

Will surface winds weaken in response to global warming?

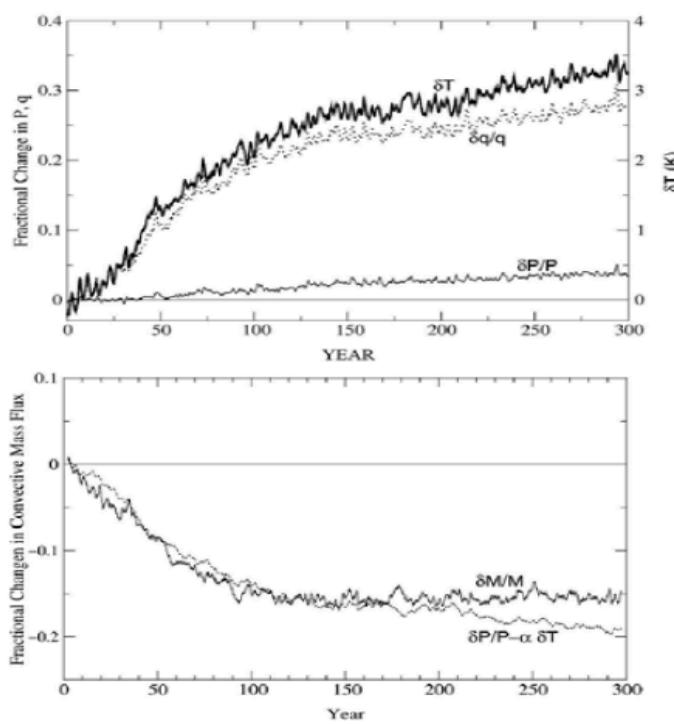
- Near-zero change but 2% K^{-1} precipitation rate
- Mean advection of stratification change
- SST pattern change

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NOAA/AOML/PhOD, UM/RSMAS/CIMAS

Tropical Circulation Slow-down



Held & Soden (2006, JC)

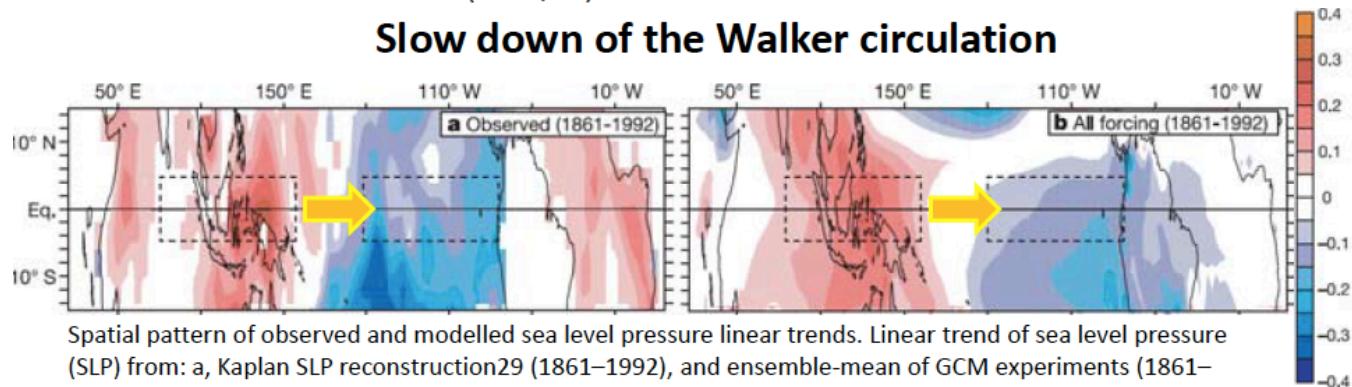
Changes in global-mean temp,
humidity & precipitation

Implications from changes in hydrological cycle

P = precipitation
M = convective mass flux
q = specific humidity

$$P = M \bullet q$$

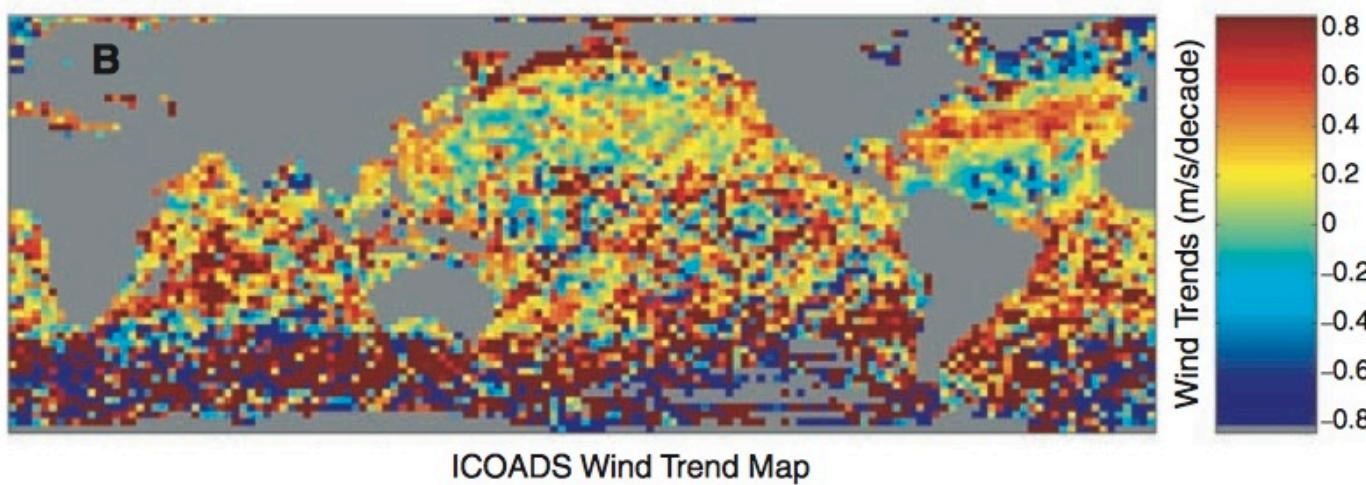
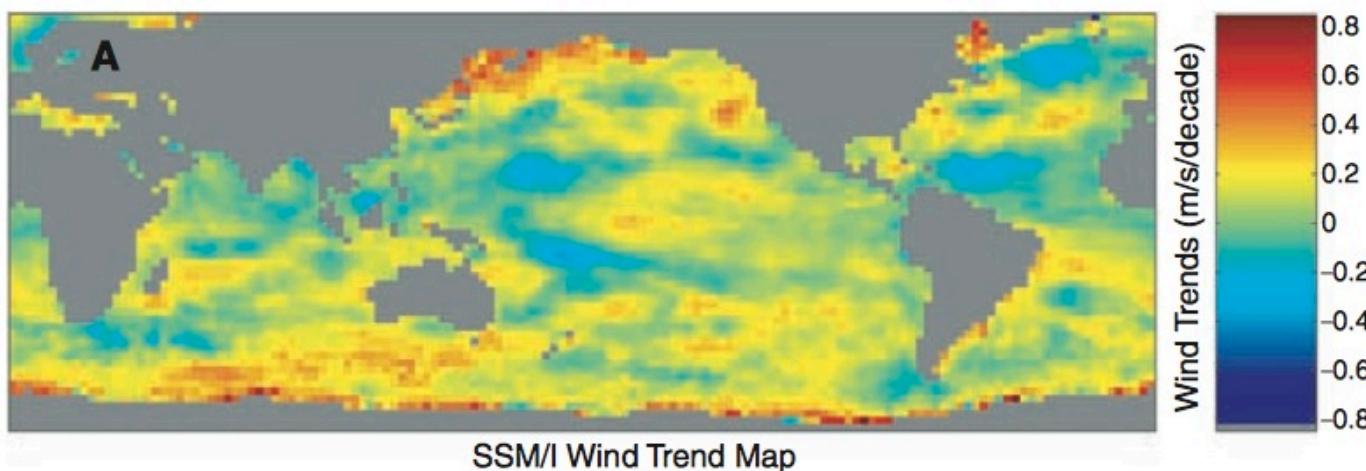
$\delta M/M = \delta P/P - \delta q/q$
 $\delta P/P \sim 2\%/\text{K}$
 $\Delta q/q \sim 7\%/\text{K}$
 $\Rightarrow M \text{ has to decrease by } 5\%/\text{K}$
 $\Rightarrow \text{tropical circulation slows down}$



Vecchi et al. (2006, Nature)

Surface Wind Enhancement?

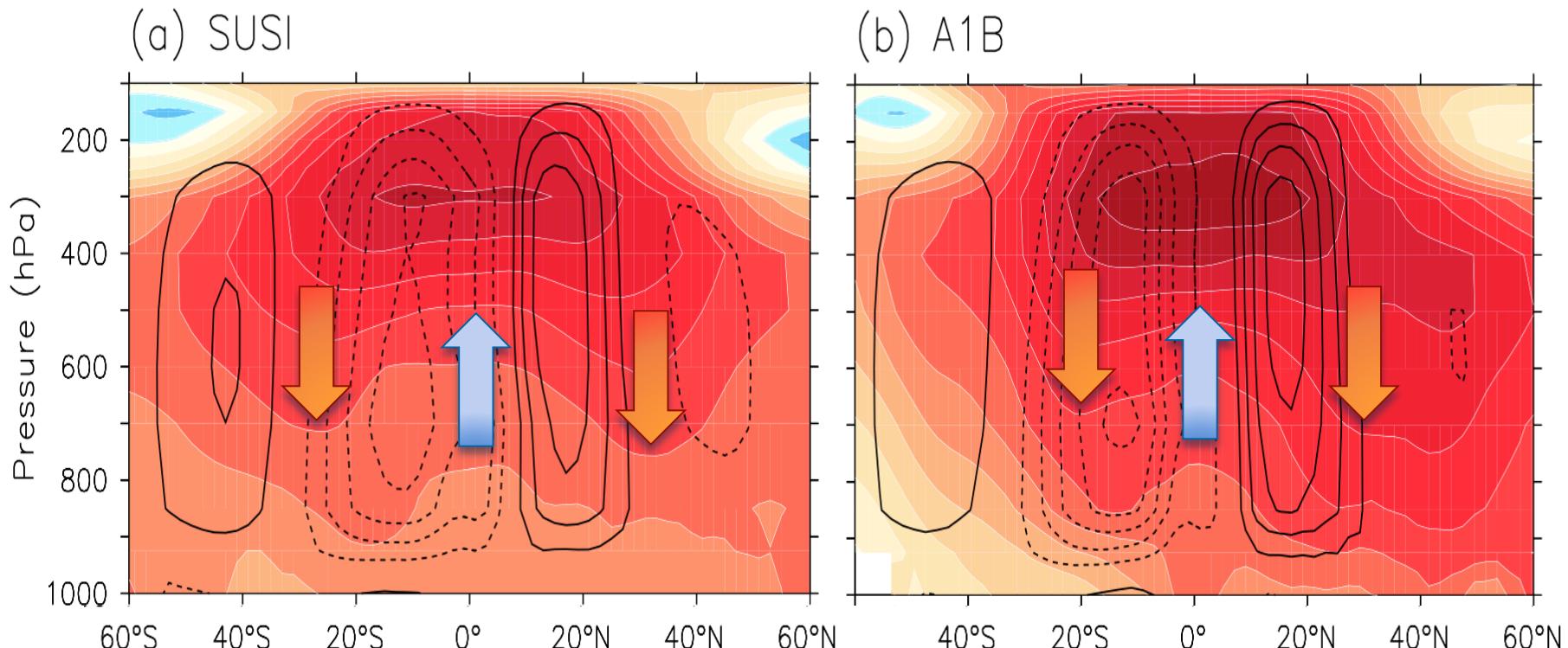
- Satellite measurements



- Wind speed: 5% (global) & 3% (tropical) $\pm 3.5\% \text{ K}^{-1}$
- Precipitation: $6\% \pm 2.5\% \text{ K}^{-1}$

Mean Advection of Stratification Change (MASC)

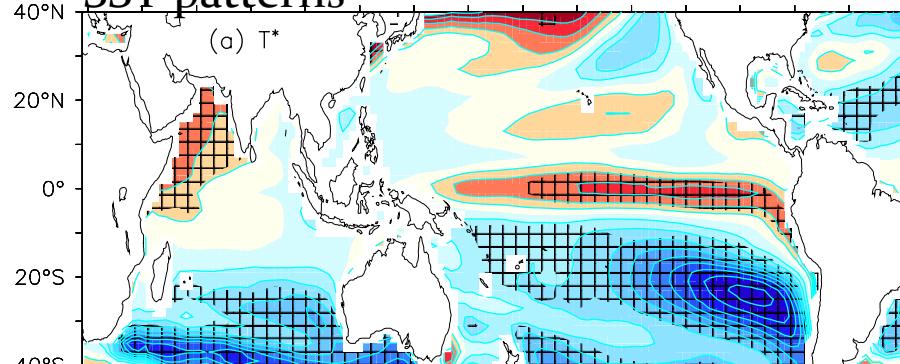
Zonal-mean tropospheric warming (color)
climatological stream function (contour)



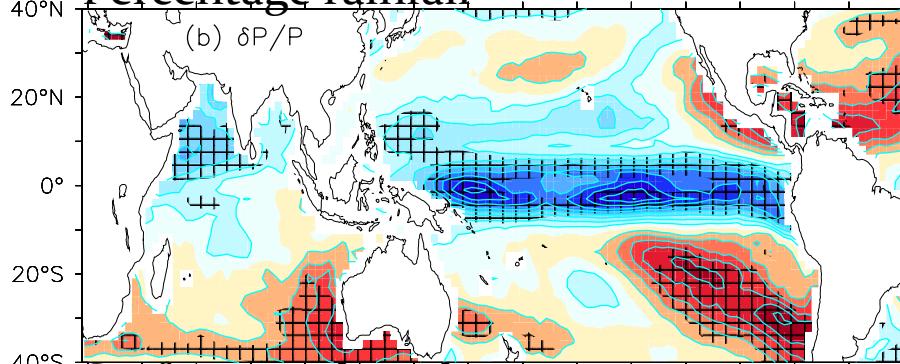
Correlation between warming profiles: 0.91

CMIP3 A1B Ensemble Mean

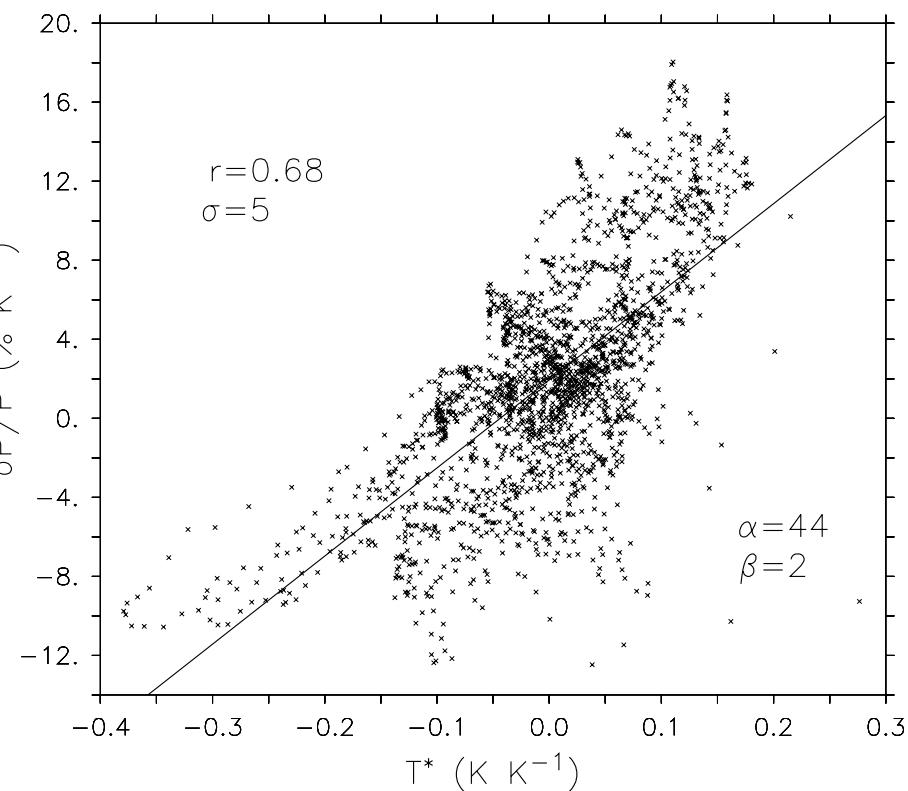
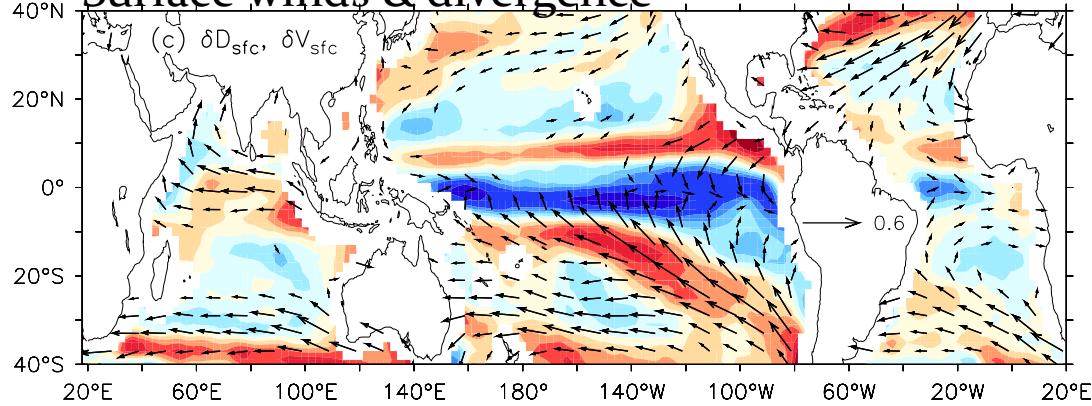
SST patterns



Percentage rainfall



Surface winds & divergence

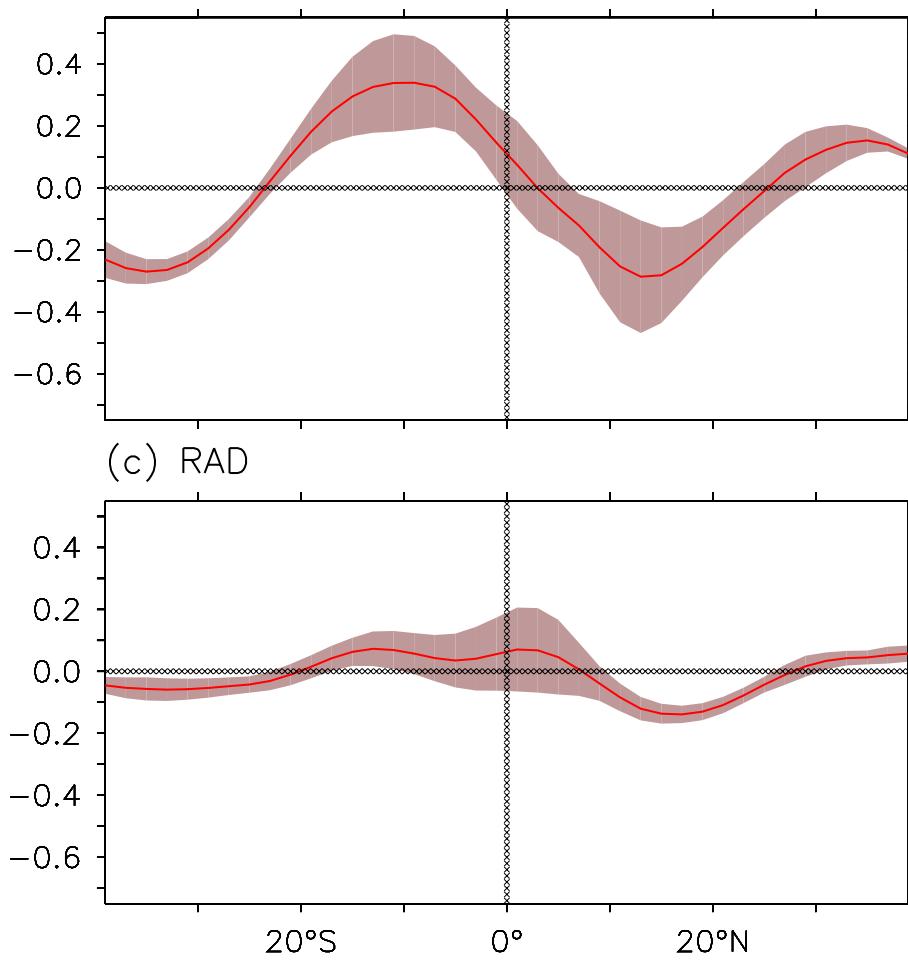


$$\delta P/P = \alpha T^* + \beta \bar{T}$$

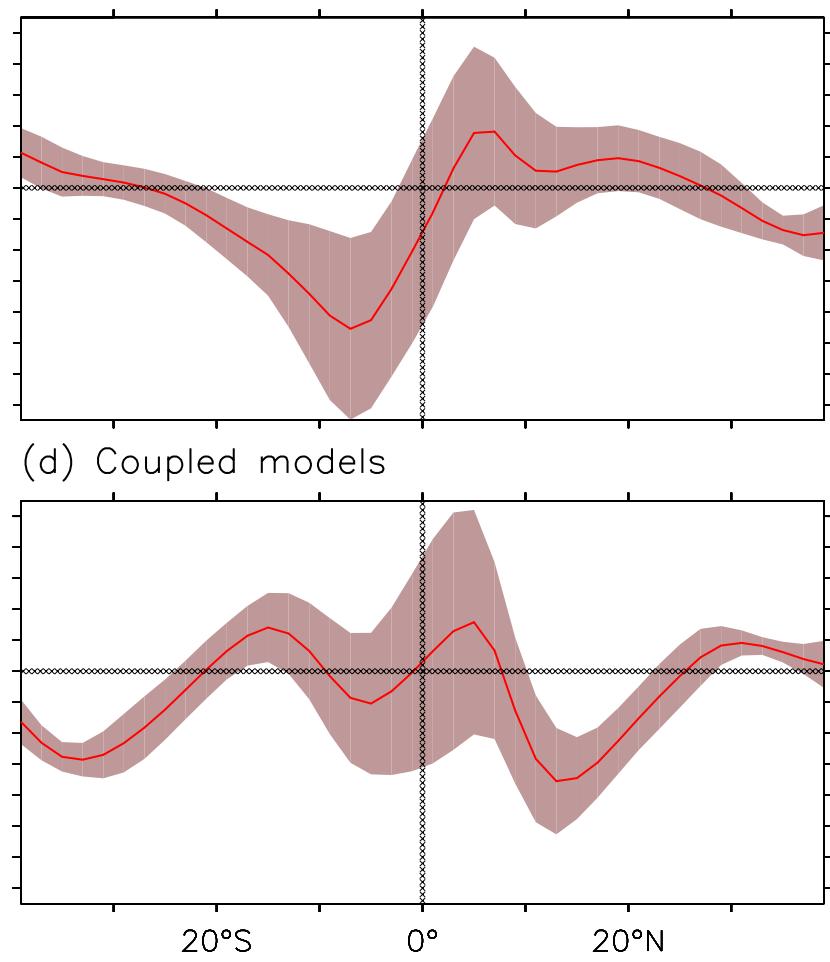
$$\begin{aligned}\alpha &= 44 \text{ \% K}^{-1} \\ \alpha_0 &= 7 \text{ \% K}^{-1} \\ \alpha &>> \alpha_0\end{aligned}$$

Robustness: Hadley Circulation

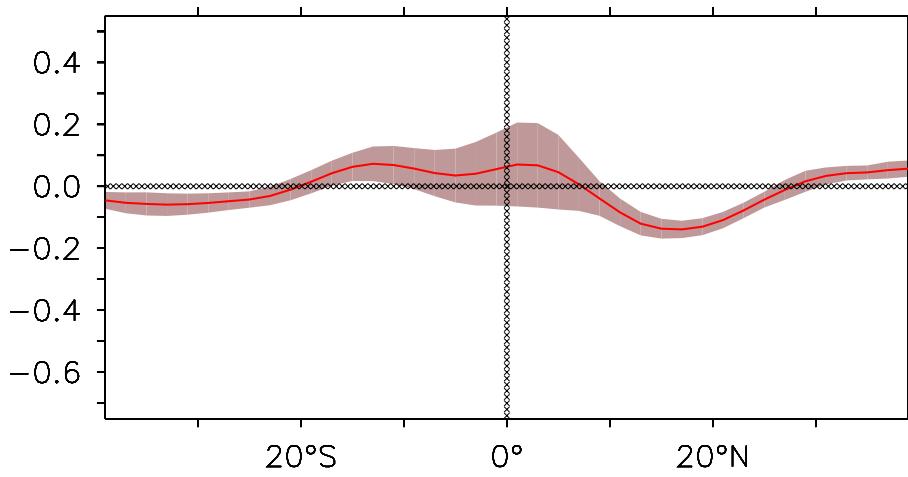
(a) SUSI



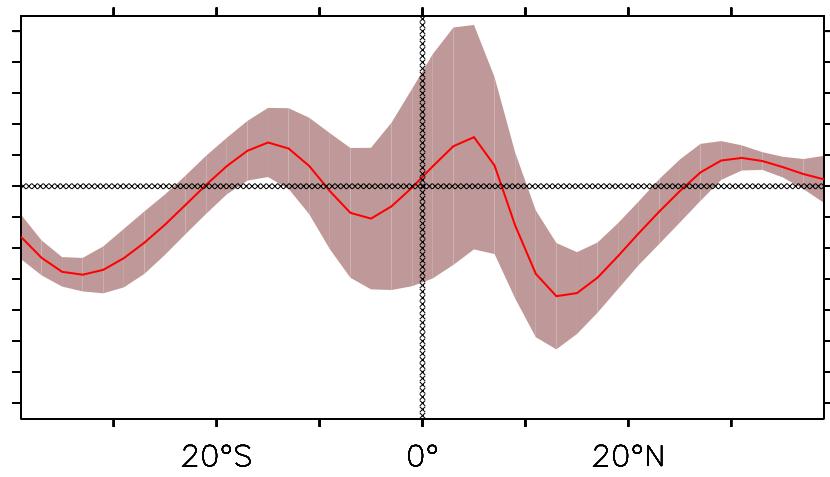
(b) SST



(c) RAD



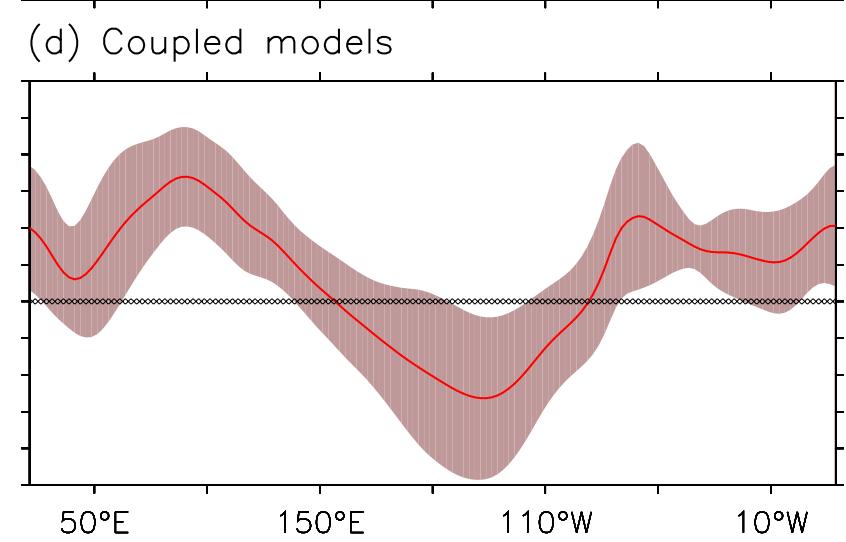
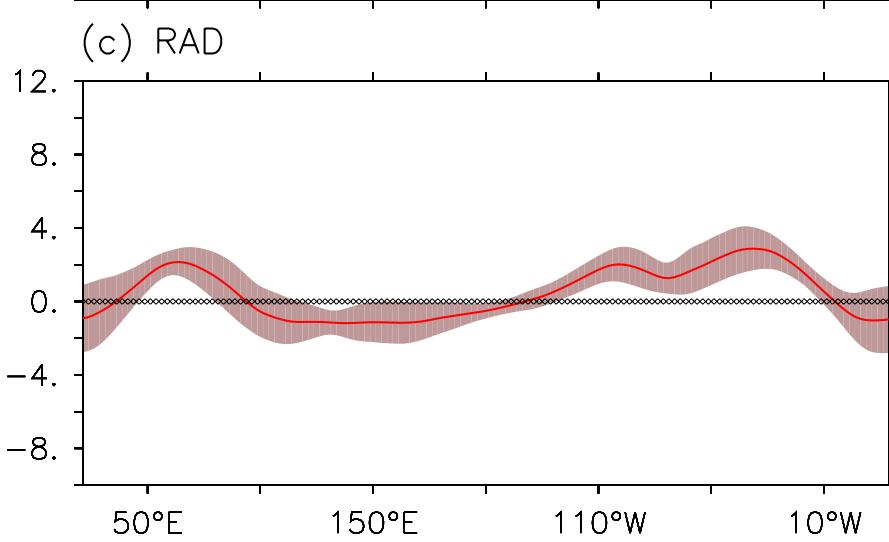
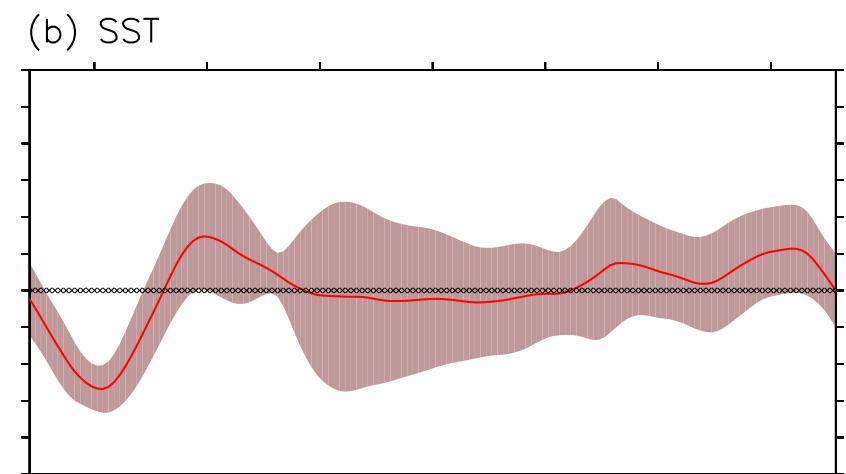
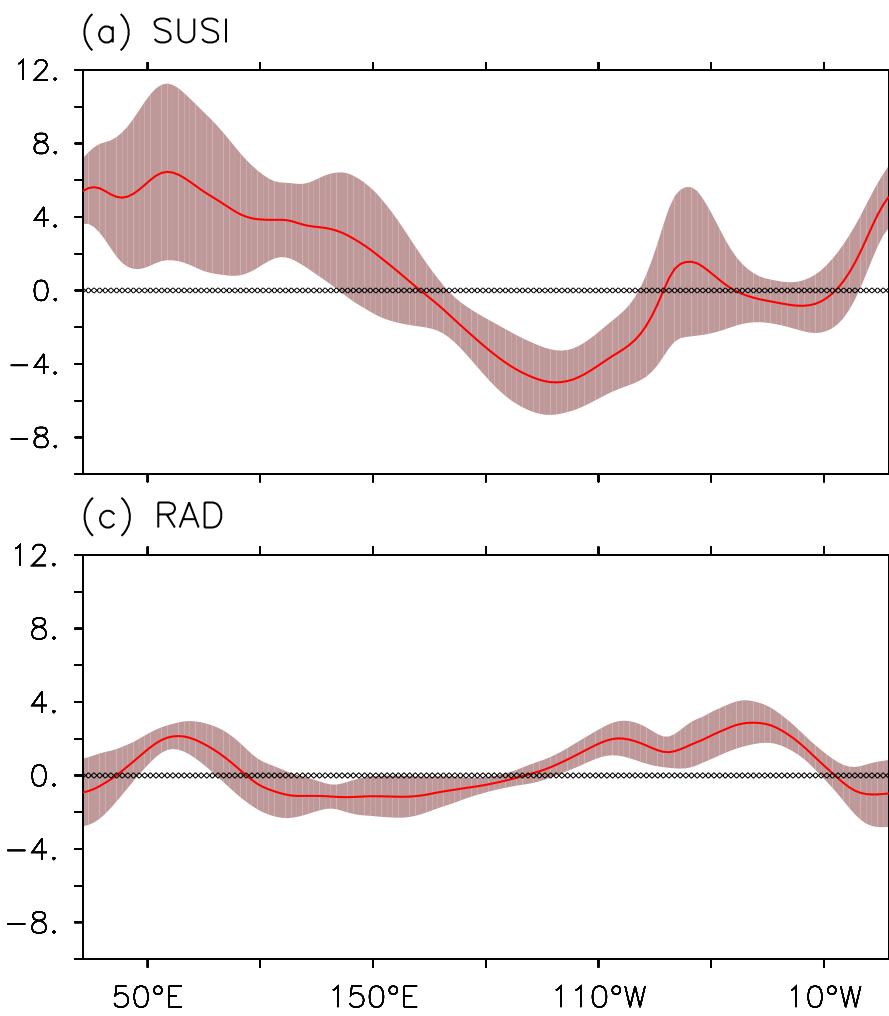
(d) Coupled models



• 500-hPa stream function

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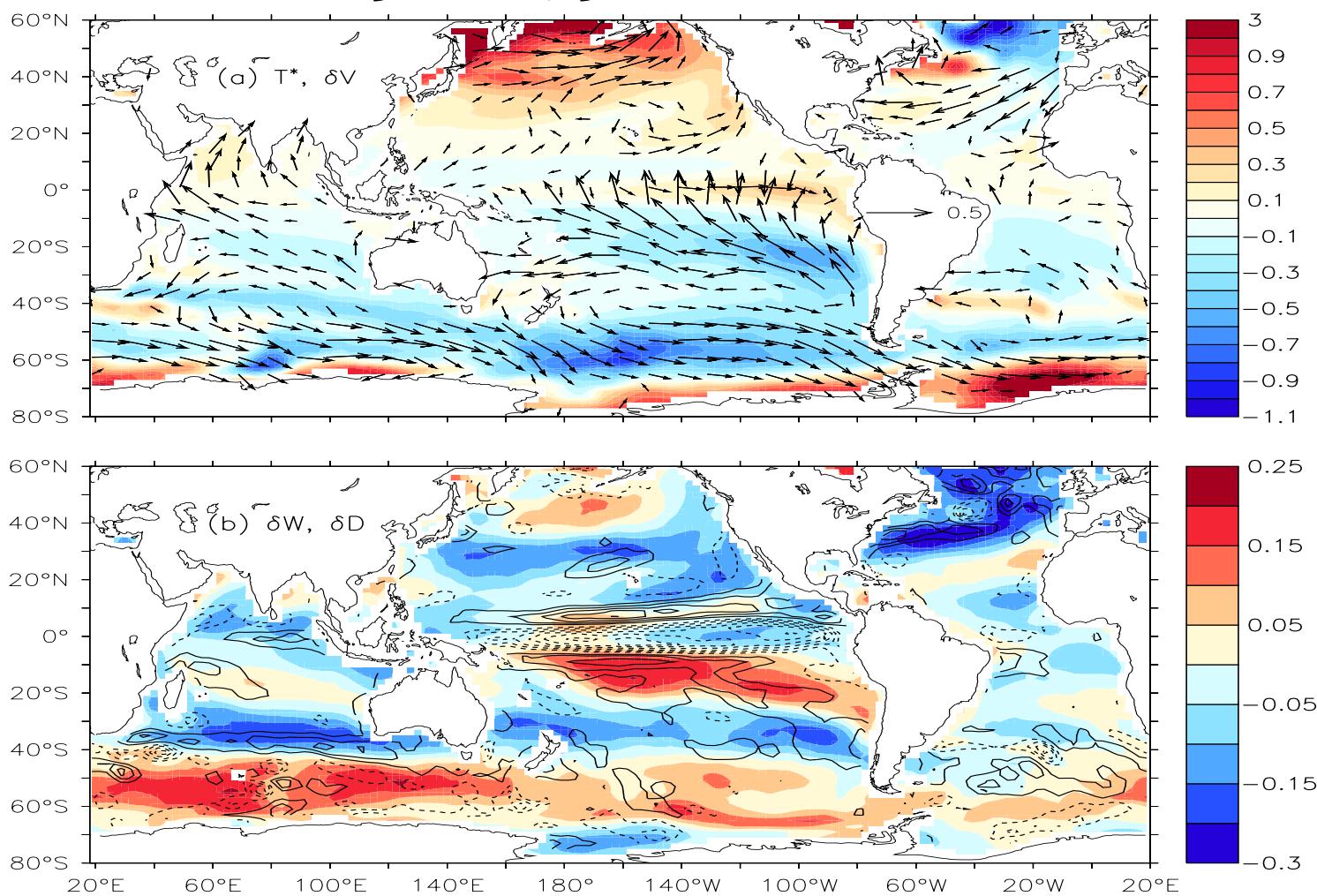
Robustness: Walker Circulation



● 250-hPa velocity potential

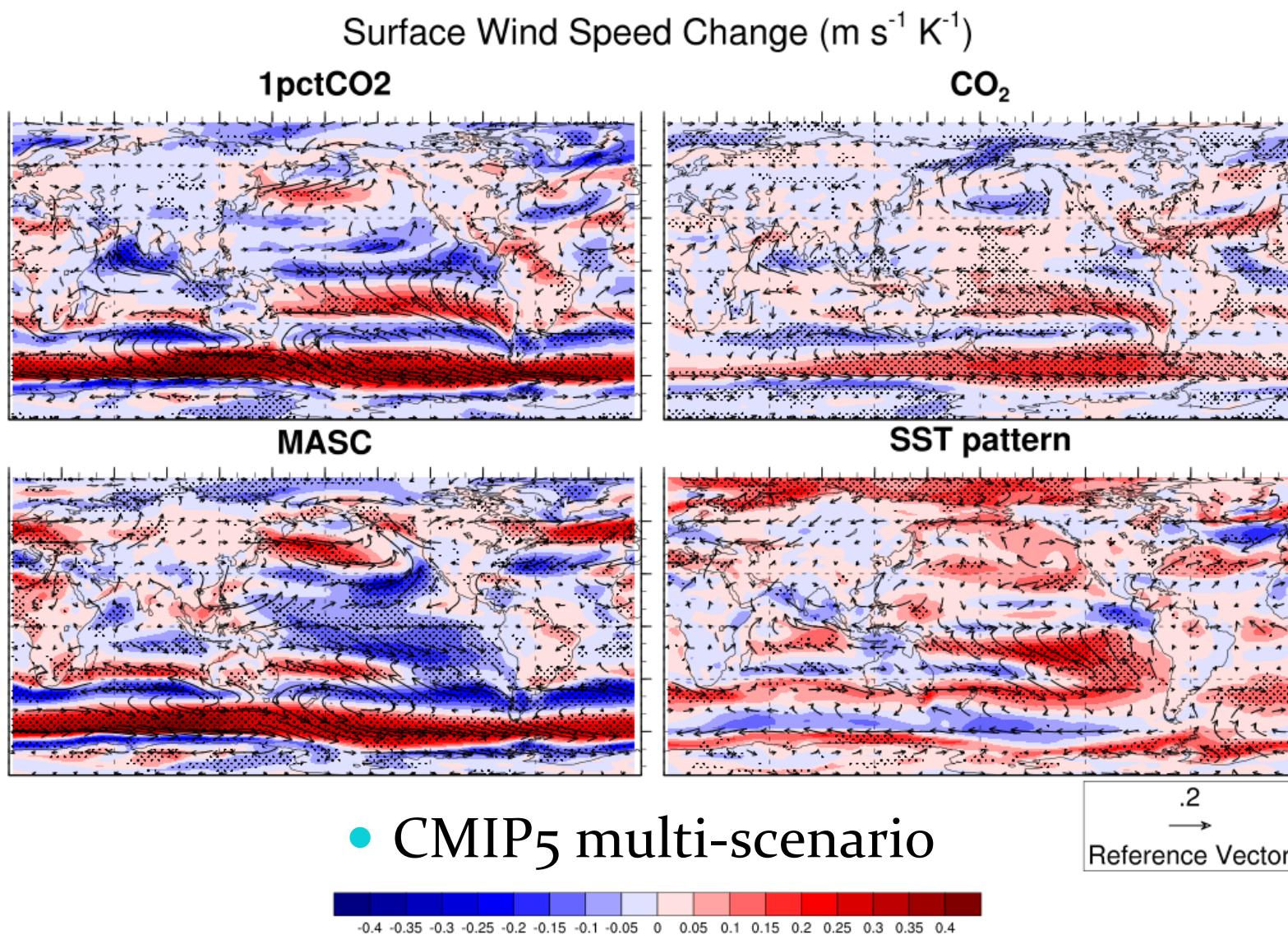
Sfc Wind: Speed & Divergence

• CMIP5 RCP4.5

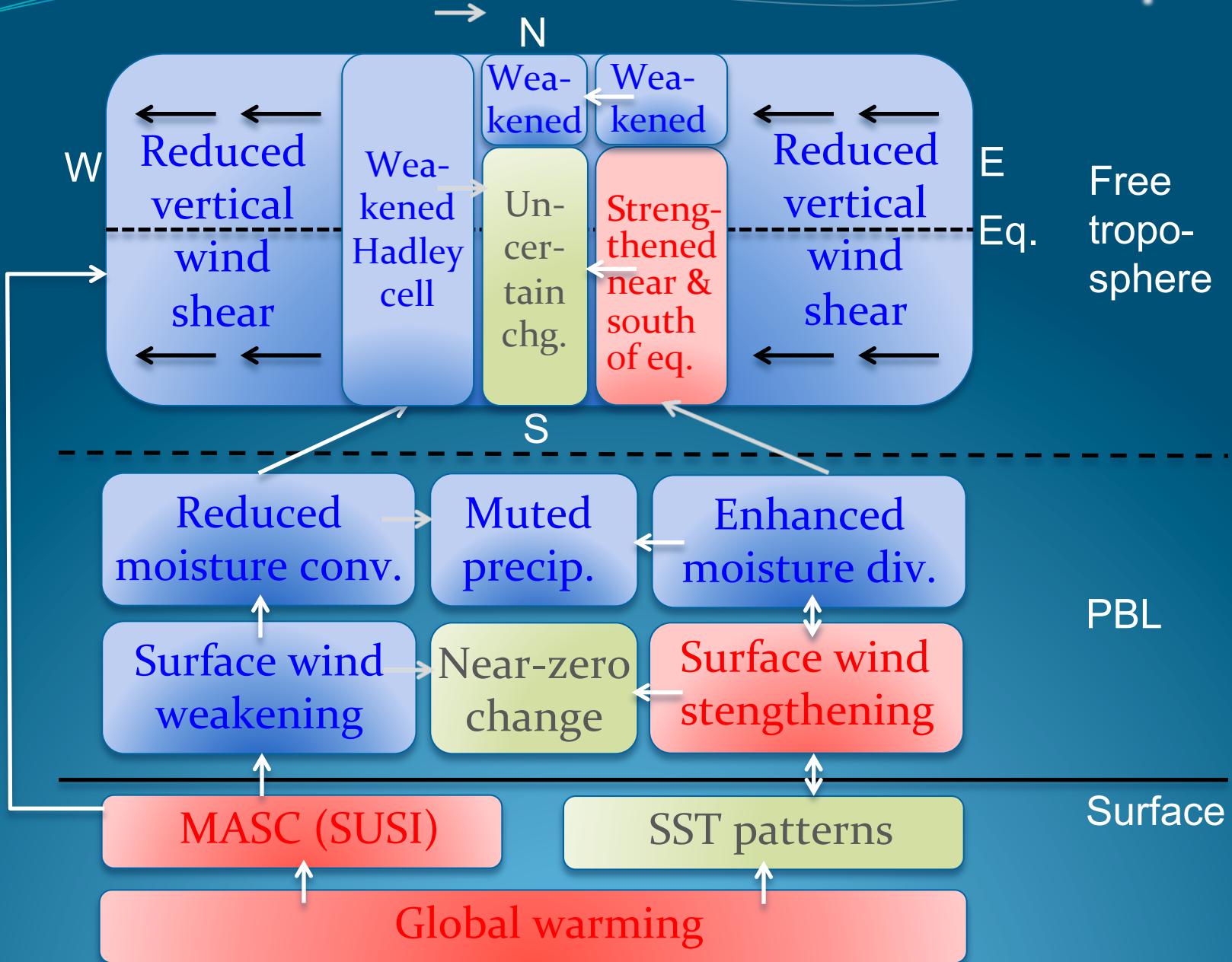


- Wind speed: $-0.2\% \pm 0.4\% \text{ K}^{-1}$
- Speed & divergence: 0.33

Surface Wind Speed: Factors

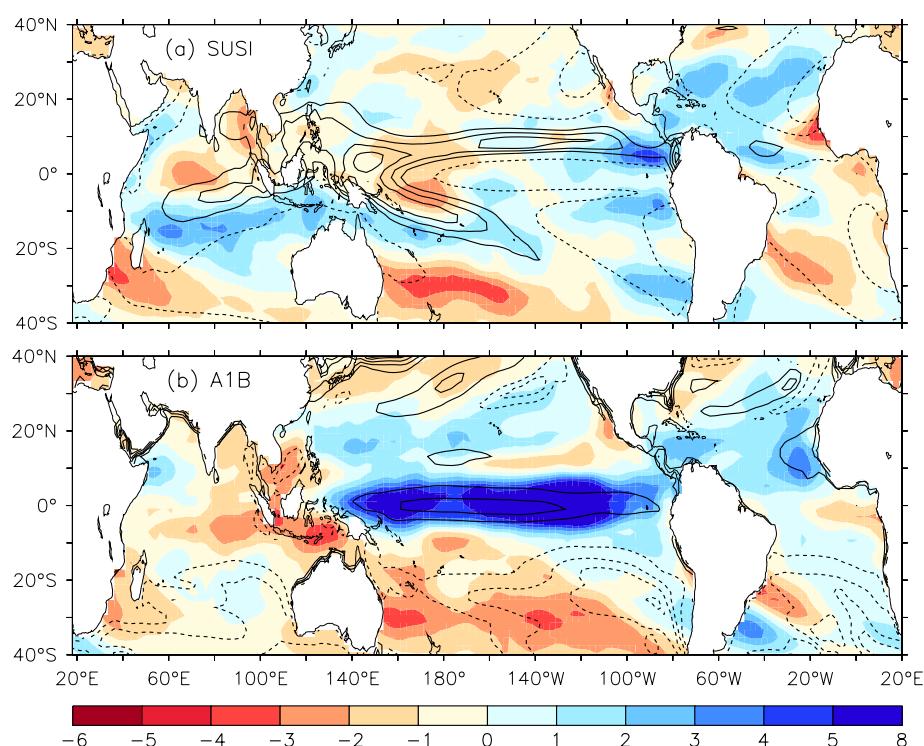


Mechanisms: Wind & Precip

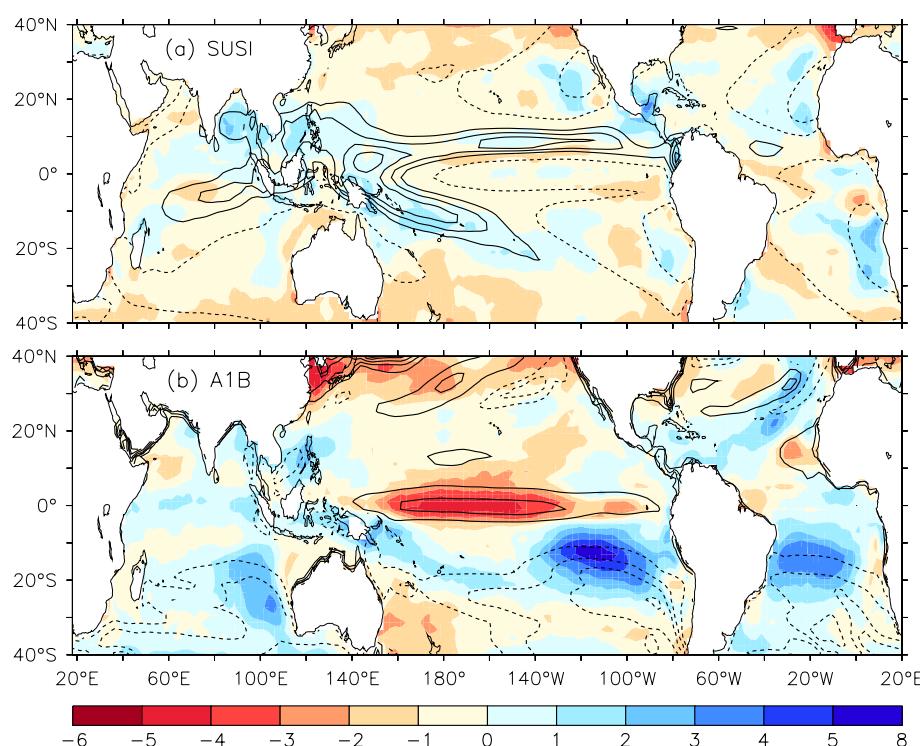


Future Work

- High cloud



- Low cloud



GFDL AM/CM2.1