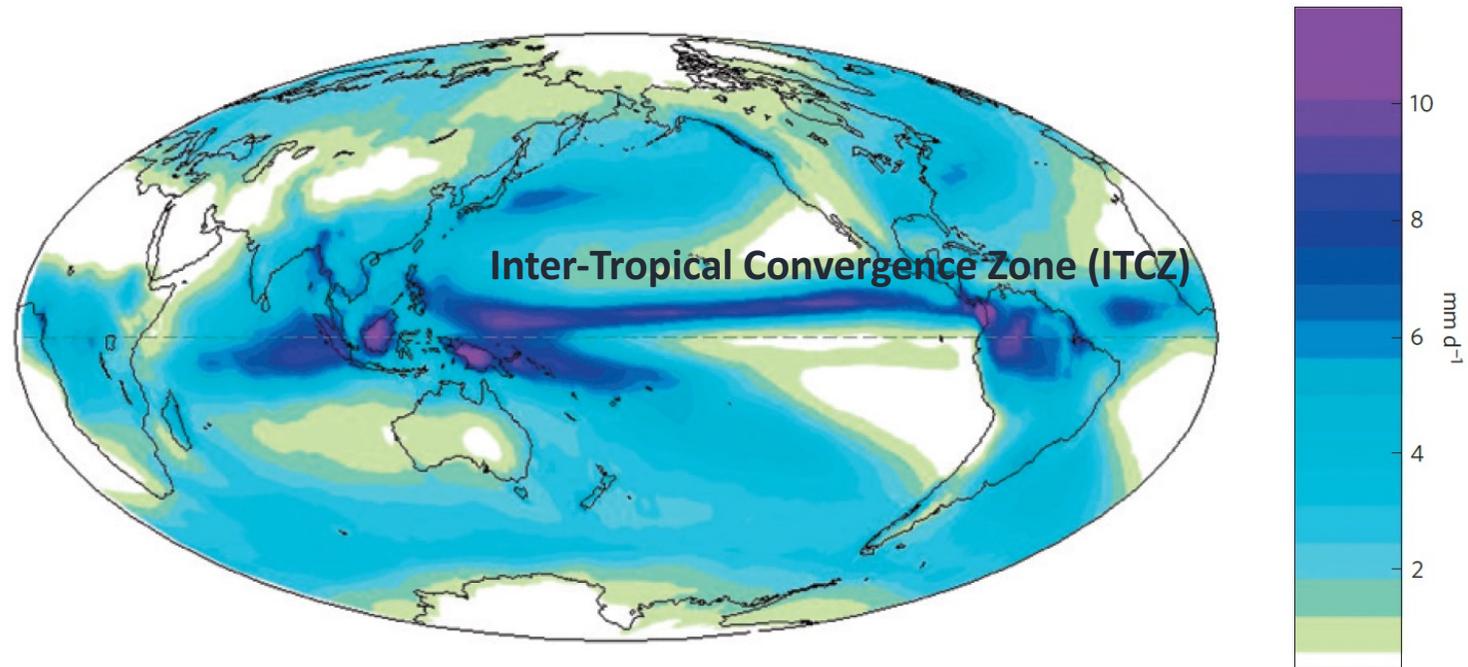


# Distinct tropical climate response to subpolar energy perturbations from the Northern or Southern Hemisphere

Sarah Kang (UNIST)

Collaborators: Shang-Ping Xie (Scripps), Yechul Shin (UNIST), Jiyeong Kim (UNIST), Malte Stuecker (IBS, PNU), Baoqiang Xiang (GFDL), Matt Hawcroft (Exeter), Yen-Ting Hwang (NTU)

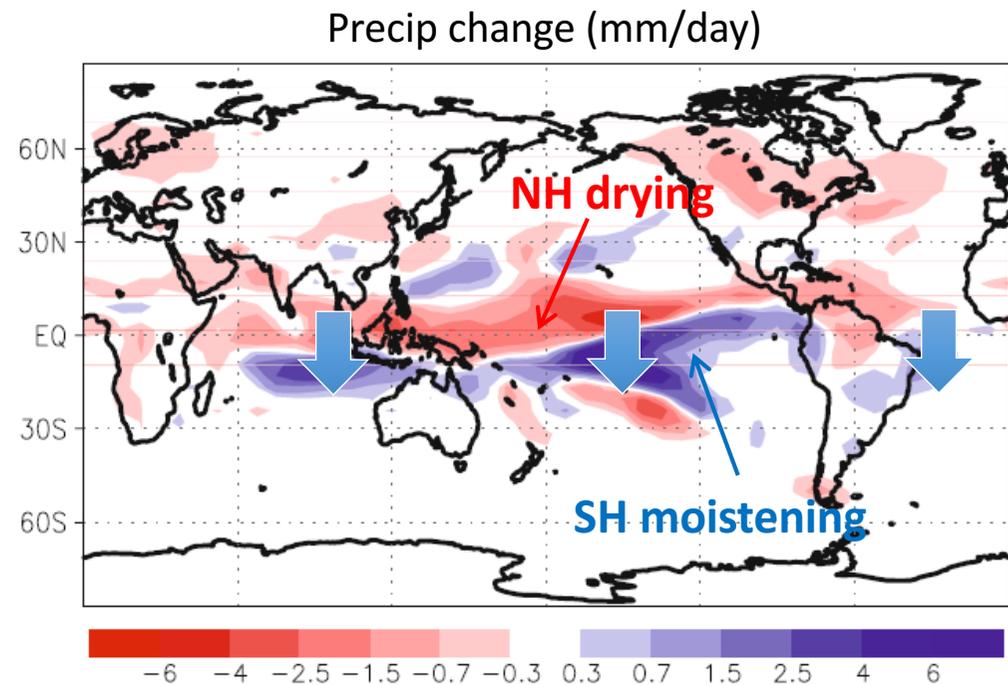
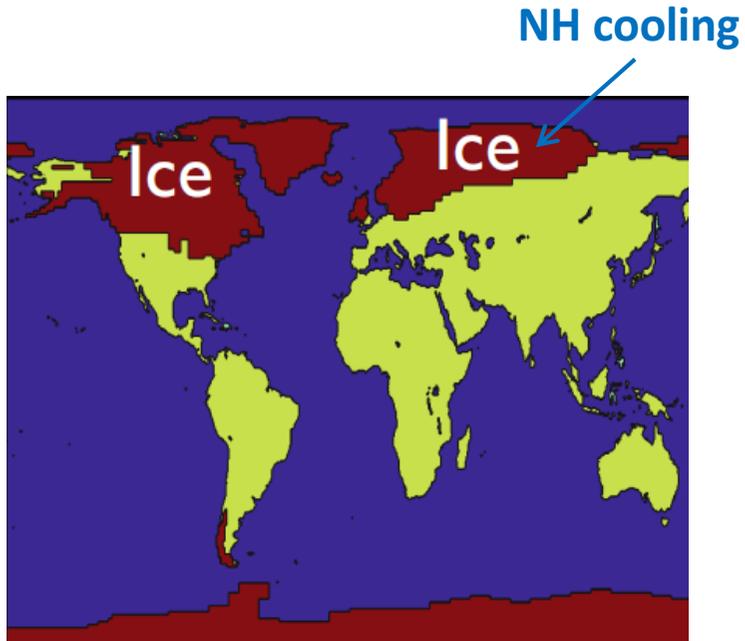
## Annual mean precipitation



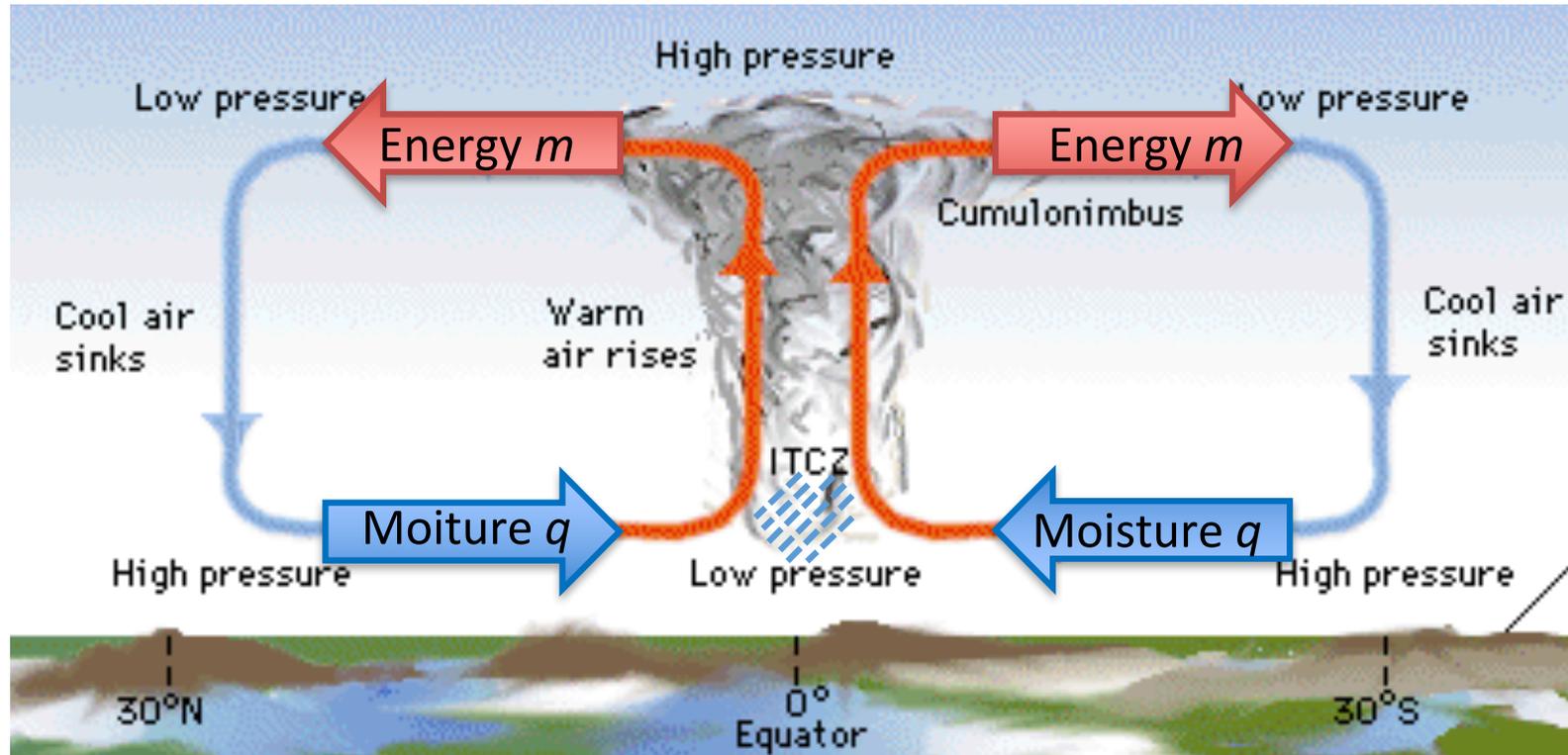
Data: 2001-2010 from GPCP Version 2.1

Adopted from Frierson et al. (2013)

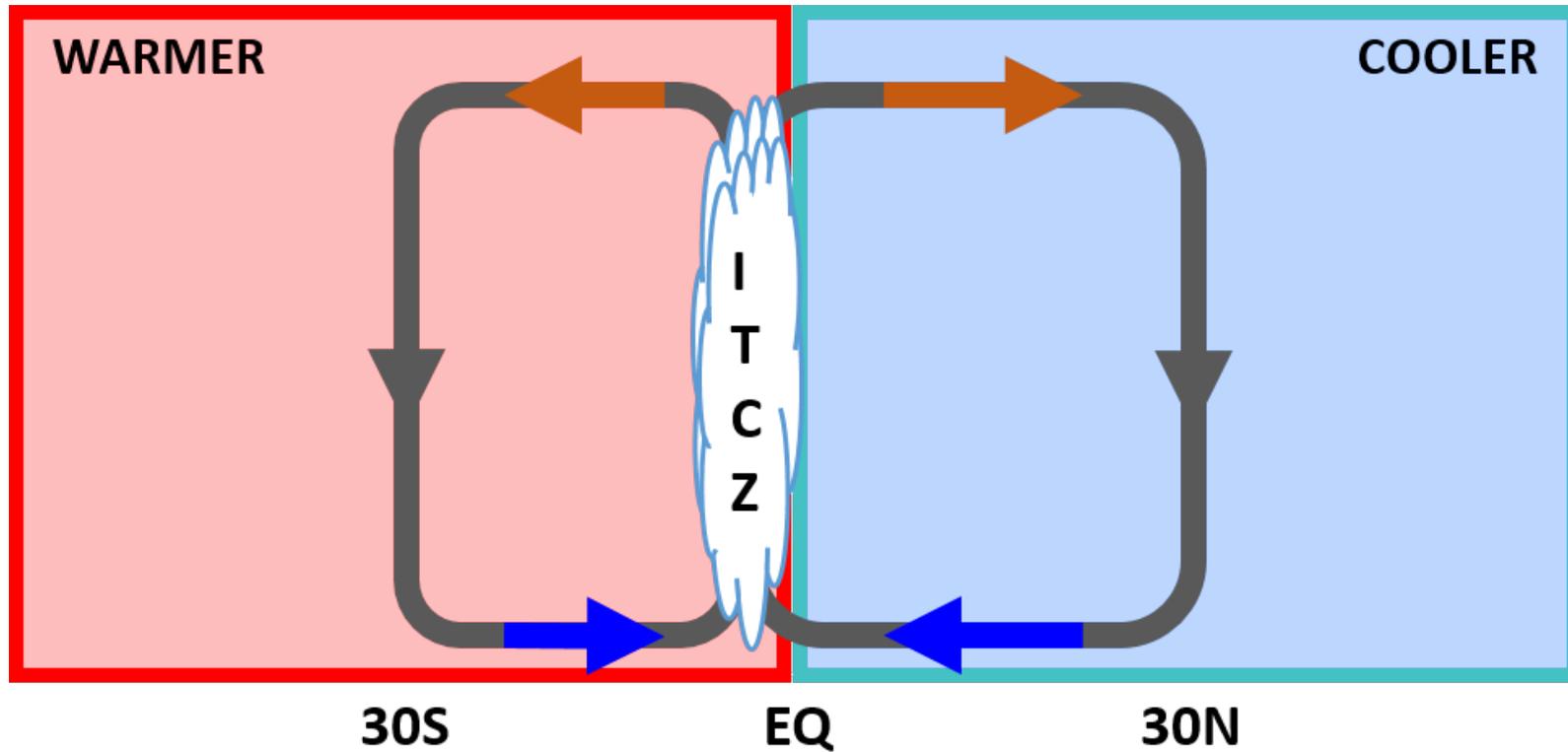
# EXTRATROPICAL IMPACT ON THE ITCZ



# THE HADLEY CELL AND THE ITCZ

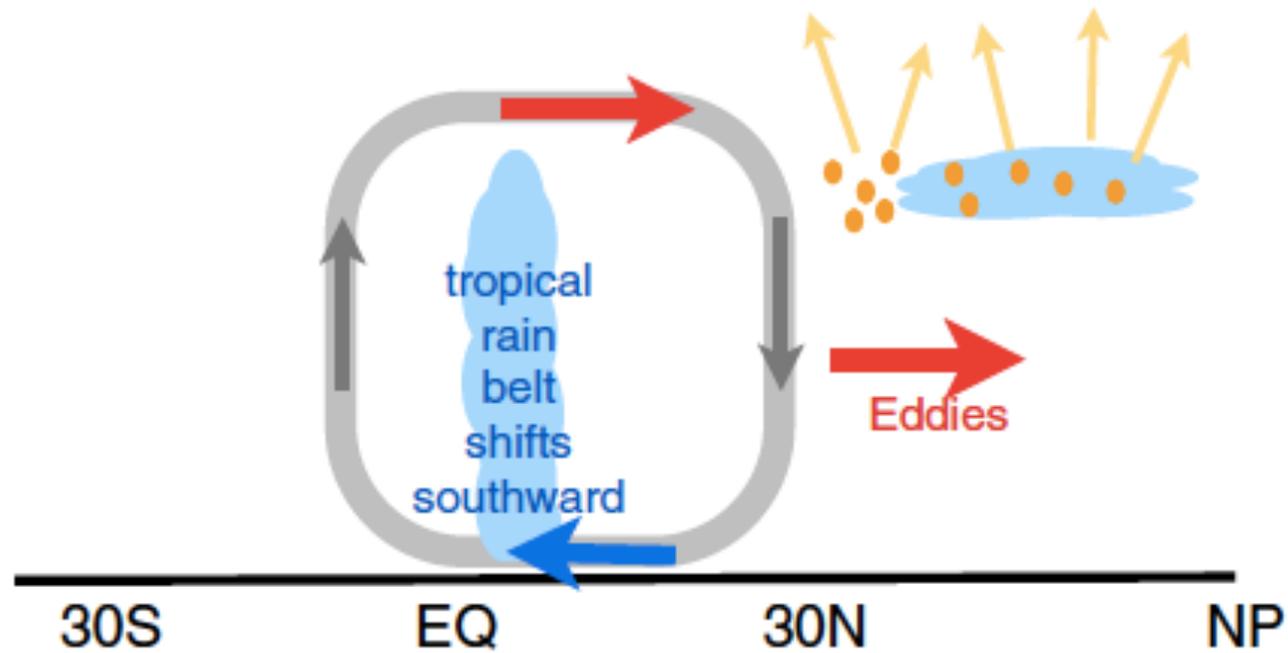


# THE HADLEY CELL AND THE ITCZ

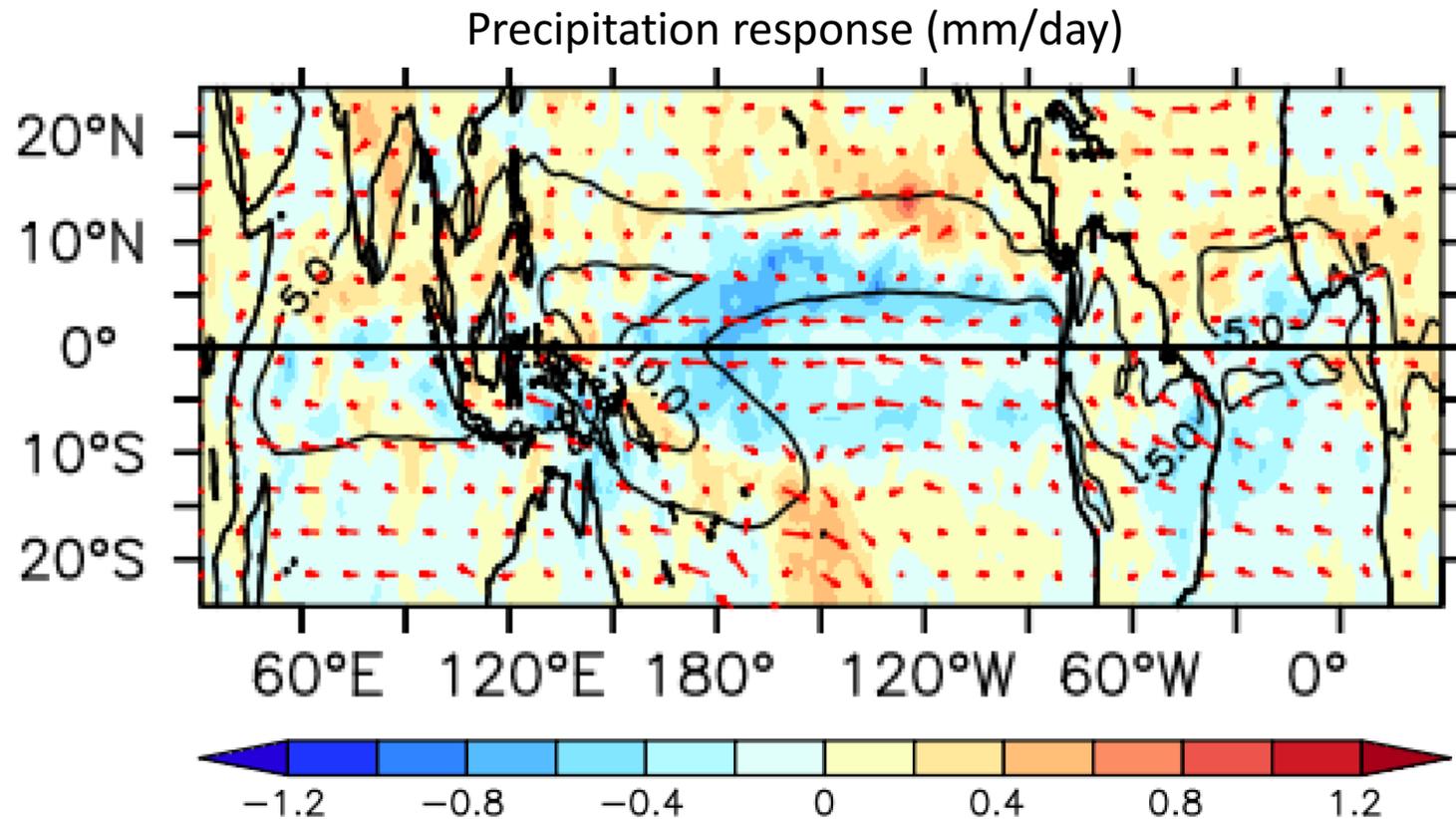


ITCZ shift  $\propto$  Hemispheric Difference of net energy input  
into the atmosphere column

# LATE 20<sup>th</sup> CENTURY AEROSOL FORCING EFFECTS

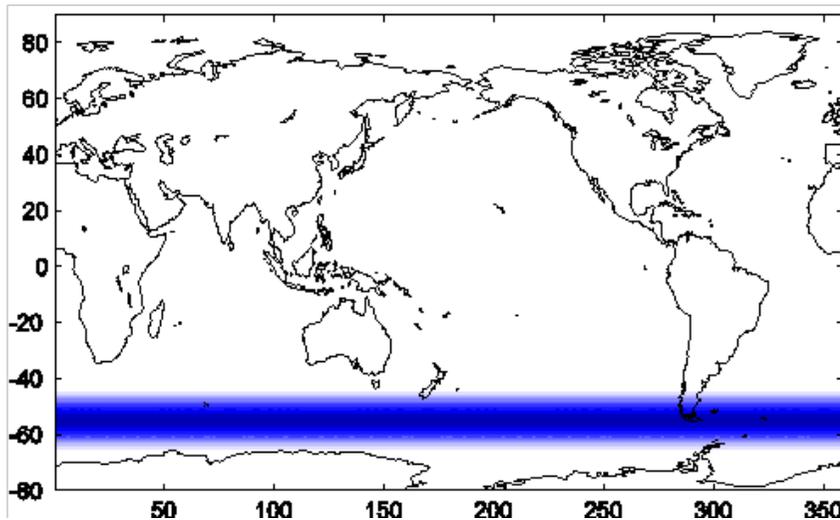


# SOUTHERN OCEAN COOLING EFFECTS

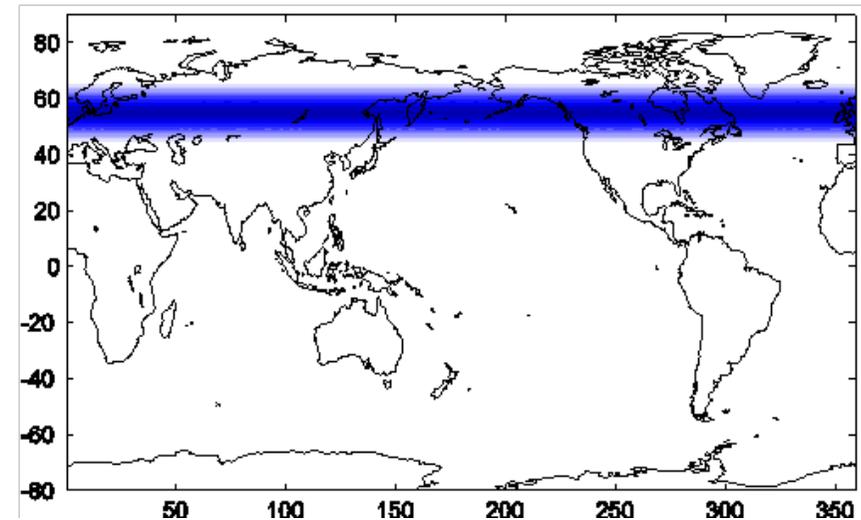


- Model
  - 1) GFDL AM2 coupled to aquaplanet slab ocean model (AQUA)
  - 2) GFDL AM4 coupled to slab ocean model (SOM) with realistic geography
  - 3) GFDL AM4 coupled to dynamic ocean model (DOM)
- Control simulation: pre-industrial run

## Forcing profiles

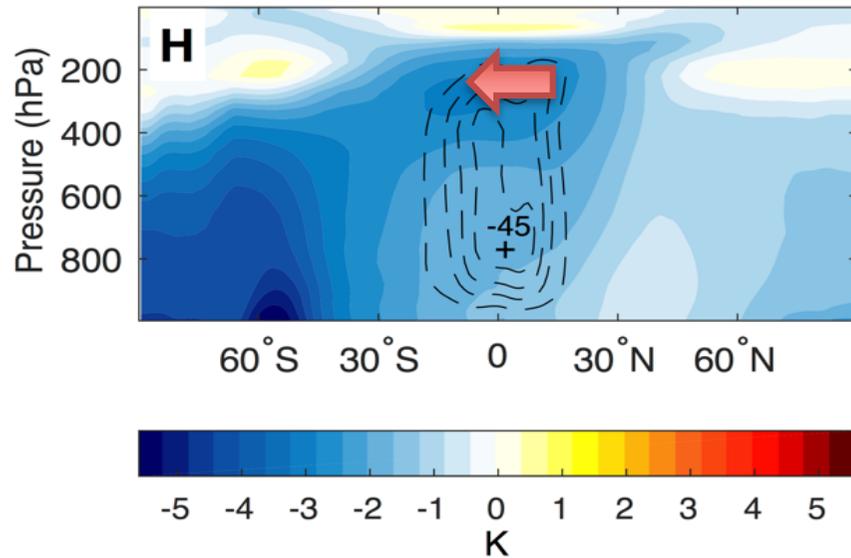
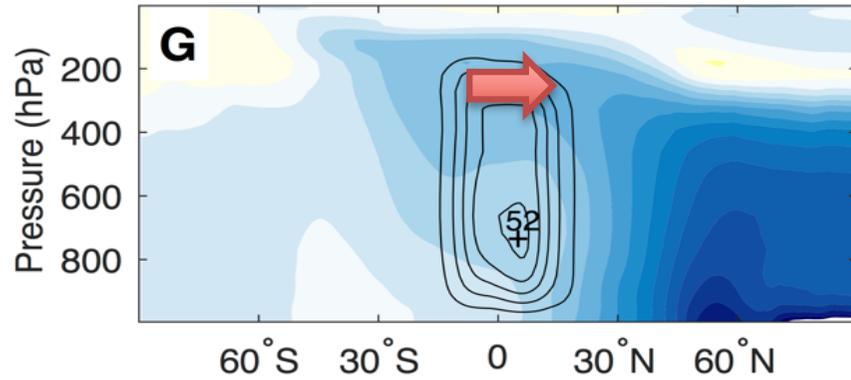


DOM-SH  
SOM-SH

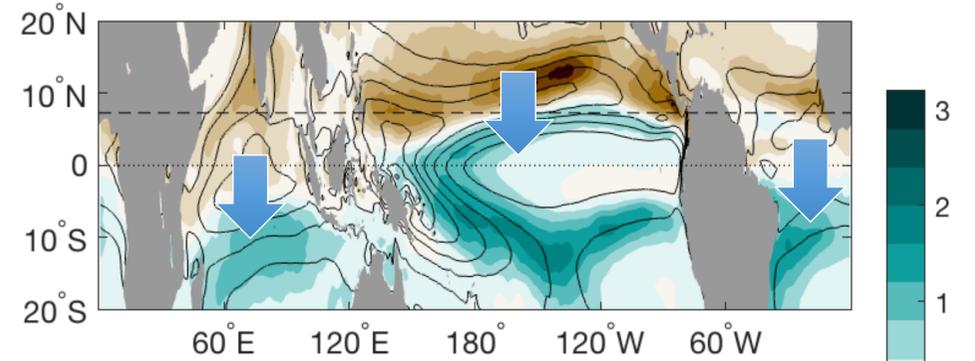


DOM-NH  
SOM-NH

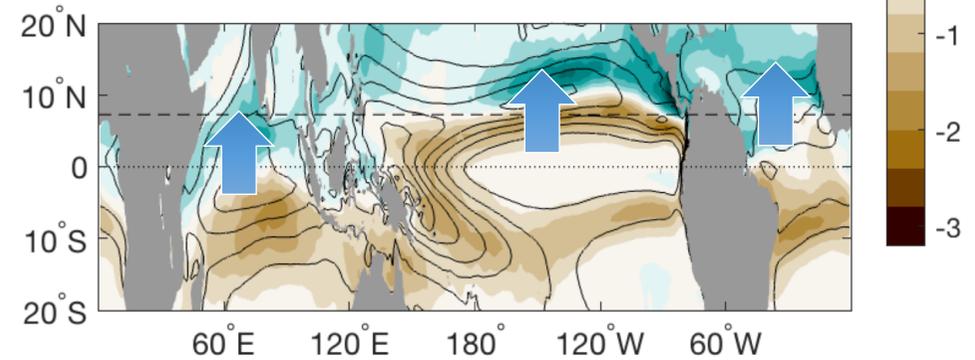
# SOM RESPONSE



## SOM-NH

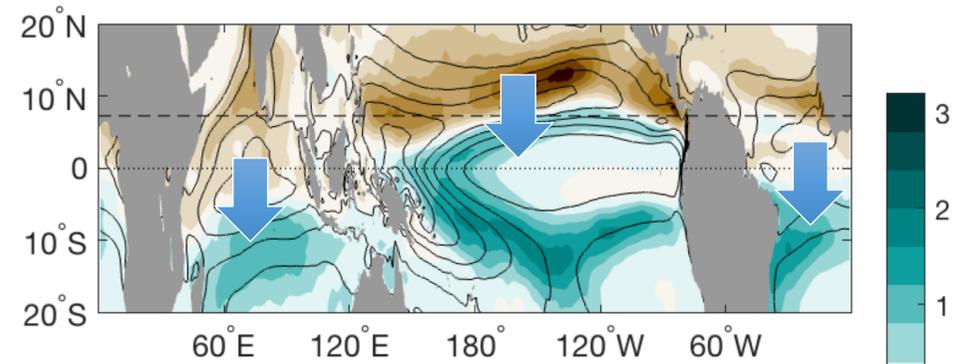


## SOM-SH

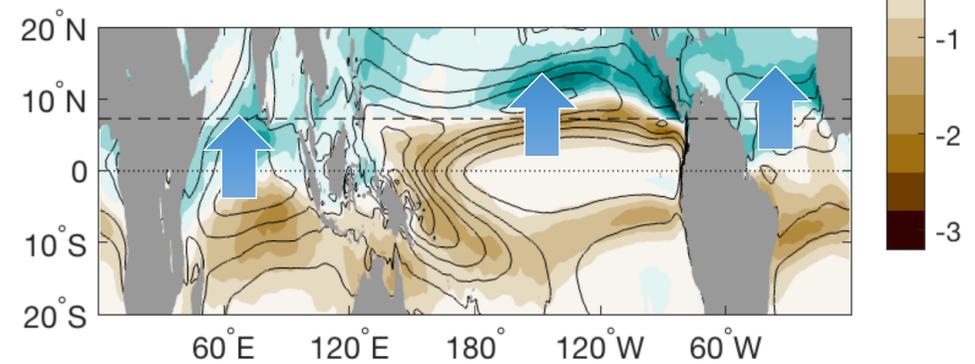


$$R = -0.76$$

### SOM-NH



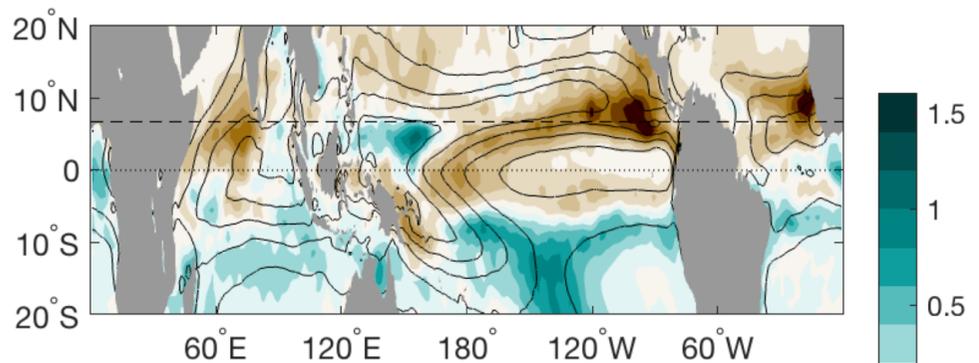
### SOM-SH



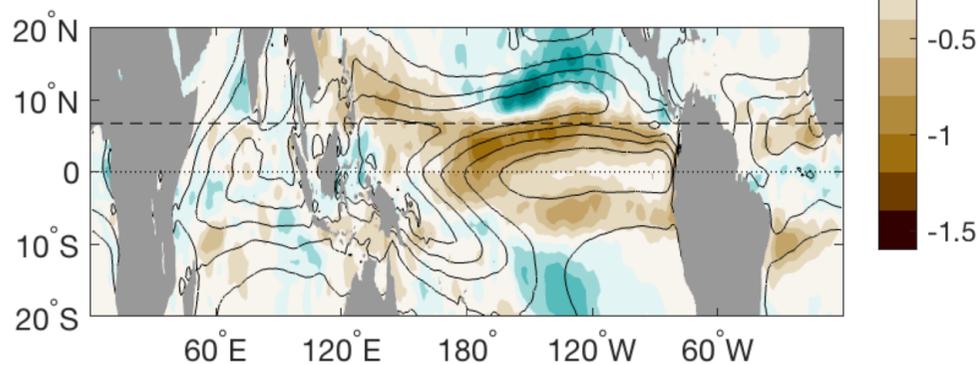
$$R = -0.76$$

# DOM RESPONSE

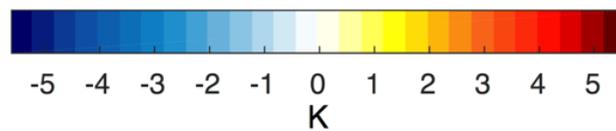
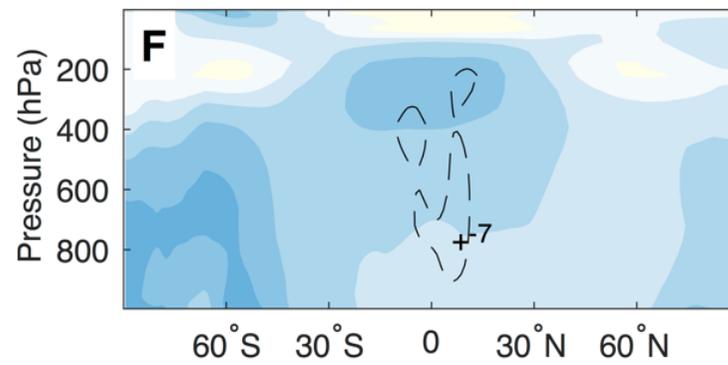
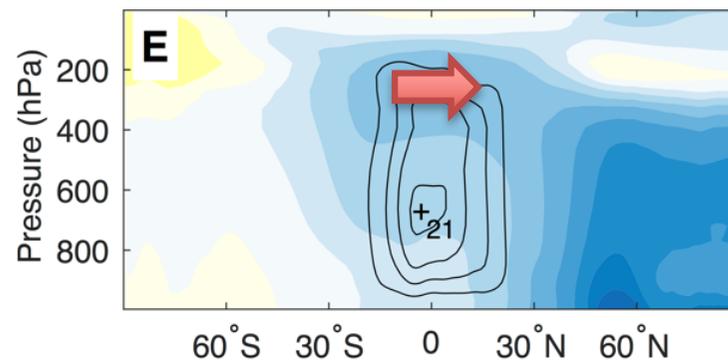
## DOM-NH (Aerosol cooling)



## DOM-SH (Southern Ocean cooling)

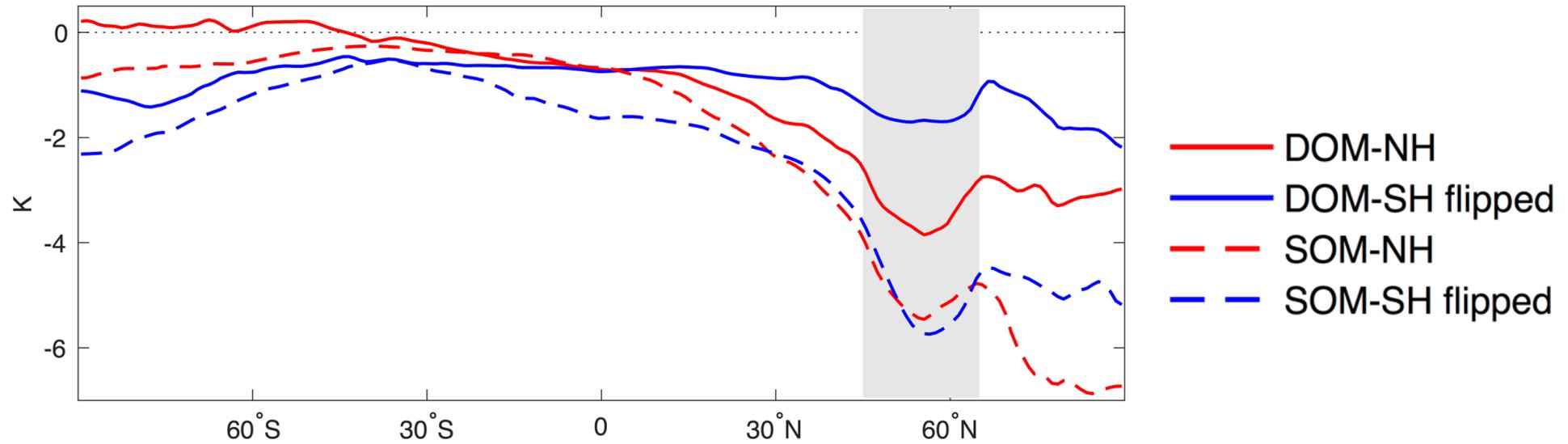


$$R = 0.33$$



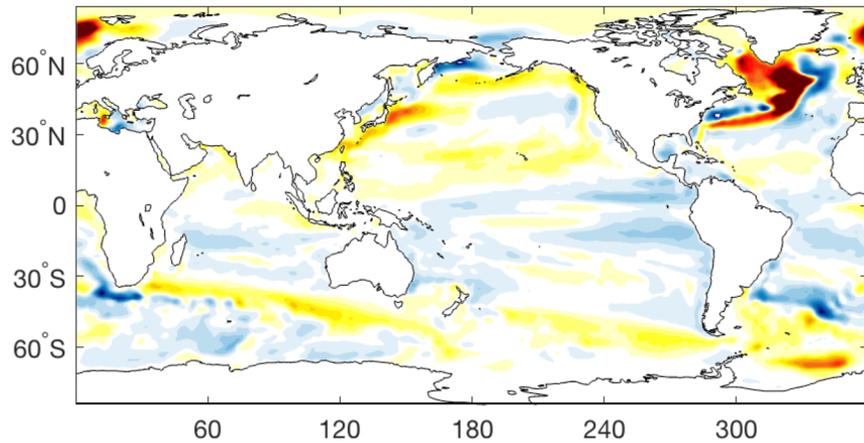
# ZONAL MEAN $T_s$ RESPONSE

**A Zonal-mean  $T_s$  anomaly**

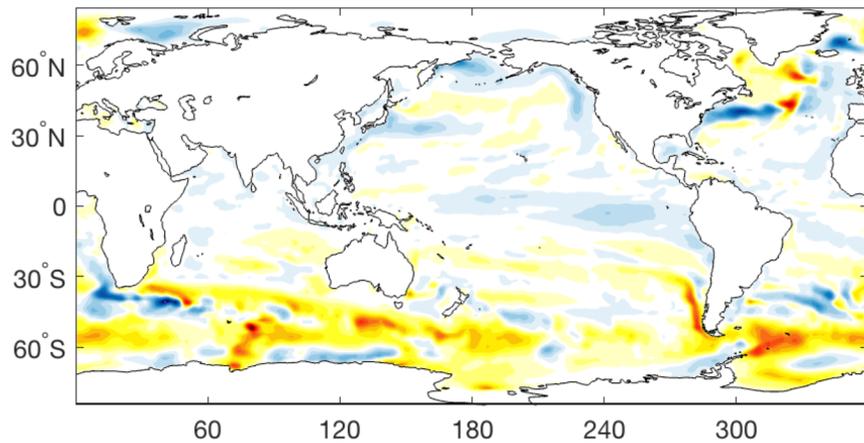


# SFC ENERGY FLUX RESPONSE

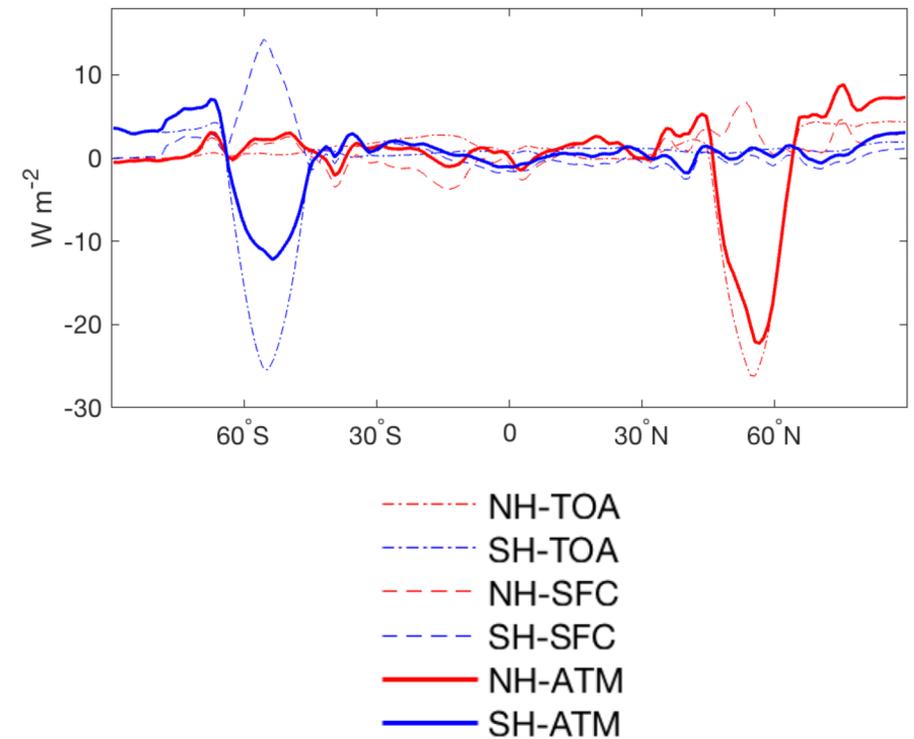
**A DOM-NH**



**B DOM-SH**



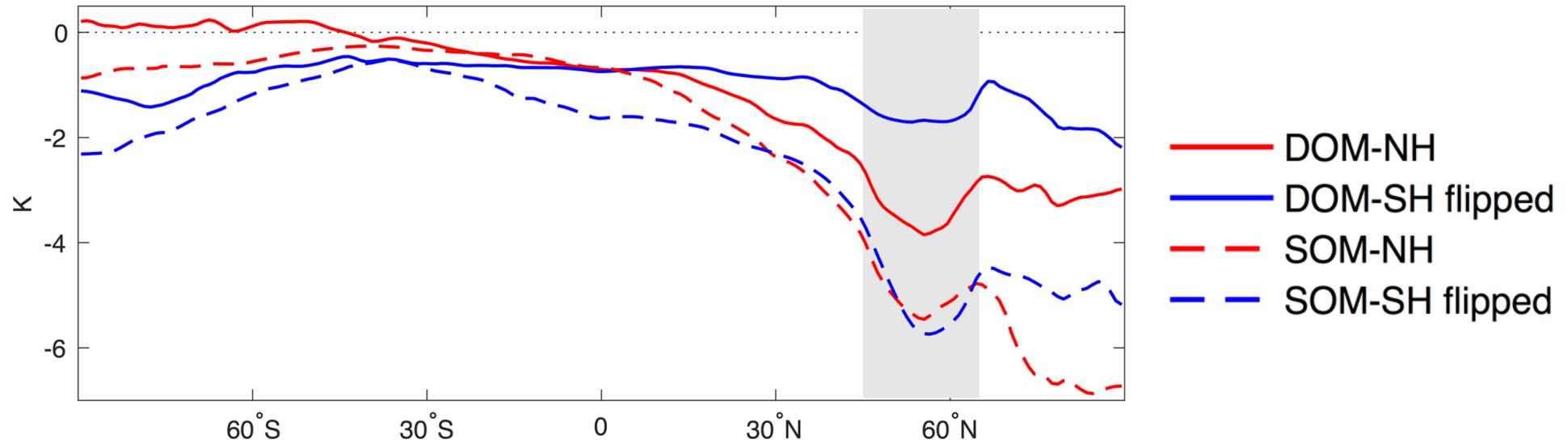
**C Zonal-mean flux anomalies**



+: into the atmosphere

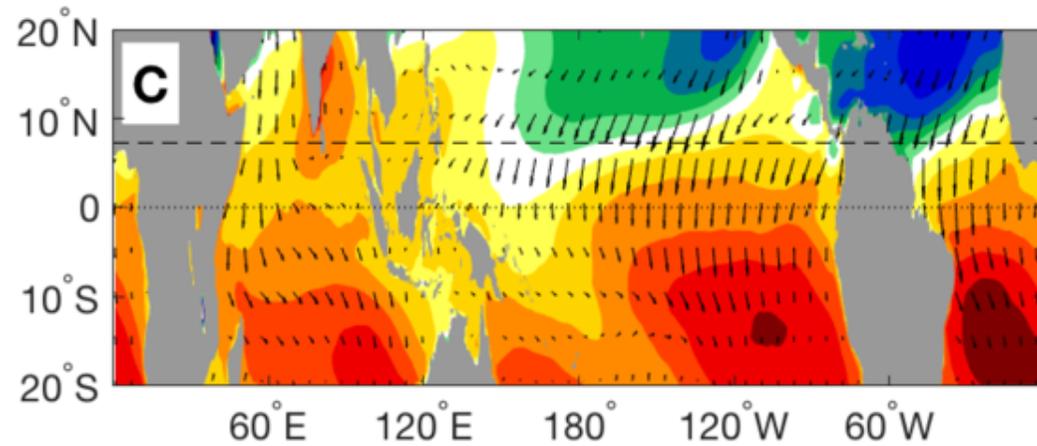
# ZONAL MEAN $T_s$ RESPONSE

**A Zonal-mean  $T_s$  anomaly**

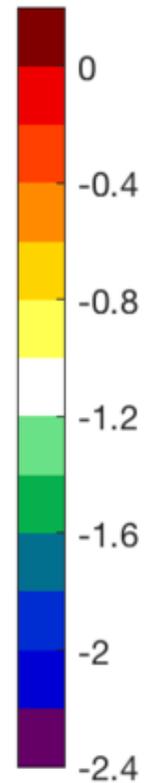
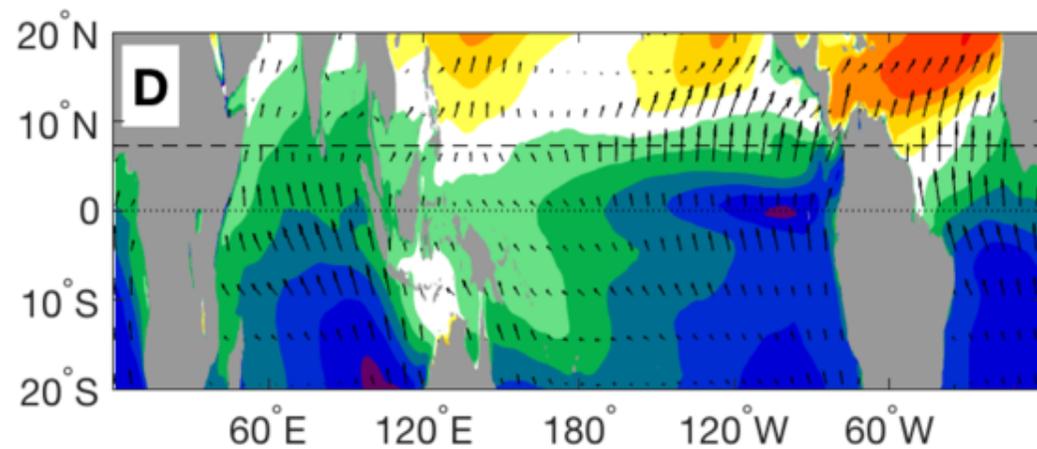


# TROPICAL $T_s$ RESPONSE

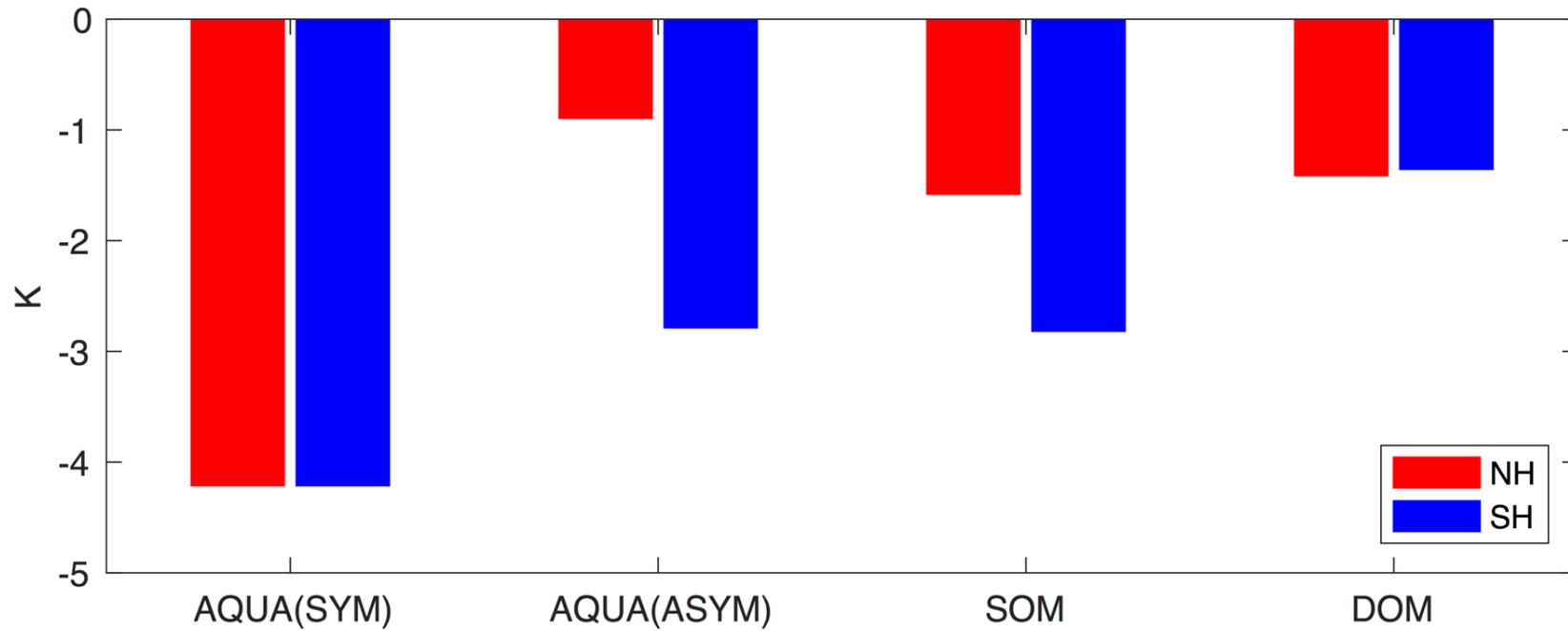
## SOM-NH

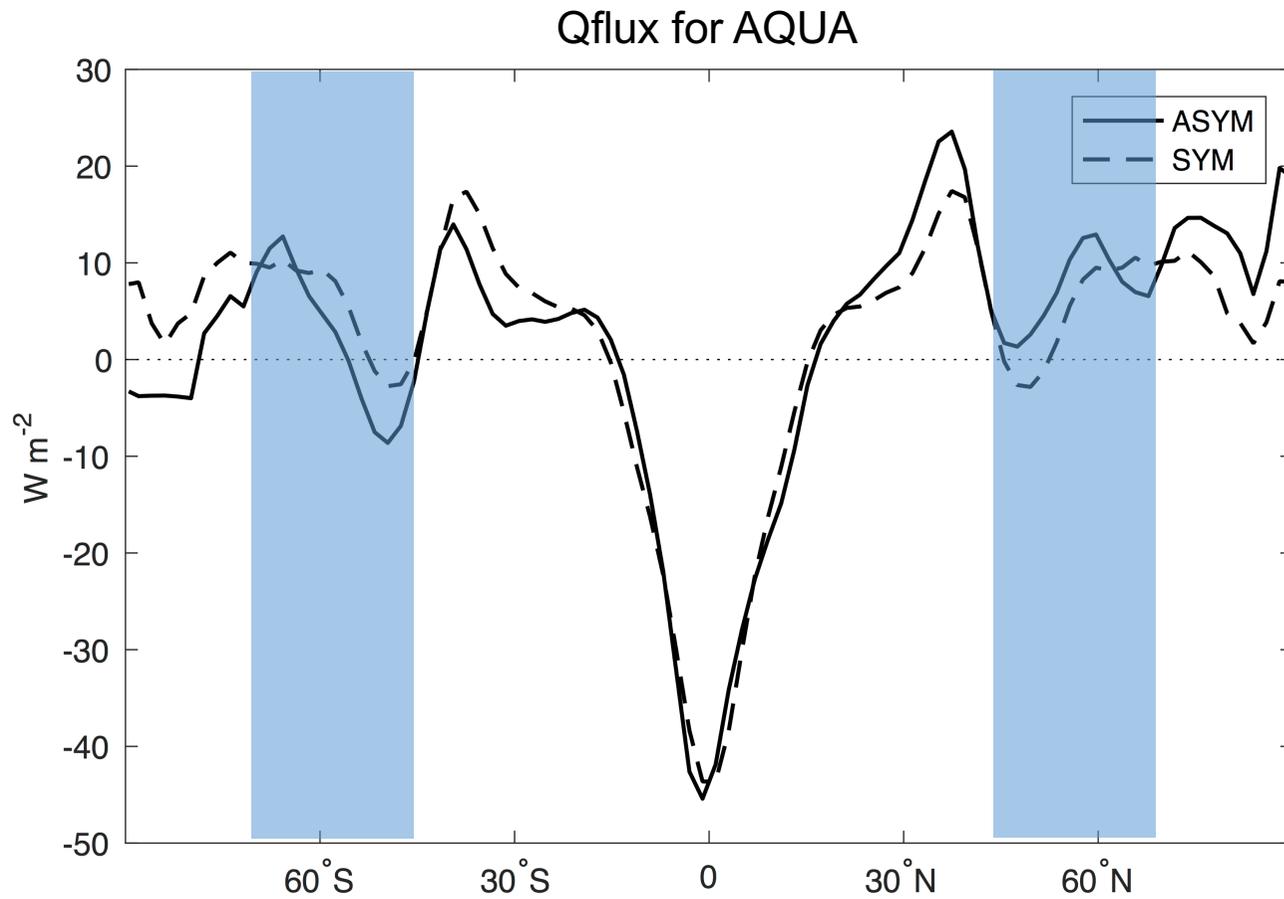


## SOM-SH



## C Equatorial $\Delta T$ at 270 hPa

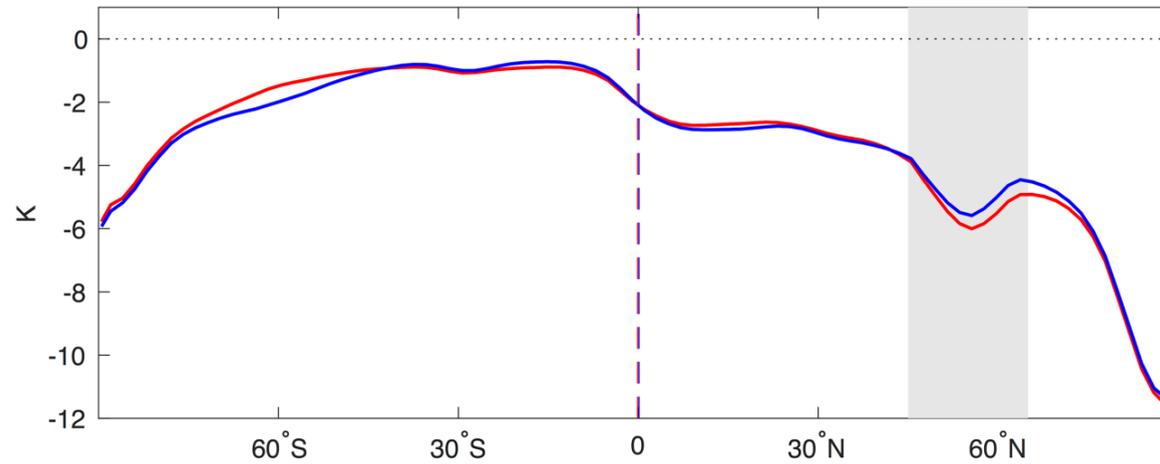




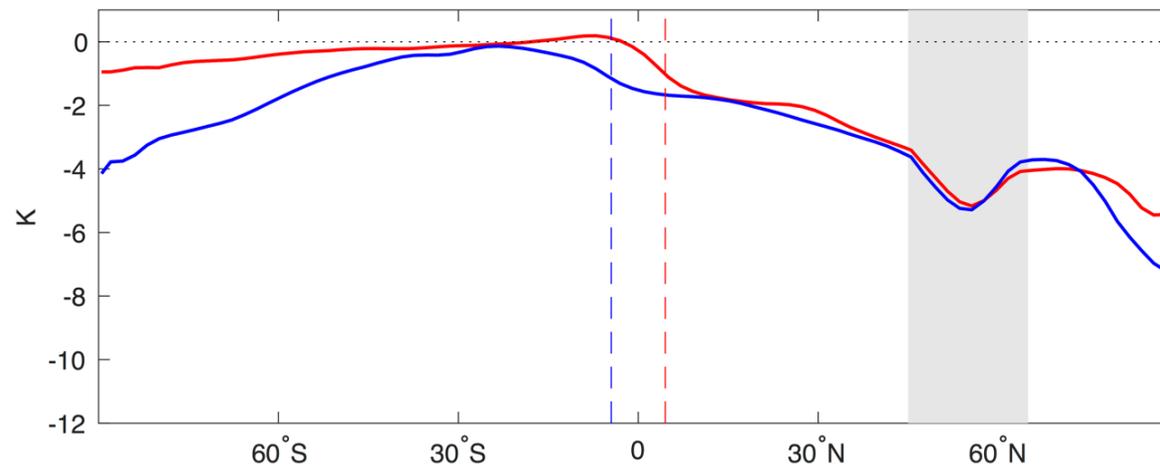
Qflux for AQUA(ASYM): Net surface heat flux from observations (Frierson et al. 2013)

# ZONAL MEAN $T_s$ RESPONSE IN AQUA

**A AQUA(SYM)**



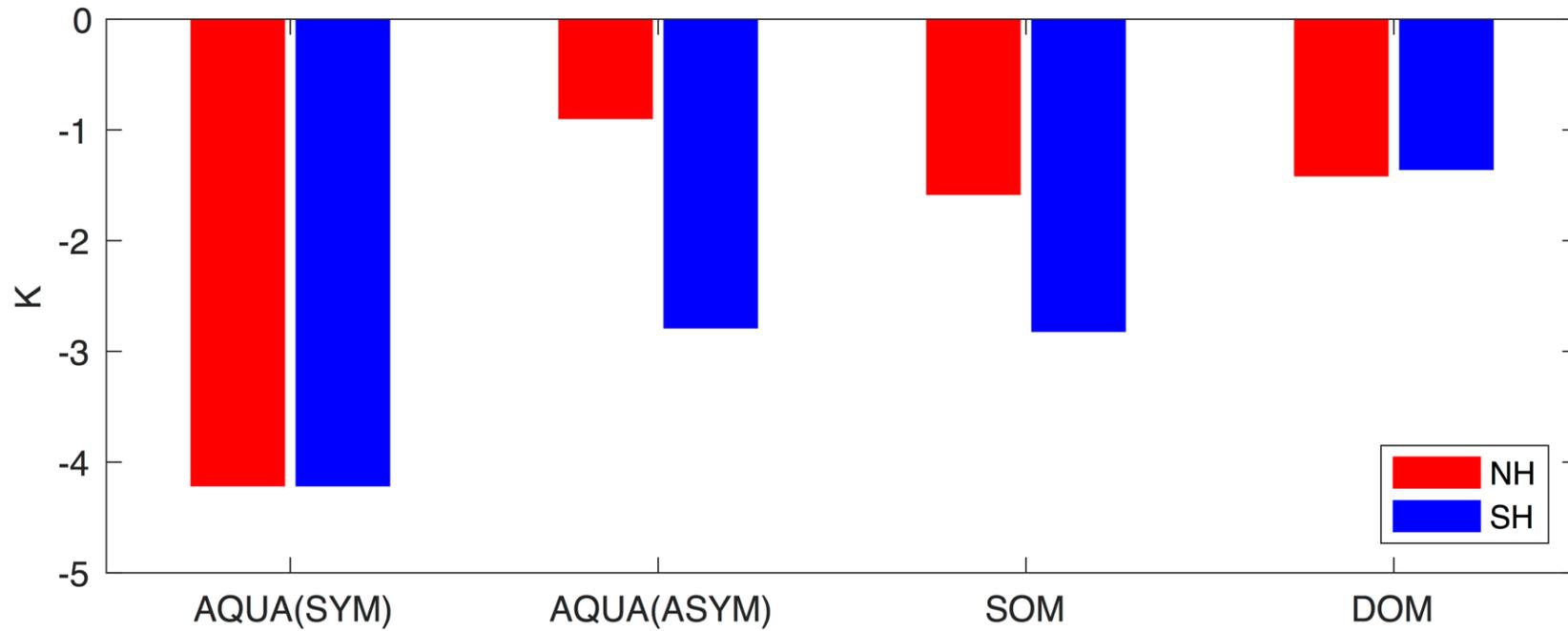
**B AQUA(ASYM)**



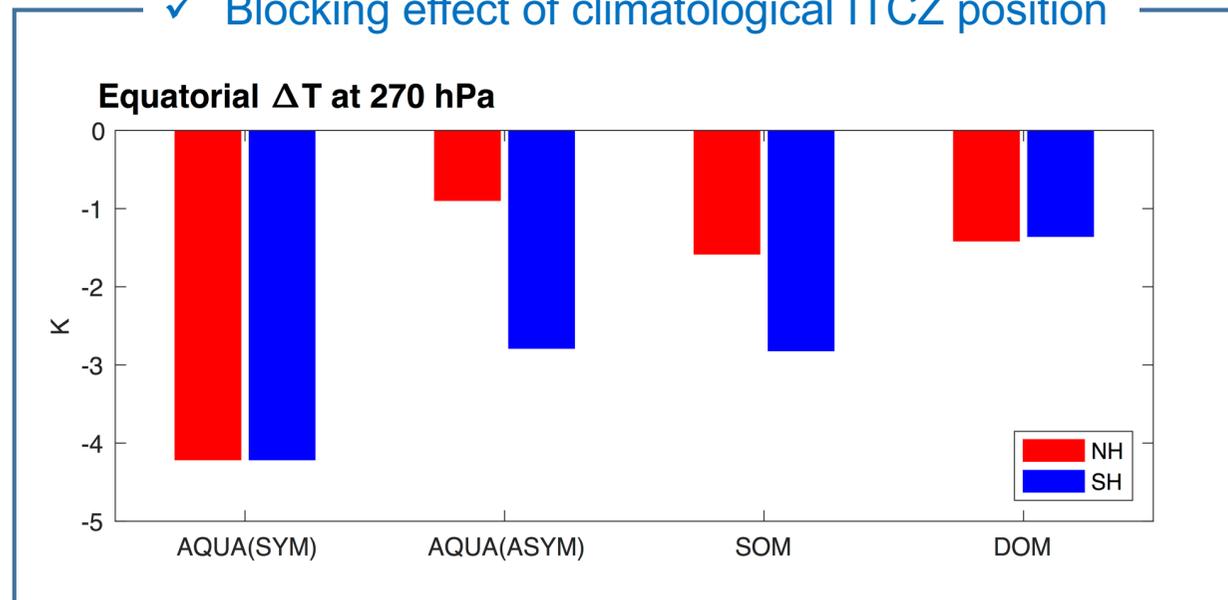
— NH — SH flipped

# BLOCKING EFFECT OF CLIMATOLOGICAL ITCZ POSITION

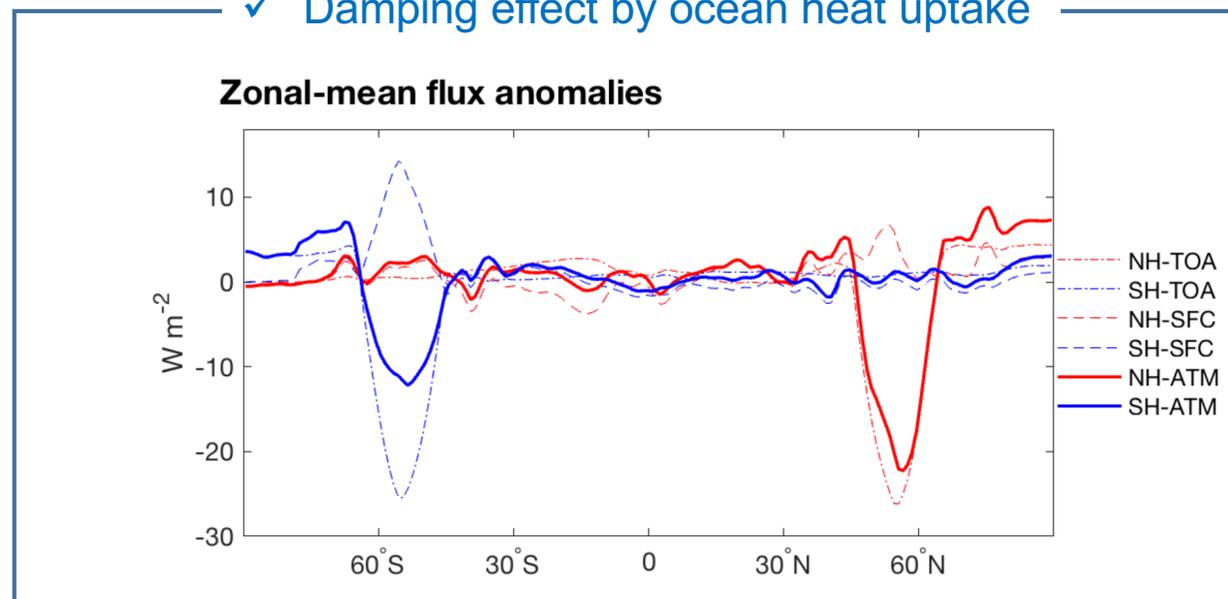
**C** Equatorial  $\Delta T$  at 270 hPa



✓ Blocking effect of climatological ITCZ position



✓ Damping effect by ocean heat uptake

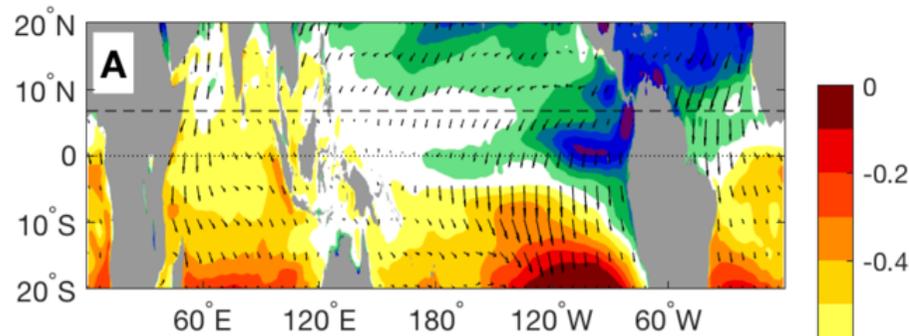


# PATTERN OF TROPICAL RESPONSES

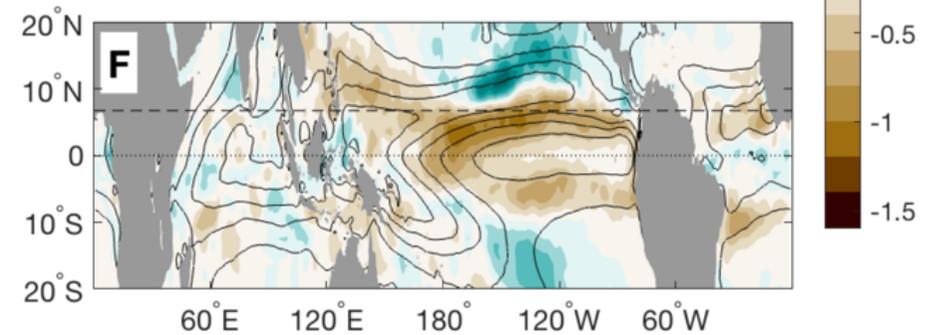
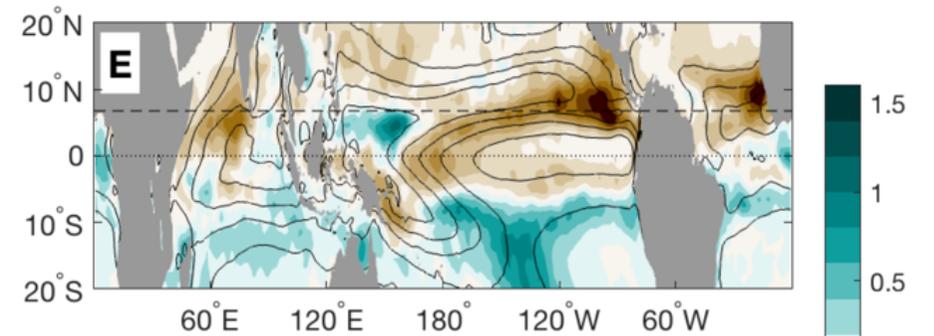
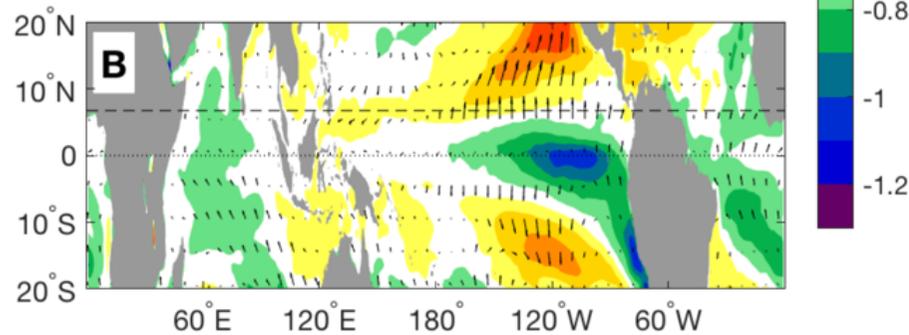
Surface temp response

Precip response

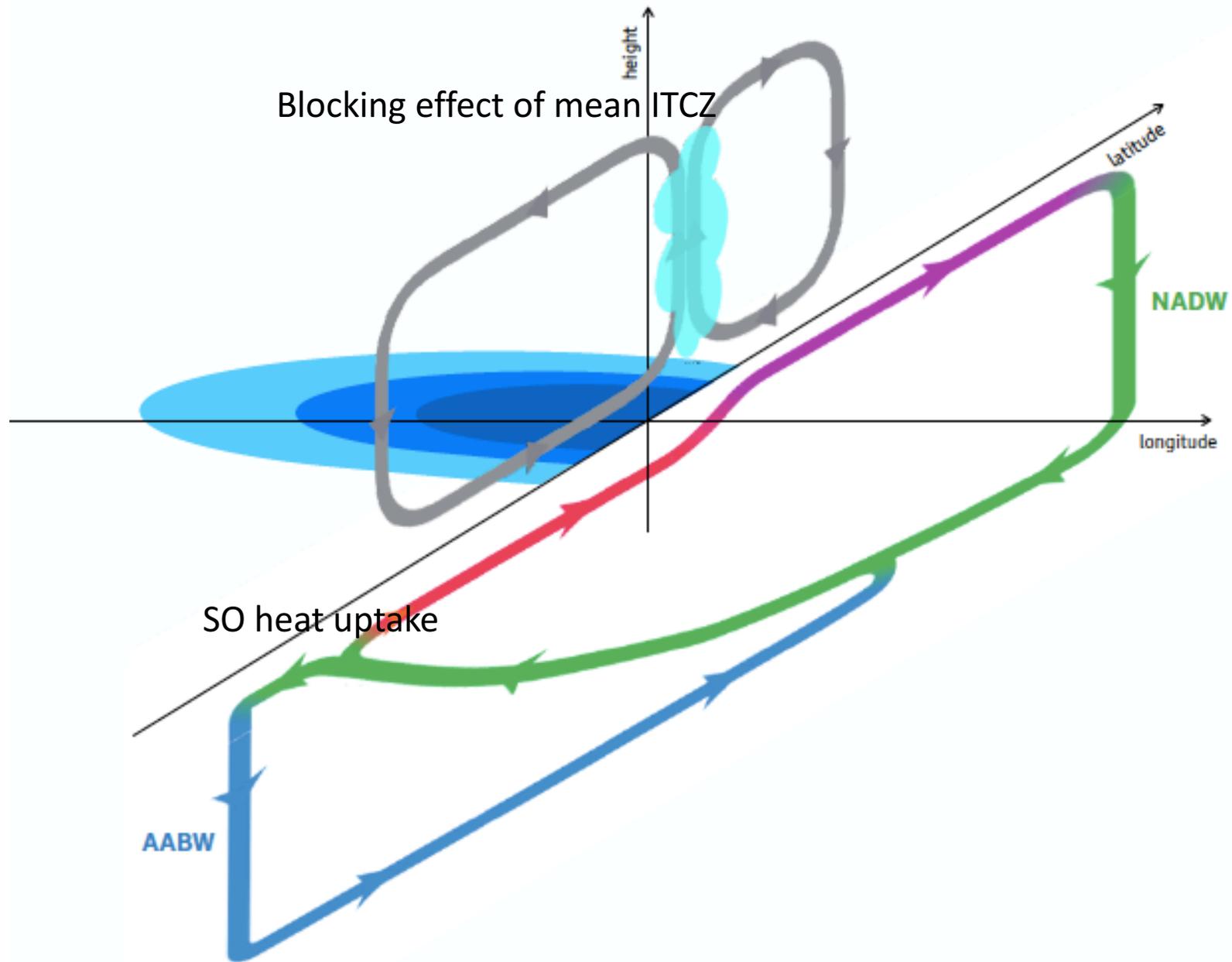
**DOM-NH**



**DOM-SH**



# SUMMARY



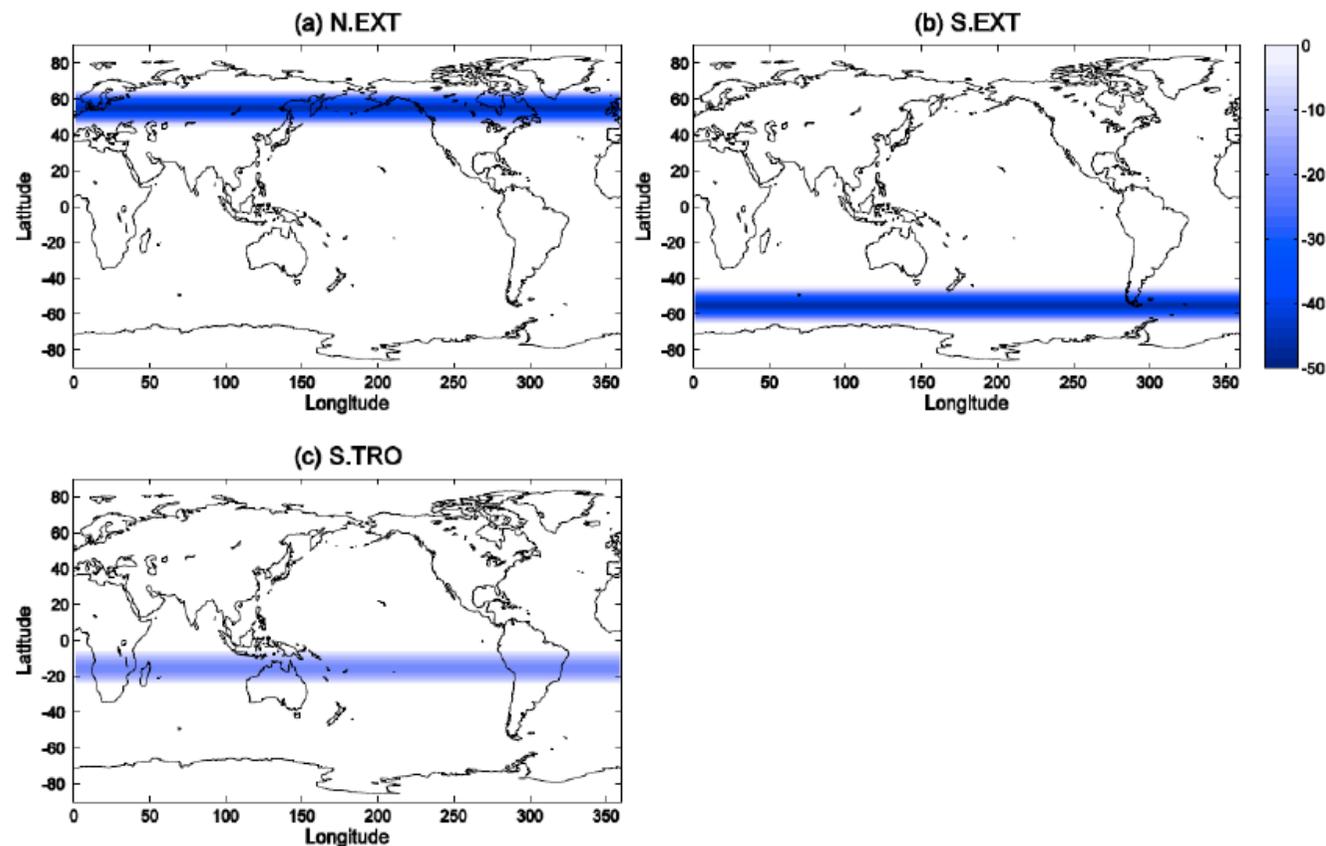
## Propose of Extratropical-Tropical Interaction Model Intercomparison Project

by

S. M. Kang, Y.-T. Hwang, M. Hawcroft, and B. Xiang

## Tier 1 experiments

[Model: GFDL CM4, HadGEM, MIROC, NCAR CESM, NorESM, ECHAM, UCLA CGCM]



Thank you for your attention