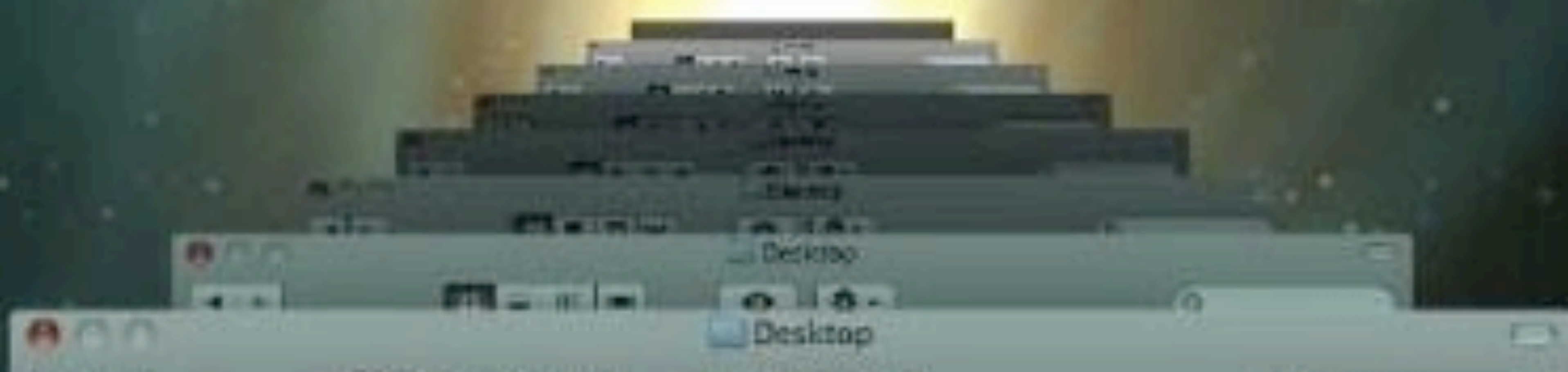
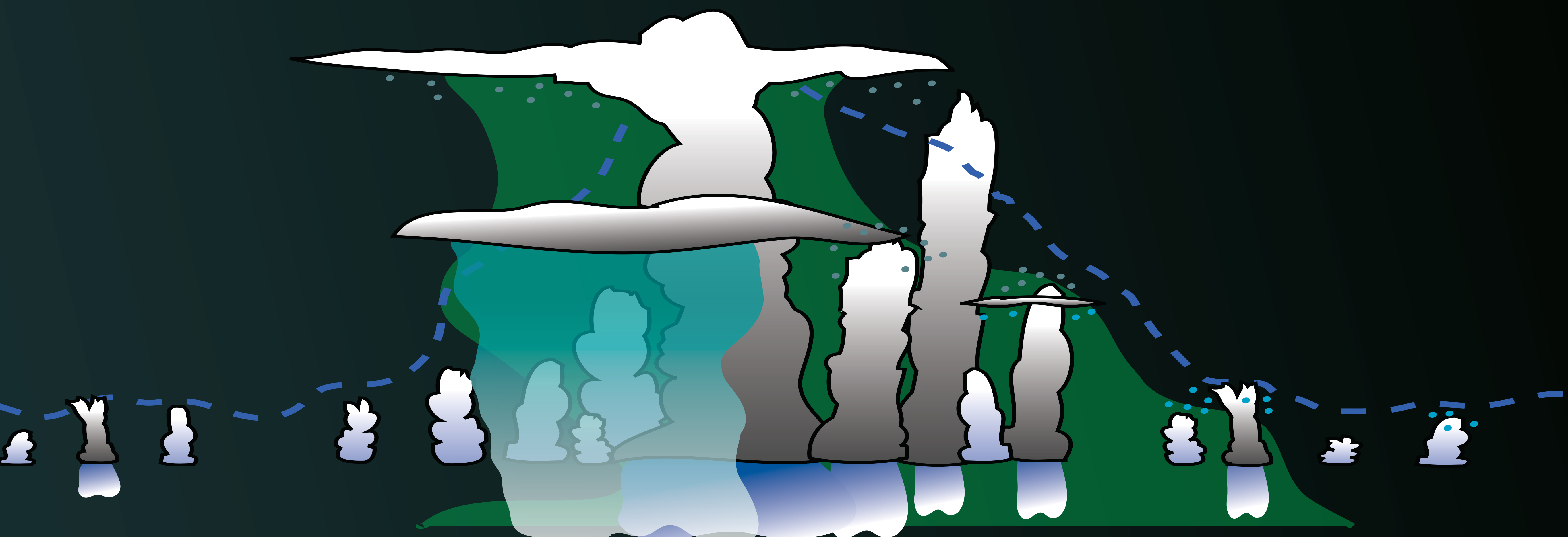
The MJO of the Future

D. Randall, C. Stan, C. DeMott, L. Xu, and M. Branson





How will the MJO change during the 21st century?

- Changes in intensity
- Changes in the zonal and meridional scales of the rainy and dry areas
- Changes in the speed of propagation
- Changes in the locations where the MJO has a significant effect on precipitation
- Changes in seasonality

Other Studies

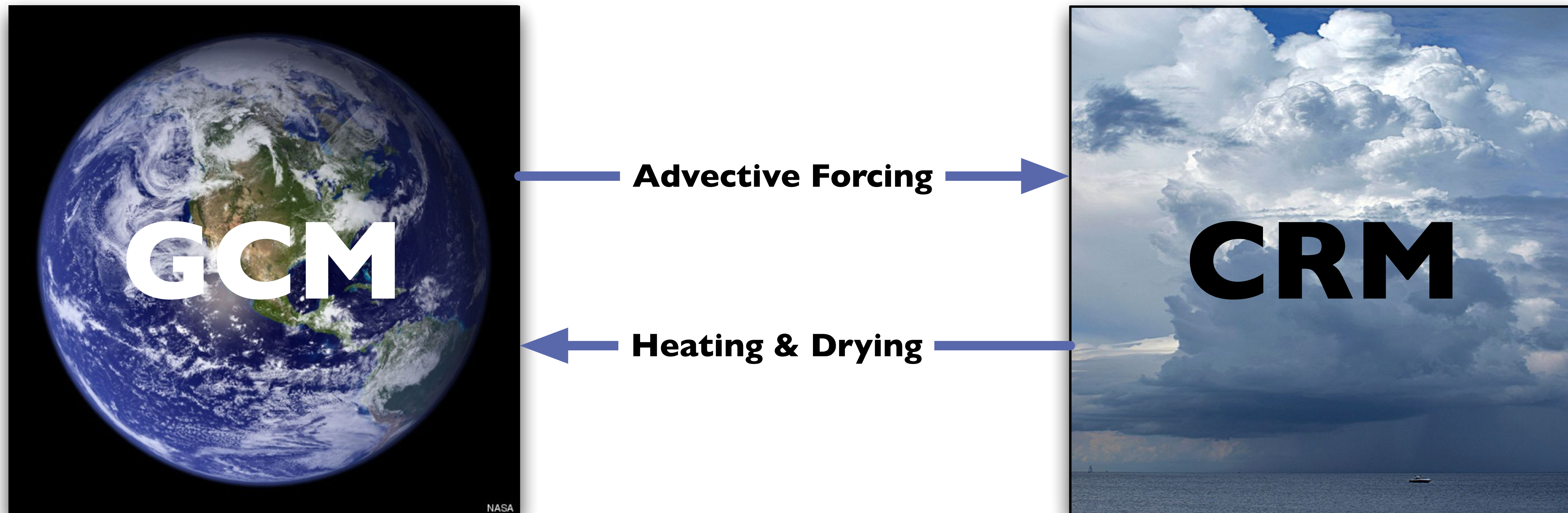
- Liu, 2012: Aquaplanet, uniform 2 K or 4 K warming, CAM2; more events, increased intensity, and shorter period
- Jones & Carvalho, 2011: Observationally based stochastic model: more events
- Caballero & Huber, 2010: CAM3.1; equatorial super-rotation with strong warming, due to angular momentum transport by increased equatorial Rossby wave activity
- Subramanian et al., 2011: CCSM4; CMIP5 runs being analyzed; poster this afternoon, A13B-0233

Experimental Design

- Detailed analysis of simulated MJO in present climate (Jim Benedict), based on the super-parameterized atmosphere model SP-CAM3 SLD
- Simulation of 4xCO_2 climate and current climate (Stan & Xu)
  - SP-CAM4 FV 2.5 x 2 deg atmosphere, 1 deg ocean
  - 40-yr simulation of present-day climate (*not equilibrated yet*)
  - CMIP5 protocol, instantaneous quadrupling of CO_2
  - Analysis based on years 9-21 of the 4xCO_2 run

Multiscale Modeling Framework

Based on an idea by Wojciech Grabowski (1999)



"Super-Parameterization"

The CRMs do not communicate with each other, so *the model is almost embarrassingly parallel.*

See publications at http://www.cmmap.org/research/pubs-mmf.html

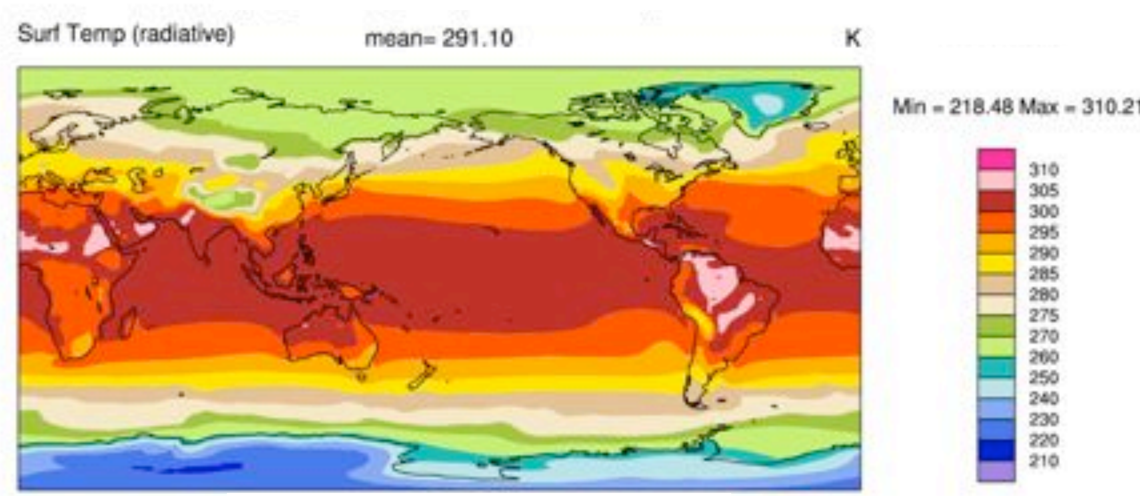
Our focus has been on variability.

- Diurnal cycle
- African Easterly Waves
- Monsoon fluctuations
- MJO
- ENSO
- And now, climate change

Surface Air Temperature

Annual mean

$4xCO_2$



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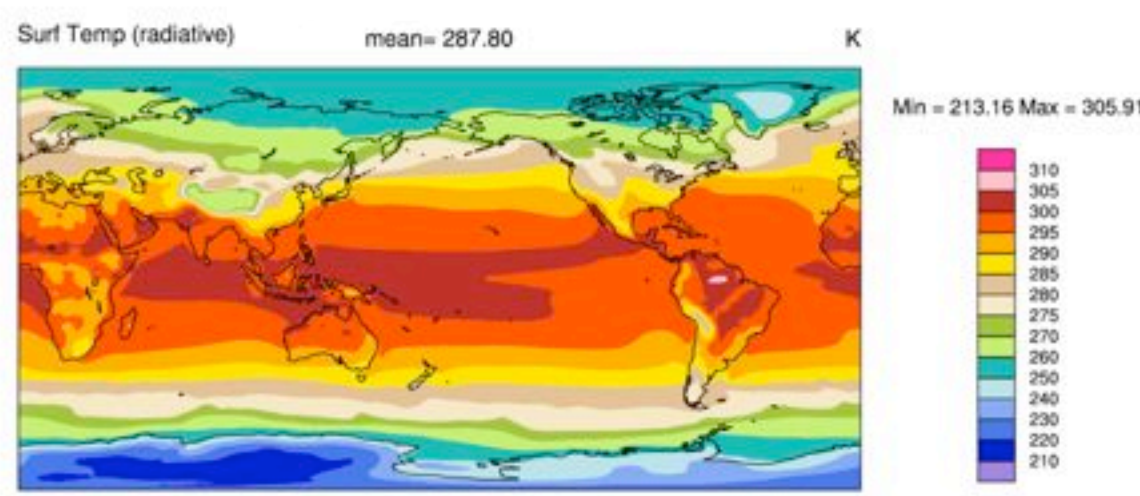
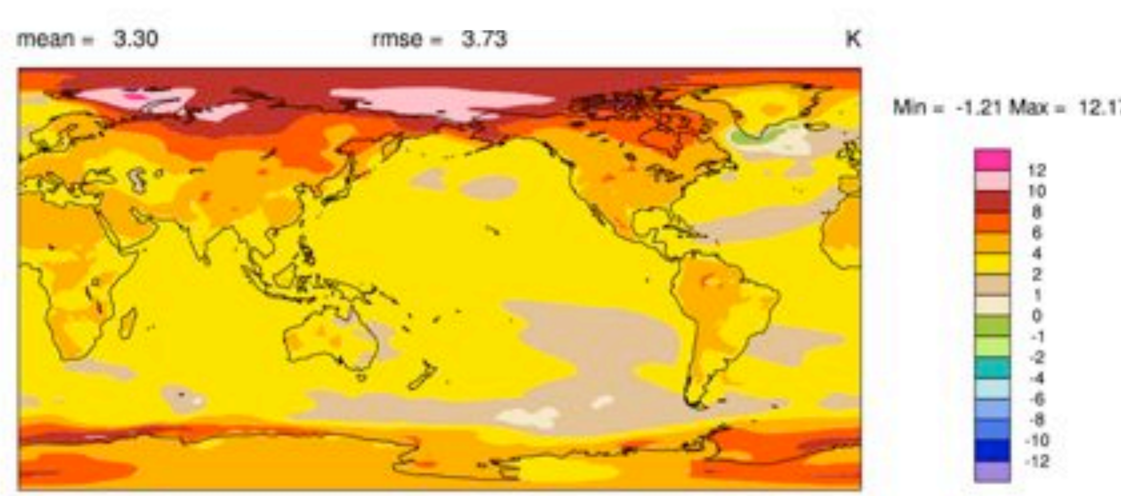


Diff



Precipitation Rate

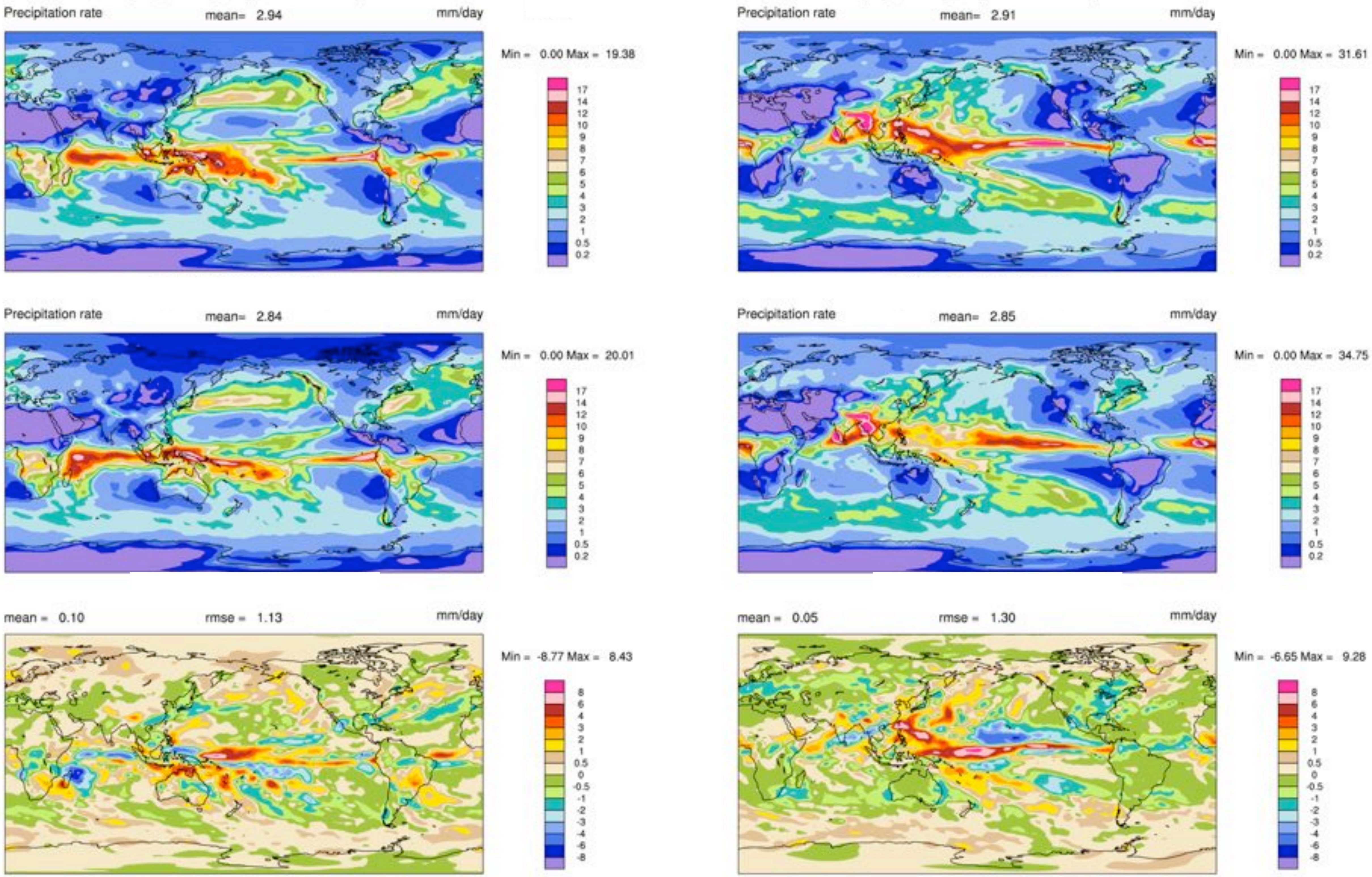
Years 10-12

DJF JJA

4xCO_2

Control

Diff

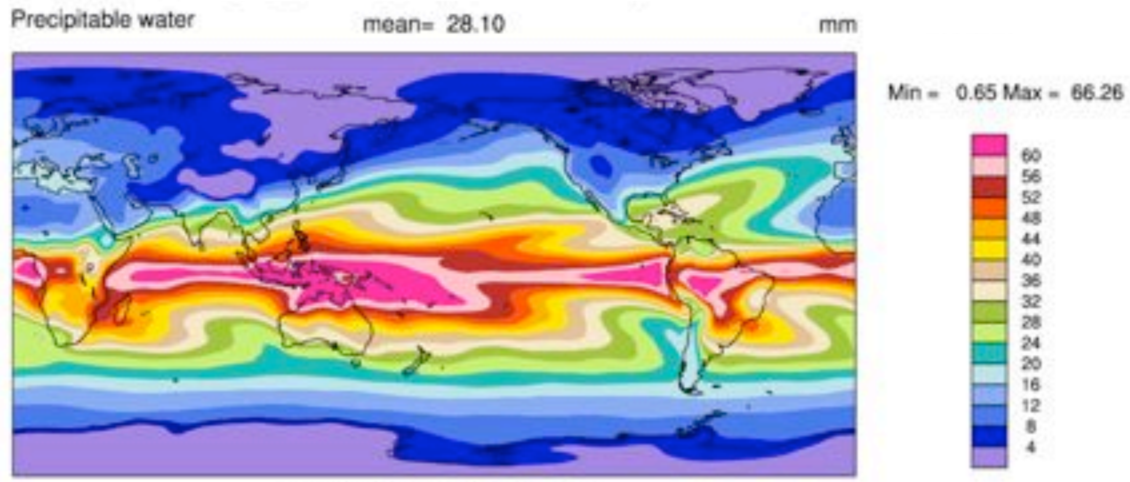


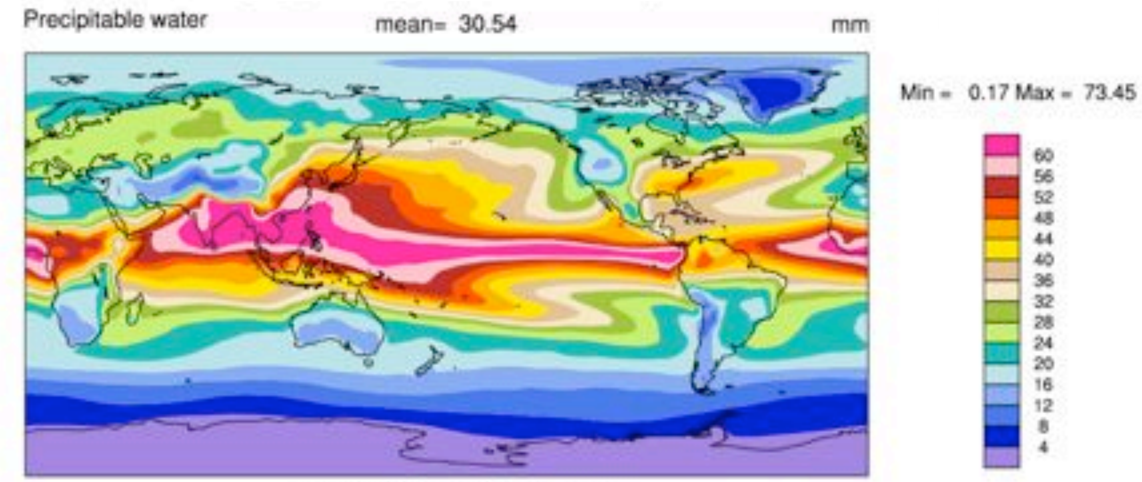
Precipitable Water

Years 10-12

	DJF	JJA

4xCO_2





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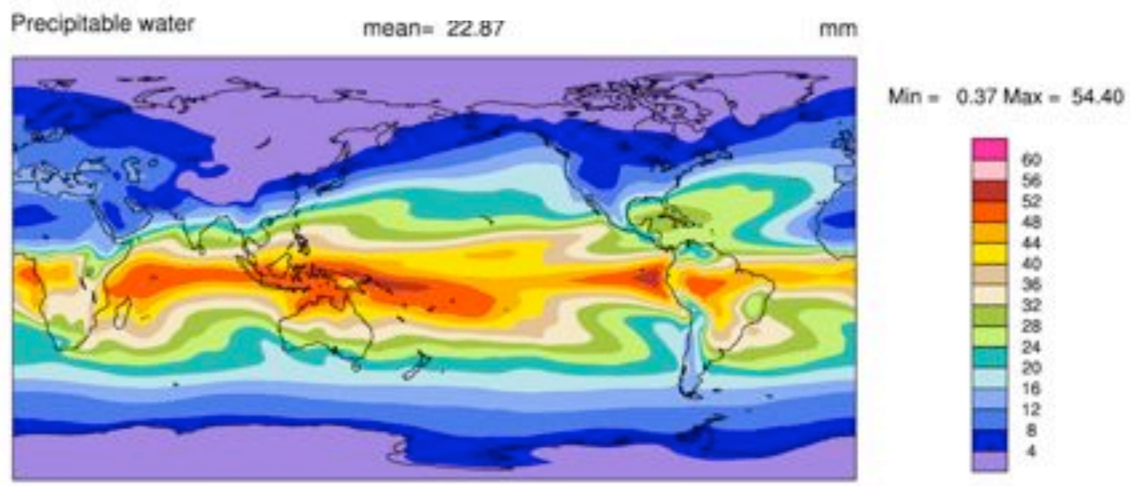

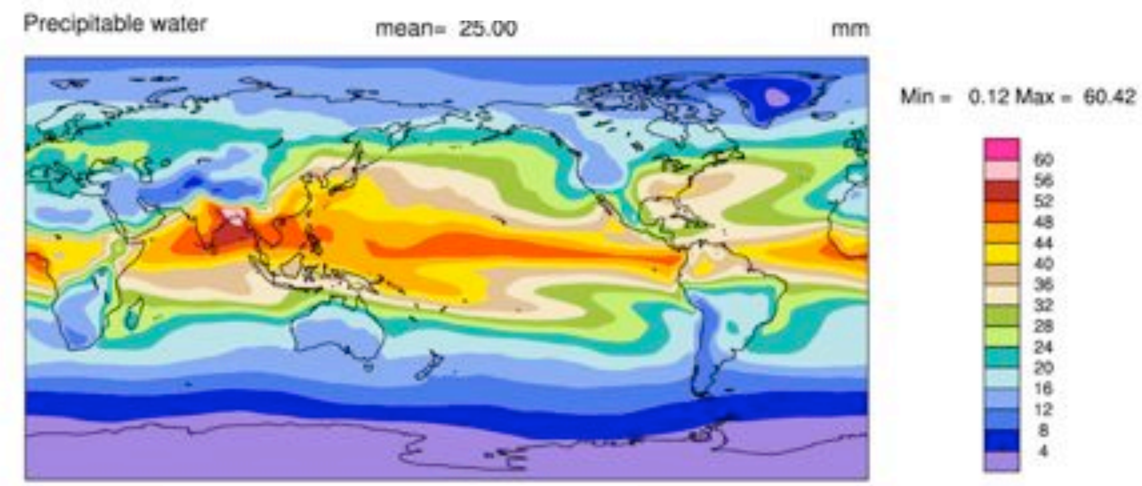

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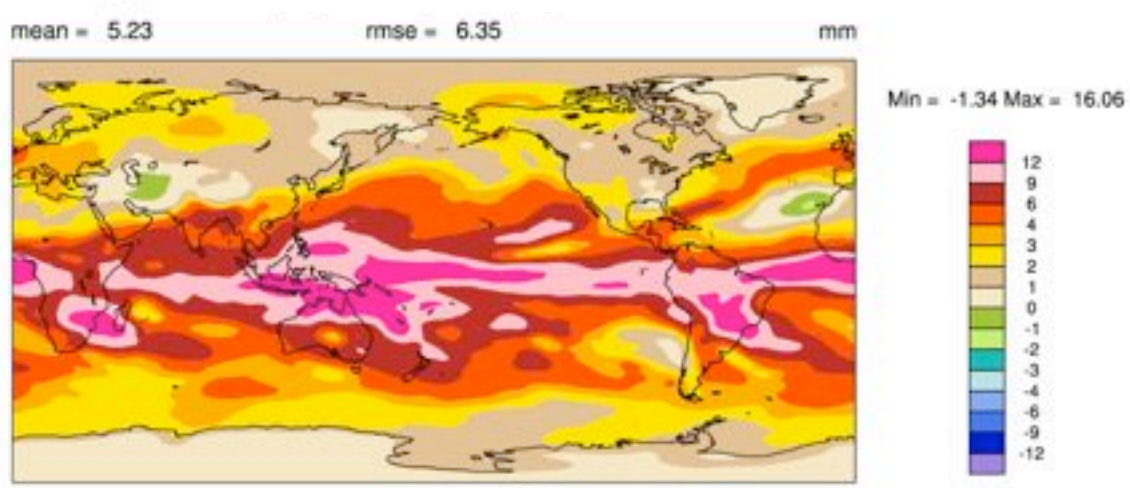
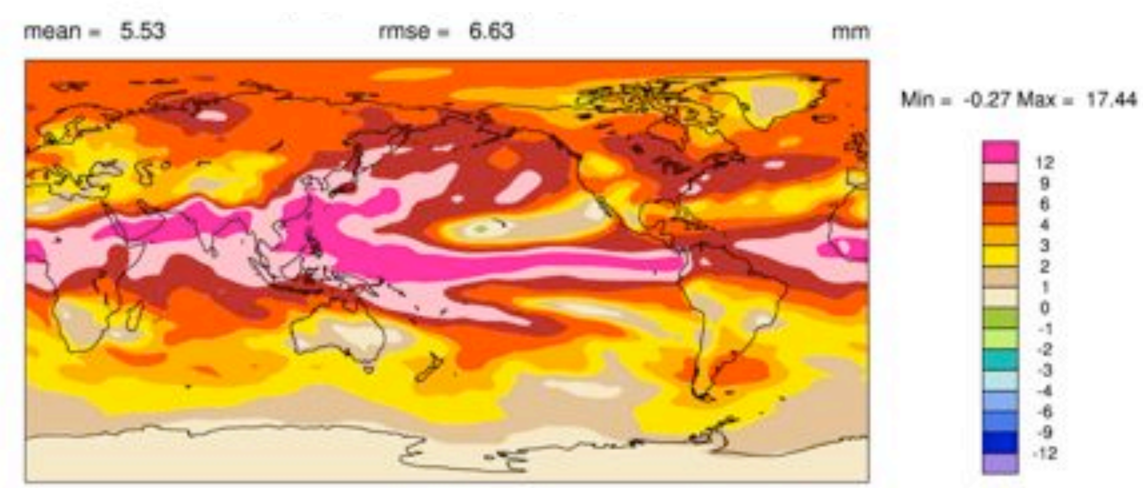
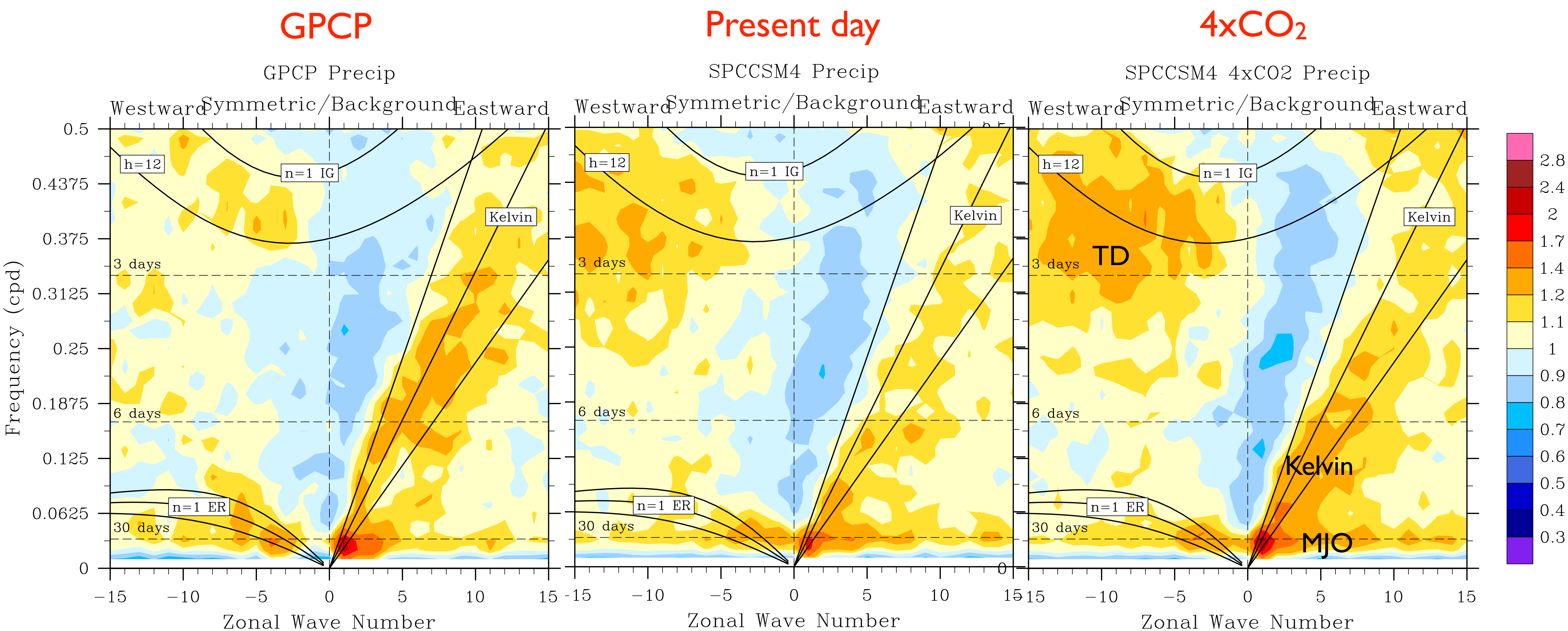


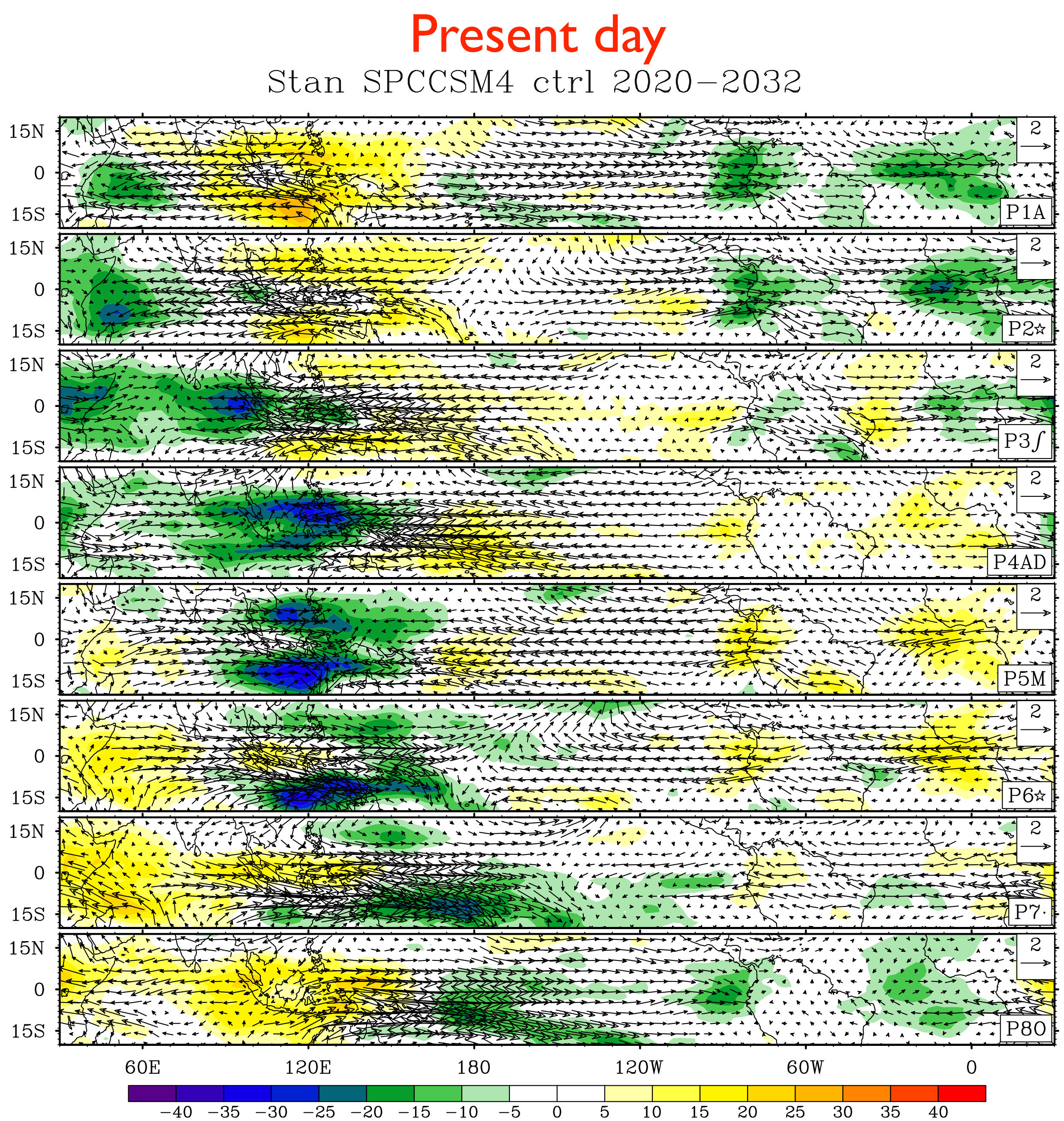


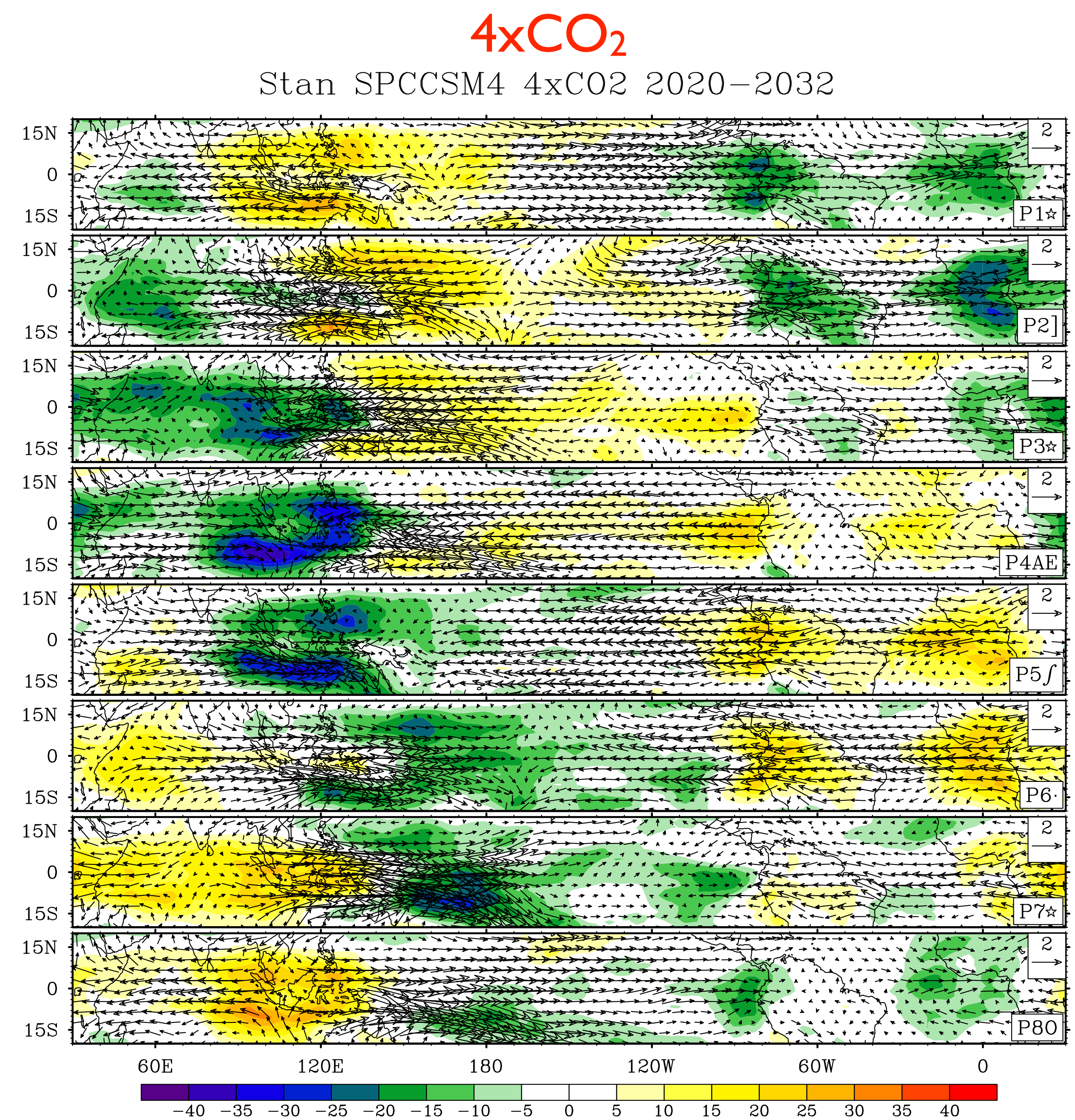


GPCP
Present day
4xCO2
GPCP Precip
SPCCSM4 Precip
SPCCSM4 4xCO2 Precip
Westward
Symmetric/Background
Eastward
Frequency (cpd)
Zonal Wave Number
h=12
n=1 IG
Kelvin
n=1 ER
3 days
6 days
30 days
TD
Kelvin
MJO

More active

Nov - Apr: Wheeler-Hendon index MJO composites

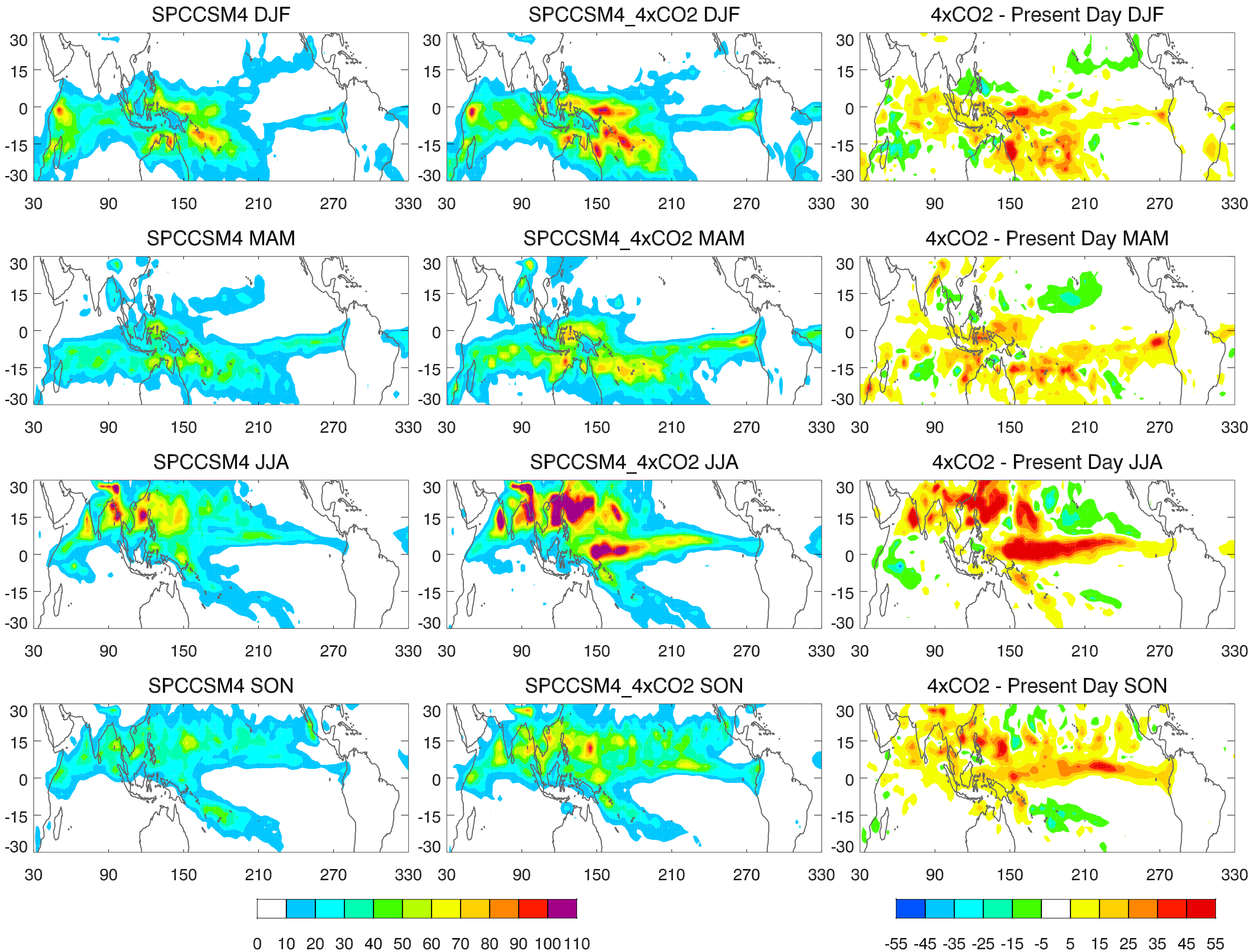




Increased intensity overall
Greater zonal extent of wet and dry sectors
Increased variability over both South America and Africa

Seasonality

Precip Variance, 20 - 100 days, $(mm/day)^2$



Preliminary Conclusions

Changes in intensity	*More intense tropical variability, including MJO power*
Changes in the zonal and meridional scales of the rainy and dry areas	*Increased zonal width*
Changes in the speed of propagation	*Need more simulated years*
Changes in the locations where the MJO has a significant effect on precipitation	*Increased intraseasonal variability over South America and Africa*
Changes in seasonality	*Intensification most noticeable in northern summer*

Ongoing work & future directions

- The simulation discussed here will be extended (work by C. Stan & L. Xu).
- We will make comparisons with results from other CMIP5 4xCO_2 runs.
- A transient climate change simulation is also running, in parallel, led by investigators at CSU and Harvard.
- We will analyze monsoon changes in both simulations (C. DeMott, lead).
- We will analyze changes in the Arctic (E. Tziperman and M. Burt).
- We will analyze global cloud feedbacks, with an emphasis on convection and cirrus.