

# Reference Climate of CESM Coupled Aqua and Ridge Planets

**Xiaoning Wu**

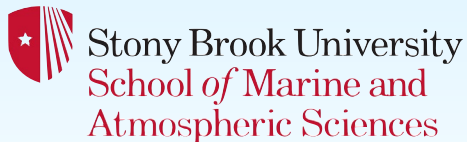
CESM Workshop (AMWG), June 16, 2020

Co-advisors: Kevin Reed & Christopher Wolfe

ASP Hosts (Oceanography Section): Scott Bachman, Frank Bryan, Gustavo Marques

*Acknowledgements (alphabetical):*

Alper Altuntas, Kyle Armour, David Bailey, Jim Benedict, Pedro Di Nezio, Erik Kluzek, Keith Lindsay, Brian Medeiros, Sarah Ragen, Mathew Rothstein, Andrew Shao

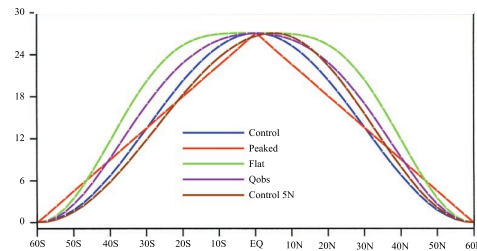


# Motivation: Gap in Hierarchy of Simpler Models

## Atmospheric component

Aquaplanet

Prescribed or slab ocean



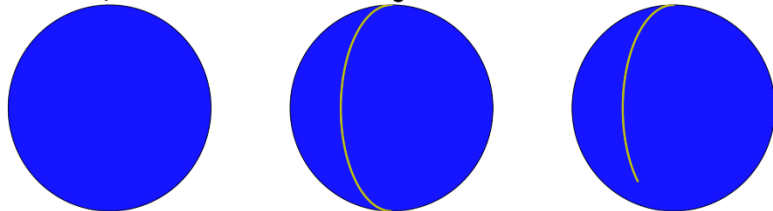
[see Neale and Hoskins, 2000; Medeiros et al., 2016; Benedict et al., 2017]

## Ocean component

Aqua

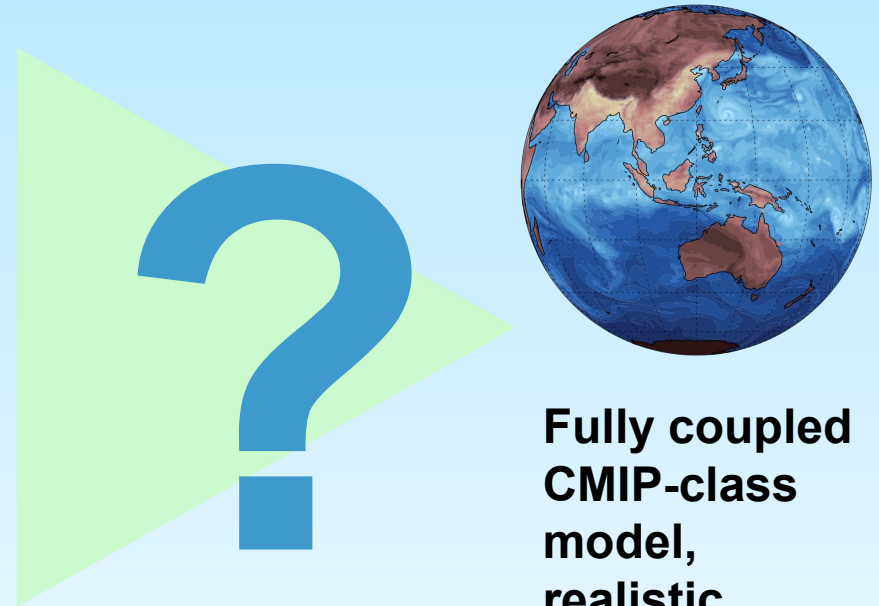
Ridge

Drake



Prescribed or "slab" atmosphere

[e.g. Enderton and Marshall, 2009; Wolfe and Cessi, 2010; Ragen and Armour, 2019]



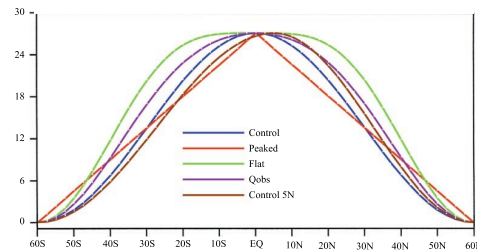
**Fully coupled  
CMIP-class  
model,  
realistic  
config.**

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## Atmospheric component

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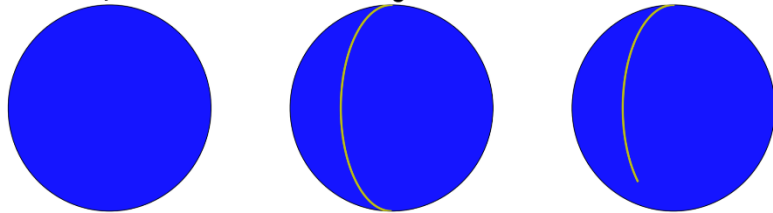
[see Neale and Hoskins, 2000; Medeiros et al., 2016; Benedict et al., 2017]

## Ocean component

Aqua

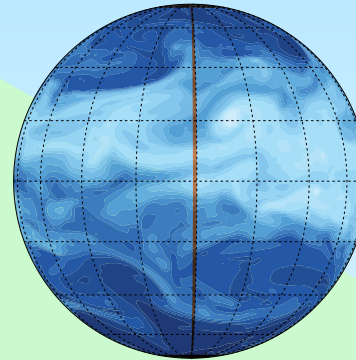
Ridge

Drake

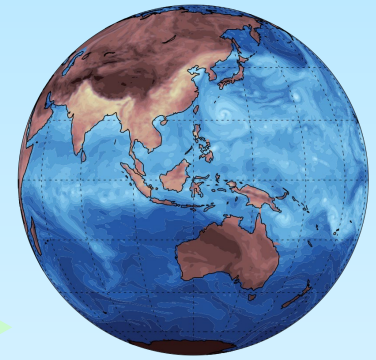


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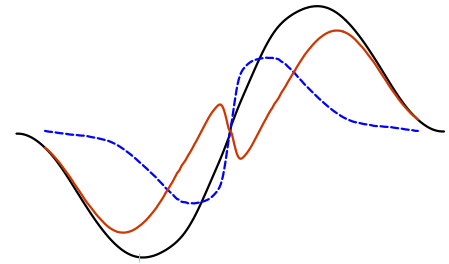
Fully coupled  
CMIP-class  
model,  
idealized  
config.



Fully coupled  
CMIP-class  
model,  
realistic  
config.

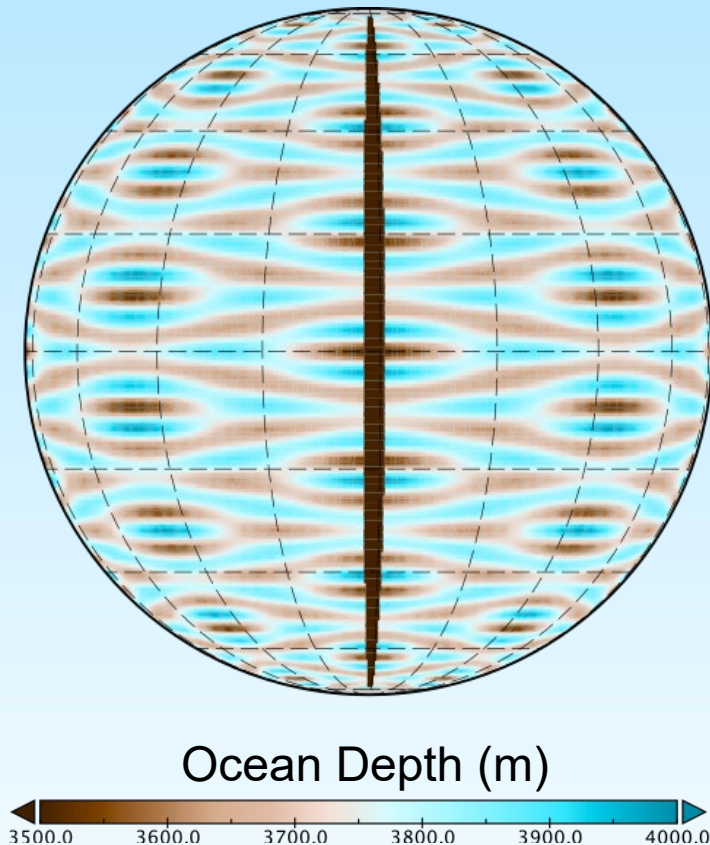
# CESM Coupled Aqua and Ridge Planets

precipitable water (kg/m<sup>2</sup>)



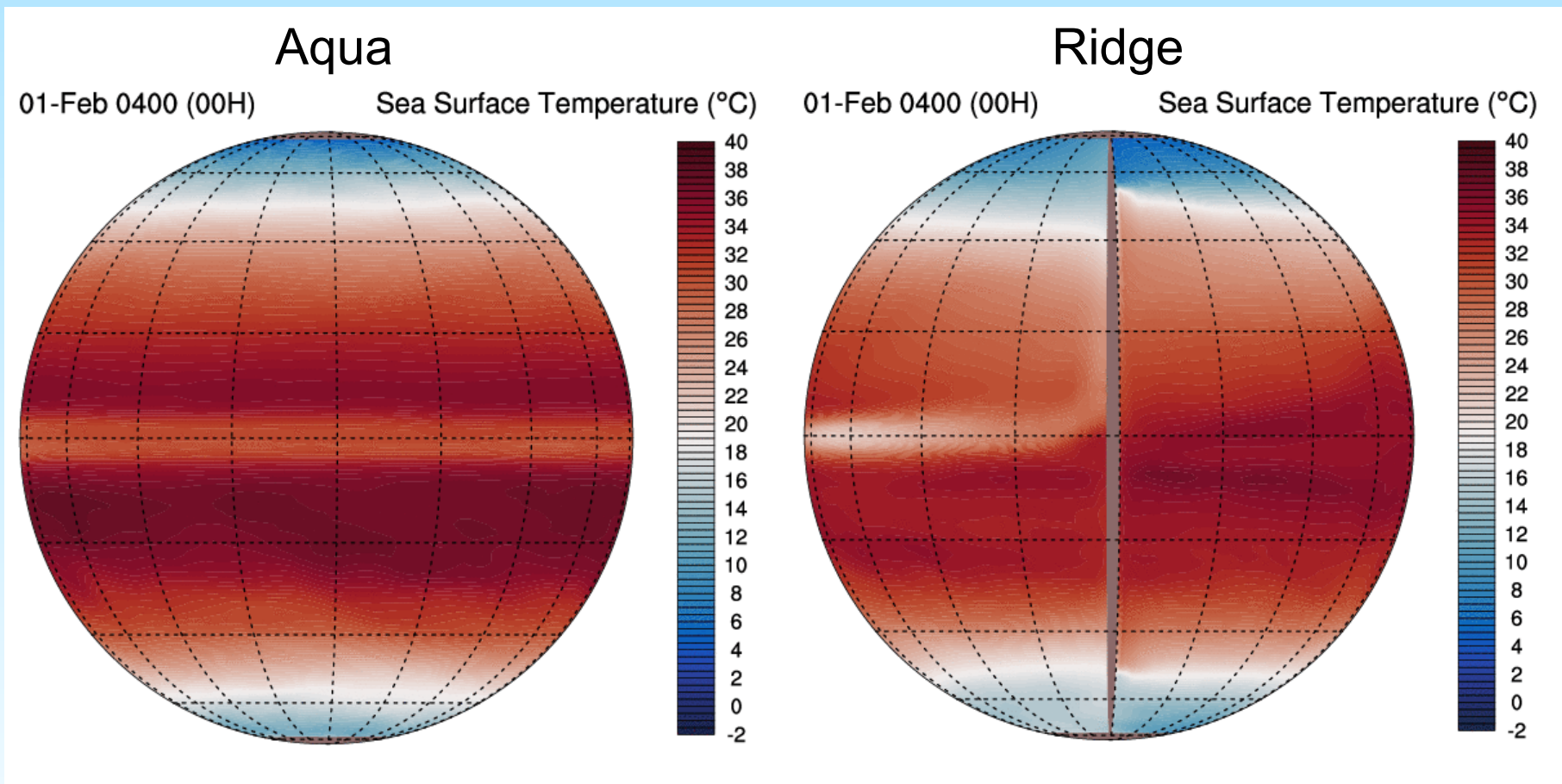


# CESM Aqua and Ridge: Coupled Model Set-up



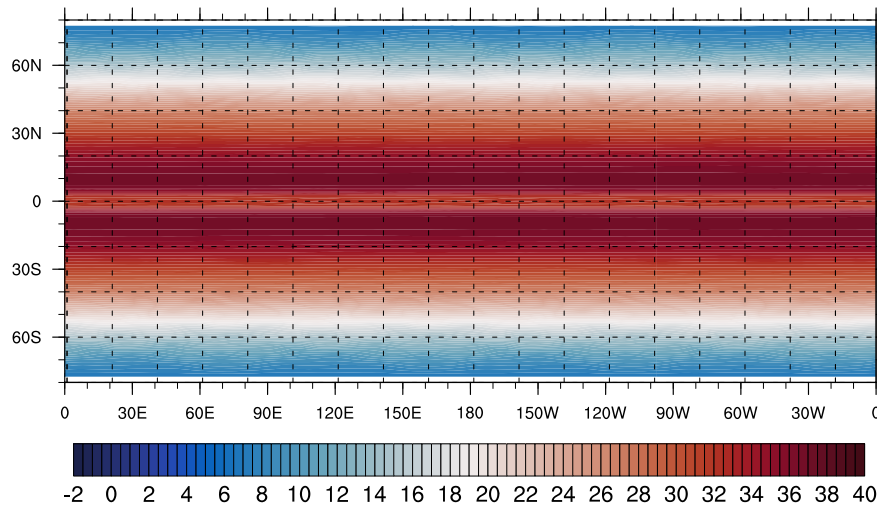
- **Atmosphere:** CAM4 @1°
- **Ocean:** MOM6 @nominal 2° with equatorial enhancement (1°); ~4000 m depth; symmetric bottom topography
- **Sea ice:** CICE5
- **Land:** CLM5 wetland; two polar land caps reaching 80°N/S (quasi-aqua); one single pole-to-pole strip, known as Ridge (Enderton and Marshall, 2009)
- Fixed orbital parameters with seasonal cycle
- Initialization: Idealized climatology for ocean (courtesy Pedro Di Nezio), default for others

# CESM Aqua and Ridge: Seasonal Cycle of SST (Yr 400)



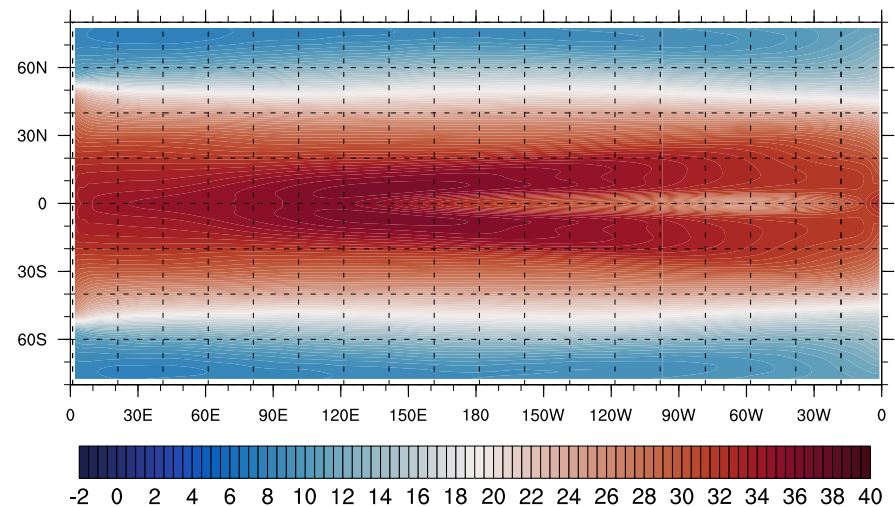
# Mean Climate (Yr 401-500): Sea Surface Temperature

Aqua, avg. = 27.5°C



Global cold belt of equatorial upwelling

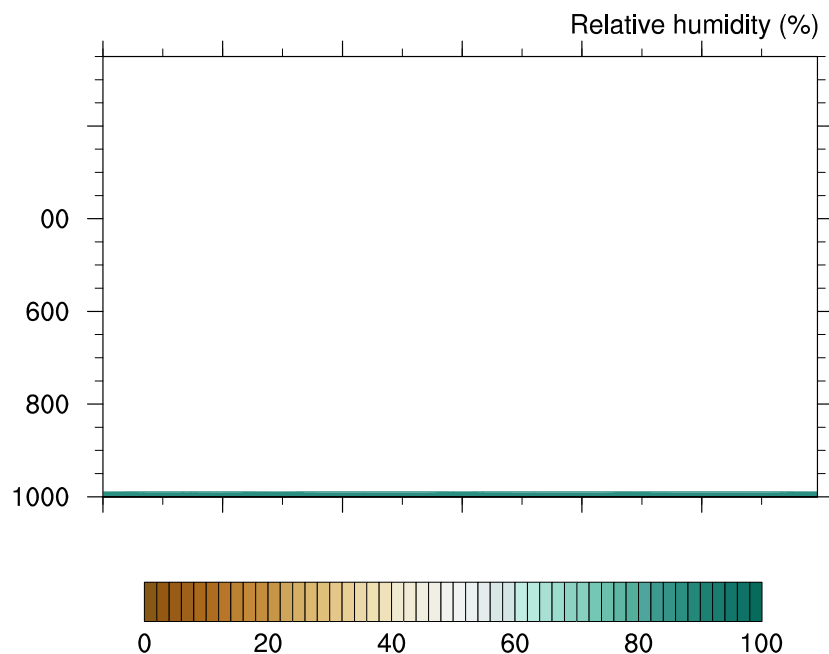
Ridge, avg. = 25.5°C



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

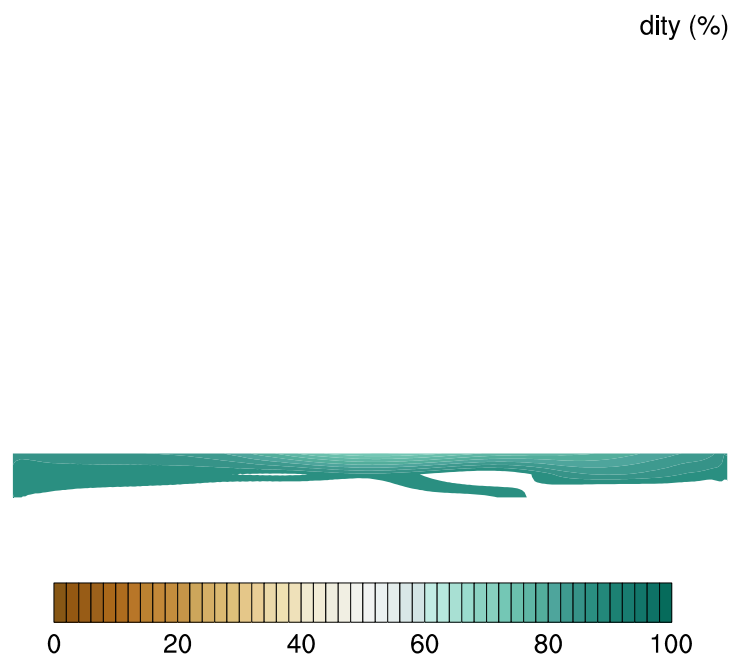
# Mean Climate: Equatorial zonal circulation (5N-5S)

Aqua



Cold and dry equatorial belt of subsidence

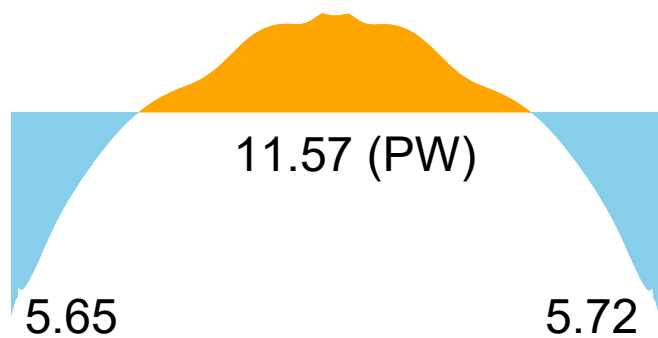
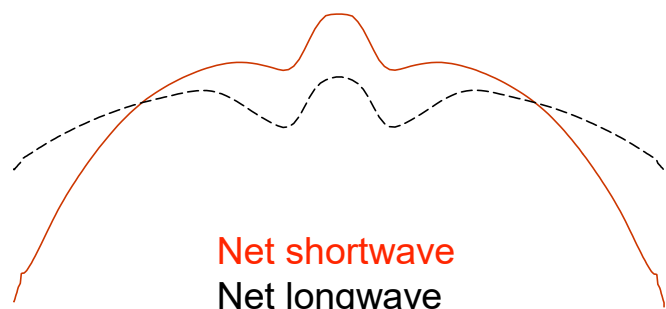
Ridge



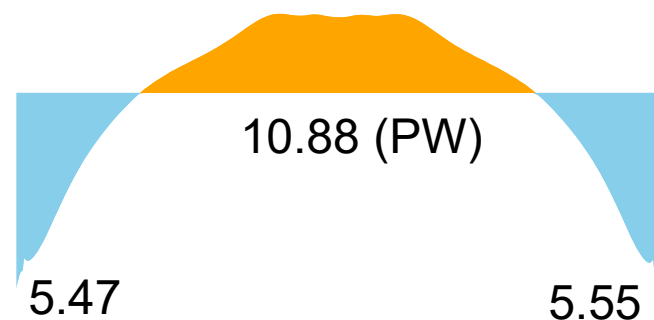
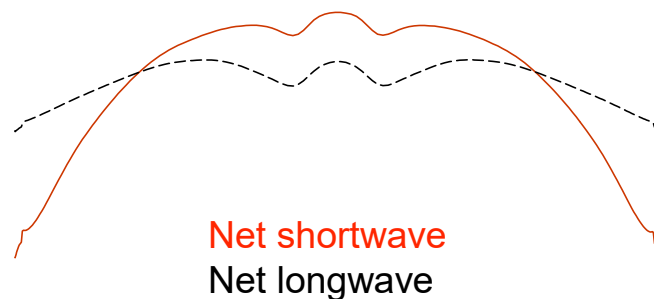
Walker-like circulation with convection on western side, and subsidence on eastern side

# Mean Climate: Top-of-Atmosphere Balance

Aqua

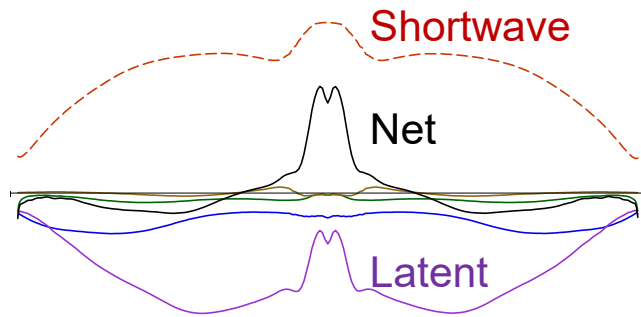


Ridge

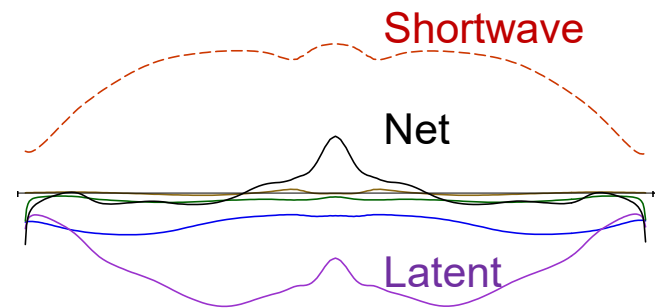


# Mean Climate: Heat Fluxes at Ocean Surface

Aqua



Ridge



Longwave, Sensible, Mass transfer

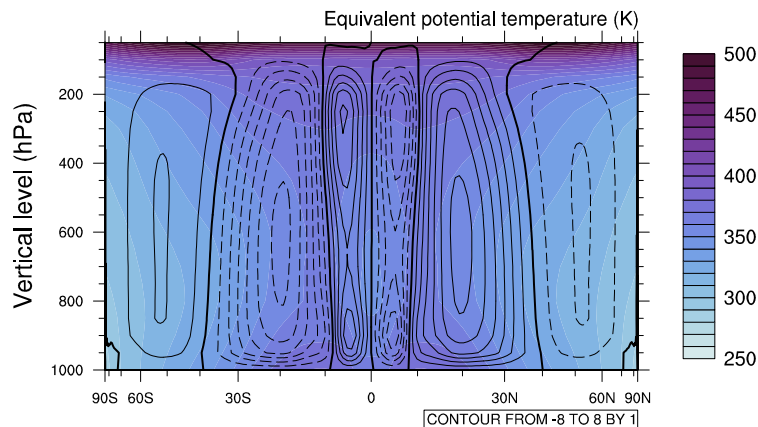
Deep tropics: More **shortwave heating**, less **latent heat loss**

Deep tropics: Less **shortwave heating**, more **latent heat loss**



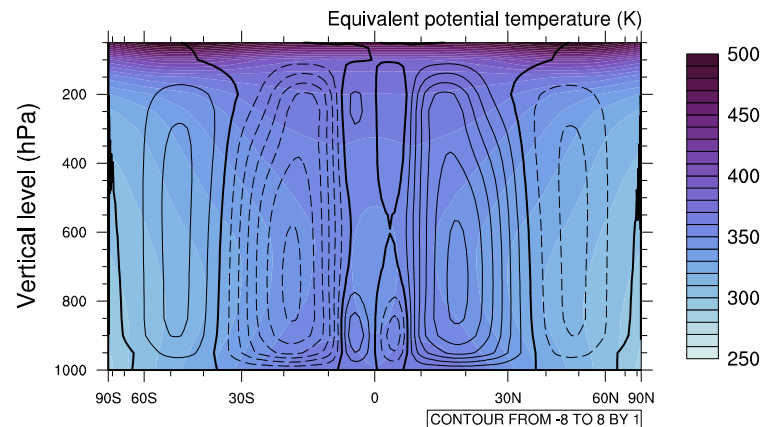
# Mean Climate: Meridional Overturning Circulation

Aqua



“Reverse Hadley cell” 10N-10S  
due to equatorial cold belt

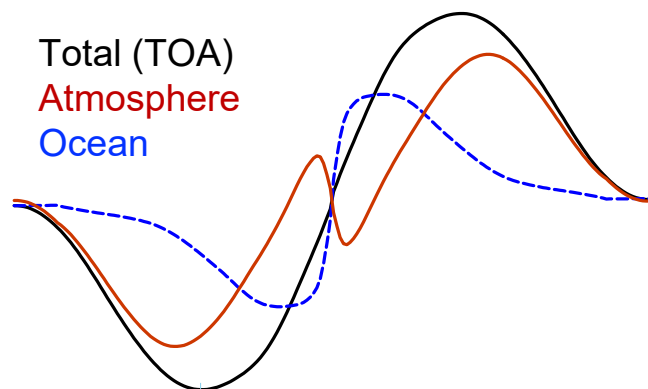
Ridge



“Reverse Hadley cell” much  
reduced, due to presence of  
western warm pool

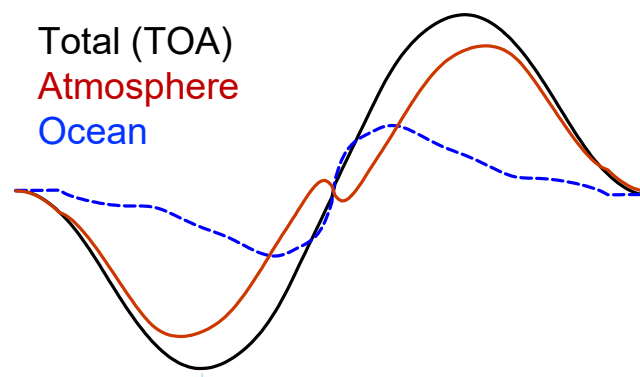
# Mean Climate: Meridional Heat Transport

## Aqua



- Equatorward **atmospheric heat transport (AHT)** 10N-10S
- Energetically required by heat budget
- Dynamically fulfilled by “reverse Hadley cell”

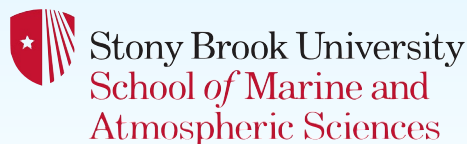
## Ridge



- Equatorward **AHT** reduced
- Energetics: cloud and water vapor feedback due to western warm pool
- Dynamics: weaker “reverse Hadley cell”

# Discussion

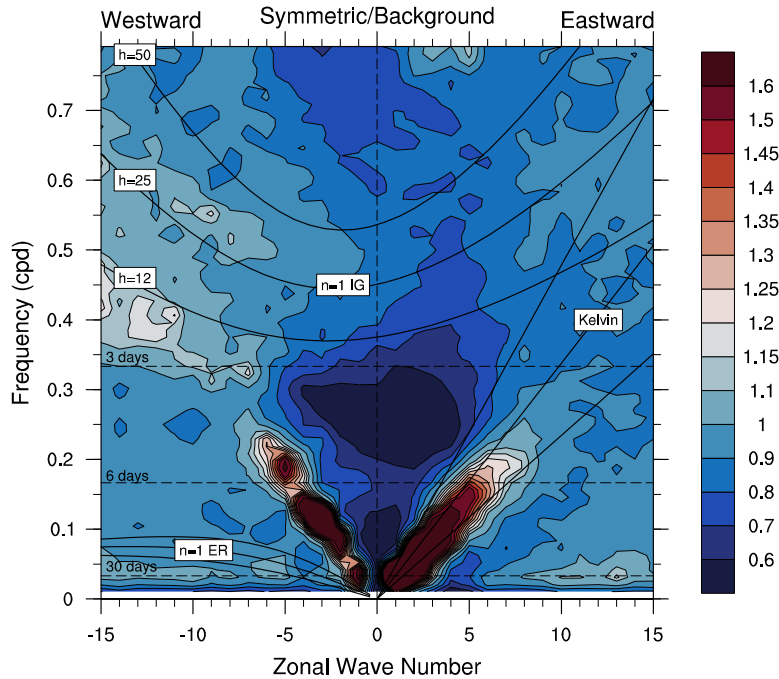
- Climates of coupled Aqua and Ridge show features relevant to understanding CMIP-class simulations
- Model availability: Coupled simpler models planned to be released in CESM, software engineering efforts underway to streamline customization
- Applications: Coupled atmosphere-ocean dynamics, scale interactions



# Variability: MJO-like (?) Mode on Ridge

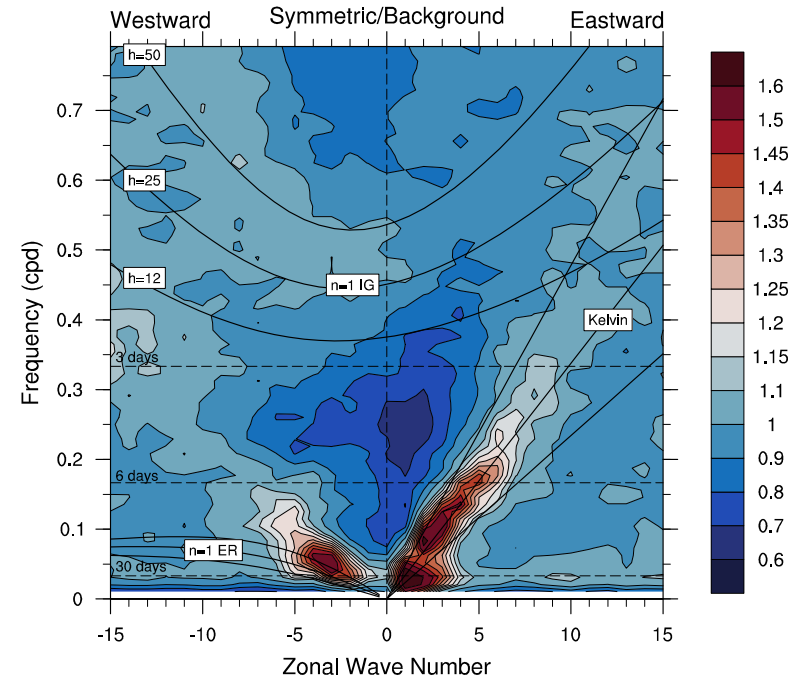
## Aqua

BMOM\_aqua\_production\_branch\_3h\_PRECT LOG[Power: 15S-15N]

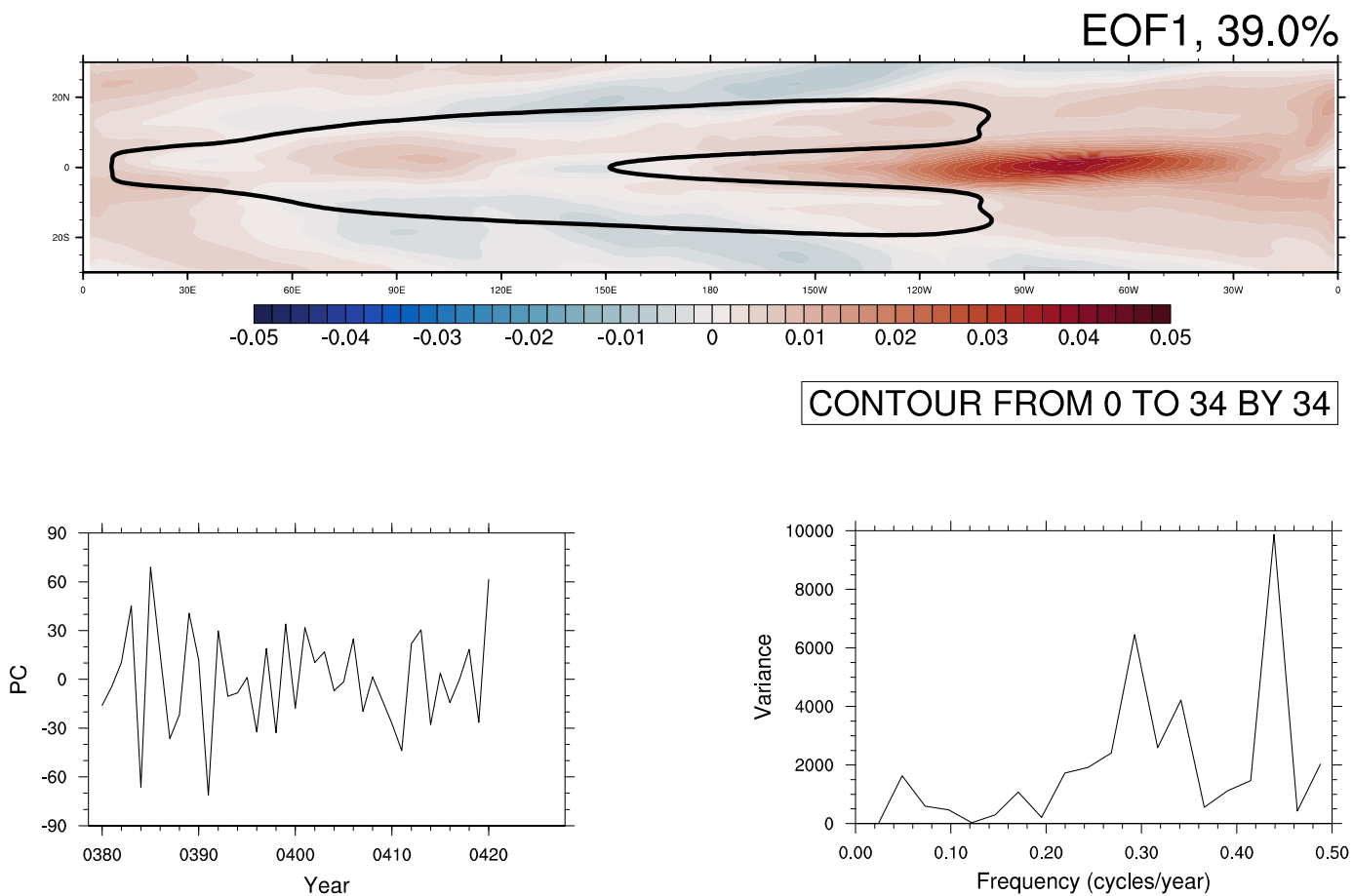


## Ridge

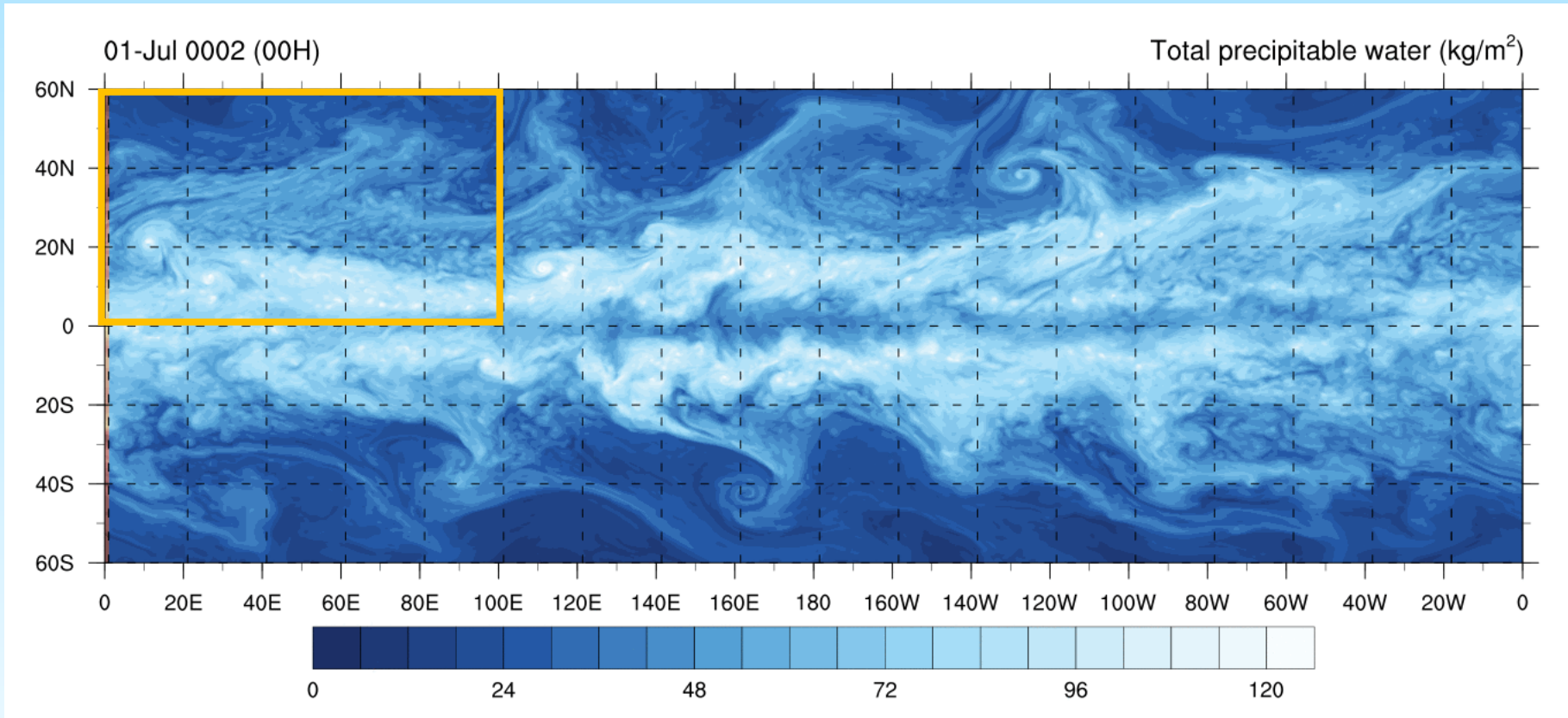
BMOM\_brdg\_production\_branch\_3h\_PRECT LOG[Power: 15S-15N]



# Variability: ENSO-like (?) Mode on Ridge

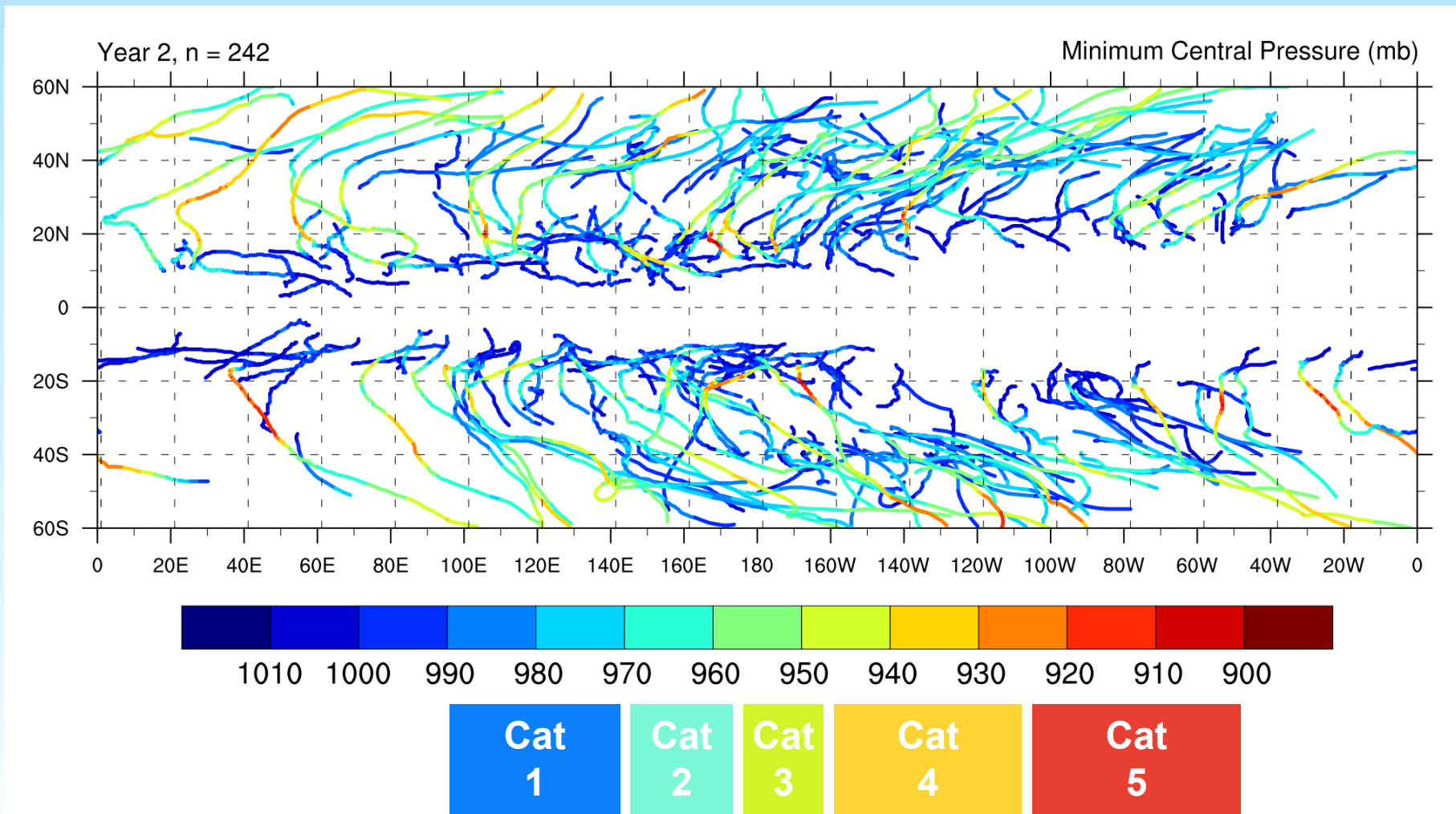


# Ridge SST -> CAM4 Aquaplanet @ 0.25°



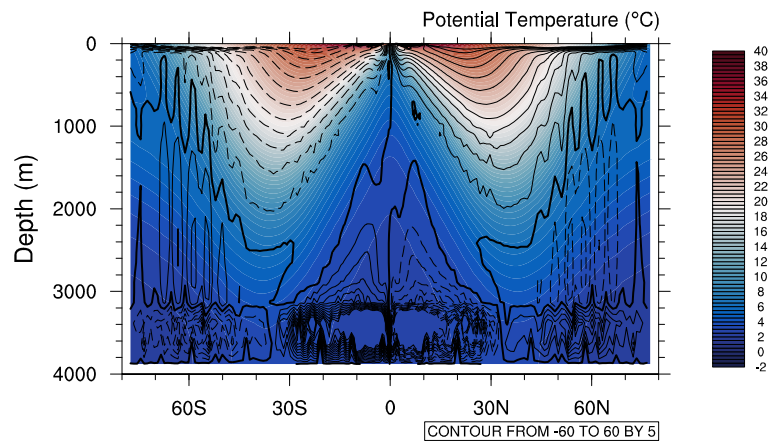
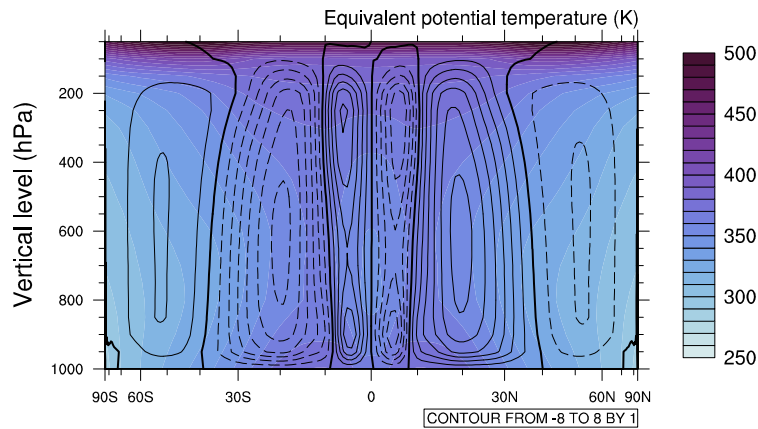


# Tropical cyclone tracks with Ridge SST



# Mean Climate: Meridional Overturning Circulation

## Aqua



## Ridge

