

Ingredients for ENSO and MJO: Tropical Variability of Coupled CESM Aqua and Ridge Planets

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CESM CVCWG Meeting, February 18, 2021

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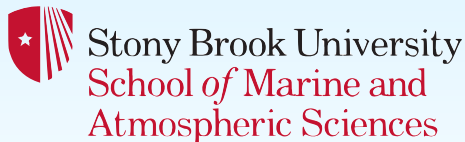
Acknowledgments (alphabetical):

Alper Altuntas, David Bailey, Jim Benedict, Brian Kauffman,
Erik Kluzek, Hui Li, Keith Lindsay, Brian Medeiros, Mathew
Rothstein, Mariana Vertenstein (NCAR)

Kyle Armour, Sarah Ragen (Univ. of Washington)

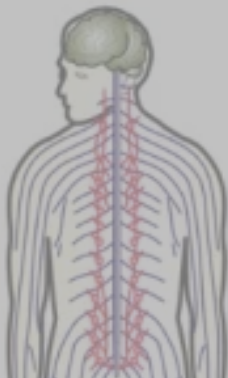
Pedro Di Nezio (Univ. of Colorado, Boulder)

Andrew Shao (Canadian Centre for Climate Modelling and
Analysis)



Rationale: Simpler Models for Better Understanding (Held 2005)

Human



[Prokop, 2015]

Mouse

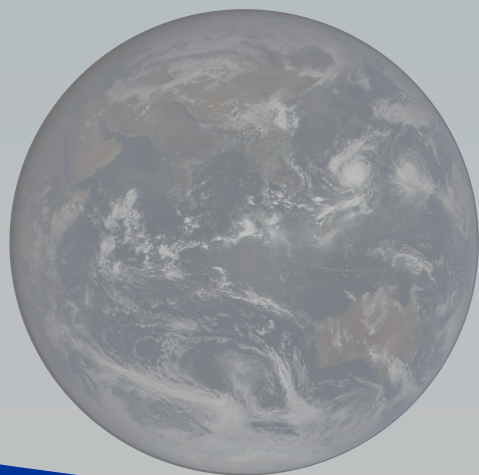


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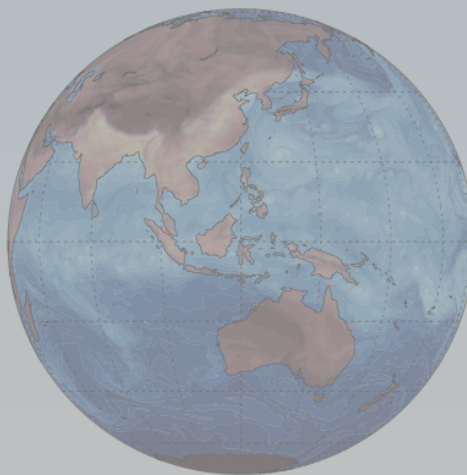
Fruit fly



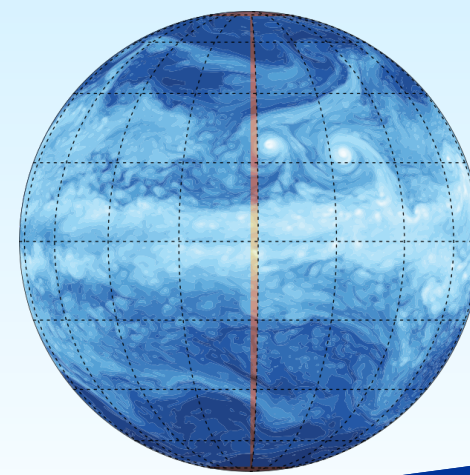
Earth's Climate



Conventional Model

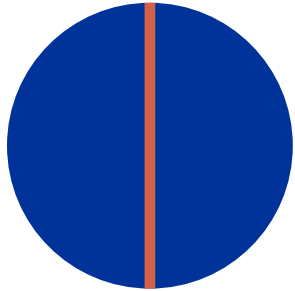


Simplified Models



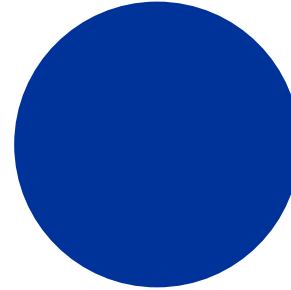
Simplified Coupled Model Set-Up (Wu et al., in revision)

Ridge



- ~97% Ocean
- Idealized Pacific
- Bounded by one single pole-to-pole strip continent (Smith et al., 2006)

Aqua



- ~98% Ocean
- Model grid requires two minimal polar land caps

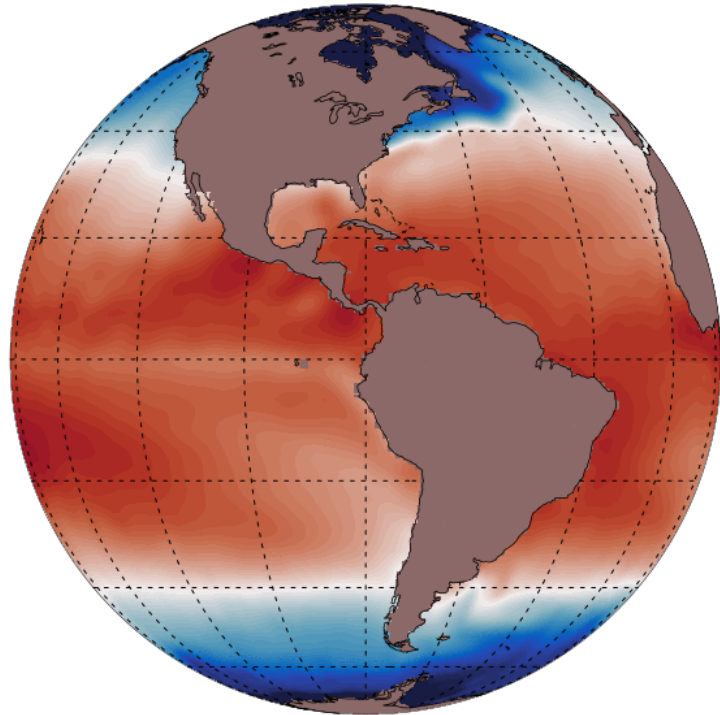
- **Model components:** Atmosphere (CAM4 $\sim 1^\circ$), ocean (MOM6 $\sim 2^\circ$), sea ice (CICE5), and land (CLM5) components from NCAR's Community Earth System Model (CESM)
- **Idealized seasonal cycle** by fixed orbital parameters
- **Simulation length:** 500 years for each; Year 401-500 for analysis

Earth vs. Ridge: Seasonal Cycle of Sea Surface Temperature

Earth

01-Feb 2001 (00H)

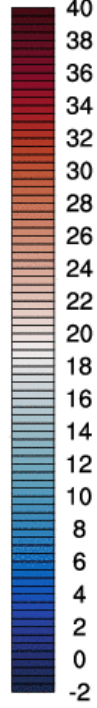
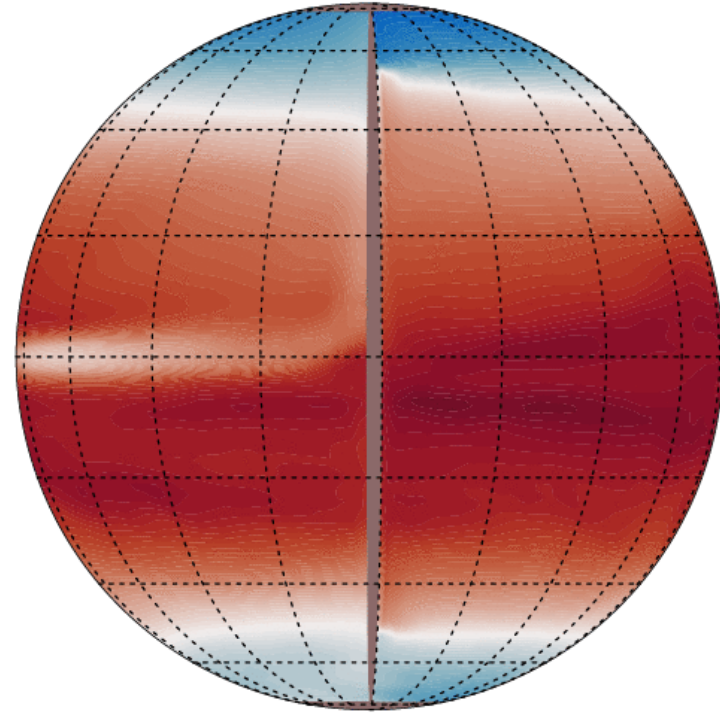
Sea Surface Temperature (°C)



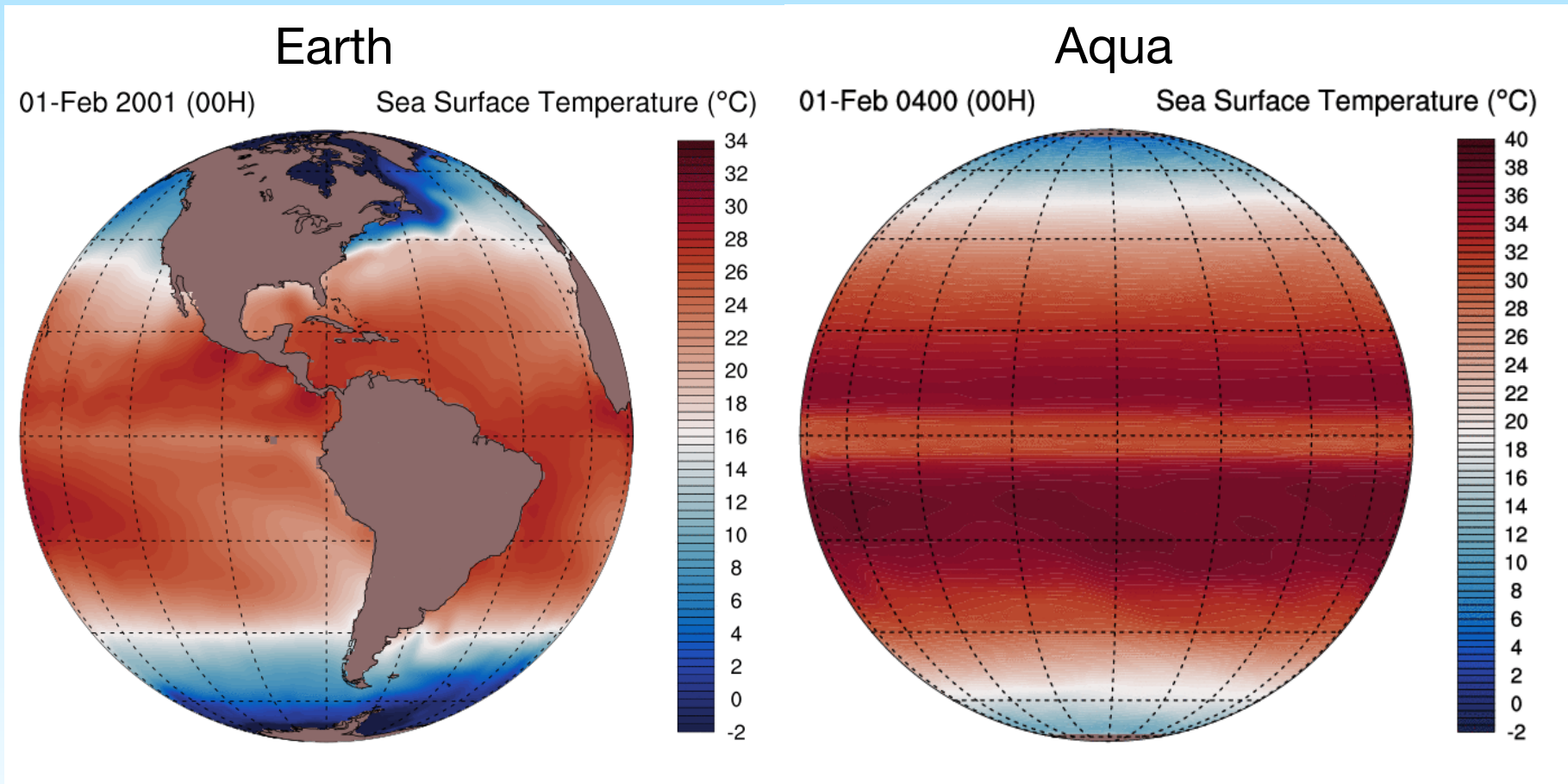
Ridge

01-Feb 0400 (00H)

Sea Surface Temperature (°C)



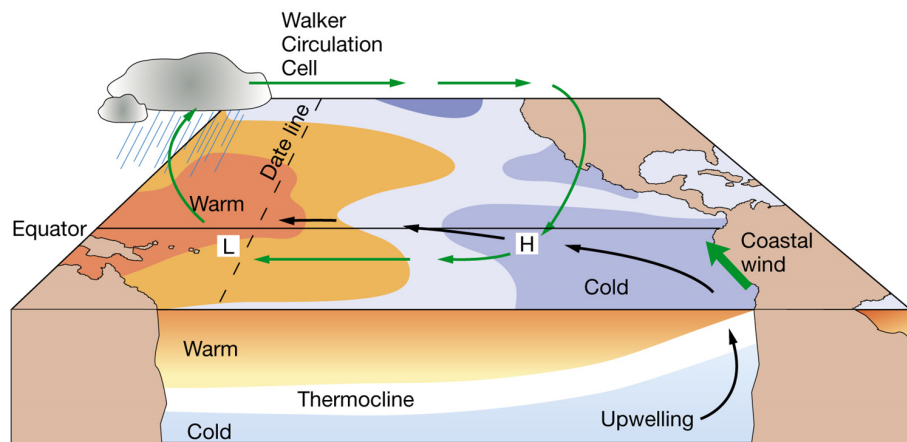
Earth vs. Aqua: Seasonal Cycle of Sea Surface Temperature



Earth vs. Ridge: Tropical Circulation (5N-5S)

Earth

Atmosphere: Cloudy and humid on western side



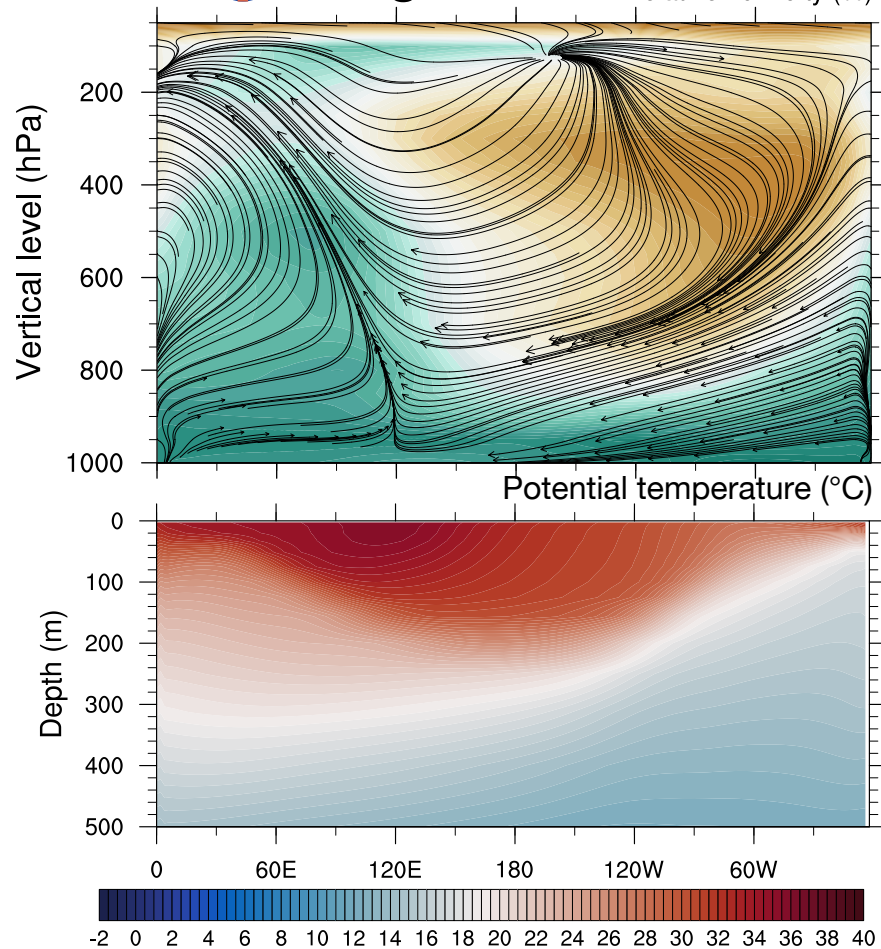
(a) Normal conditions

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Ocean: Deep layer of warm waters on western side

Ridge

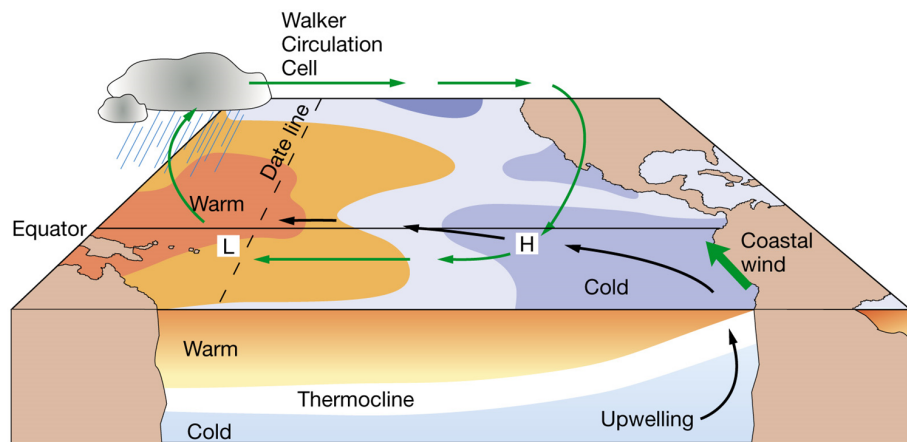
0 100
Relative humidity (%)



Earth vs. Aqua: Tropical Circulation (5N-5S)

Earth

Atmosphere: Cloudy and humid on western side



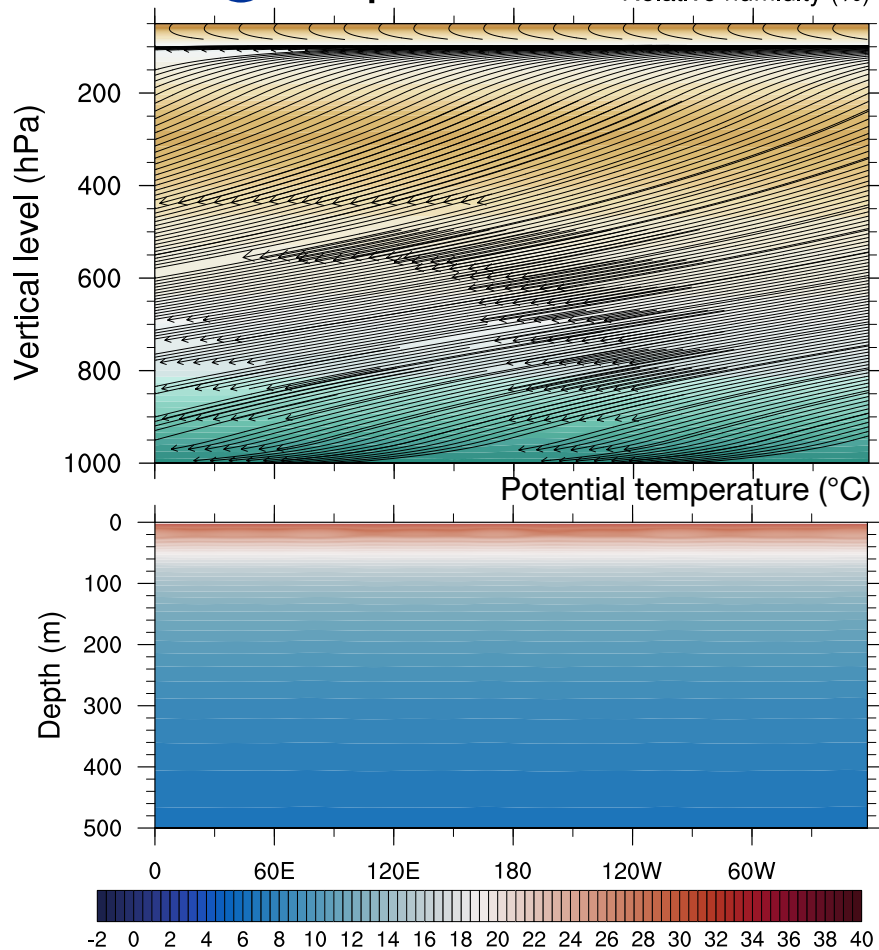
(a) Normal conditions

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Ocean: Deep layer of warm waters on western side

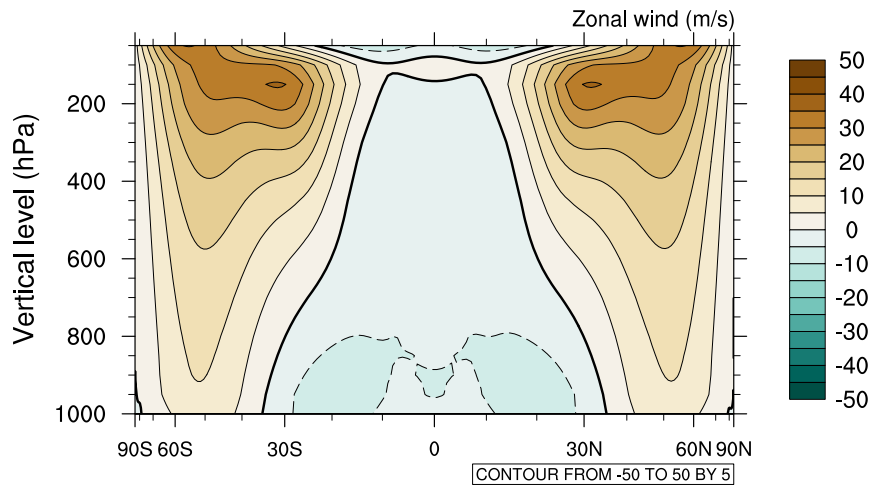
Aqua

0 100
Relative humidity (%)



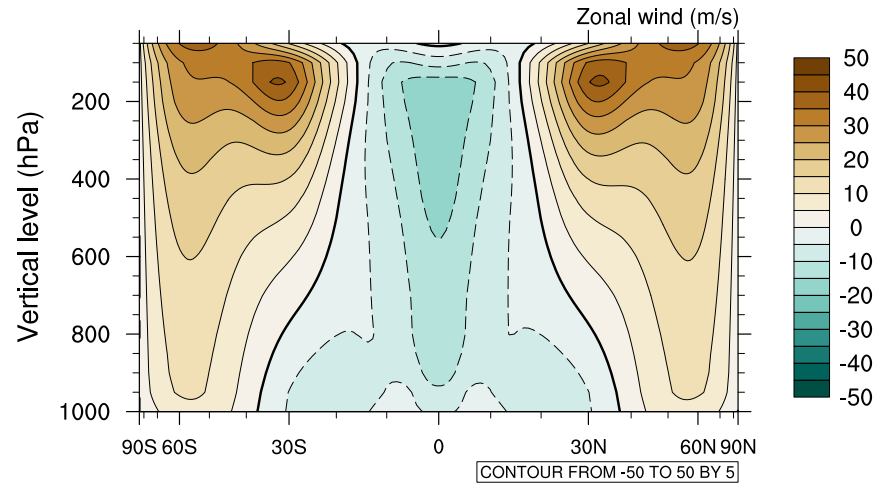
Mean Climate: Atmospheric circulation, zonal average

 Ridge



- Mean U-wind in the tropics: approx. -5 m/s

 Aqua

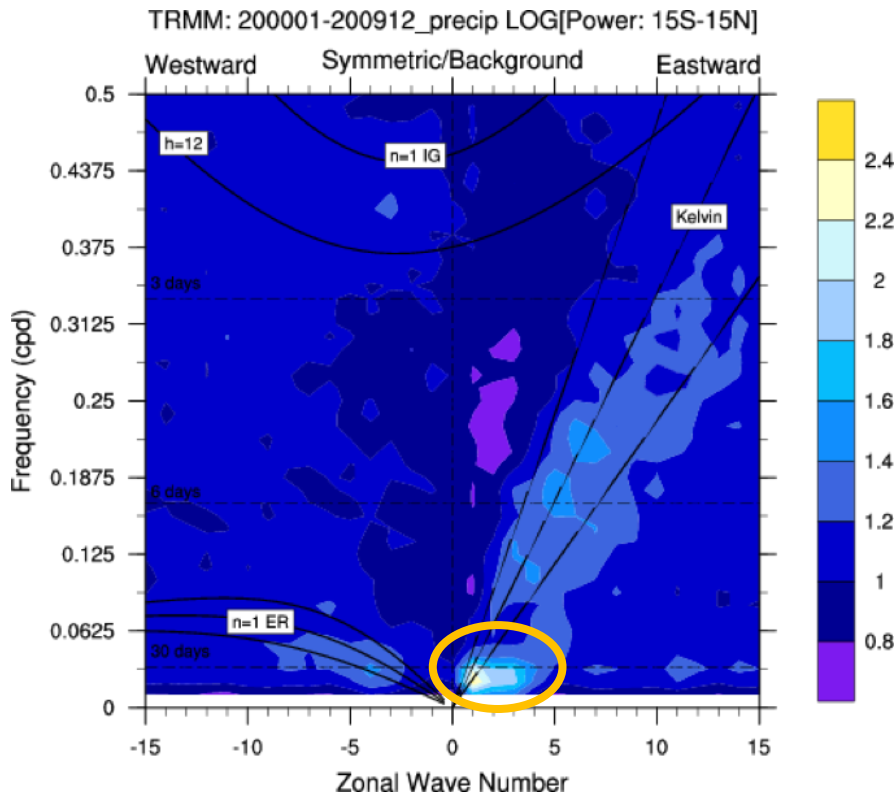


- Mean U-wind in the tropics: approx. -10 m/s

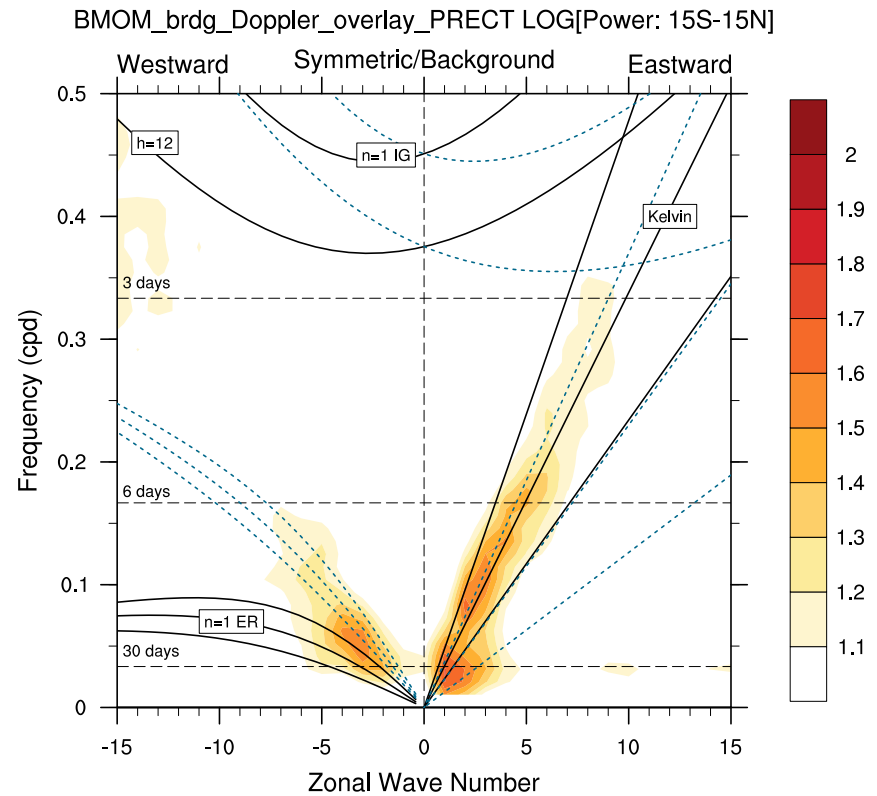
(Sub-)Seasonal Variability: MJO-like (?) Mode on Ridge

Earth

 Ridge (U = -5 m/s)



[Fig: ncl.ucar.edu]

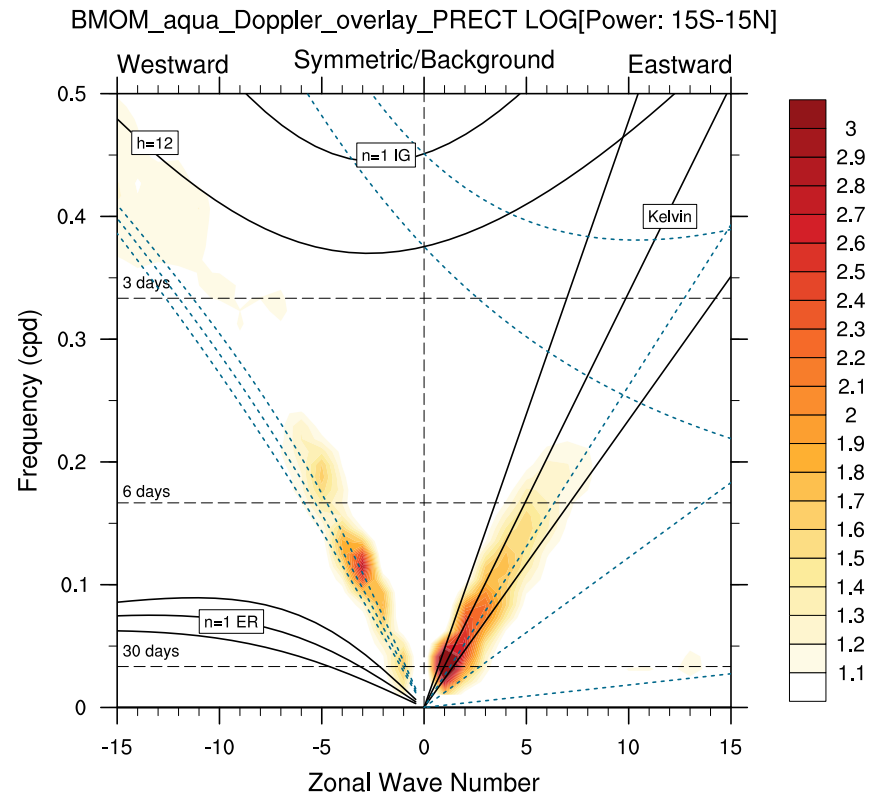
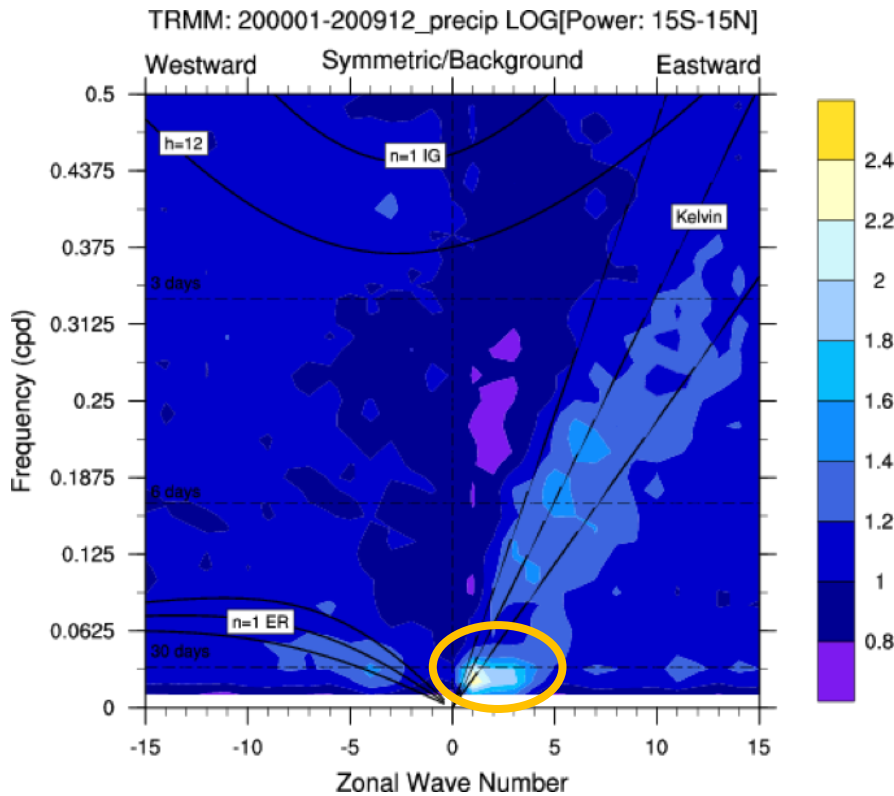


$$\hat{\omega} = \omega - \mathbf{U} \cdot \mathbf{k}$$

(Sub-)Seasonal Variability: Low-freq. Mode on Aqua

Earth

● Aqua ($U = -10$ m/s)

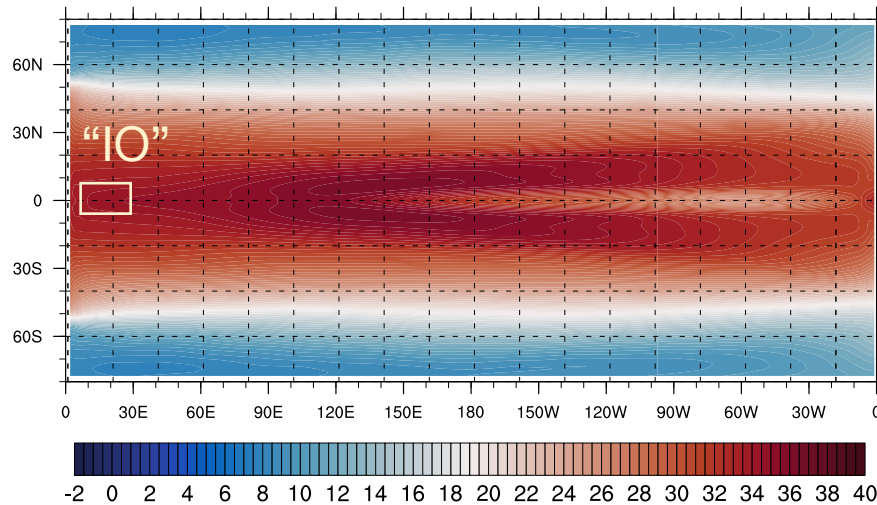


[Fig: ncl.ucar.edu]

$$\hat{\omega} = \omega - \mathbf{U} \cdot \mathbf{k}$$

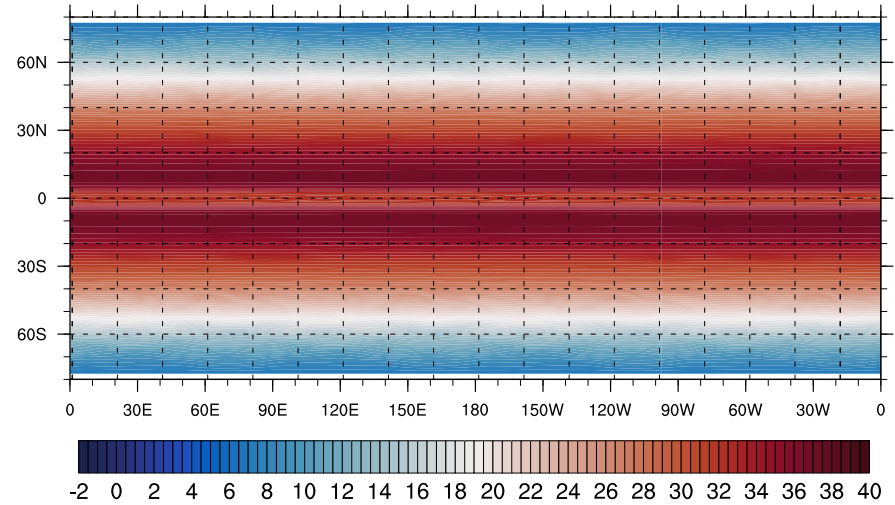
Climatological SST/Precip. <-> Variability

 Ridge



Formation of western warm pool reduces extent of upwelling to eastern cold tongue

 Aqua

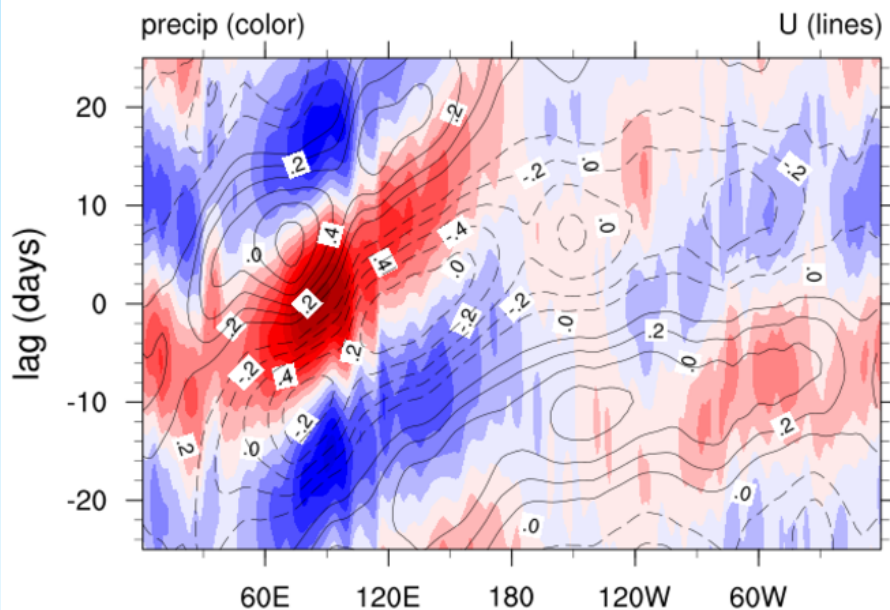


Global cold belt of equatorial upwelling

Ridge: "MJO" propagation

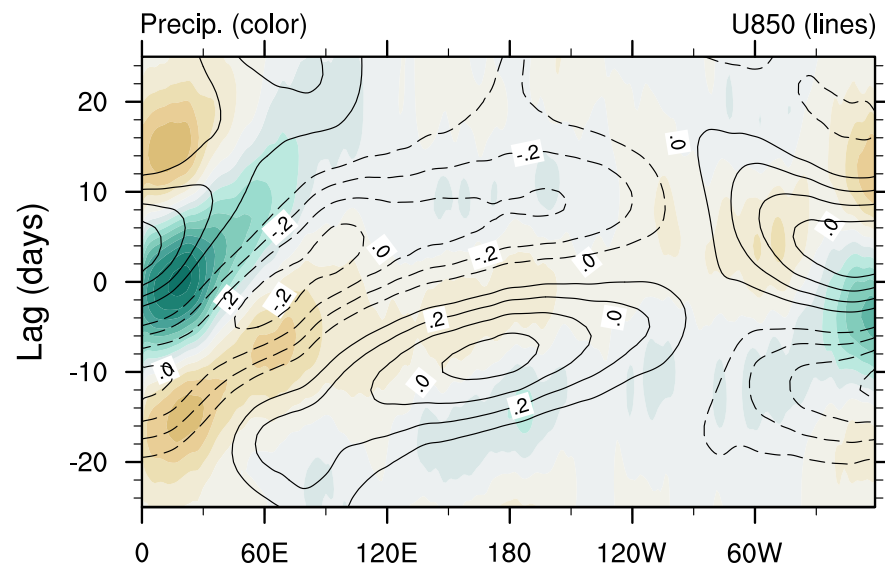
Earth

annual: 19961001-20051231



 Ridge

annual: 04010101-04201231

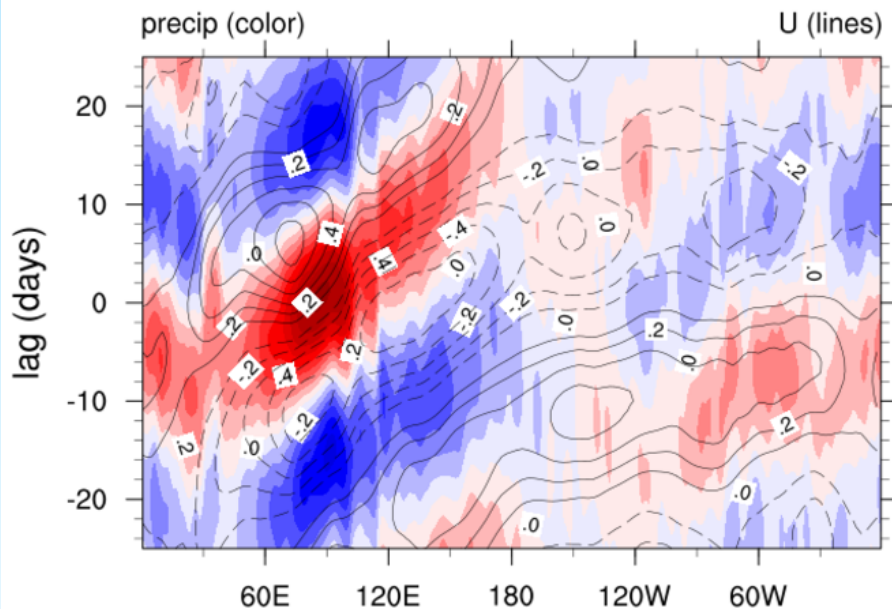


[Fig: ncl.ucar.edu]

Aqua: Low-freq. mode propagation

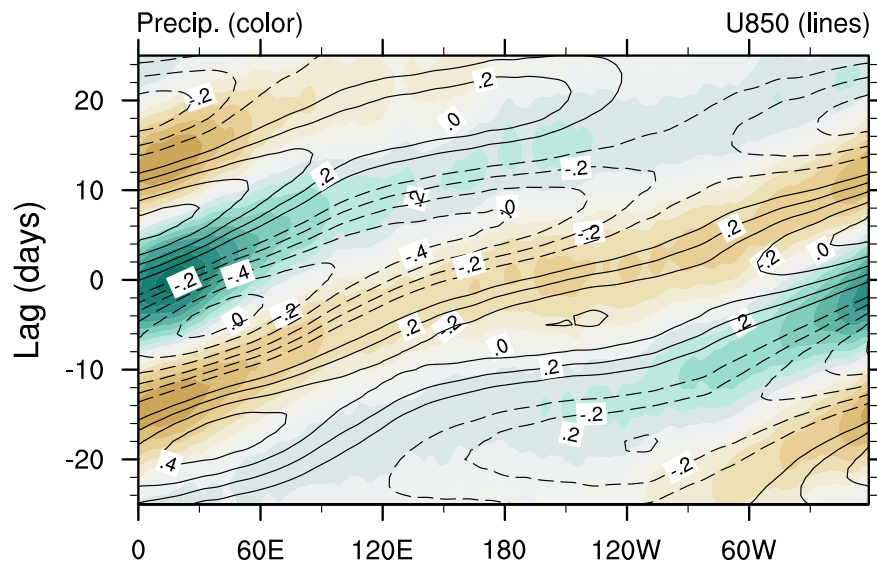
Earth

annual: 19961001-20051231



● Aqua

annual: 04010101-04201231

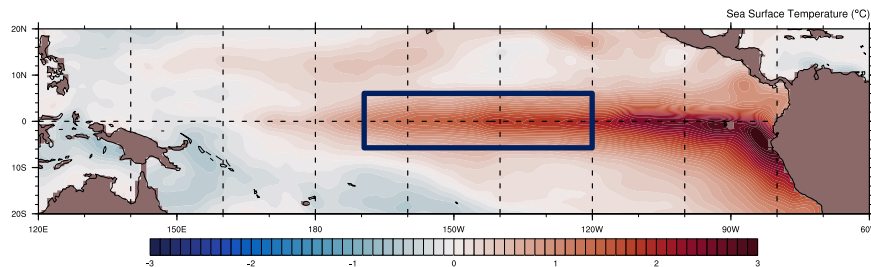


[Fig: ncl.ucar.edu]

Interannual Variability: Cold Tongue Warming/Cooling on Ridge

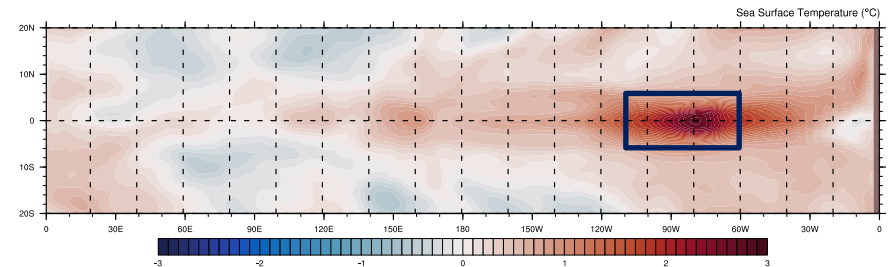
Earth

SST anomaly (1997)

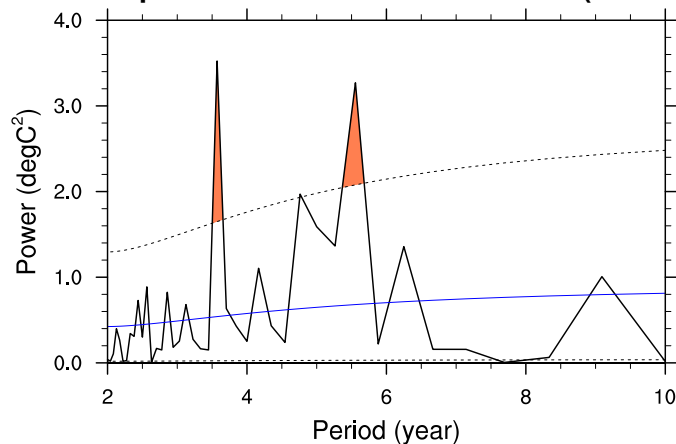


Ridge

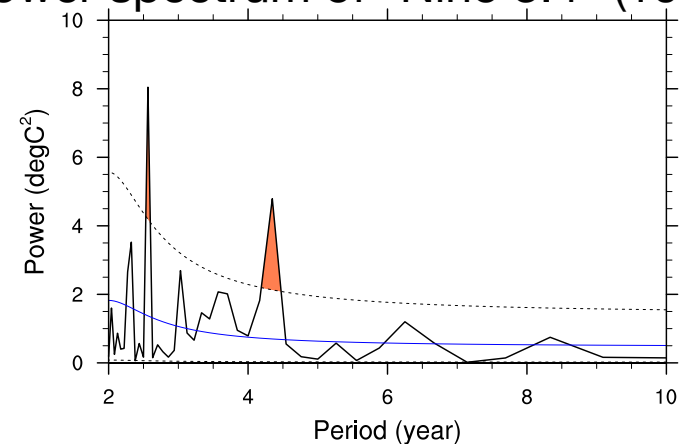
SST anomaly (cold tongue warming)



Power spectrum of Niño 3.4 (1920-2019)



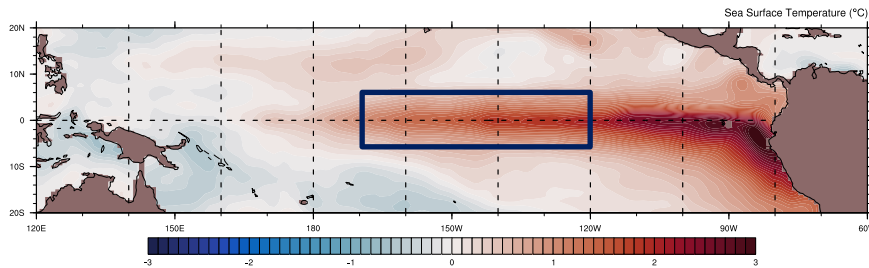
Power spectrum of “Niño 3.4” (100-yr)



Interannual Variability: Cold Belt Warming/Cooling on Aqua

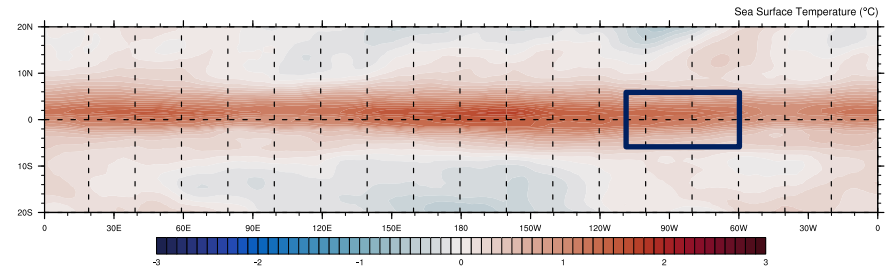
Earth

SST anomaly (1997)

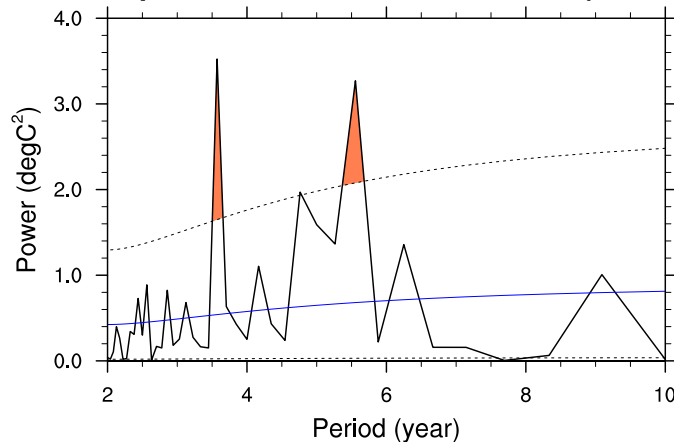


● Aqua

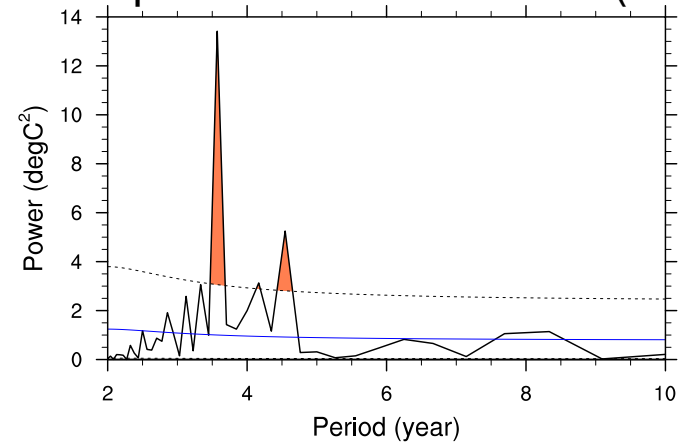
SST anomaly (equatorial warming)



Power spectrum of Niño 3.4 (1920-2019)

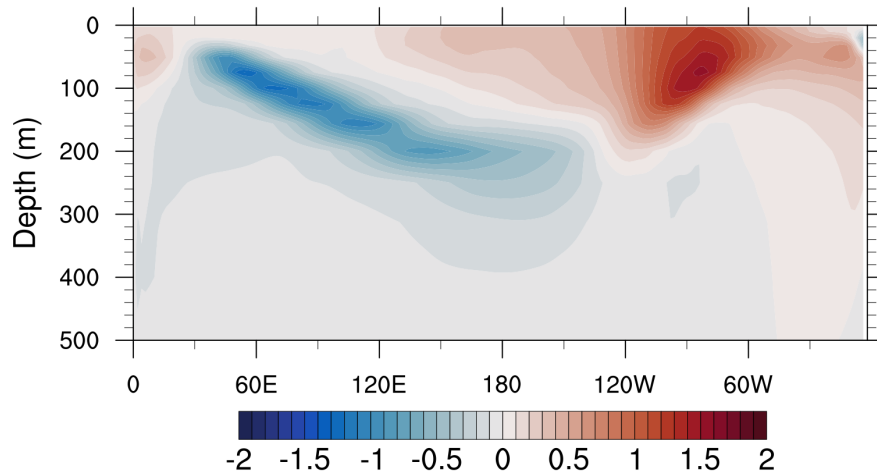


Power spectrum of “Niño 3.4” (100-yr)



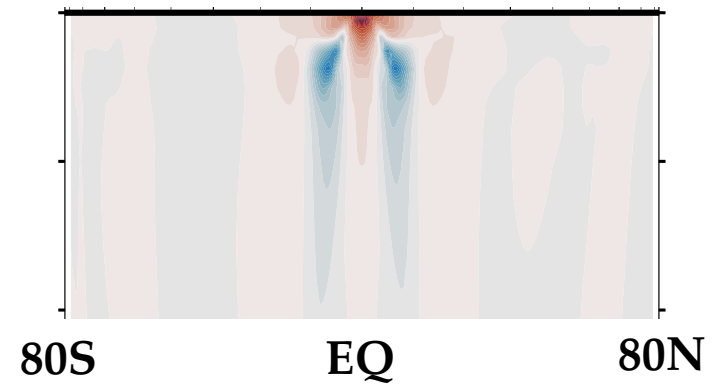
Interannual Variability: Ocean composite of “Nino” years

Ridge



- Zonal pattern in thermocline response

Aqua



- Off-equatorial subsurface cooling -> role in phase-switching?

Discussion

- Equatorial waves: Doppler-shifting by background mean flow
- “MJO ingredients”: Factors affecting propagation and the distinction from Kelvin waves
- “ENSO ingredients”: Is Aqua’s interannual mode “real” or relevant?
- How / to what extent do these features relate to CMIP-class simulations? -> Avenue for further investigation with hierarchy of simplified models

