Understanding future changes in the Southern Annular Mode using perturbation experiments

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Australian Government
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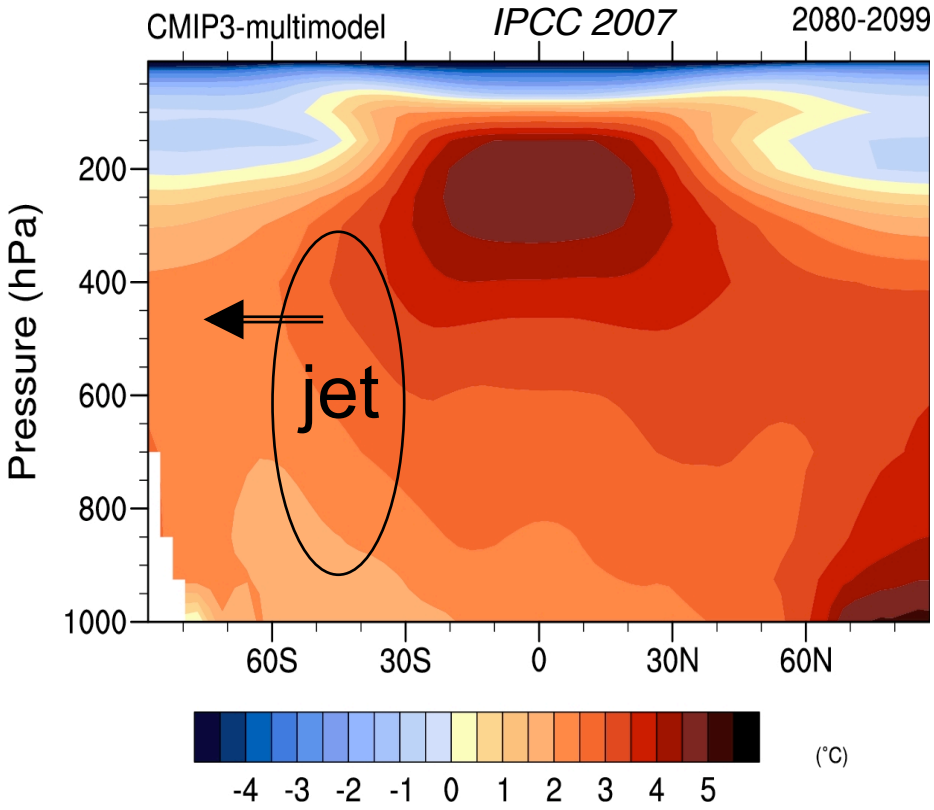
Future change in SH extratropical circulation

Increased EQ-pole temperature gradient → positive Southern Annular Mode (SAM) trend



Future change in SH extratropical circulation

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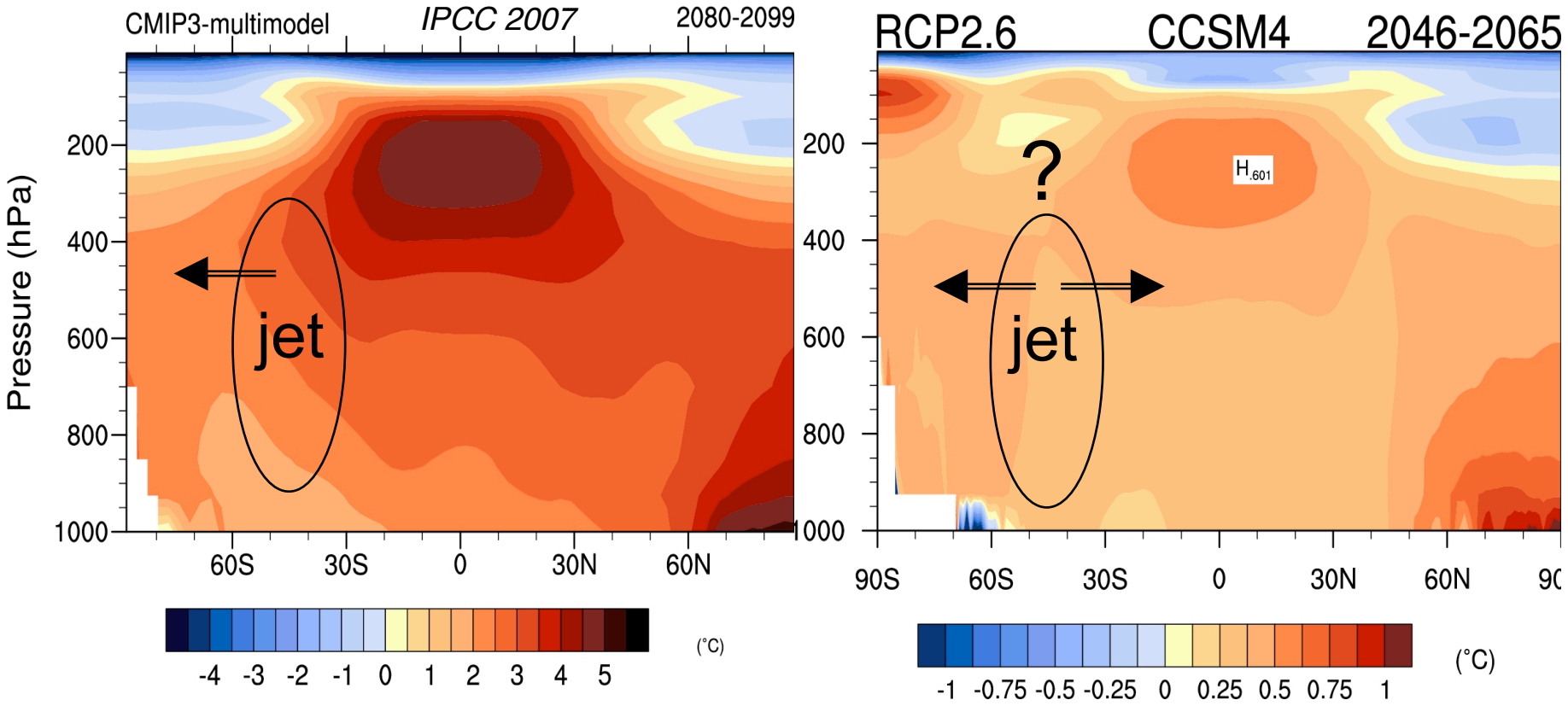
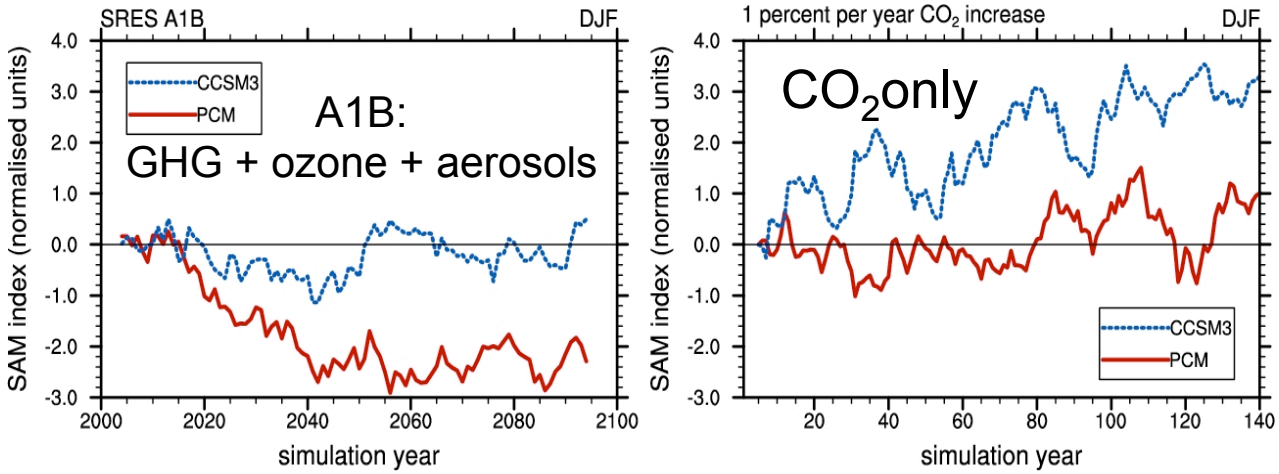


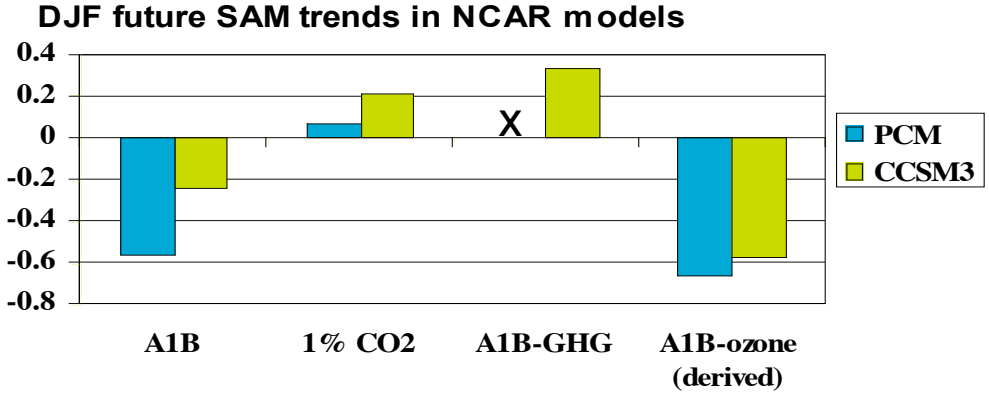
Future SAM changes in NCAR coupled runs

Investigated two coupled models with identical forcings

SAM timeseries = difference in zonal mean sea level pressure between 40S and 65S (Marshall, 2003)



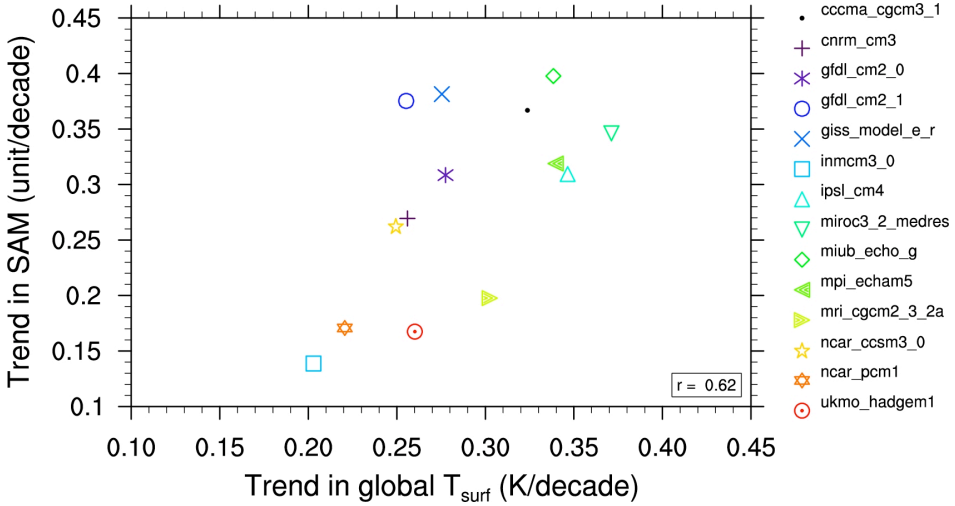
Climate sensitivity plays a strong role in the variation in SAM trends between the two models



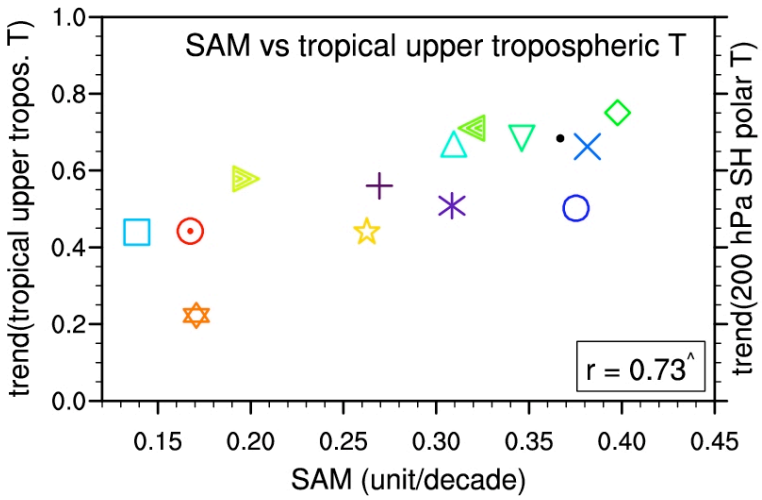
Arblaster, Meehl, Karoly GRL 2011

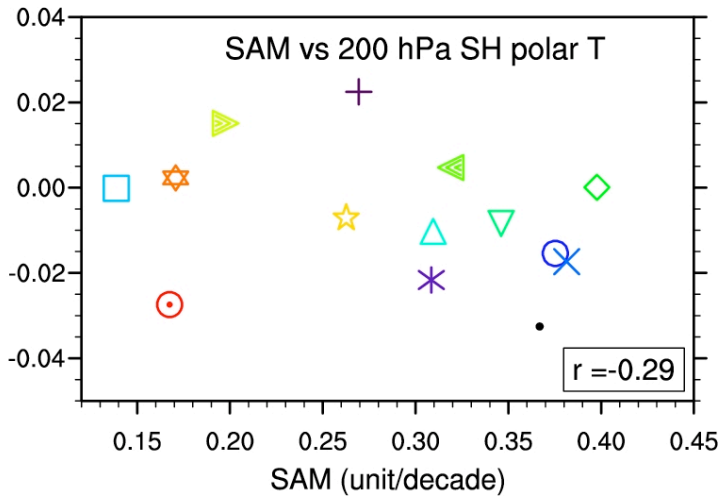
Relationship of SAM trend to warming in CMIP3 1% runs

Magnitude of future SAM trend strongly related to climate sensitivity



Intermodel spread of SAM trends is strongly correlated with strength of global surface temperature trends



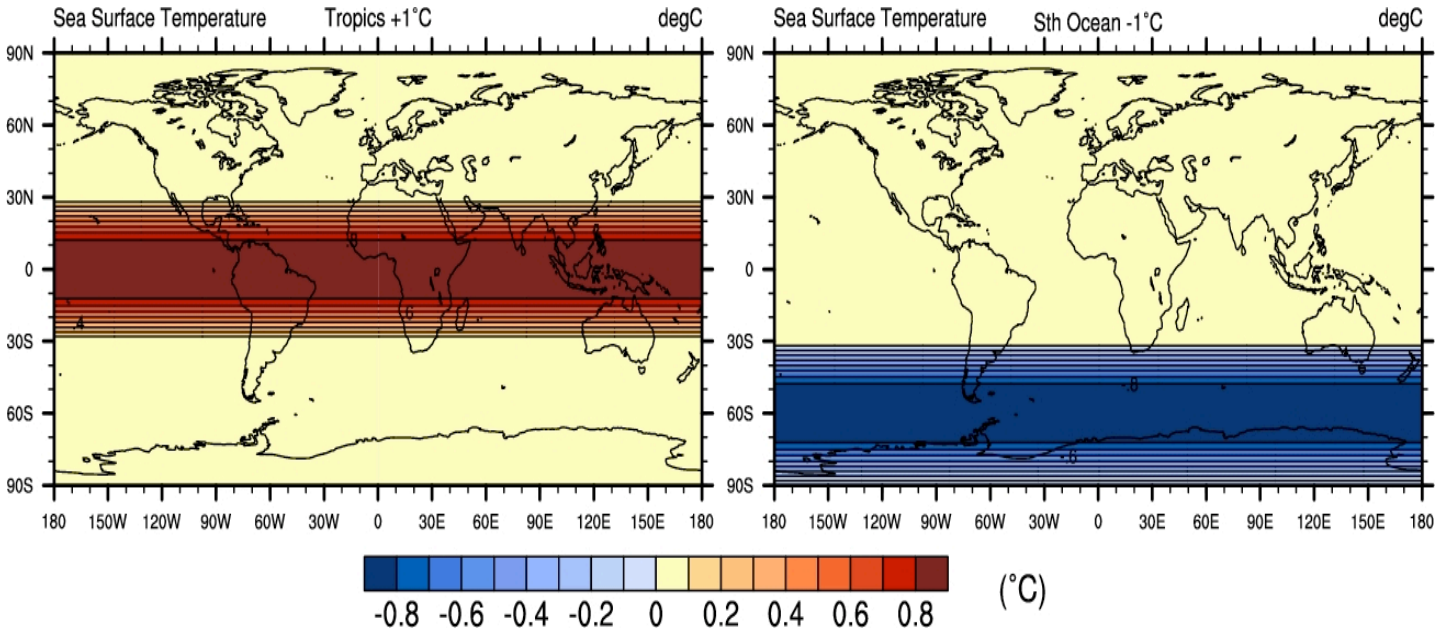


Arblaster, Meehl, Karoly GRL 2011

AGCM perturbation experiments

ACCESS & NCAR CAM4 perturbation experiments

control	Control run with repeating climatological SST
TO+1	Climatological SST + 1°C in tropics
SO-1	Climatological SST - 1°C in Southern Ocean



Complementary to simple model experiments and extending work by Marshall & Connelley (2006)

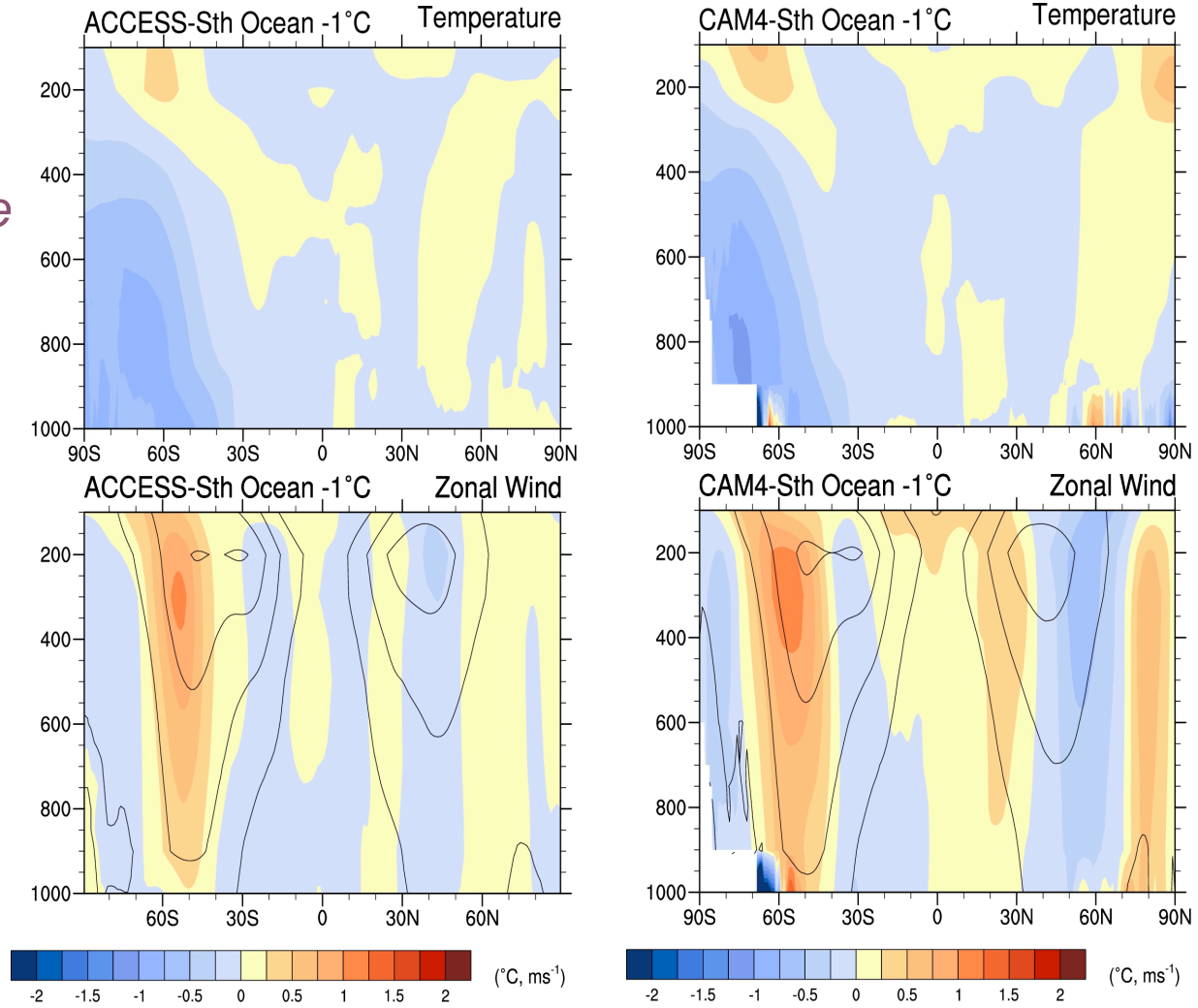
Southern Ocean -1°C perturbation experiments

ACCESS

CAM4

Zonal temperature

Zonal wind



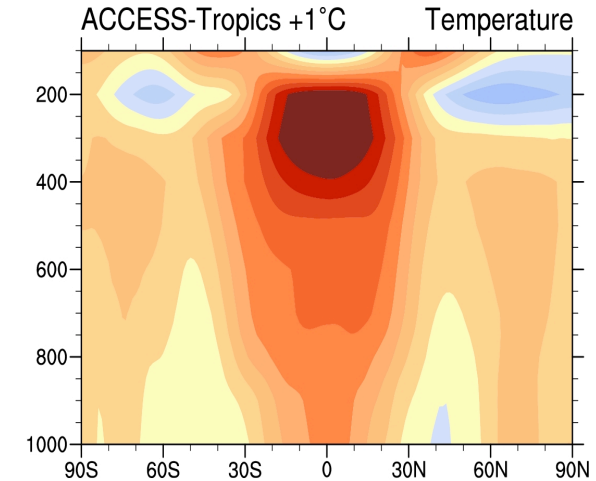
Tropics + 1°C perturbation experiments

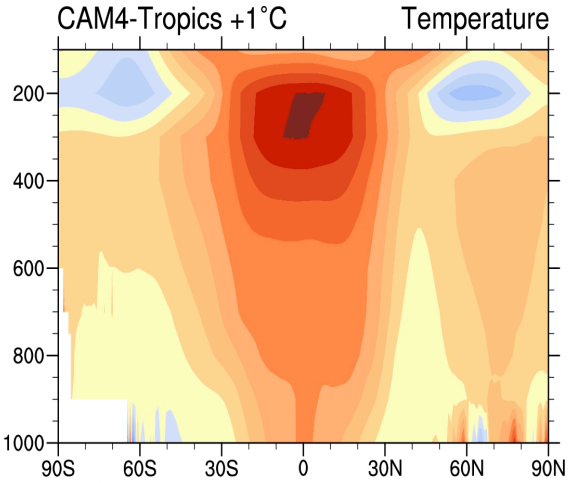
ACCESS

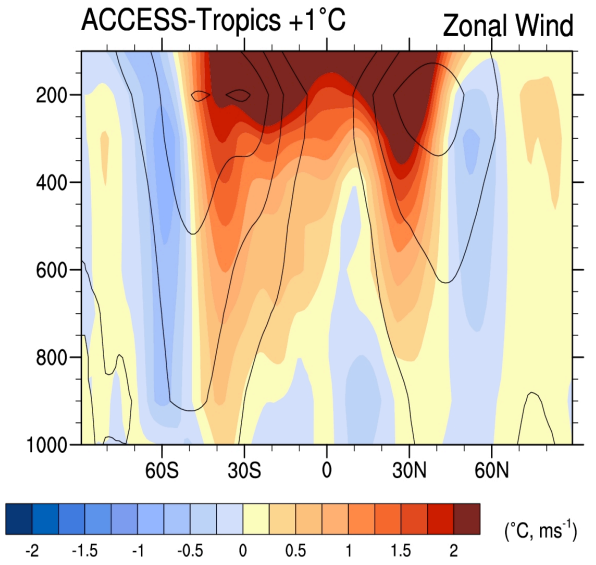
CAM4

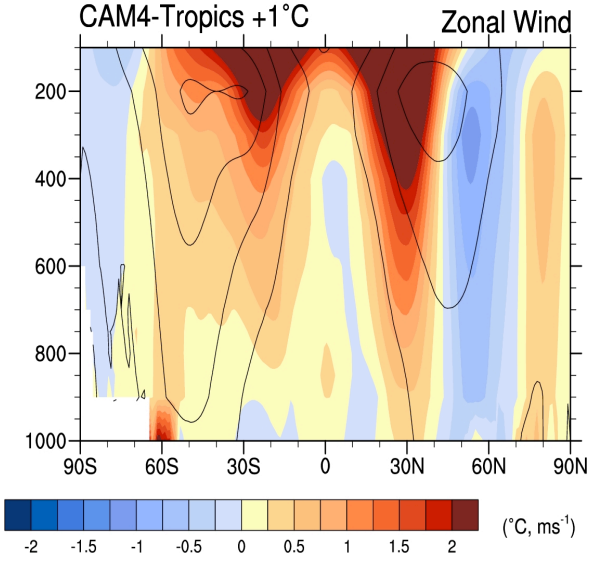
Zonal temperature

Zonal wind

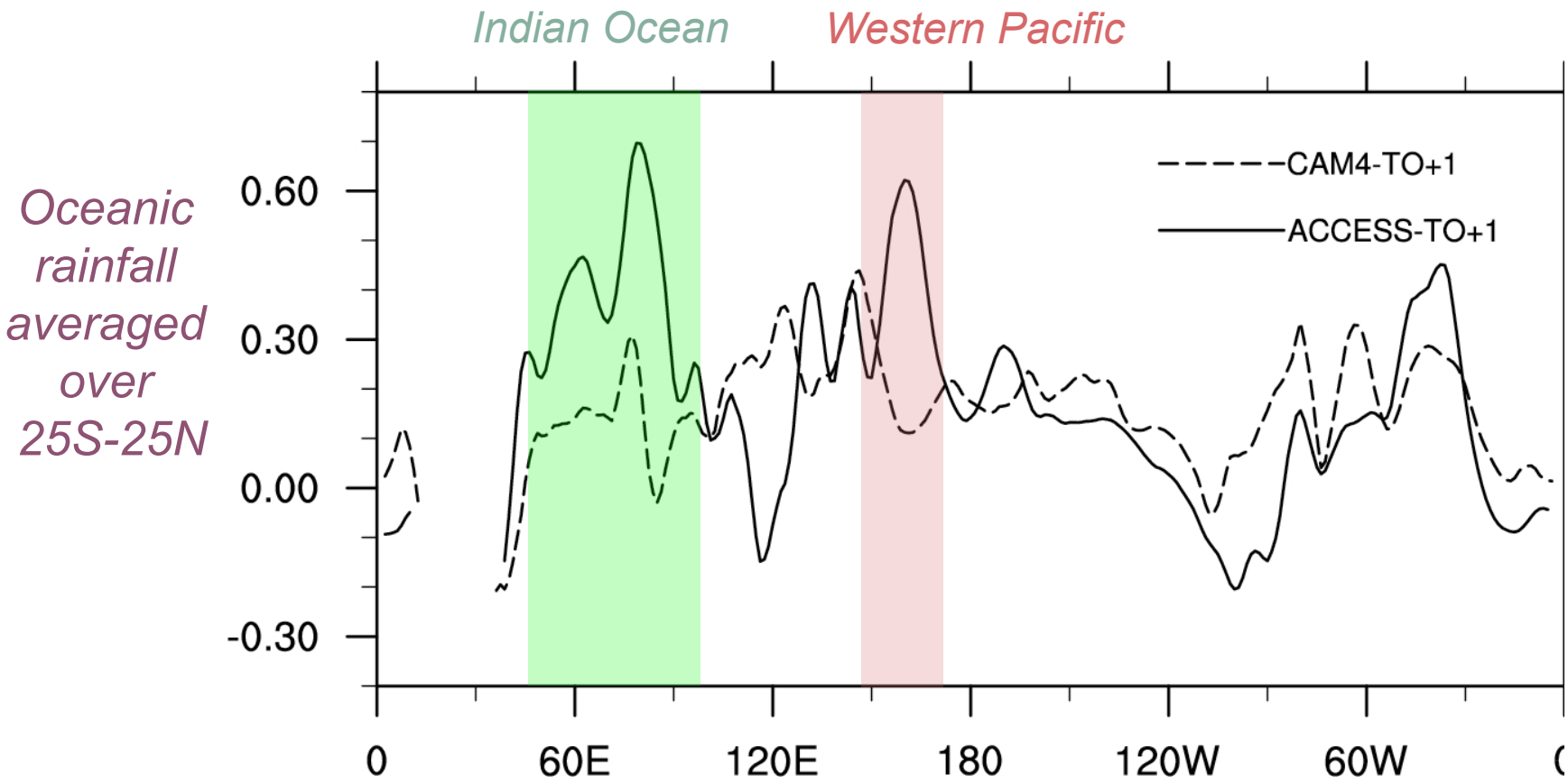








Tropics+1°C perturbation experiments: rainfall



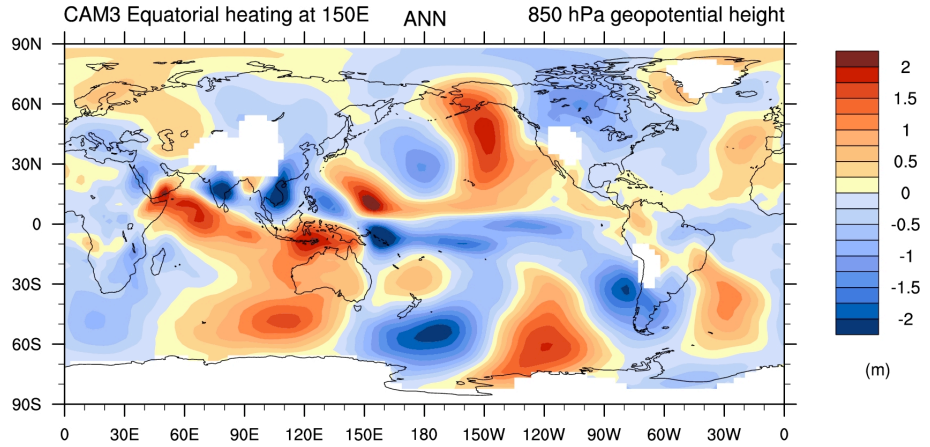
ACCESS model has more tropical rainfall over Indian Ocean and Western Pacific compared to CAM4

Atmospheric heating perturbation experiments

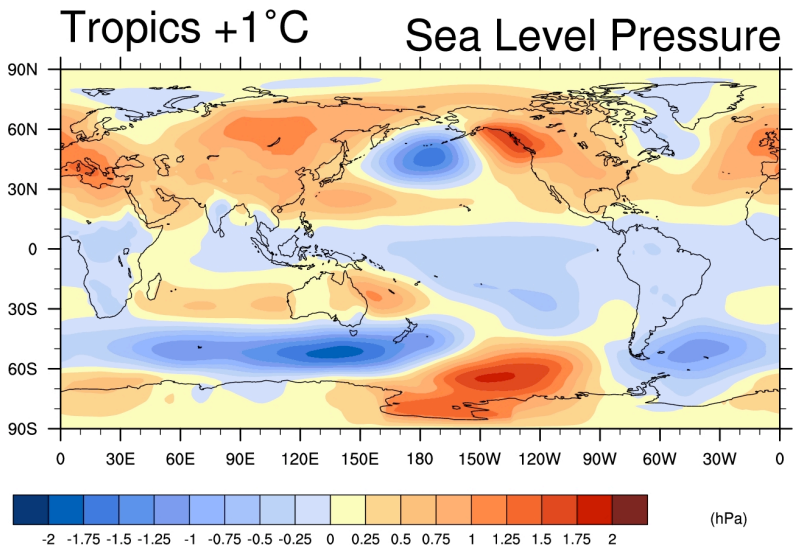
Convective heating in equatorial regions creates a wave-train response over the SH extratropics

Courtesy: Grant Branstator and Andy Mai

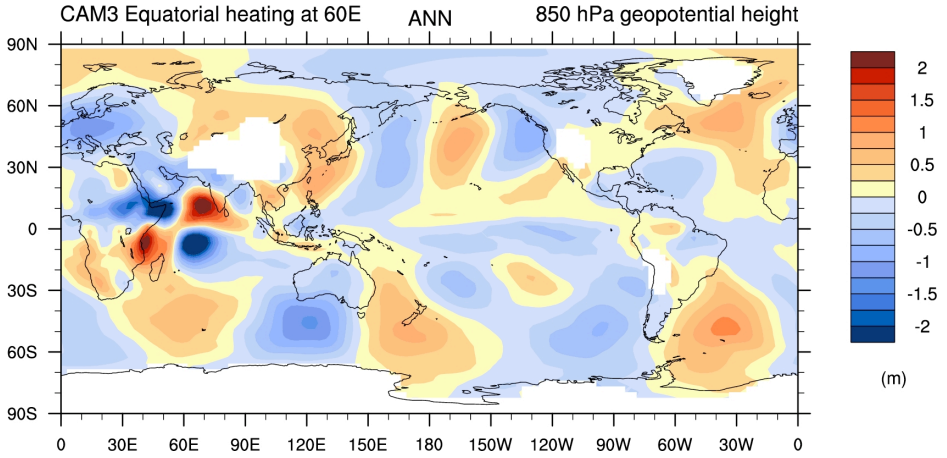
Atmospheric heating at 150E, EQ



ACCESS



Atmospheric heating at 60E, EQ

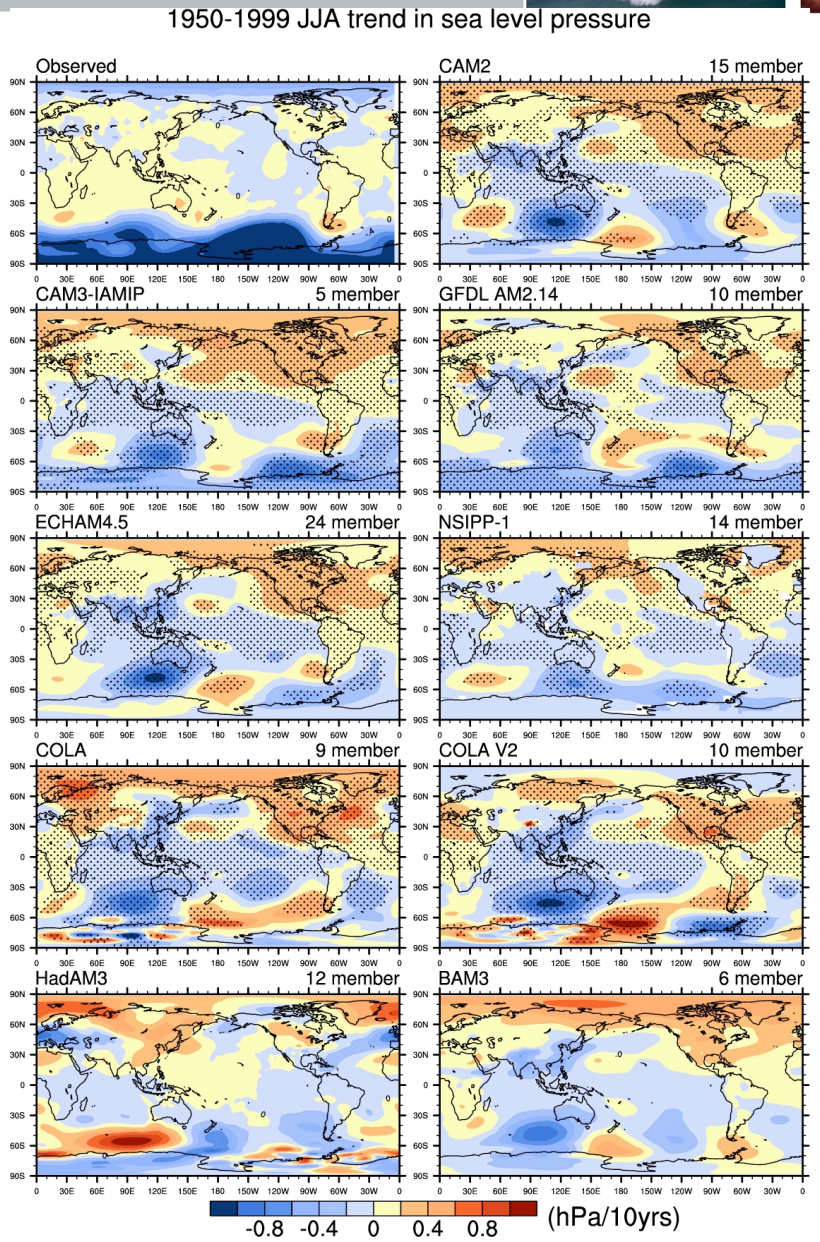


Systematic bias in rainfall & SLP trends in SST-forced runs

Similar wave-train response found in experiments forced with observed changes in SSTs

=>

model biases or bad framework?



Conclusions

SAM trends strongly correlated with climate sensitivity and upper tropospheric warming in CMIP3 models

=> the larger the warming, the larger the trend in the SAM

Response of the SH extratropics to increased tropical SSTs is model dependent

=> opposite shifts in the jet found between two models

Difference in response is linked to different rainfall and convective atmospheric heating response to identical SSTs

Next steps

Motivation is to understand the response of coupled models to warming

Additional experiments planned:

- *Use tropical diabatic heating from the coupled experiments to force the AGCMs*
- *replace climatological SSTs with a slab ocean model to assess the role of coupling*

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Thank you

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