AMWG 2025 - Atmospheric Variability in CESM3
(Timestep) Daily to Sub-seasonal

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AMWG Winter Workshop

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Simulations

CESM3 (121)
- BLT1850 pre-industrial (101-150), L58
- BLTHIST historical (ens. 01)

CESM2 (LENS2)
- B1850 pre-industrial (501-550), L32
- BHIST historical (ens. 1001-01)

CESM1 (LENS1)
- BHIST historical (ens. 001)

CAM7
- FLTHIST, L58

CAM6
- FHIST, L32

CAM7_noZM-PBL
- FLTHIST, L58

GPCP: (2000-2009)
TRMM: (2000-2013)
ERA5 (1979-2005)
MERRA (1979-2005)

Atmospheric Blocking 

Monsoons 

Tropical Waves 

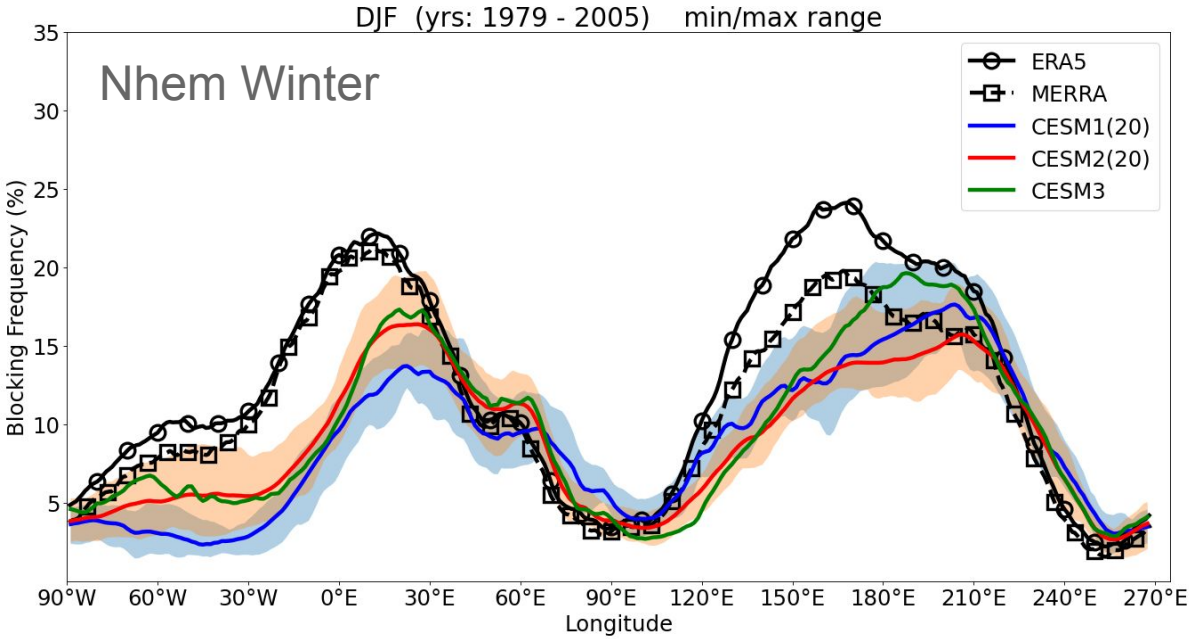
Madden Julan Oscillation (MJO) 

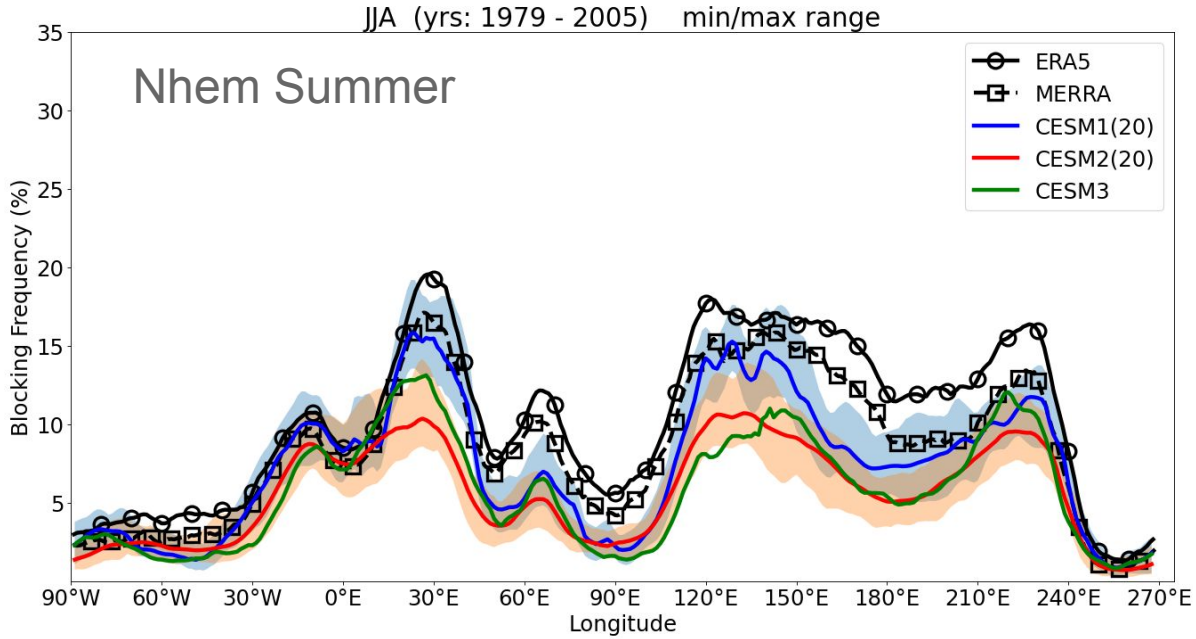
Diurnal Cycle ? 

Convection Precipitation Relationships 

1 degree
Daily averages
3-hourly averages

Atmospheric Blocking



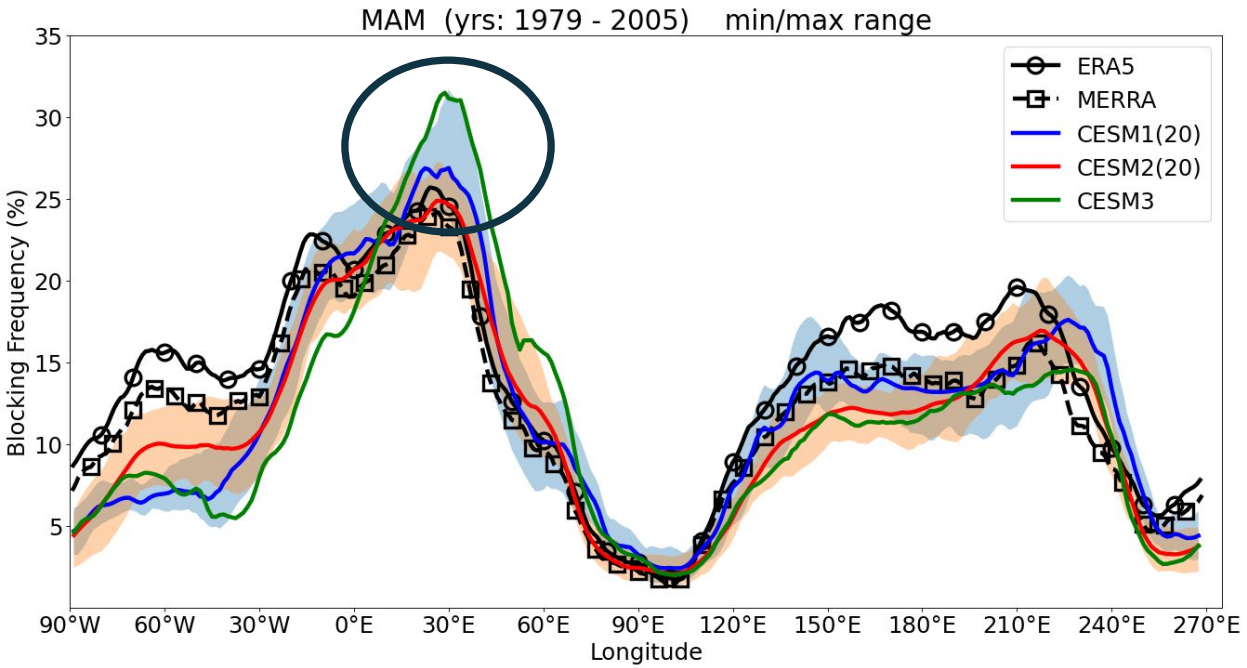


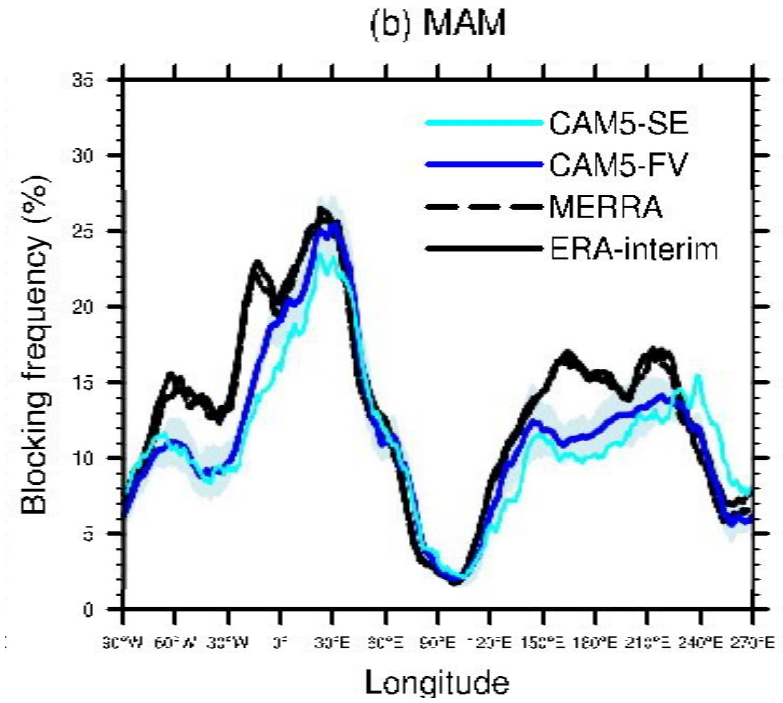
- Atlantic winter ‘hole’ remains (Greenland)
- Similar performance to CESM2
- Underestimates summer frequency
- Although, this metric is a poorer representation

Meridional gradients of daily 500-mb height

“Atmospheric blocking is a weather pattern where a stationary high-pressure system disrupts typical atmospheric flow, causing prolonged weather conditions like heatwaves, cold spells, or heavy rainfall over specific regions.”

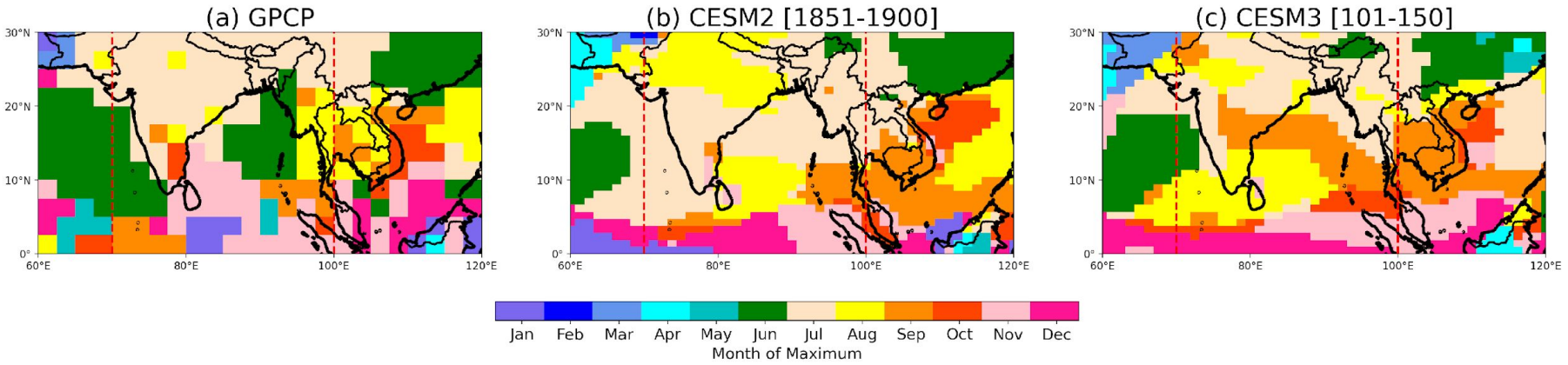
Atmospheric Blocking

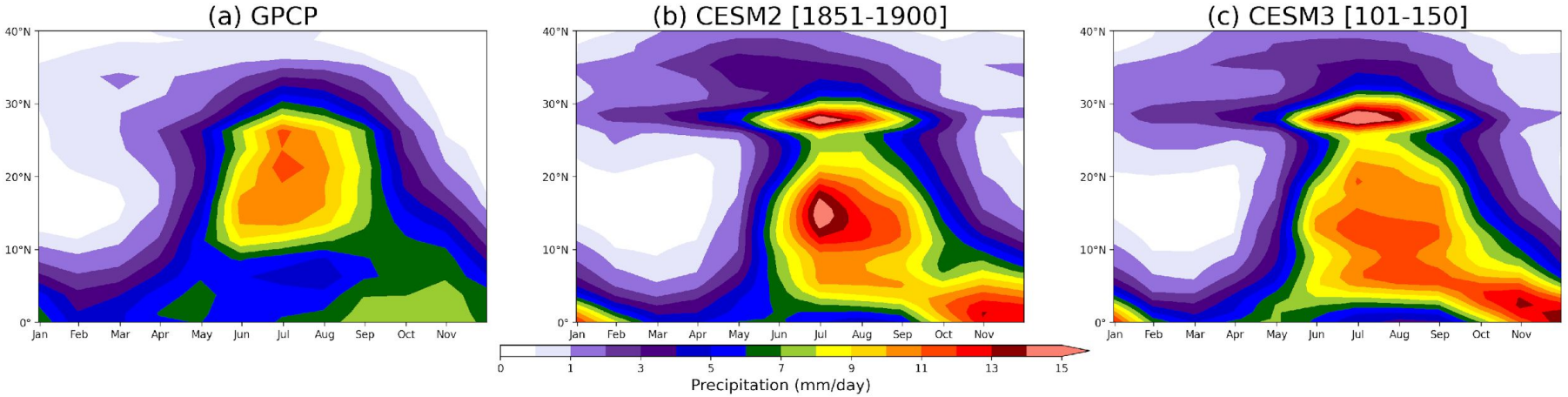




- Spectral element vs. finite volume (CAM6 -> CAM7)
- Does not seem to play a role

Monsoons





South Asian Monsoon

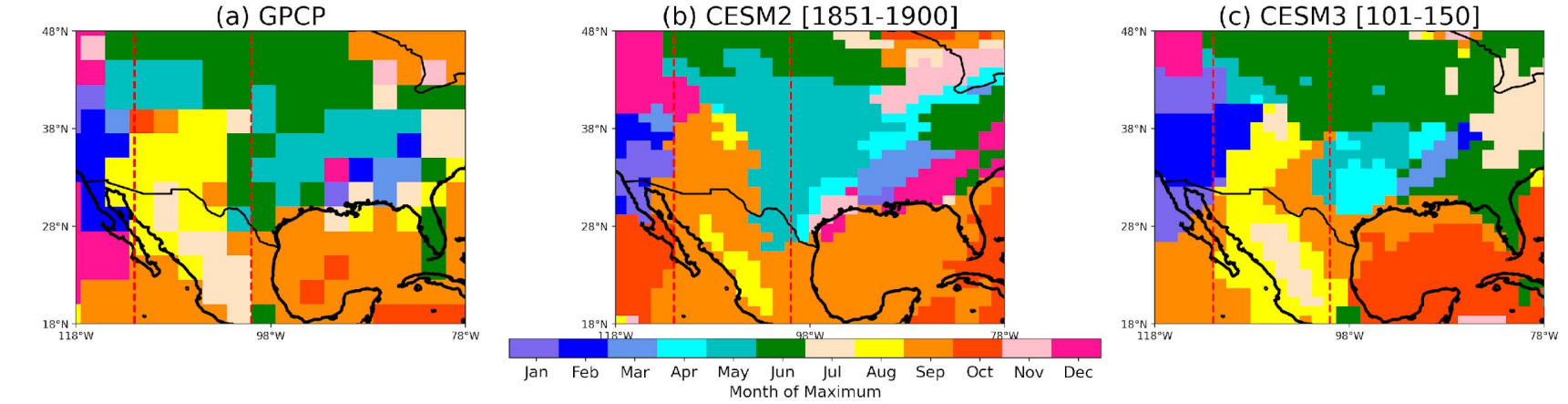
Monthly mean phase (month of precip. Peak)

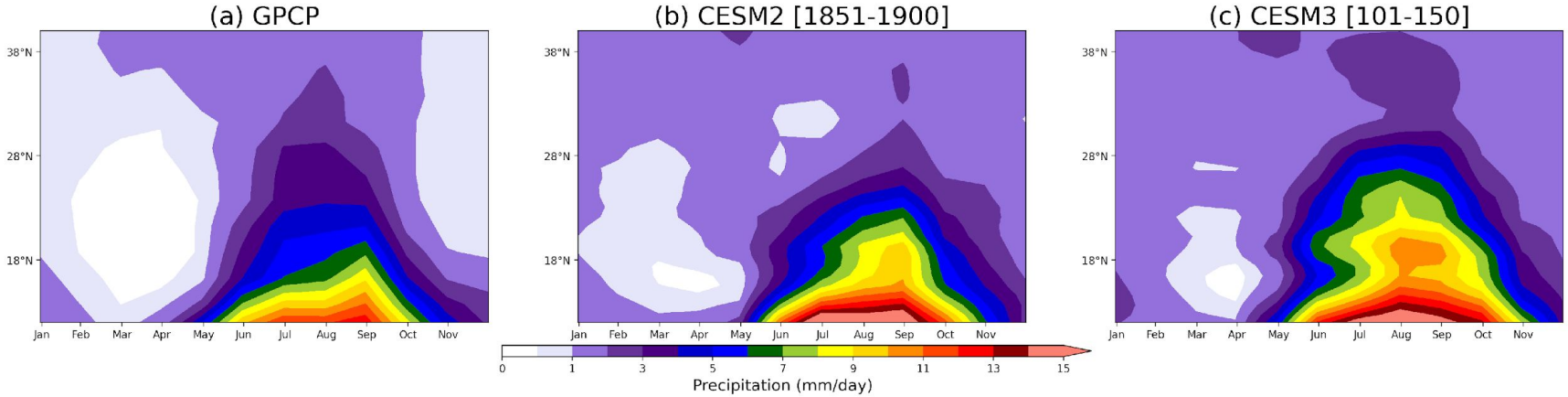
- Peak largely in Jul
- Too late (Jul -> Aug/Sep)
- Later than CESM2

Monthly Mean Variation (between red lines above)

- Weaker then CESM2 in Indian region
- Start of October Jump?
- Intense contribution from mean Himalayan bias

Monsoons





North American Monsoon

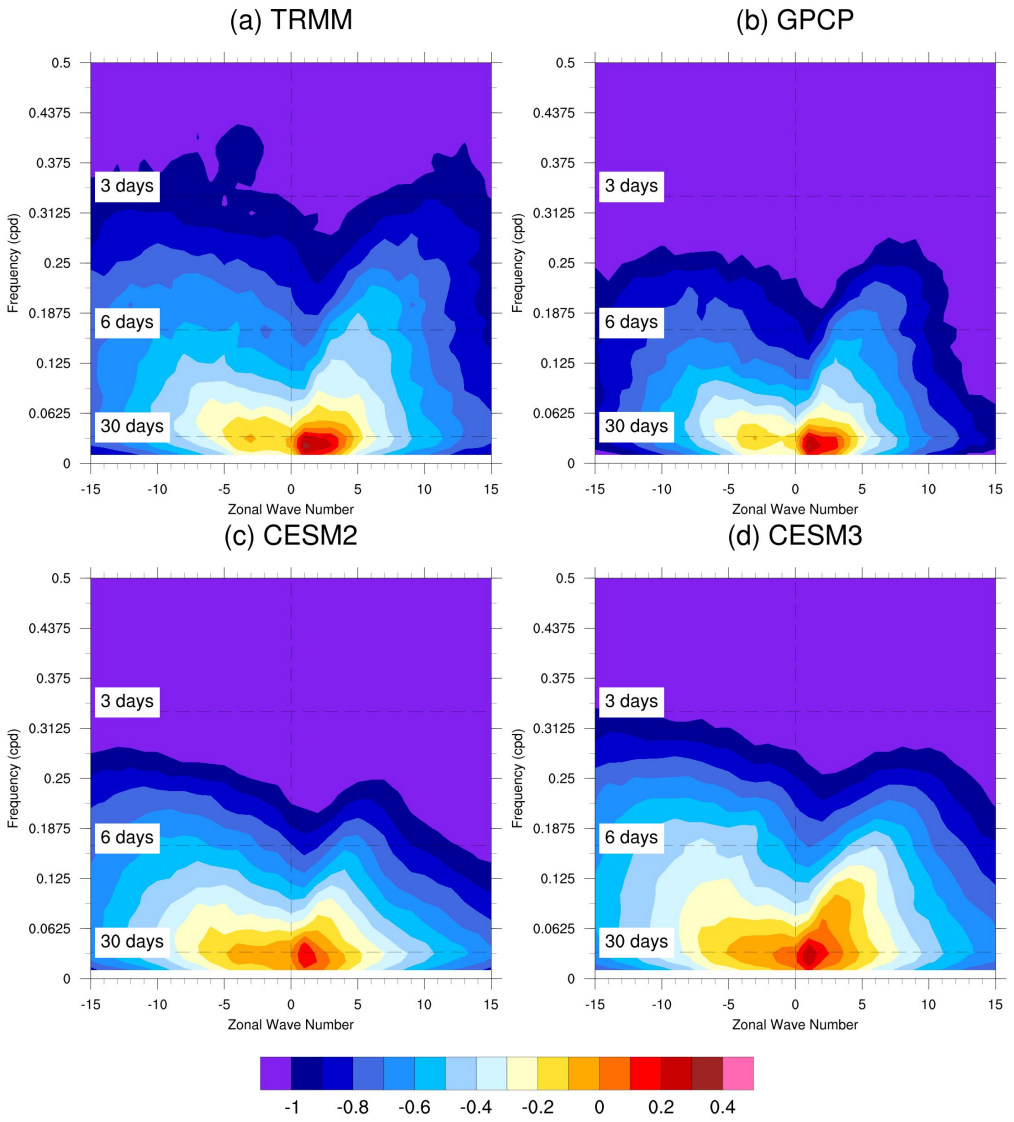
Monthly mean phase (month of precip. Peak)

- CESM3 less dominated by the May peak
- Core NAM region has better Aug peak

Monthly Mean Variation (between red lines above)

- Spurious secondary peak at 12N
- Improved northward extension?

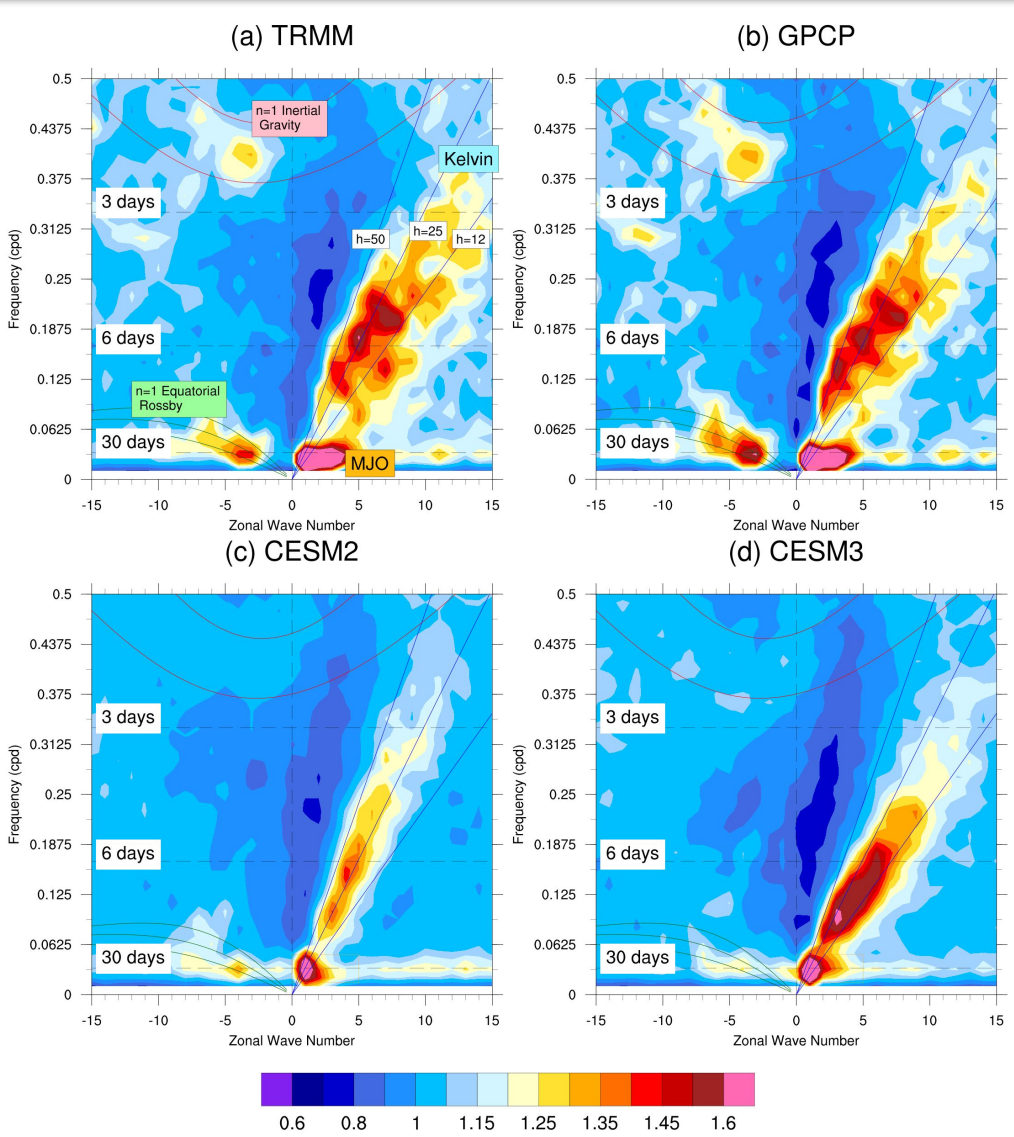
Tropical Waves – Unfiltered



2D Fourier decomposition of daily precipitation along the equator in longitude (pre-industrial)

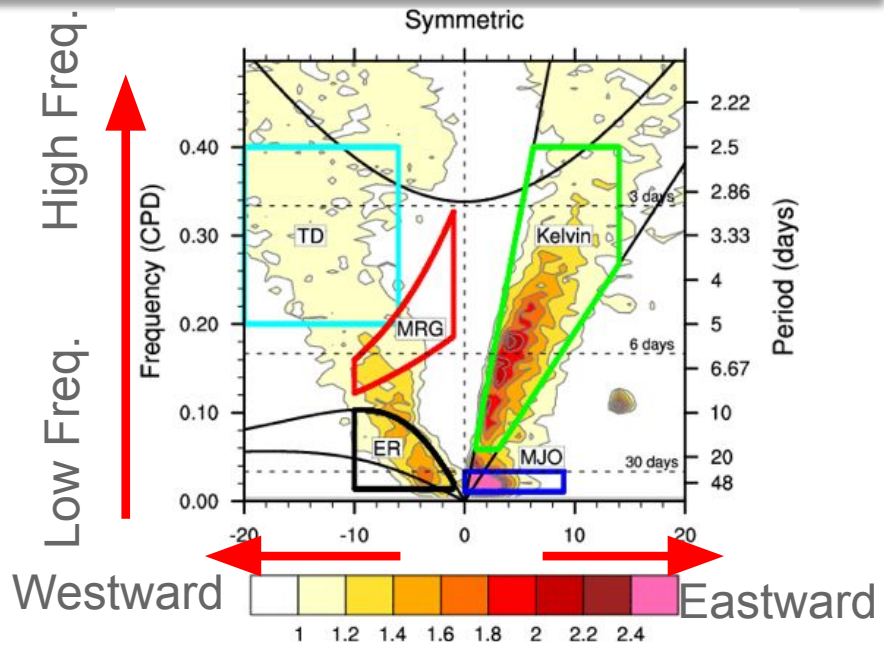
- CESM3 maintains CESM2 skill
- May even be better when compared with TRMM
- What do the wave mode structures look like?

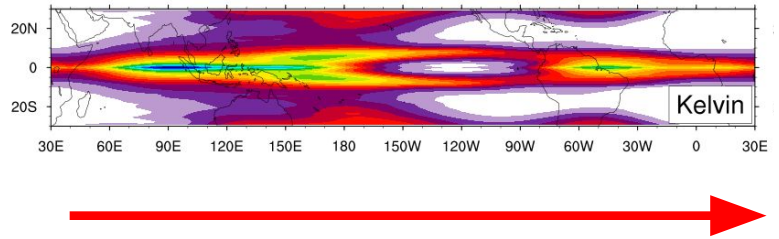
Tropical Waves – Symmetric Modes



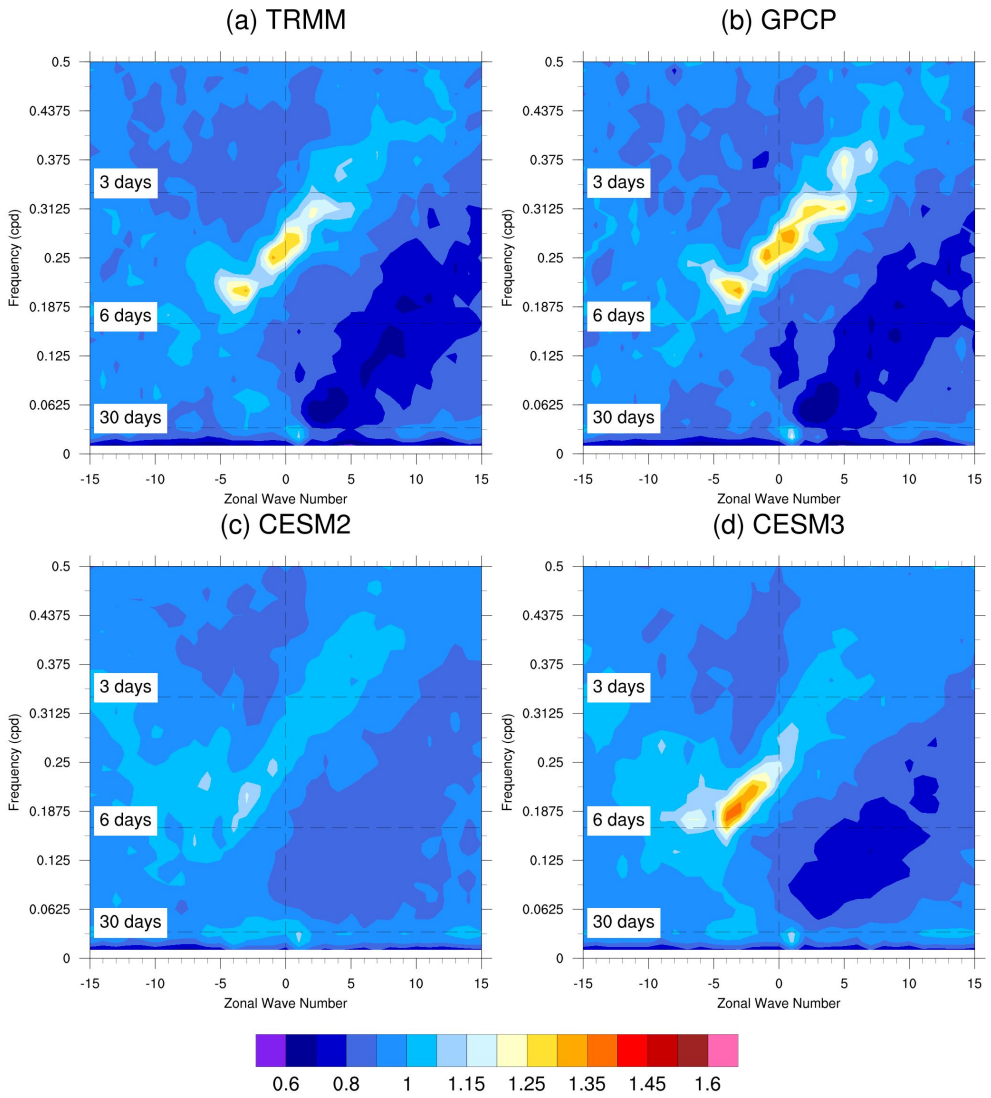
Result of removing a smoothed back ground spectrum reveals symmetric modes.

- CESM3 improves on CESM for Kelvin wave mode.
- Maintains MJO power (next!)



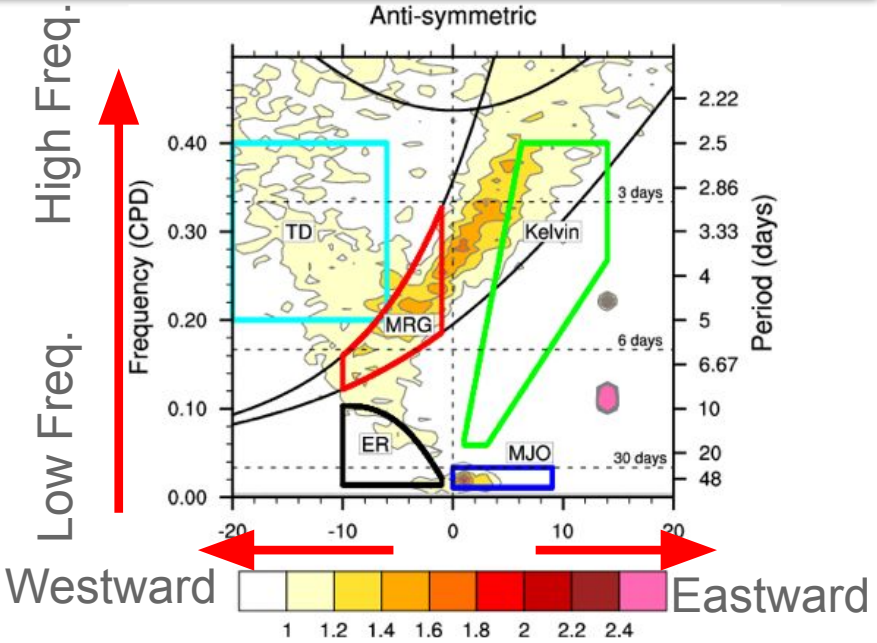


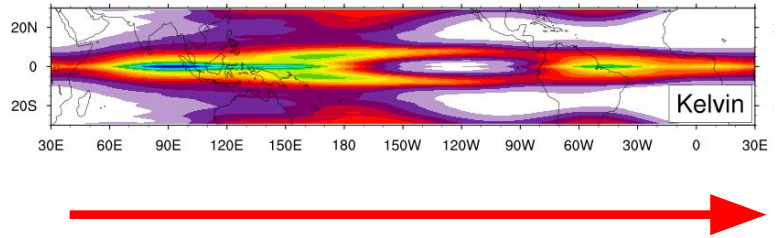
Tropical Waves – Antisymmetric Modes



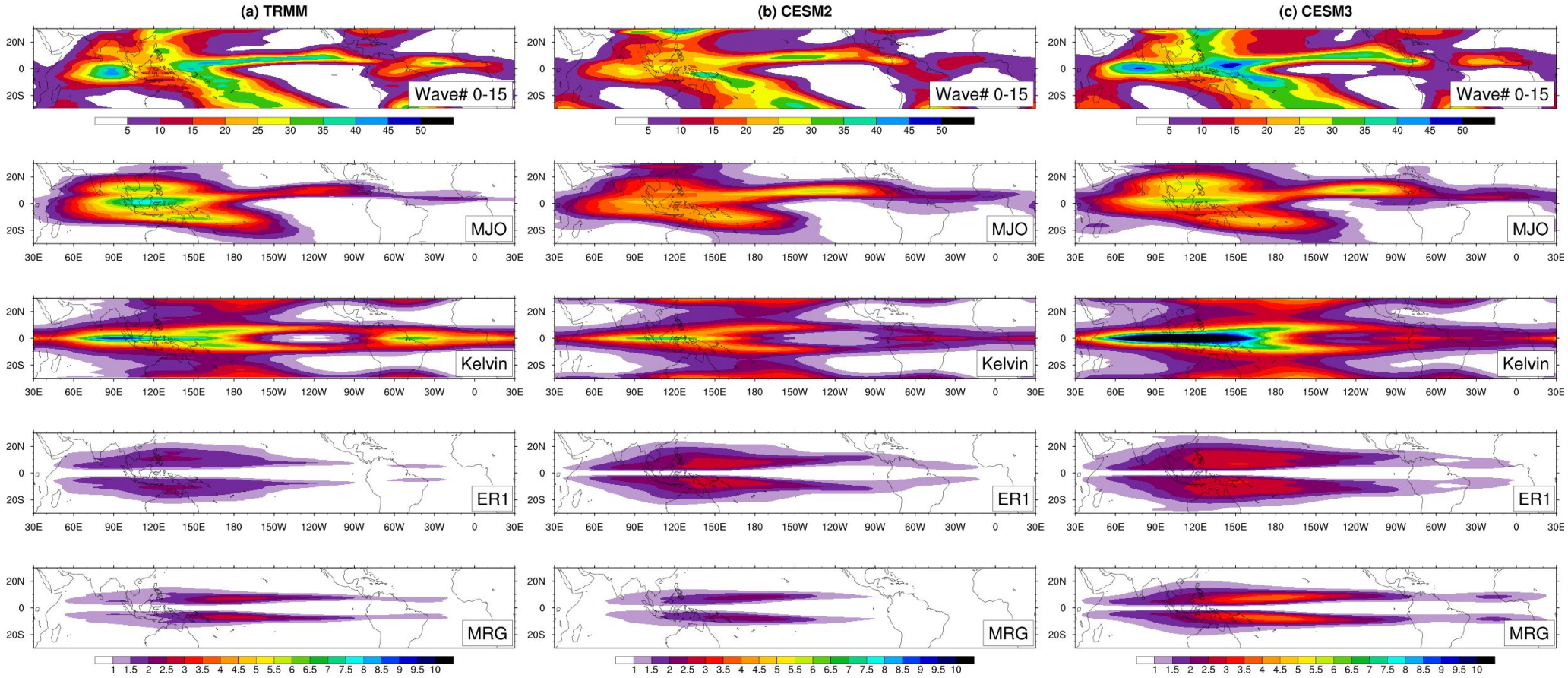
Result of removing a smoothed back ground spectrum reveals antisymmetric modes.

- CESM3 has significant power in Mixed Rossby Wave modes
- Absent previously

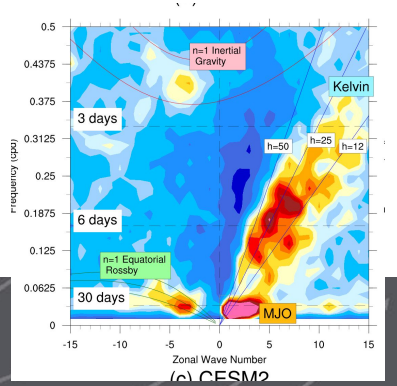




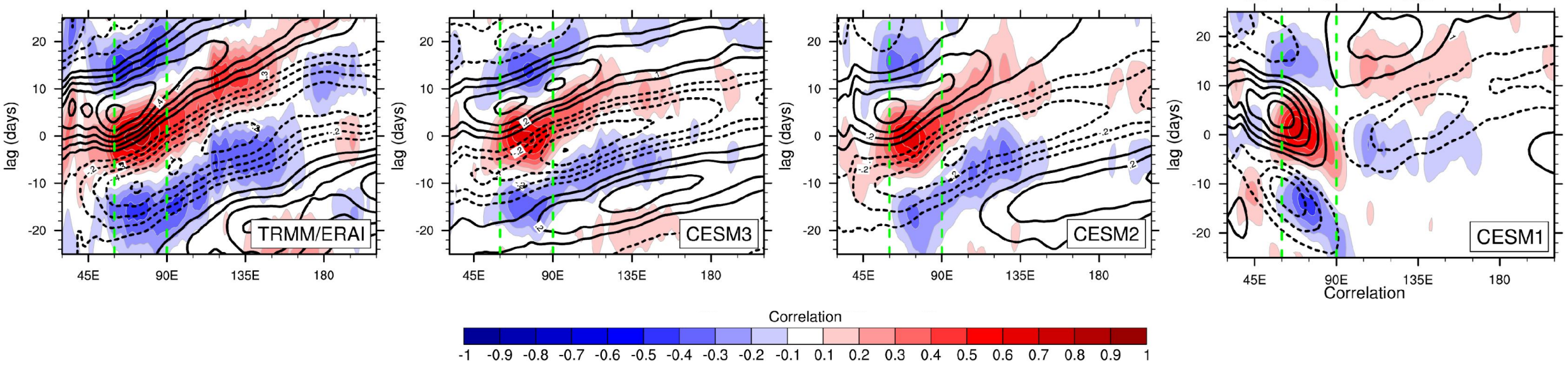
Tropical Waves – Annual Modes



- Overall increased power of the spectrum reflected in waves modes
- MJO improved; Kelvin waves too strong

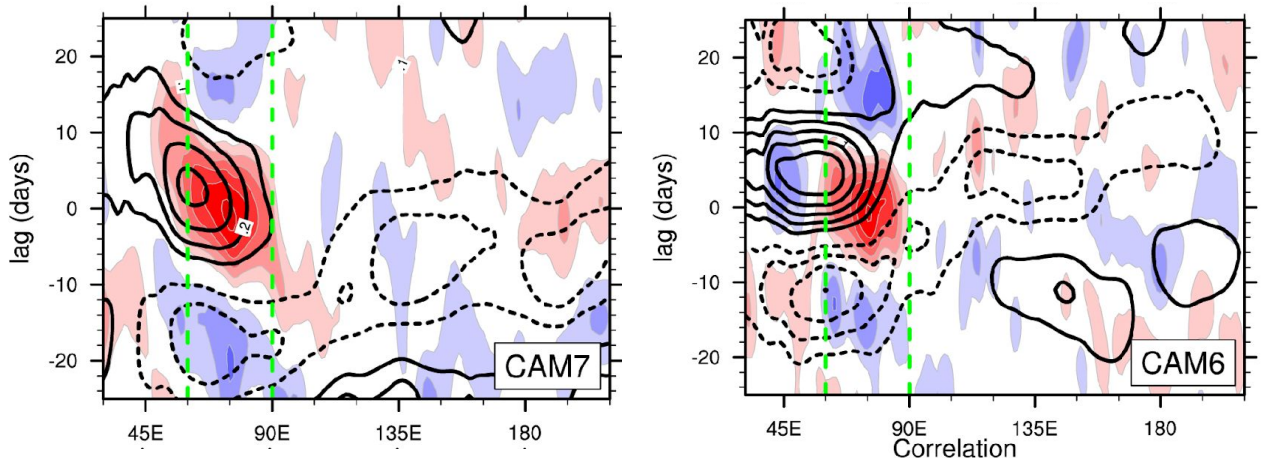


Madden Julian Oscillation (MJO)

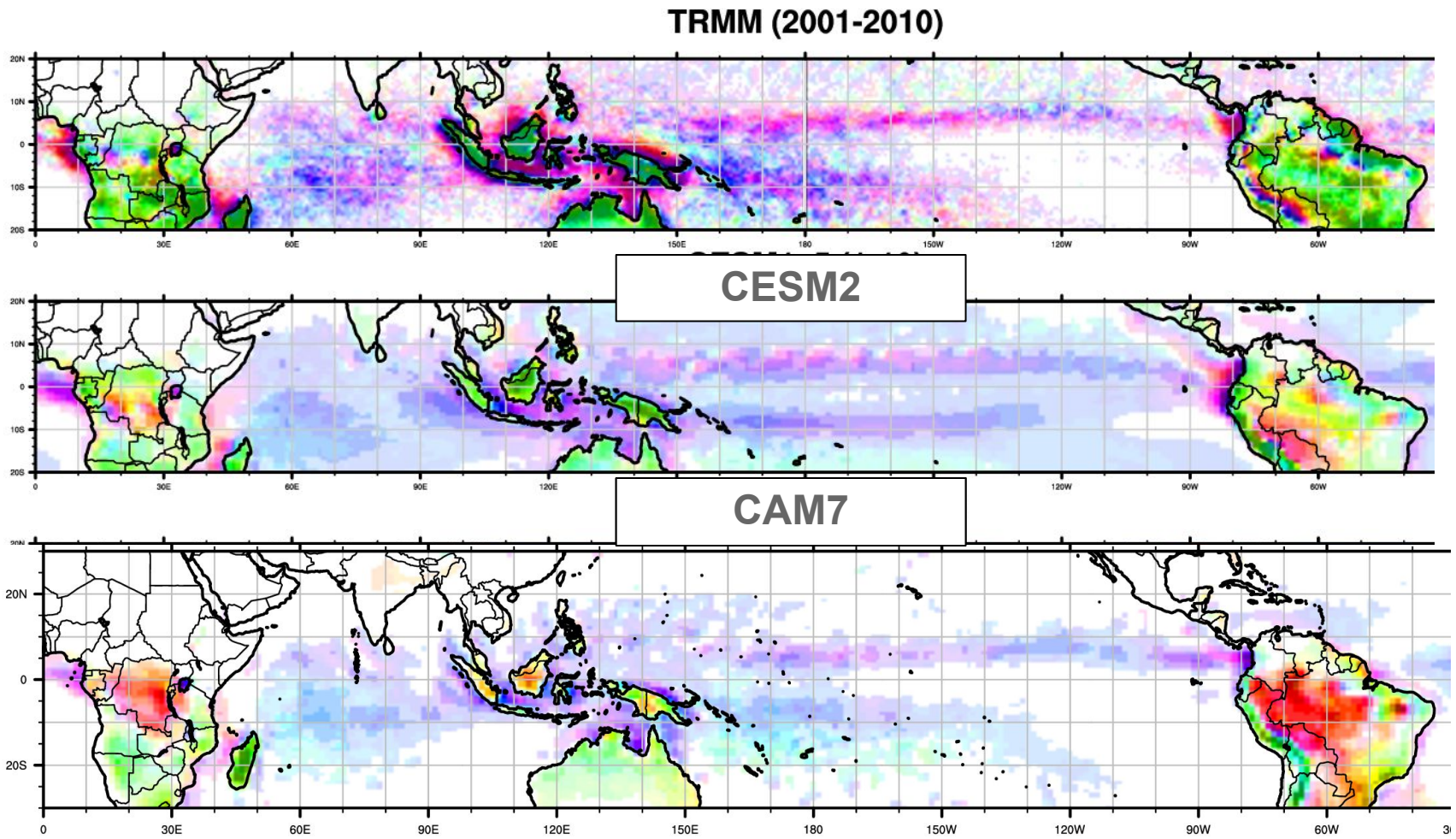


Lag Correlations of U850 (red/blue) and prect (contours) . Intraseasonal filtered daily data (DJF, 0-15S): 1850 + AMIP (1995-2006)

- Very similar to CESM2; faster than obs.
- Stronger coupling into the mid-Pacific?
- Poor skill still remains in the AMIP simulations



Precipitation Statistics



Fair?

Atmospheric Blocking 

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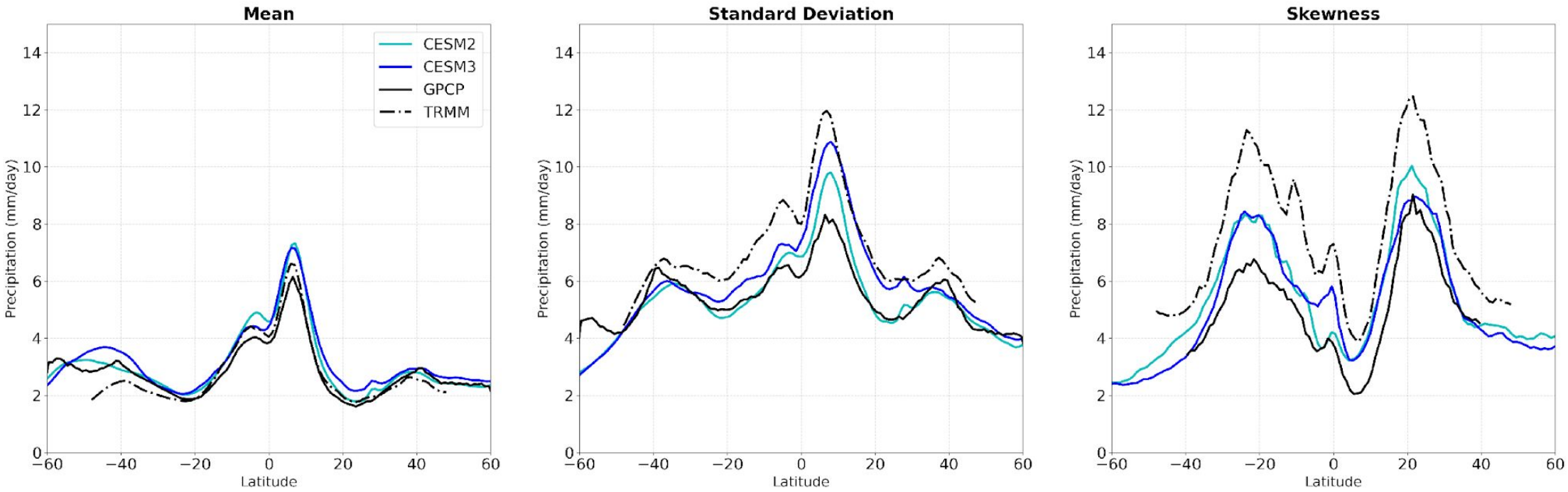
Madden Julian Oscillation (MJO) 

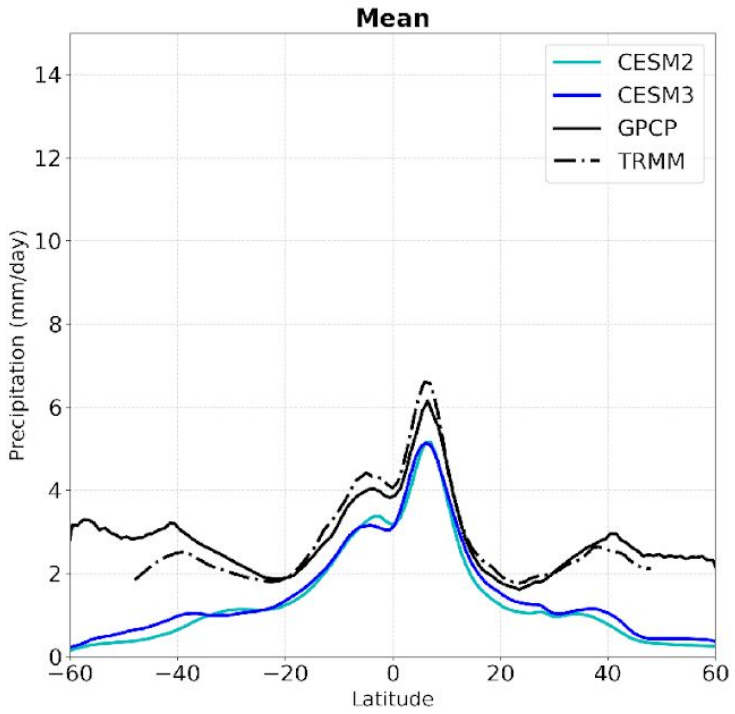
Diurnal Cycle 

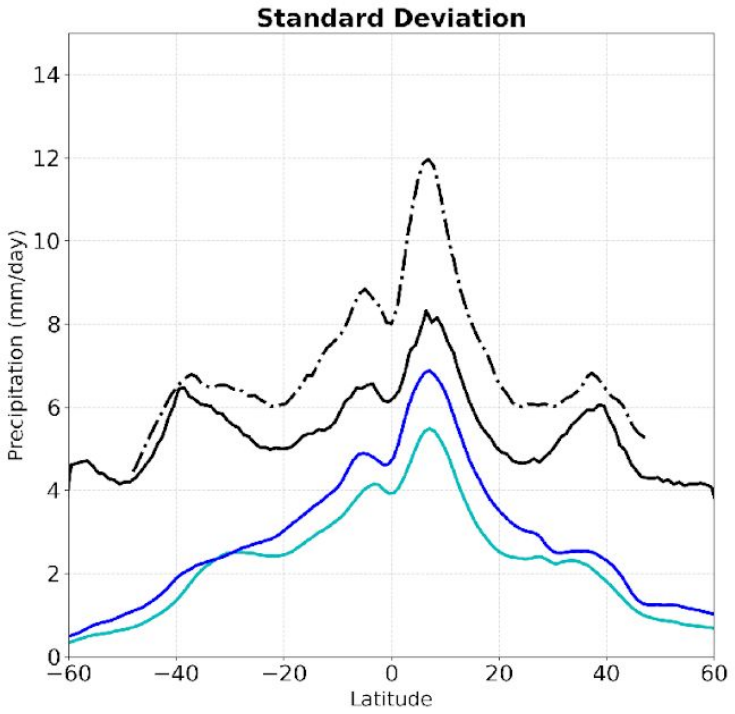
Convection Precipitation Relationships 

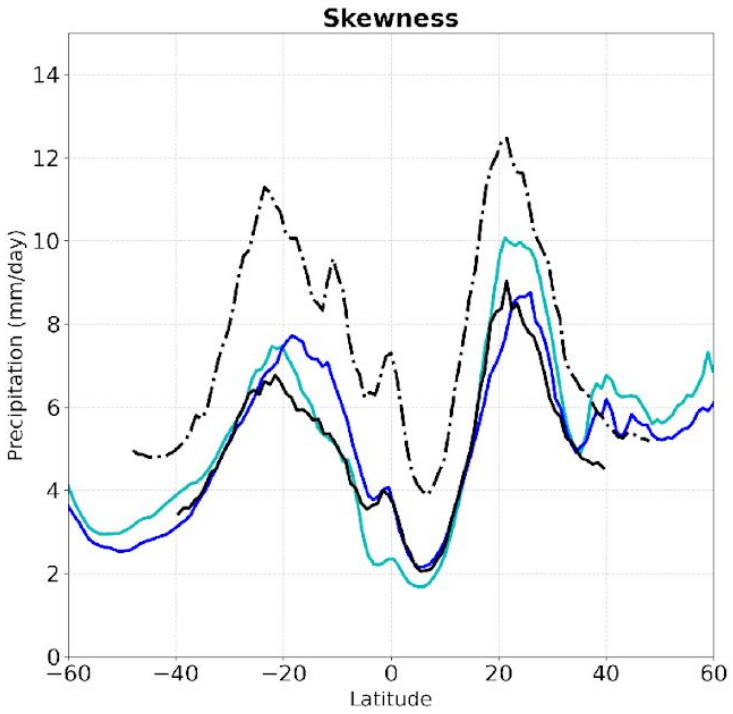
Total Precipitation Statistics



Convective Precipitation Statistics







L32->L58: ZM Parcel Modification