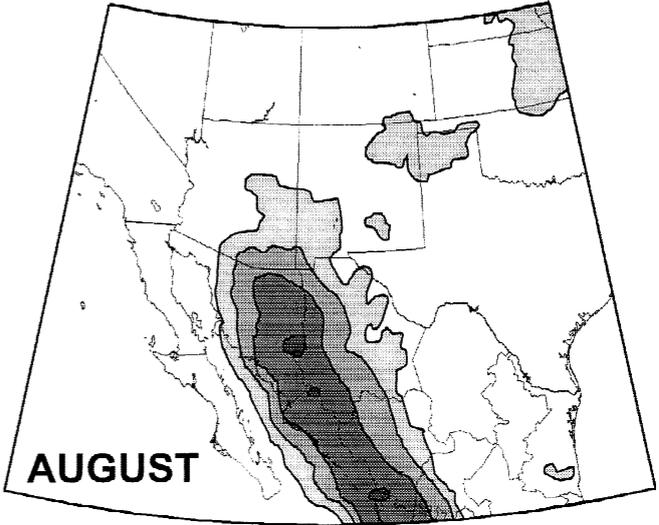
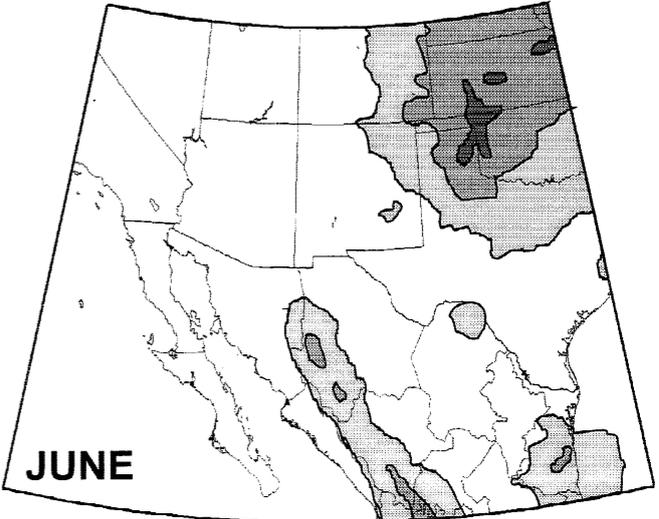
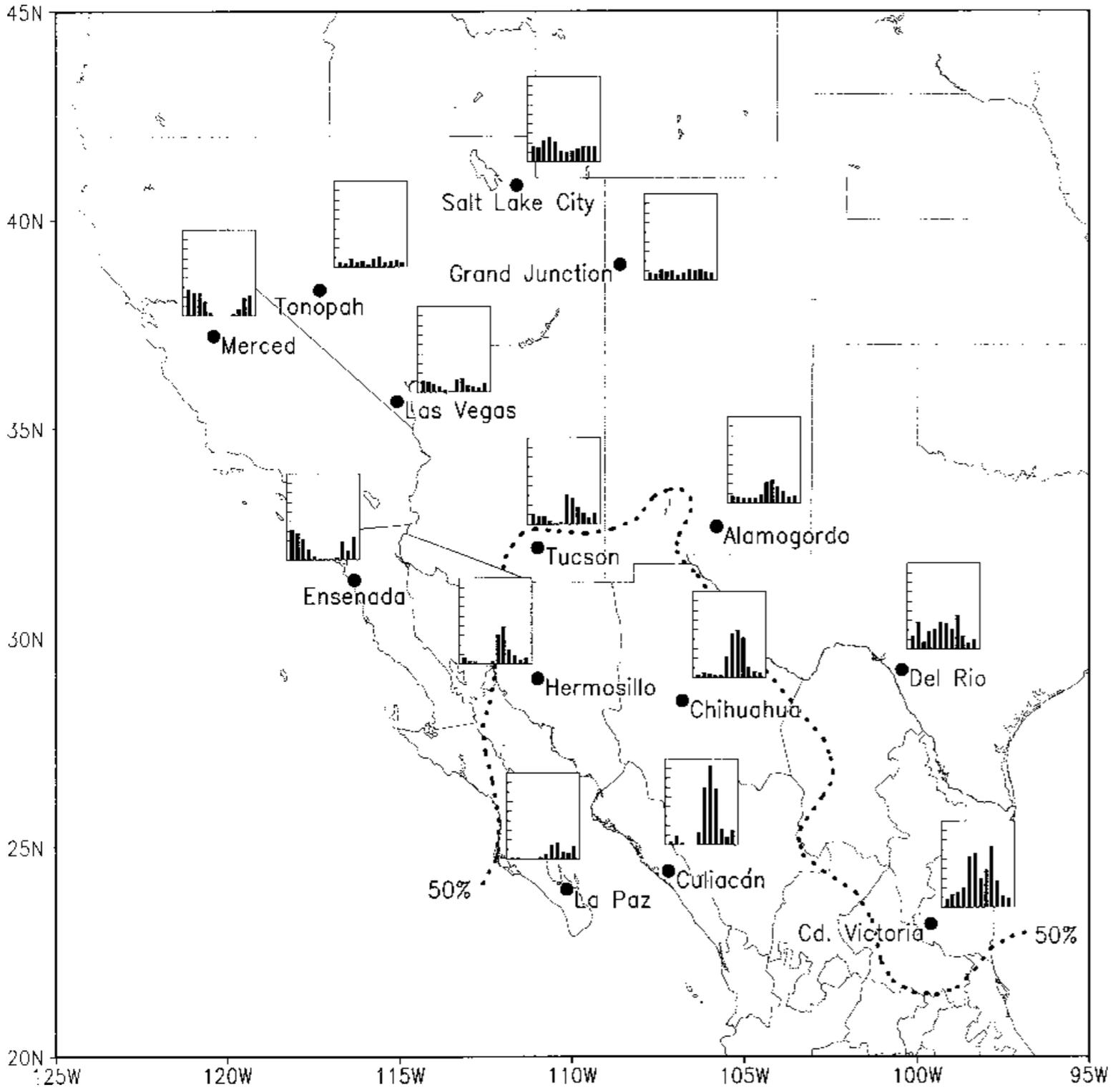


# **The Response of the North American Monsoon to Increased GHG Forcing**



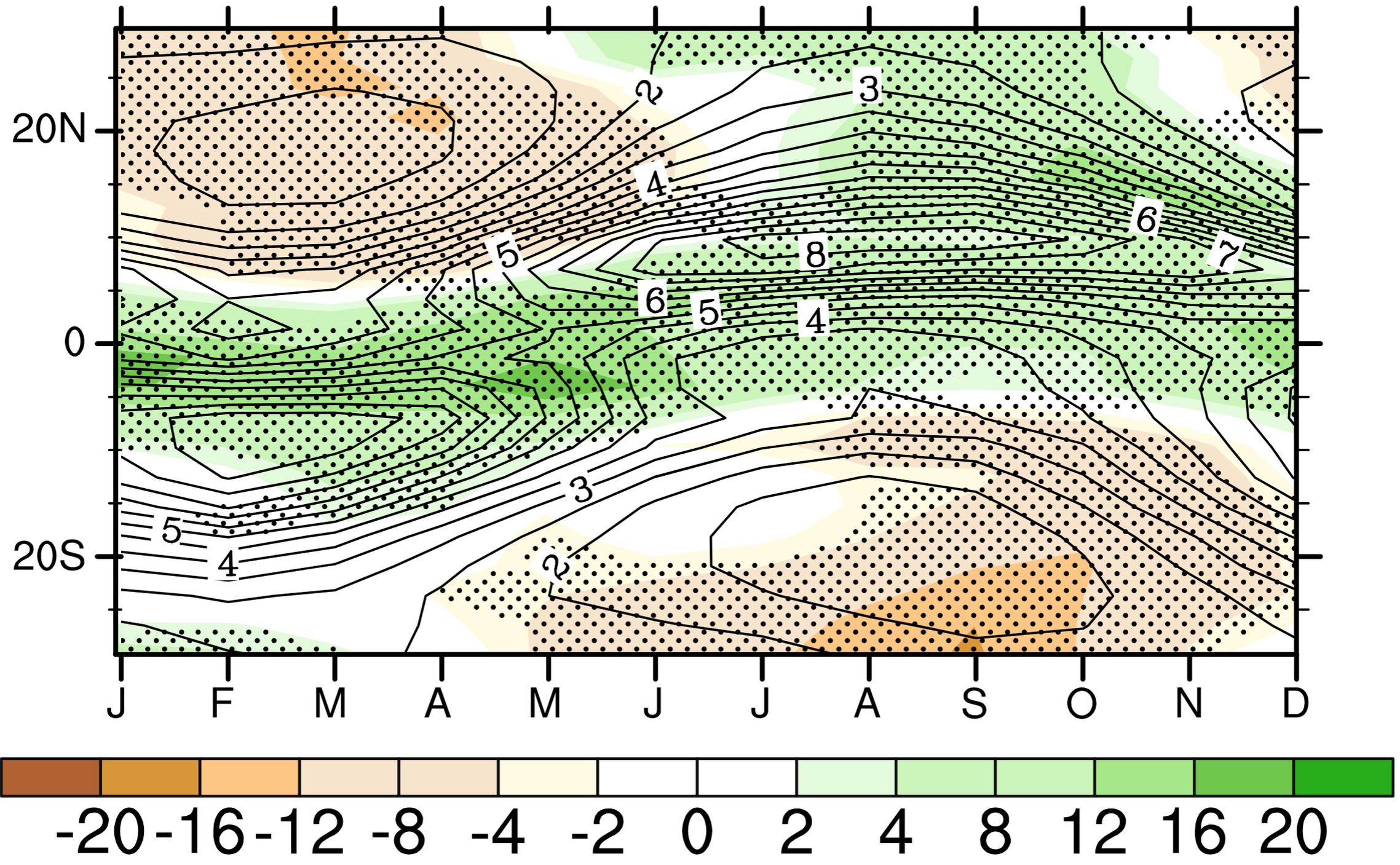
# The North American Monsoon



source: Adams & Comrie, 1997

# Delayed monsoon onset/ withdrawal w/ +GHG

**a** Global

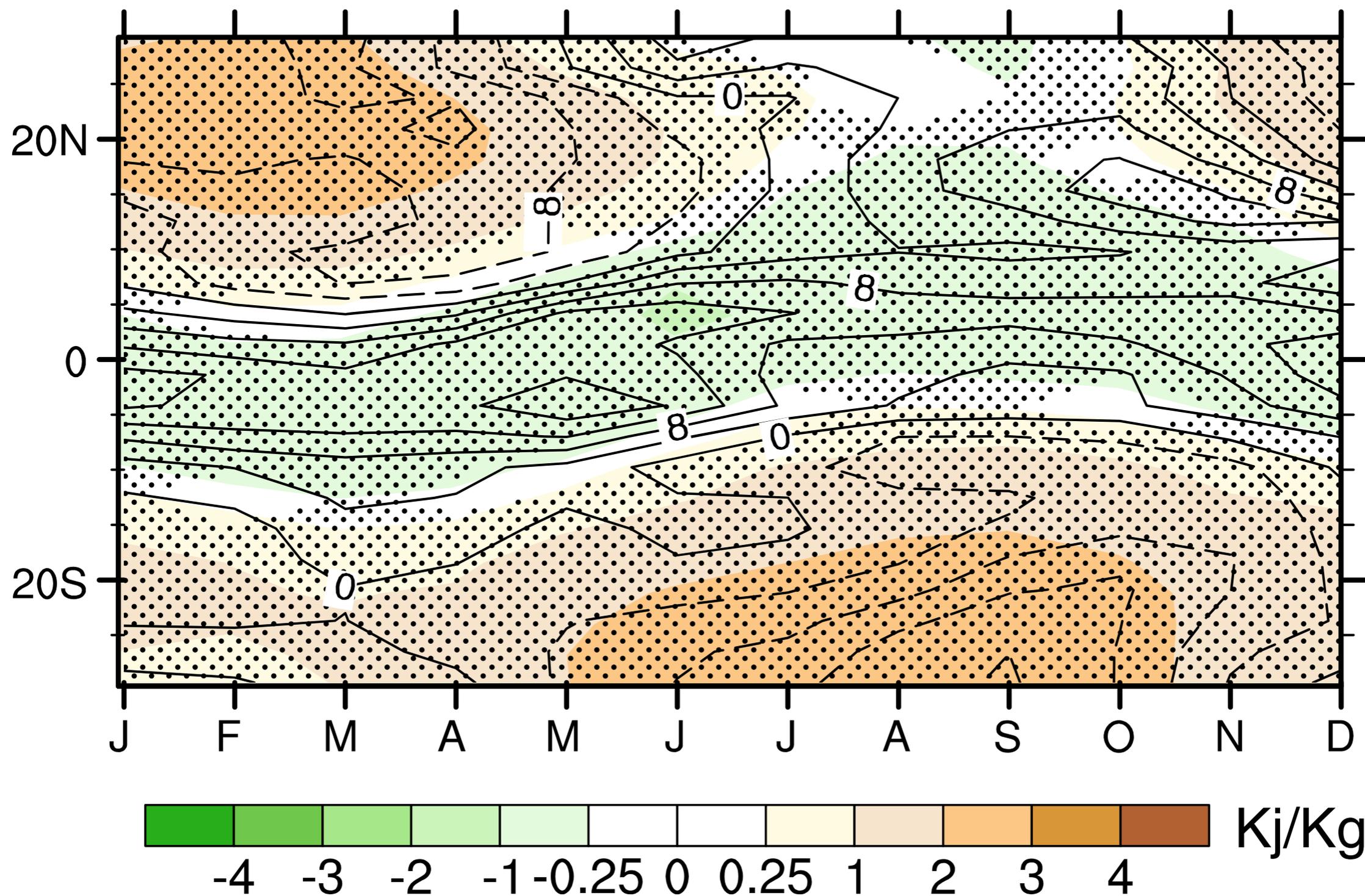


**source: % Prec Change, Seth et al, 2011**

# MSE and Atmospheric Stability

**C** Global

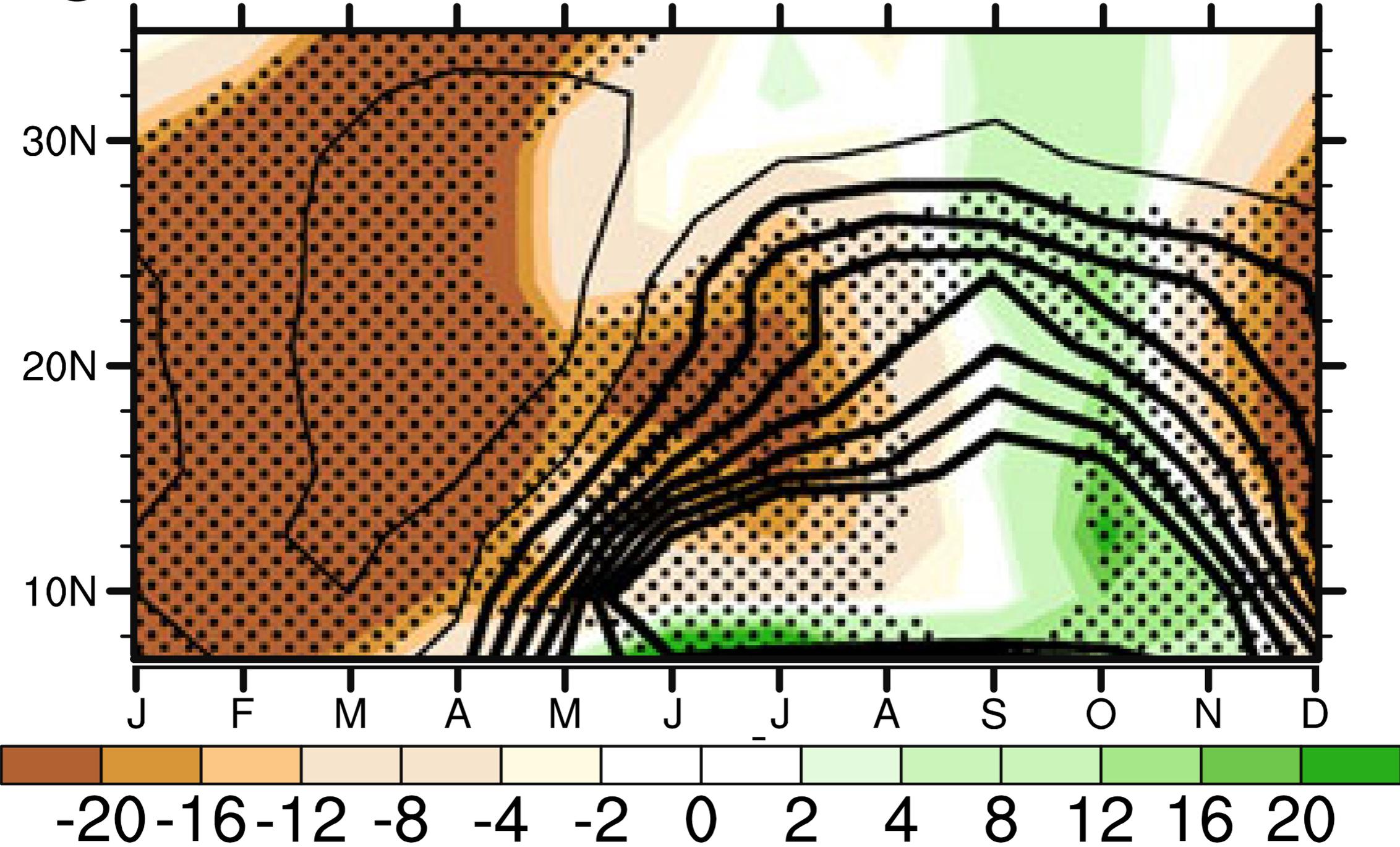
DSE200-MSE850



**source: Seth et al, 2011**

# The North American Monsoon

**C** North America



source: Seth et al, 2011

How well do CMIP5 models simulate the NAM?

How does the NAM respond to +GHG forcing in the CMIP5 experiments (historical vs RCP 8.5)?

Are these shifts consistent with stability changes due to atmospheric warming and changes in surface moisture?

# Moist Static Energy

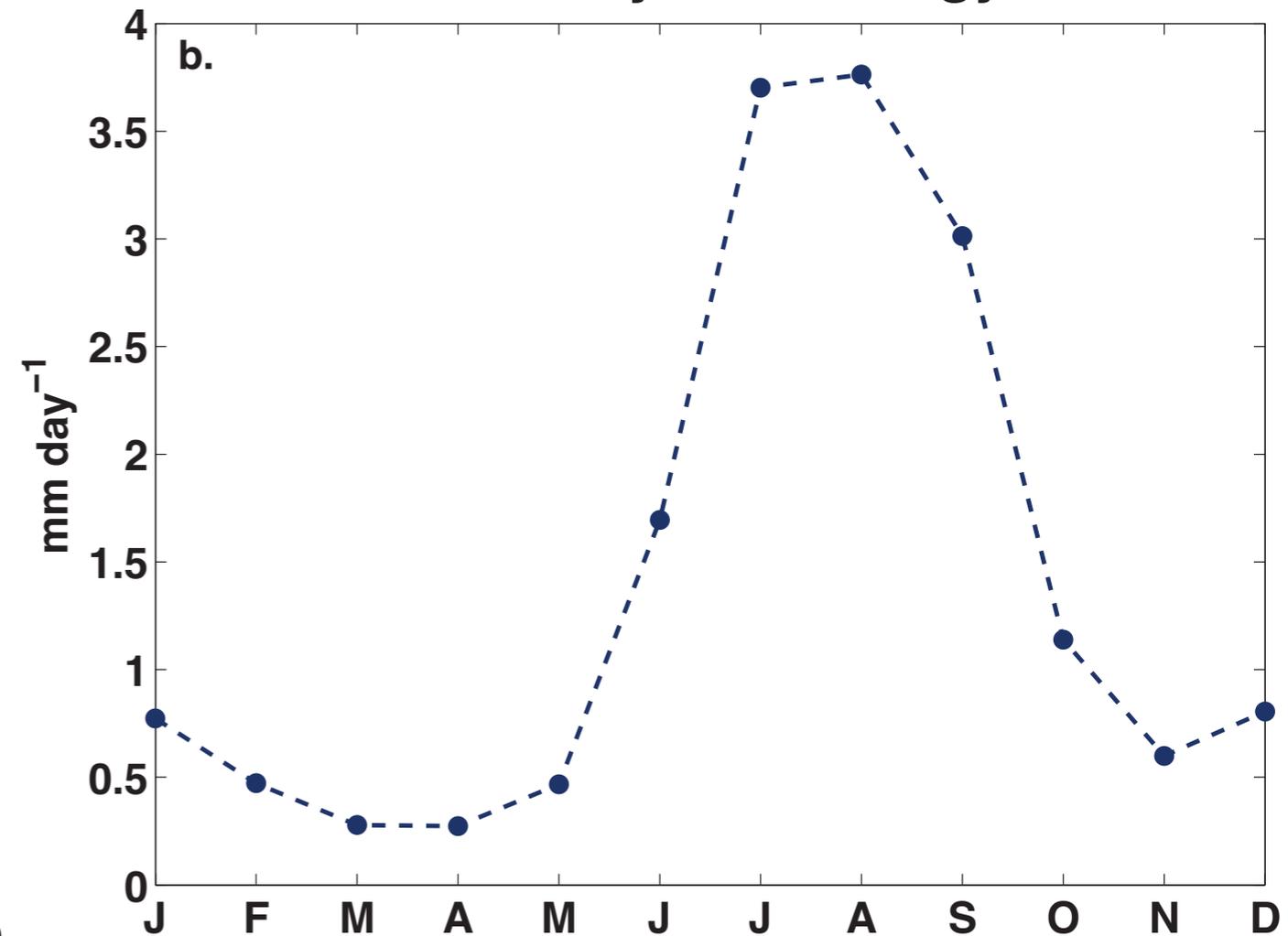
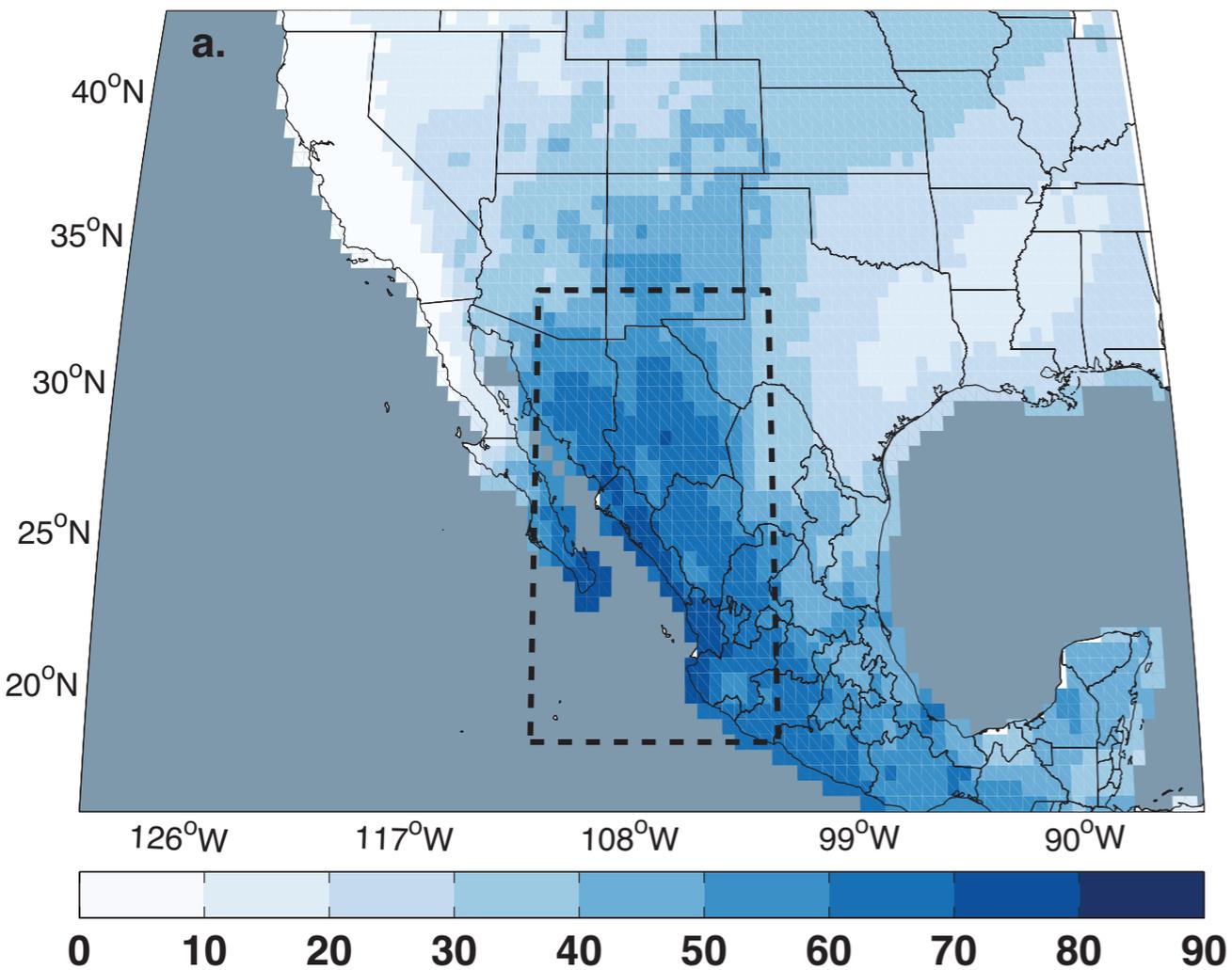
$$MSE_{700}^* = C_p T_{700} + L_v q_{700}^* + g z_{700}$$

$$MSE_{surf} = C_p T_{2m} + L_v q_{2m}$$

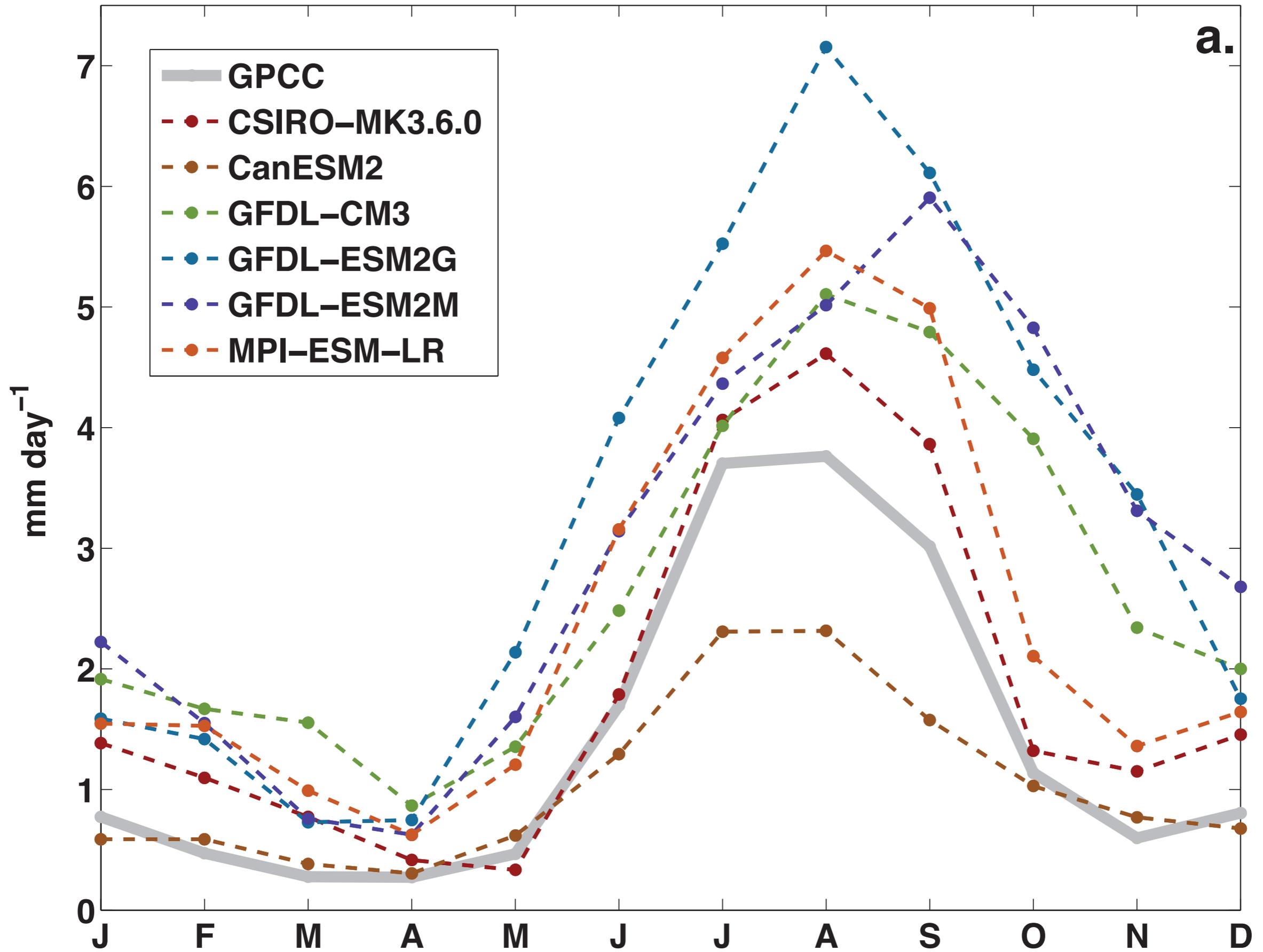
# The North American Monsoon (GPCC, 1980-1999)

## JAS Precipitation, % of Annual

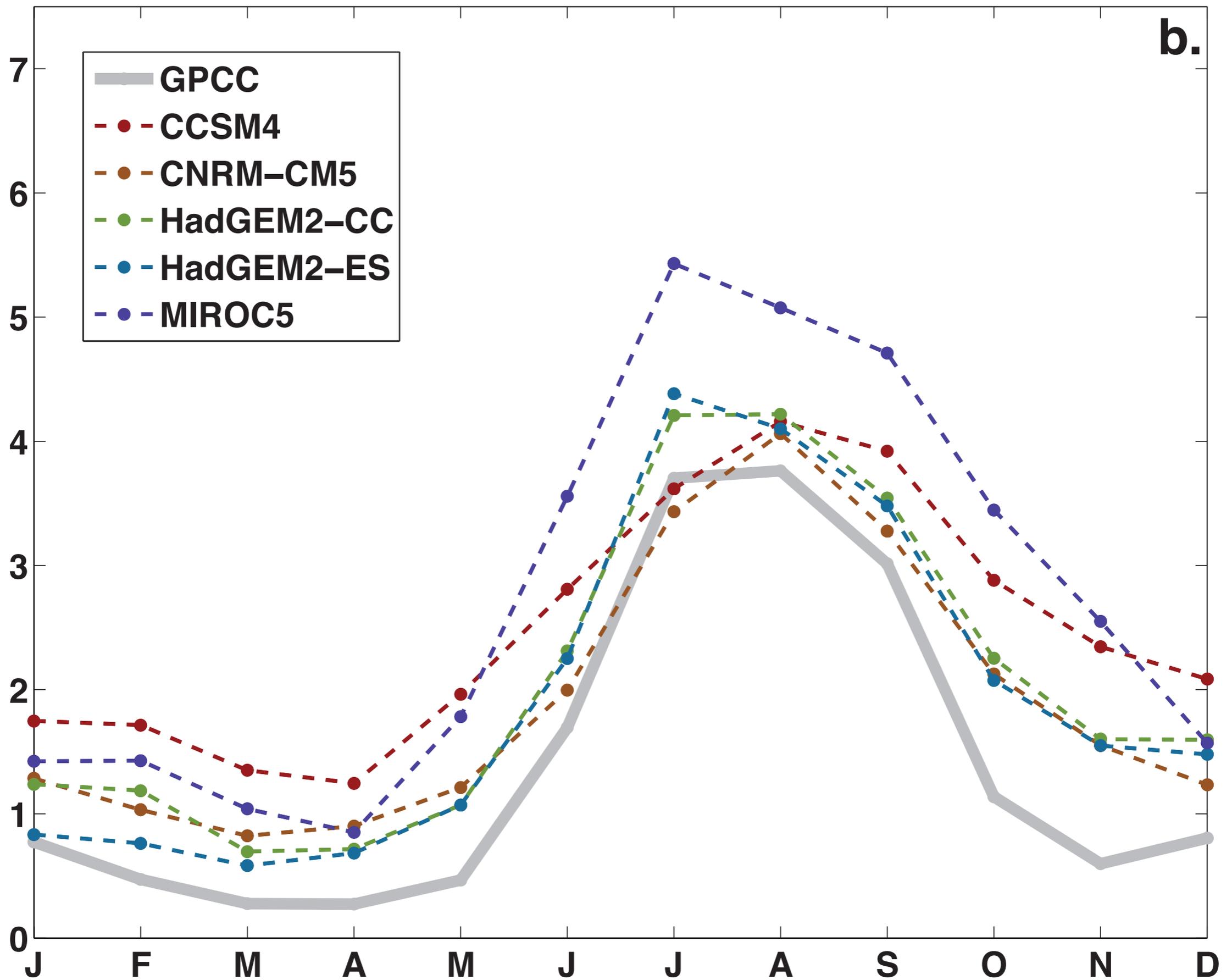
## Monthly Climatology



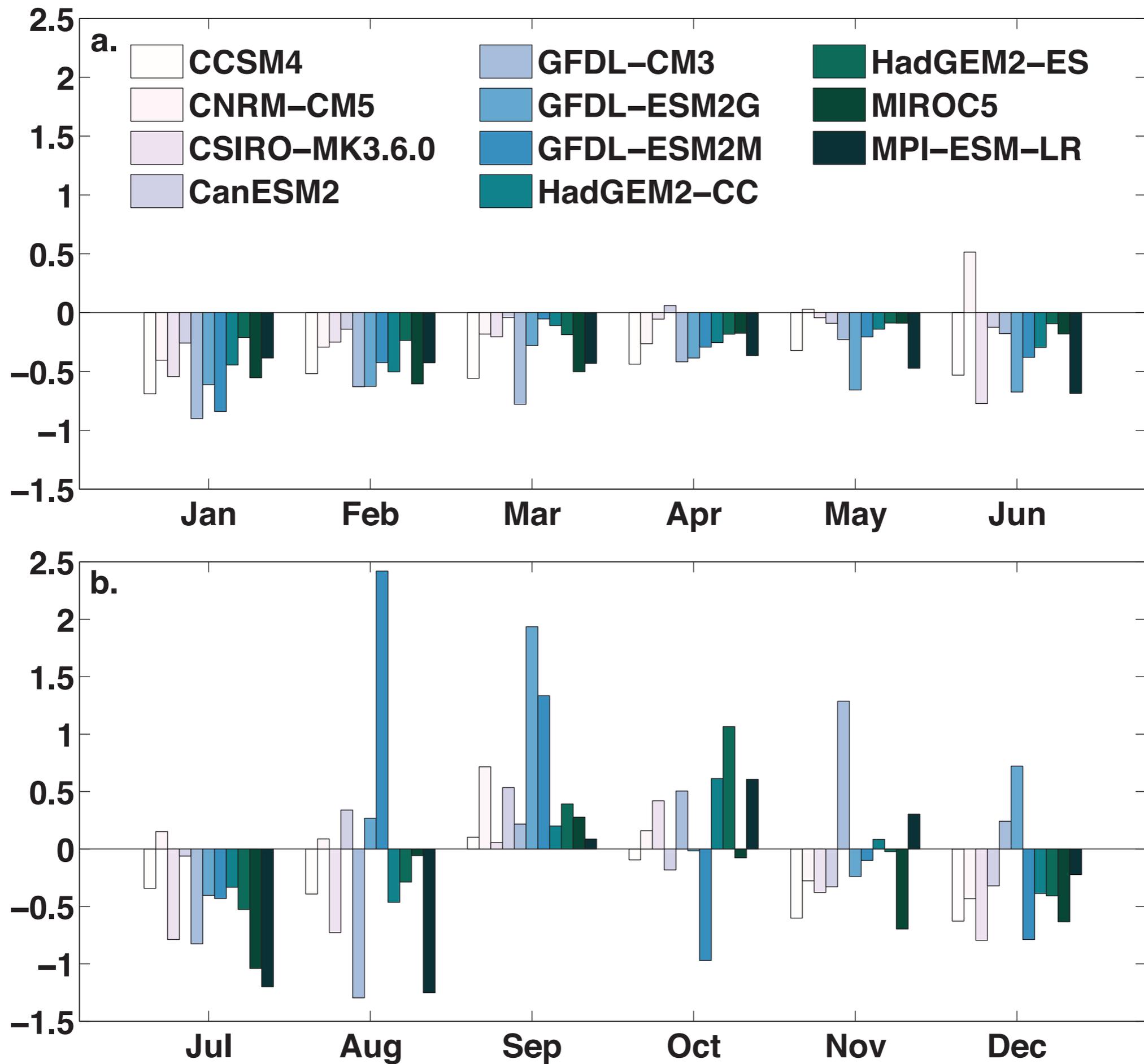
# Lower Resolution



# Higher Resolution

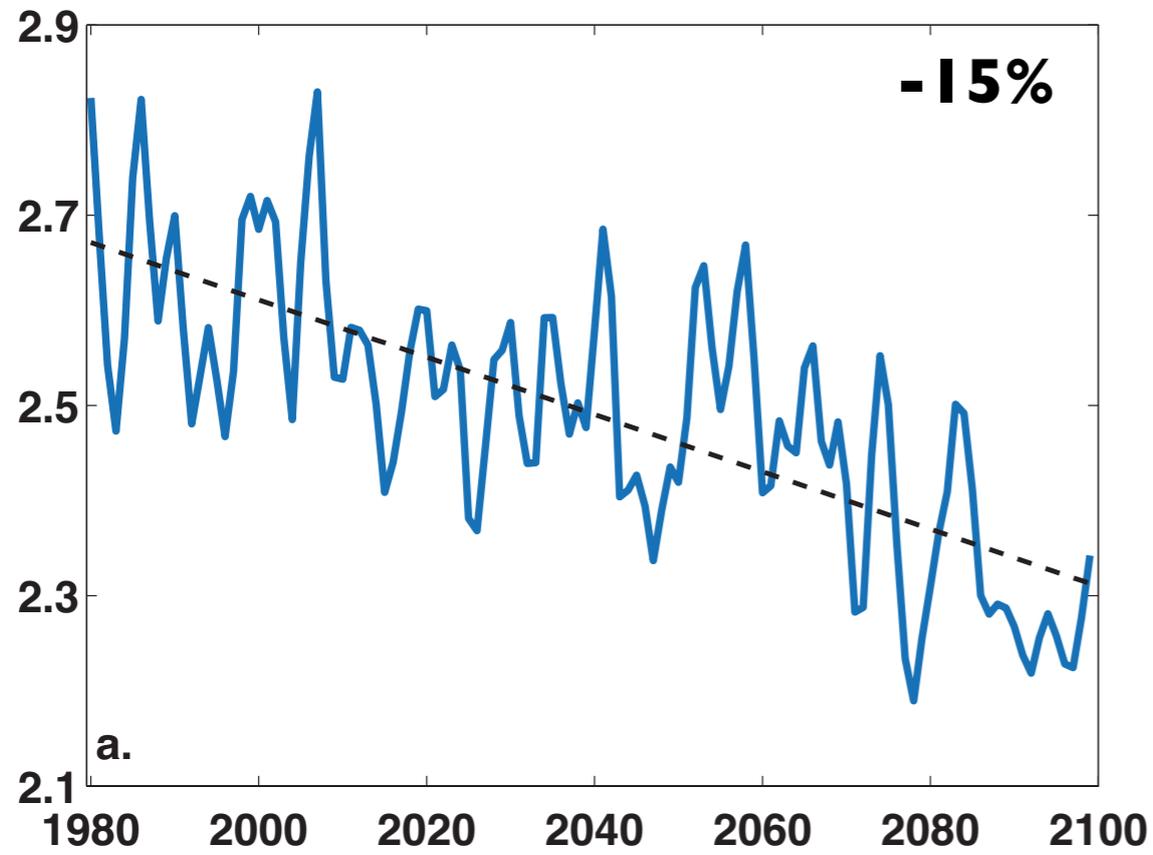


# $\Delta$ Precip, RCP 8.5, mm d<sup>-1</sup> (2080–2099 vs 1980–1999)

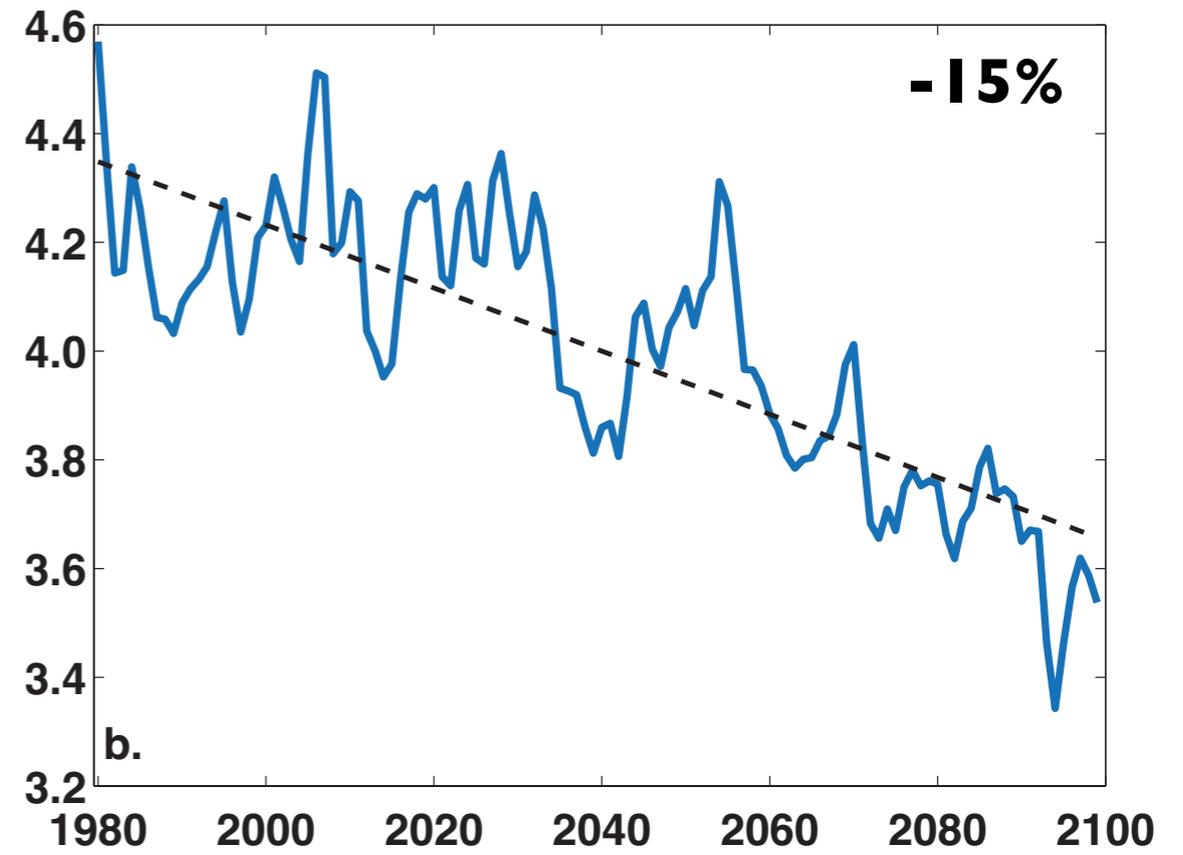


# Multi-Model Mean Precip, mm d<sup>-1</sup> (1980–2099)

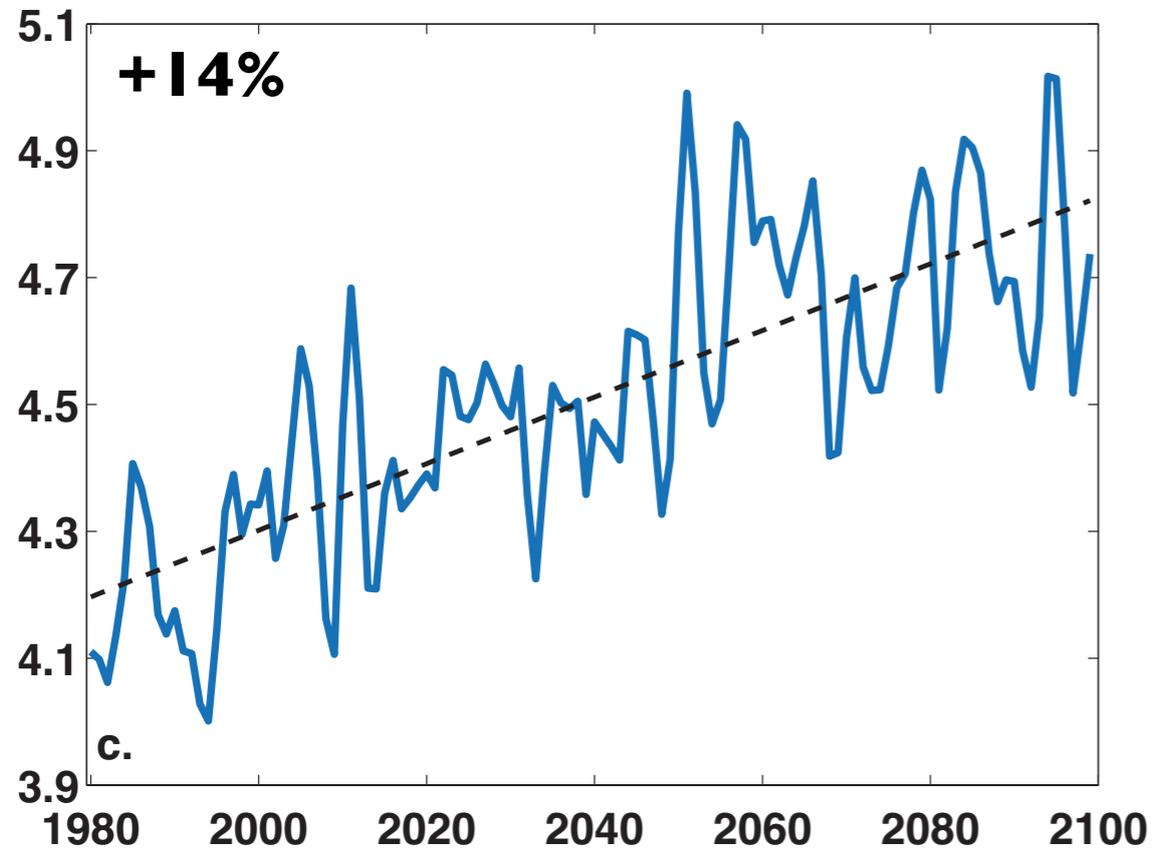
## June



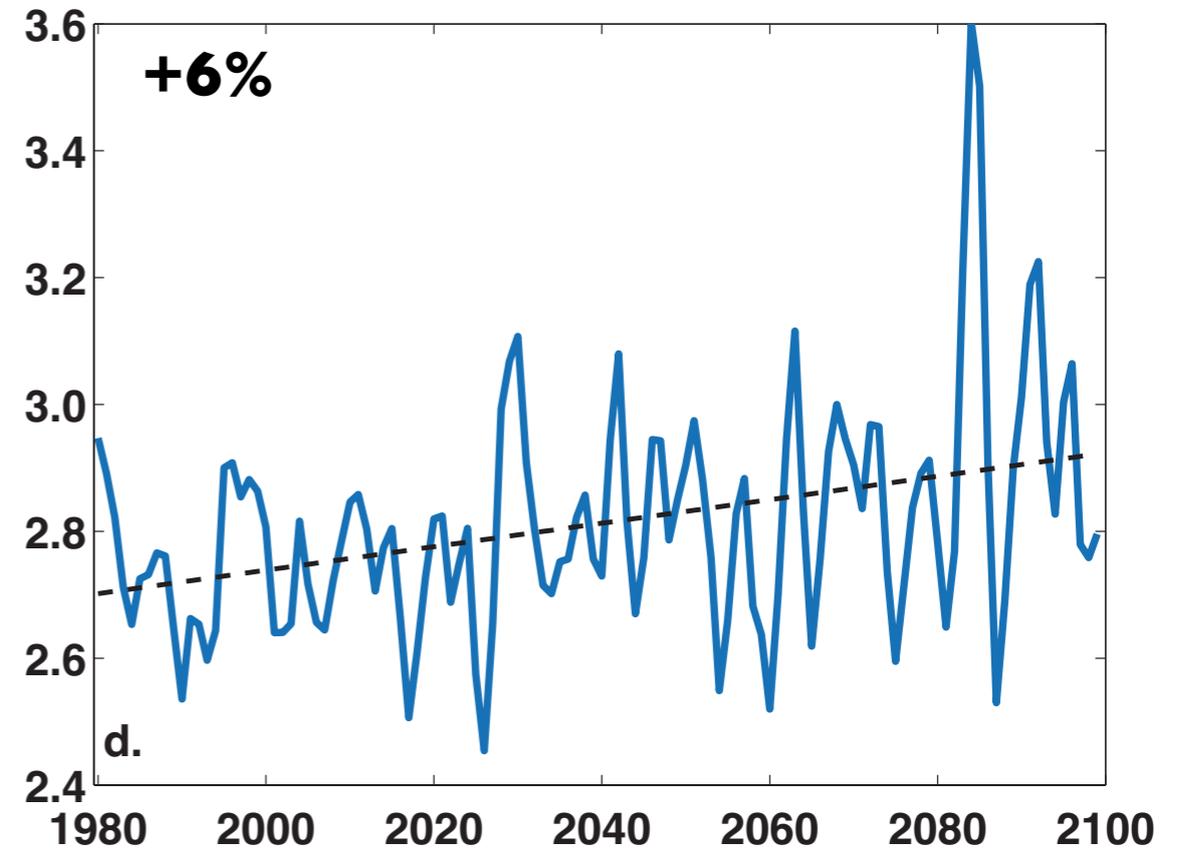
## July



## September



## October

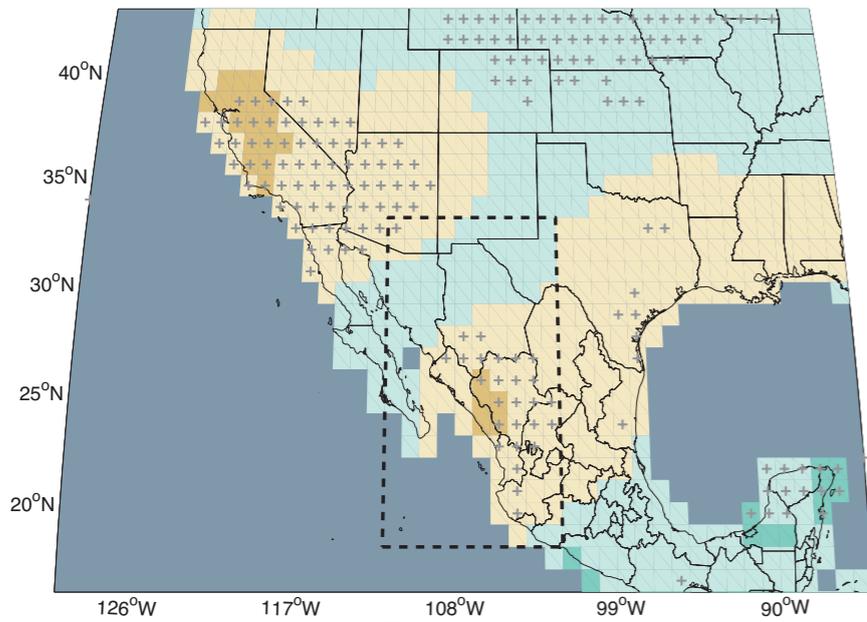


Total Change, Monsoon  
Season (Jun-Oct): **-2%**

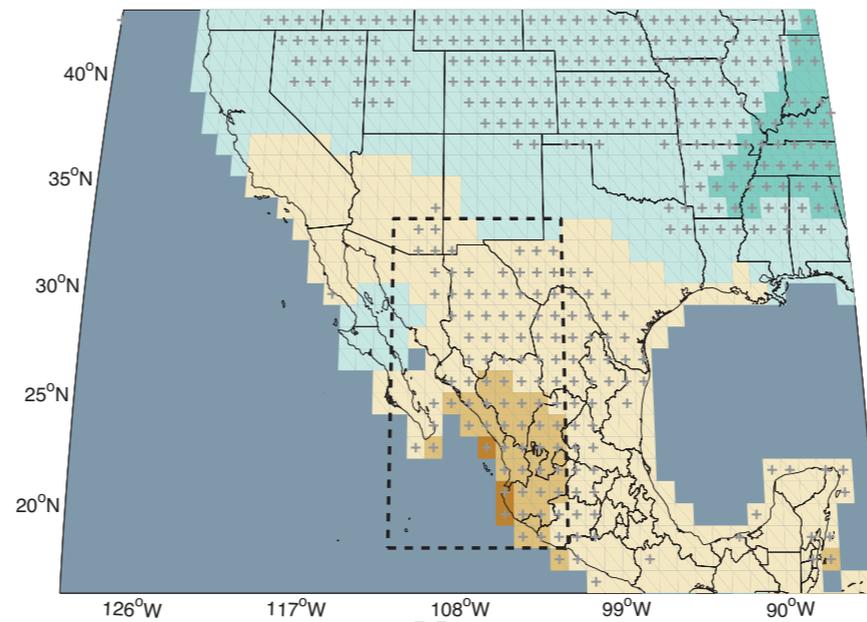
Total Change, Annual  
Total: **-26%**

# $\Delta$ Precip, RCP 8.5, mm d<sup>-1</sup> (2080–2099 vs 1980–1999)

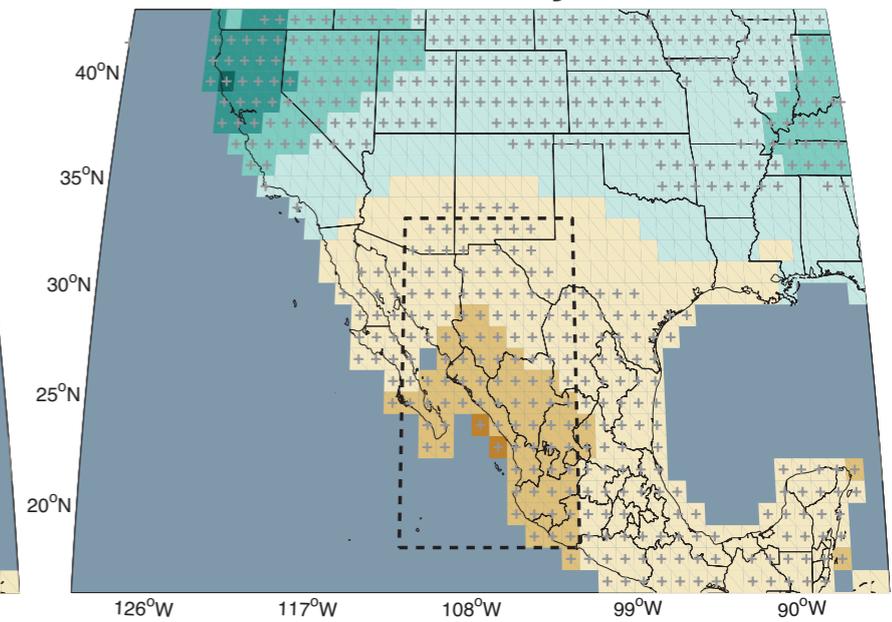
November



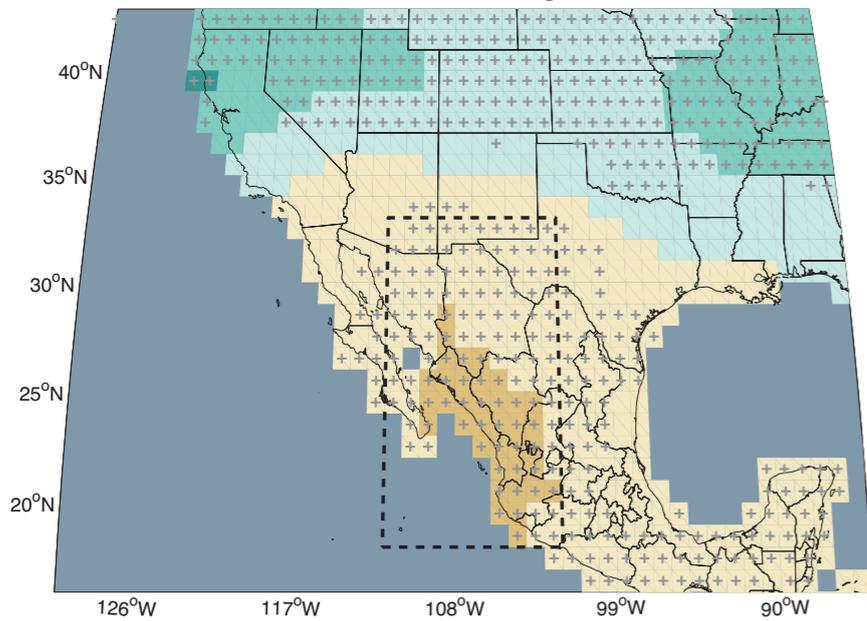
December



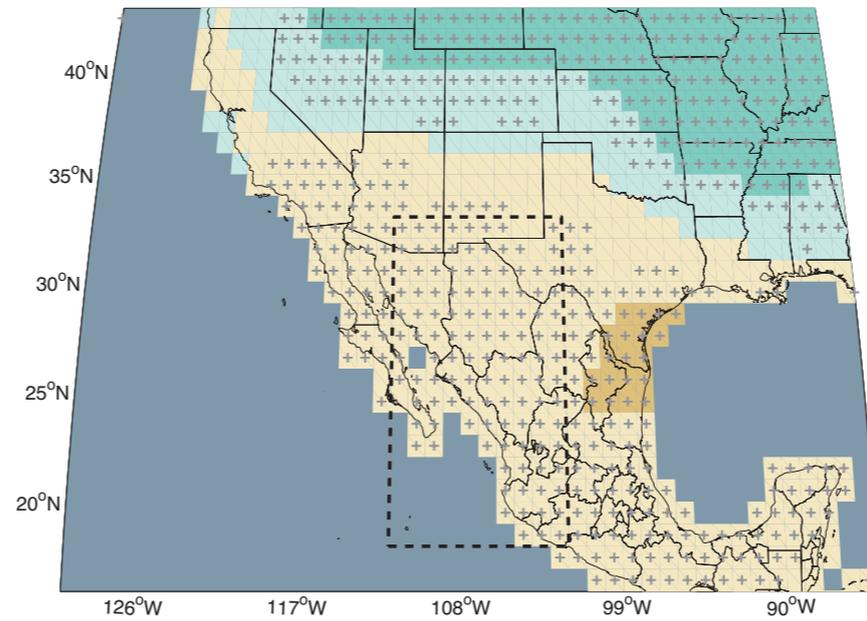
January



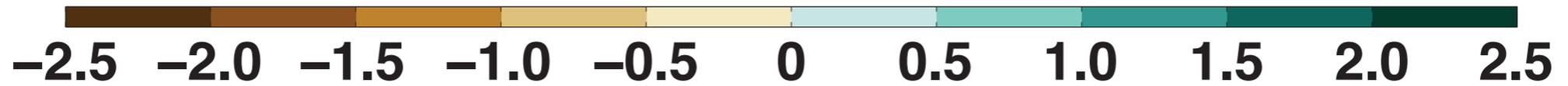
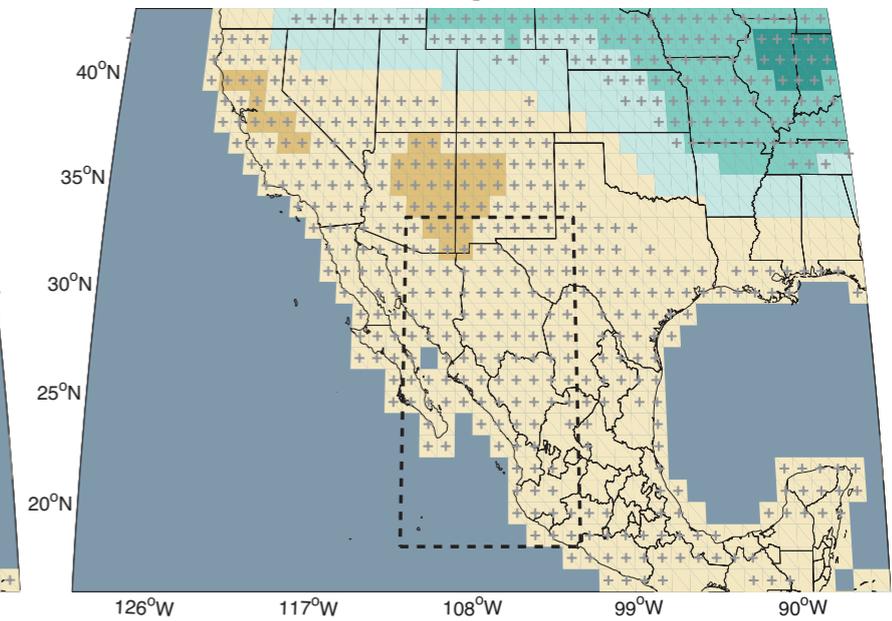
February



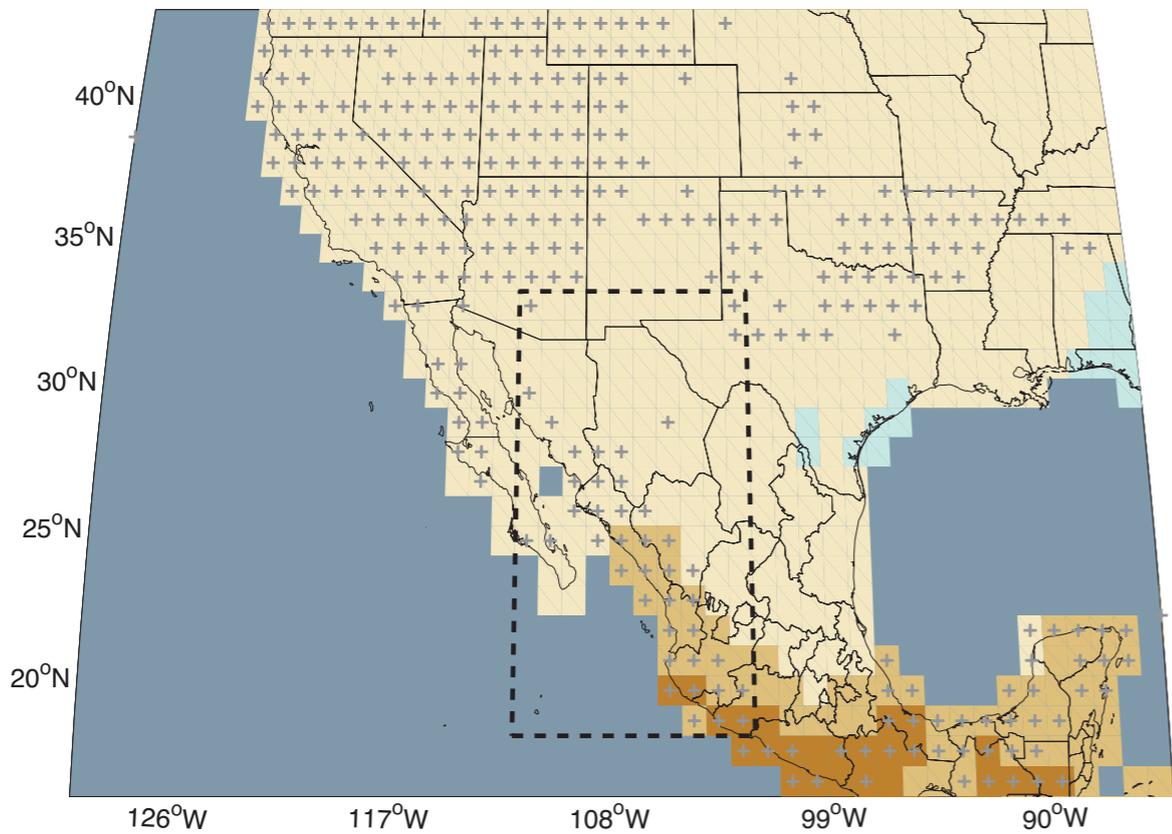
March



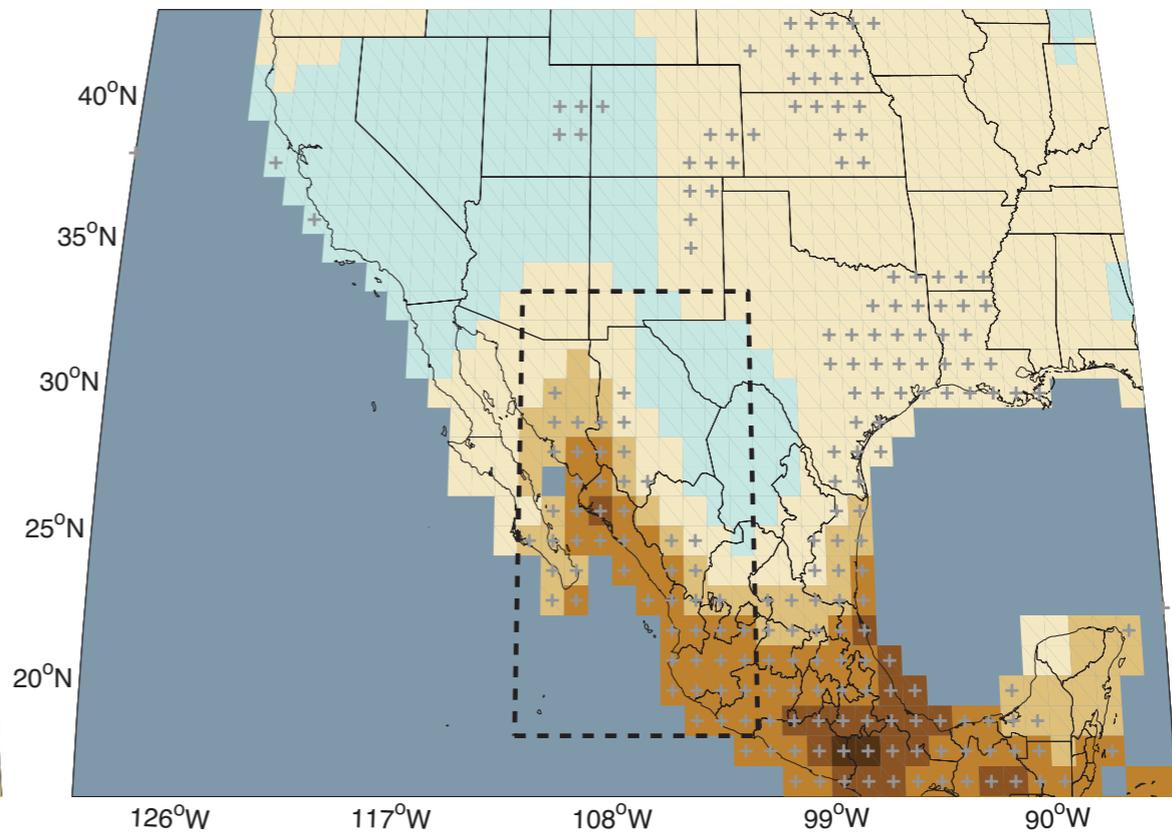
April



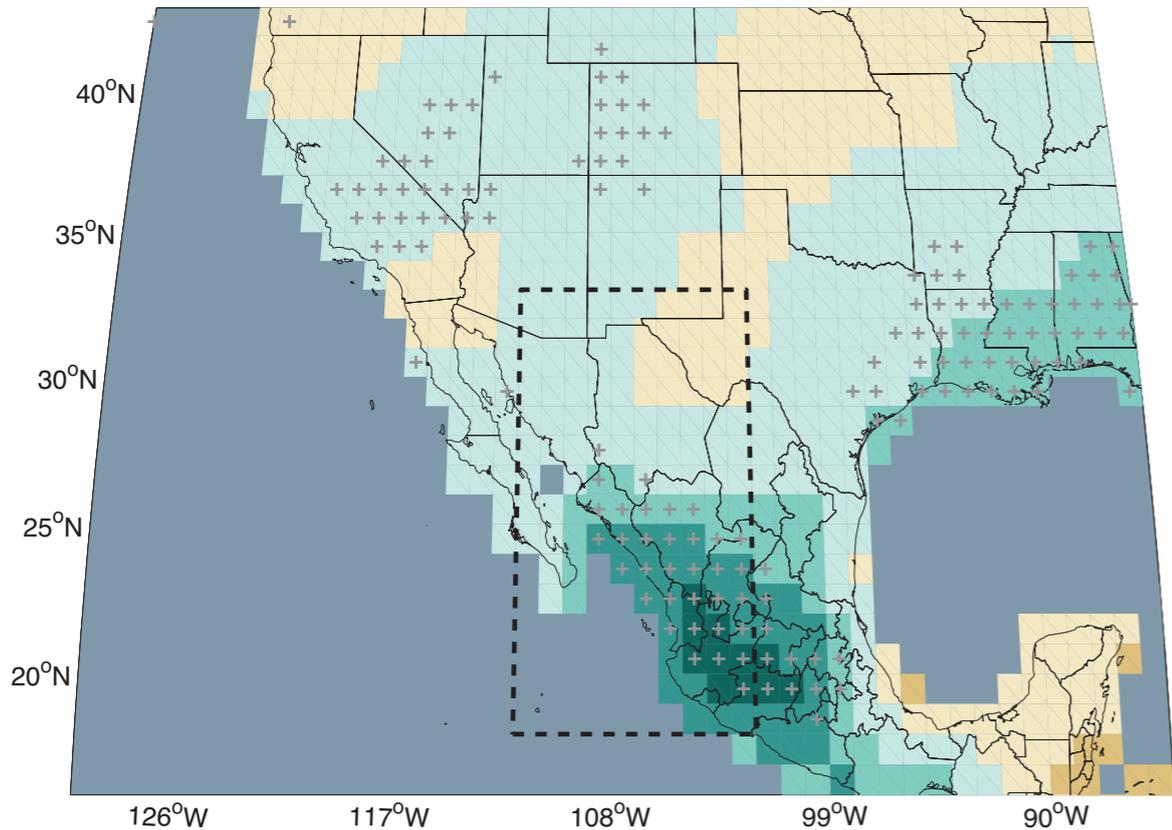
# June



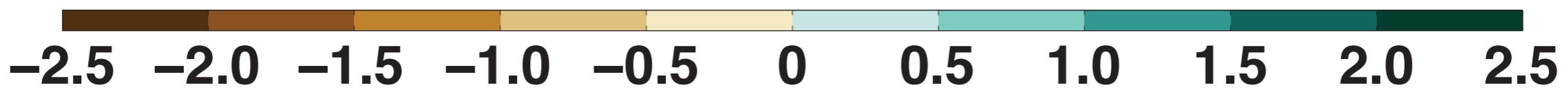
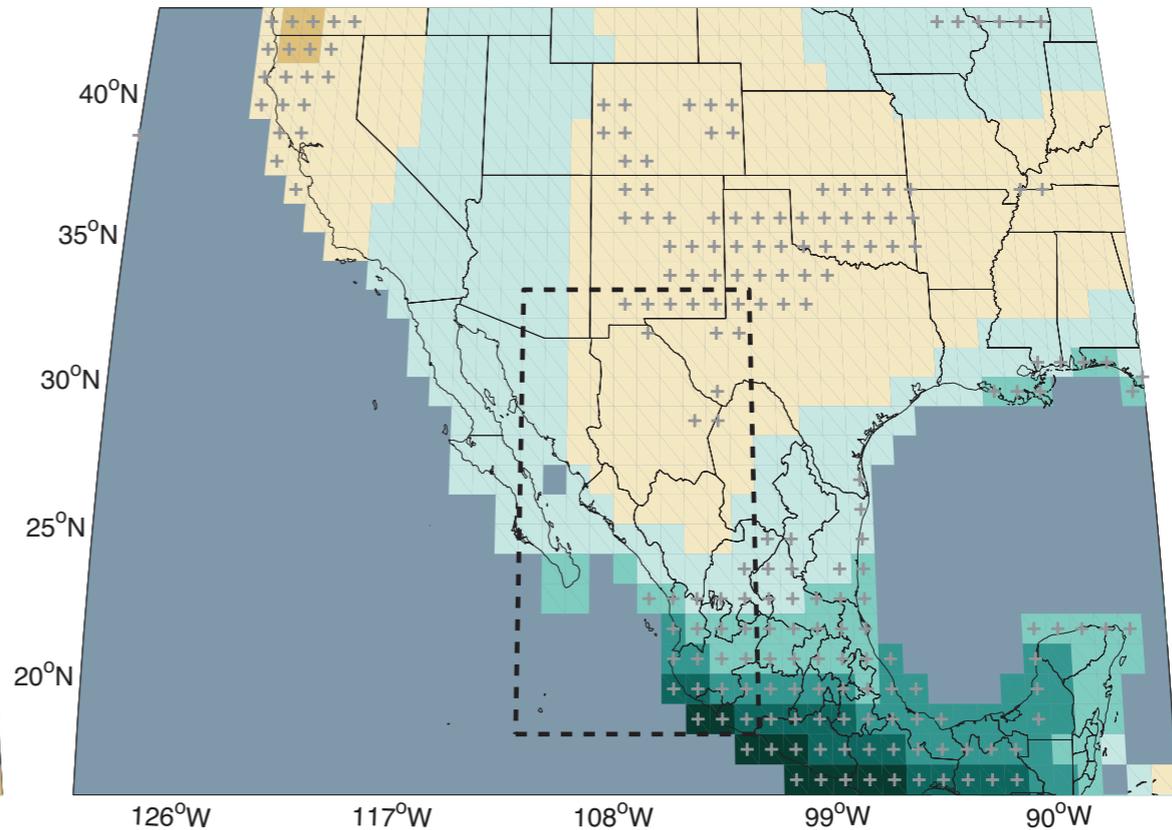
# July



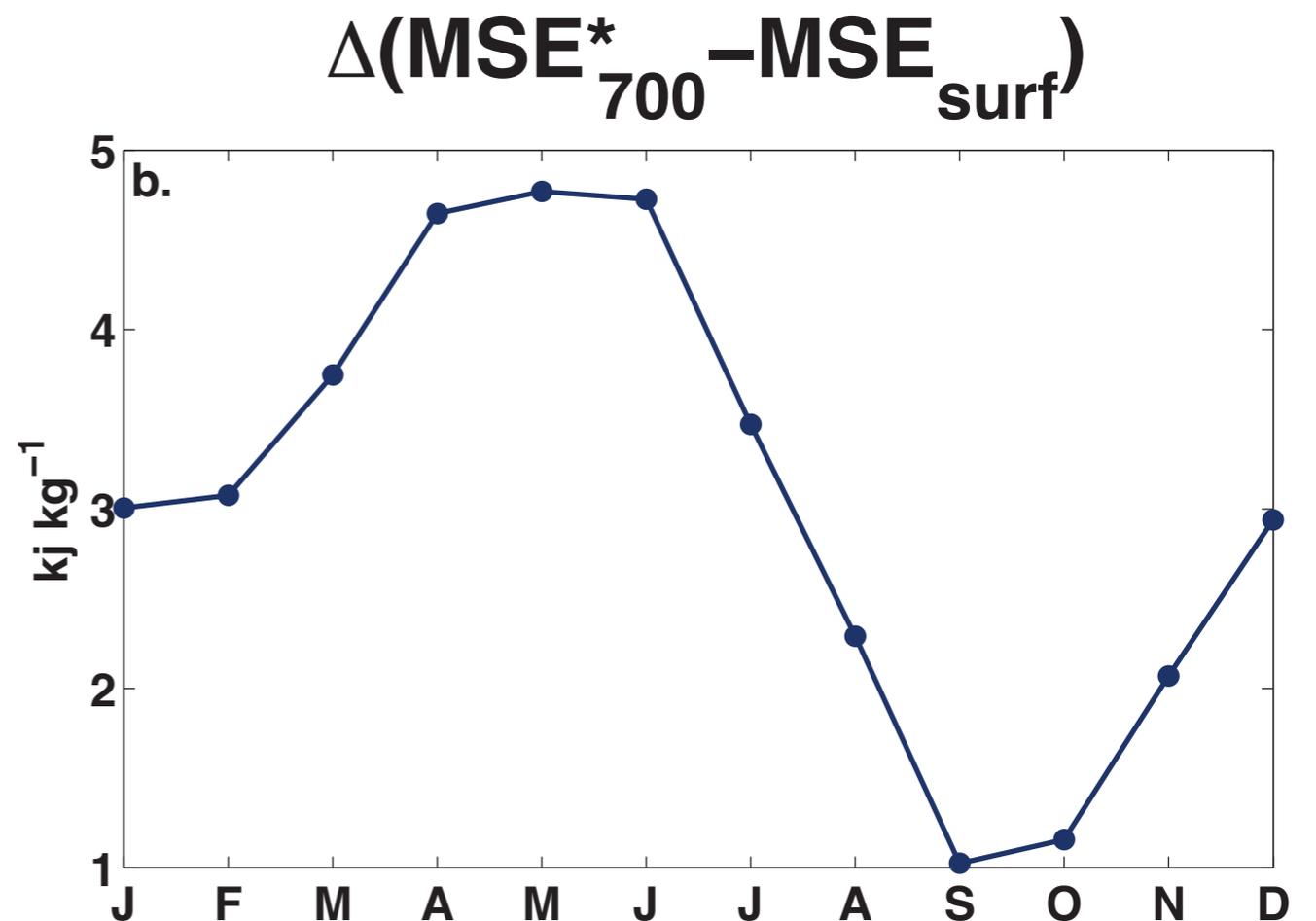
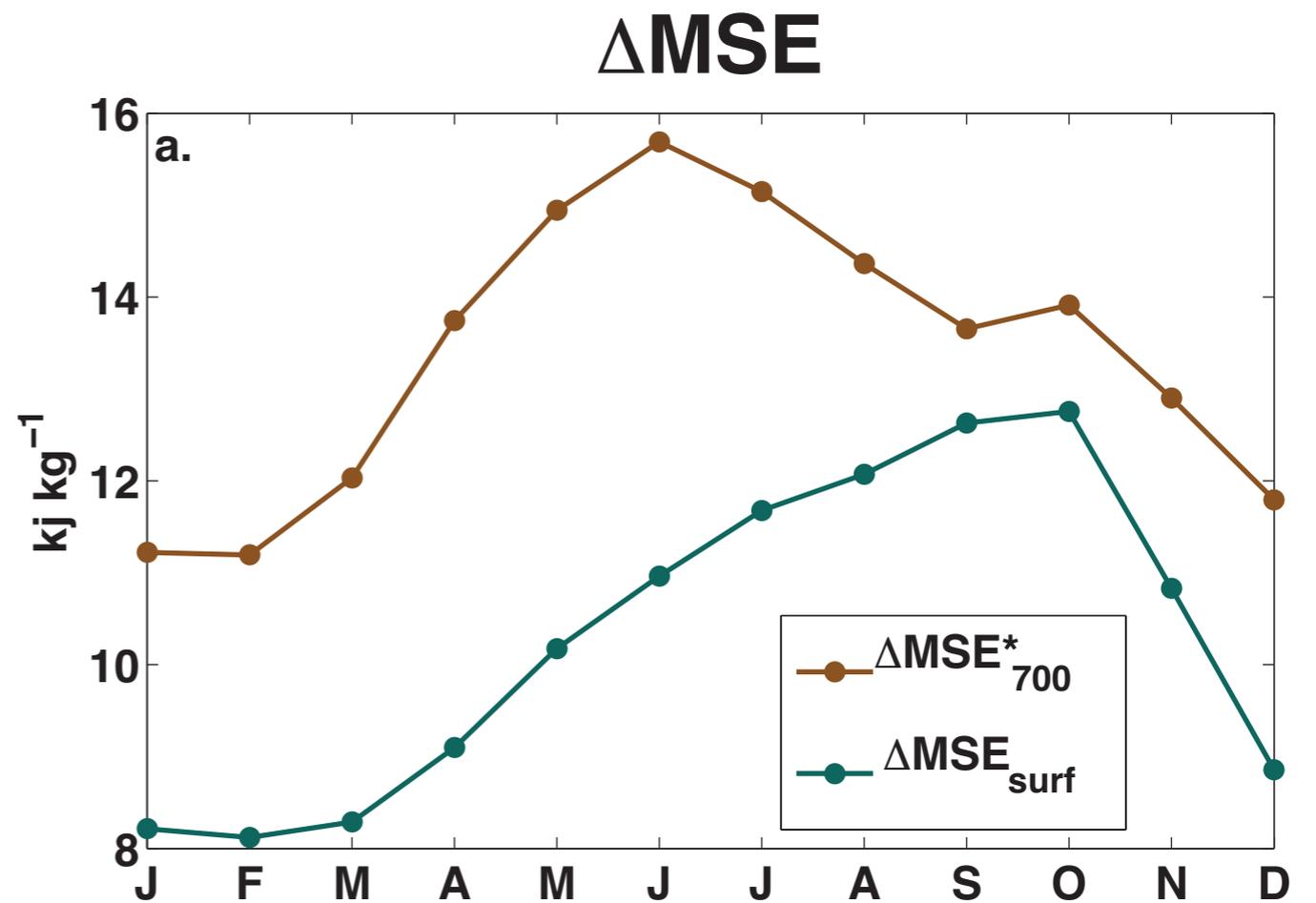
# September



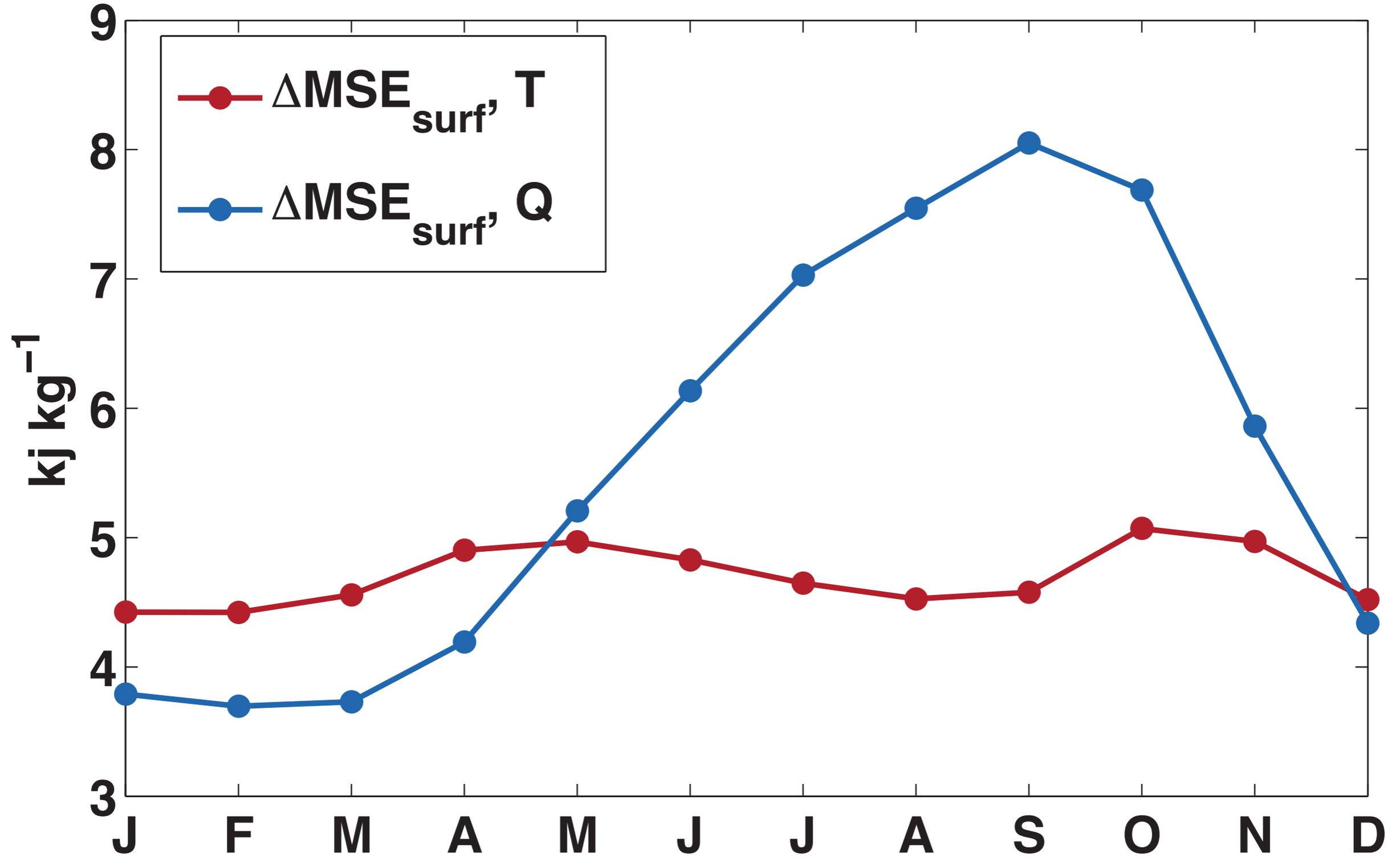
# October



# Moist Static Energy



# $\Delta\text{MSE}_{\text{surf}}$ Terms



**CMIP5 models show changes in the NAM  
consistent with other monsoon areas**

**Physics consistent with expected change to  
atmospheric stability**

**Model wet biases?**