

# *Atmospheric Variability in CESM1.5 at Daily and Higher Time Frequencies*

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U.S. DEPARTMENT OF  
**ENERGY**



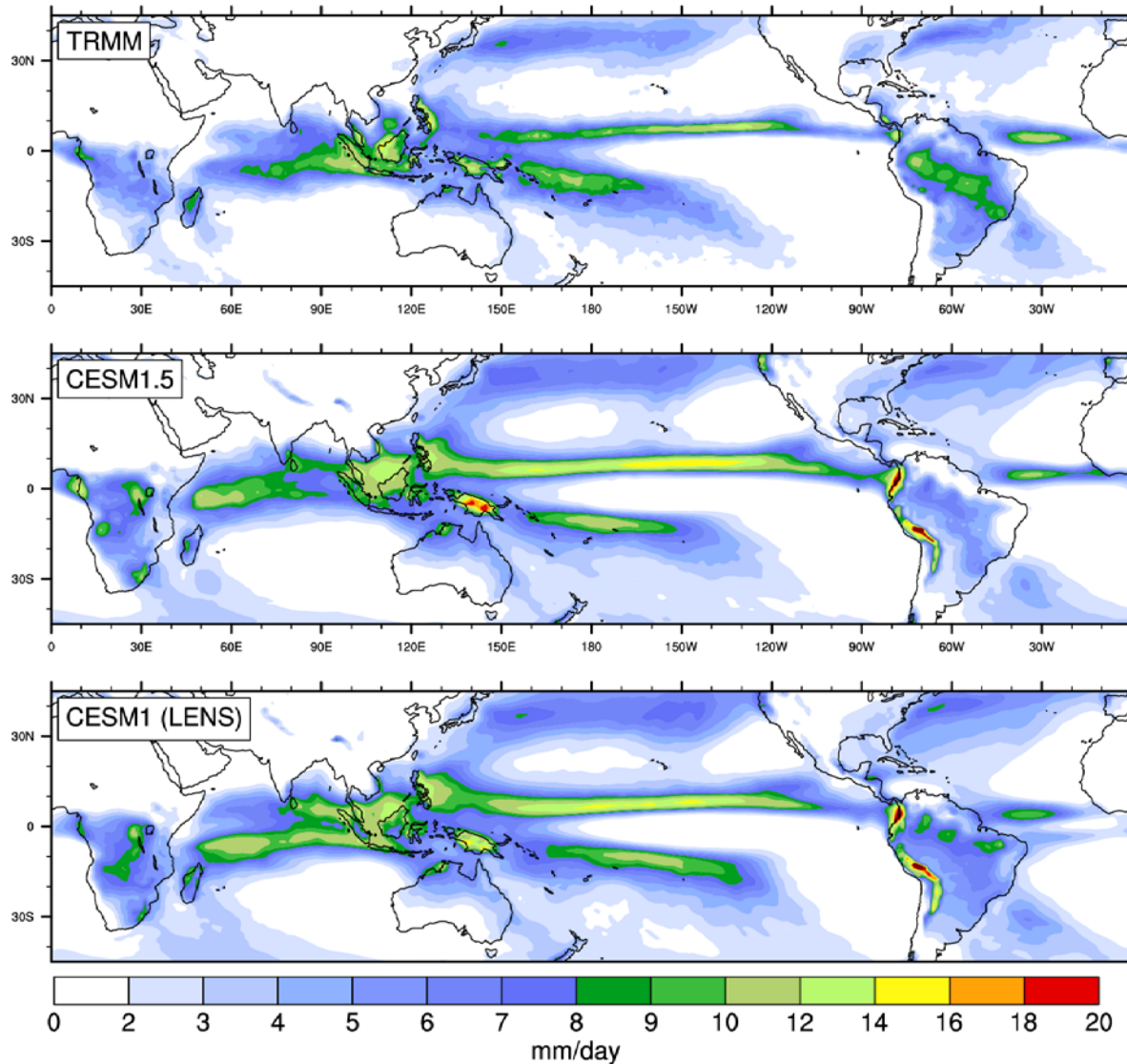
# Simulations and output

- Simulations (1850 controls)
  - Large-ensemble (**CESM1-LENS**)
  - Simulation '28' of **CESM1.5** development
- Analysis
  - 10 years of output
  - 3-hourly, 6-hourly and daily analyses
  - Atmosphere, single level variables only
- New model version
  - LENS + (CLUBB, Microphysics (MG2), Aerosols (MAM4))

# What are we looking at?

- Precipitation statistics
  - Variance/standard deviation
  - PDFs (frequency, rate contribution)
  - Diurnal cycle (phase and amplitude)
- Equatorial wave modes
  - Madden Julian Oscillation (MJO)
  - Equatorial wave mode variance
  - Power, frequency
  - Regional characteristics
- Blocking
  - Frequency, location

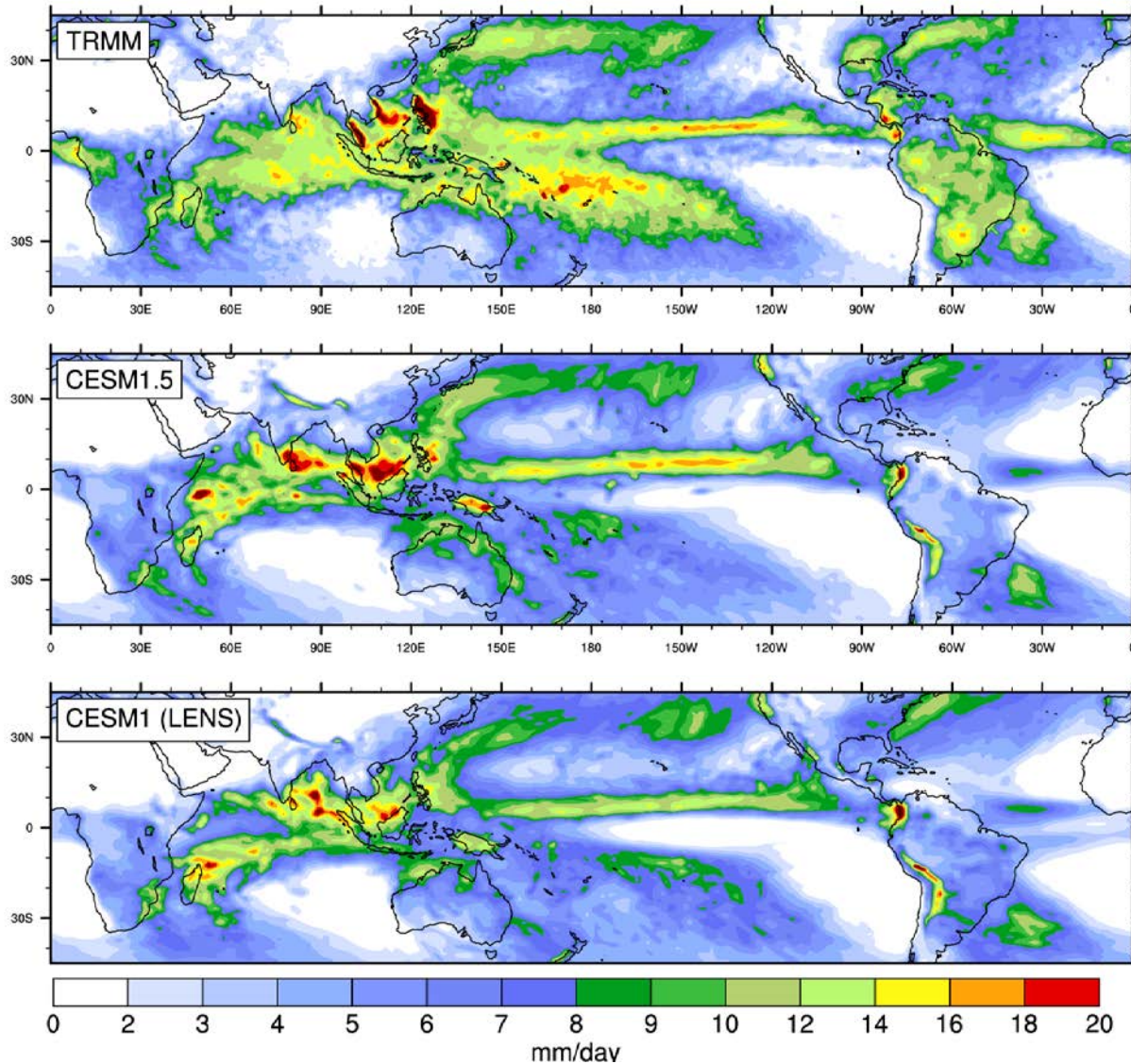
# Mean Precipitation (DJF, mm/day)



- Strong rainfall
- Double ITCZ
- Weak Amazon
- Orographic precip. large

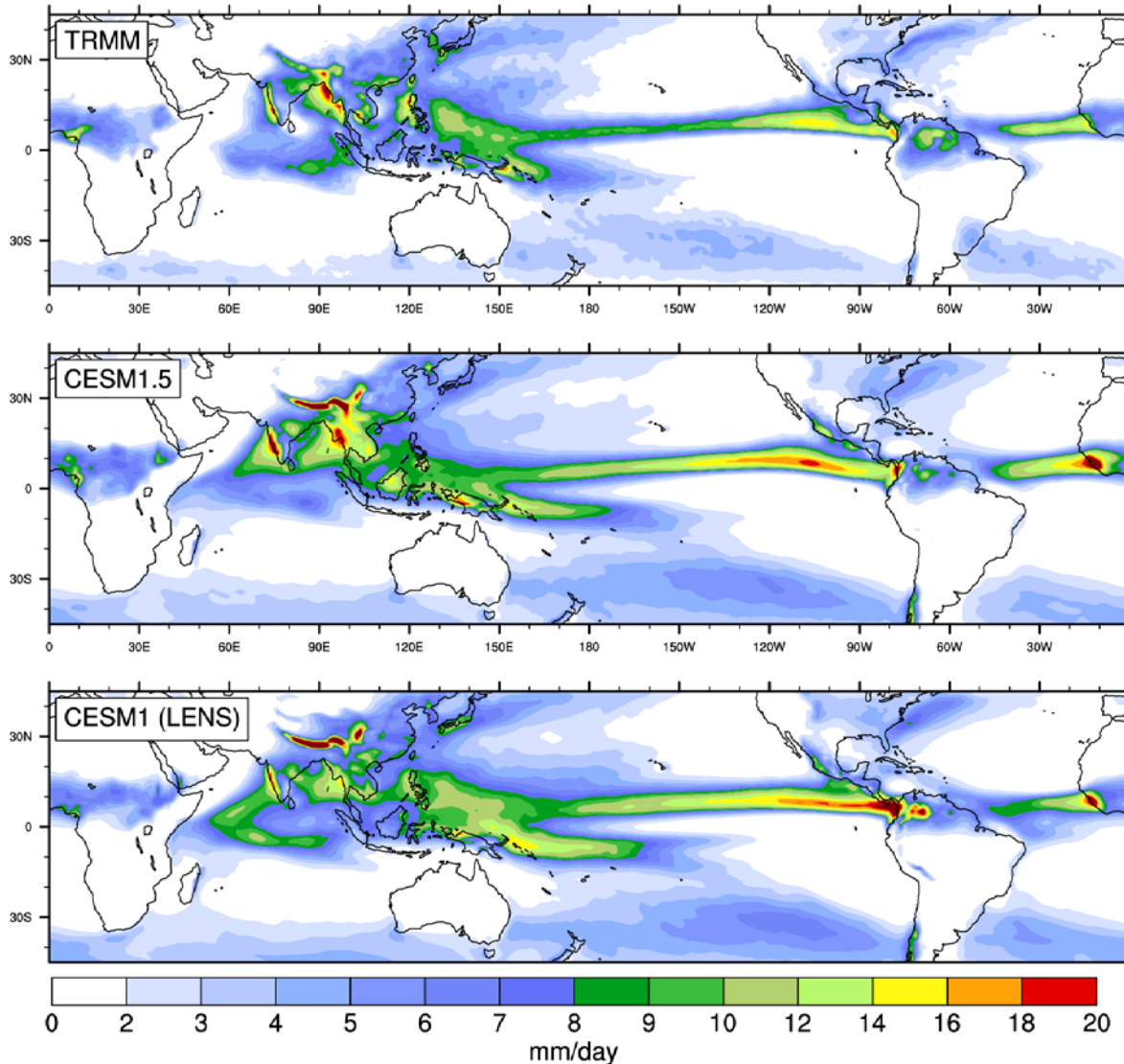


# Precipitation Standard Deviation (DJF, mm/day)



- Weak variance
- Locally high
- ITCZ better

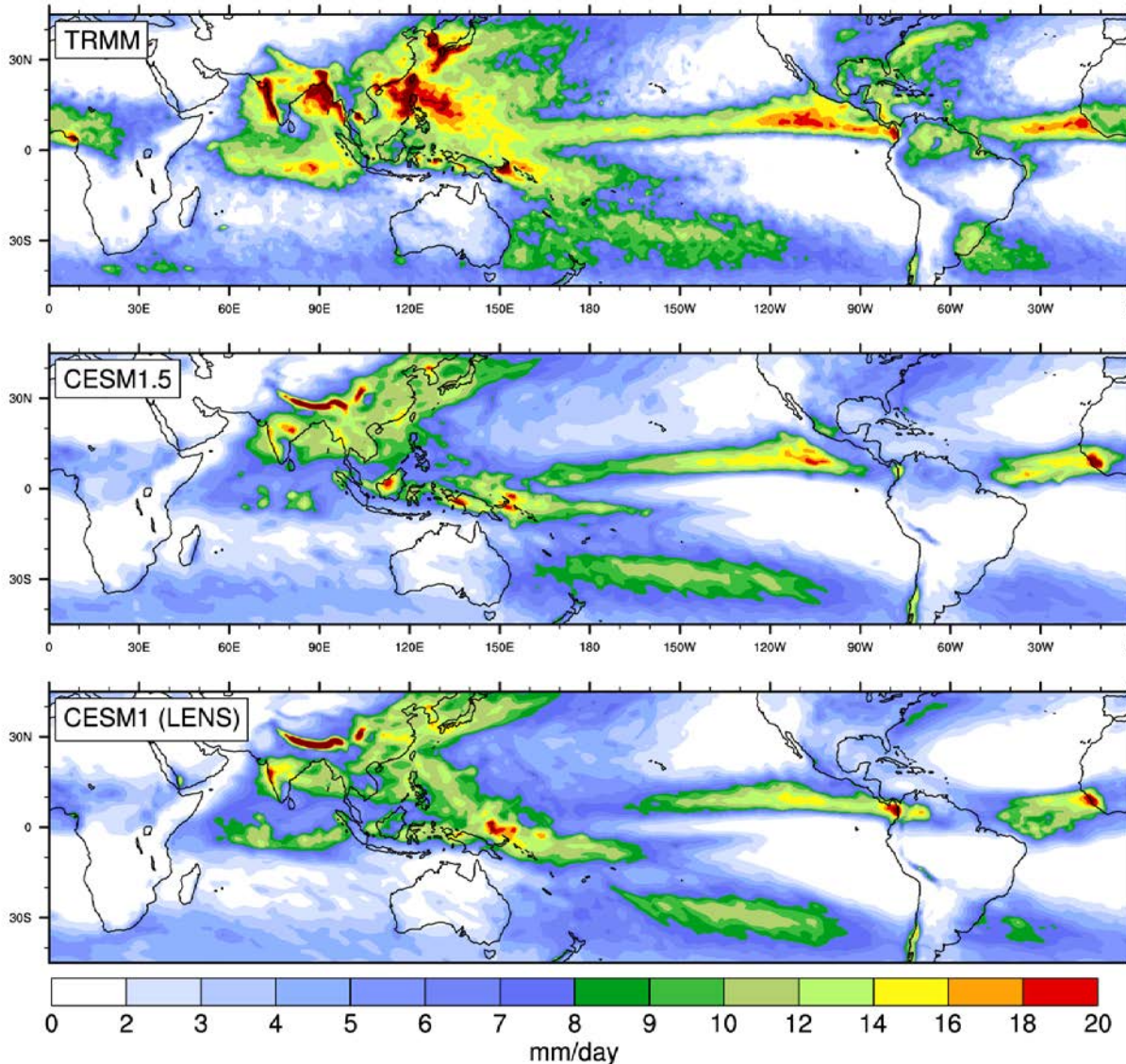
# Mean Precipitation (JJA)



- Strong rainfall
- Better SPCZ
- W Pacific maxima gone
- Better E. Pac ITCZ
- Monsoon maxima
- Worse Atlantic
- Venezuela max!



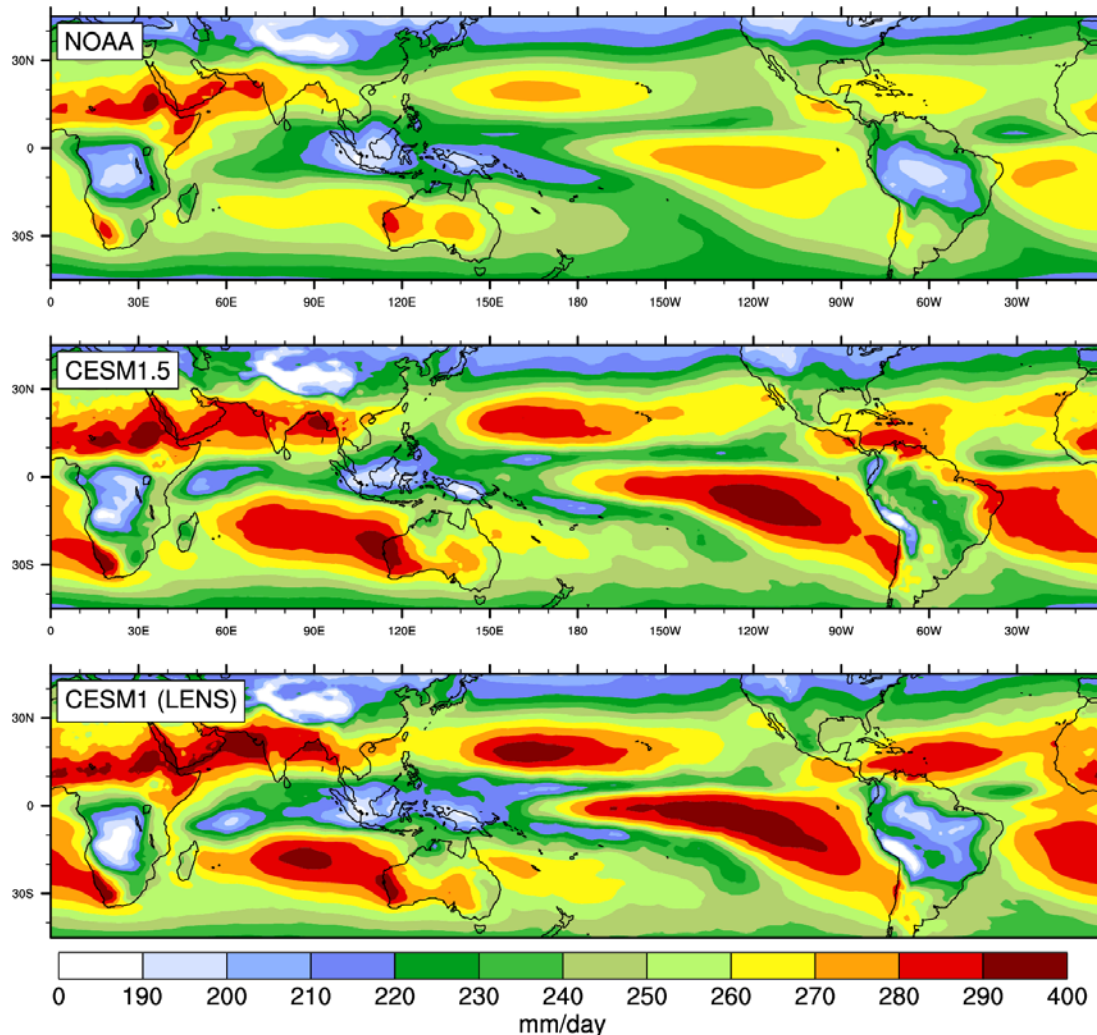
# Precipitation Standard Deviation (JJA)



- Weak variability
- Particularly in Monsoon region
- Better in E. Pac
- Tibetan maximum

# Mean Outgoing LW Radiation (DJF, mm/day)

Mean - TOA Outgoing Long-Wave ( $\text{W/m}^2$ ) - DJF

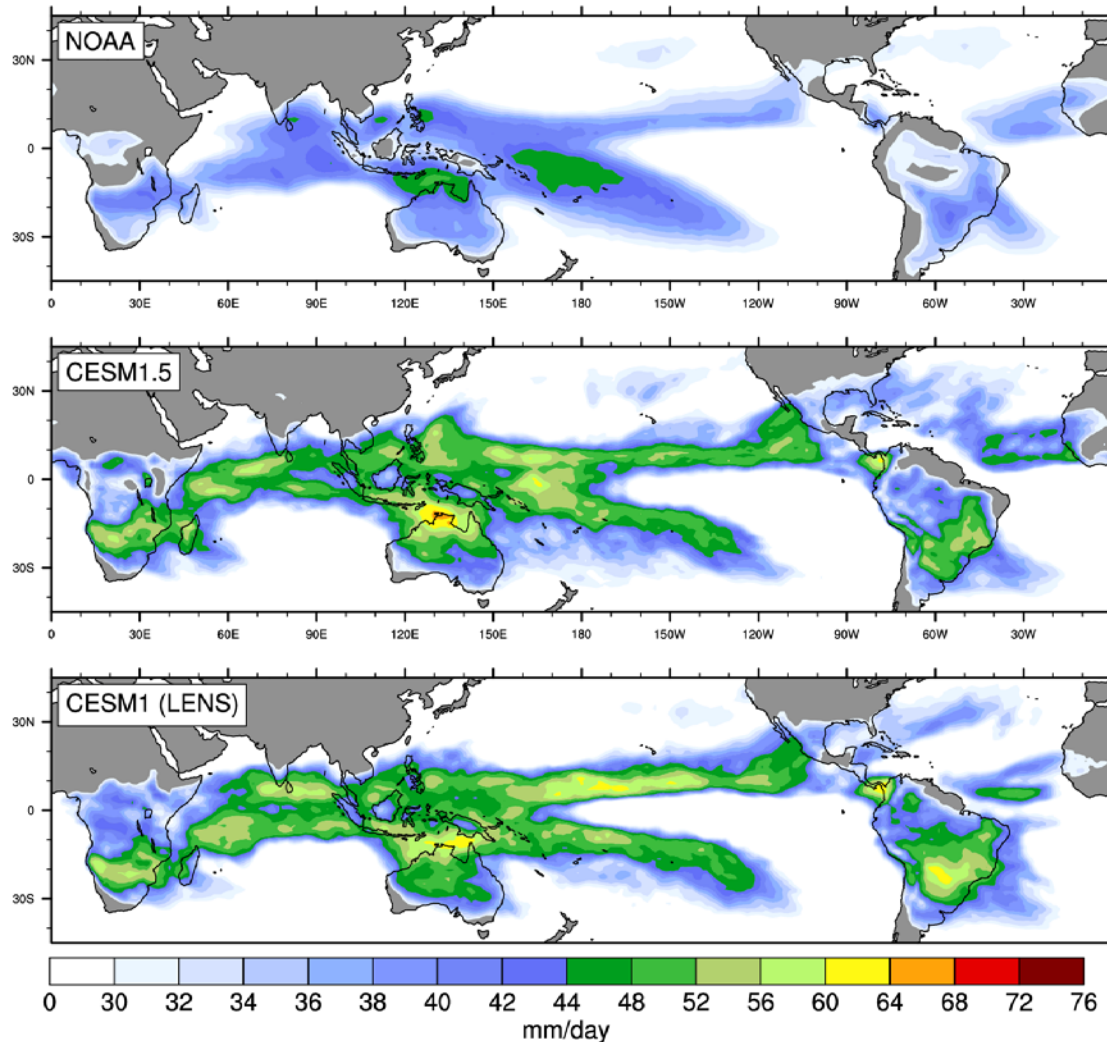


- Strong OLR in oceanic dry and descending regions
- Too moist?



# OLR Standard Deviation (DJF, mm/day)

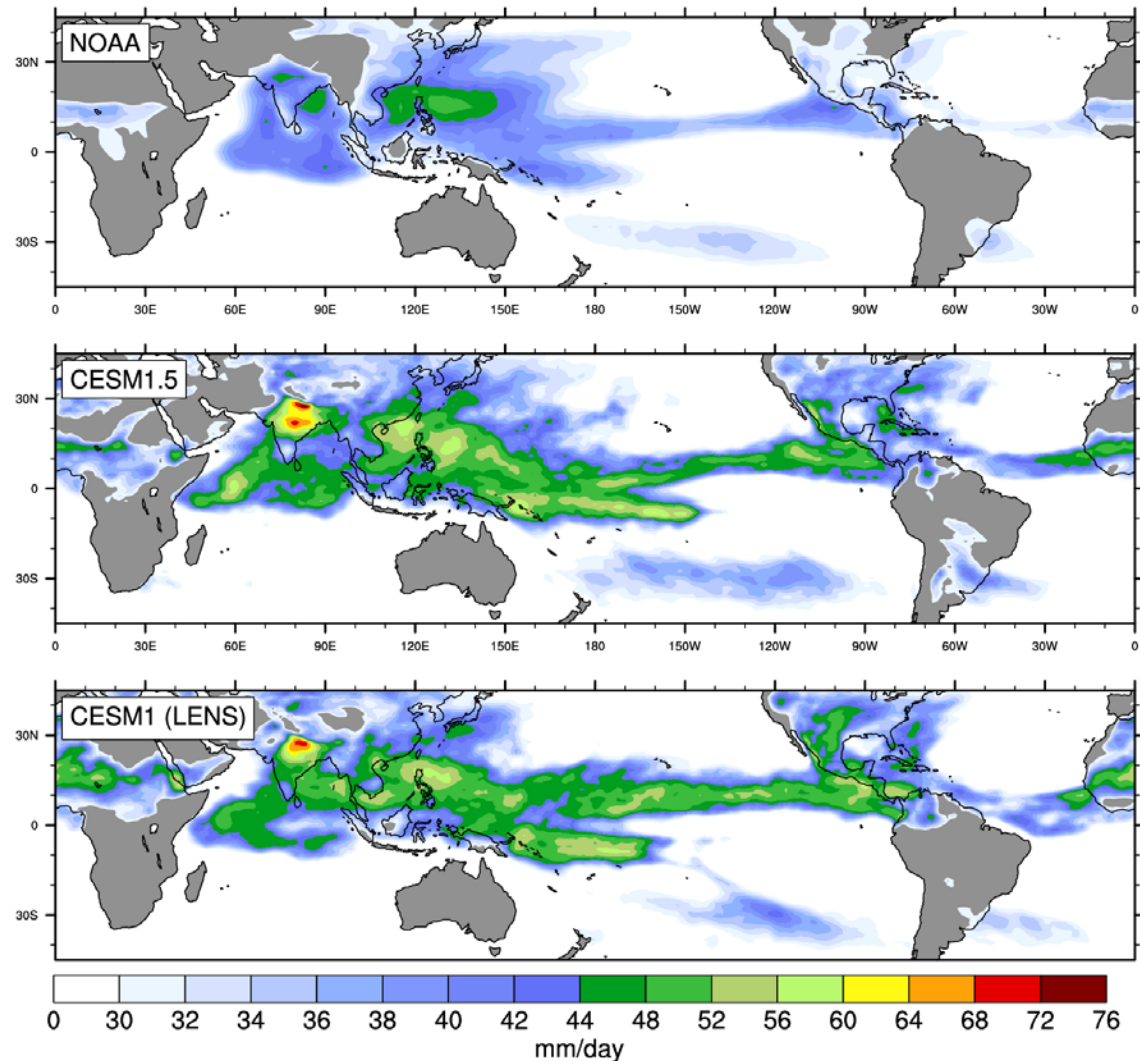
Standard deviation - TOA Outgoing Long-Wave ( $W/m^2$ ) - DJF



- Stronger variability
- Opposite to precip.
- Cloud field and convection linkages
- Surprising, given different cloud schemes

# OLR Standard Deviation (JJA, mm/day)

Standard deviation - TOA Outgoing Long-Wave ( $\text{W/m}^2$ ) - JJA

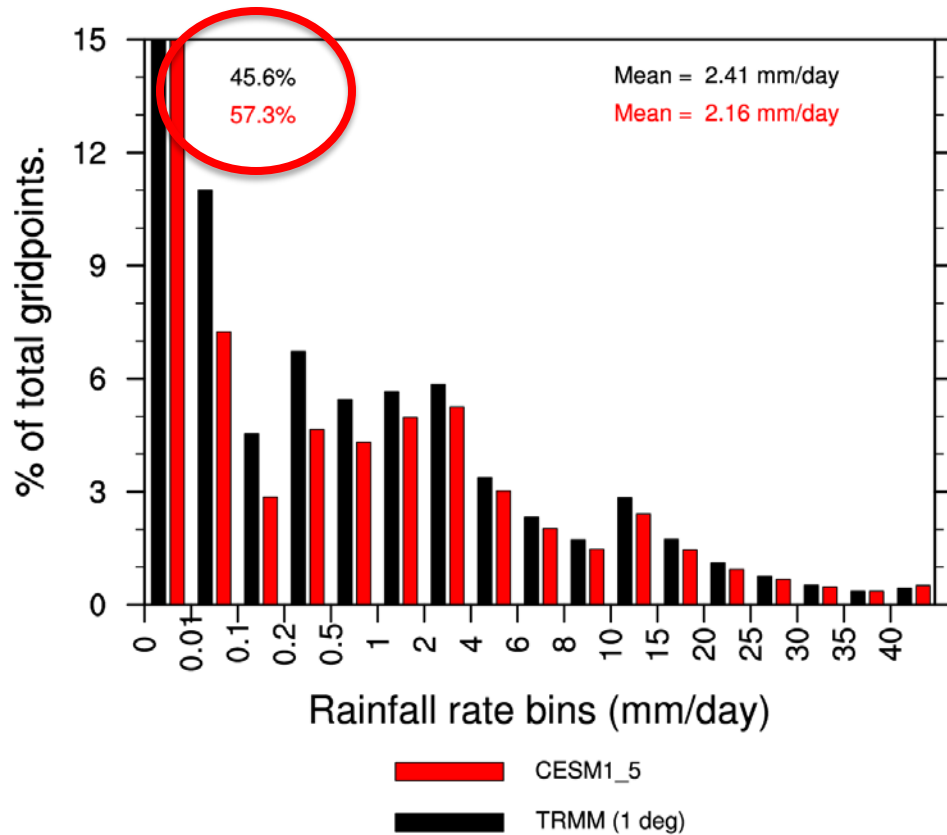


- Stronger variability
- Very high over India

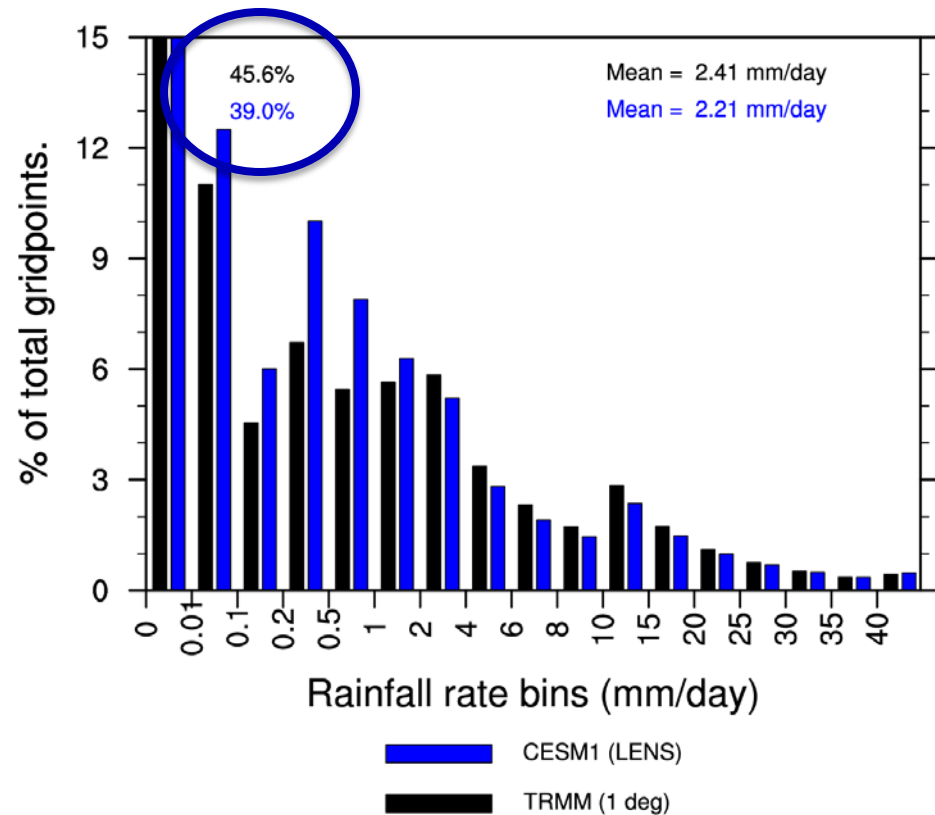


# US Precipitation %gps PDF (DJF) - Daily

## CESM1.5

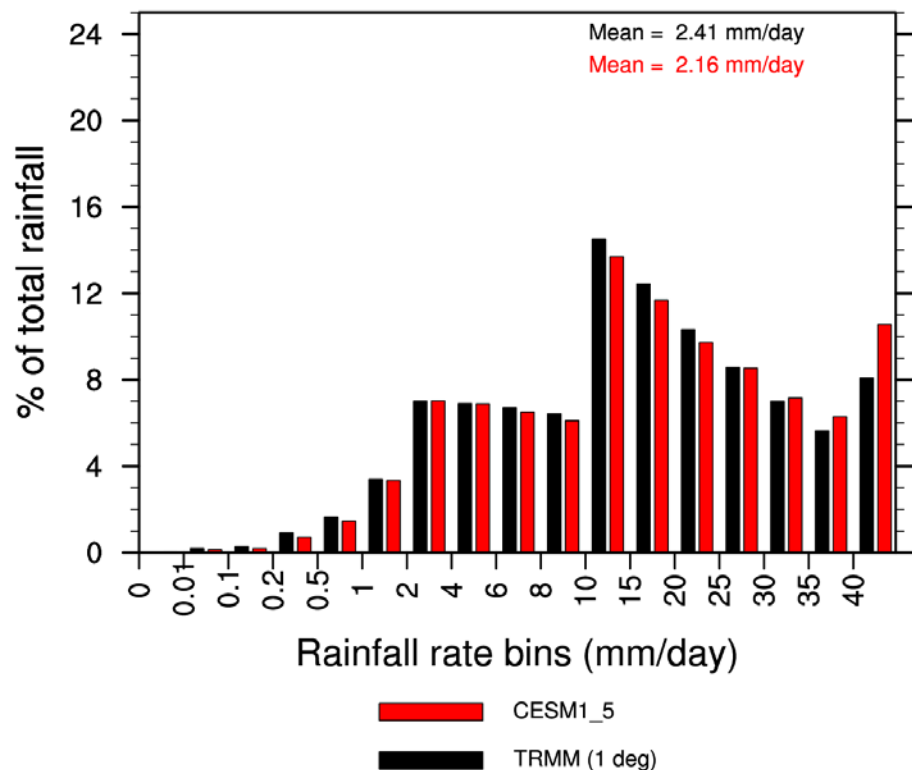


## CESM1 (LENS)

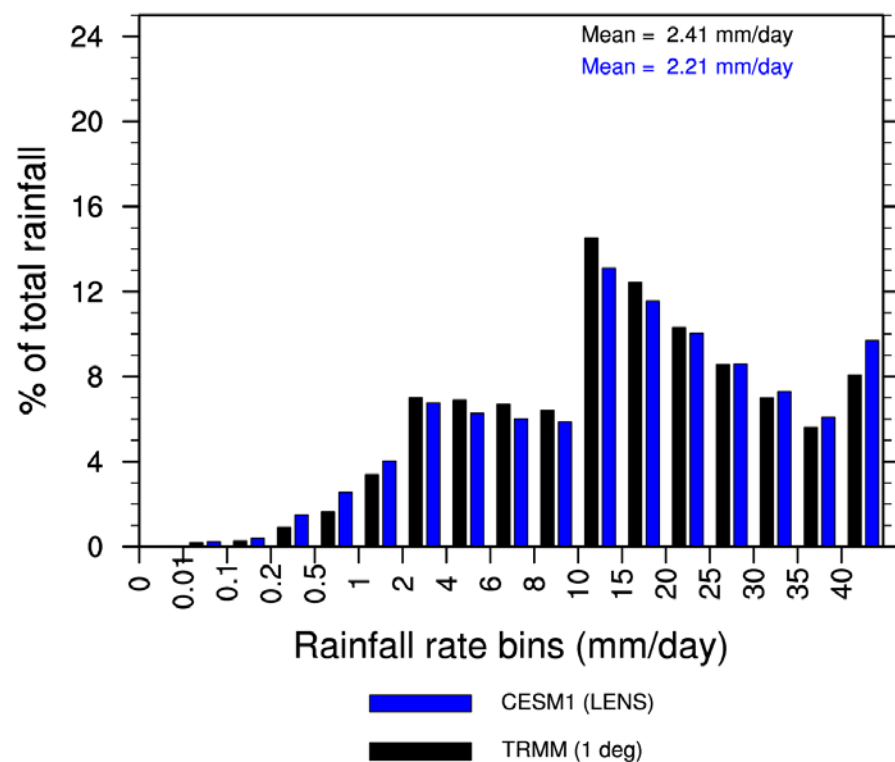


# US Precipitation %rain PDF (DJF) - Daily

## CESM1.5



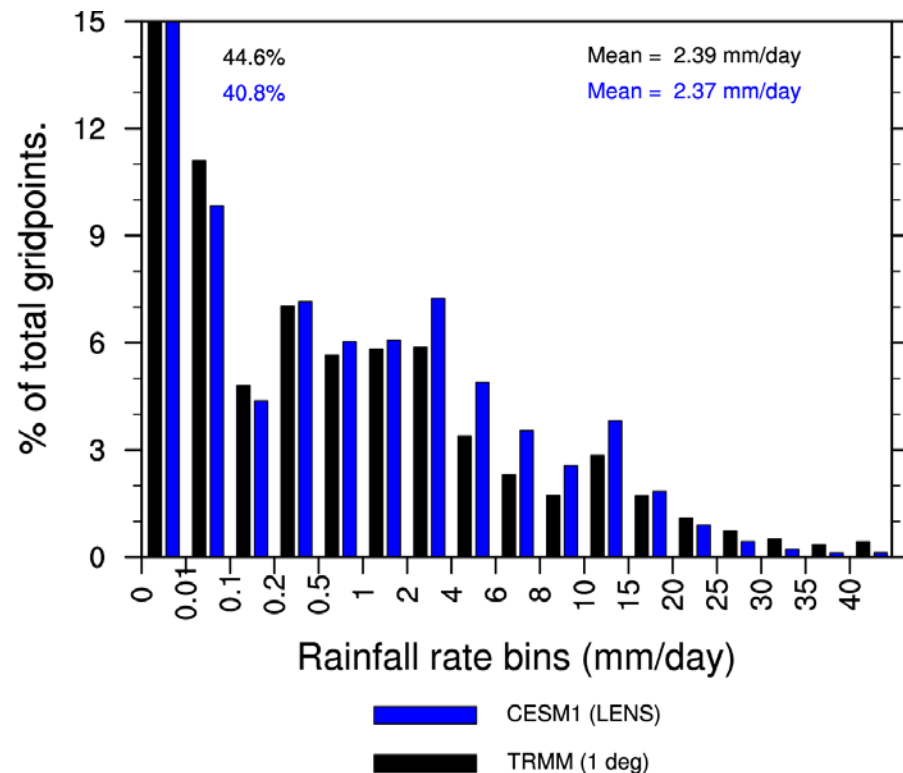
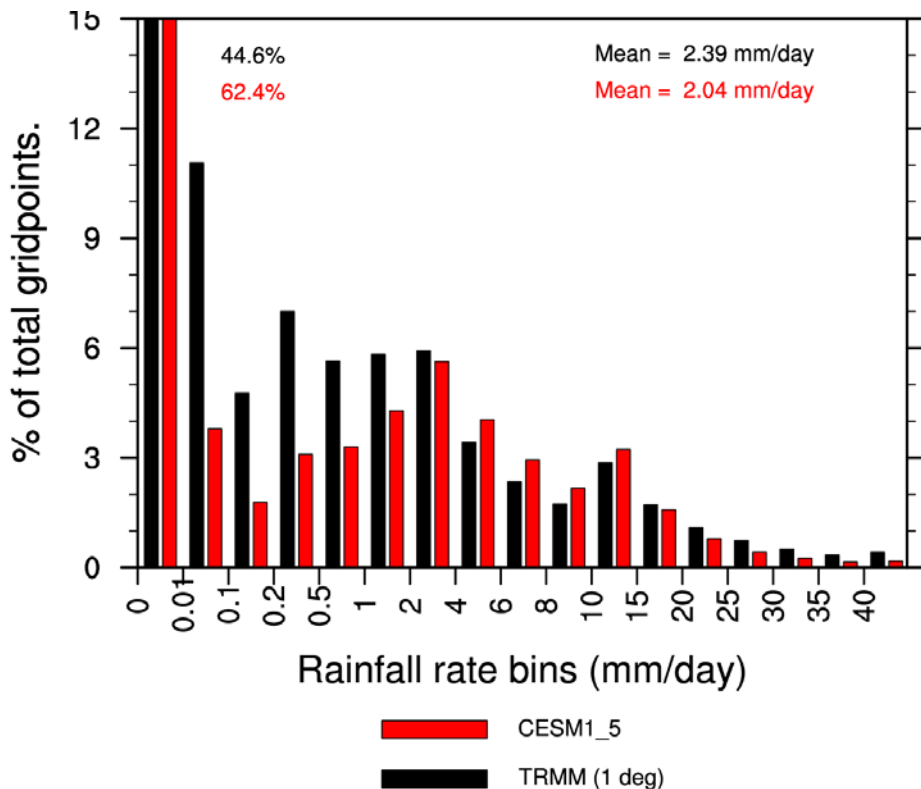
## CESM1 (LENS)



# US Precipitation %gps PDF (JJA) - Daily

## CESM1.5

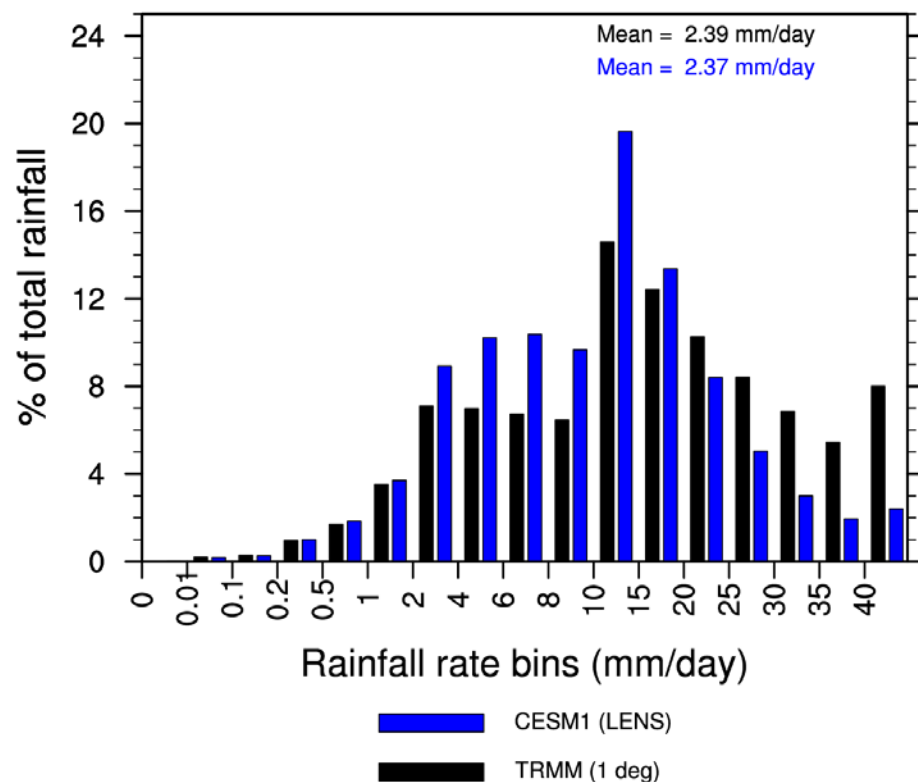
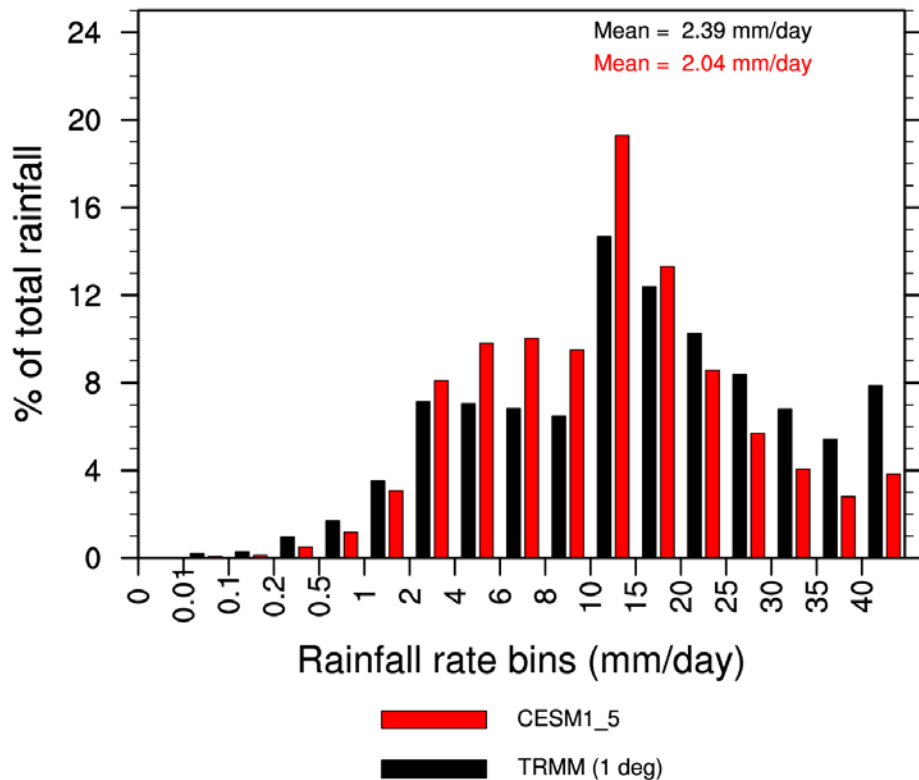
## CESM1 (LENS)



# US Precipitation %rain PDF (JJA) - Daily

**CESM1.5**

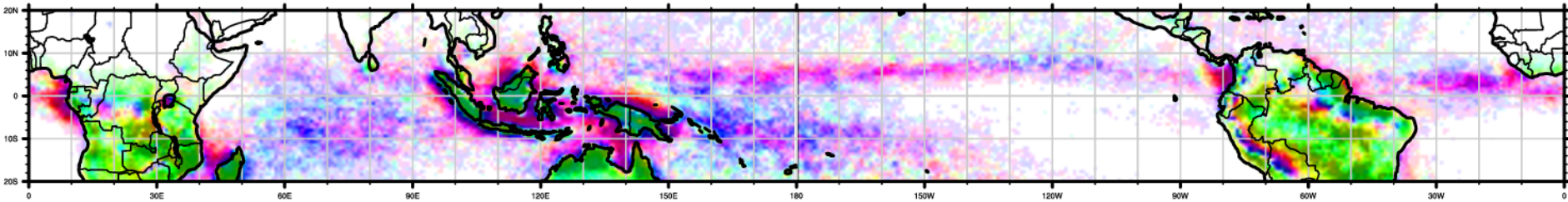
**CESM1 (LENS)**



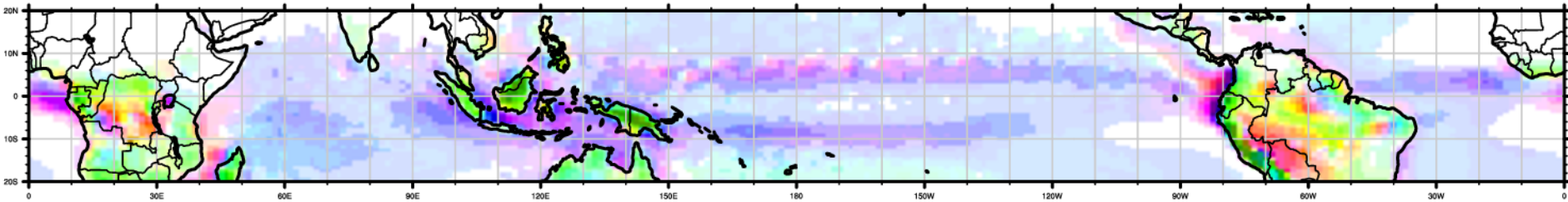
# Precipitation Diurnal Cycle (DJF)



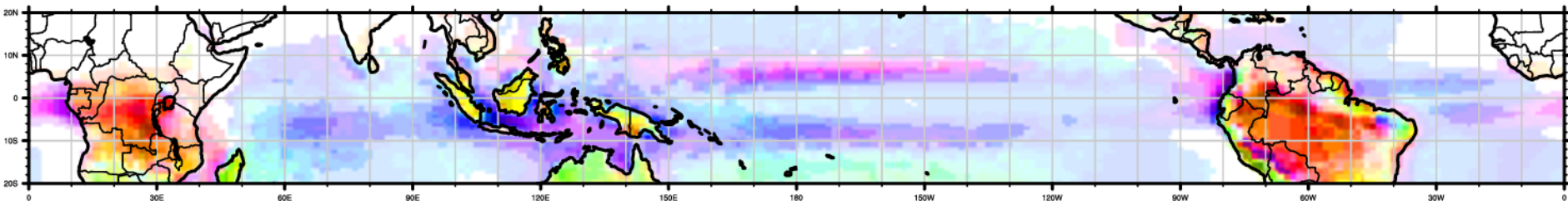
TRMM (2001-2010)



CESM1\_5 (1-10)



CESM1 (LENS) (1-10)

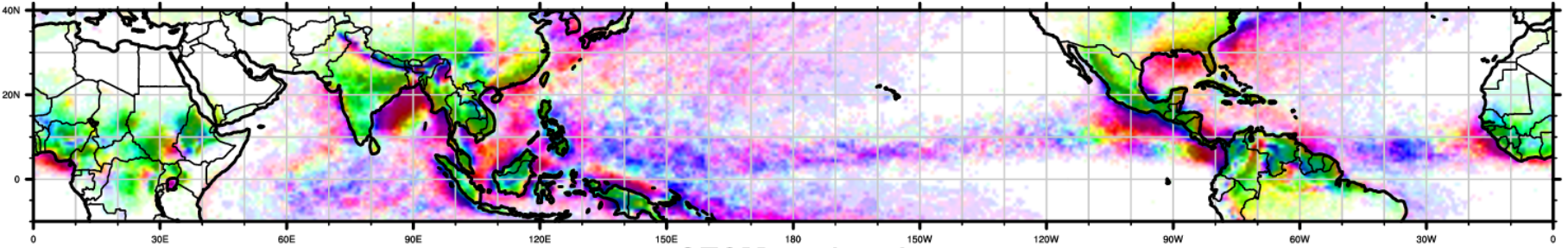




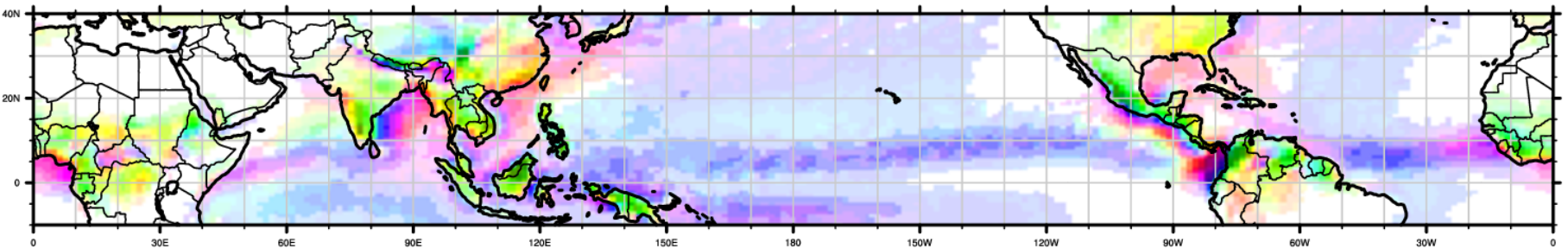
# Precipitation Diurnal Cycle (JJA)



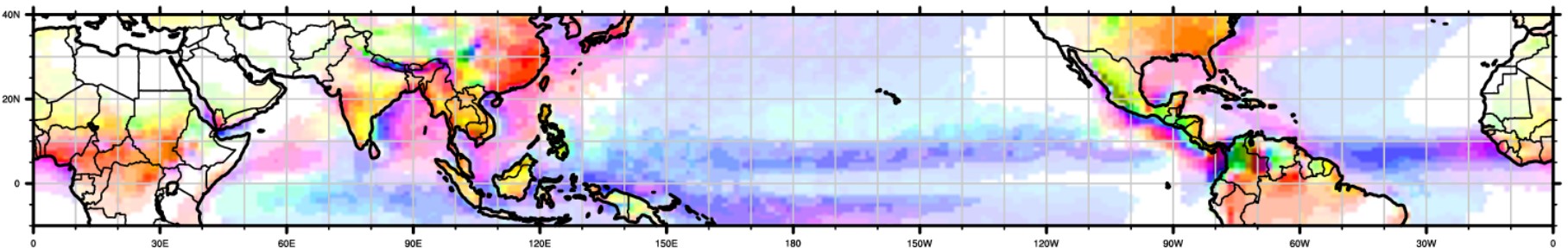
TRMM (2001-2010)



CESM1\_5 (1-10)



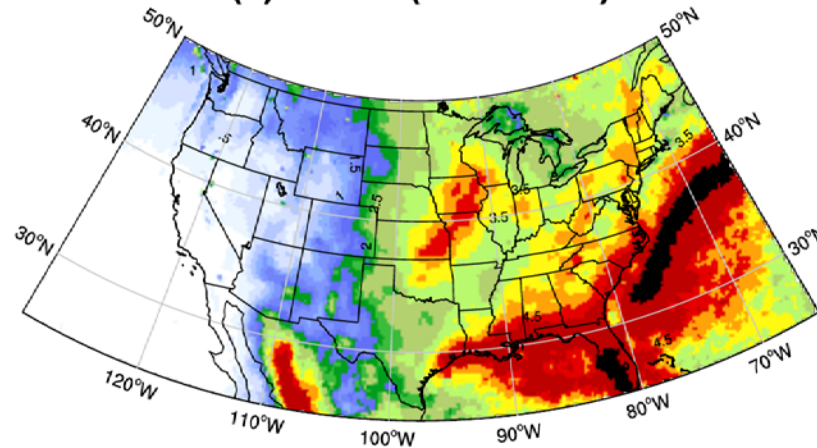
CESM1 (LENS) (1-10)



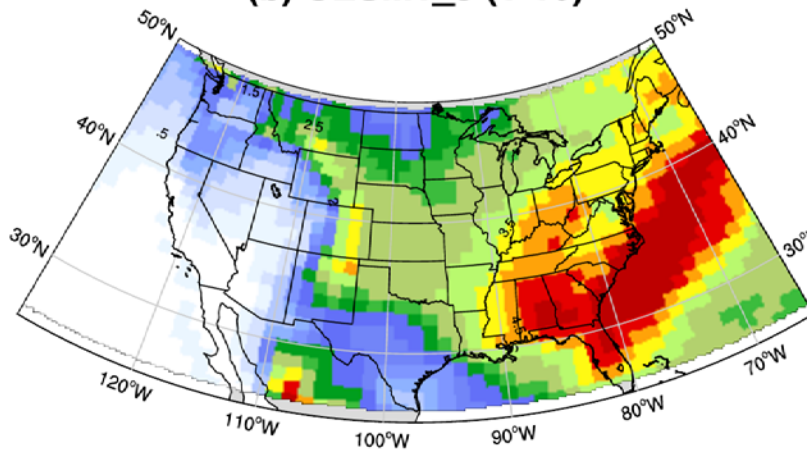


# US Precipitation Diurnal Cycle (JJA)

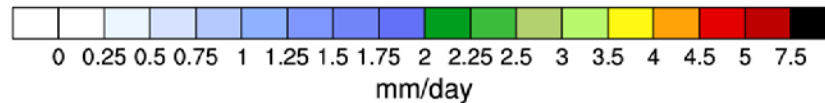
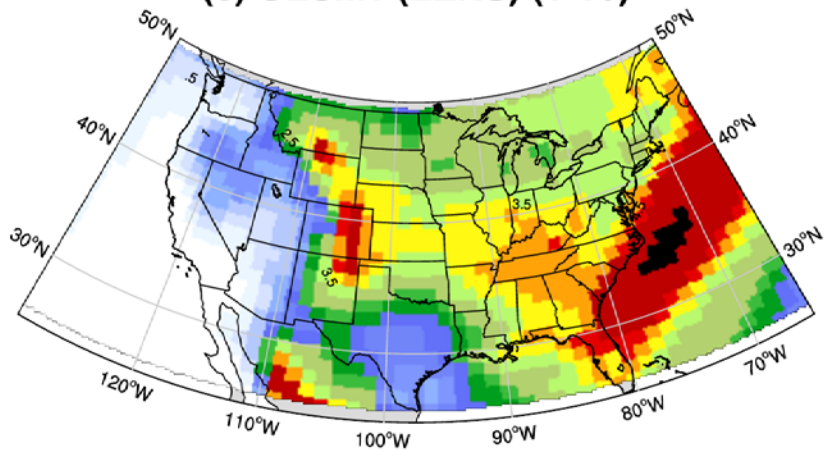
(a) TRMM (2001-2010)



(b) CESM1\_5 (1-10)

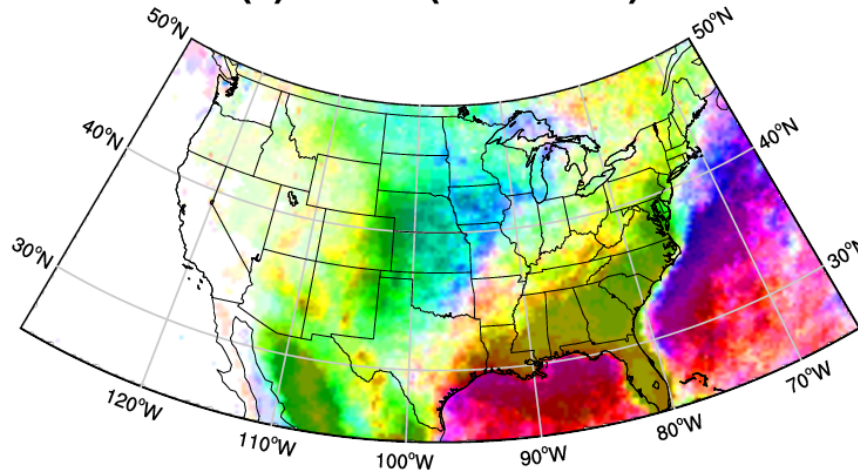


(c) CESM1 (LENS) (1-10)

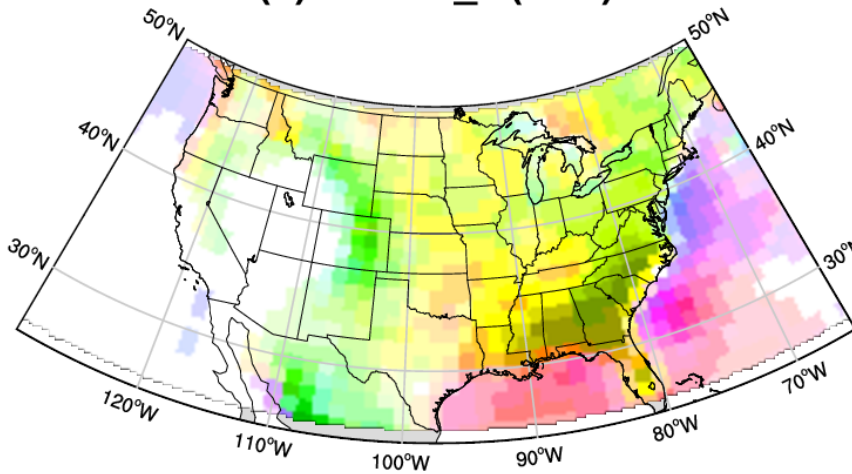


# US Precipitation Diurnal Cycle (JJA)

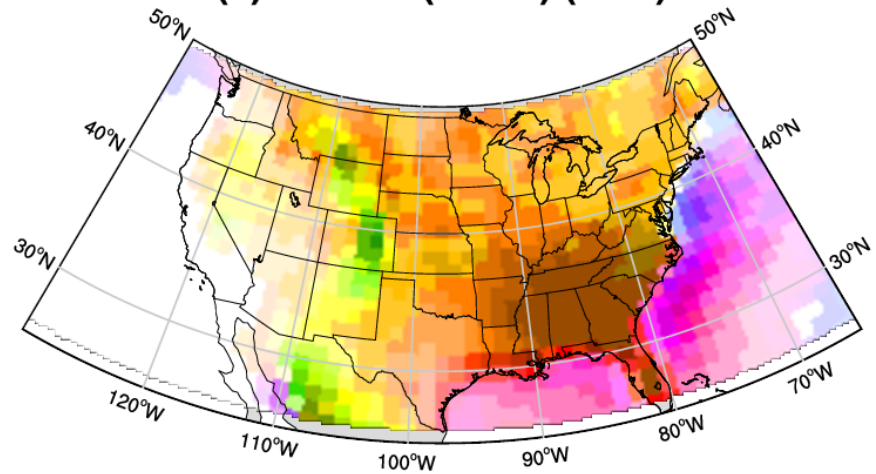
(a) TRMM (2001-2010)



(b) CESM1\_5 (1-10)

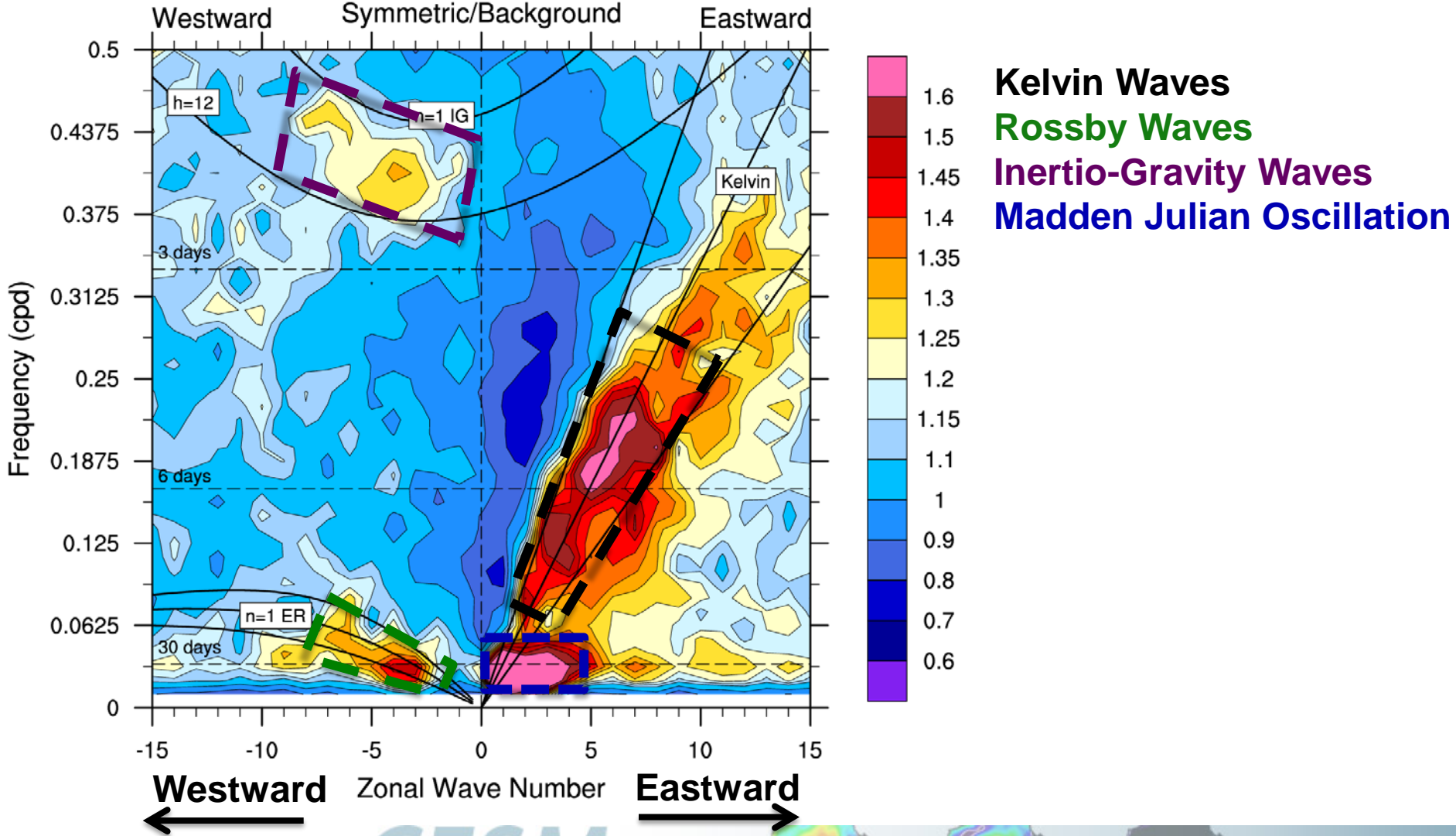


(c) CESM1 (LENS) (1-10)



# Equatorially trapped wave modes (symmetric)

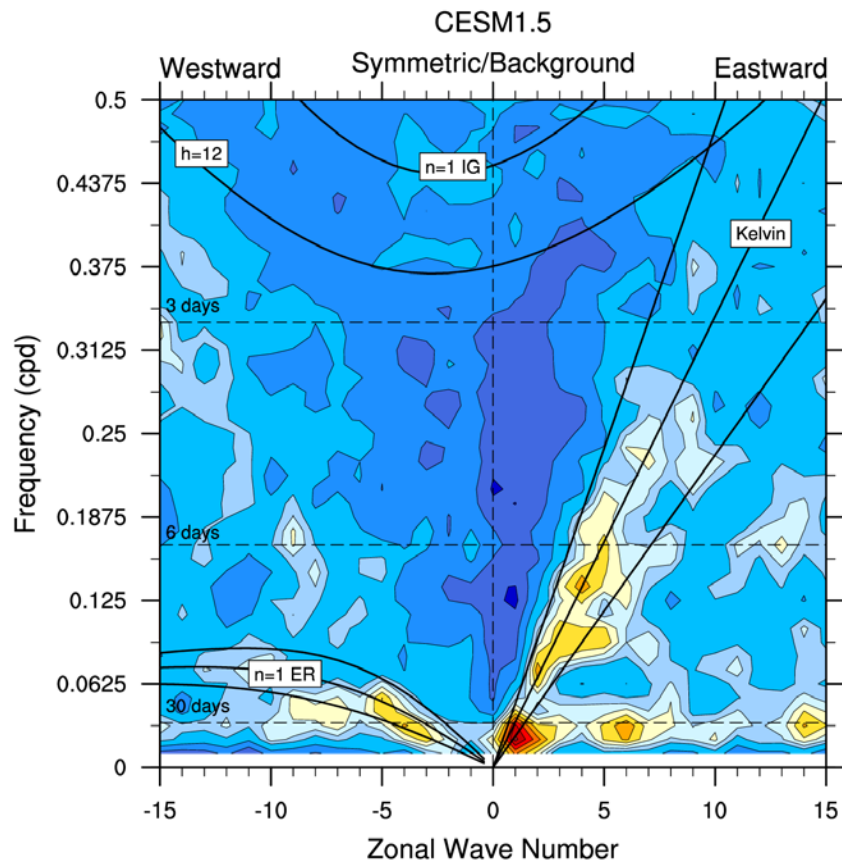
## Rainfall (TRMM)



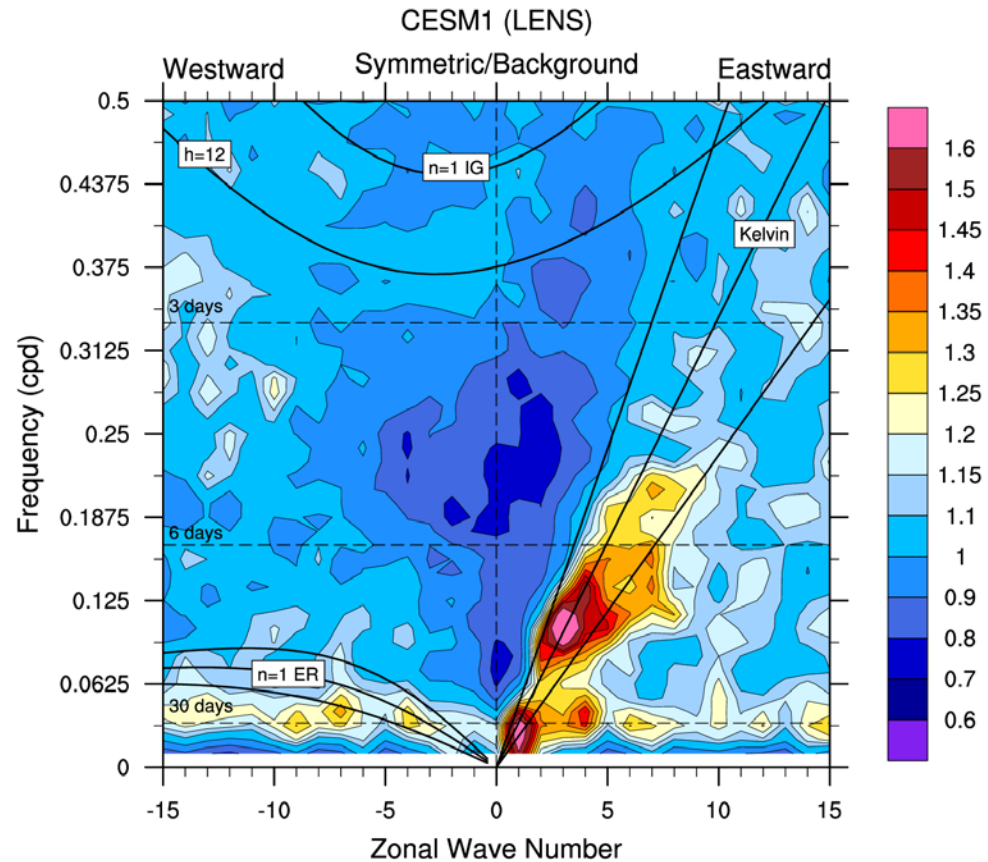


# Topical Wave-Number Frequency Variance - Rainfall

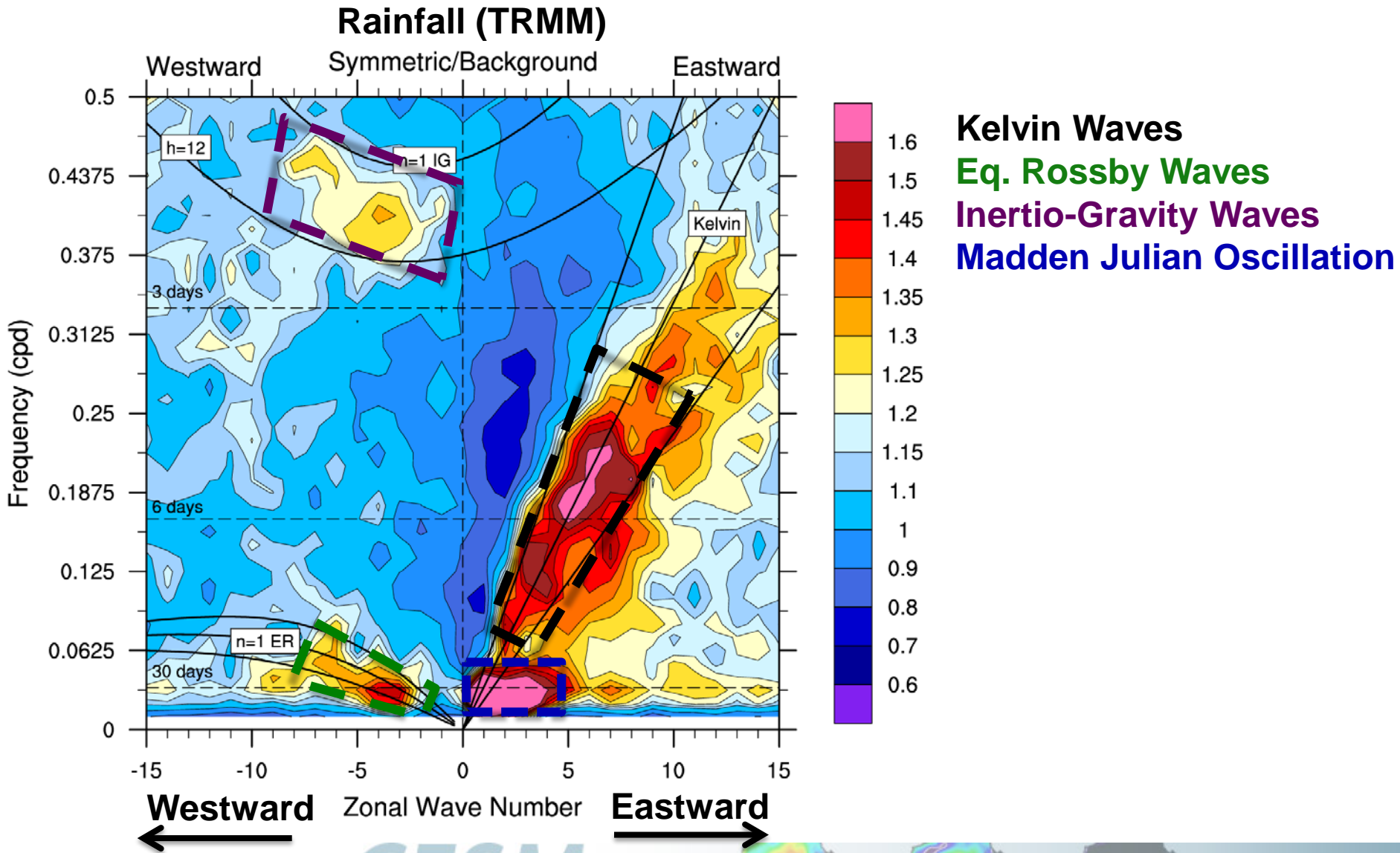
**CESM1.5**



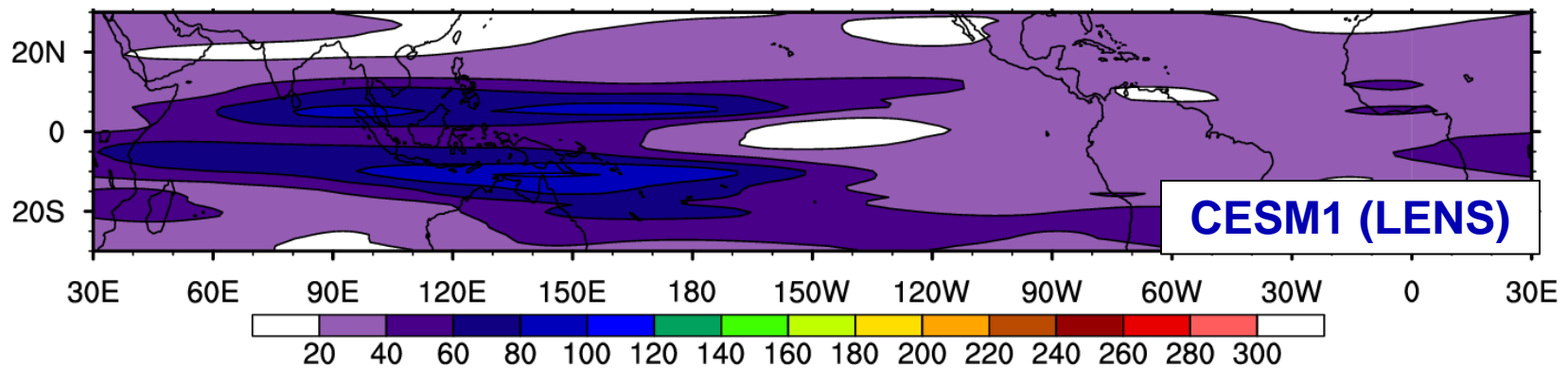
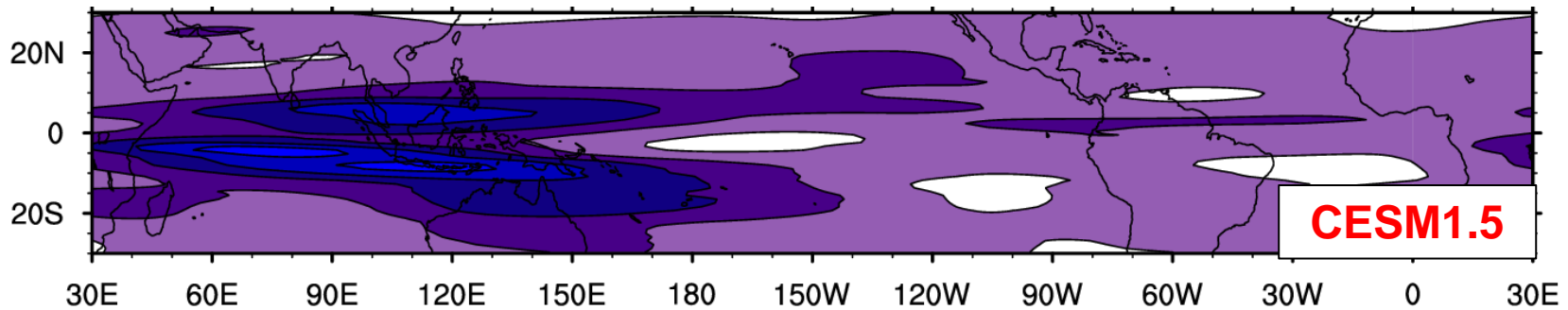
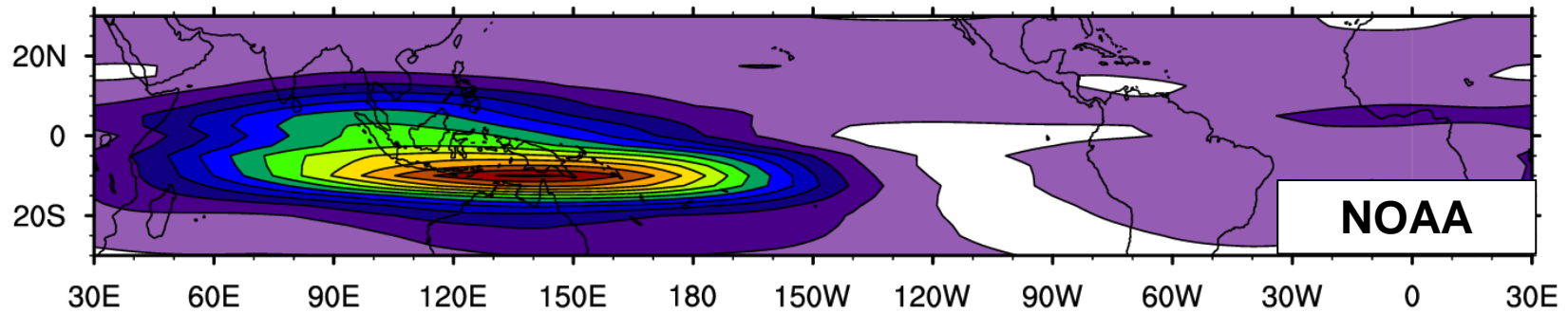
**CESM1 (LENS)**



# Equatorially trapped wave modes

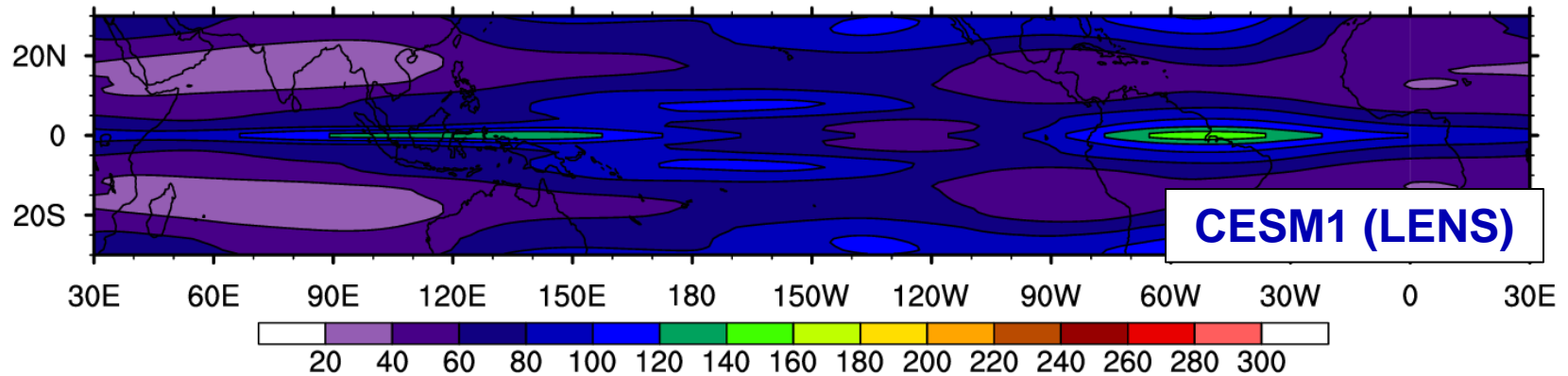
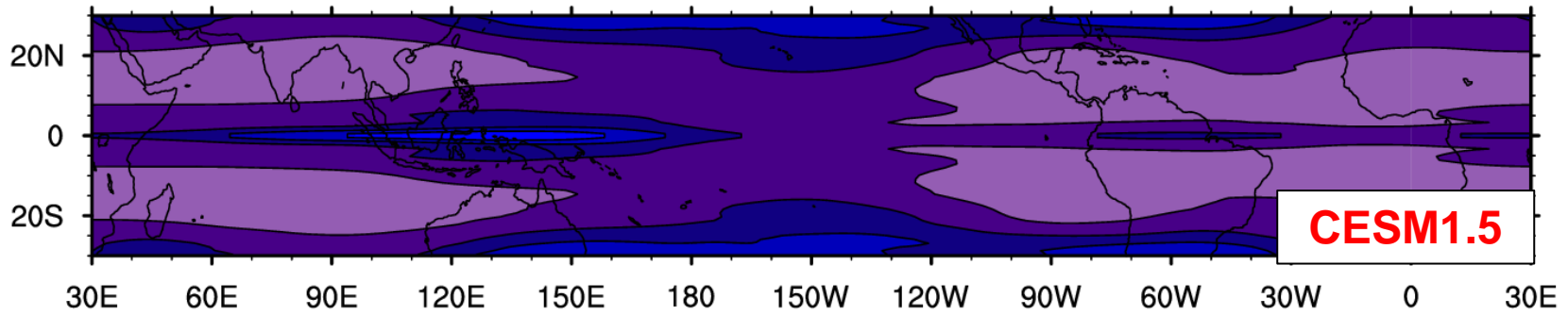
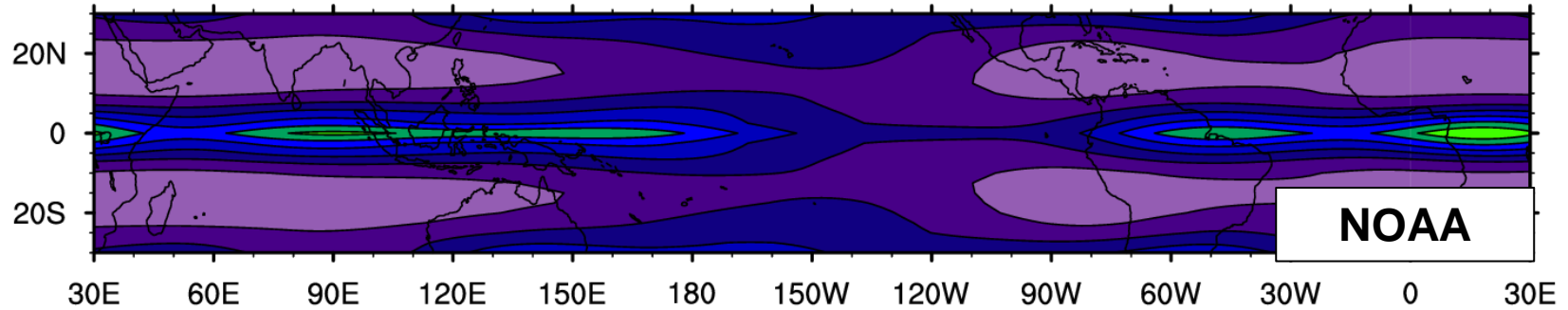


# Topical Wave-Mode Variance (OLR) – MJO (DJF)





# Topical Wave-Mode Variance (OLR) – Kelvin (DJF)

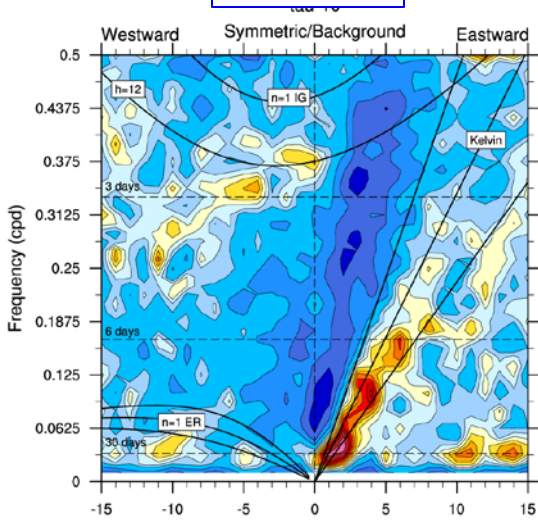
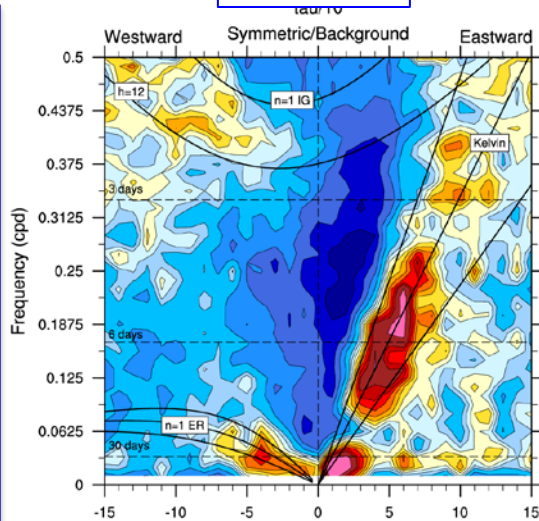
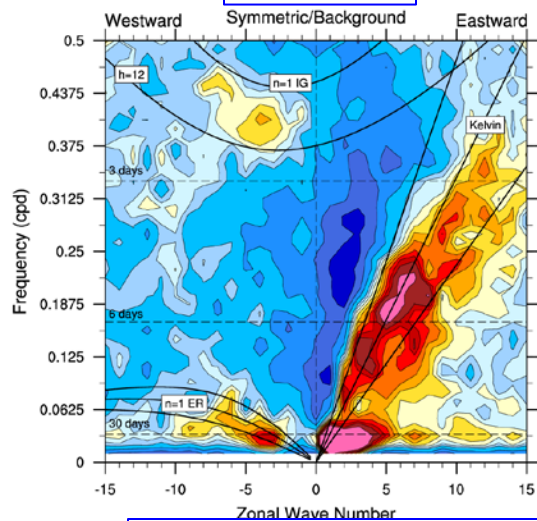


TRMM

Rainfall

tau/10

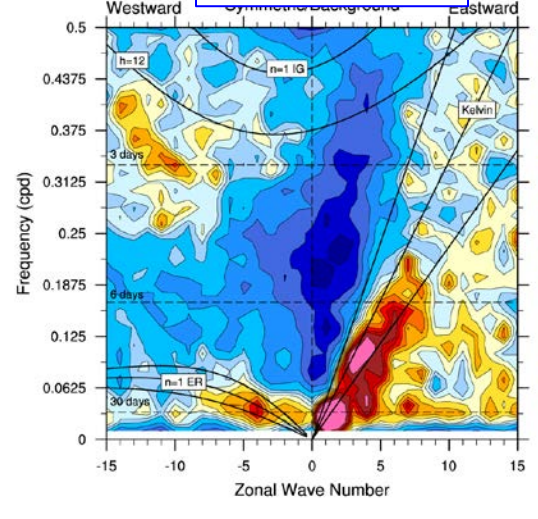
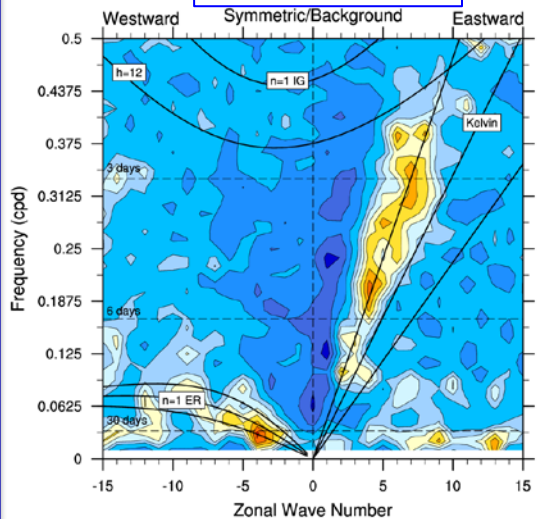
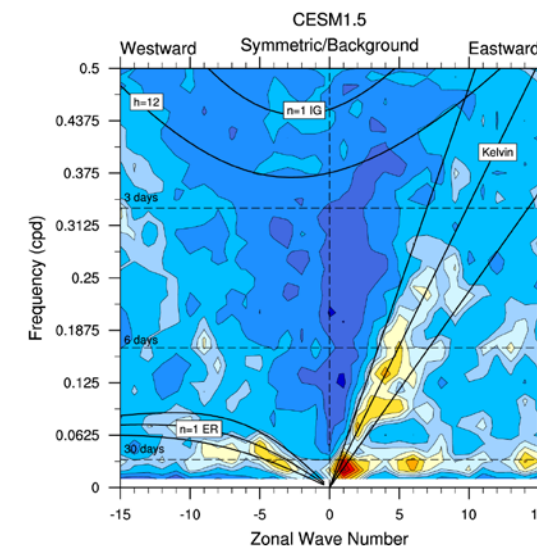
tau\*10



CESM1/CAM5.5

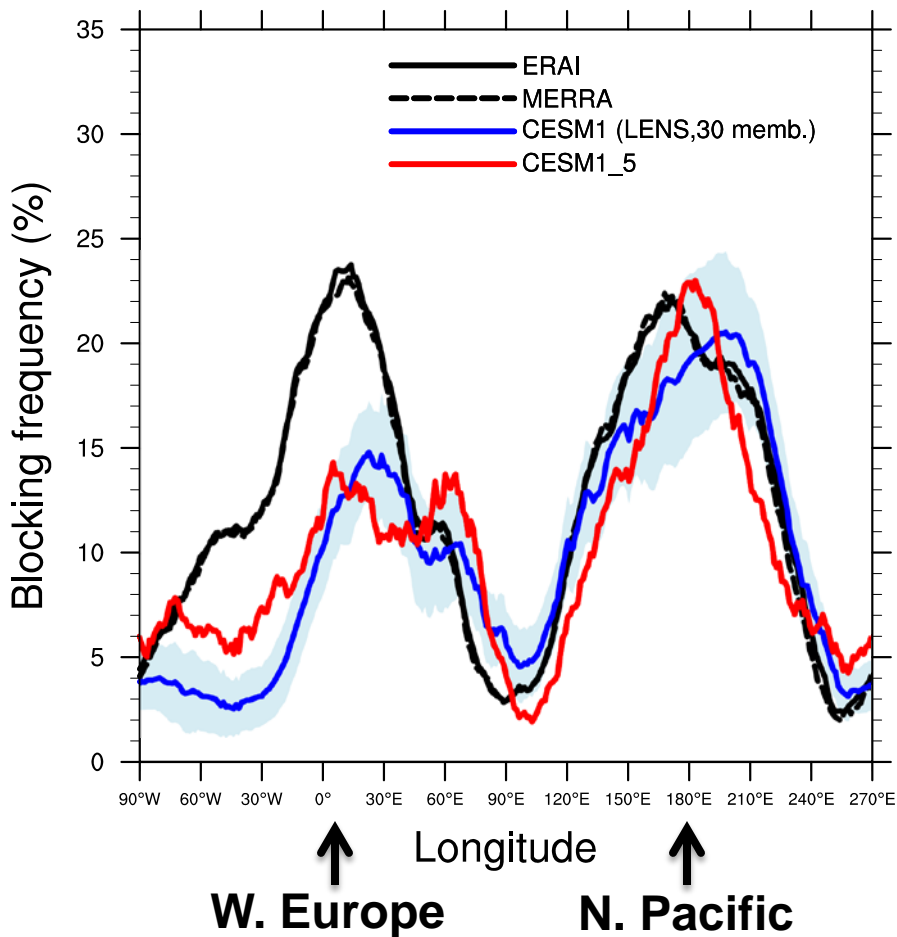
dmpdz/10

dmpdz\*10

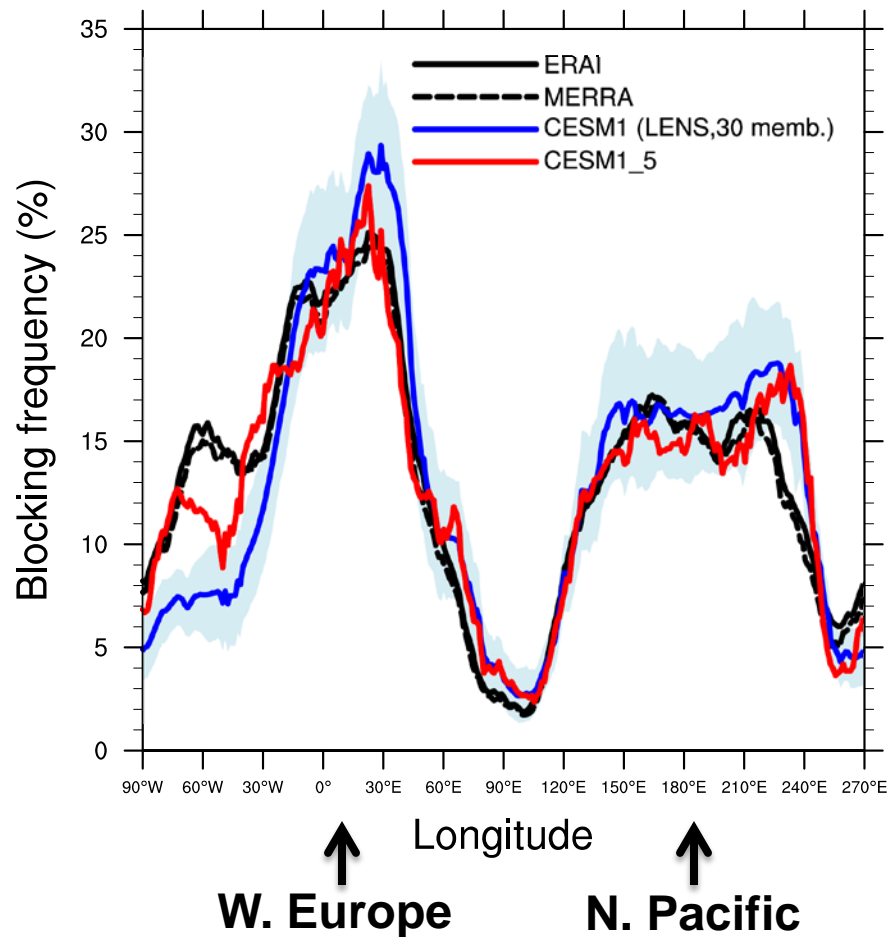


# Blocking Frequency (daily 500mb height, 50N)

## DJF Blocking frequency



## MAM Blocking frequency

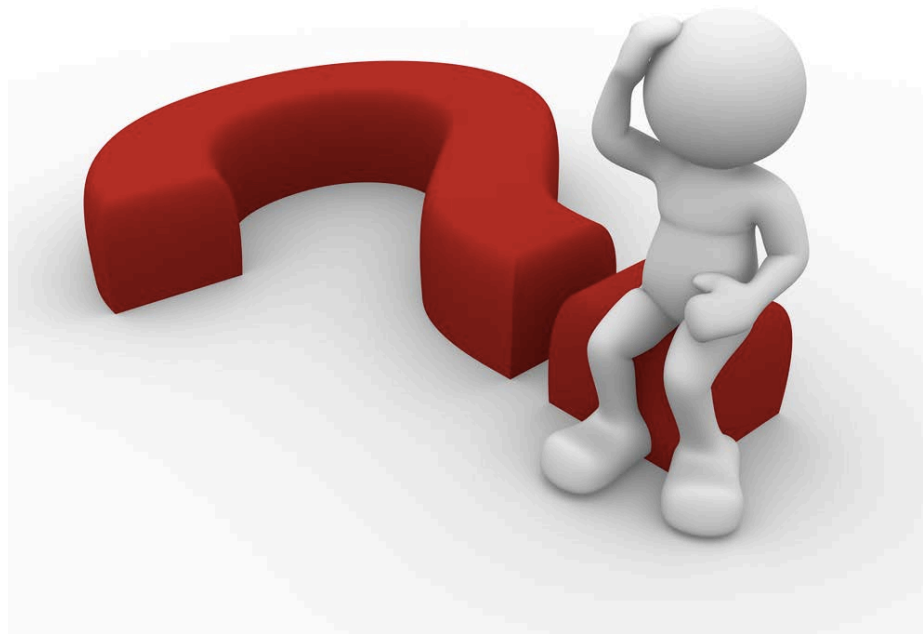


# Summary

- **Overall sub-seasonal variability weak (weaker in CESM1.5)**
- **Tropical variability: Weak rainfall, strong OLR (Clouds)**
  - Wave mode variance lower in CESM1.5
  - Kelvin waves and MJO have reduced strength in CESM1.5
  - Known deep convection sensitivities: Negative impacts on mean/dcycle
- **Rainfall PDF**
  - Good distribution in DJF; JJA too many weak and too few intense events
  - Indonesia: Too few dry days, CESM1.5 more dry days
- **Diurnal cycle**
  - Timing over land later everywhere (12pm → 5pm, obs. 8pm)
  - Amplitude weakens
  - JJA US MCSs still absent
- **Atmospheric Blocking**
  - Similar behavior: CESM1.5 some Greenland increases
  - Updates to surface drag formulation may provide changes



# Questions?

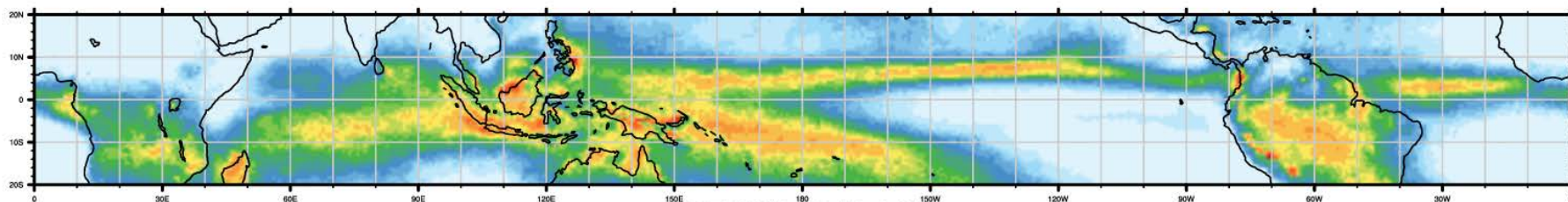


# Extra Slides

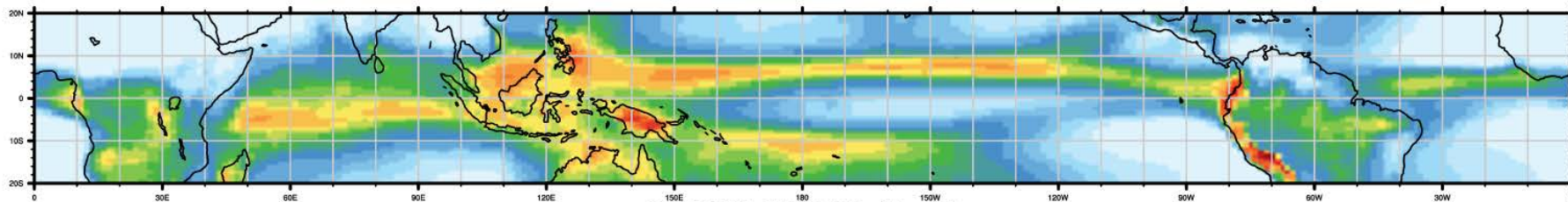


# Precipitation Diurnal Cycle (DJF)

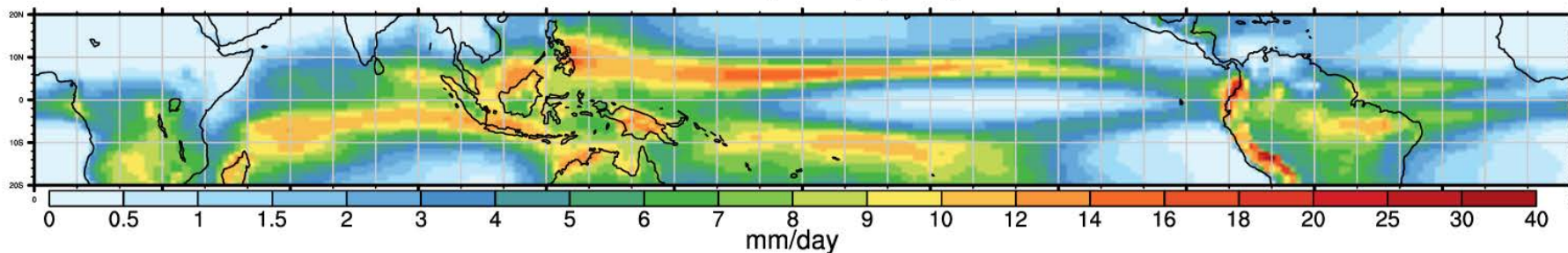
TRMM (2001-2010)



CESM1\_5 (1-10)

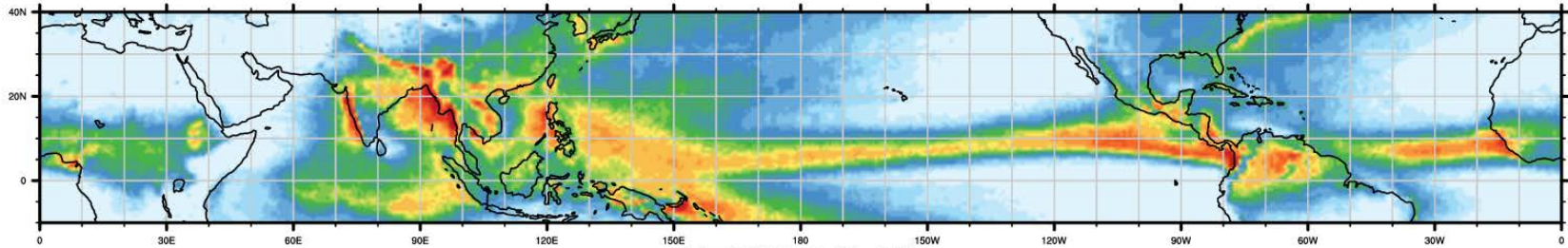


CESM1 (LENS) (1-10)

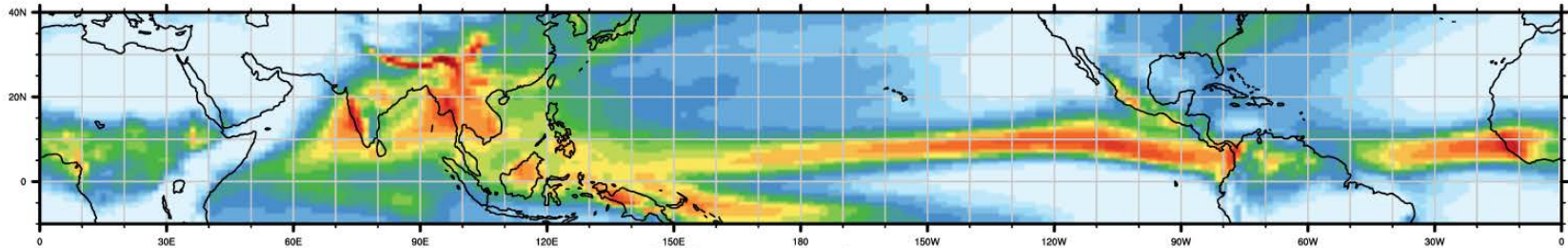


# Precipitation Diurnal Cycle (JJA)

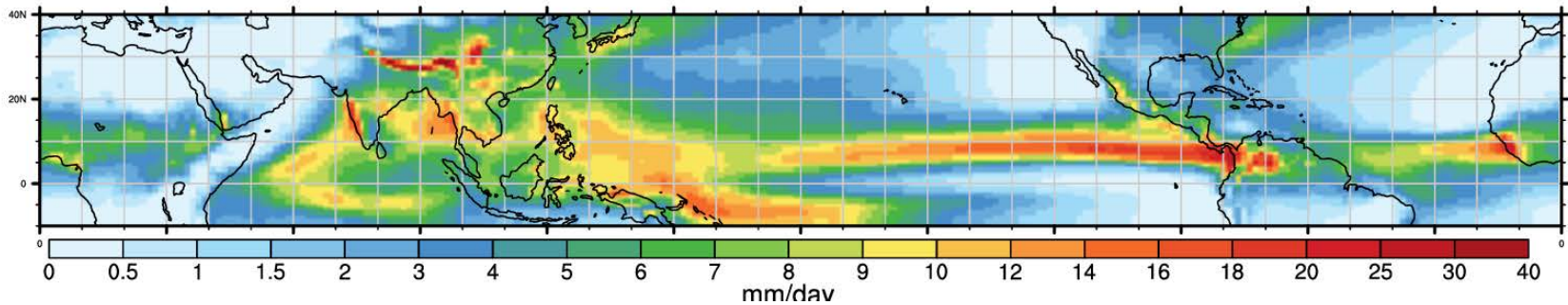
TRMM (2001-2010)



CESM1\_5 (1-10)



CESM1 (LENS) (1-10)

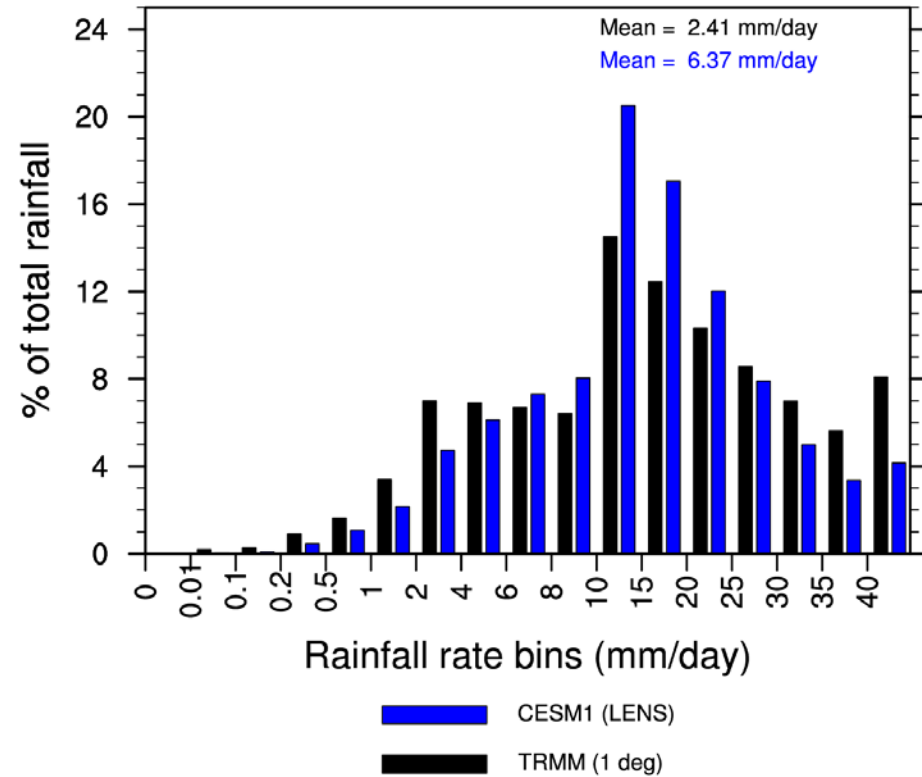
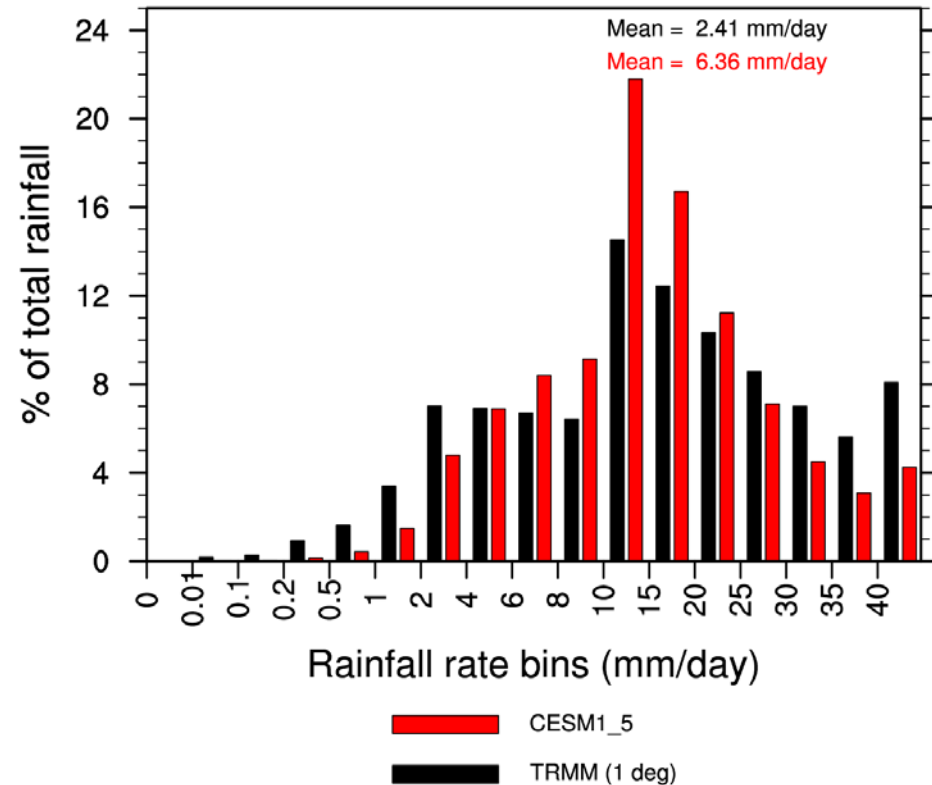




# Maritime Continent Precipitation PDF (DJF) - Daily

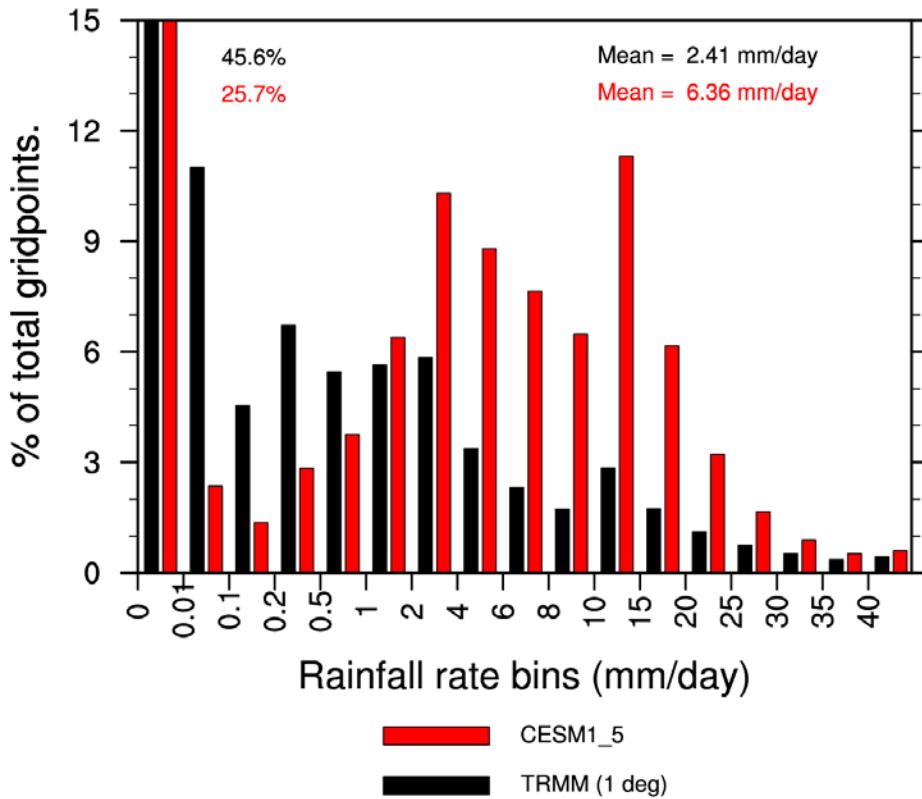
**CESM1.5**

**CESM1 (LENS)**

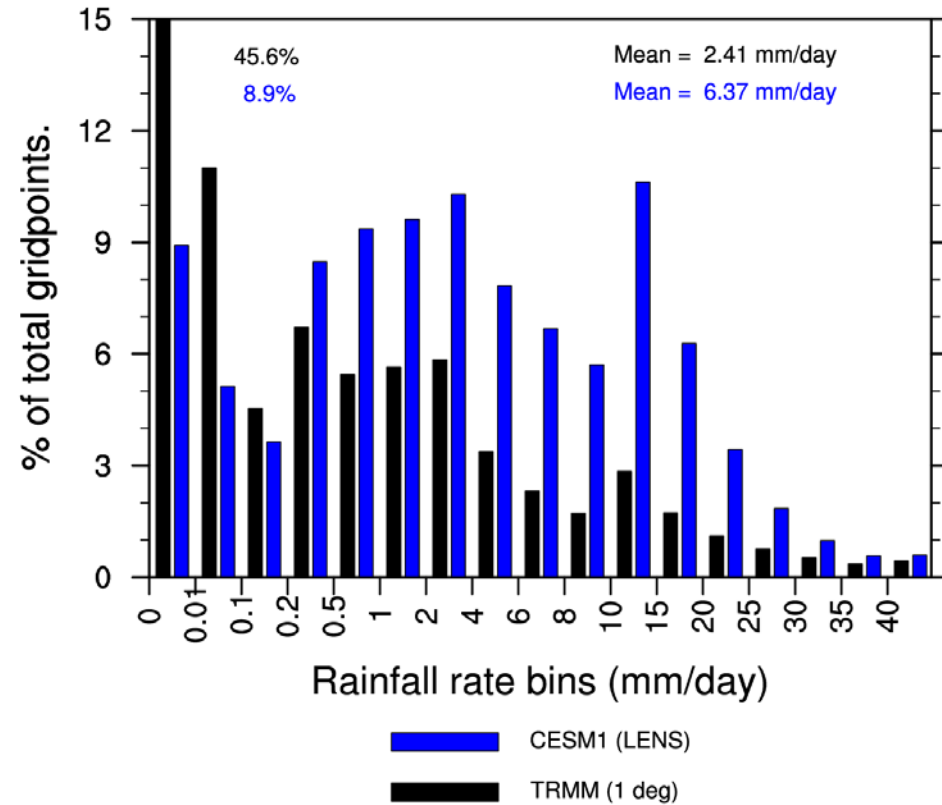


# Maritime Continent Precipitation PDF (DJF) - Daily

## CESM1.5

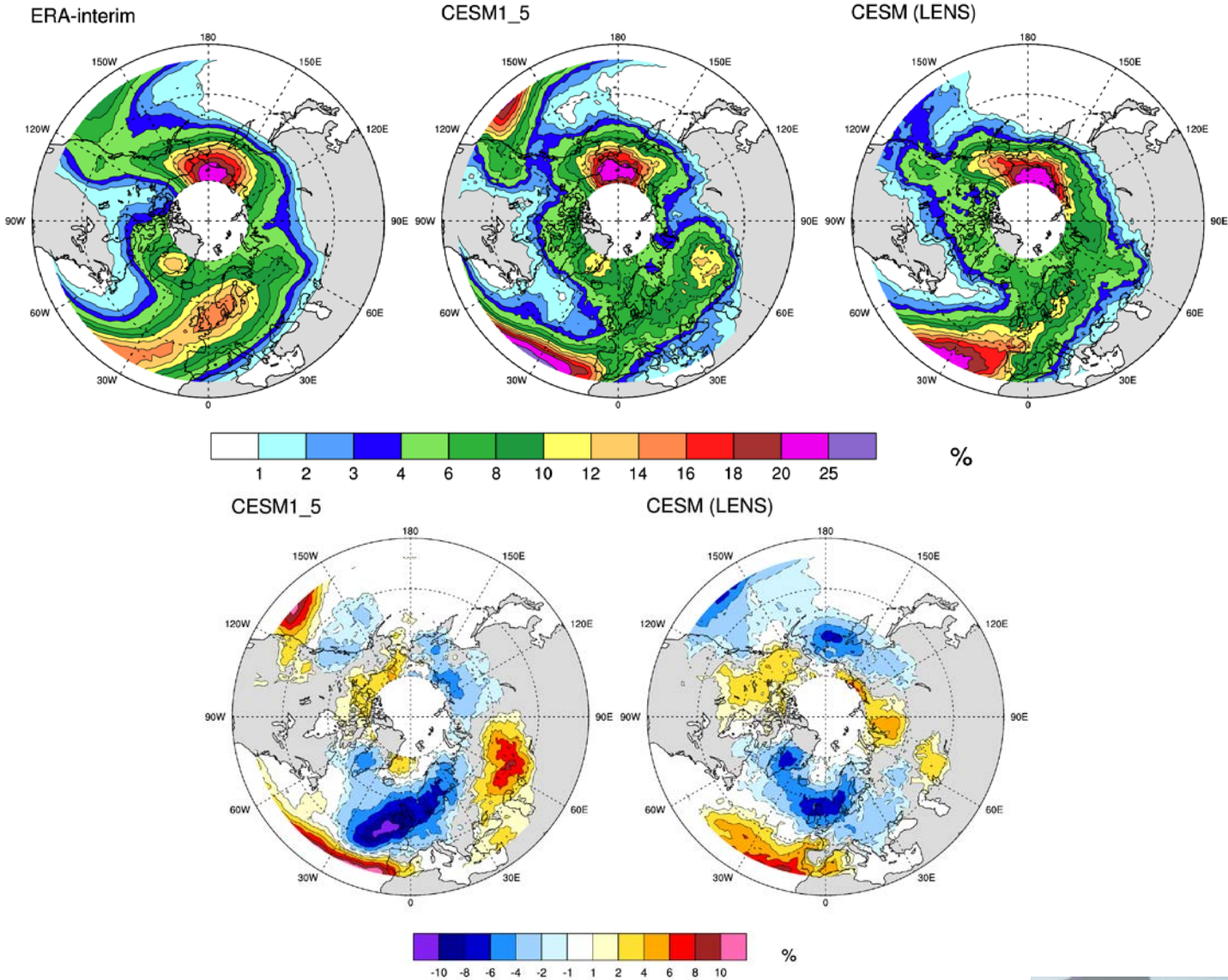


## CESM1 (LENS)





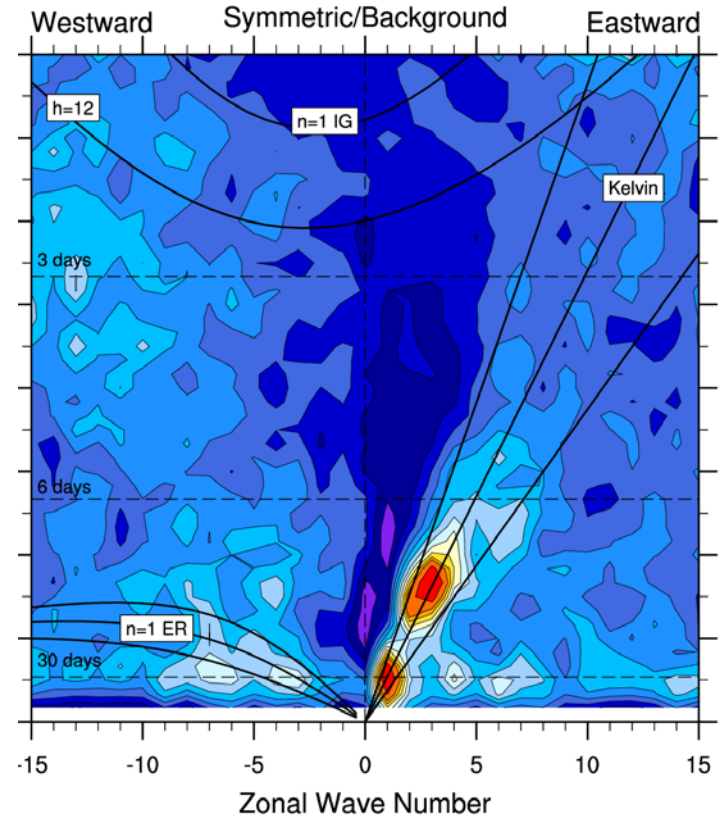
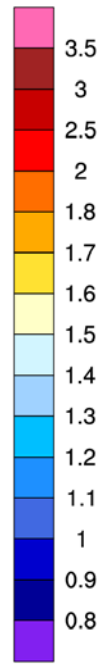
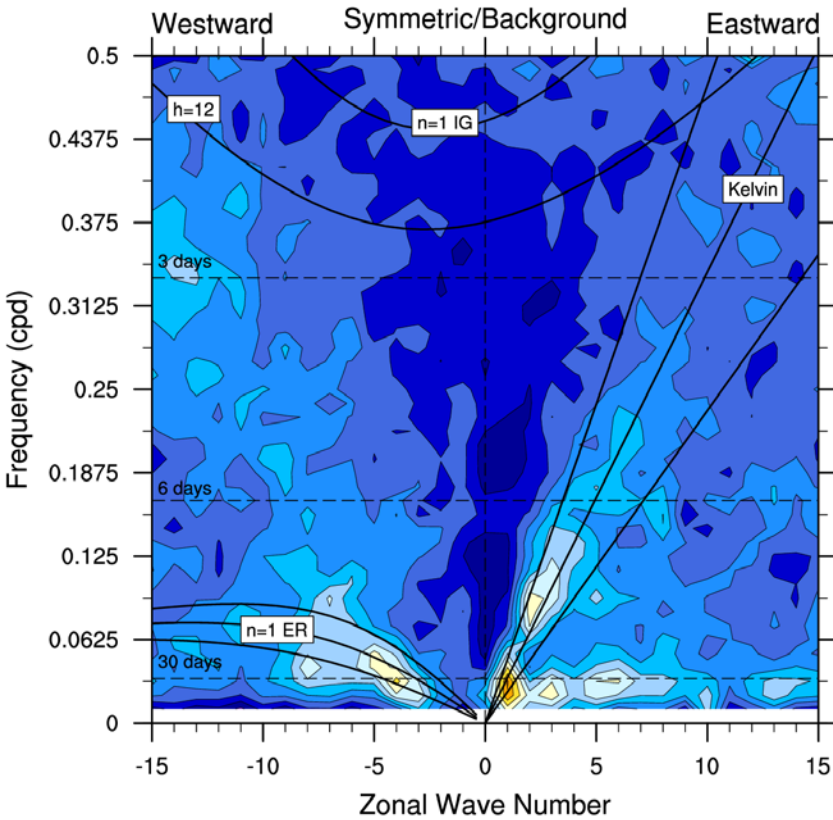
# Blocking Frequency (DJF, daily 500mb height, 50N)



# Topical Wave-Number Frequency Variance - OLR

**CESM1.5**

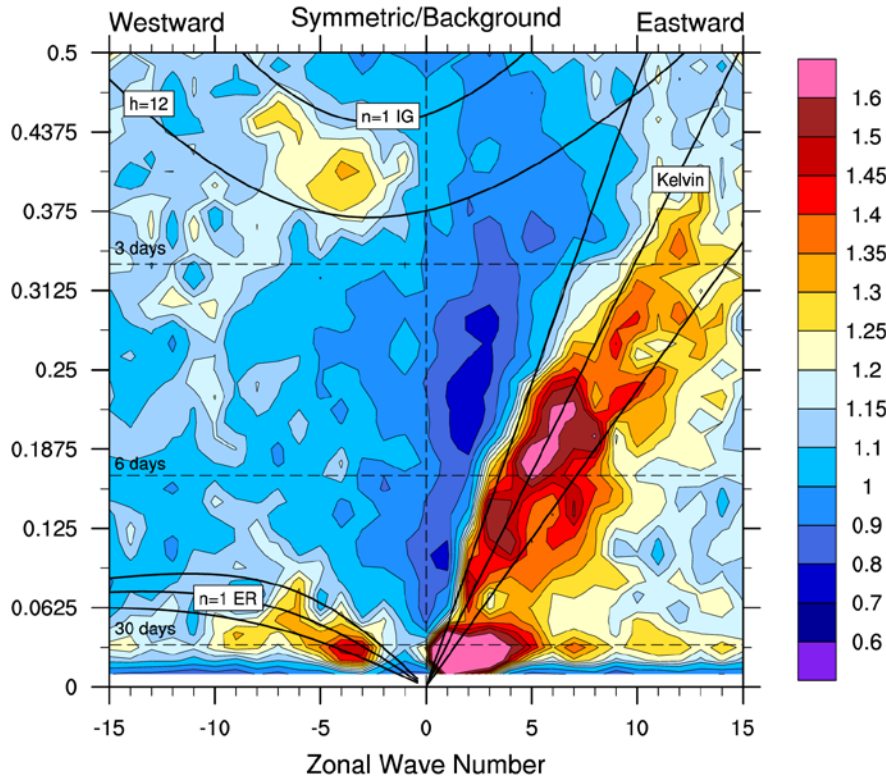
**CESM1 (LENS)**



# Topical Wave-Number Frequency Variance

## Rainfall

TRMM



## Outgoing LW Radiation (TOA)

NOAA

