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

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Annual mean precipitation

Inter-Tropical Convergence Zone (ITCZ)

Data: 2001-2010 from GPCP Version 2.1
Adopted from Frierson et al. (2013)
**EXTRATROPICAL IMPACT ON THE ITCZ**

Chiang and Bitz (2005)
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

Kang et al. (2008, 2009)
LATE 20th CENTURY AEROSOL FORCING EFFECTS

Hwang et al. (2013)
Precipitation response (mm/day)

Xiang et al. (2018)
MODEL EXPERIMENTS

• 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
SOM RESPONSE

\[ R = -0.76 \]
$R = -0.76$
DOM RESPONSE

DOM-NH (Aerosol cooling)

DOM-SH (Southern Ocean cooling)

\[ R = 0.33 \]
A Zonal-mean $T_s$ anomaly

- **DOM-NH**
- **DOM-SH flipped**
- **SOM-NH**
- **SOM-SH flipped**

Graph showing zonal mean $T_s$ anomaly with different lines representing various scenarios or models.
SFC ENERGY FLUX RESPONSE

A DOM-NH

B DOM-SH

+: into the atmosphere

C Zonal-mean flux anomalies

NH-TOA
SH-TOA
NH-SFC
SH-SFC
NH-ATM
SH-ATM
A. Zonal-mean $T_s$ anomaly

- DOM-NH
- DOM-SH flipped
- SOM-NH
- SOM-SH flipped
TROPICAL $T_s$ RESPONSE

SOM-NH

SOM-SH
BLOCKING EFFECT OF CLIMATOLOGICAL ITCZ POSITION

C Equatorial \( \Delta T \) at 270 hPa

- AQUA(SYM)
- AQUA(ASYM)
- SOM
- DOM

NH
SH
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)

- Red: NH
- Blue: SH flipped
BLOCKING EFFECT OF CLIMATOLOGICAL ITCZ POSITION

C Equatorial $\Delta T$ at 270 hPa

- AQUA(SYM)
- AQUA(ASYM)
- SOM
- DOM

**K**

- NH
- SH
PHYSICAL MECHANISMS

- Blocking effect of climatological ITCZ position

Equatorial ΔT at 270 hPa

- Damping effect by ocean heat uptake

Zonal-mean flux anomalies
PATTERN OF TROPICAL RESPONSES

Surface temp response

Precip response

DOM-NH

DOM-SH

A

B

E

F
SUMMARY

Blocking effect of mean ITCZ

SO heat uptake
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