The Madden Julian Oscillation in CAM5/6

Coupling and Improvements

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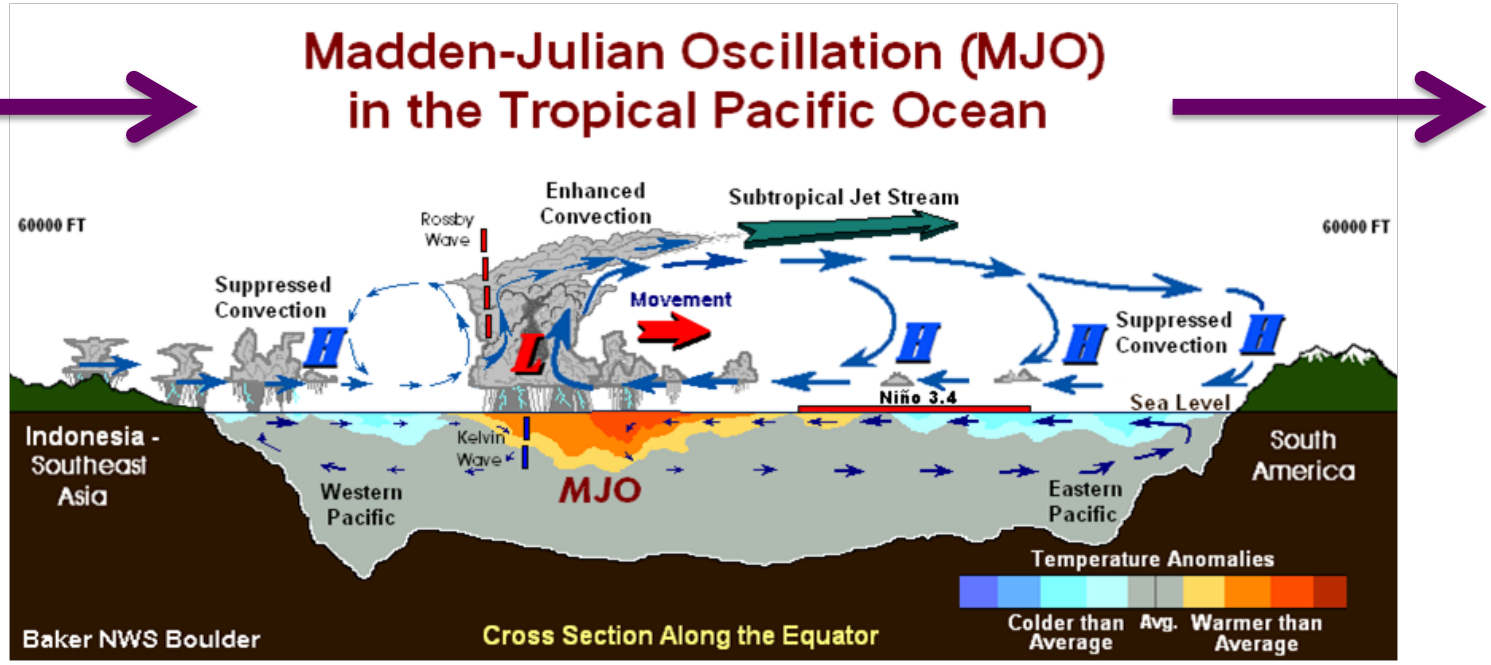
Community Earth System Model CESM

The Madden Julian Oscillation (MJO)



- Dominant large-scale east-ward mode of variability on intraseasonal (20-100 day) timescales in the tropics – winter-time
- Convection organizes in Indian Ocean propagates into the Pacific
- Multiple interactions: ENSO, Monsoons, North Pacific wave propagation
- Potential to extend predictability to multiple weeks
- **Does ocean forcing/coupling affect MJO characteristics?**

Large Ensemble Simulations

1850 Forcing (each has 50 years of daily data)

Uses CAM5 (1 deg.)

1. *Fully coupled CESM1 simulation (CPL, u,v and T,s)*
2. *Slab-ocean simulation (SOM, T(1) only, 50 m)*
3. *Prescribed SST simulations (AMIP, fixed SSTs from LENS)*

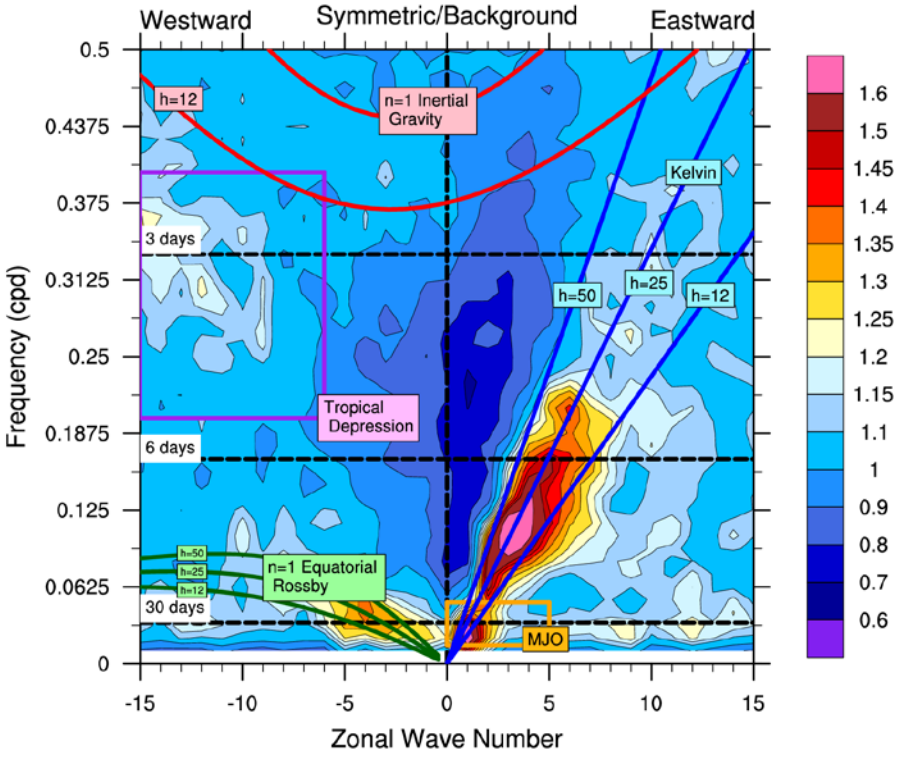
Ocean-atmos. coupling frequency

1. 24 hours 2. and 3. 30mins (same as CAM DTIME)

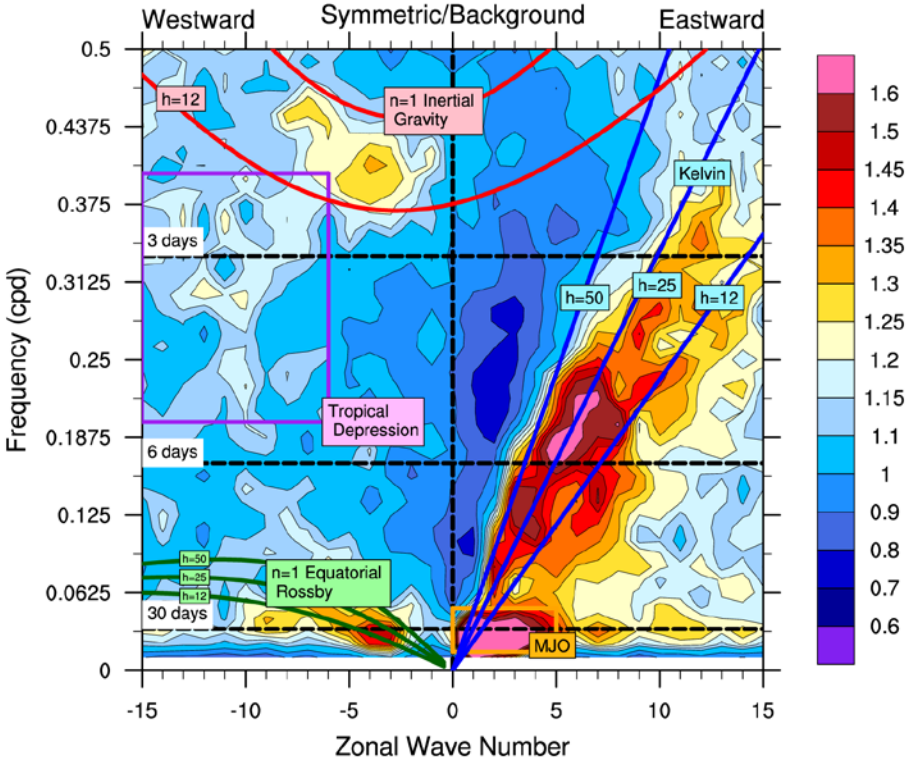
CAM5 Tropical Variability

- Kelvin-wave: Improvement on recent versions (CAM3/CAM4)
- MJO: Slight degradation from CAM4/CCSM4

CESM1-CAM5



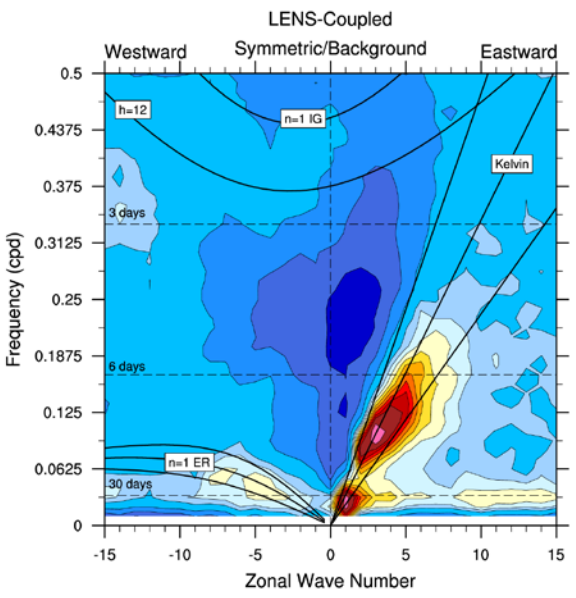
TRMM



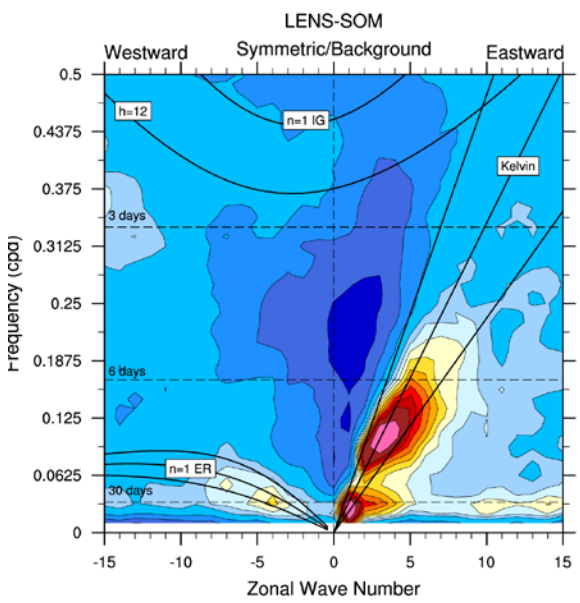
CESM-LENS Tropical Variability

- Power spectrum very robust across configuration
- Fully coupled has a reduced power in MJO and K-waves.

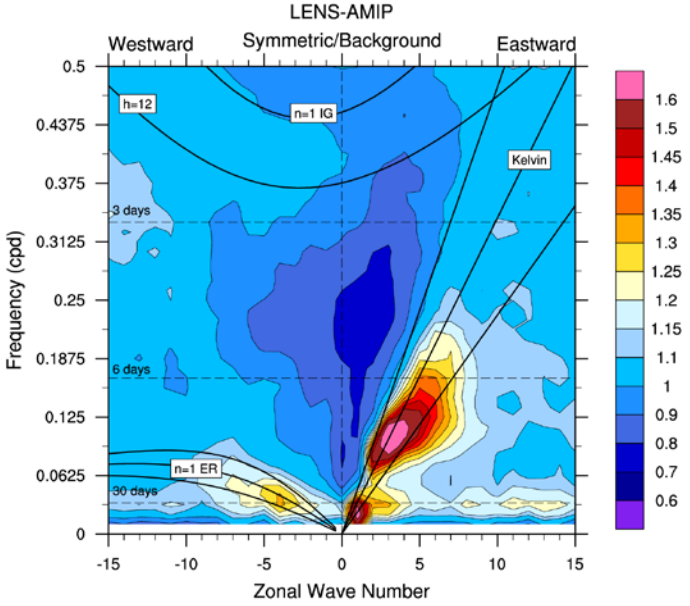
LENS-Coupled



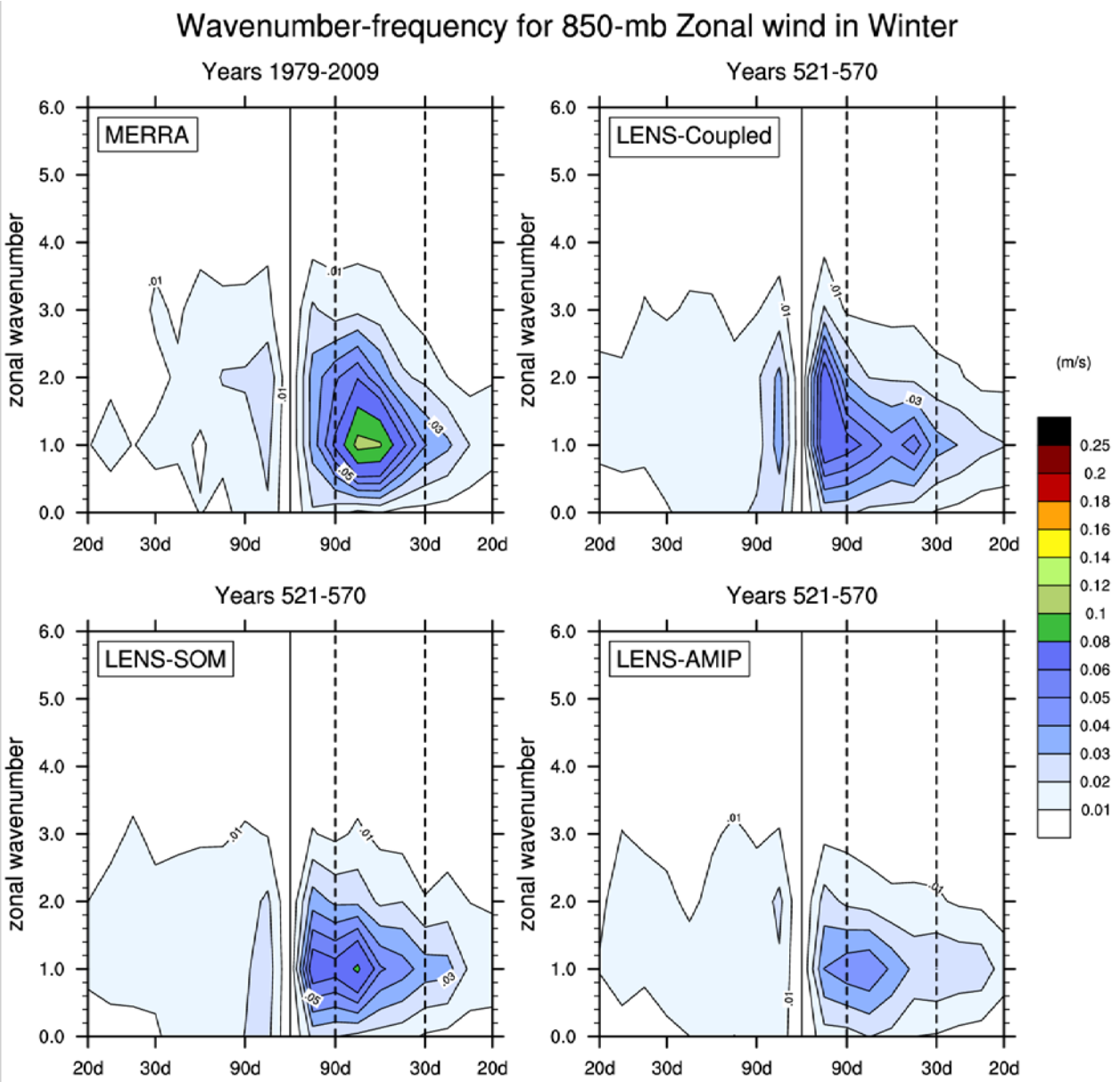
LENS-SOM



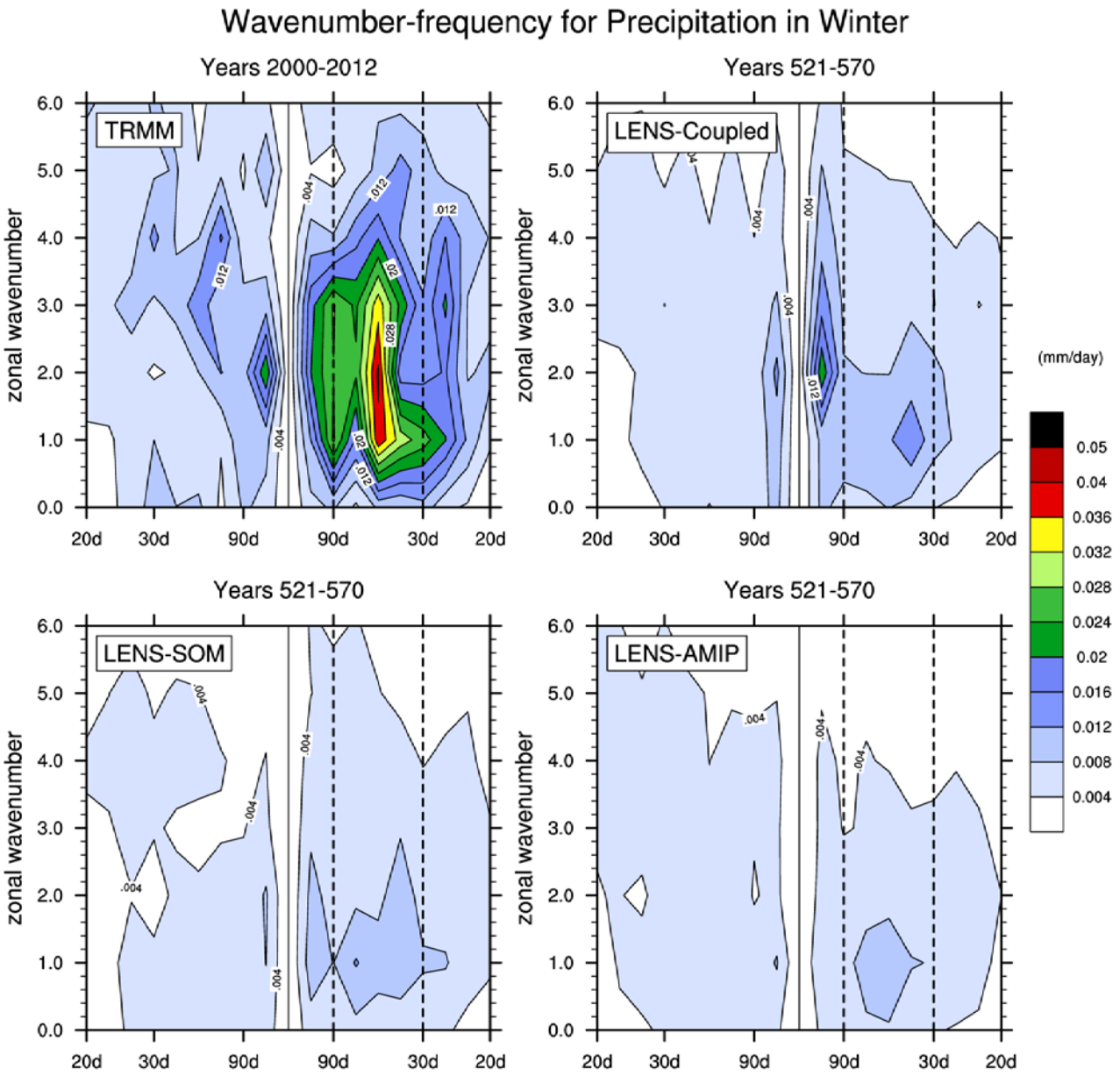
LENS-AMIP



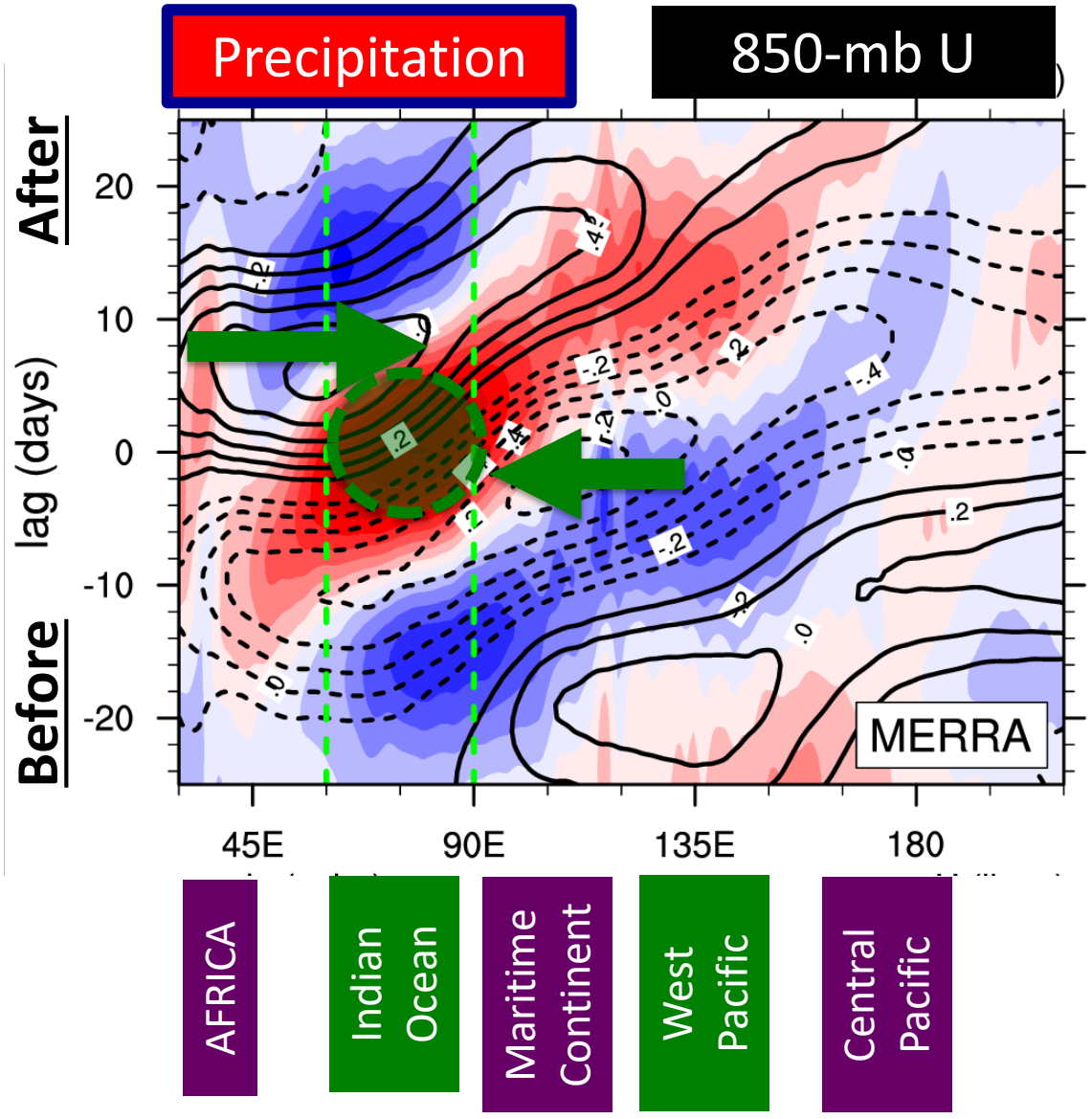
Wavenumber Frequency: U850mb



Wavenumber Frequency: Precipitation



Lagged Anomaly Correlations



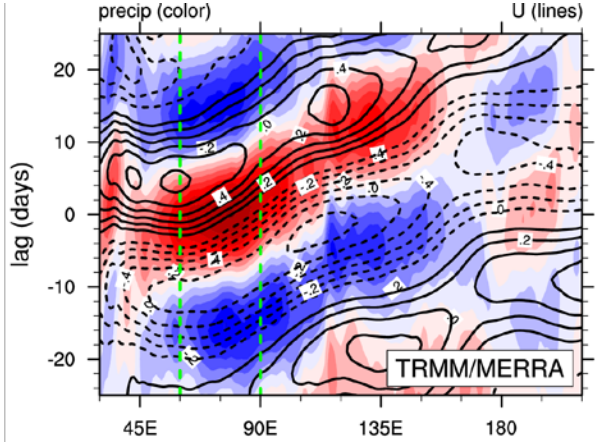
- Daily averages ('79-'10)
- 10N-10S averages
- 20-100-days band pass filtering
- Correlation with Indian Ocean precipitation

Shows

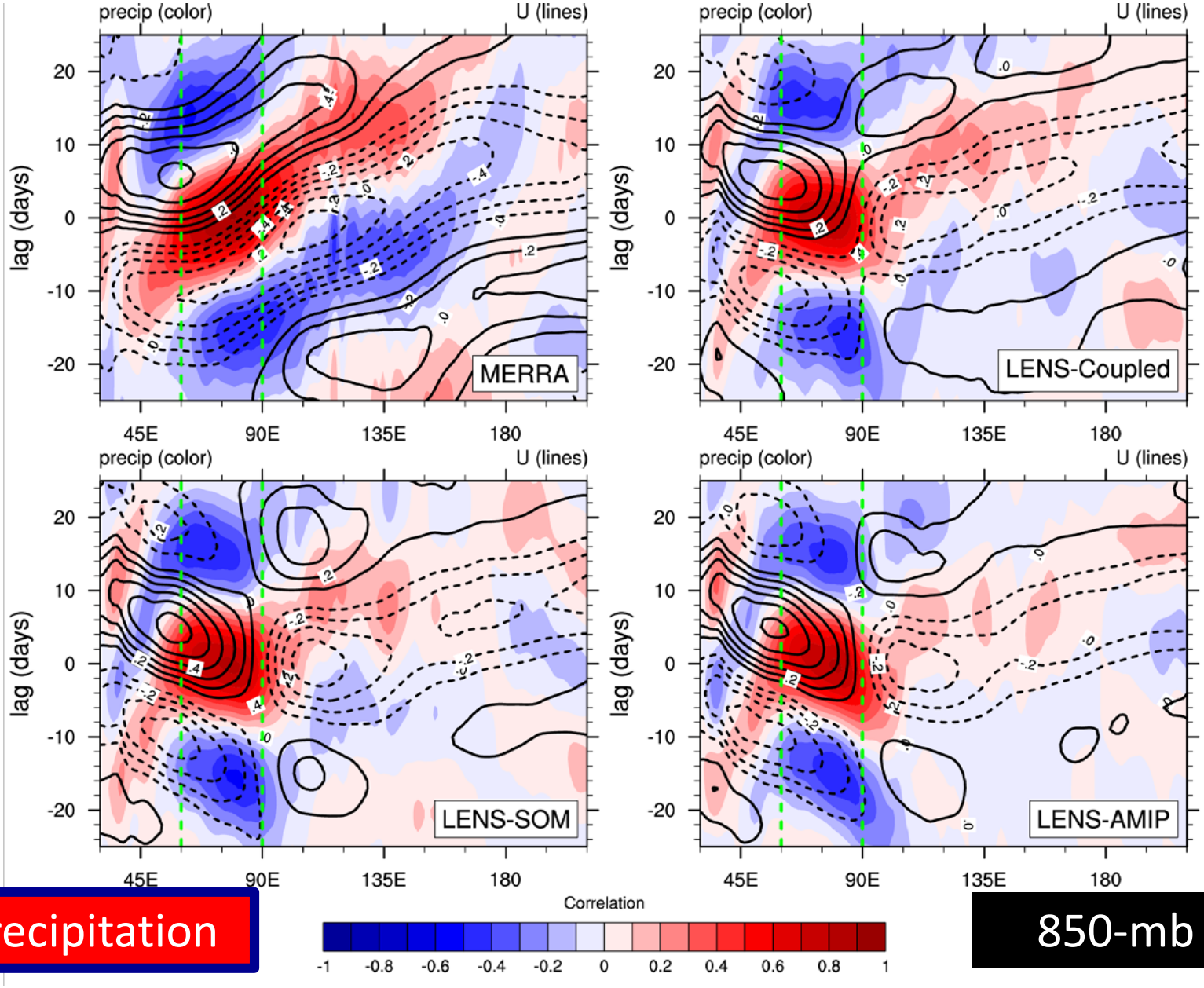
-West to east propagation

-Dry follows wet follows dry

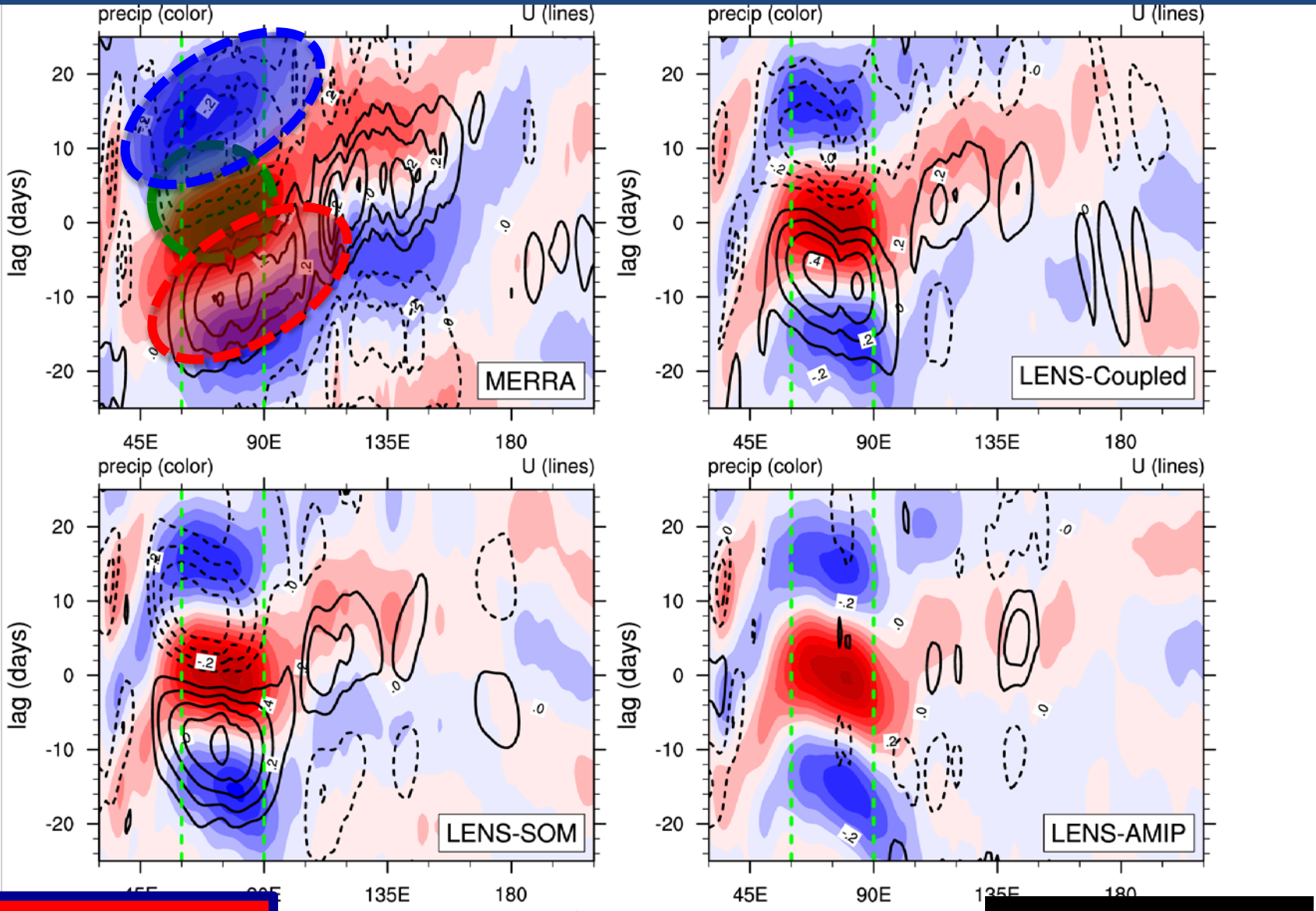
-Circulation in quadrature



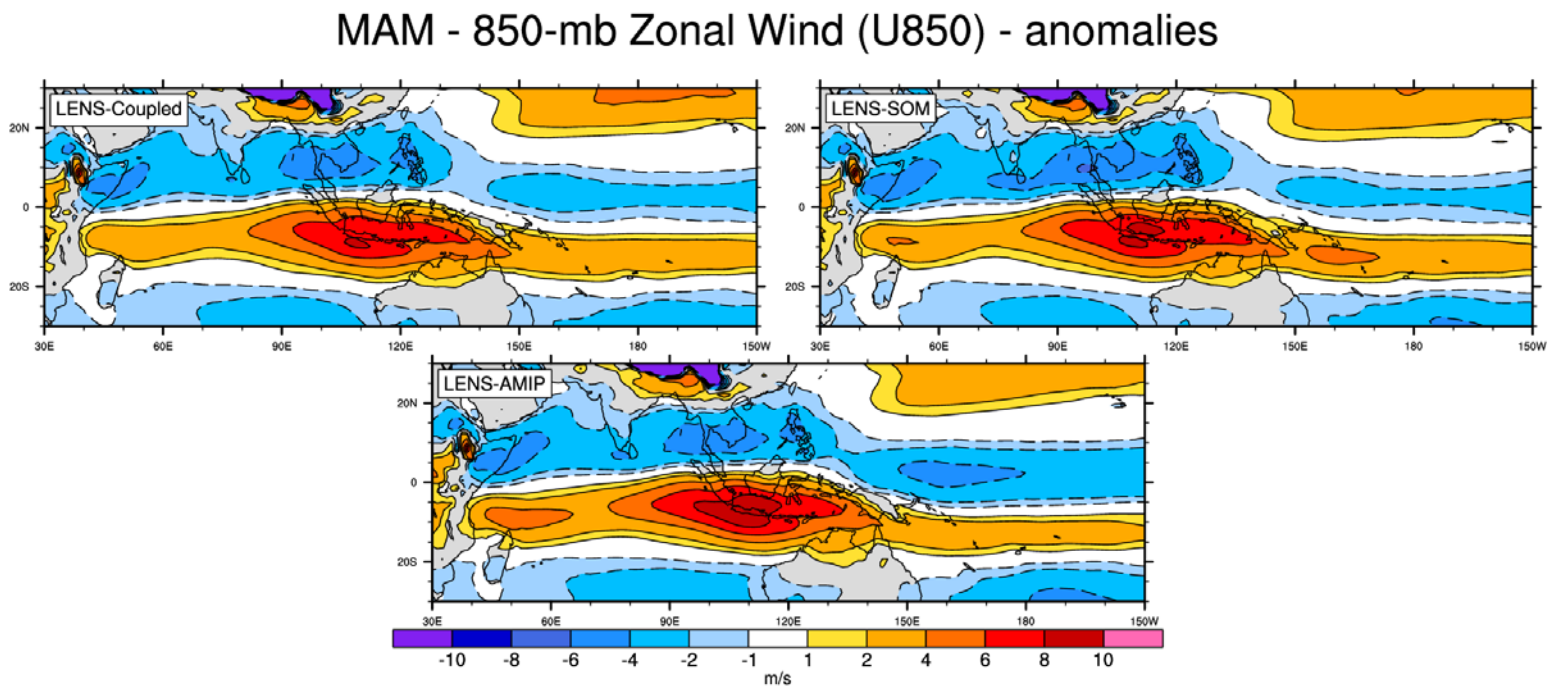
MJO – Dynamically Coupled

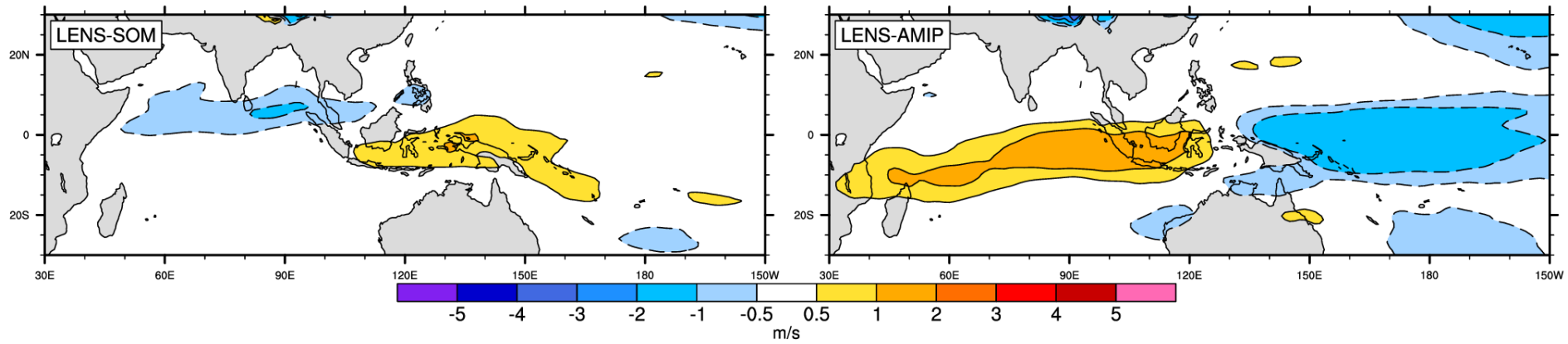


MJO – Surface coupling?

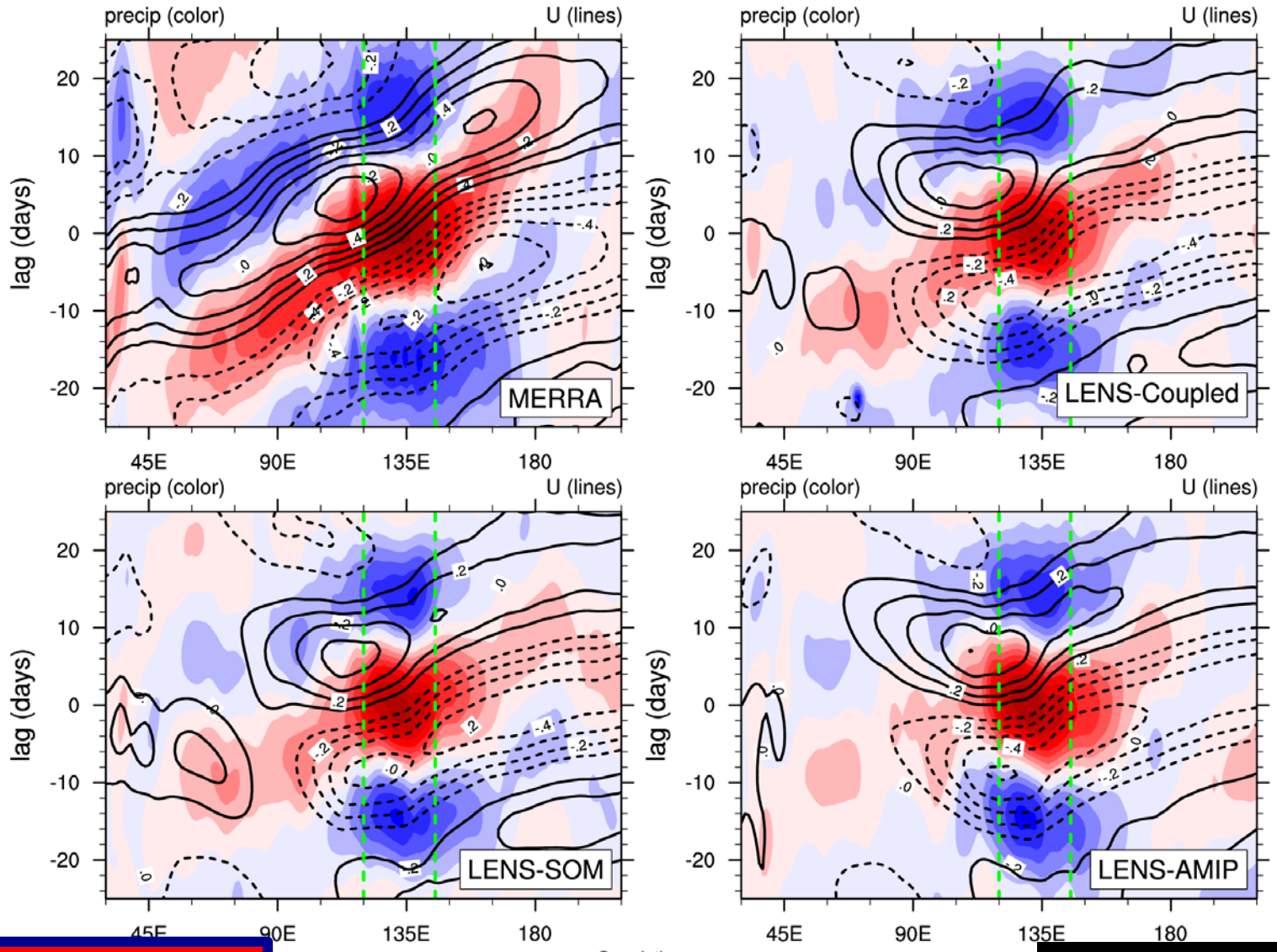


Basic State Influence?





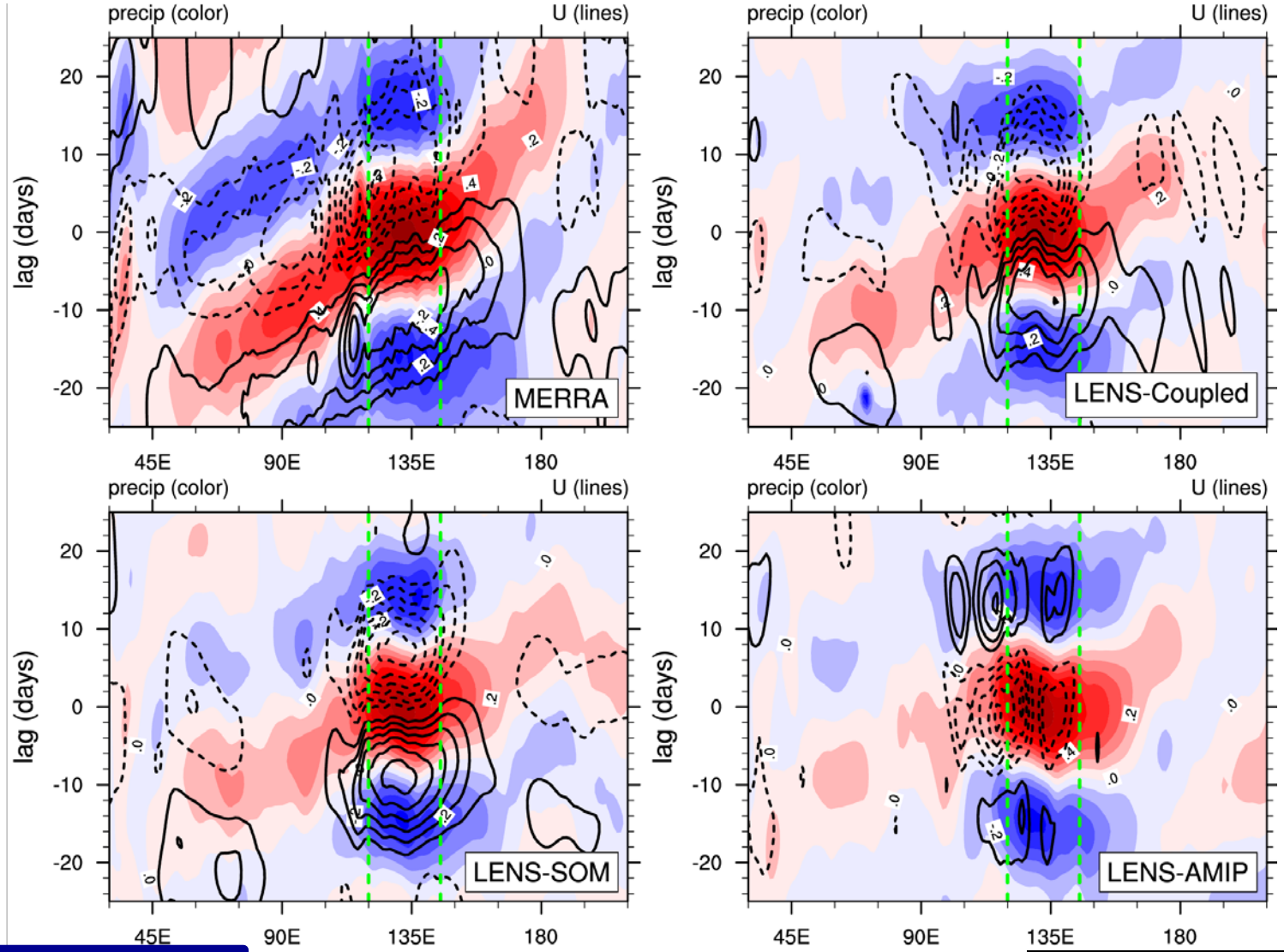
MJO – Maritime Continent Barrier?



Precipitation

850-mb U

MJO – Maritime Continent Barrier?

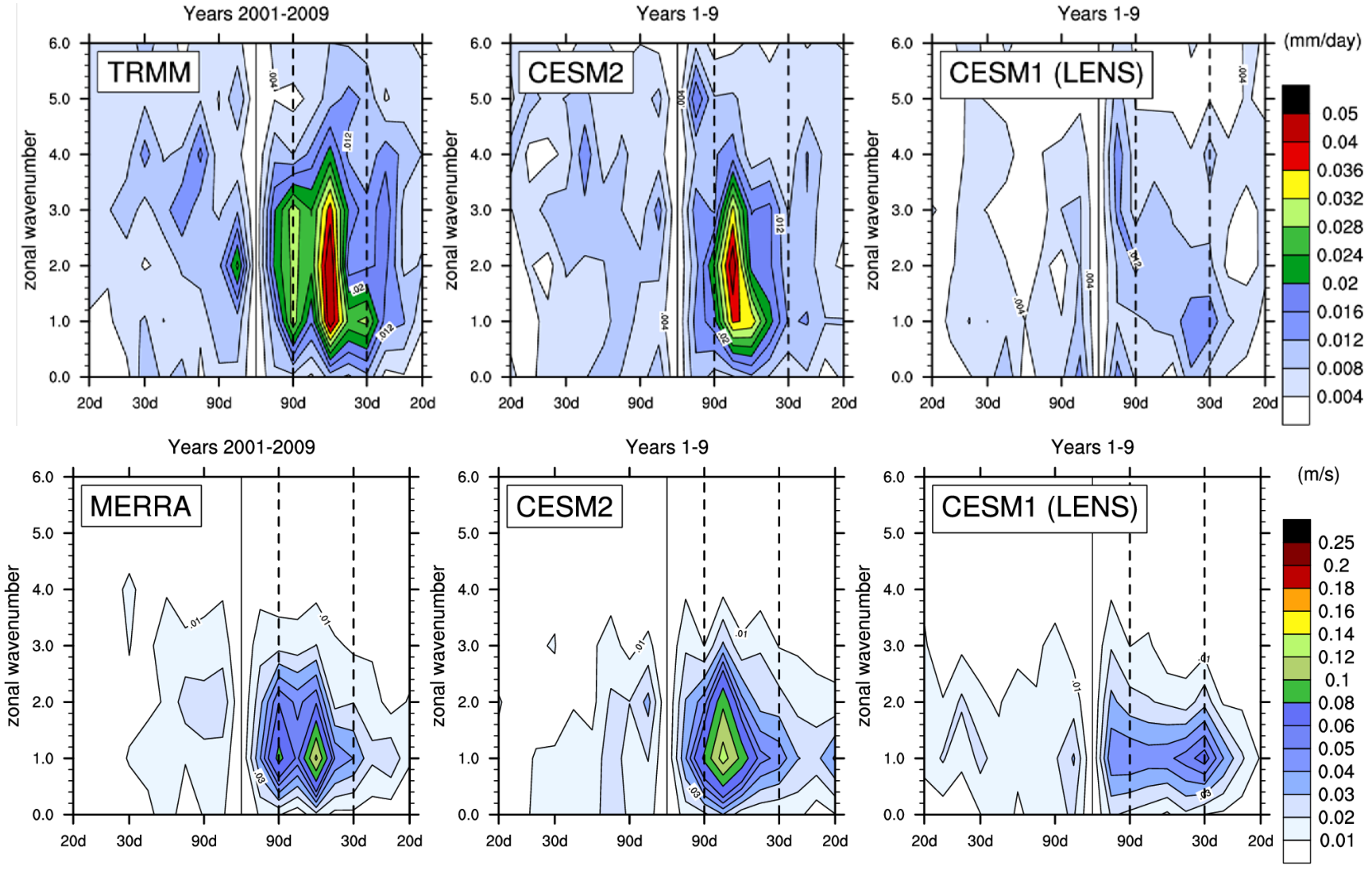


Precipitation

SST

CESM2 simulations

CESM2 simulation (#125)



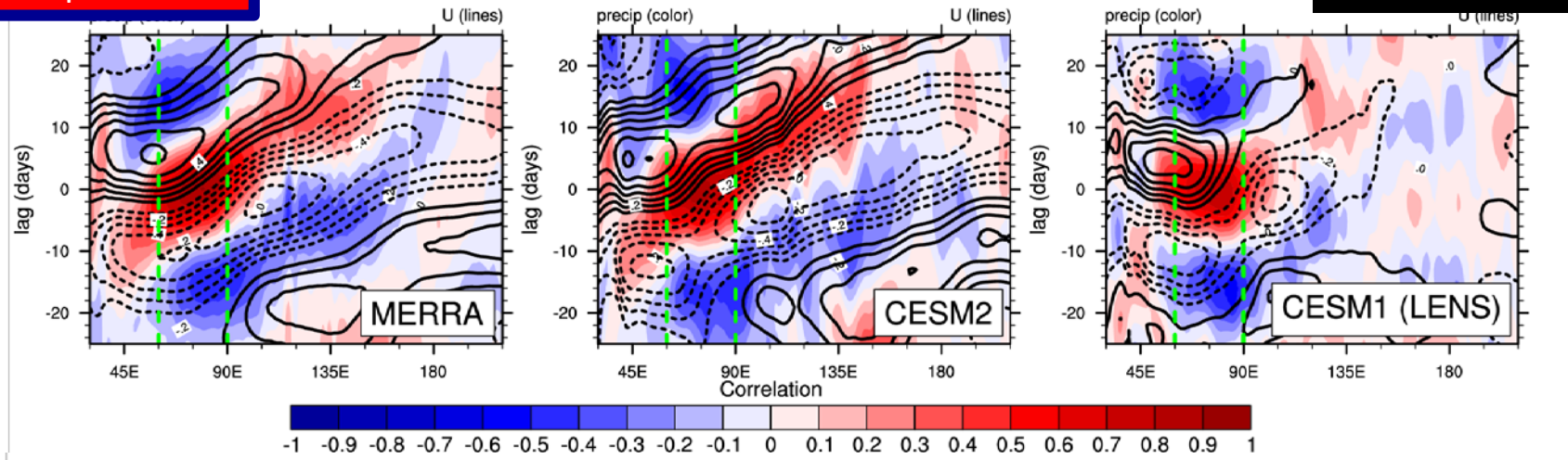
Precipitation

850-mb zonal wind

CESM simulation (125)

Precipitation

850-mb U

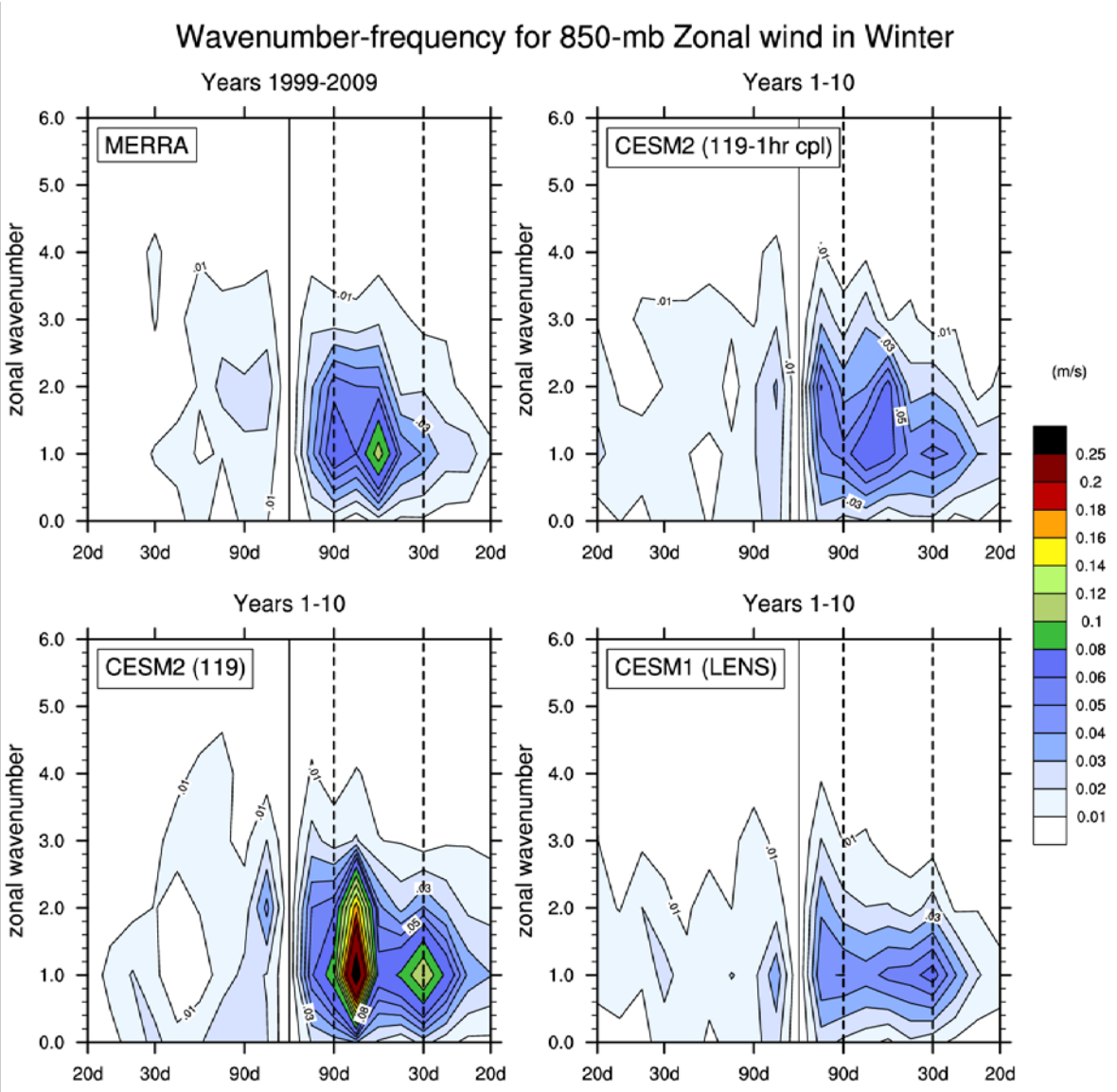


Precipitation

OLR

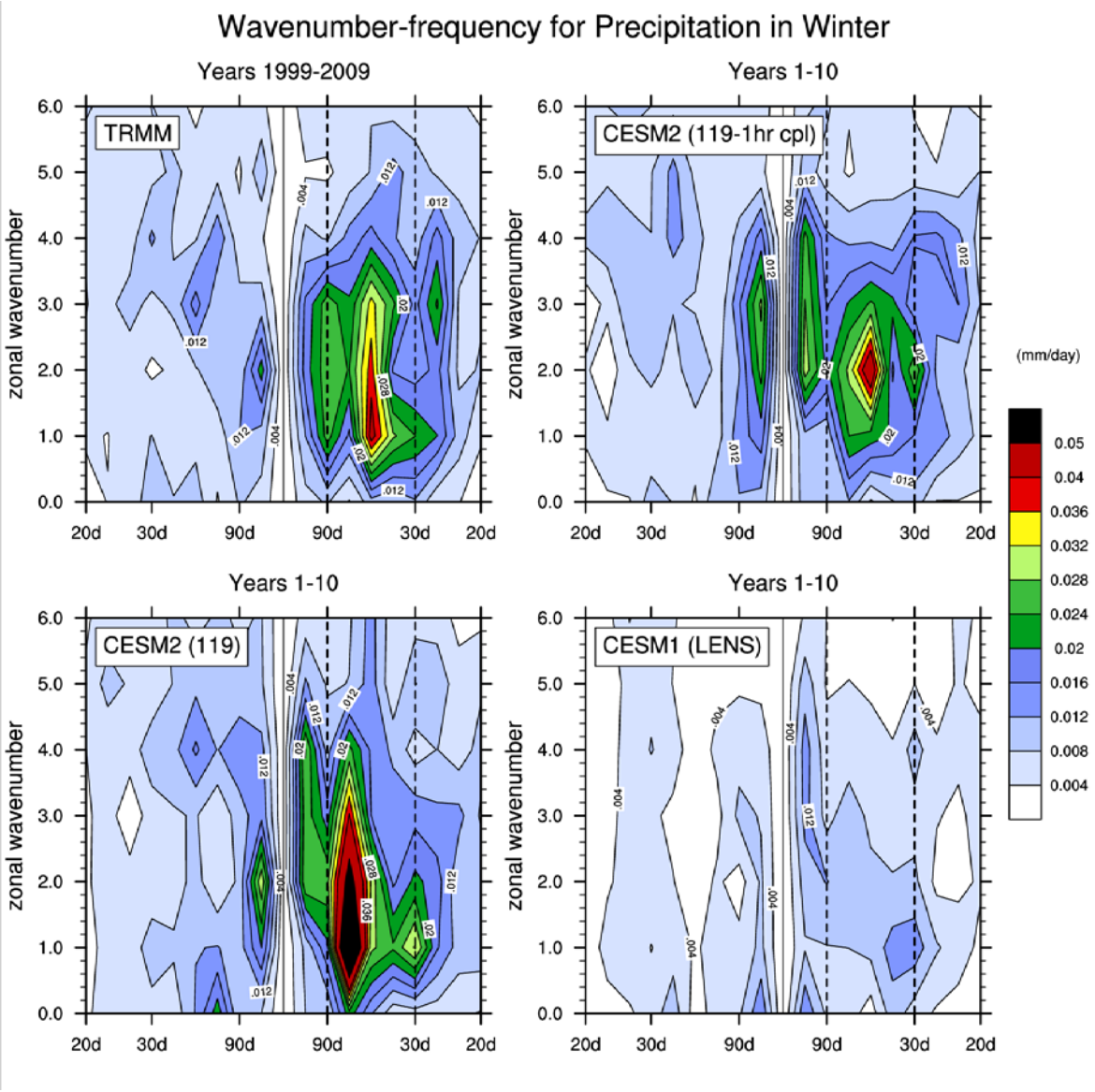
- Lag correlation with Indian-Ocean precip
- 20-100day band pass filter, 10S-10N
- 9 years, DJFMAM

CESM2 Coupling Frequency: U-850mb



- MJO robust in previous ‘CAM6’ version with 2-hourly coupling
- With 1-hourly coupling MJO seems to intensify
- Unsure of the response across the change from 24-houlry to 2-hourly coupling
- Need additional simulations.

CESM2 Coupling Frequency: Precipitation



- MJO robust in previous 'CAM6' version with 2-hourly coupling
- With 1-hourly coupling aspects of the MJO seem to intensify
- Unsure of the response across the change from 24-houlry to 2-hourly coupling
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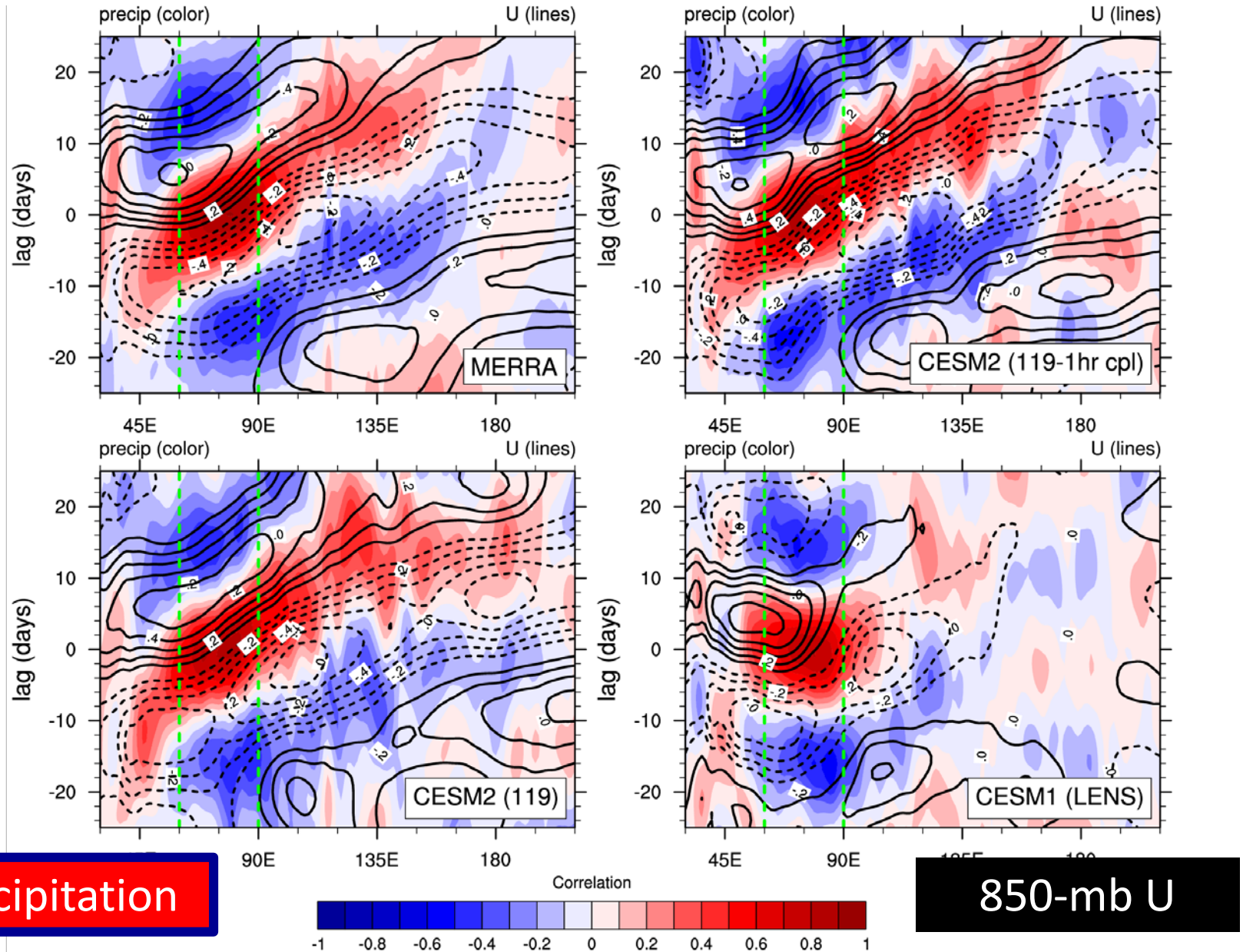
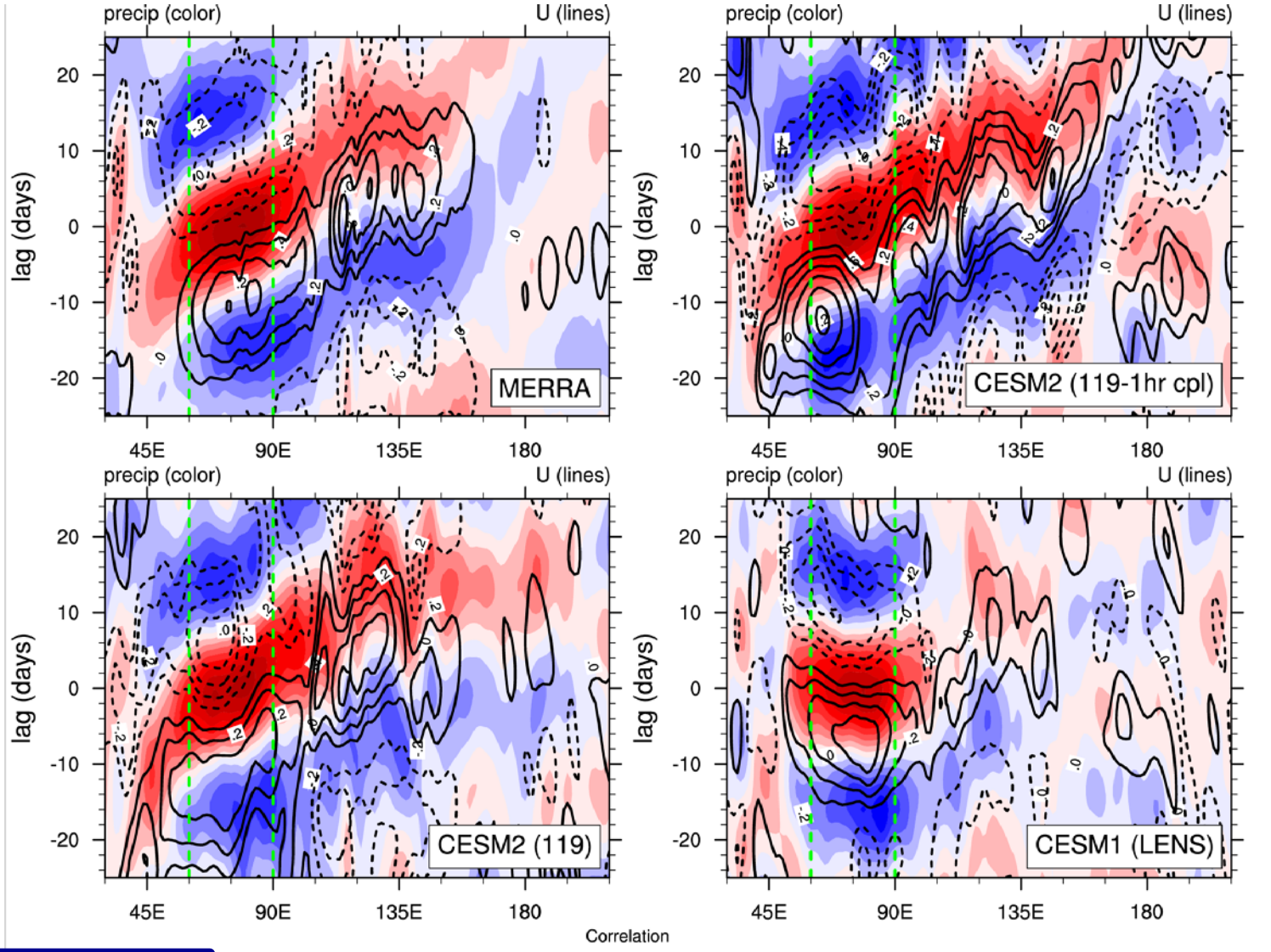
CESM2 Coupling Frequency: U850



CESM2 Coupling Frequency: SST

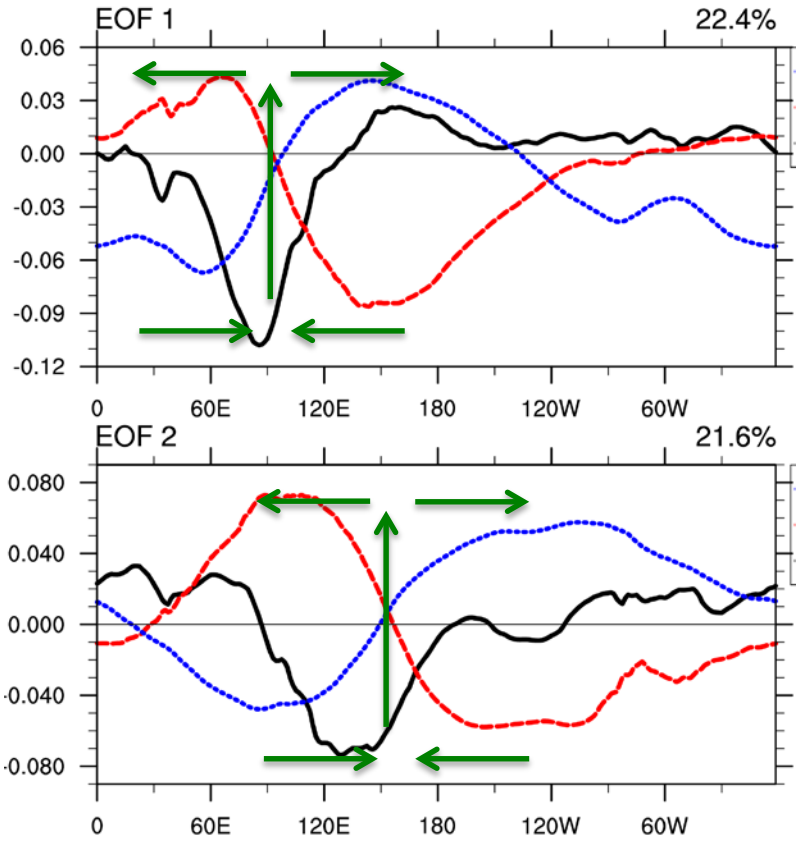


Precipitation

SST

Intraseasonal Variance from MJO ‘mode’

Multivariate EOFs (OLR, U850, U200)	PC1 (%)	PC2 (%)
Observed	22.4	21.6
LENS-Coupled	14.5	14.1
LENS-SOM	15.9	15.0
LENS-AMIP	14.3	13.2
CESM2-CAM6 (2hr-cpl)	21.2	17.9
CESM2-CAM6 (1hr-cpl)	19.0	16.8
CESM2-CAM6 (125)	21.0	17.9

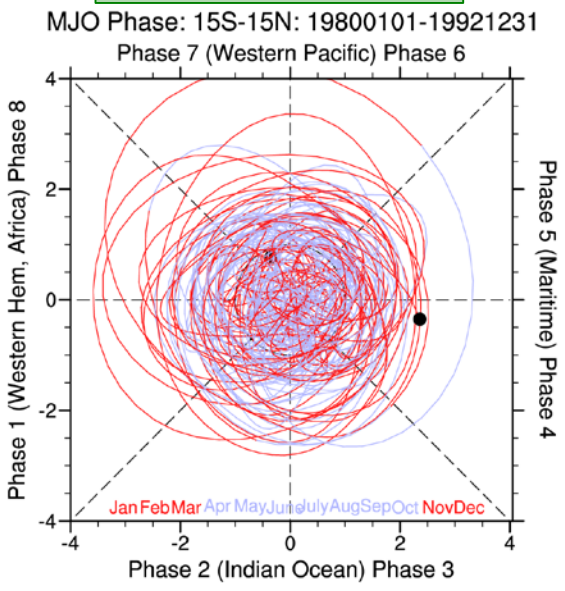


OLR **U850mb**

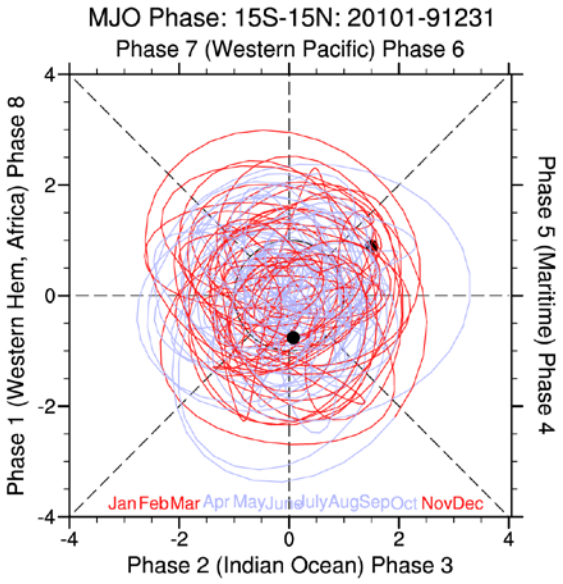
U200mb

Equatorial Circuits

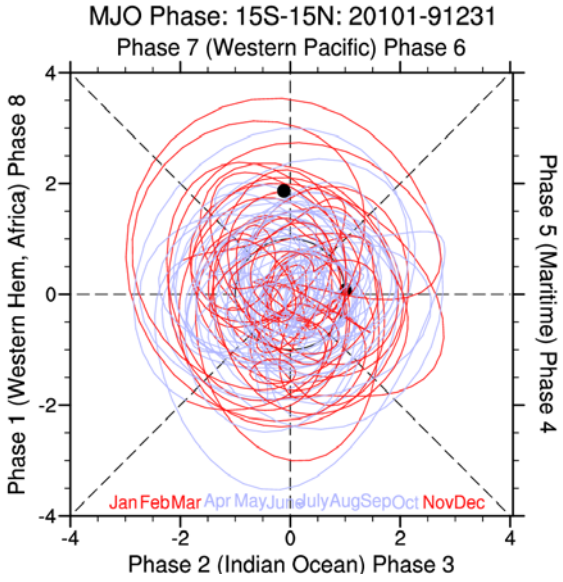
ERA-interim



CESM1 (LENS)

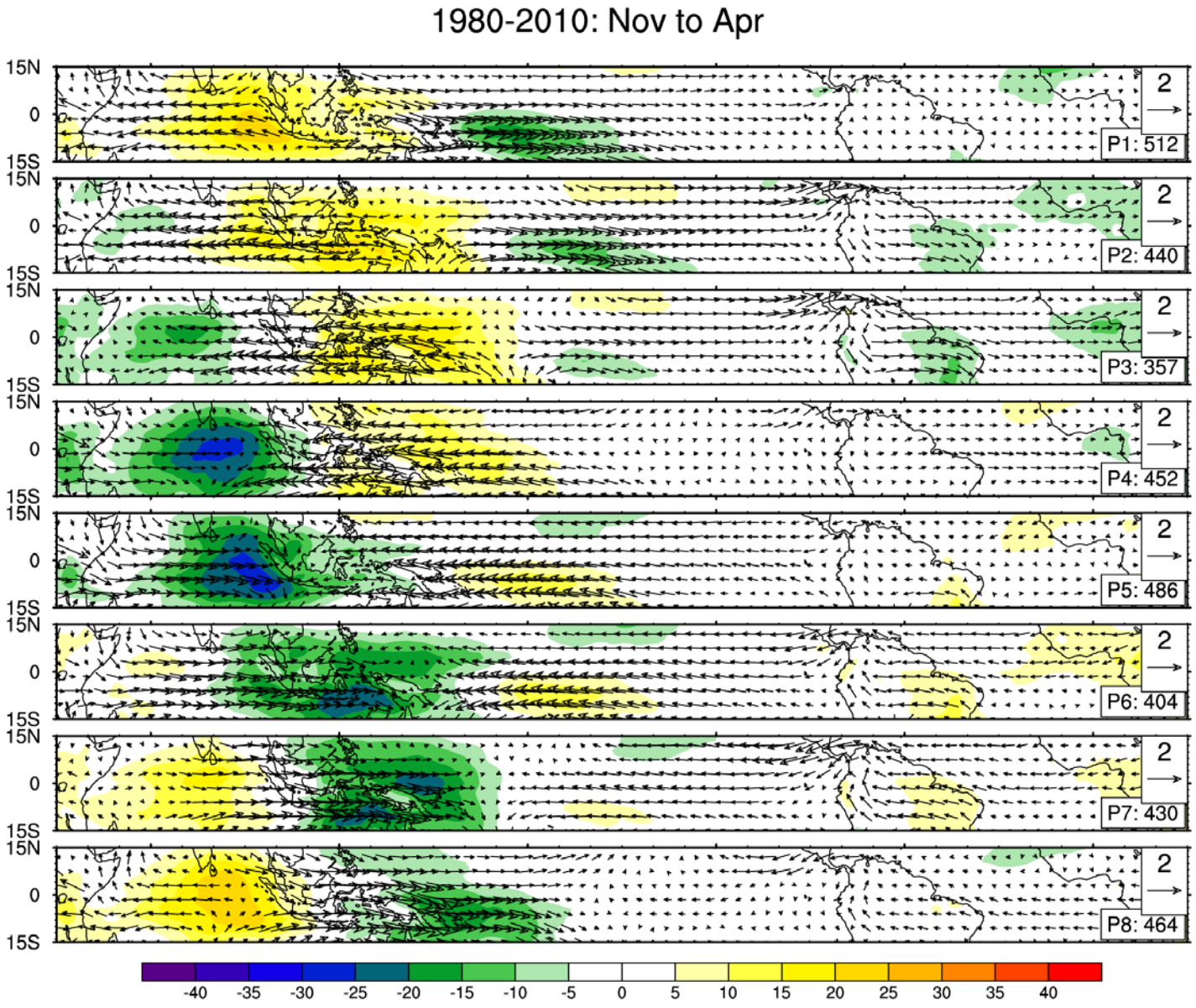


CESM2 (CAM6)



- Winter (red), summer (Black)
- Equatorial ‘octant’ circuits of PC1/PC2 combined max location

Propagating Composite: ERA-interim



Project onto PC1/PC2 For each 'octant'

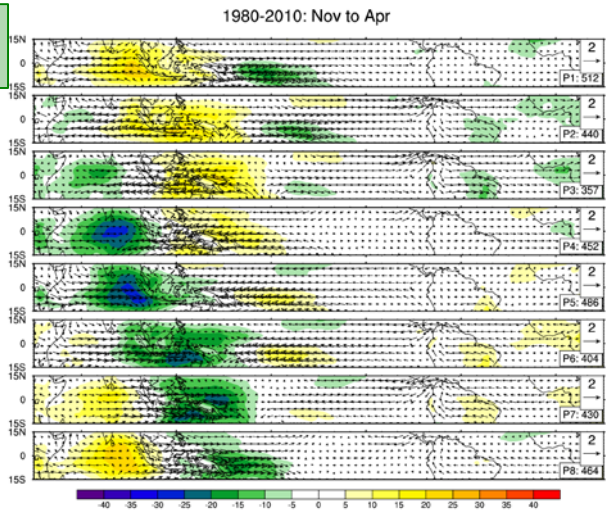
-ve OLR

+ve OLR

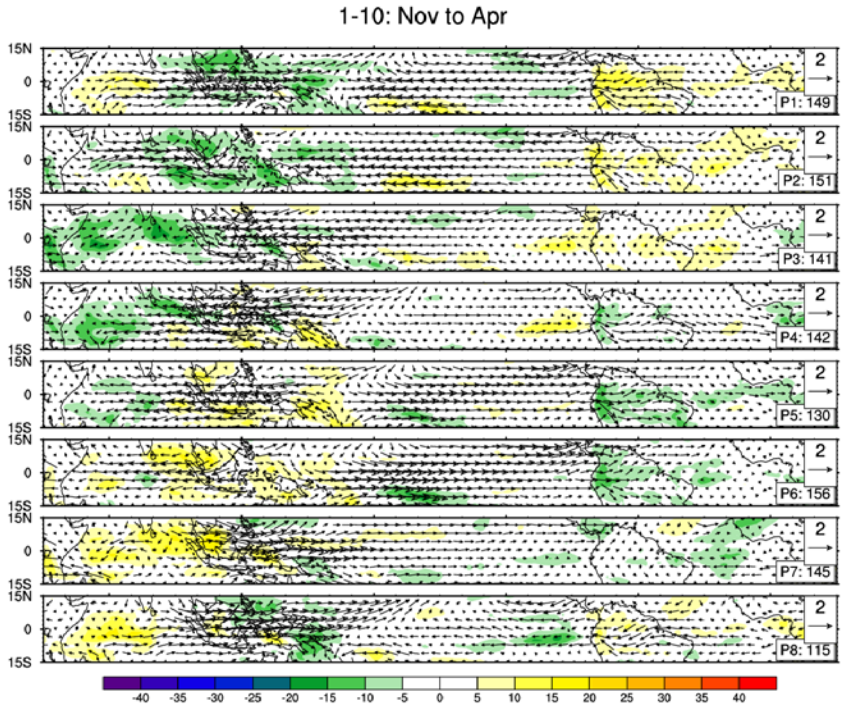
U850,V850

Propagating Composite: All

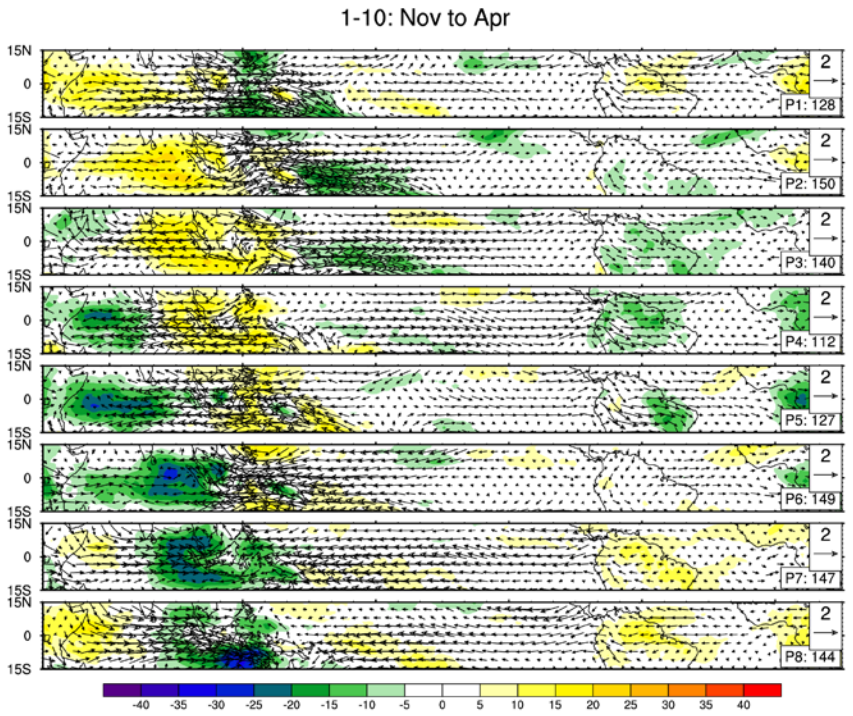
ERA-interim



CESM1 (LENS)



CESM2 (CAM6)



Summary

- LENS variants have very similar (poor) MJOs
- LENS-CPL/SOM better, LENS-AMIP worse
- Traversing Maritime Continent difficult + westward!
- From W. Pacific, some SST relationship

- CAM6, much improved MJO (deep convection changes)
- Very coherent precipitation SST anomaly coupling
- Coupling further strengthens with 1-hourly coupling
- But not necessarily for all certain measures of the MJO

BUT

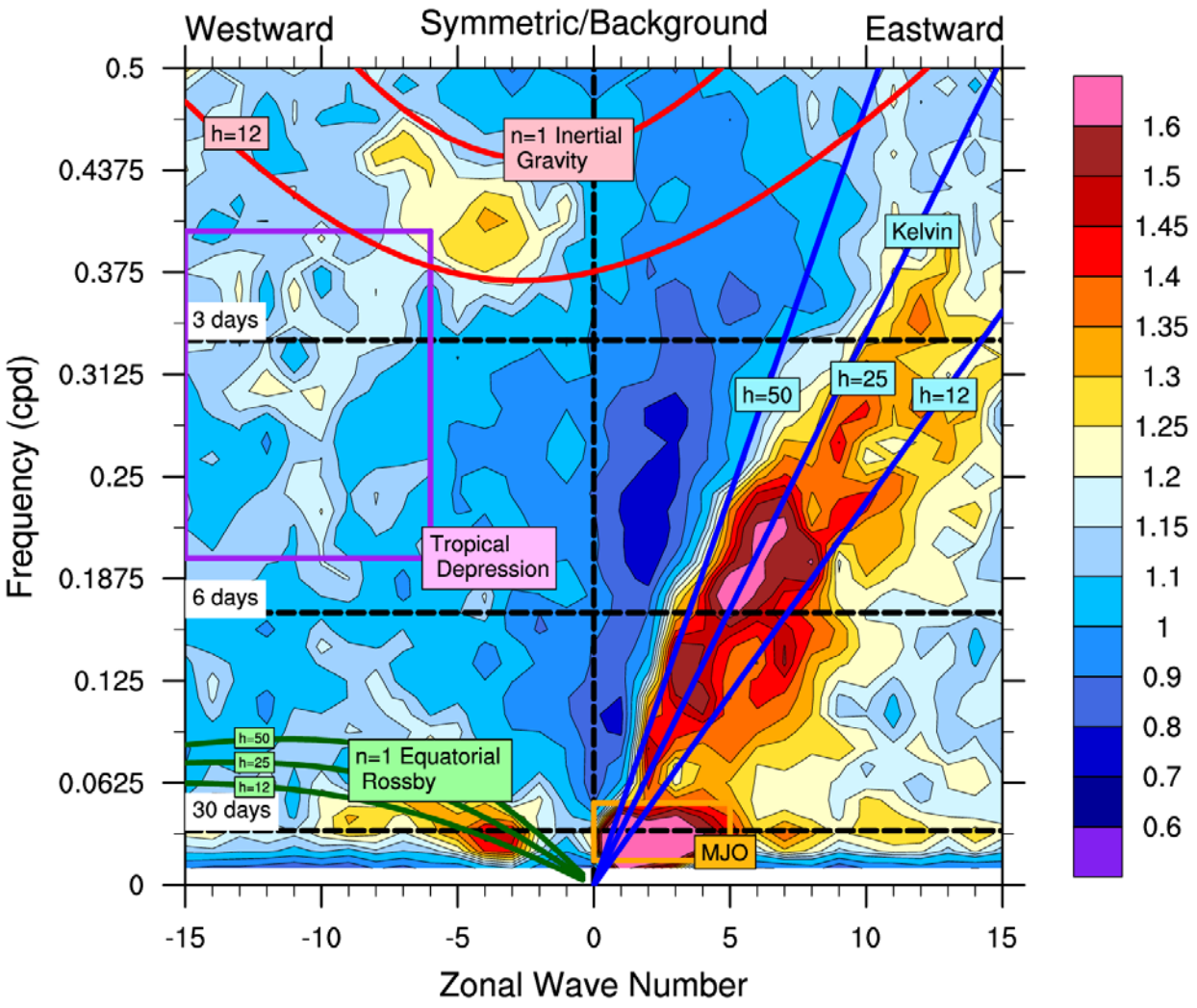
- Disentangling coupling timescale versus ocean model difficult
- Role of basic state shifts is unclear
- With CAM6 can design a more useful set of experiments

Thanks!!

AMWG Discussion

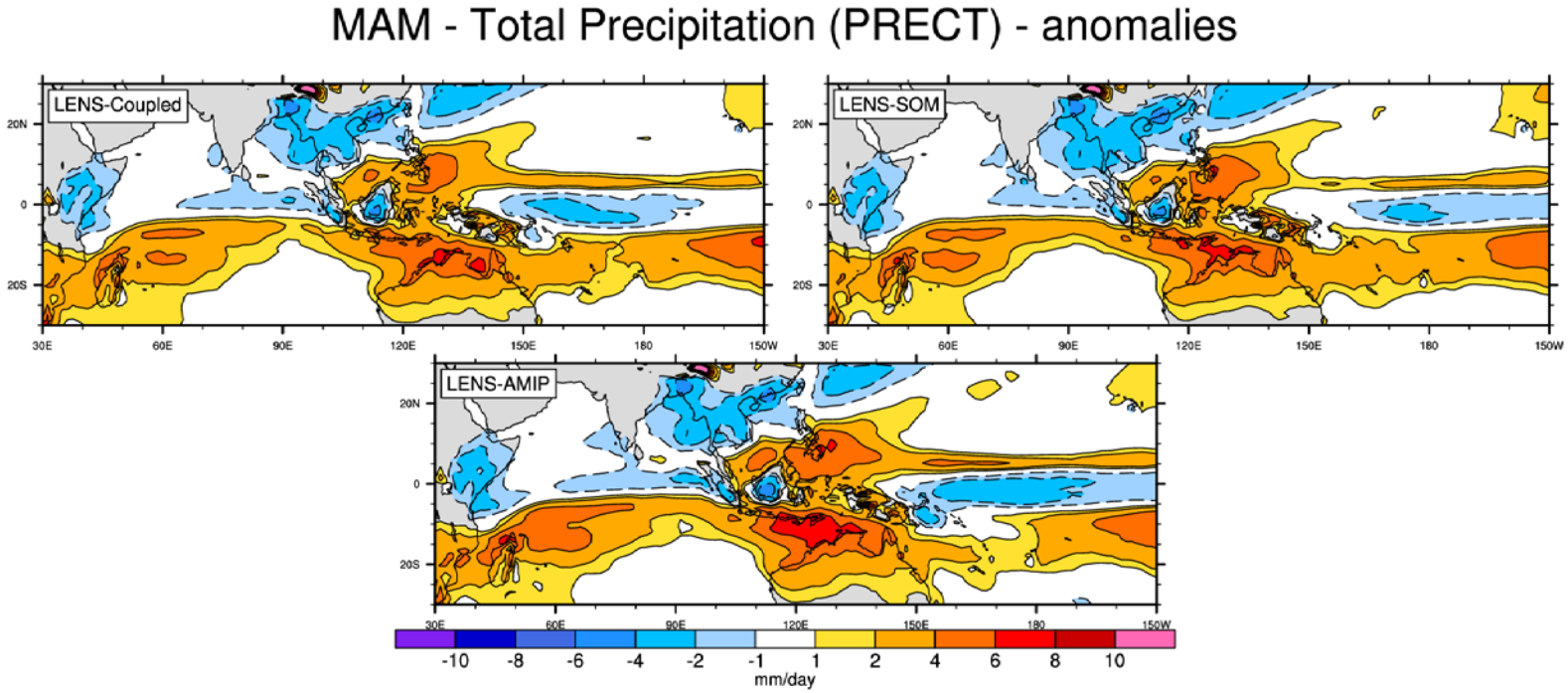
- CESM2 OK?
- Anything missing from the release plans?
- Proposed papers
- High-resolution strategy (uniform)
  - Vertical: ACME problem – Marine SCu
- Forecasting tools (CAPT/intra-seasonal/decadal/DA)
- Do we need to make any kind of plans in the short term (CESM3)?
  - New dy-cores, MPAS, FV3-NH(NOAA), (SE-deep)
  - Conservation properties/priorities (momentum)
- Anything else?

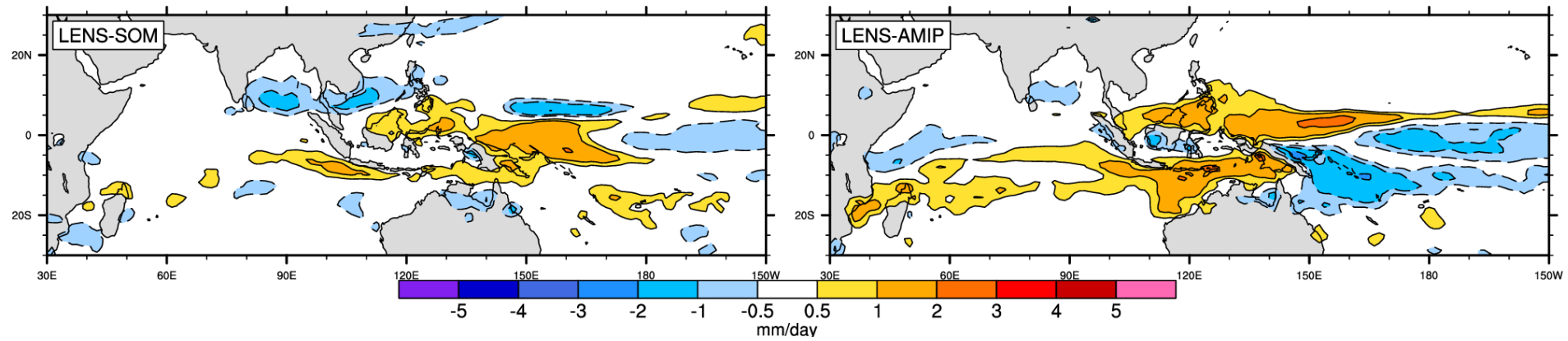
Tropical Wave Activity: Precipitation



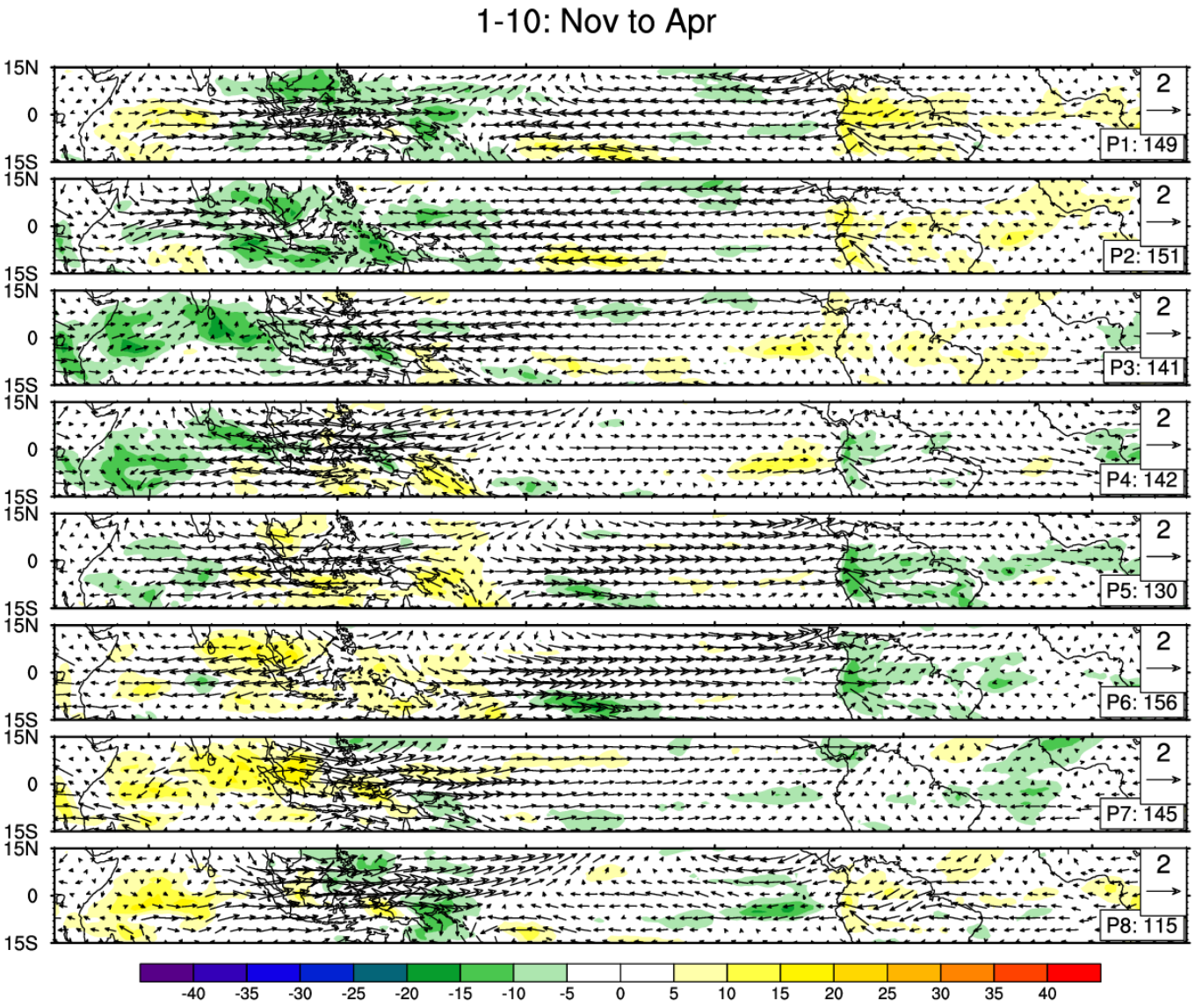
- Estimate a background red spectrum
- Smooth in wavenumber/frequency
- Divide raw/smooth spectrum
- Scaling above background

Basic State Influence?





Propagating Composite: CESM1-LENS



Propagating Composite: CESM2 (CAM6)