

Simulations of the Asian Monsoon

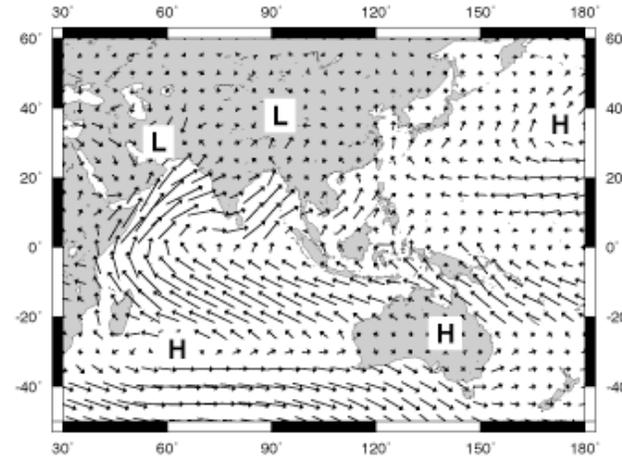
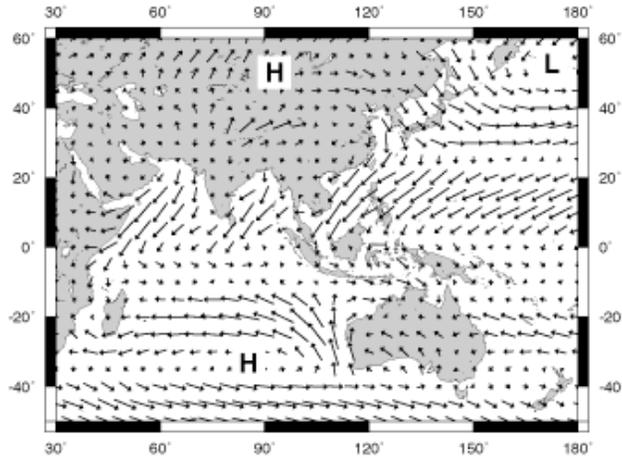
Charlotte DeMott, Cristiana Stan, and Dave Randall

The Asian Monsoon

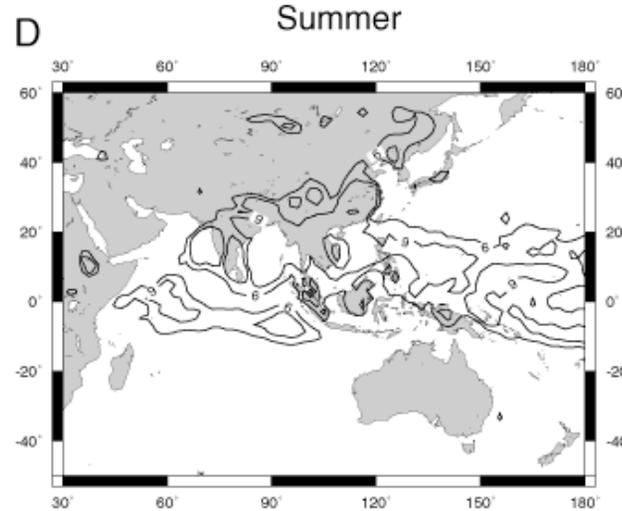
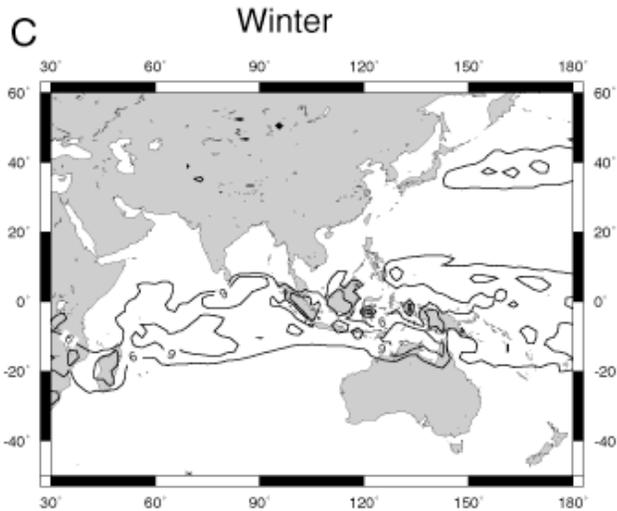
Winter

Summer

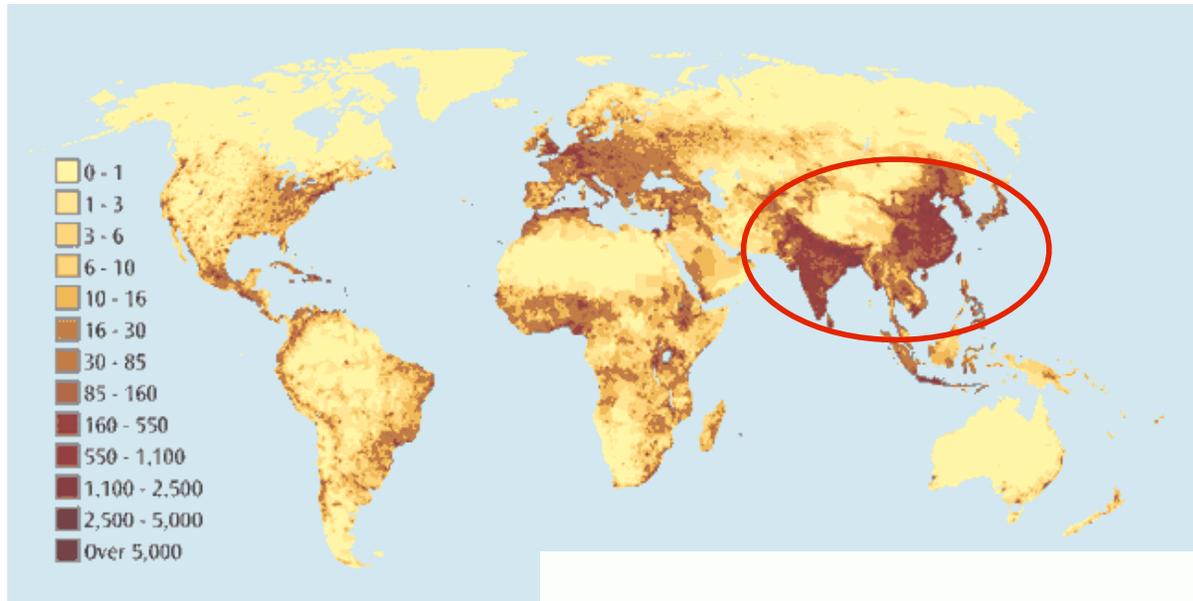
Winds



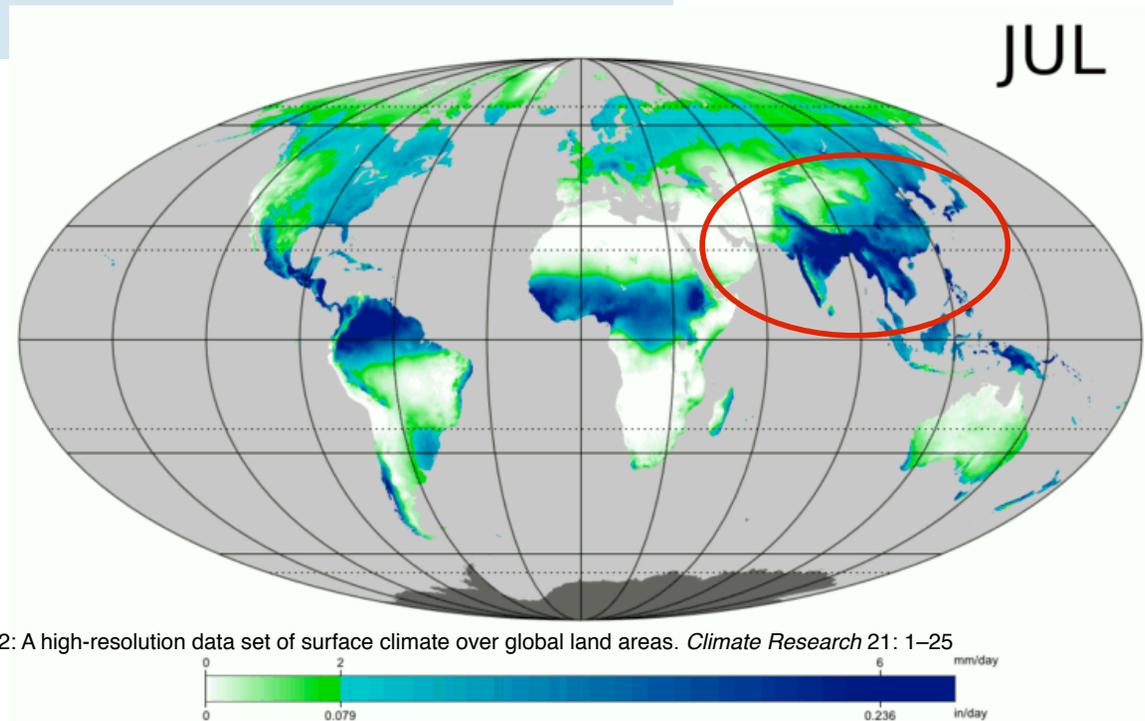
Rain



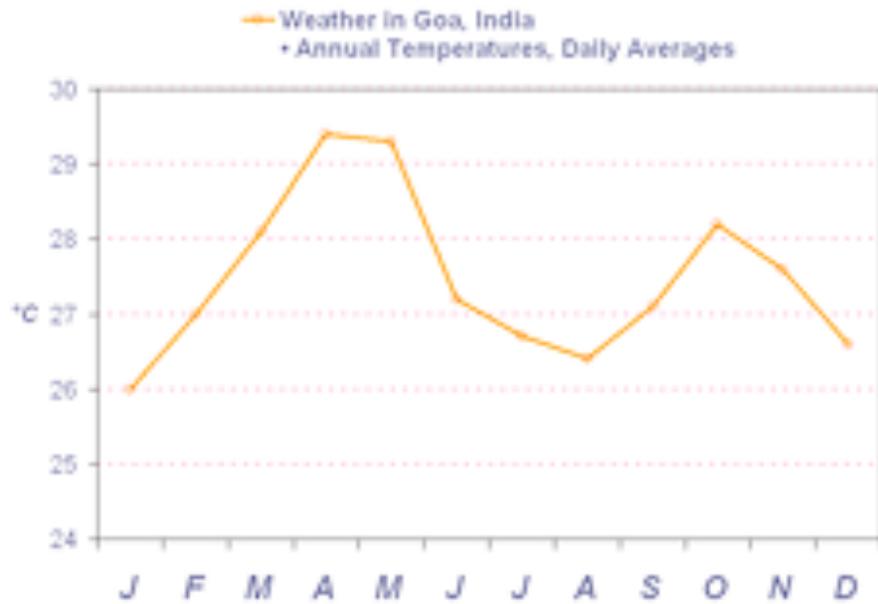
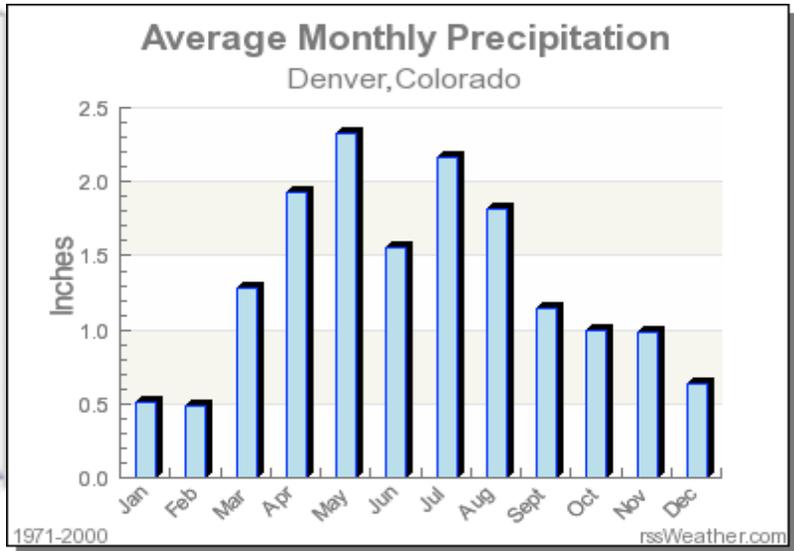
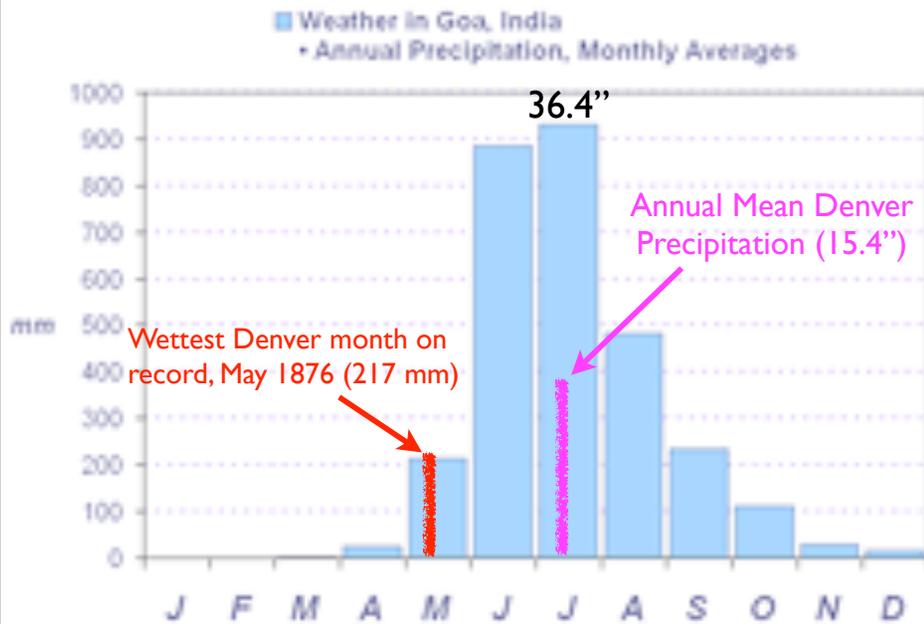
Population Density



July Precipitation



(New, M., Lister, D., Hulme, M. and Makin, I., 2002: A high-resolution data set of surface climate over global land areas. *Climate Research* 21: 1–25)



MONSOONS

Edited by

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Washington, DC*

“...nothing short of living through [the monsoon] can fully convey all it means to a people for whom it is not only the source of life, but also their most exciting contact with nature.”

–Khushwant Singh, Indian parliamentarian and journalist

The Hot Season

“The summer monsoon is preceded by desolation.”

“The sun goes on, day after day,...scorching relentlessly.”

“...both man and beast are struck down with the heat.”

“[The people] are disillusioned, dejected, thirsty, and sweating.”

The Wet Season



“Its advent is greeted with joy.”



“After a few days the flush of enthusiasm is gone.”



(mosquitos, mold, damaged crops)

“The earth becomes a big stretch of swamp and mud.”

(power outages, transportation delays)

“Roads, railway tracks, and bridges go under water.”



**How well do we
simulate the monsoon?**

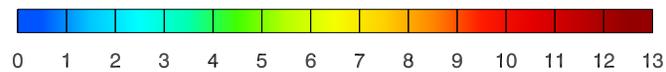
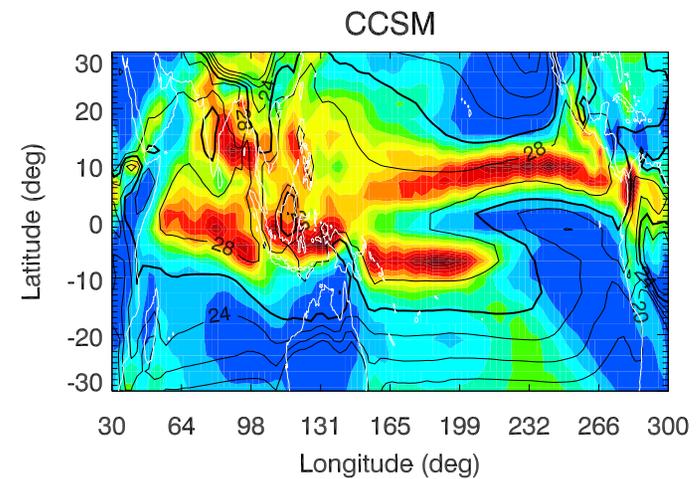
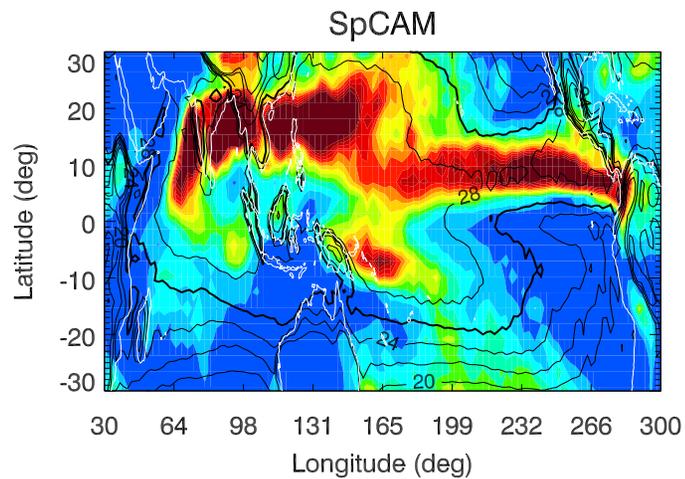
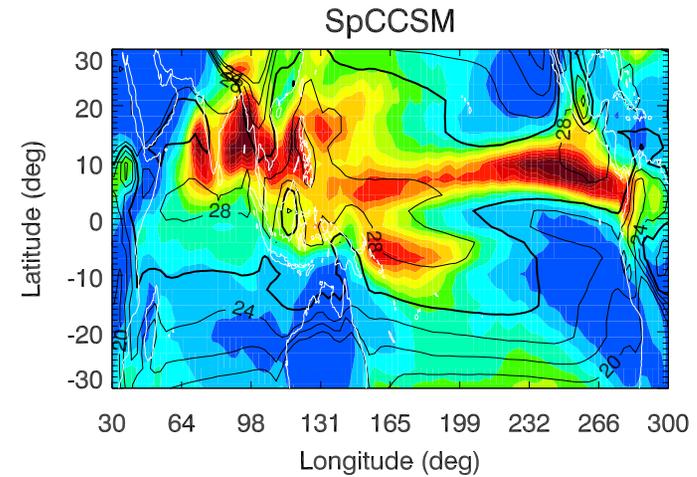
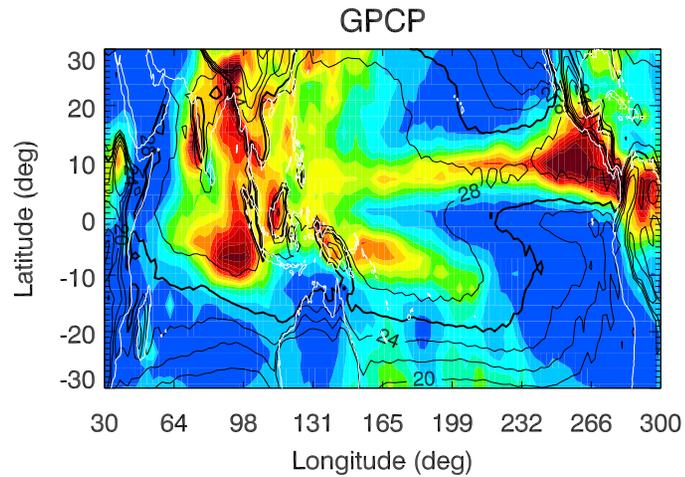
The Simulations

	Atmosphere only	Ocean coupling
Traditional cumulus parameterization	CAM (not shown)	CCSM (years 4-23)
Super-parameterization	SpCAM (14 year AMIP)	SpCCSM (years 4-23)

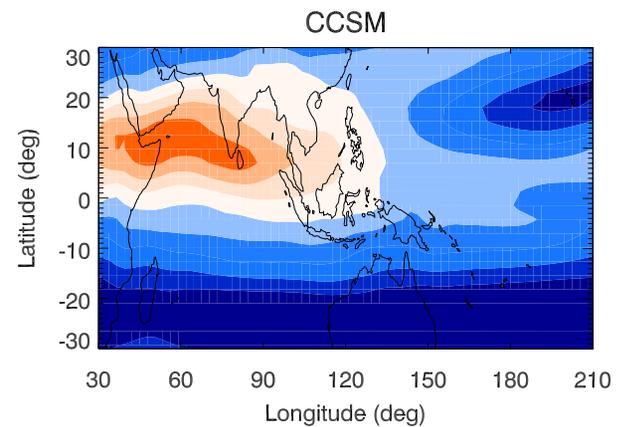
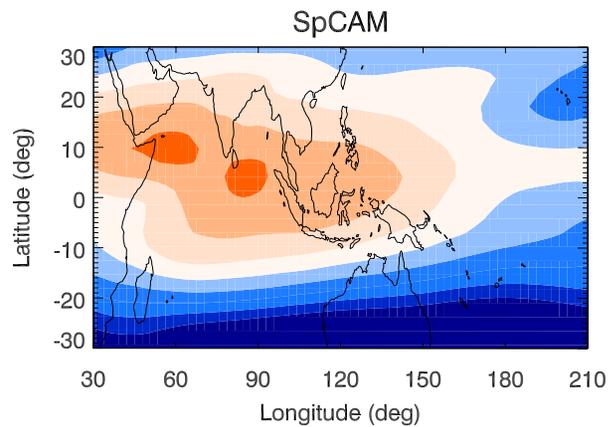
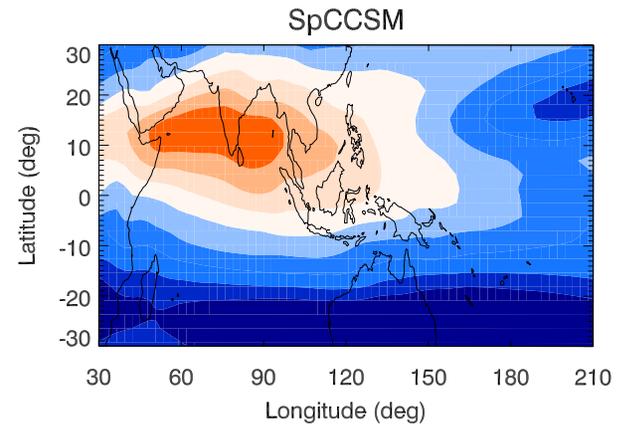
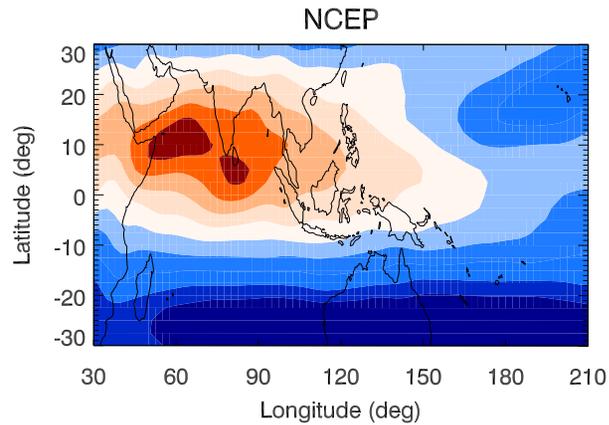
CAM = Community Atmospheric Model (v3.0)

- *CCSM = Community Climate System Model*
- *Coupled to POP ocean model gx3x5 for coupled runs*
- *T42 atmospheric resolution*

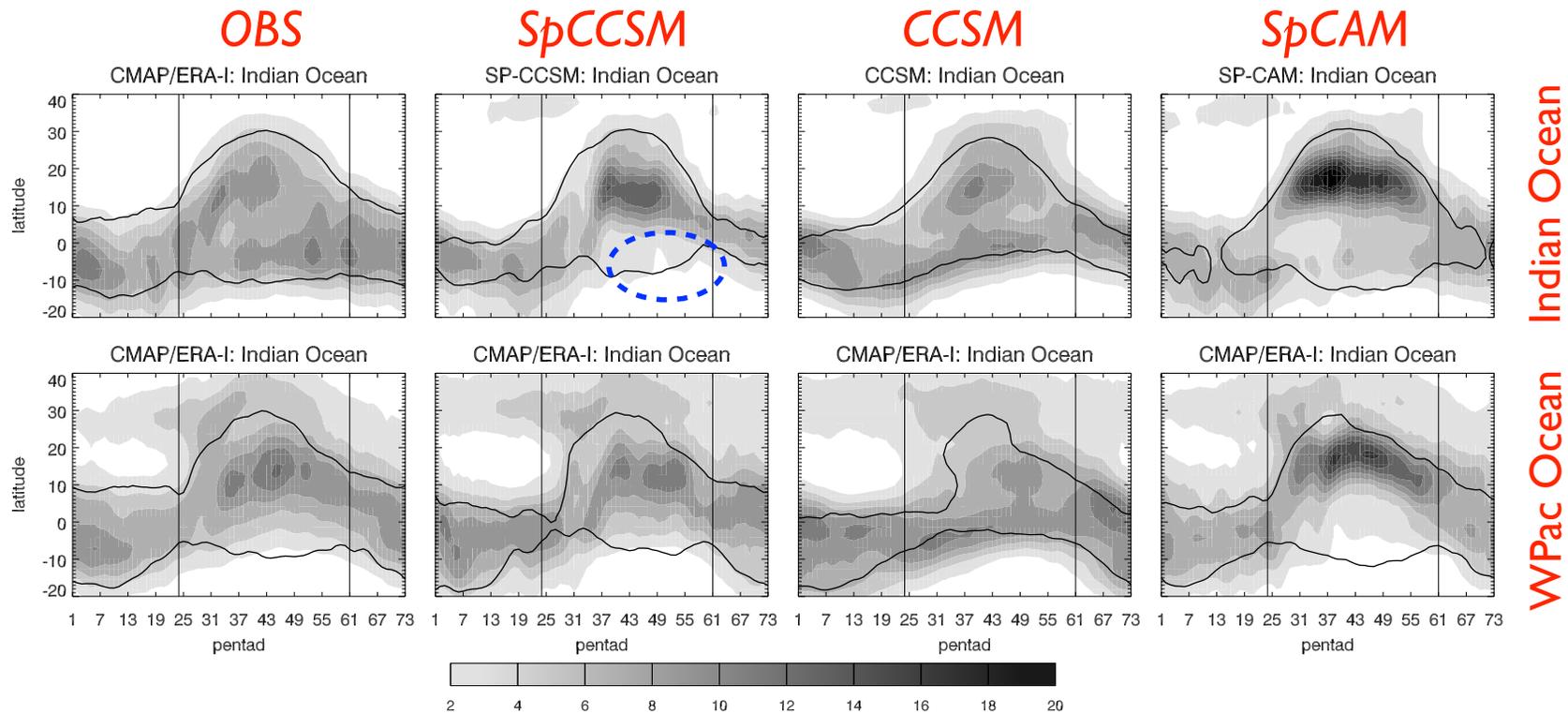
Jun-Sep Rainfall, SST



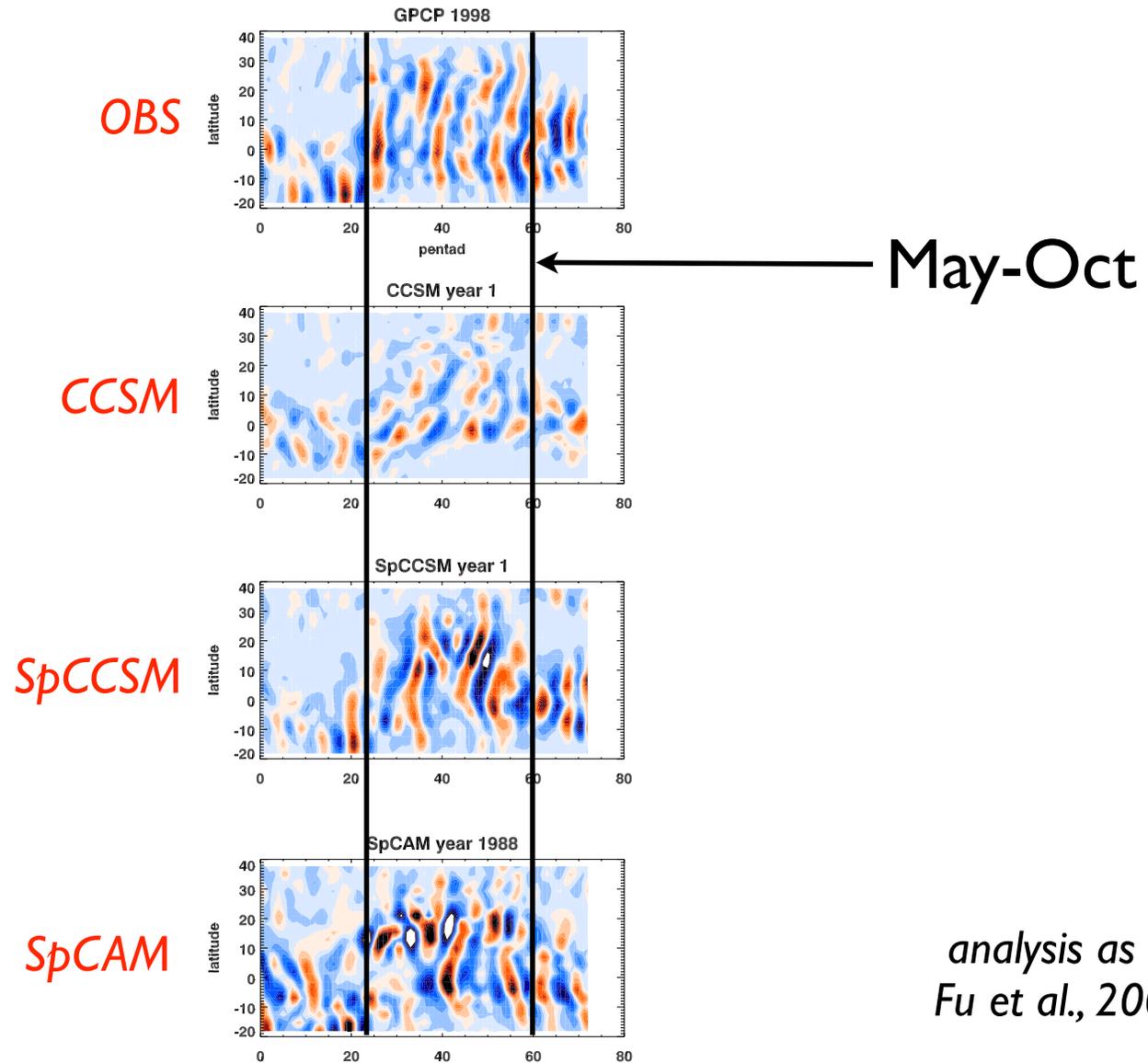
Jun-Sep Zonal Wind Shear



Annual Cycle



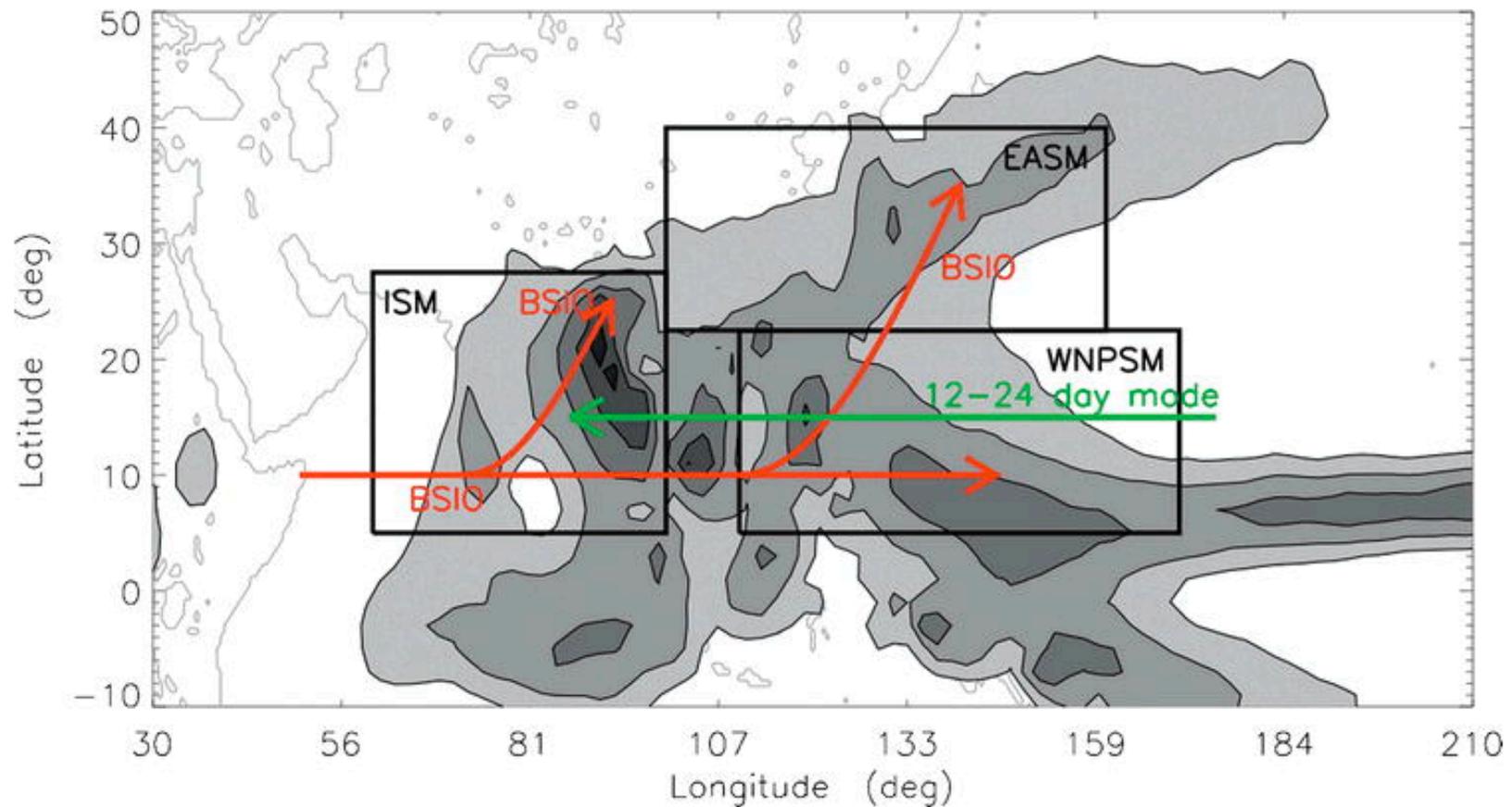
Northward-propagating precipitation



*analysis as in
Fu et al., 2003*

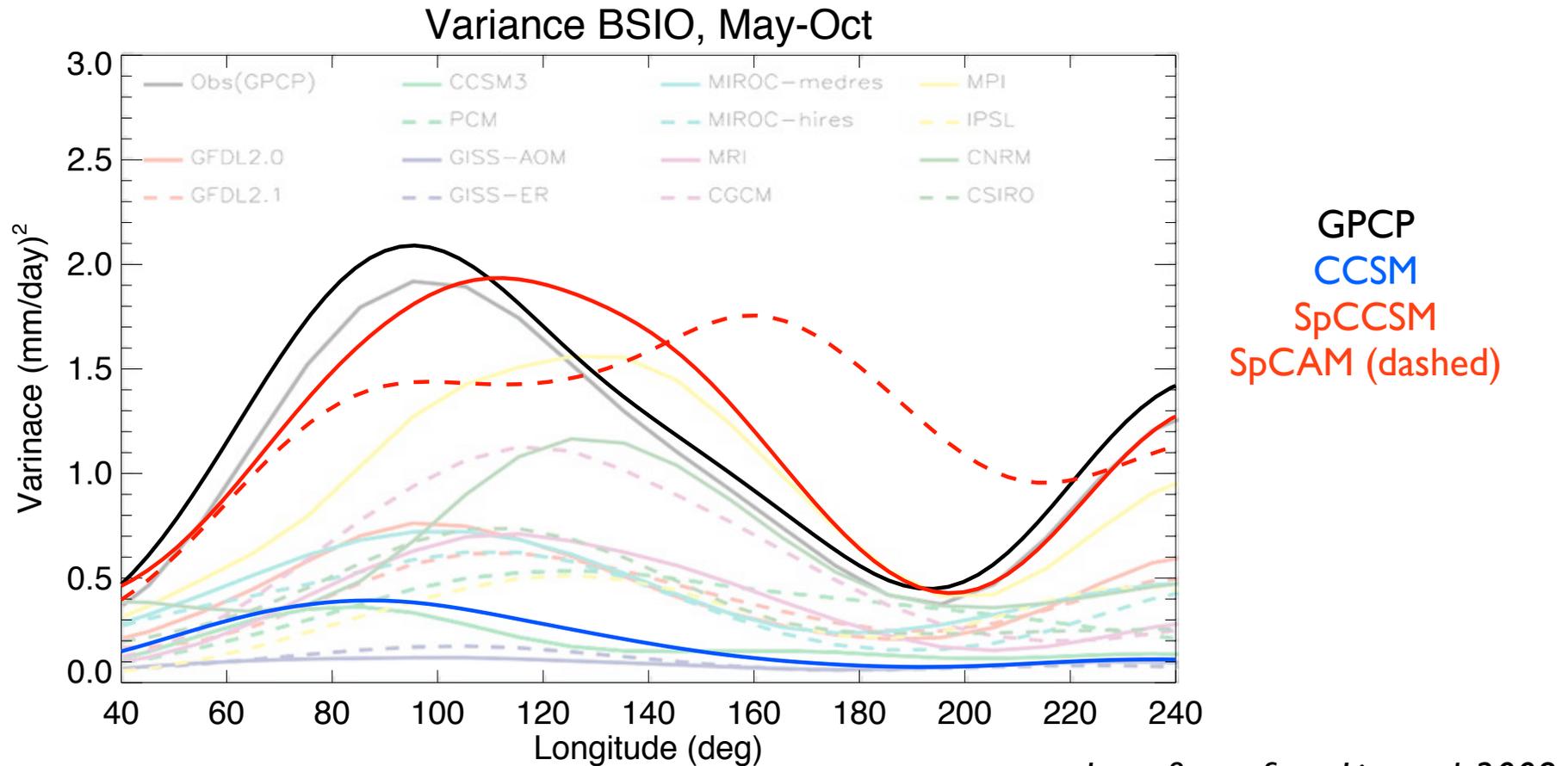
The Dynamic Monsoon

May-Oct mean precipitation



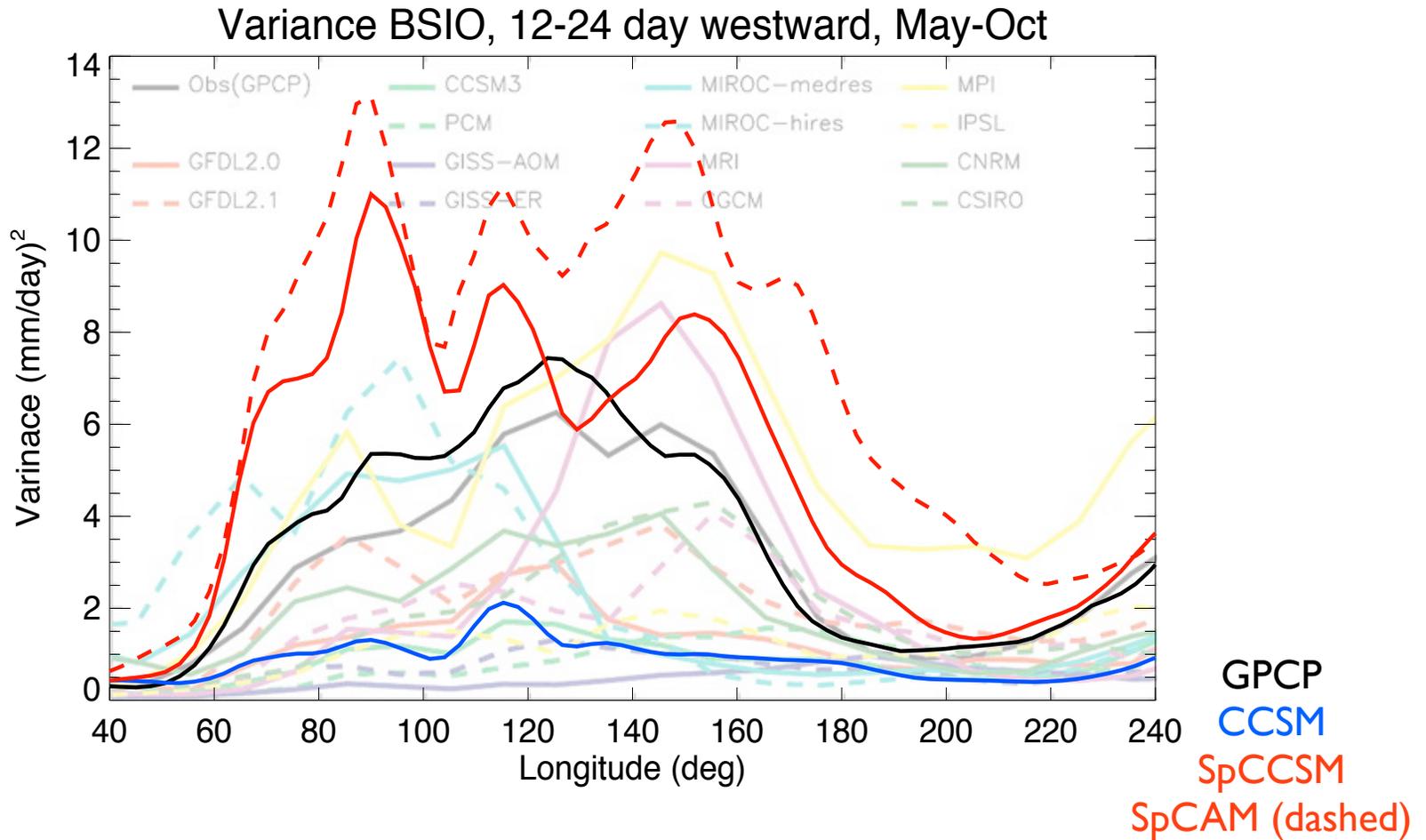
from Lin et al. 2008

Eastward-propagating precipitation

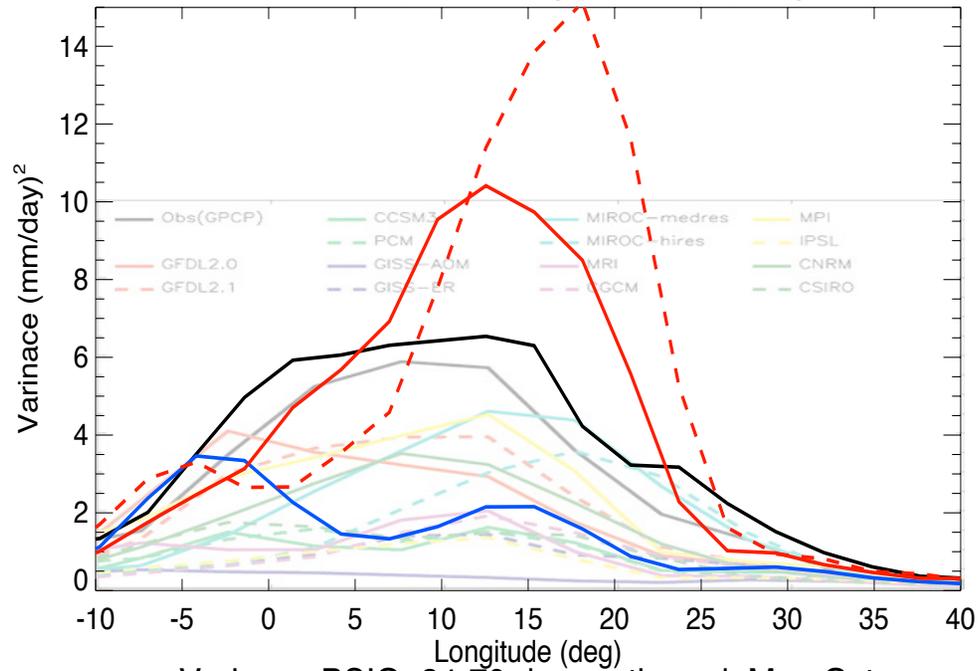


5N-25N, eastward wave #s 1-6, periods 24-70 days

Variance of May-October westward-propagating 12-24-day mode



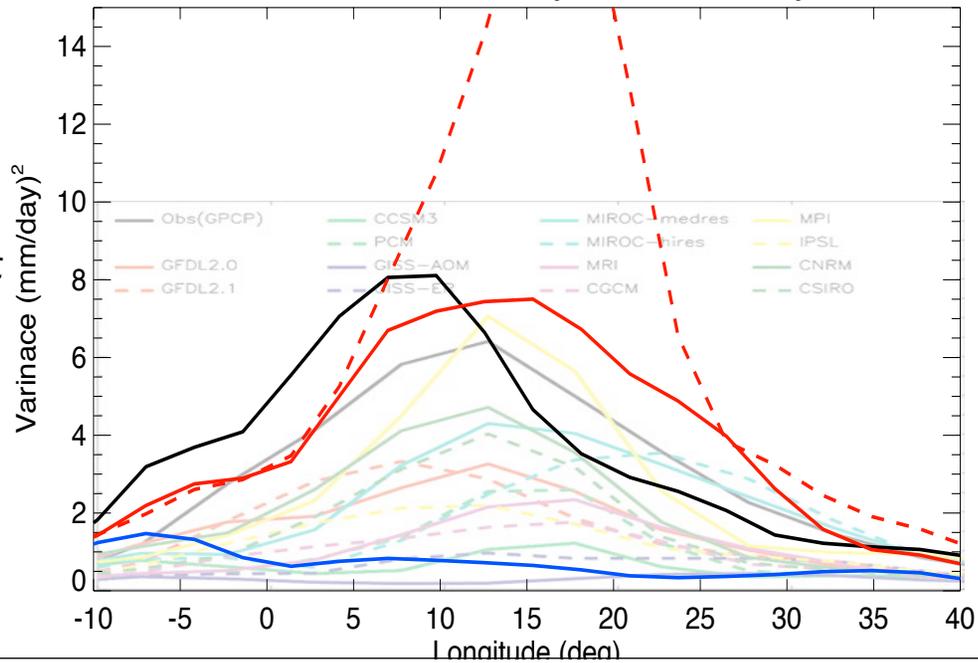
Variance BSI0, 24-70 day northward, May-Oct



GPCP
 CCSM
 SpCCSM
 SpCAM (dashed)

a) Indian Ocean

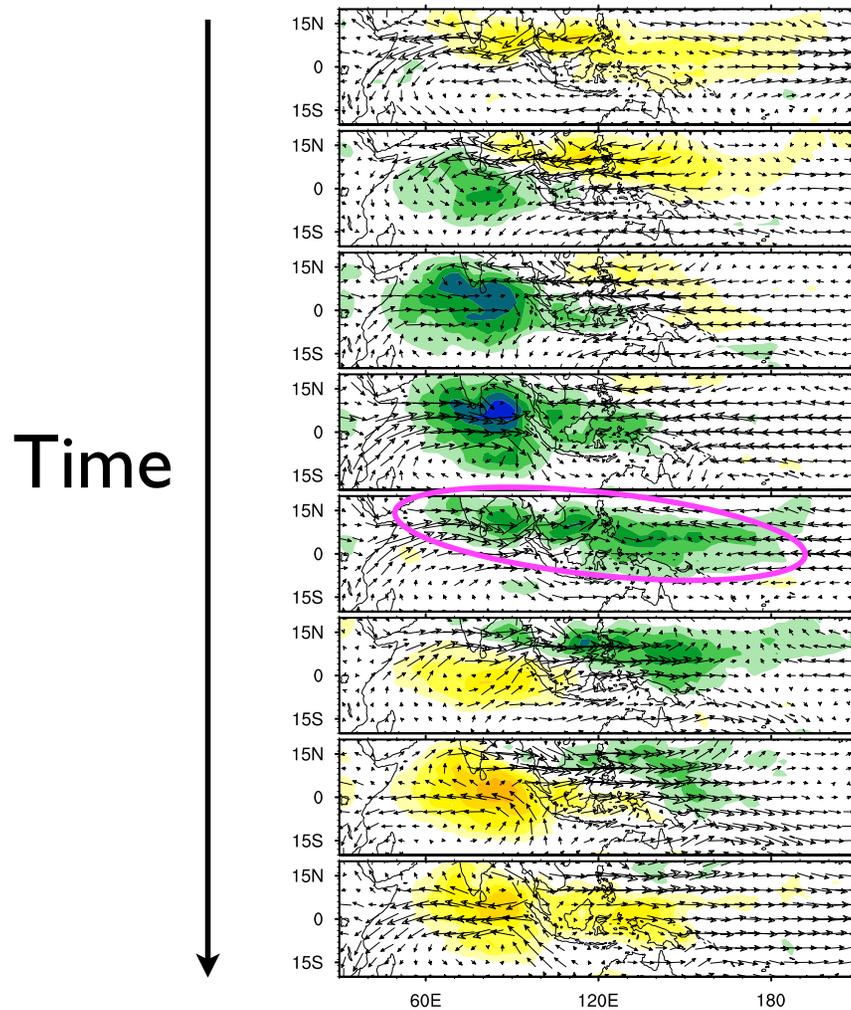
Variance BSI0, 24-70 day northward, May-Oct



b) western Pacific

May-Oct Composite Monsoon

OBS



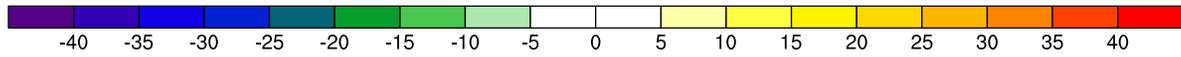
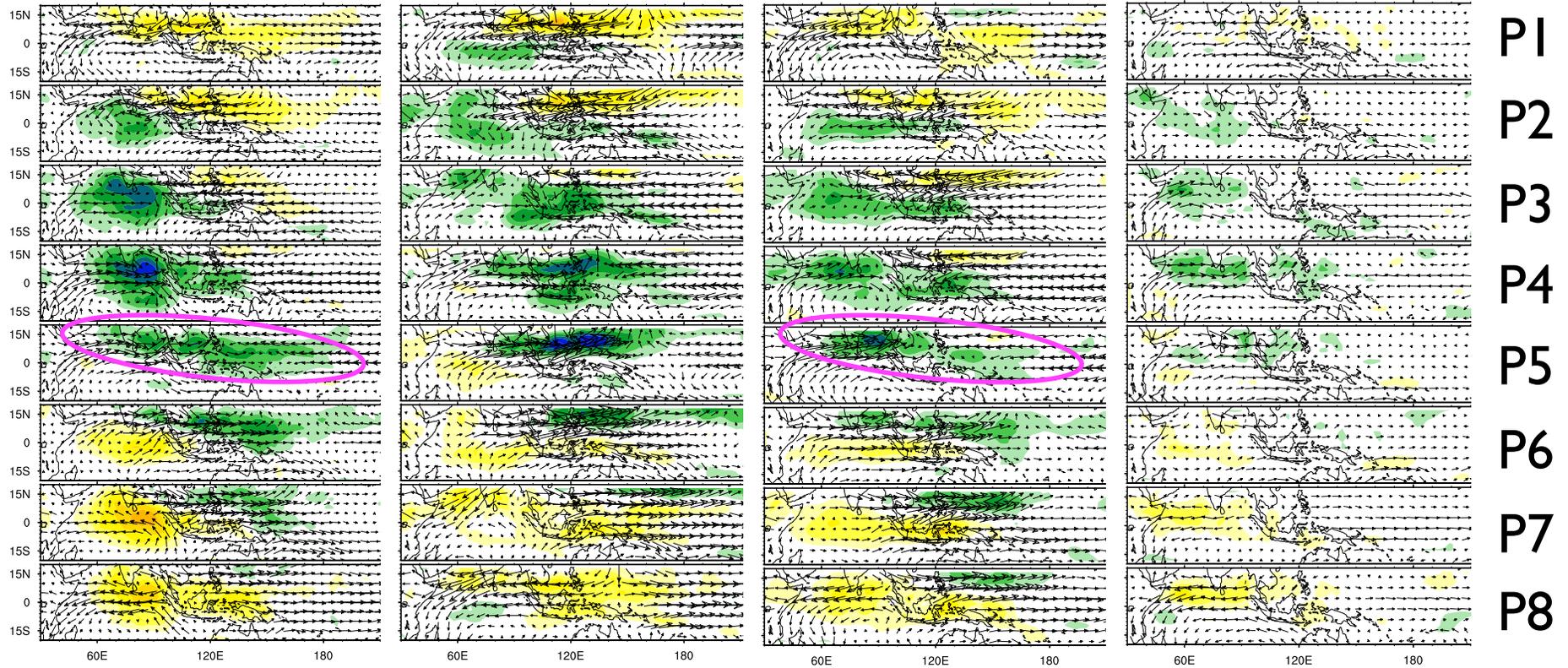
May-Oct Composite OLR

OBS

SpCAM

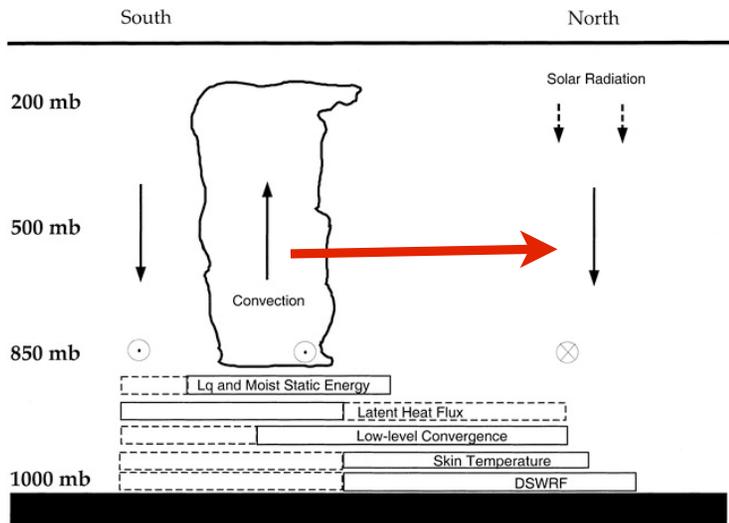
SpCCSM

CCSM

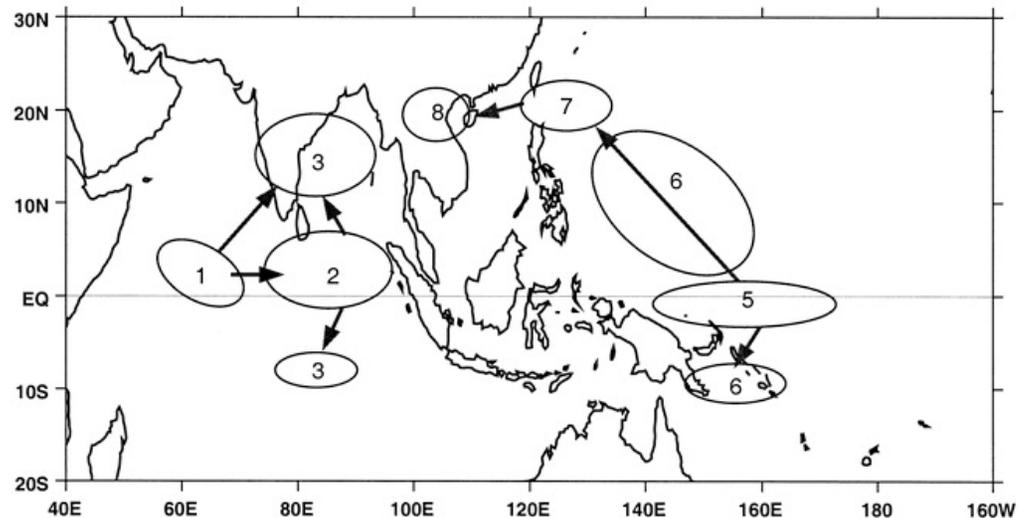


Factors relevant to northward propagation:

Air-Sea coupling/ surface fluxes



Northwestward-propagating Rossby waves



Figures from Kemball-Cook and Wang, 2001

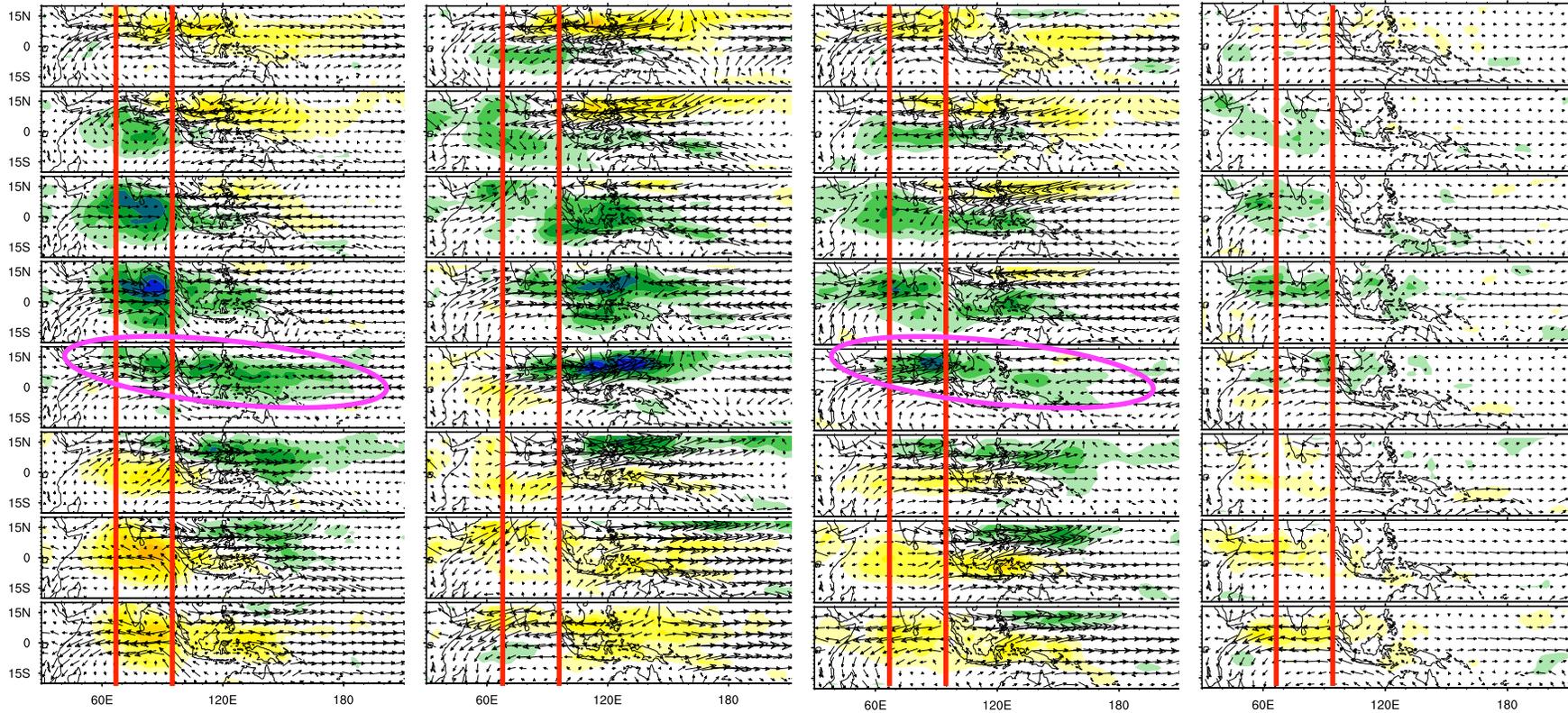
May-Oct Composite ISO

OBS

SpCAM

SpCCSM

CCSM



P1

P2

P3

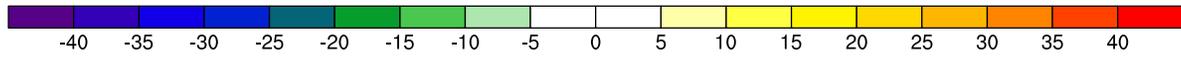
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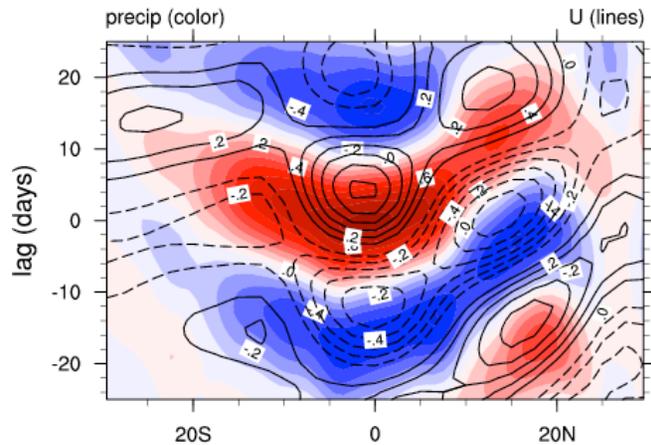
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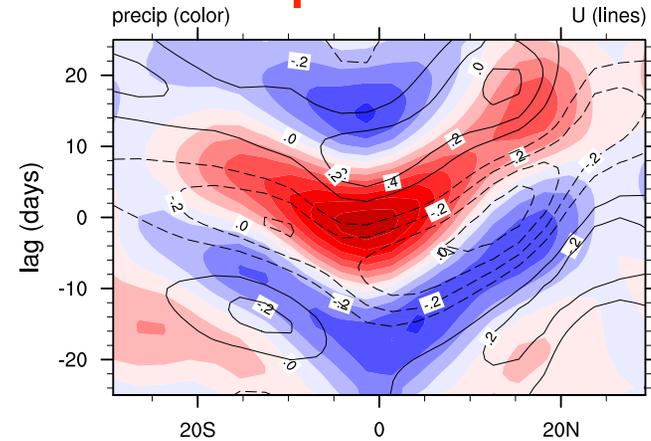


Variability: Summer ISO

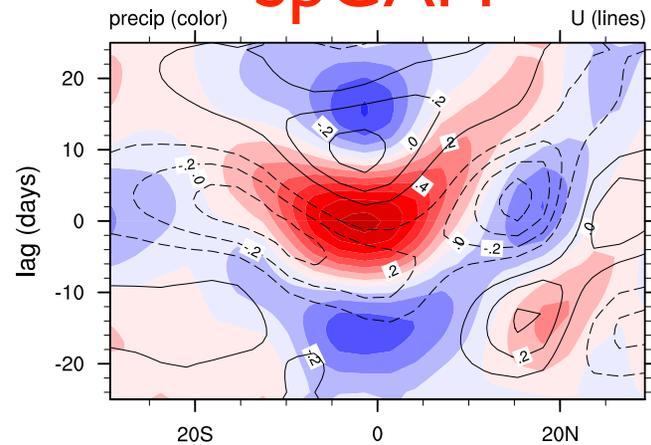
OBS



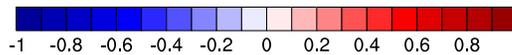
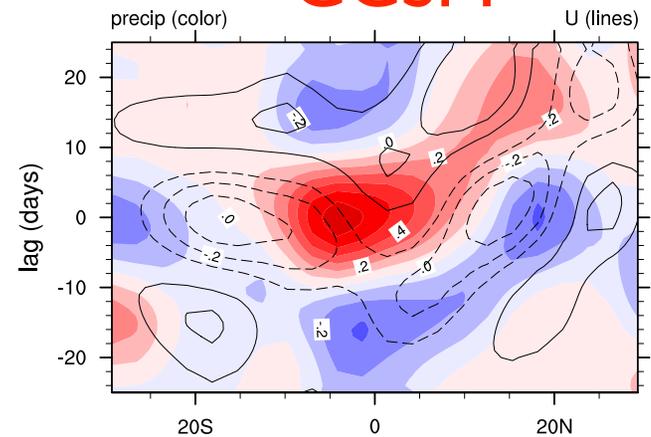
SpCCSM



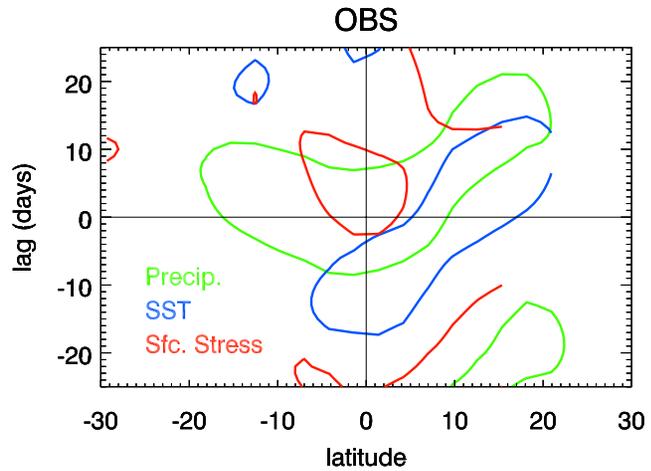
SpCAM



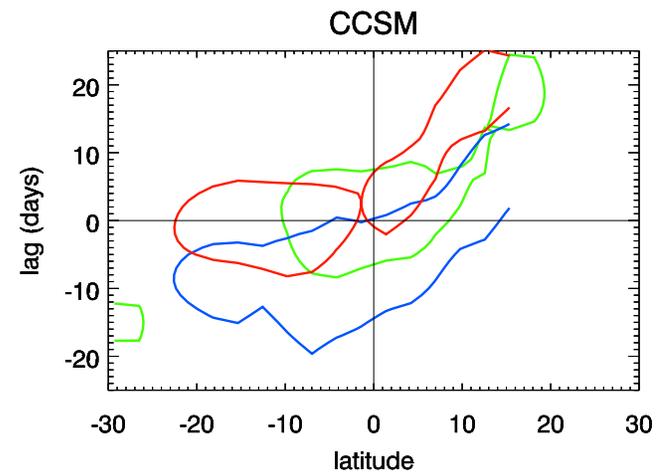
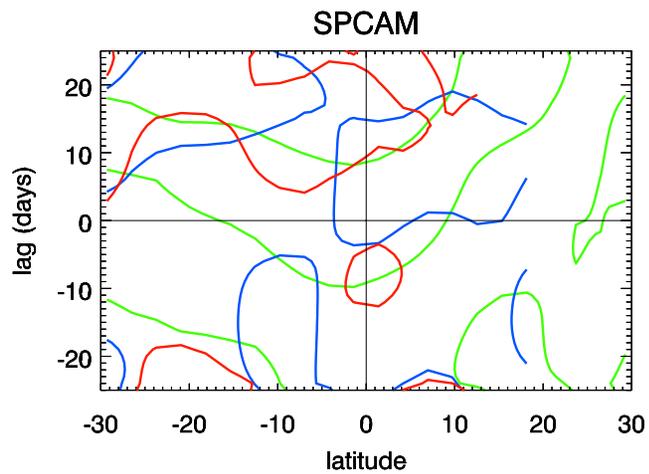
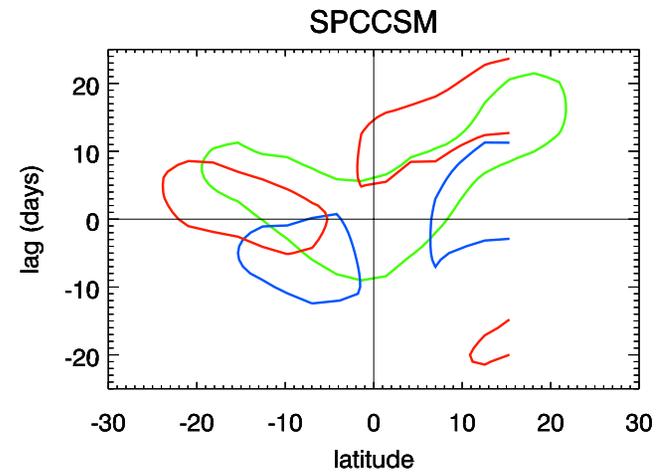
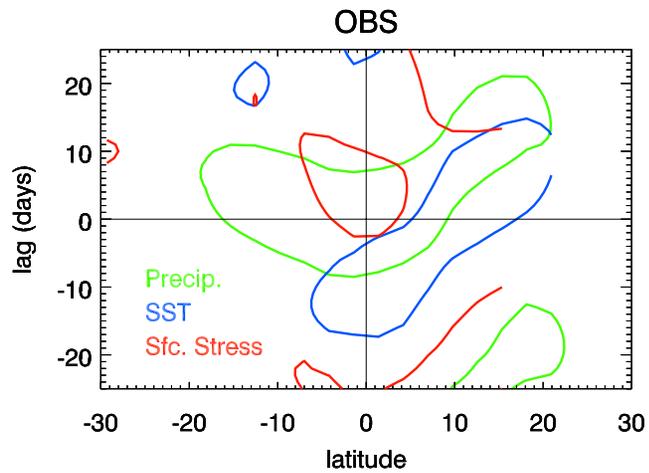
CCSM



Air-Sea Interactions

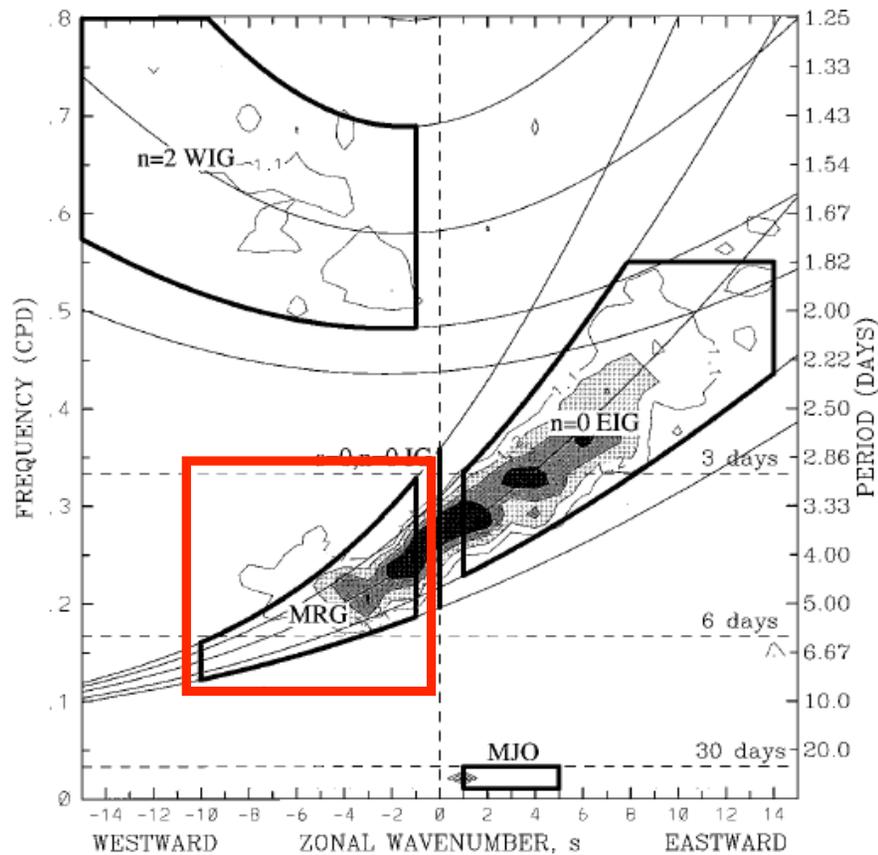


Air-Sea Interactions

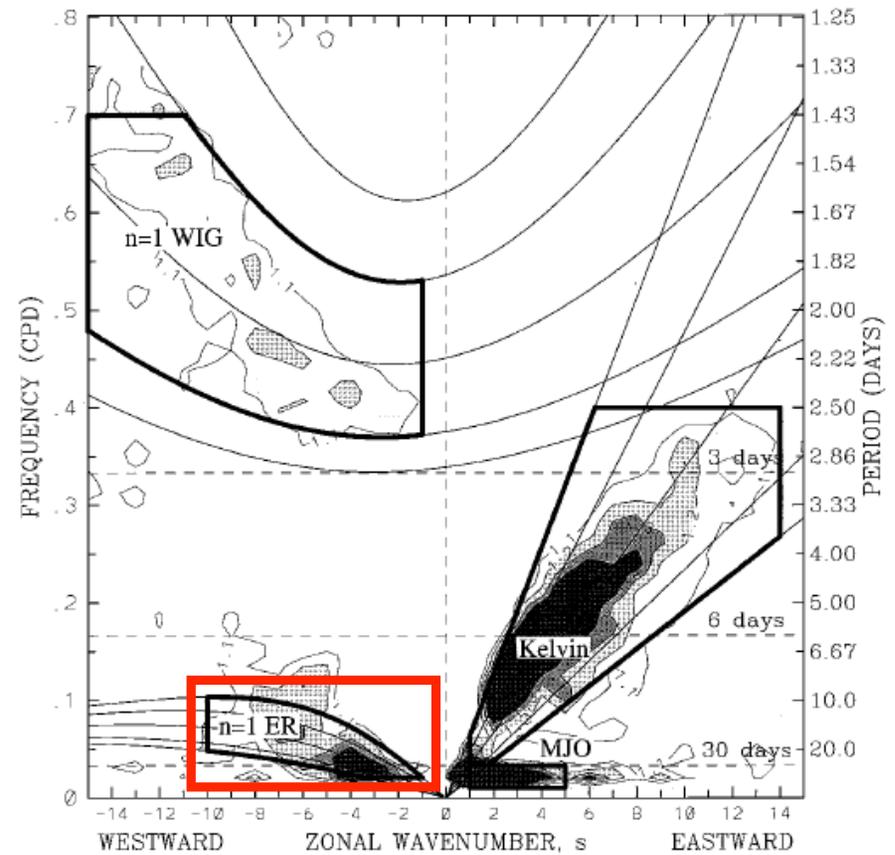


Filtering Equatorial Waves

a) Regions of filtering for OLR A (Antisymmetric)

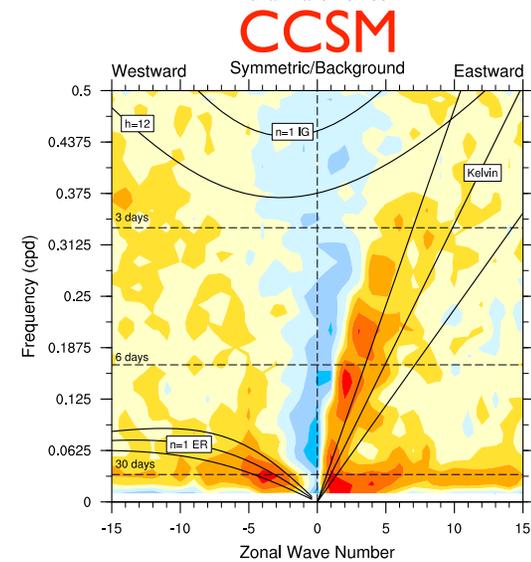
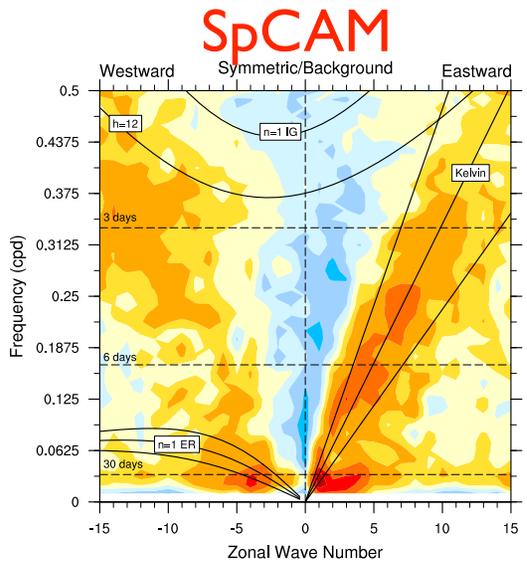
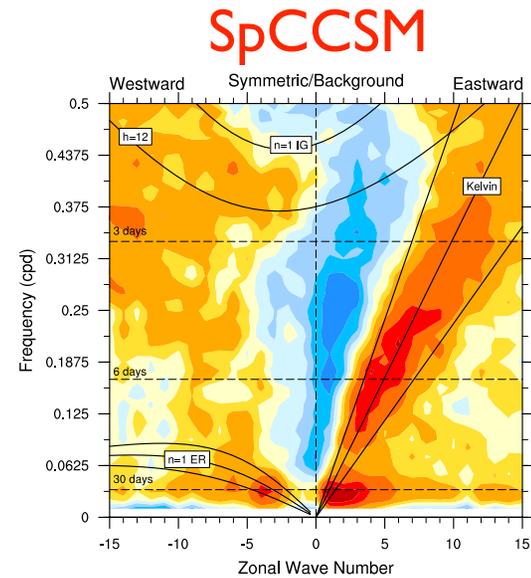
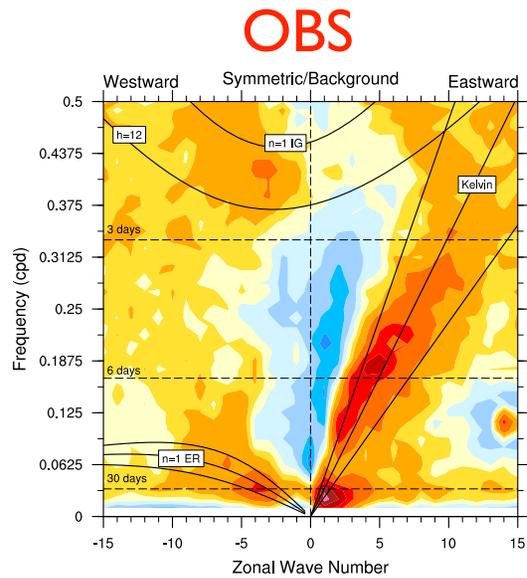


b) Regions of filtering for OLR S (Symmetric)

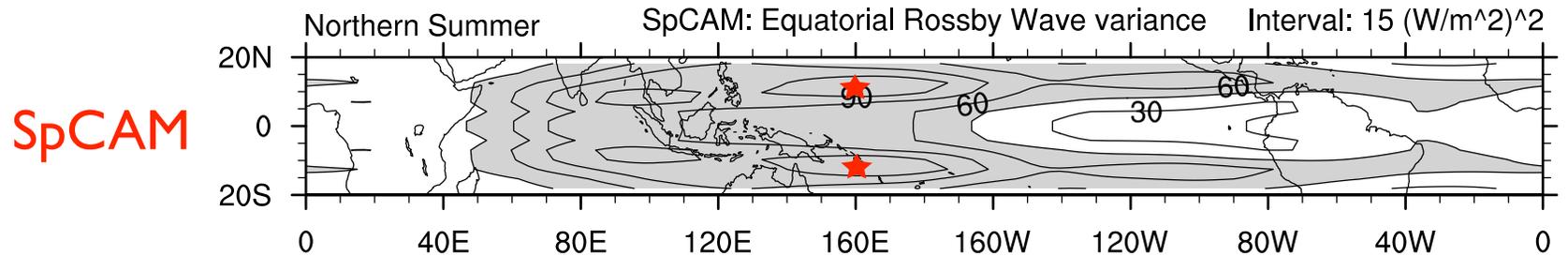
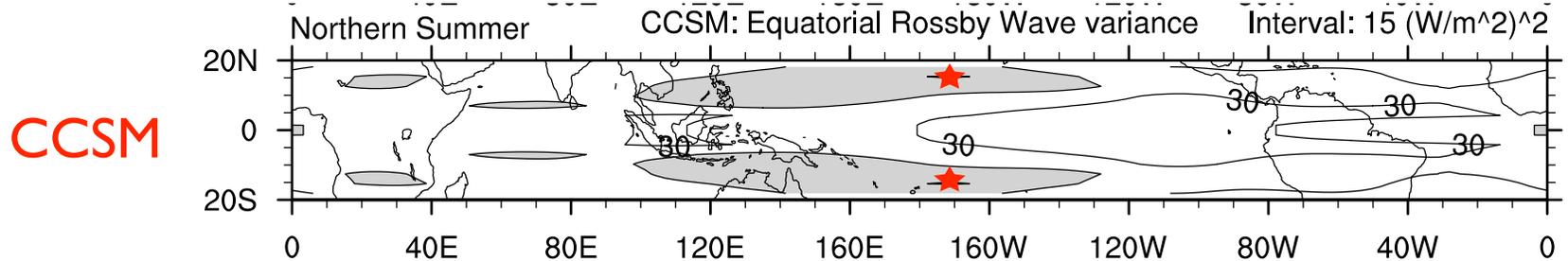
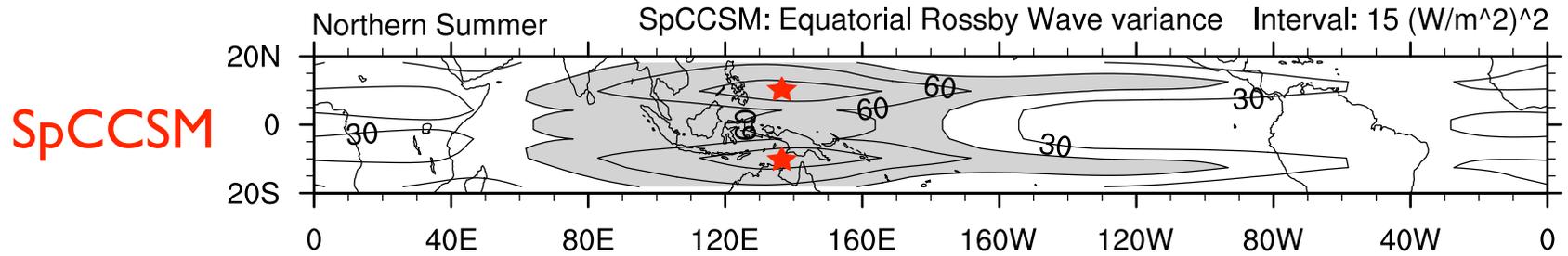
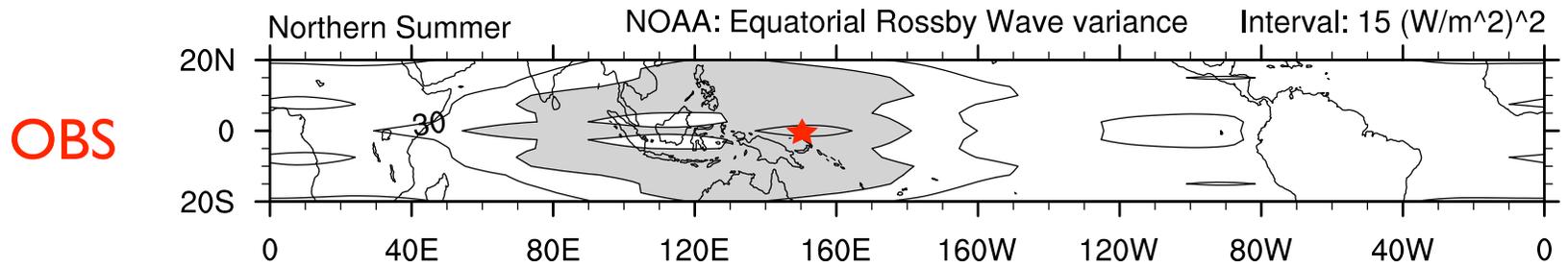


from Wheeler & Kiladis, 1999

Equatorial Waves (sym)

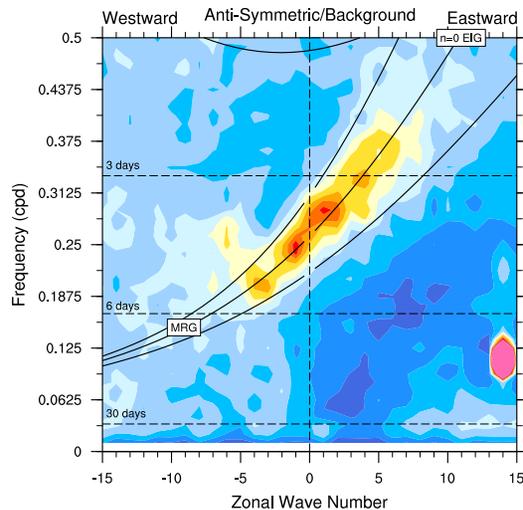


Equatorial Rossby Waves

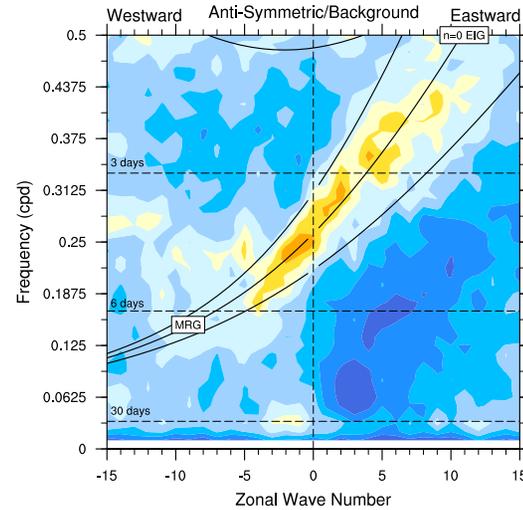


Equatorial Waves (asym)

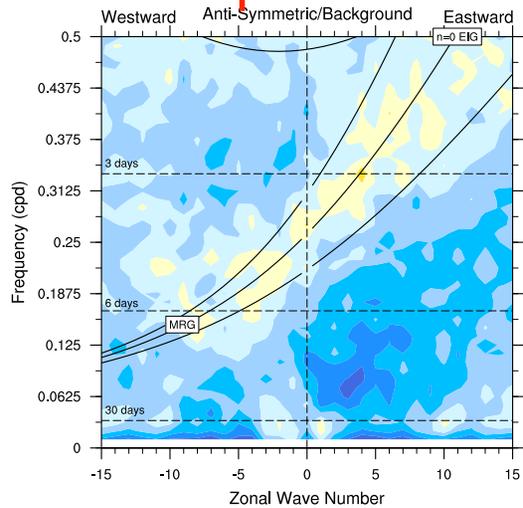
OBS



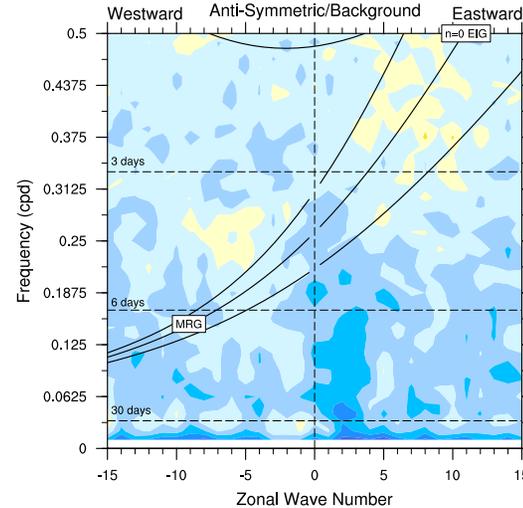
SpCCSM



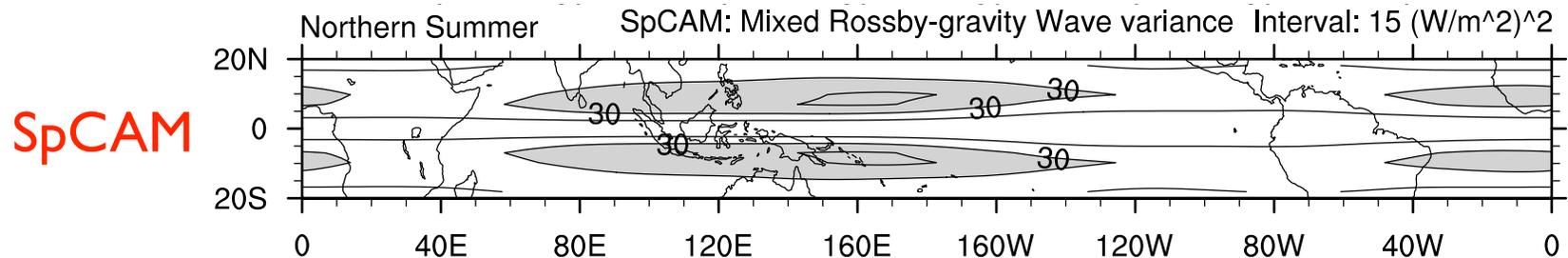
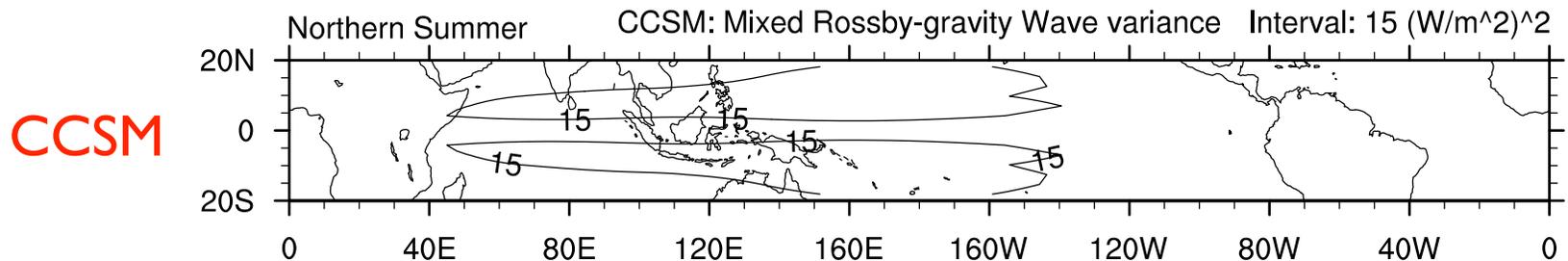
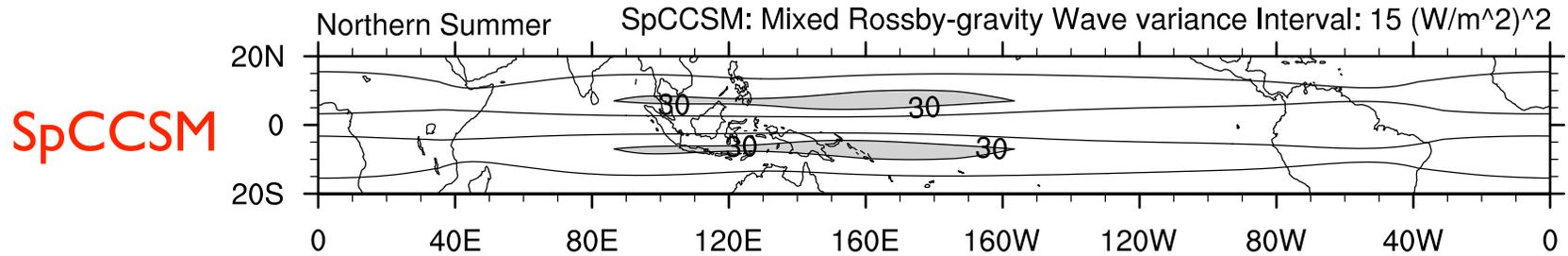
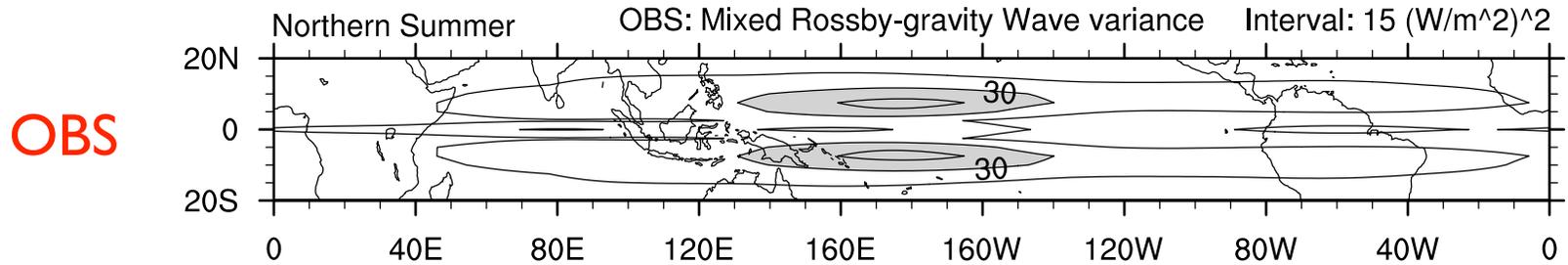
SpCAM



CCSM



Mixed Rossby-Gravity Waves



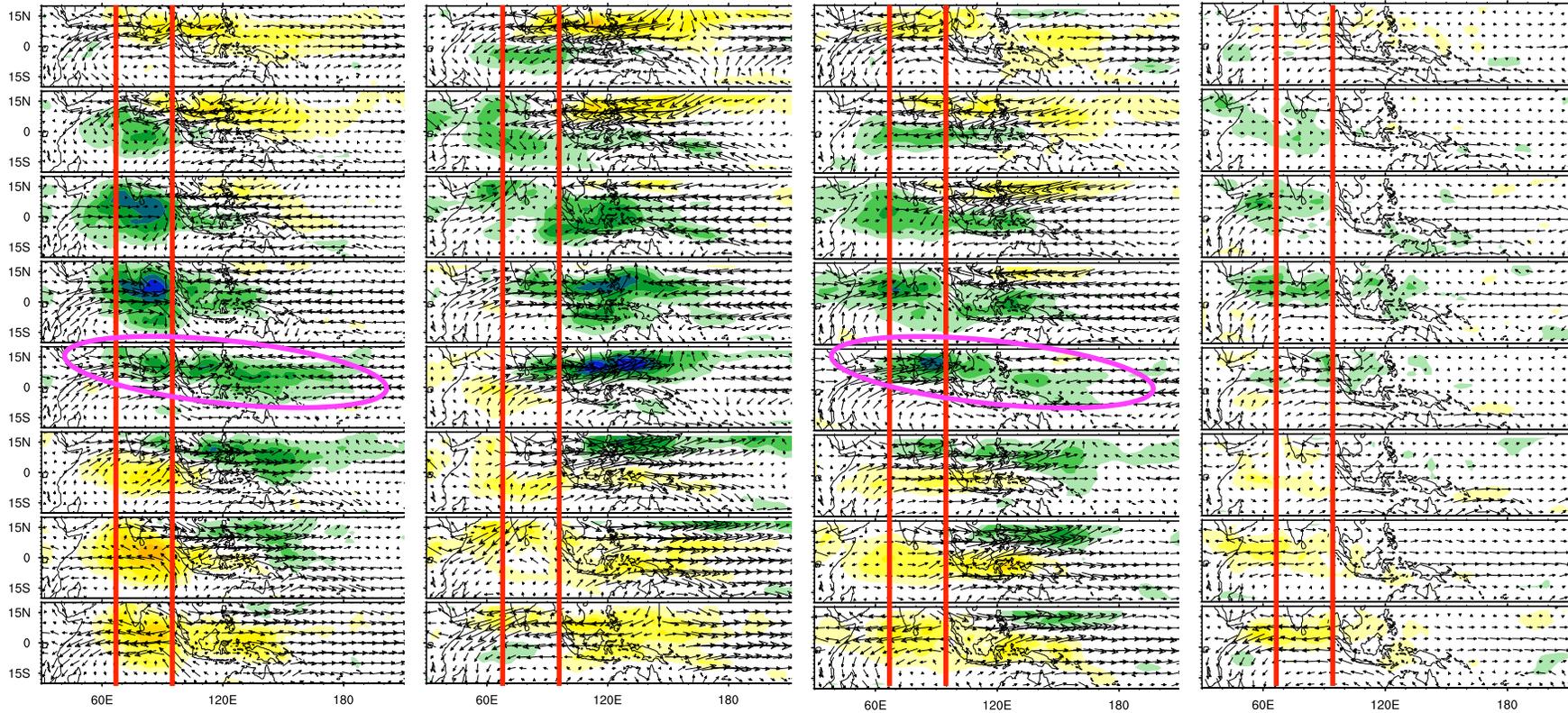
May-Oct Composite ISO

OBS

SpCAM

SpCCSM

CCSM



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P3

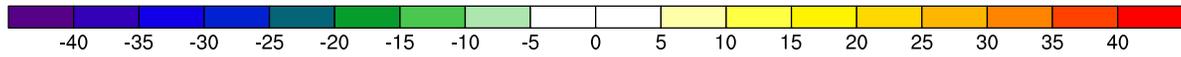
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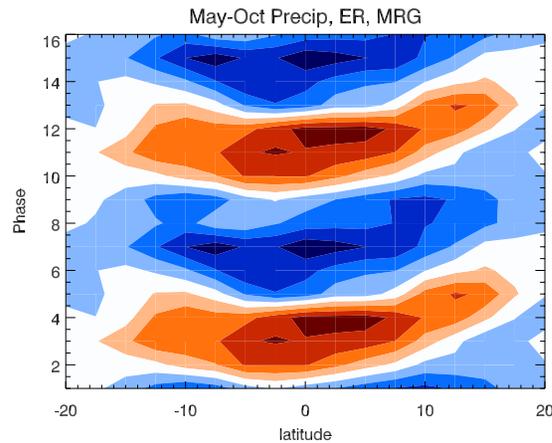
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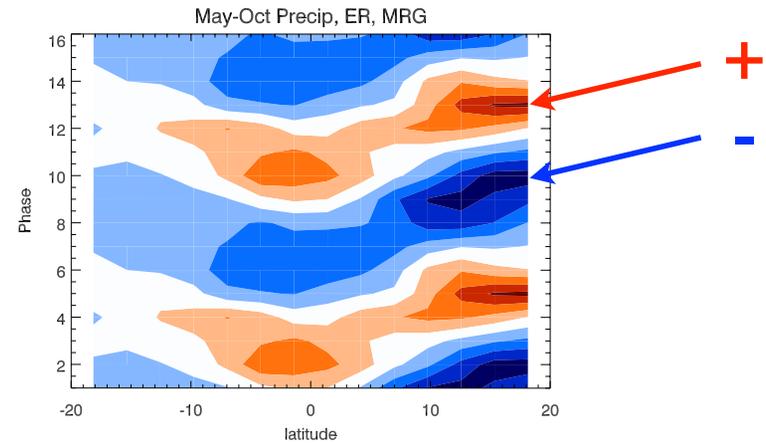


Indian Ocean meridional composite by MJO PCI+PC2 phase (2 cycles shown)

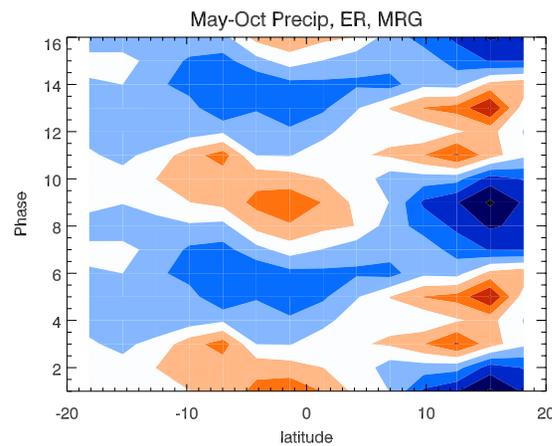
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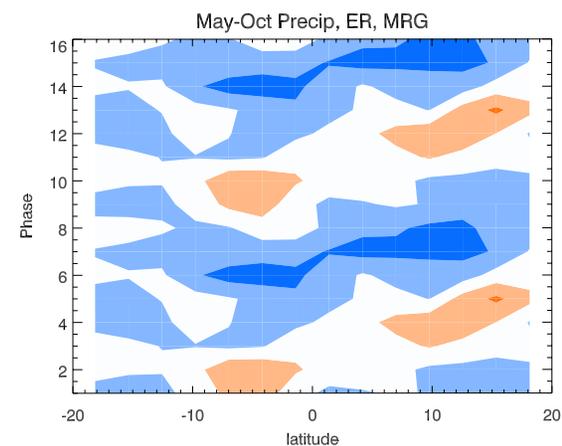
SpCCSM



SpCAM



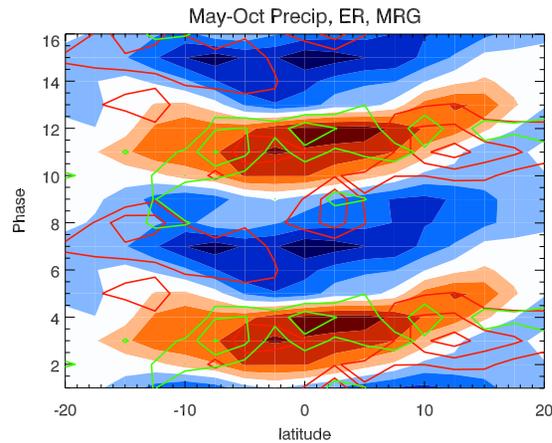
CCSM



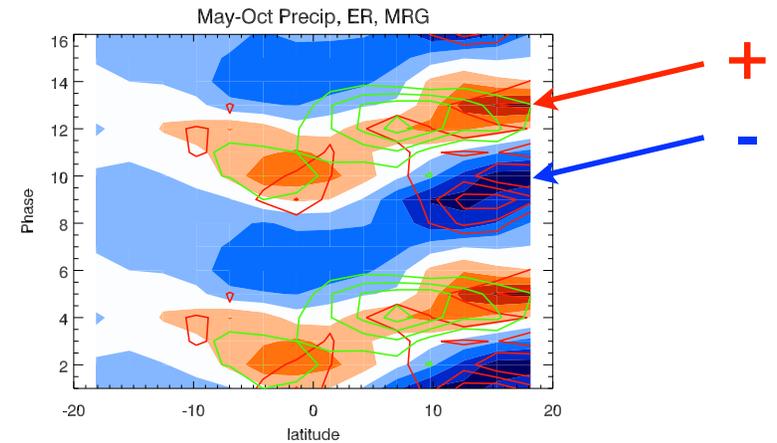
Precip' (red= positive anomaly)

Indian Ocean meridional composite by MJO PCI+PC2 phase (2 cycles shown)

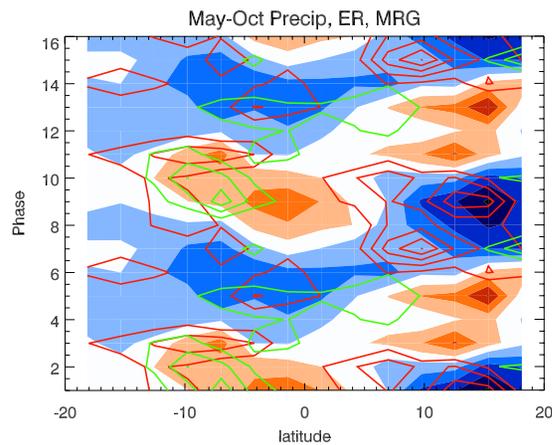
OBS



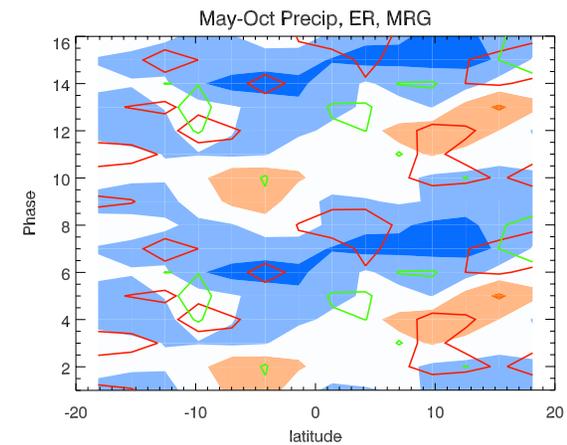
SpCCSM



SpCAM



CCSM



Precip' (shaded), +MRG', +ER'

Summary

SP improves monsoon variability in CCSM.

Coupling to the ocean improves the basic state.

Coupling to the ocean improves northward propagation.

Coupling to the ocean improves the ER and MRG waves.

Sperber and Annamalai, 2008:

“...*unstable coupled modes* at intraseasonal time scales *owe their existence to atmospheric waves* that are then destabilized and modified by:

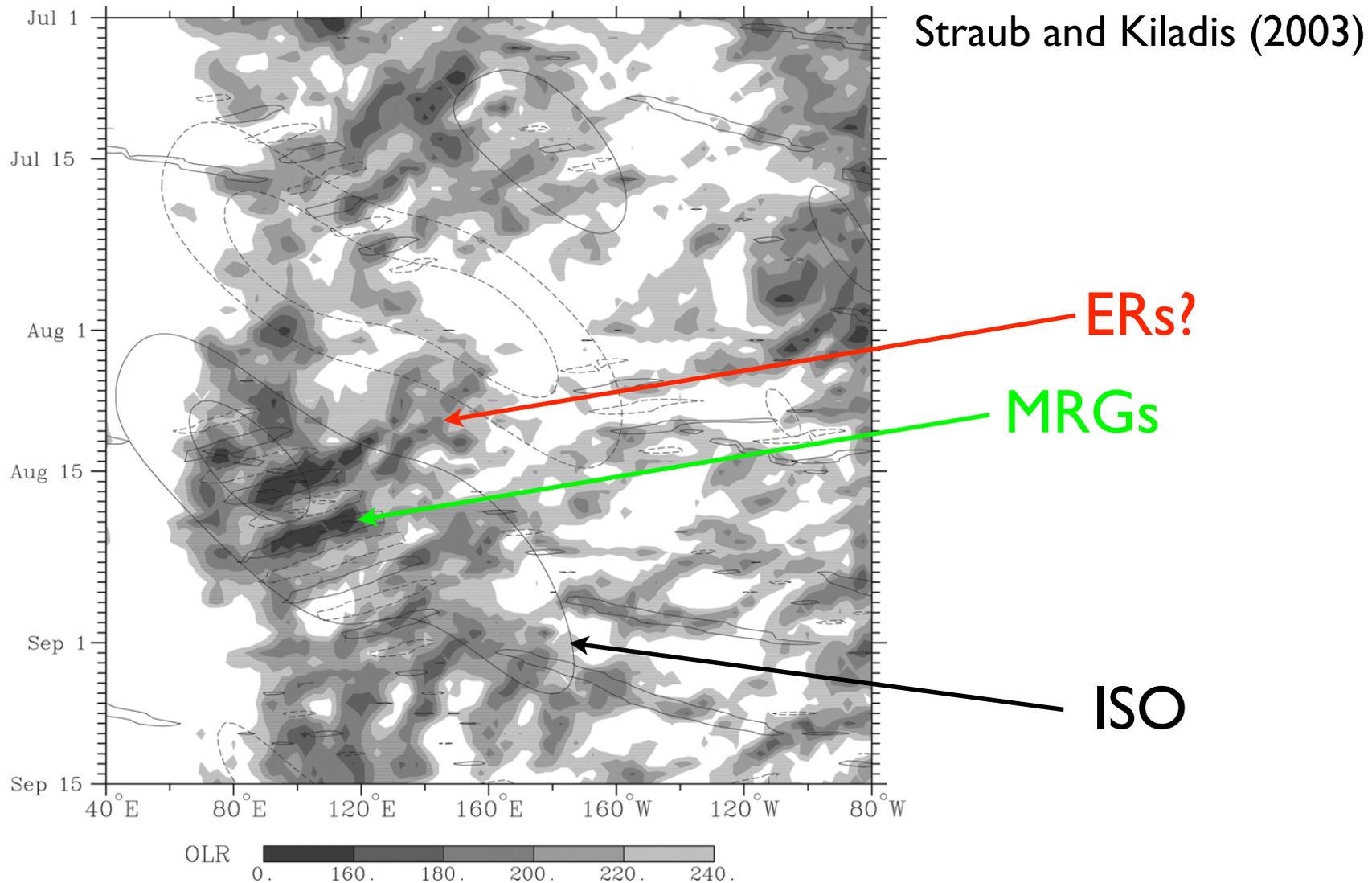
- *the basic state*
- *air-sea interactions*
- *cloud-radiation [feedbacks]*
- *convection-water vapor feedbacks.*

Thus, the mere representation of *the time-mean basic state alone does not guarantee a realistic simulation* of the BSISV.”



The End

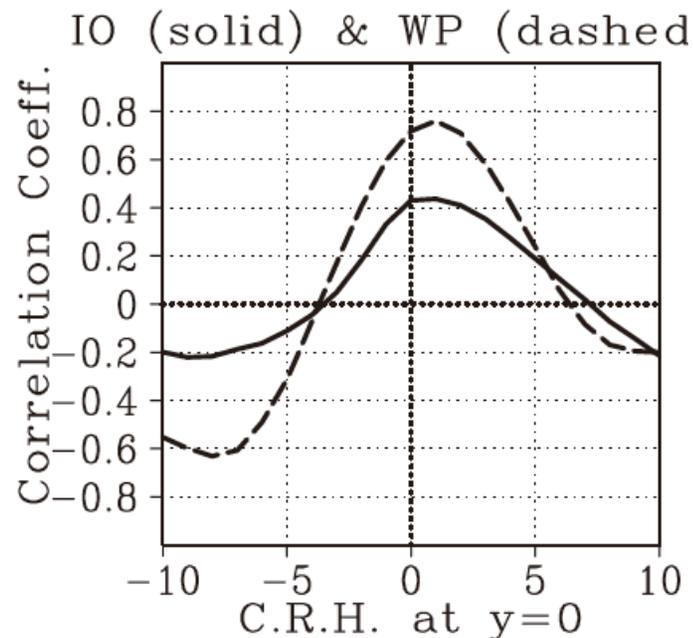
Example of MRGs in Asian Monsoon



“The [MRG] wave is found to be closely connected to the lower-level [ER] wave that appears earlier and seems to provide organization for the convection, which in turn forces the [MRG] wave.” – Yang et al. (2007).

“The ER wave convection is led by moisture convergence but lagged by column relative humidity.” – Masunaga (2007).

(CRH correlated to deep stratiform cloud)



lag > 0 means CRH lags deep stratiform

How do air-sea interactions improve wave activity?

