Summary of Recent Research

Youkyoung Jang

- Global Drought in future climate
- US drought with Pacific SST
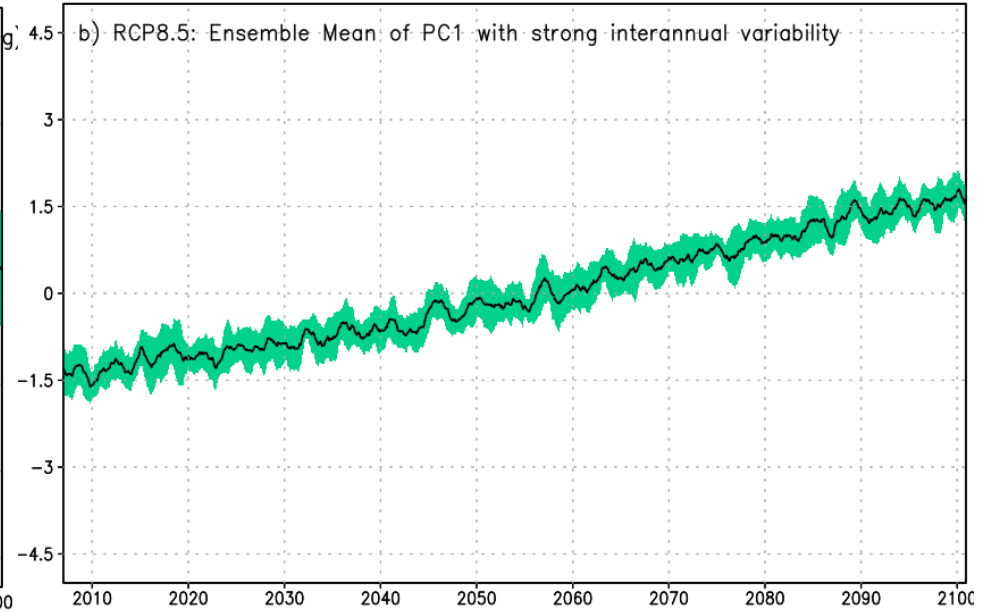- Diabatic heating bias correction in CESM
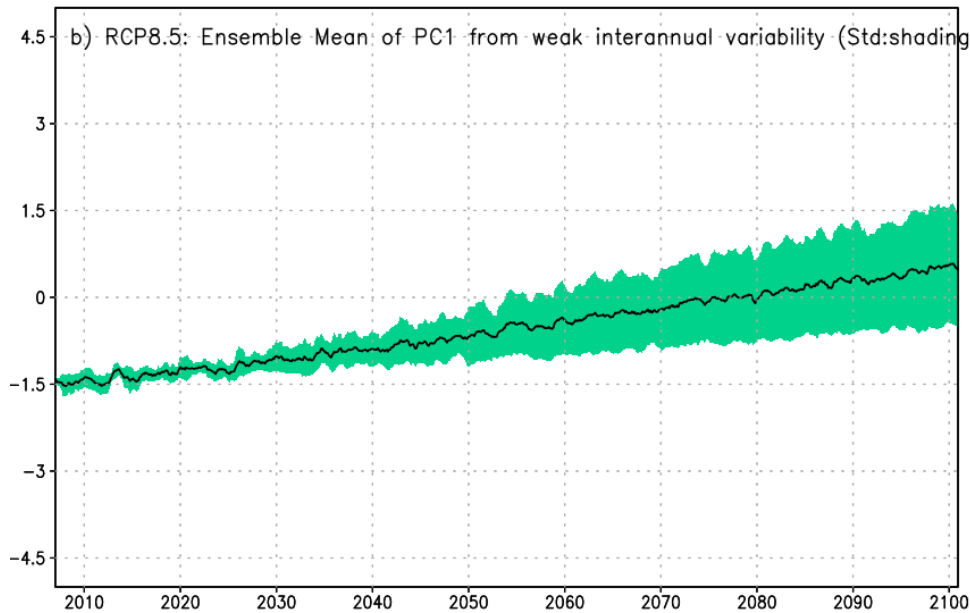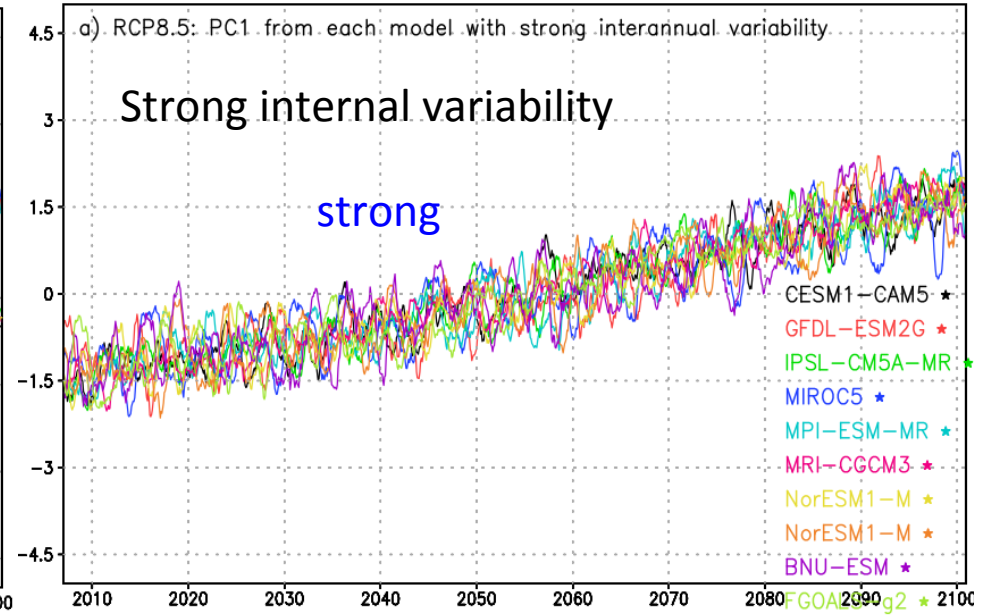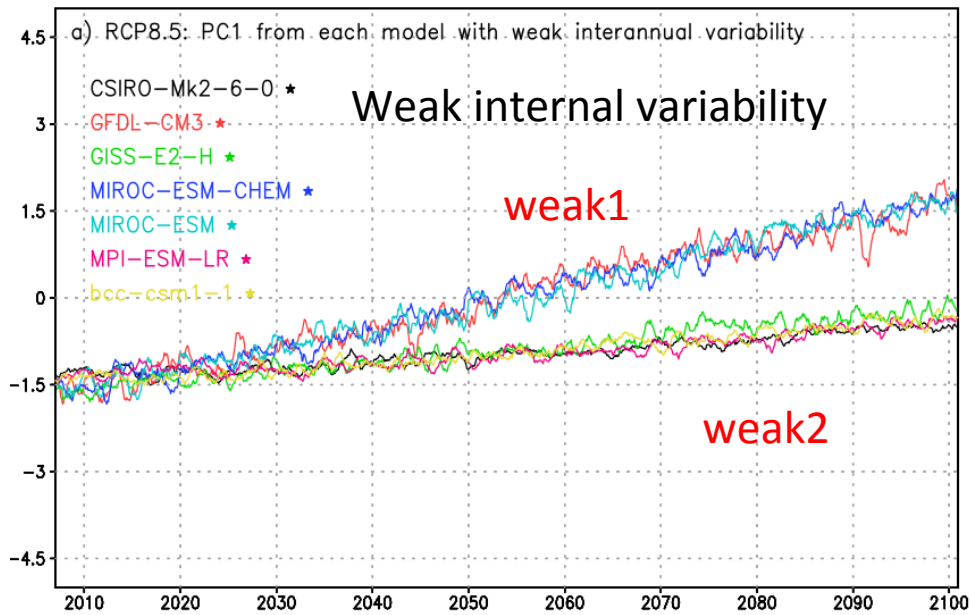
Global Droughts in Future Climate

- Increased droughts since 1950 and its risk in 21st century (Dai 2011, Ault et al. 2014, Diffenbaugh and Giorgi 2012)

- Internal variability (Fischer et al. 2013, Tebaldi et al. 2011): difficult to determine changes in extremes strength, lack of model agreement

- Dai 2012: Increasing drought under global warming in observations and models
  - Maximum covariance analysis with Palmer drought severity index (PDSI) 1923 ~ 2010, ~2100 (RCP4.5)
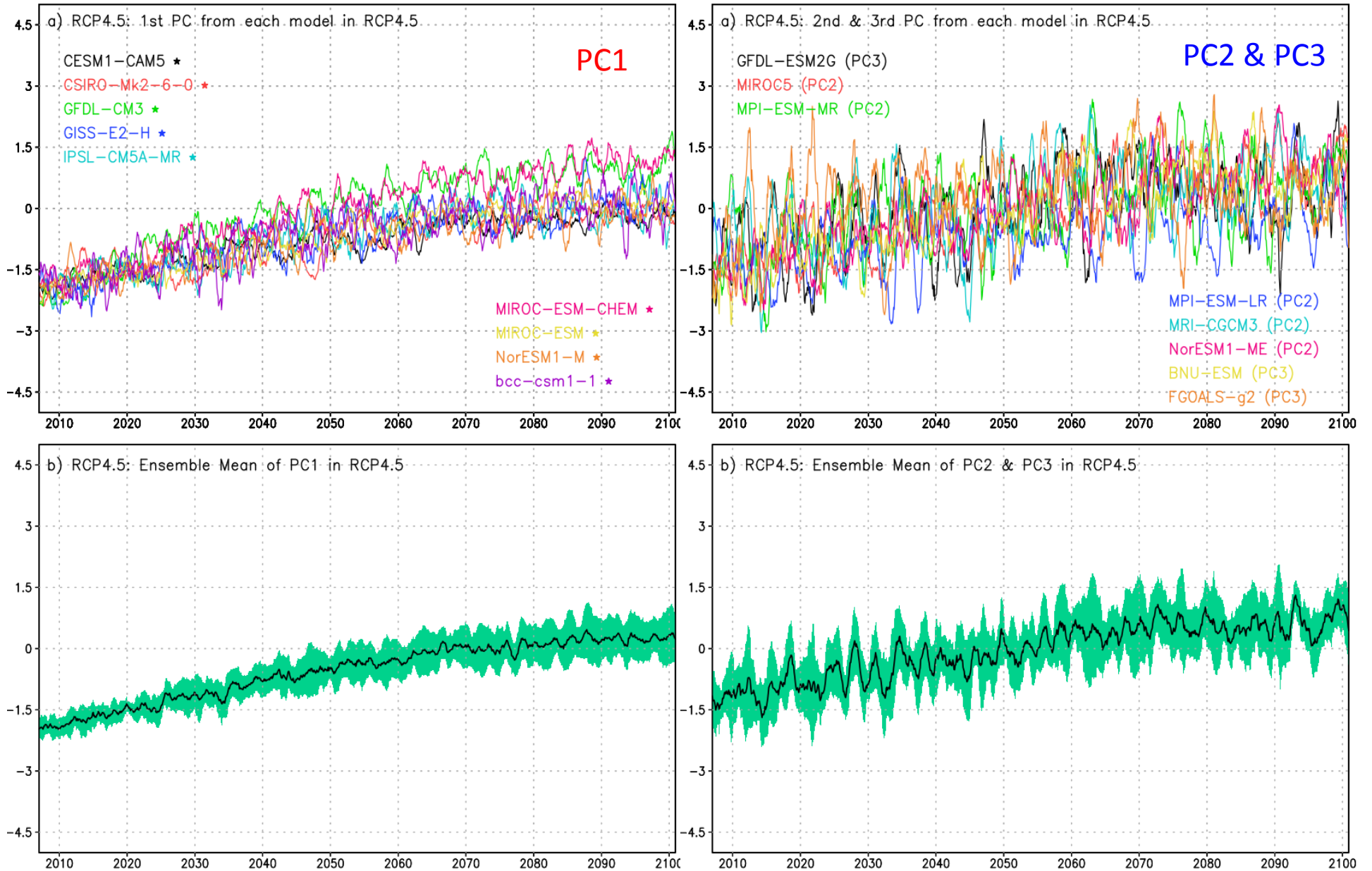 - ENSO influenced drought & global aridity trend

Global Droughts in Future Climate

- As CO2 emissions increase, do droughts also increase?

- If CO2 emissions are not controlled, do we have more droughts?

- My Research
  – Standardized Precipitation Index (SPI12) long-term droughts
  – RCP8.5, RCP4.5, and RCP2.6 from CMIP5
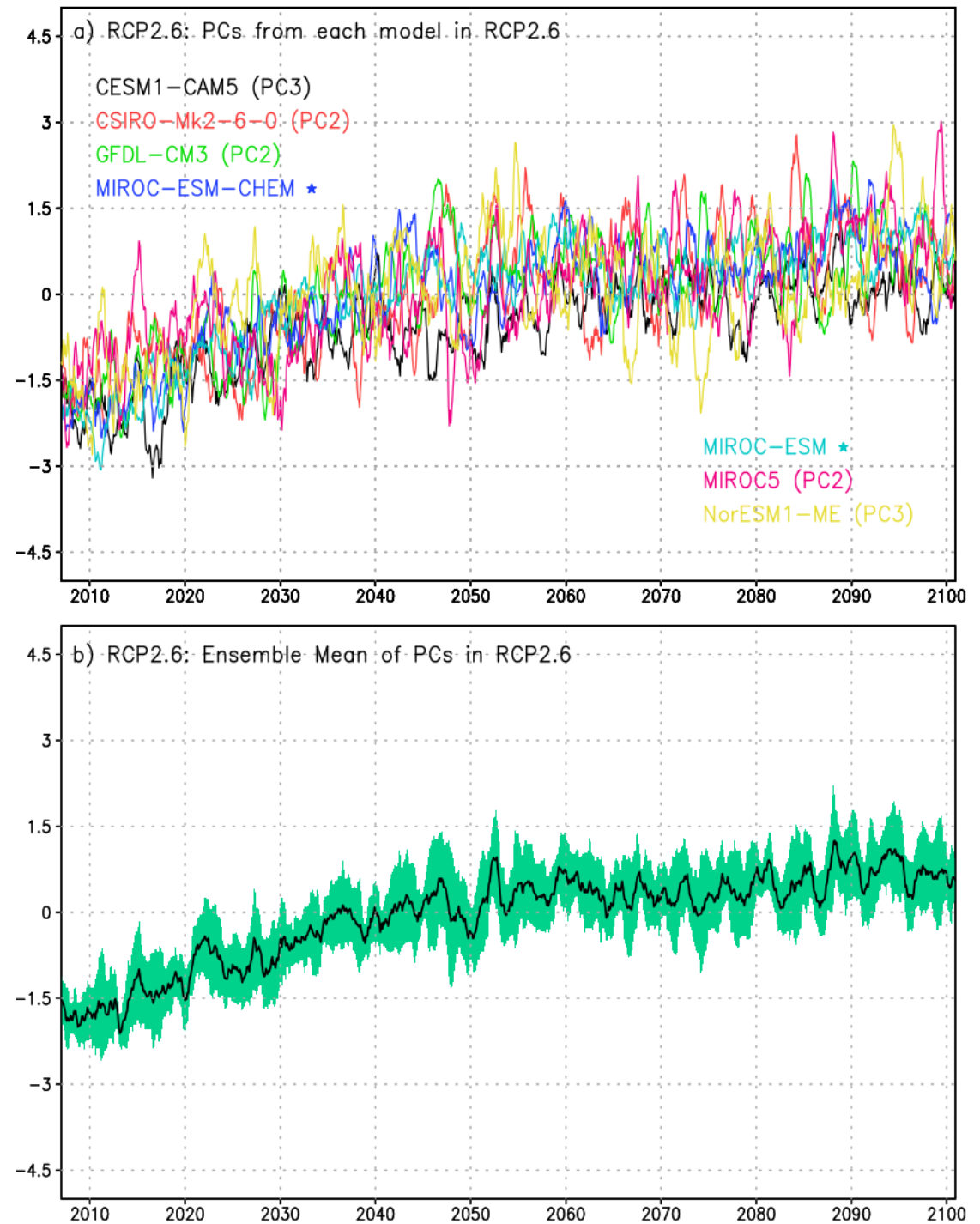 – Rotational Empirical Orthogonal Function (REOF)
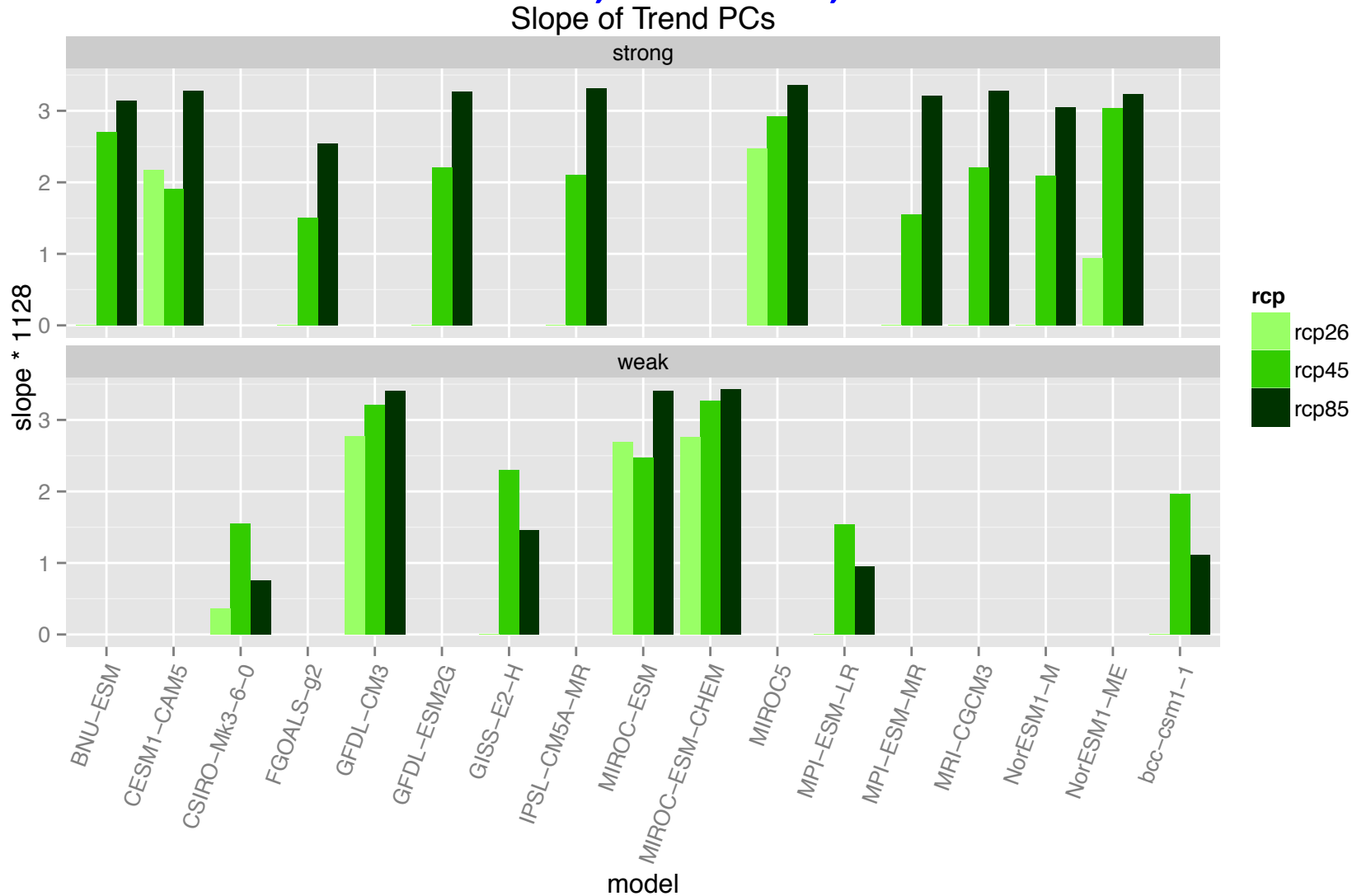
RCP8.5: Trend PC (PC1) - 17 models

a) RCP8.5: PC1 from each model with weak interannual variability

Weak internal variability

CSIRO-Mk2-6-0 ⋆
GFDL-CM3 ⋆
GISS-E2-H ⋆
MIROC-ESM-CHEM ⋆
MIROC-ESM ⋆
MPI-ESM-LR ⋆
bcc-csm1-1 ⋆

weak1

weak2

a) RCP8.5: PC1 from each model with strong interannual variability

Strong internal variability

strong

CESM1-CAM5 ⋆
GFDL-ESM2G ⋆
IPSL-CM5A-MR ⋆
MIROC5 ⋆
MPI-ESM-MR ⋆
MRI-CGCM3 ⋆
NorESM1-M ⋆
NorESM1-M ⋆
BNU-ESM ⋆
FGOALS-g2 ⋆

b) RCP8.5: Ensemble Mean of PC1 from weak interannual variability (Std:shading)

b) RCP8.5: Ensemble Mean of PC1 with strong interannual variability

RCP4.5: Trend PC (PC1, PC2, PC3)- 17 models

RCP2.6: Trend PC (PC1, PC2, PC3) : 7 models

a) RCP2.6: PCs from each model in RCP2.6

CESM1-CAM5 (PC3)
CSIRO-Mk2-6-0 (PC2)
GFDL-CM3 (PC2)
MIROC-ESM-CHEM ★

MIROC-ESM ★
MIROC5 (PC2)
NorESM1-ME :(PC3)

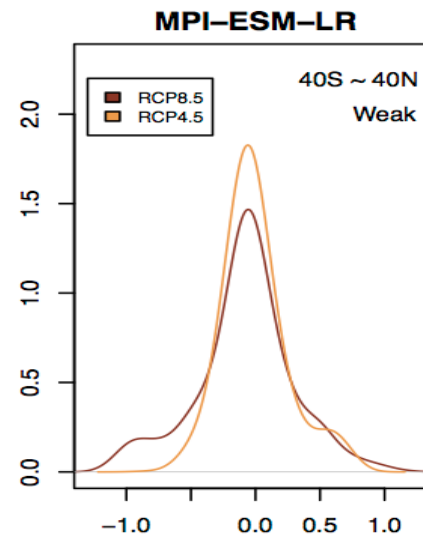b) RCP2.6: Ensemble Mean of PCs in RCP2.6

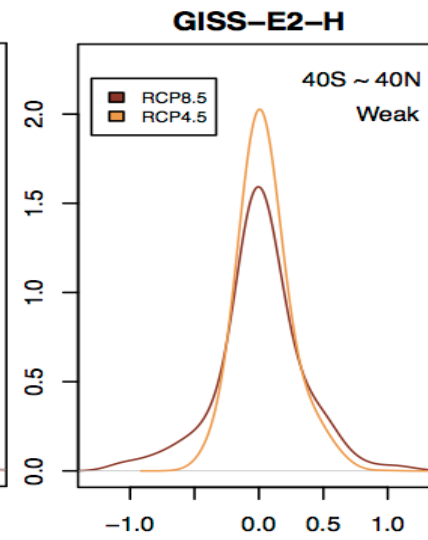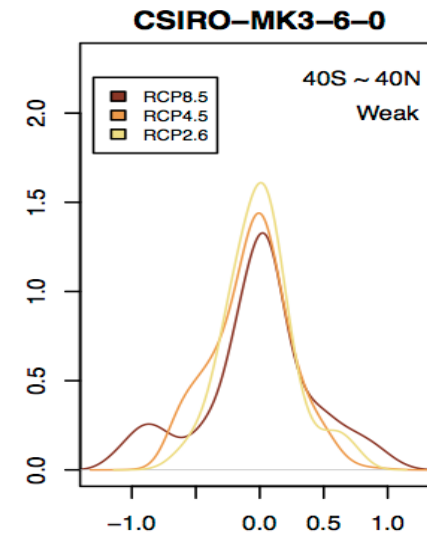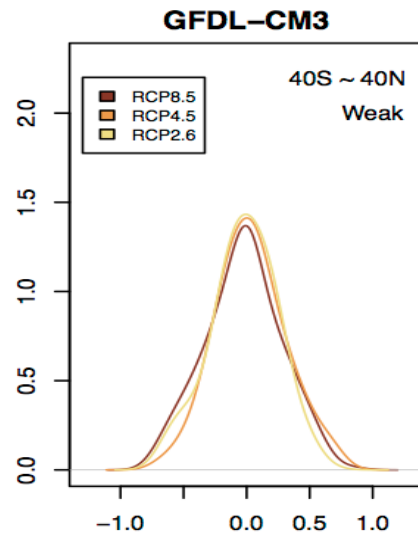Slopes of Trend PCs
in RCP8.5, RCP4.5, RCP2.6

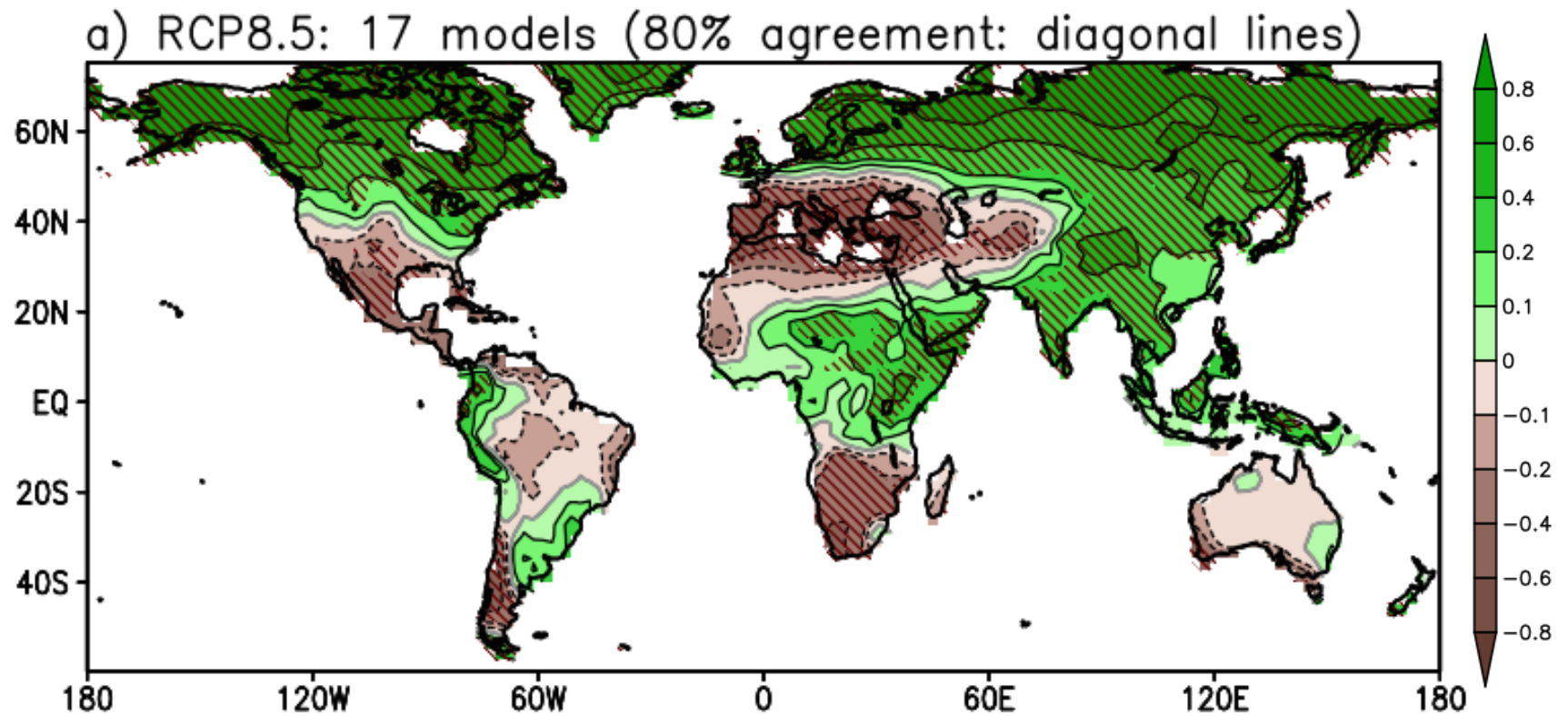# Is there spatial increase in droughts (PDF)?

"Slope Increased Model"   vs   "No Slope Increased Models"

Ensemble Mean of SPI12 REOF

a) RCP8.5: 17 models (80% agreement: diagonal lines)
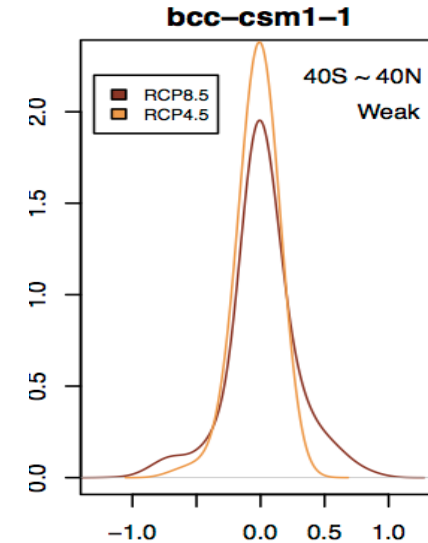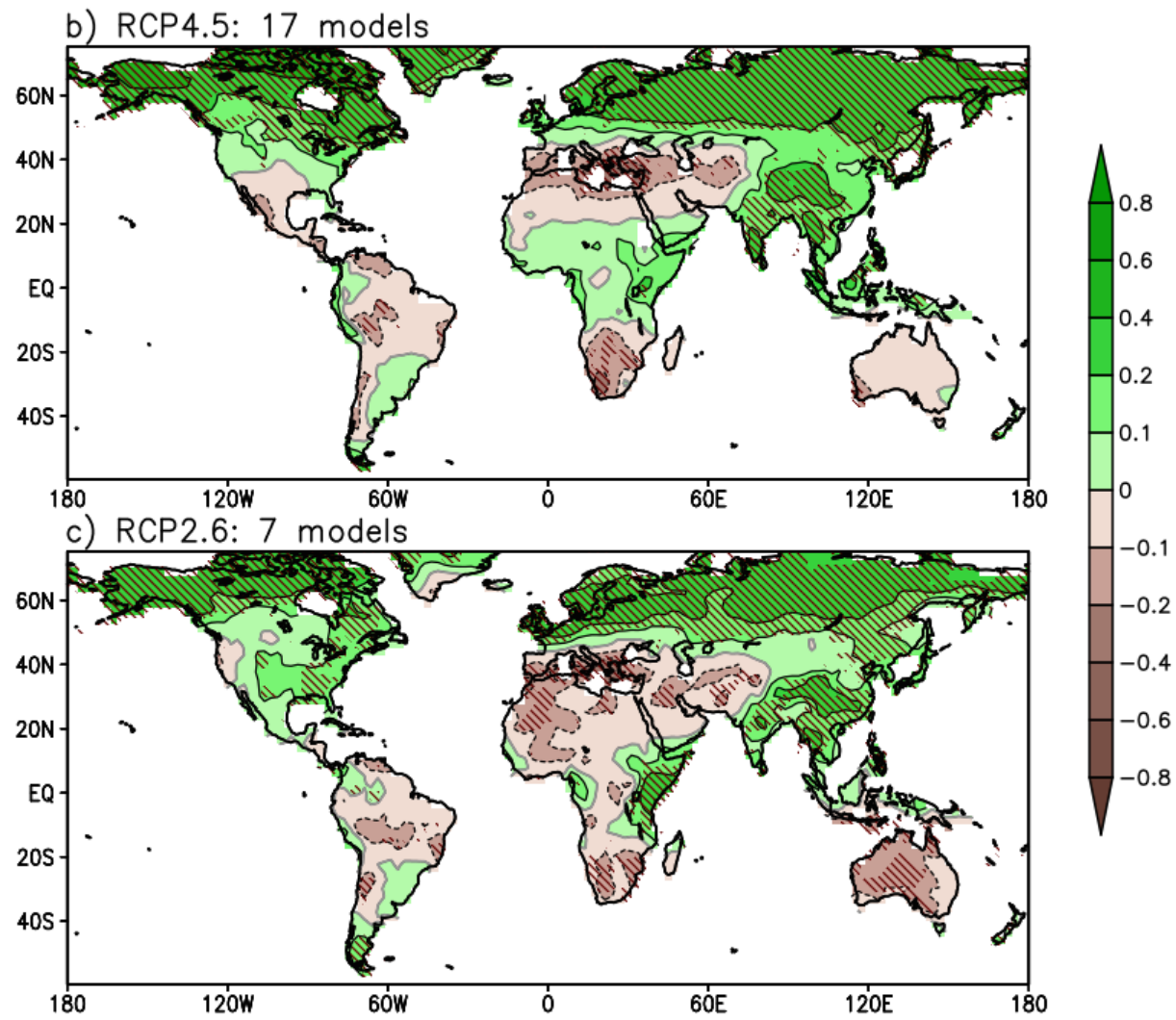
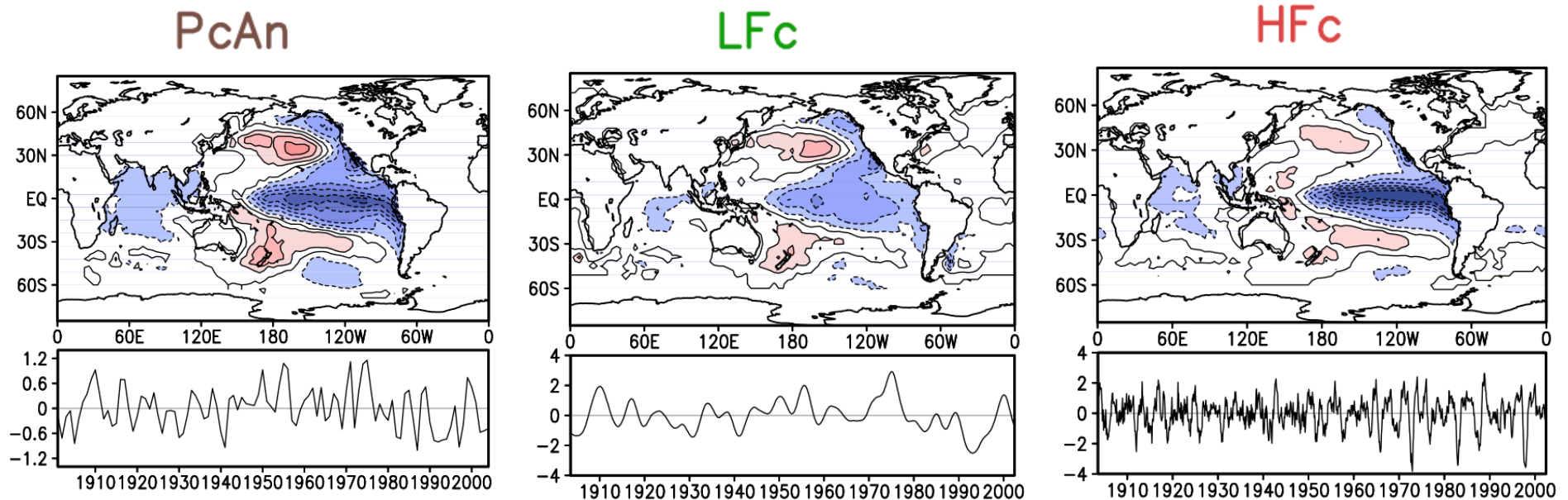# Ensemble Mean of SPI12 REOF

Summary

- As CO2 emissions increase, do droughts increase?

- SPI12 from precipitation in CMIP5 RCP8.5, 4.5, 2.6
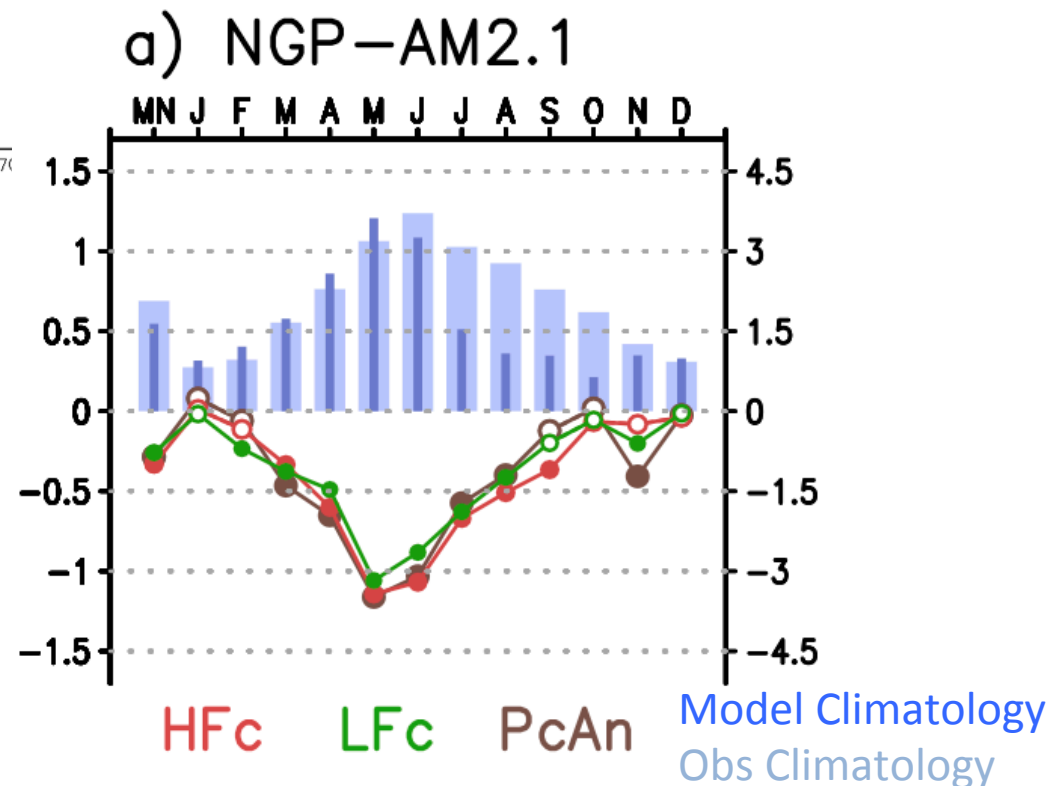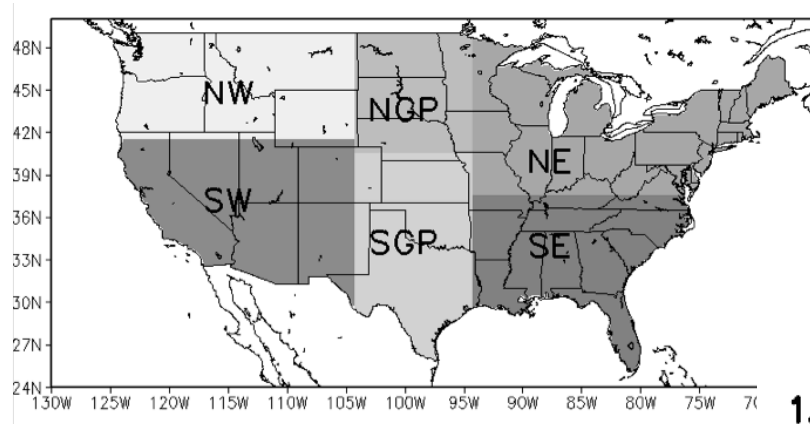- PCs and REOF of SPI12

Yes, increase in strength (PC slopes) and spatial extent
(PDF of REOF)

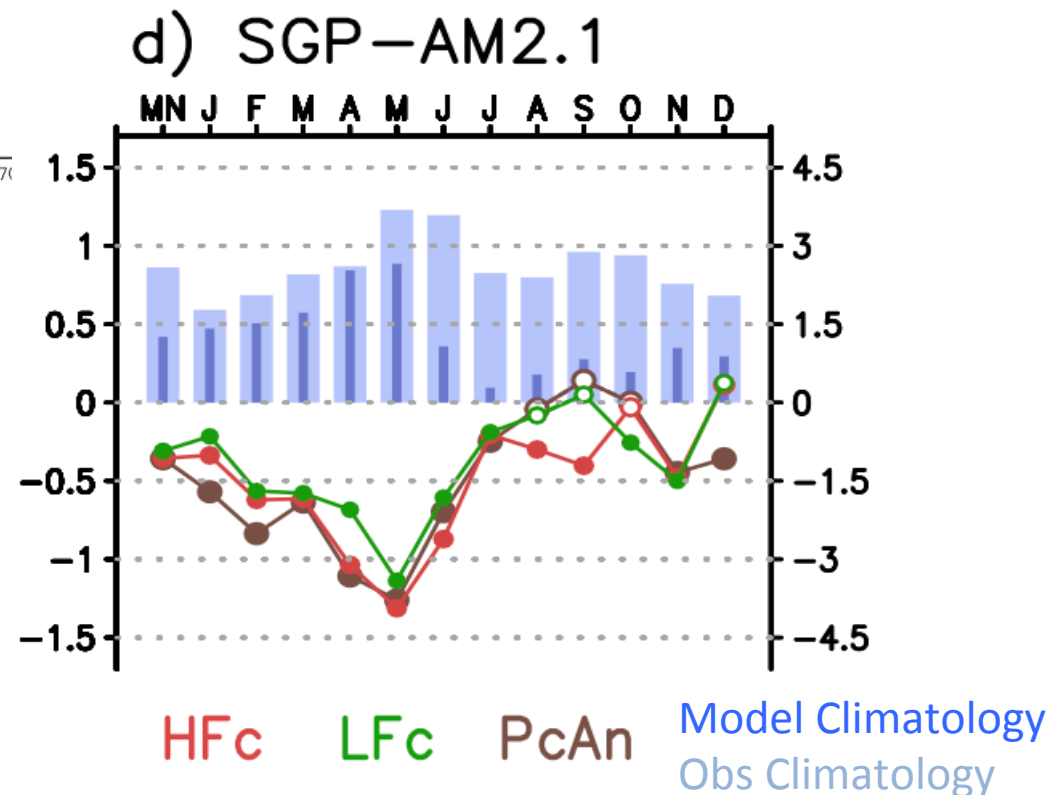# Simulated U.S. Drought response to Interannual and decadal Pacific SST variability (Burgman and Jang 2015)
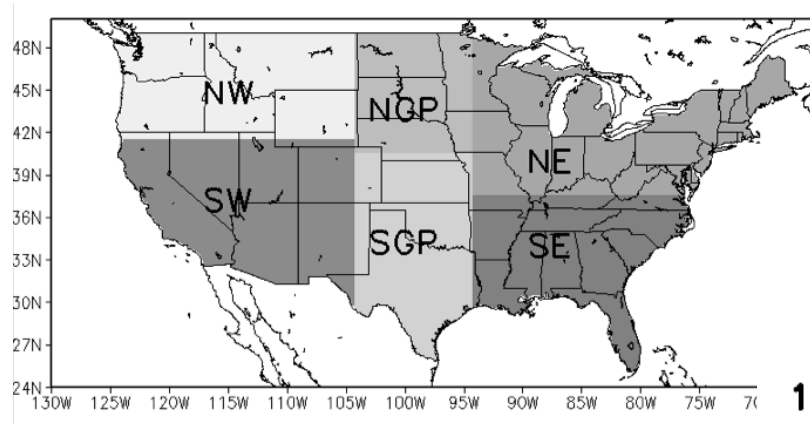
- CLIVAR Drought Working group
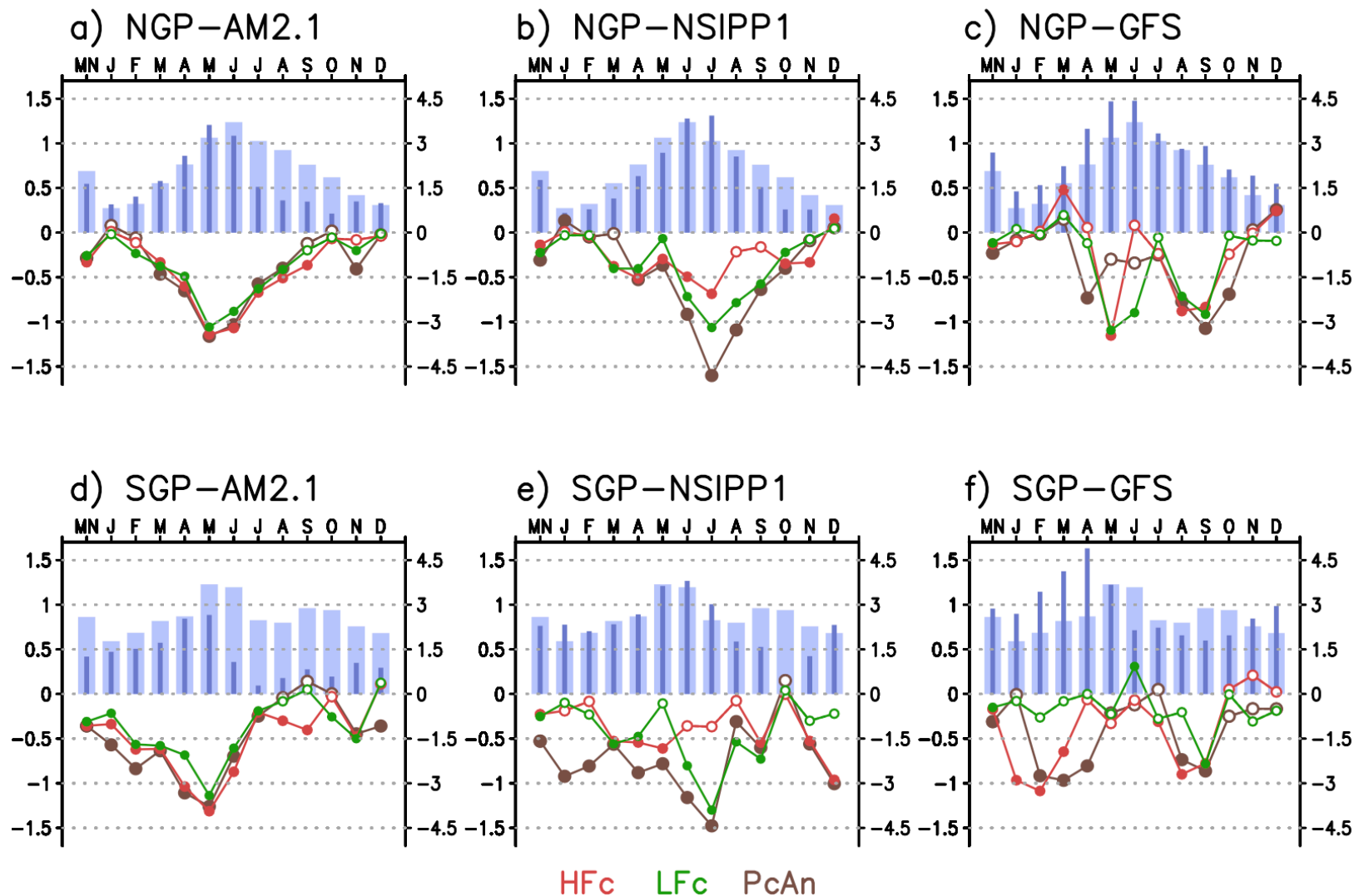- Idealized SST experiments (AM2.1, NSIPP1, GFS)

Mean/Monthly Precipitation
over Southern/Northern Great Plains

Mean/Monthly Precipitation
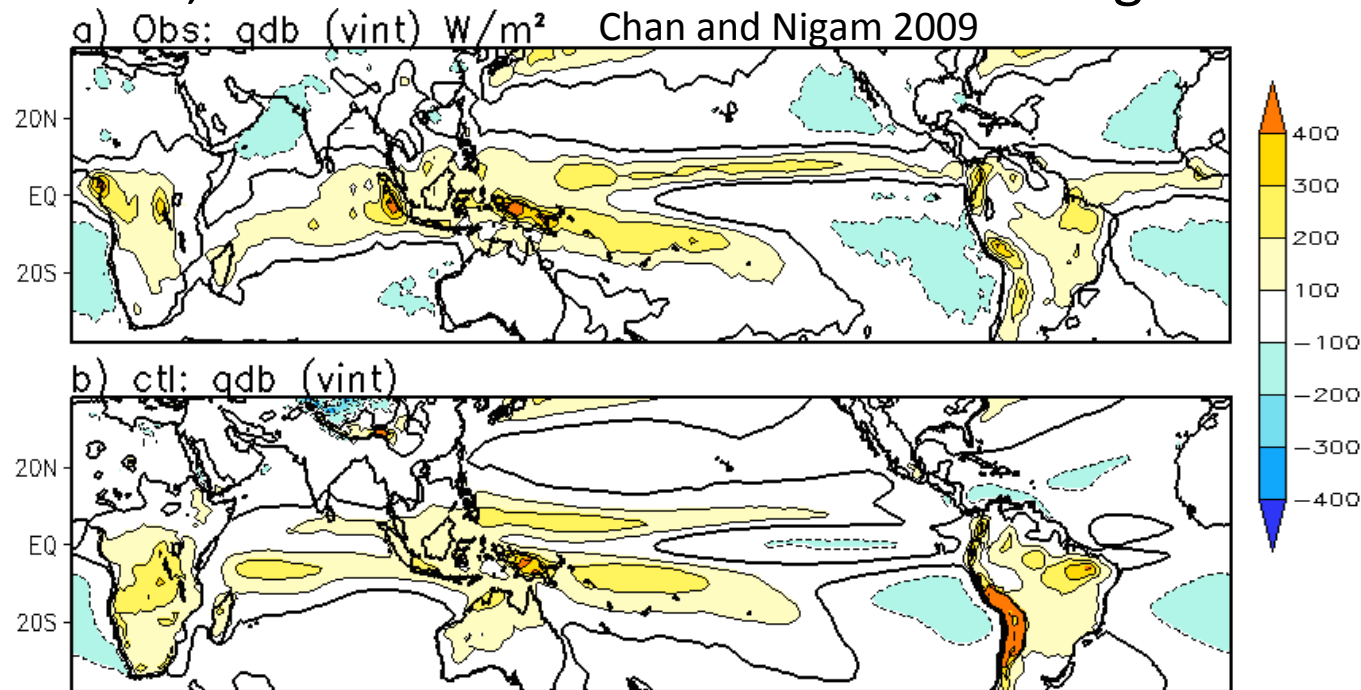# over Southern/Northern Great Plains

Mean/Monthly Precipitation over Southern/Northern Great Plains

a) NGP−AM2.1   b) NGP−NSIPP1   c) NGP−GFS

d) SGP−AM2.1   e) SGP−NSIPP1   f) SGP−GFS

HFc   LFc   PcAn

Empirical Correction To Tropical Heating:
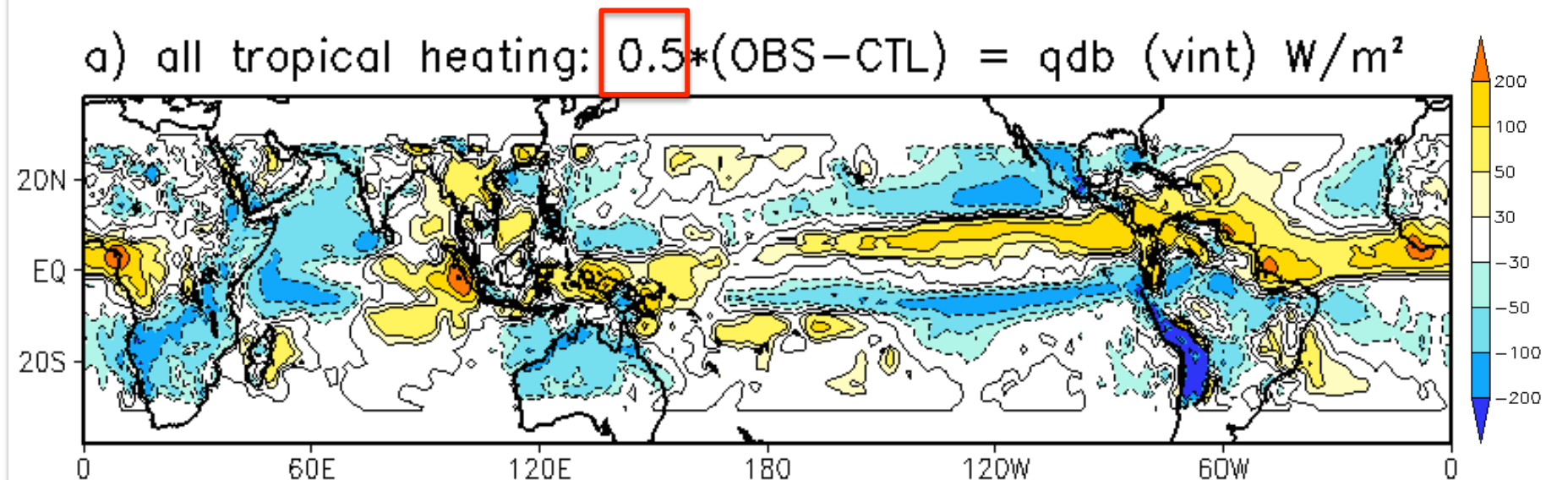## Can We Correct Mid-Latitude Model Biases? (Straus and Jang)

- The bias correction term is added to temperature tendency terms in CESM.

- The model moist and radiative parameterizations are still fully operative, thus can react to the added heating.

a) Obs: qdb (vint) W/m²   Chan and Nigam 2009
b) ctl: qdb (vint)

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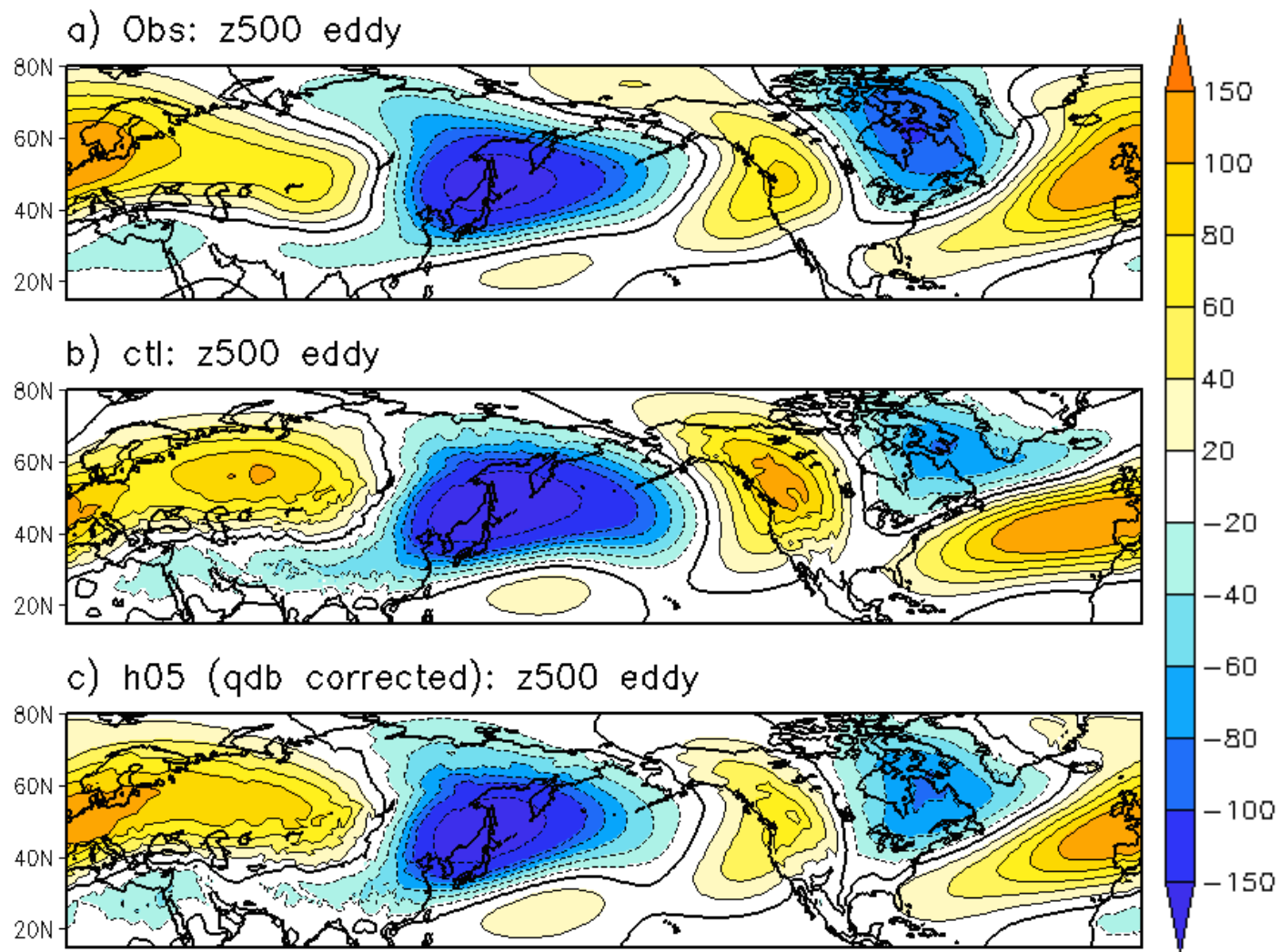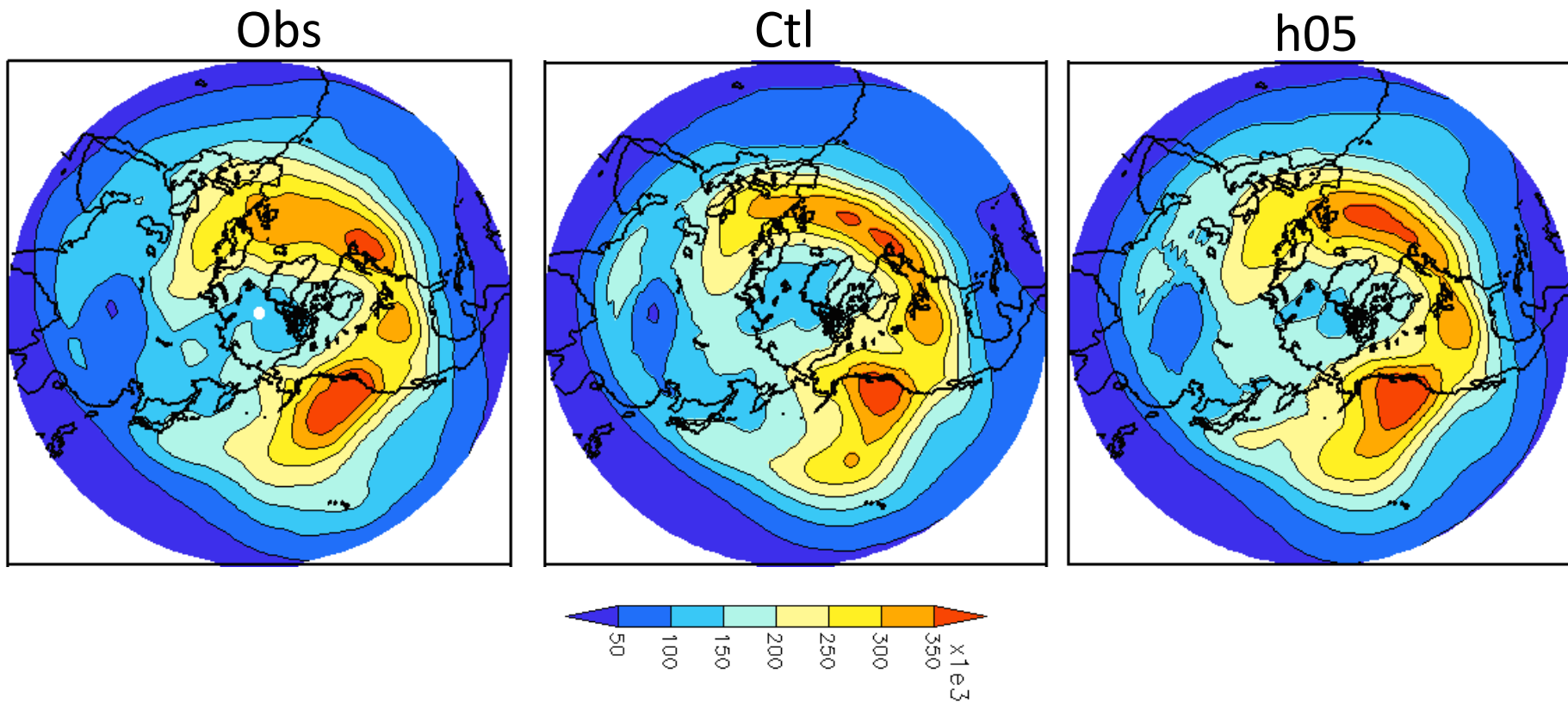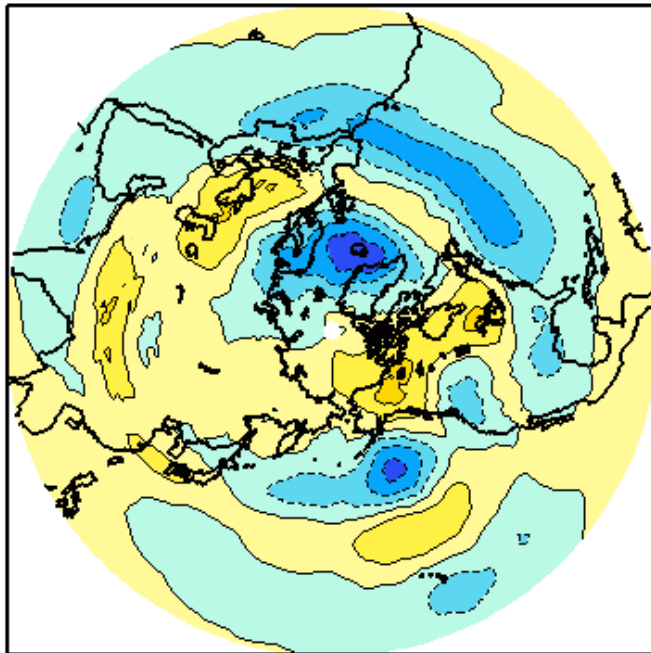

a) all tropical heating: 0.5*(OBS−CTL) = qdb (vint) W/m²

500 hPa Geopotential Height Eddy (Oct-Mar)

Sub-Monthly Transients 300 hPa meridional velocity

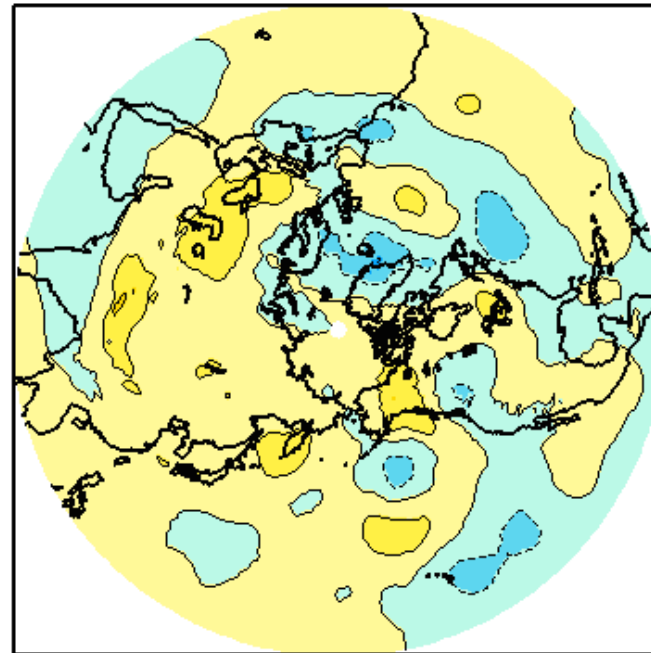- <v'v'> : <v> = time mean (DJFM) of v, v' = v - <v>

Obs   Ctl   h05

Biases in Transients

a)DJFM vv300: CTL — OBS

b)DJFM vv300: 0.5HTG — OBS

Summary

- Diabatic heating bias correction in CESM improves mid-latitude large atmospheric circulation.

- US drought with Pacific SST: sensitive to SST patterns and model climatological precipitation

- Droughts in future climate intensify or spatially expand with increased CO_2 emissions.