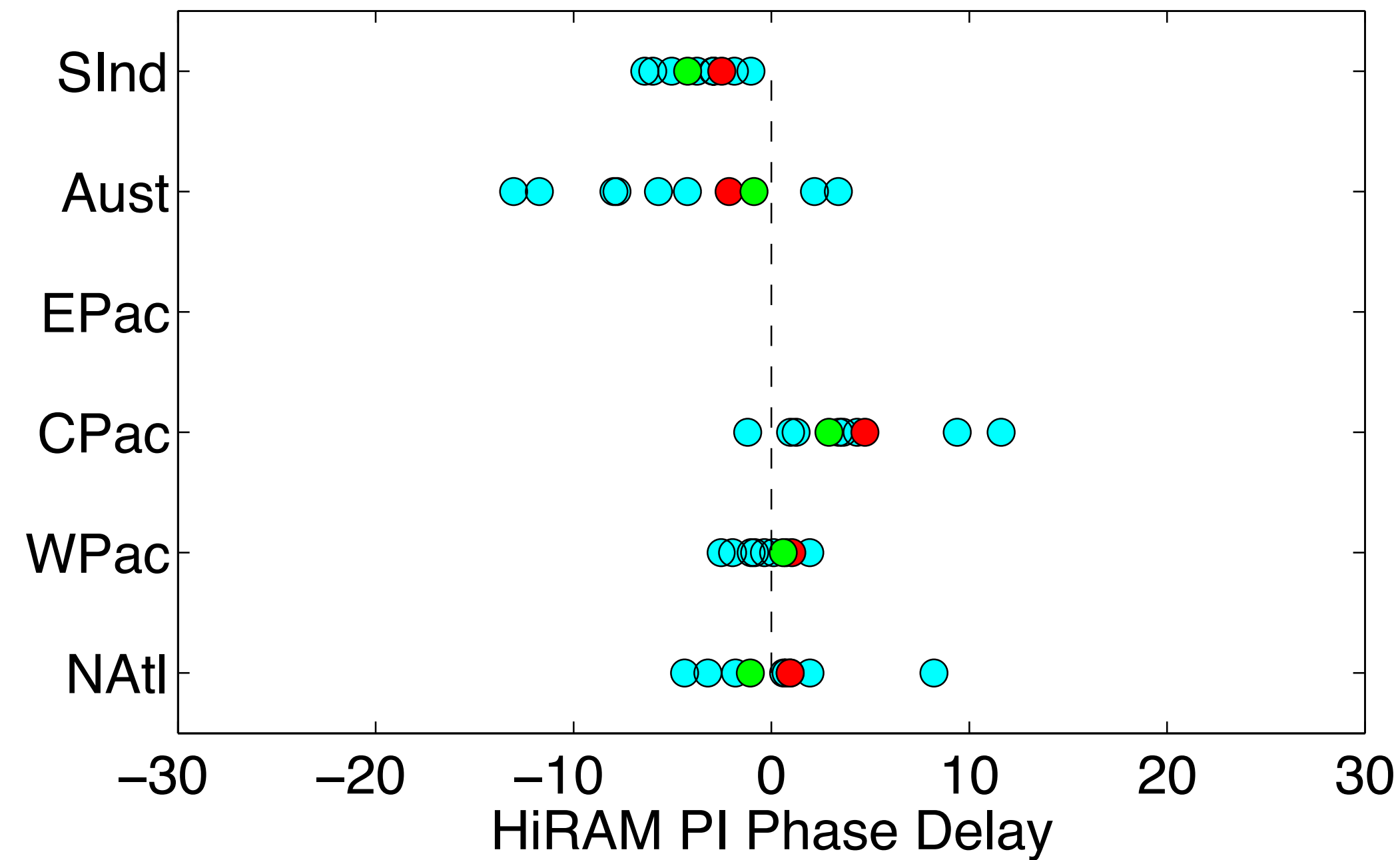
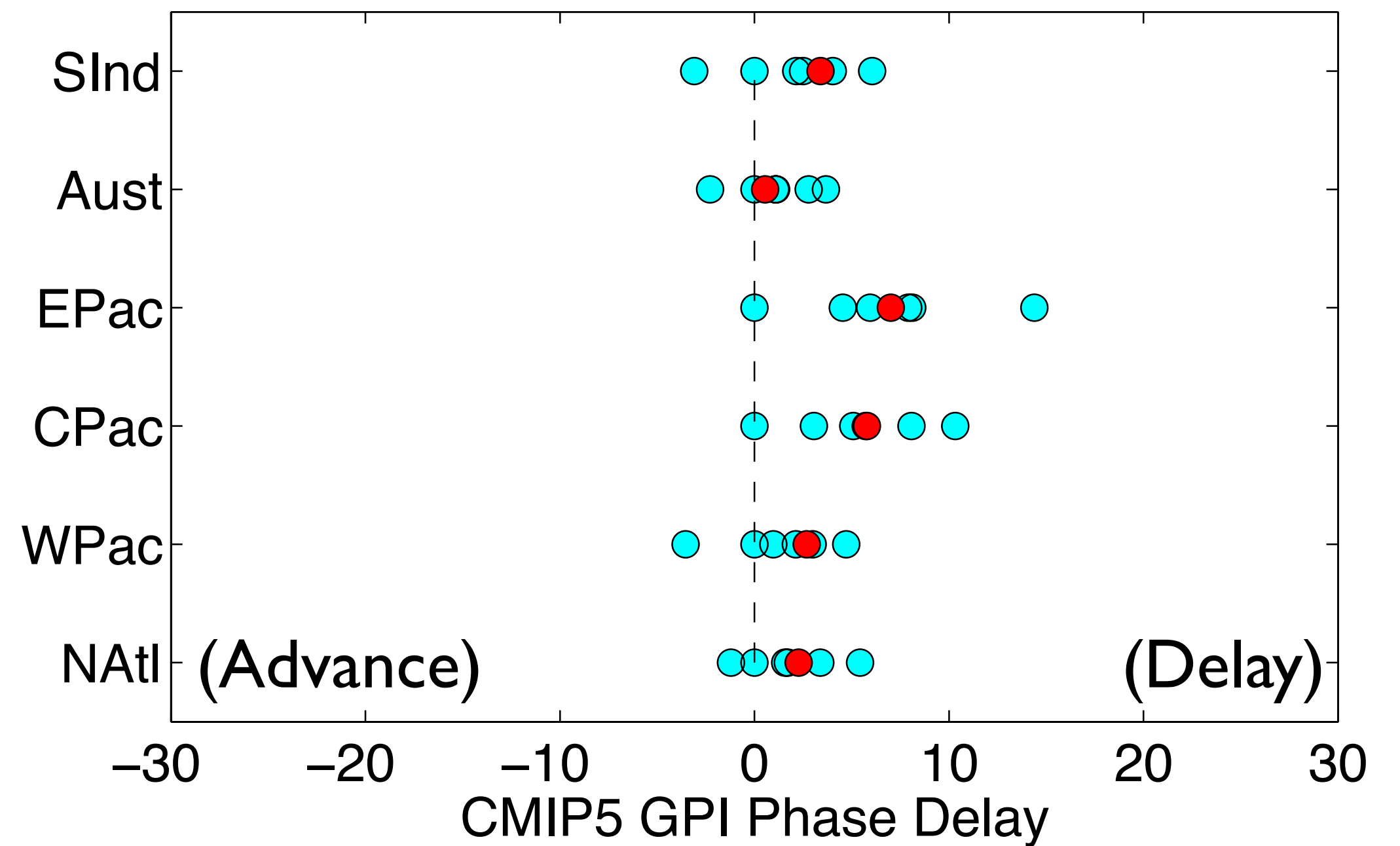
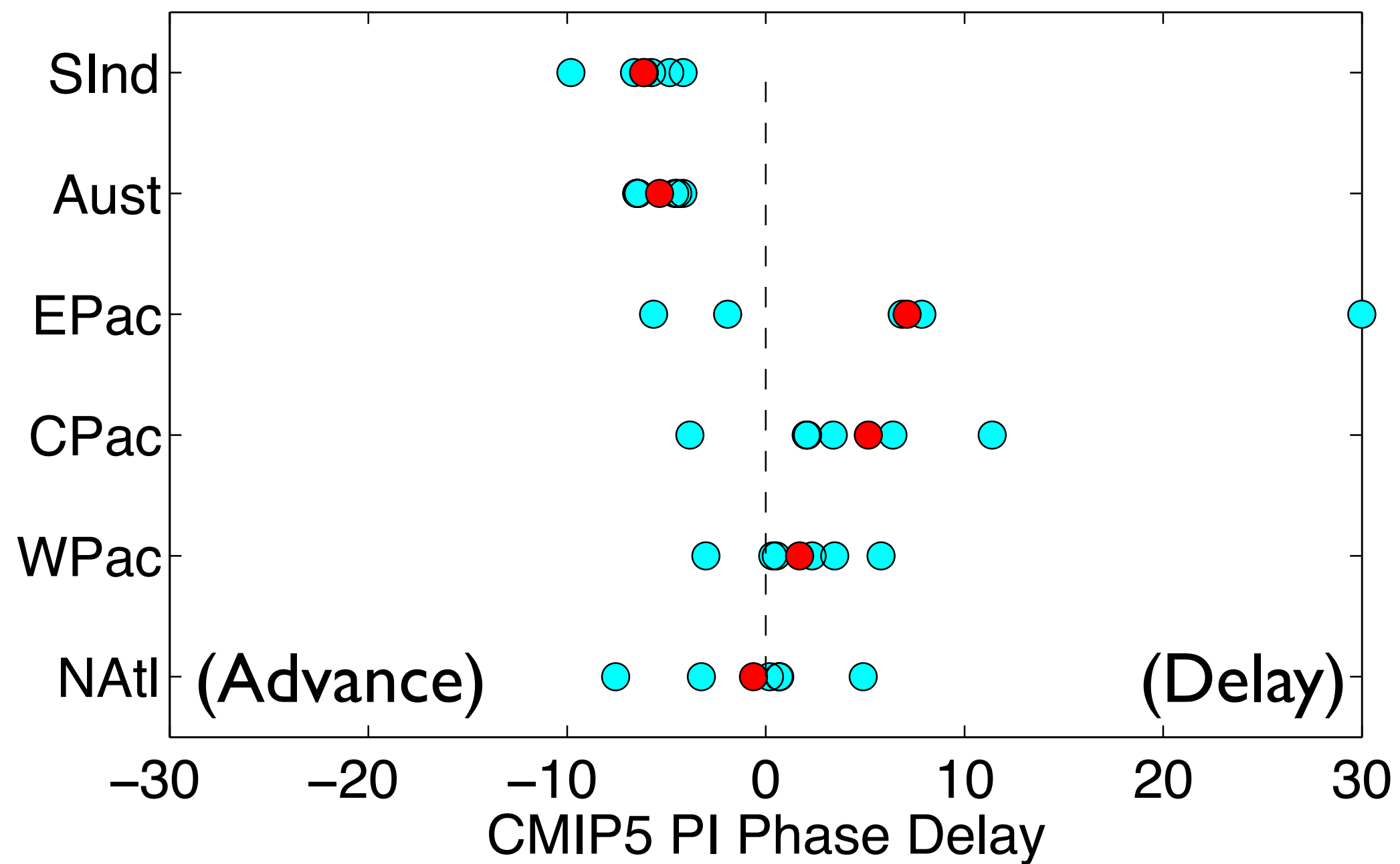


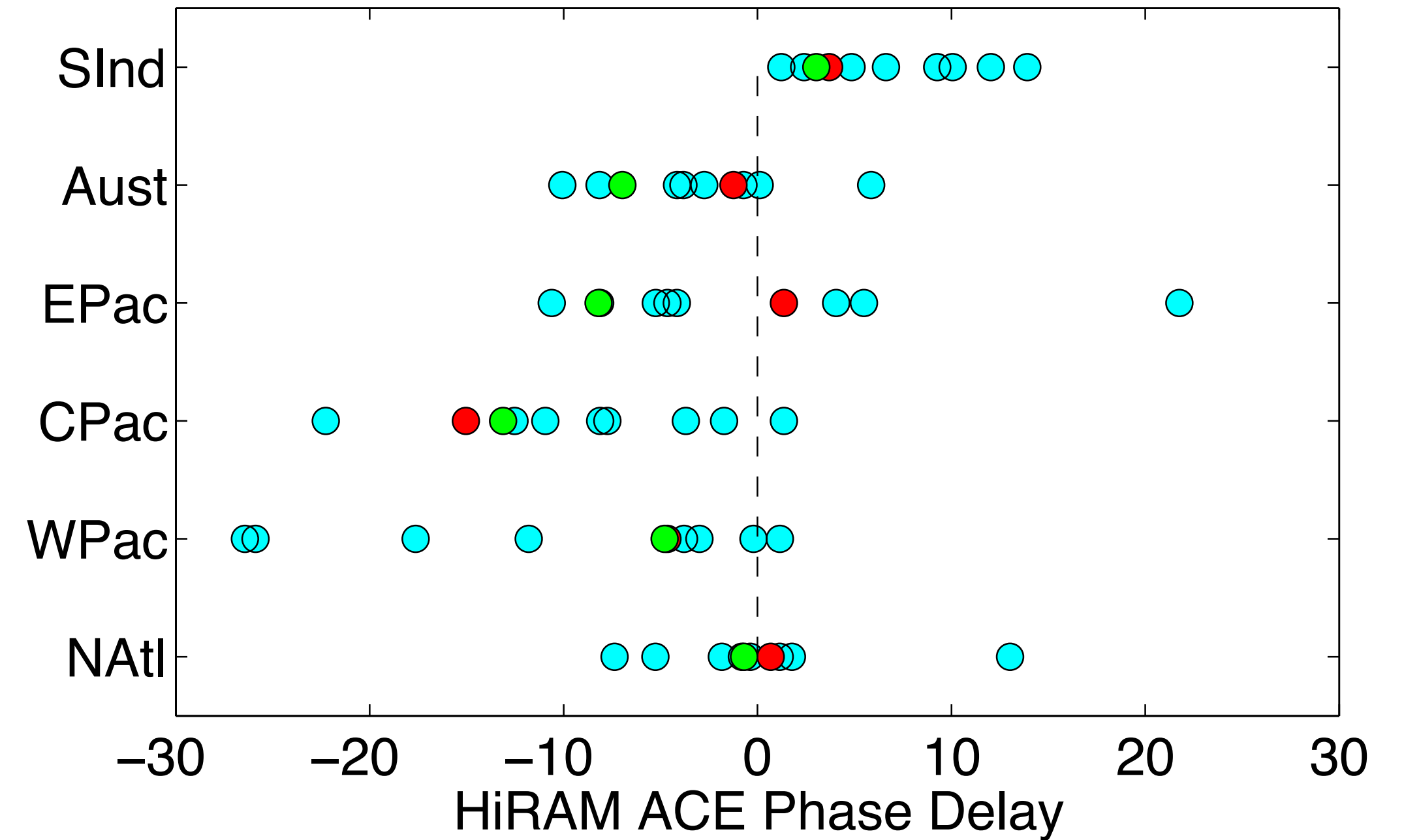
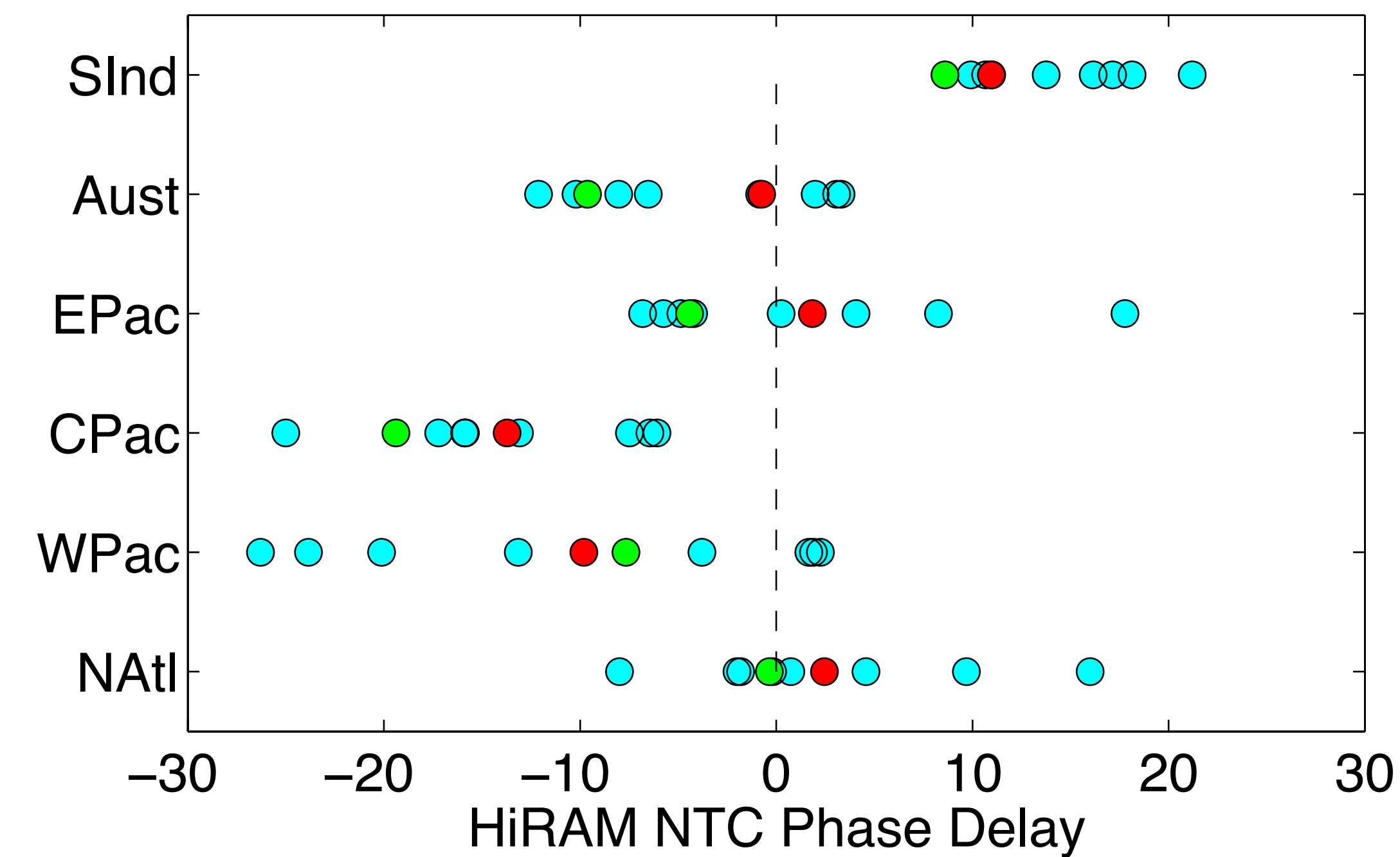
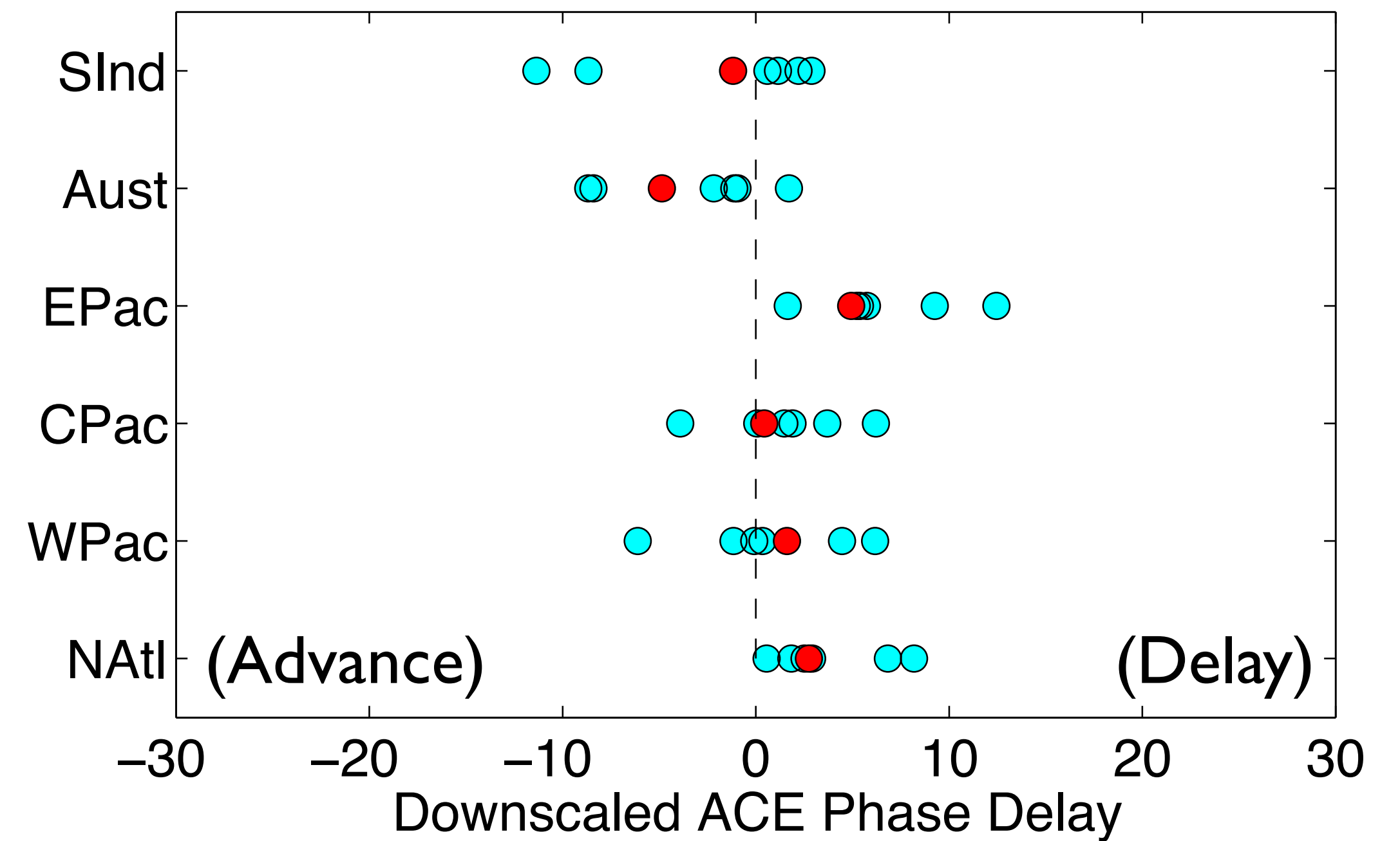
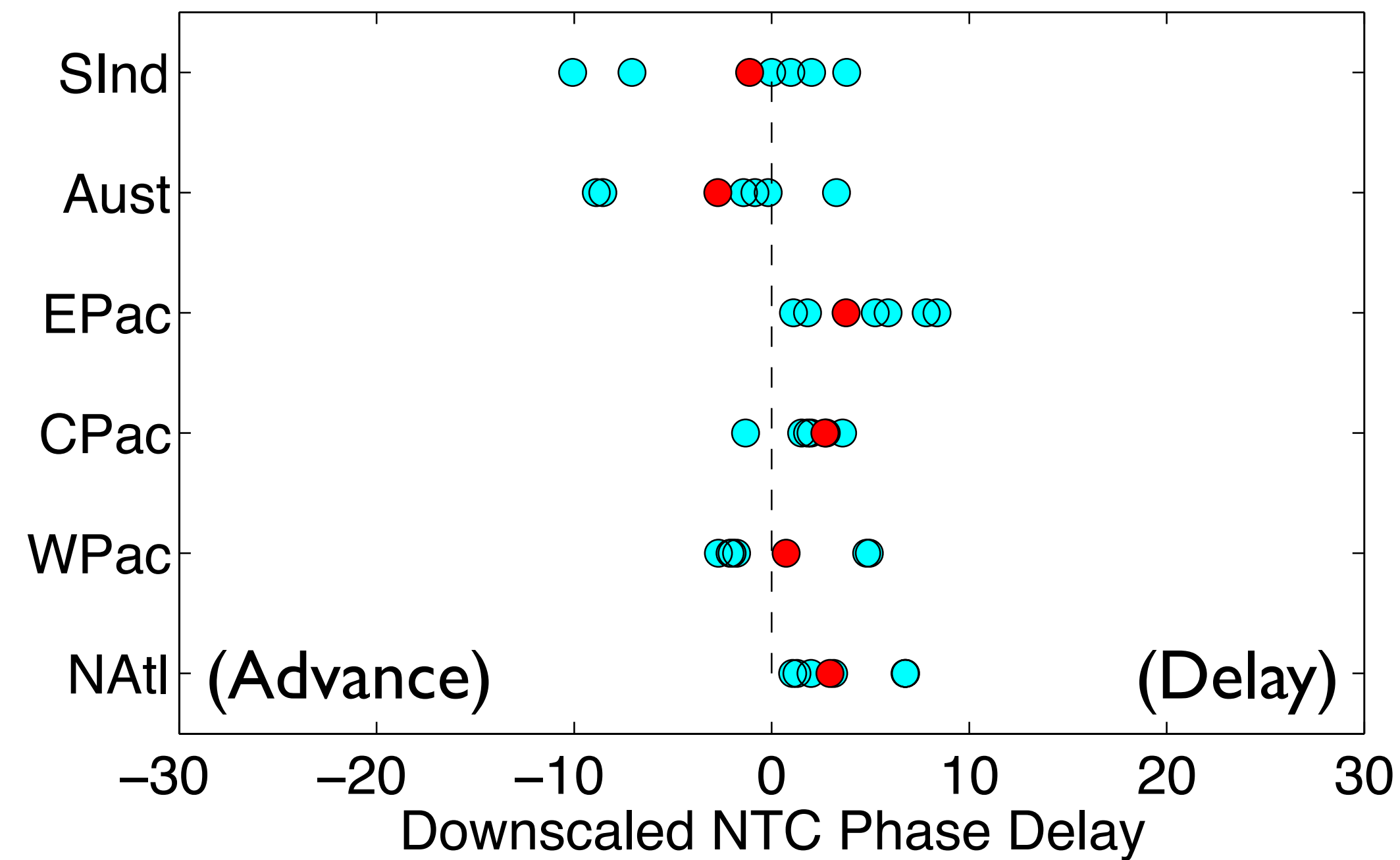
HiRAM NTC Aust PV=90%



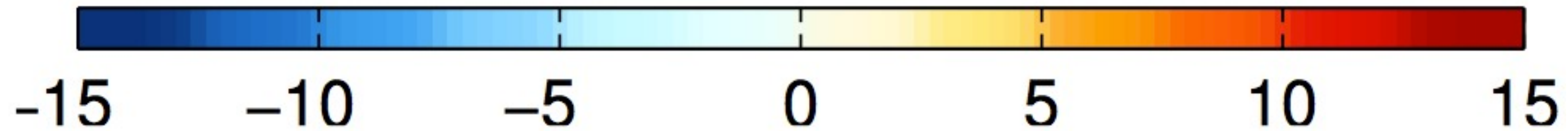
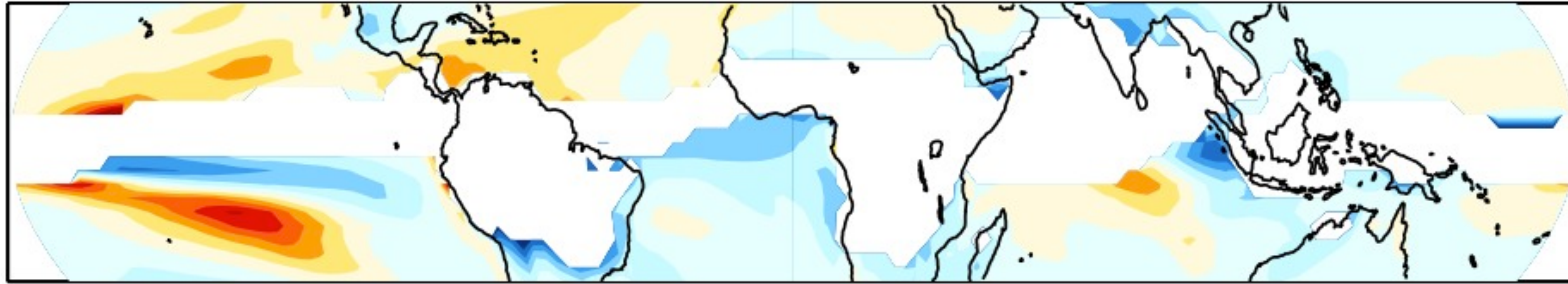
ACE



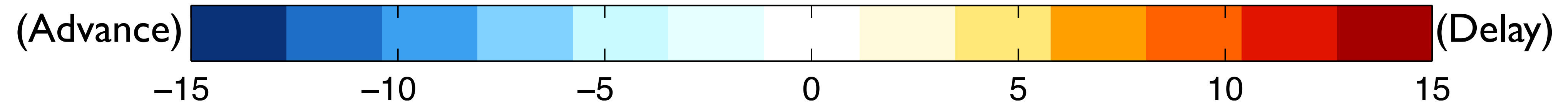
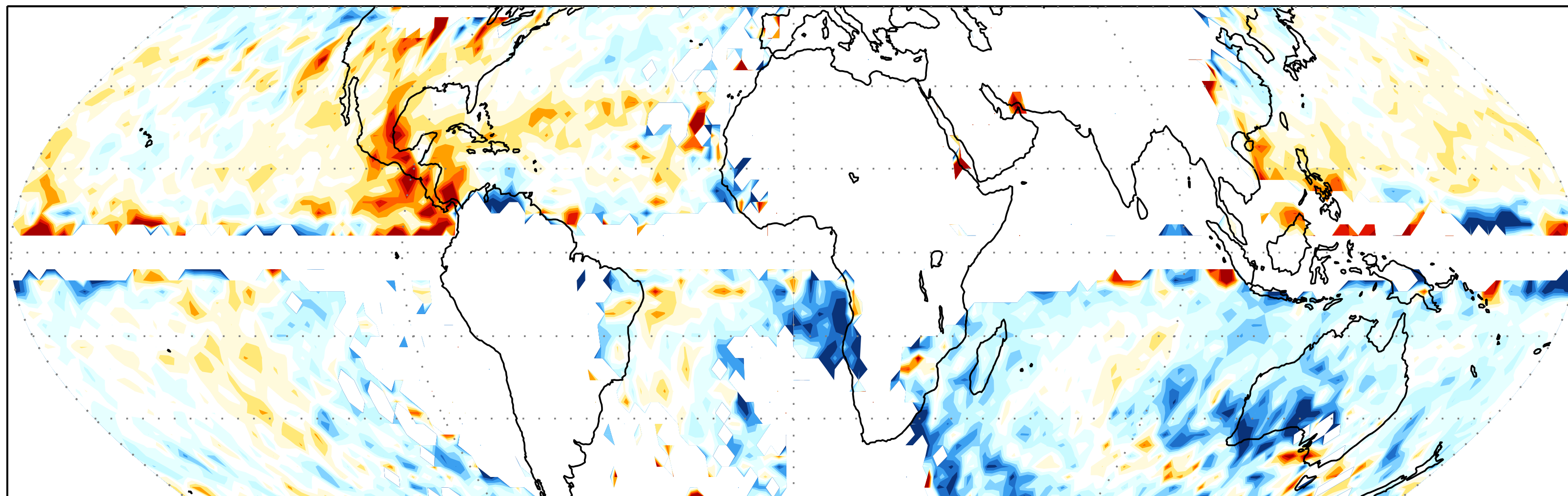




CMIP5 Phase Delay of Surface Temperature [days]



Downscaled Track Density MMM Δ Phase [days]



Conclusions

- Both the CMIP5 and the HiRAM simulations show a delay to the timing of PI & GPI in most NH basins and an advance in the SH basins in 21st century simulations
- Downscaled tracks (Emanuel et al., 2008) show a phase delay in NH basins and a phase advance in SH basins
- Results from HiRAM show evidence of an advance in most basins, but more data is needed to characterize
- There's some evidence of spatial correlation between SST phase changes and downscaled track density phase changes