Downscaling Global Warming with a Regional Ocean-Atmosphere Model over the Tropical Atlantic

Role of equatorial ocean dynamics:

equatorial upwelling and ocean mesoscale variability

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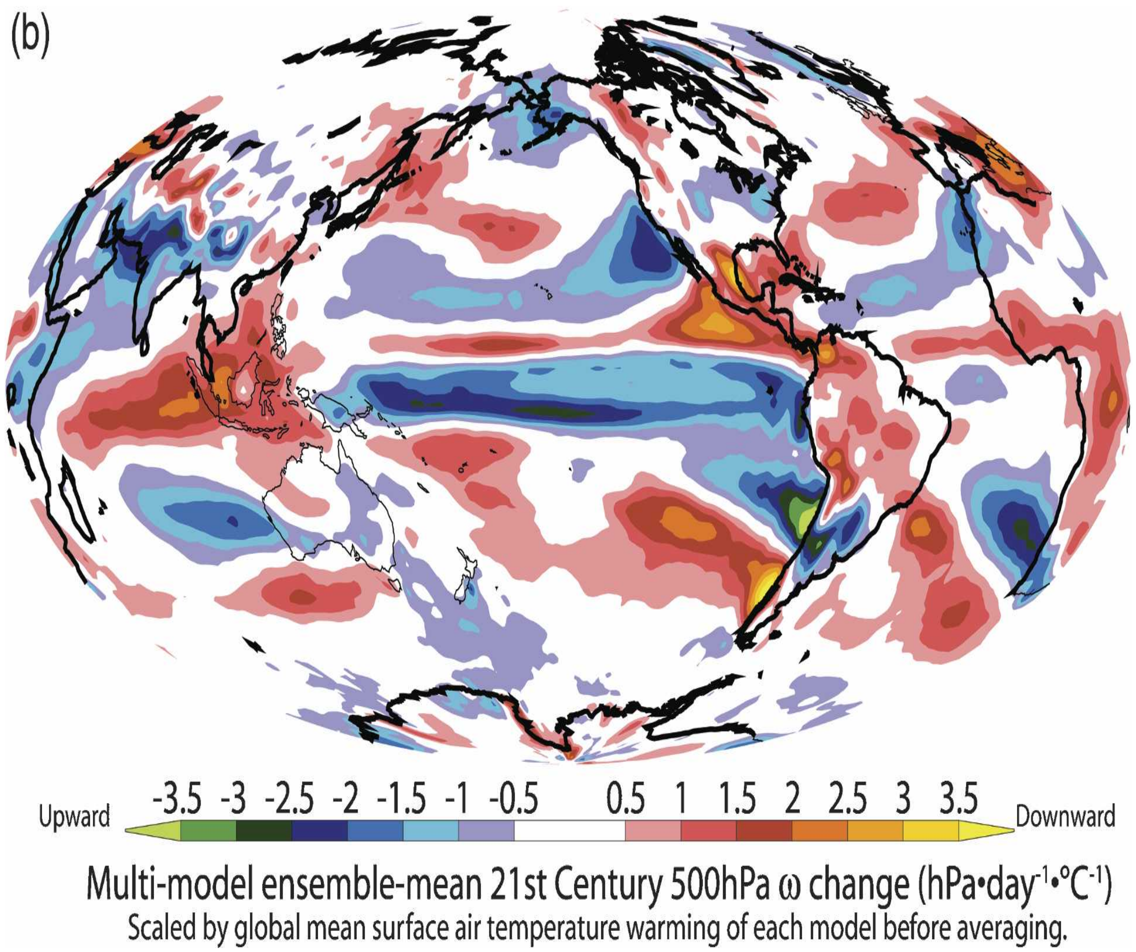
Raghu Murtugudde, Markus Jochum,
and Art Miller

Introduction:
Weakening of Walker circulation and ocean heat transport

Multi-model ensemble change
(A1B-20C) in ω(500hPa)



Vecchi and Soden 2007

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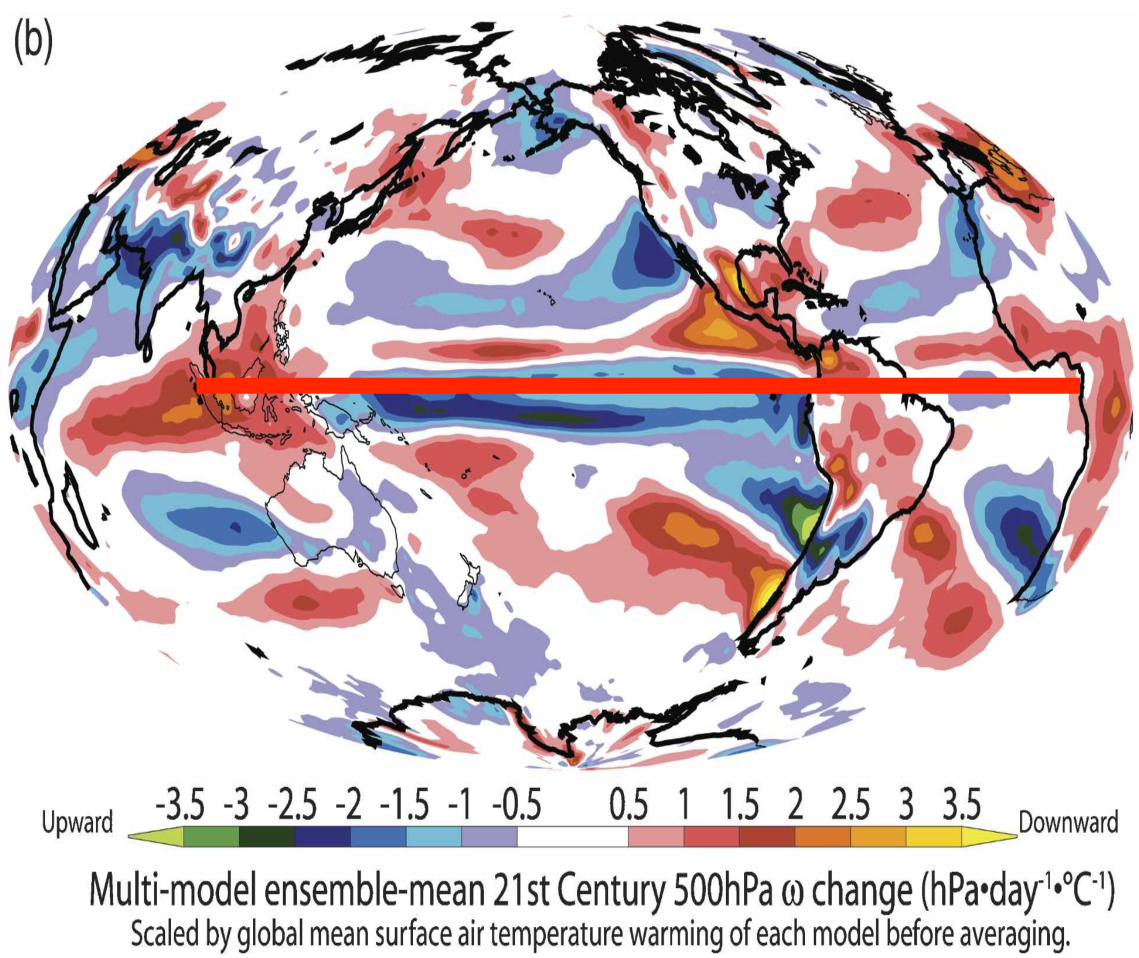

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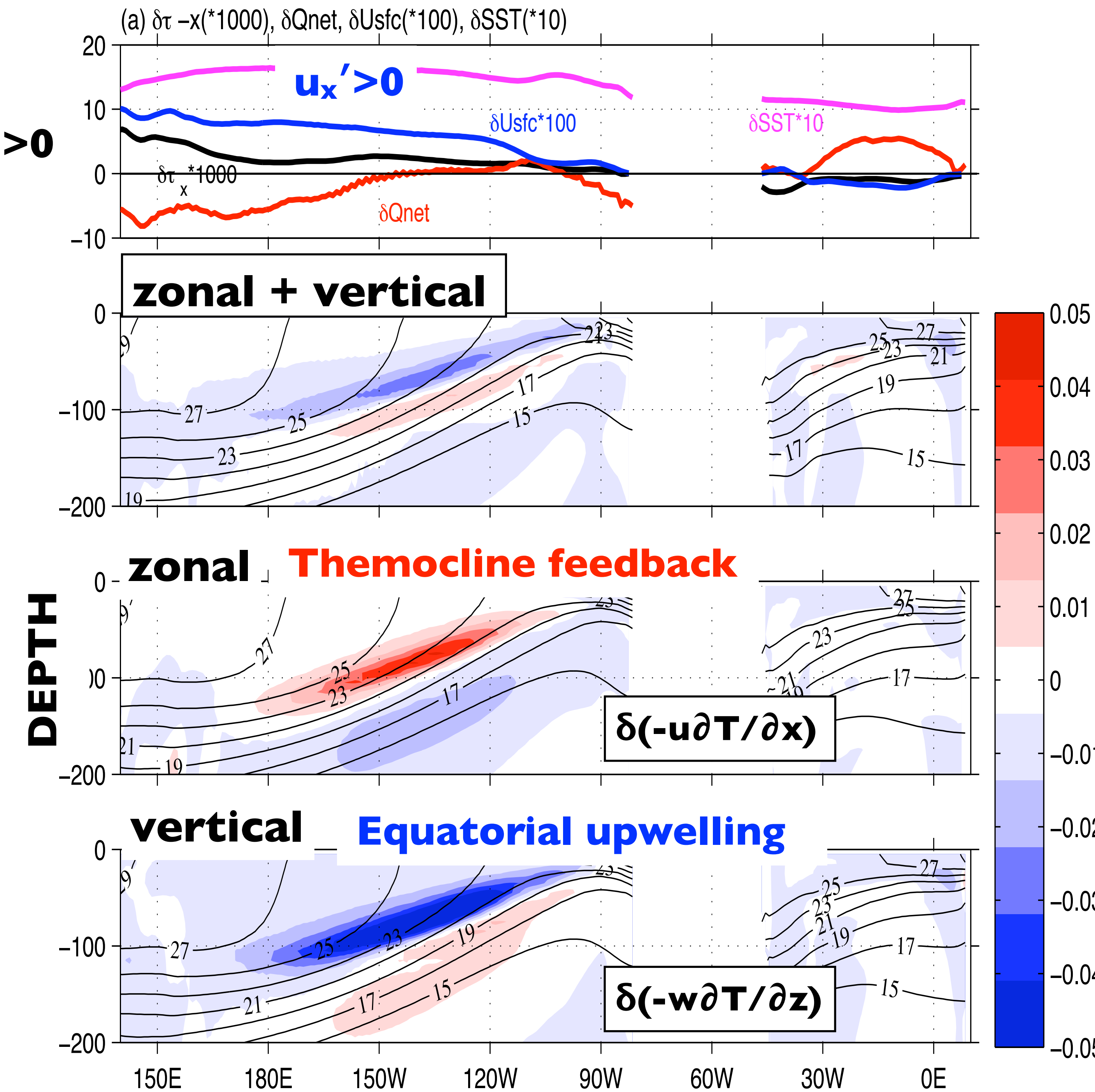
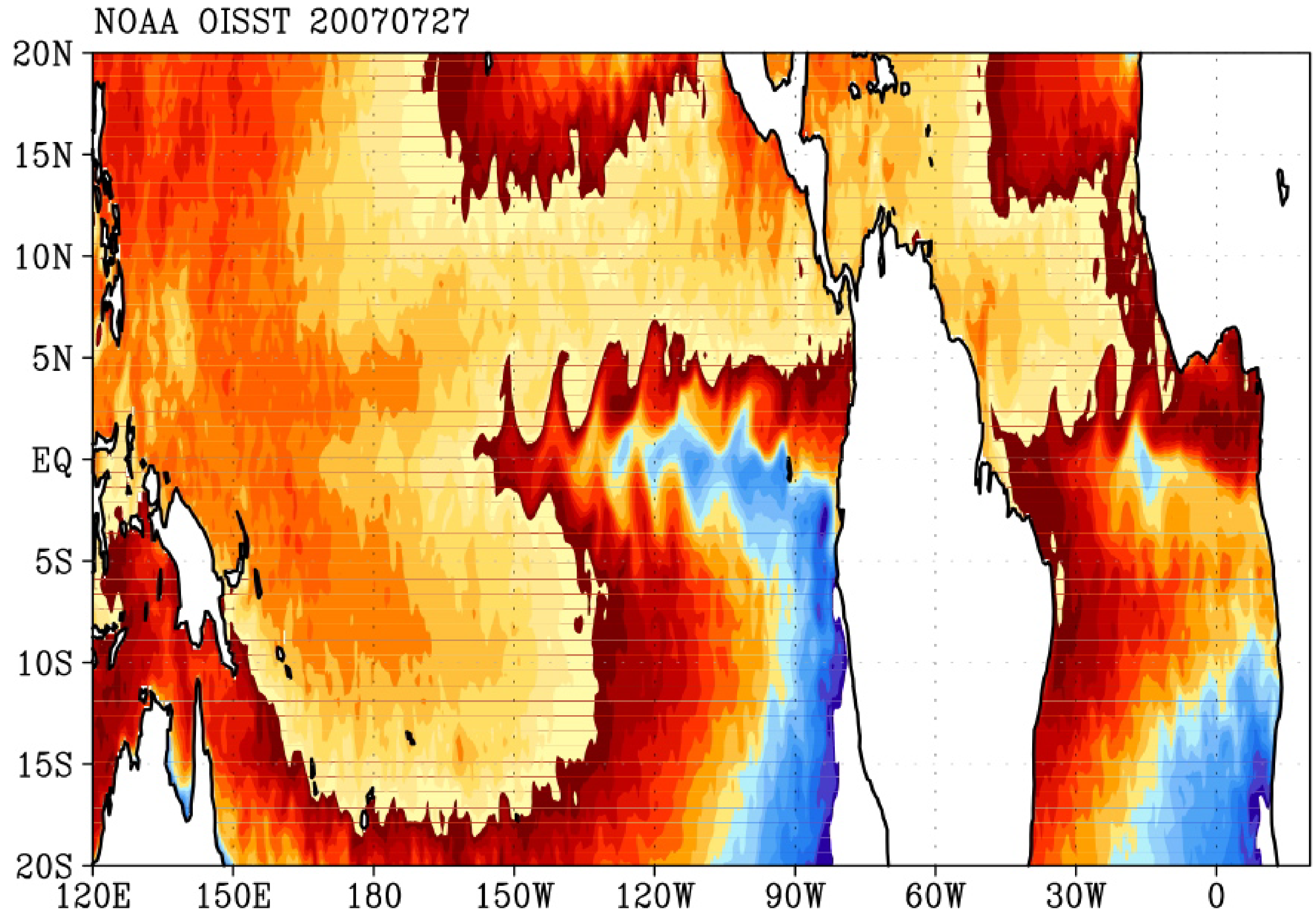


Change in ocean heat transport

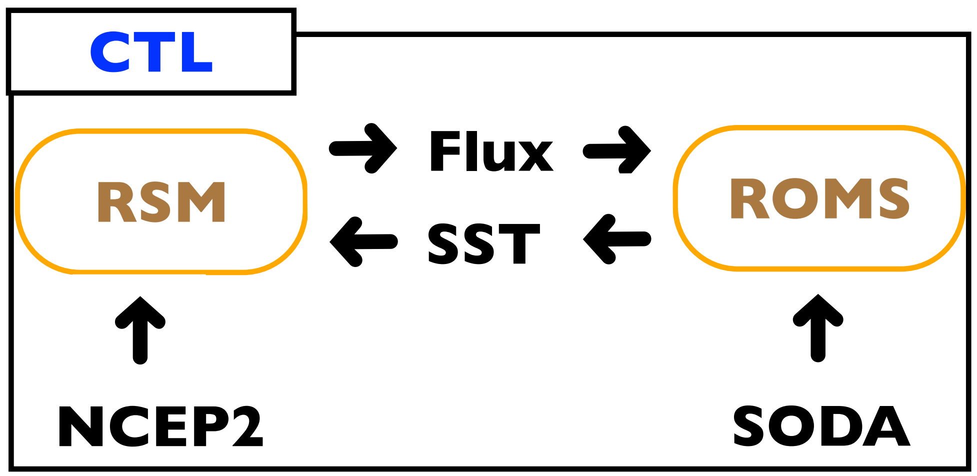
GFDL CM2.1 10-member ensemble (2046-2050) - (1996-2000)

- **Tropical Instability Waves (TIWs)** are the undulations of equatorial SST front in the Pacific and Atlantic.
- Generated by oceanic intrinsic instability.
- Primarily sub-seasonal, but important for low-frequency tropical climate.
- Not well-resolved in the IPCC-AR4 models. So we need to **downscale**.



Model and Experiments

Scripps Coupled Ocean-Atmosphere Regional Model*
Atmosphere: Regional Spectral Model (Scripps RSM)
Ocean: Regional Ocean Modeling System (ROMS)



- **CTL**: RSM (NCEP2 6hrly) + ROMS (SODA monthly)
- 25 km ROMS + 50 km RSM
- Daily coupling
- 28-yr. integration: 1980-2007

***Seo, Miller and Roads, 2007**: The Scripps Coupled Ocean-Atmosphere Regional (SCOAR) model, with applications in the eastern Pacific sector. *Journal of Climate*

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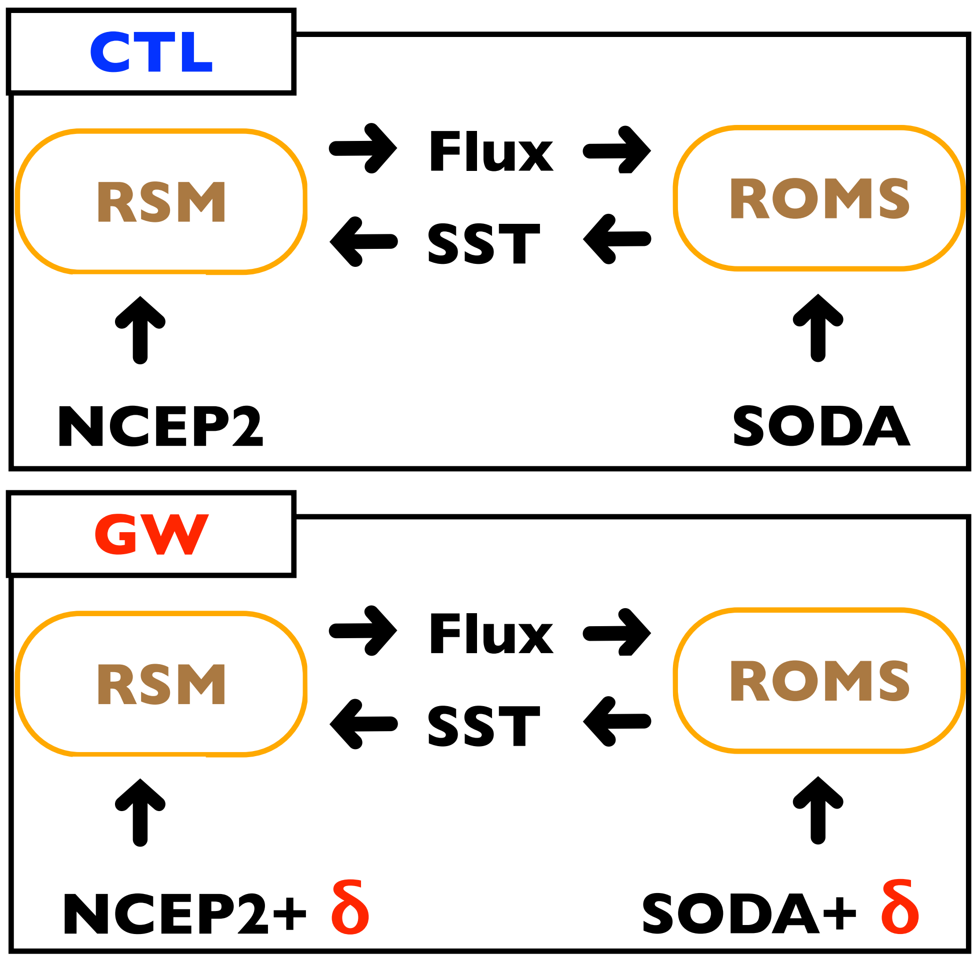

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- δ=GFDL CM2.1 monthly difference:
- (2045-2050: A1B)-(1996-2000: 20C)
- **GW**: RSM (NCEP2 6-hrly + δ) + ROMS (SODA monthly + δ)

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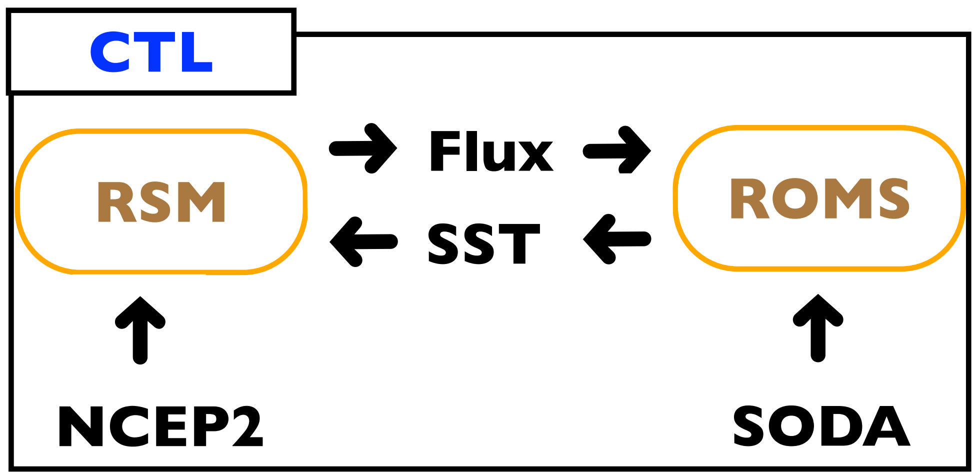

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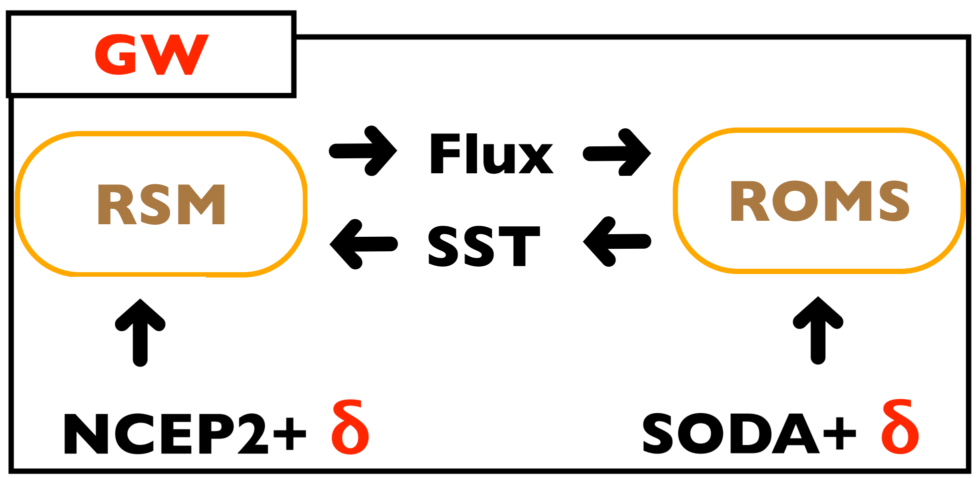

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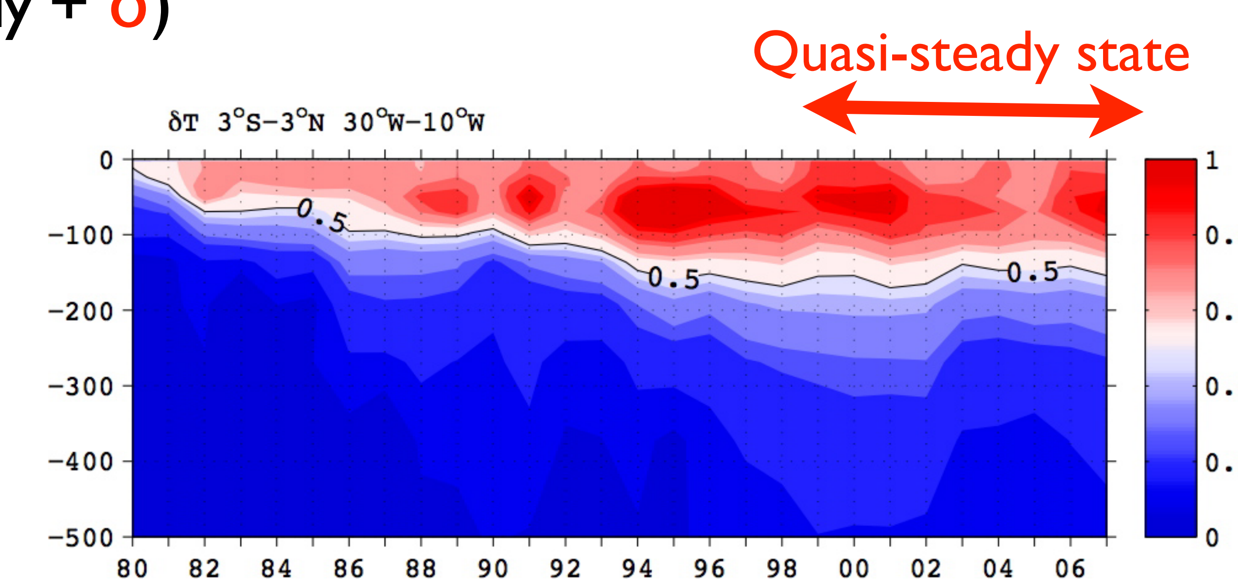
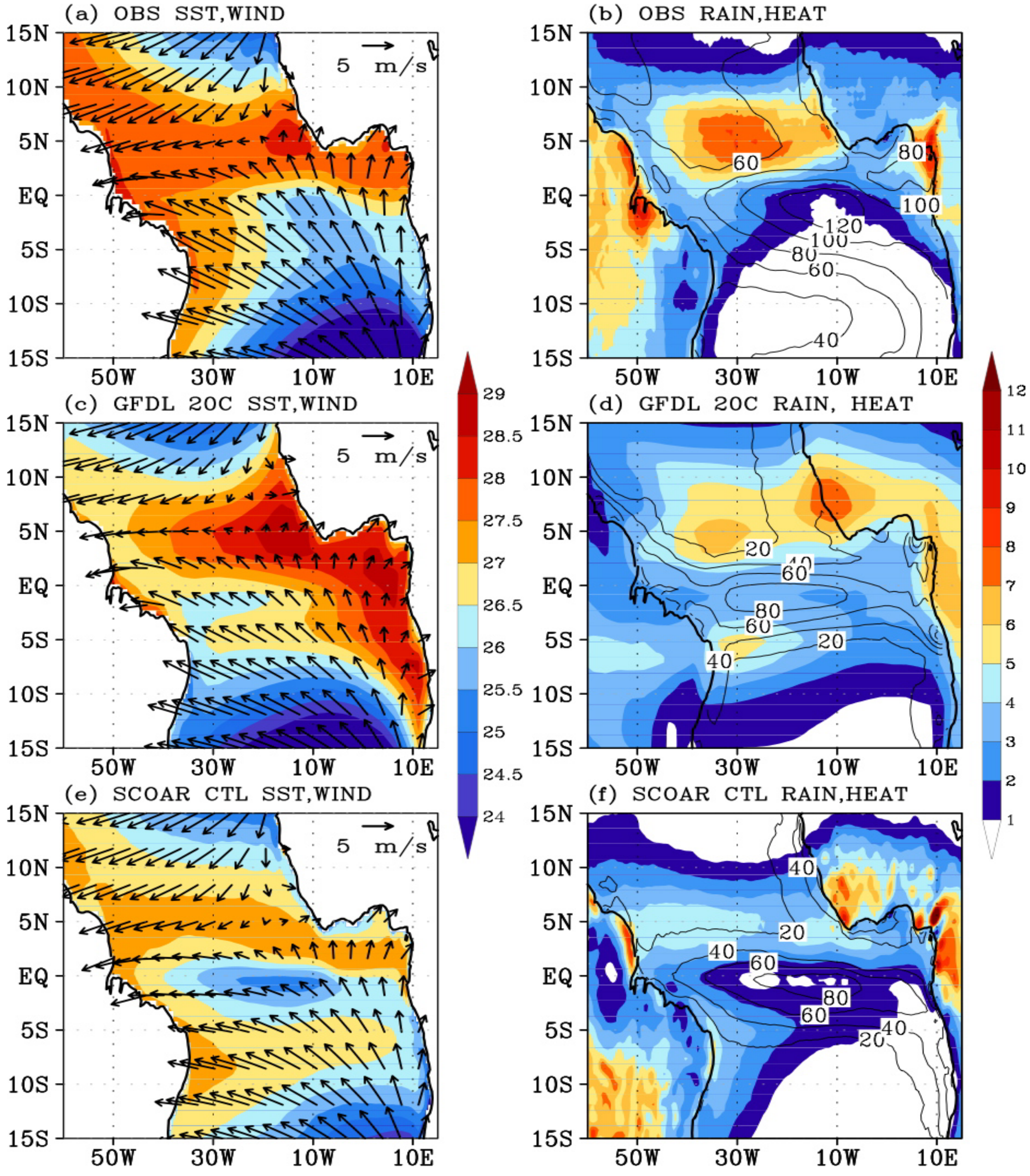


Simulation of present-day climate and global warming response:
Annual mean SST, surface winds, and precip.

Simulation of present-day climate



- Zonal SST gradient and equatorial cold tongue in SCOAR

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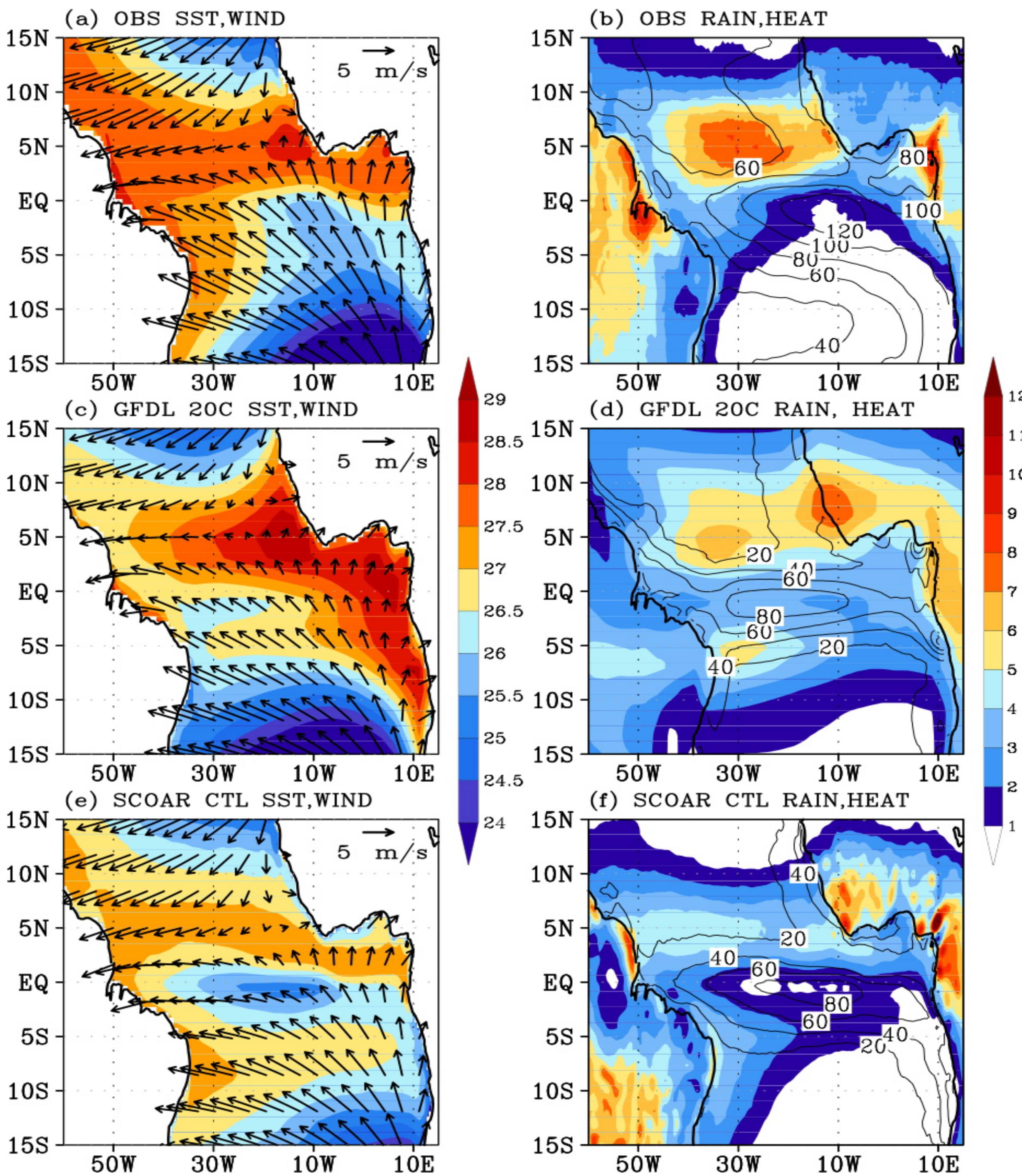

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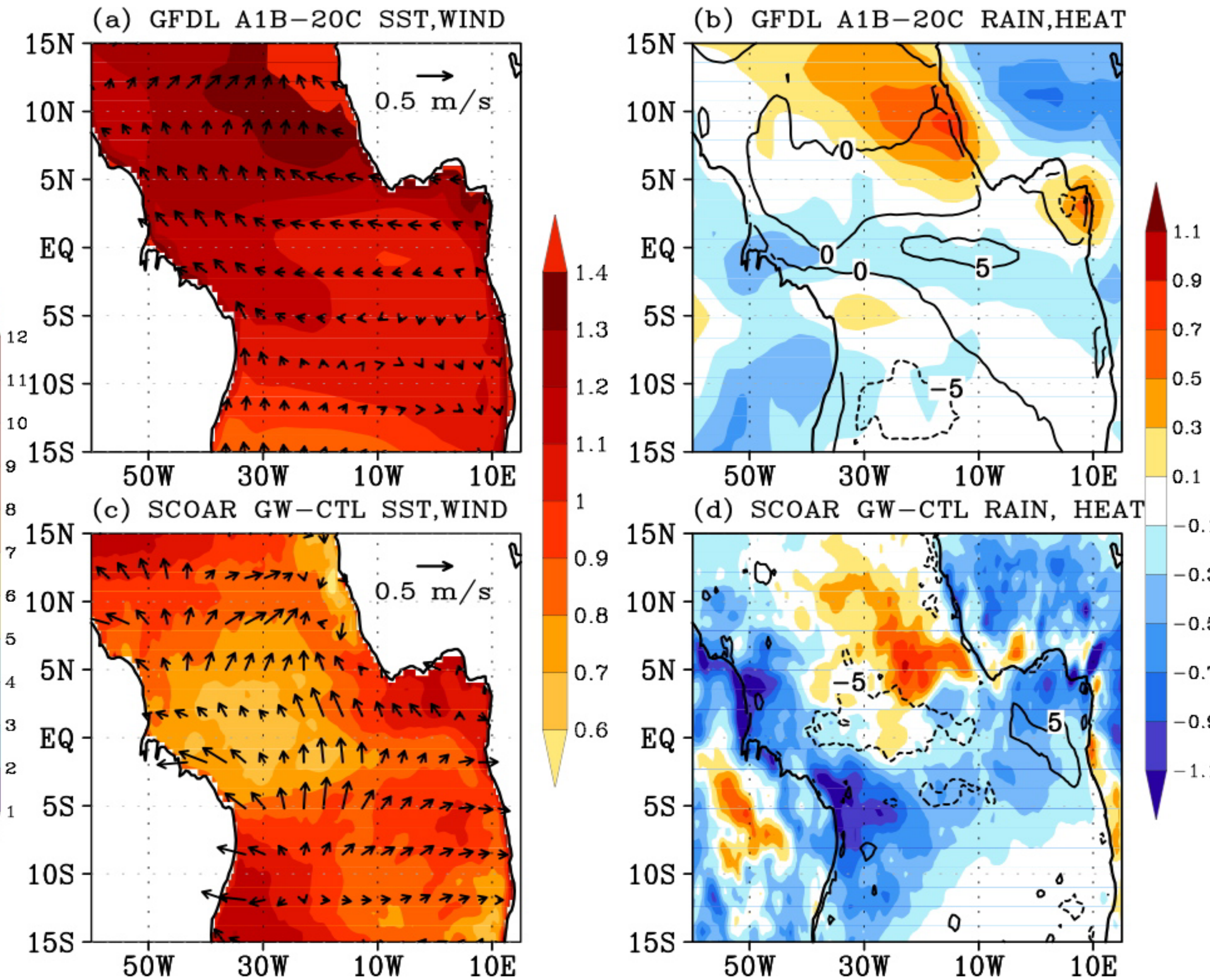
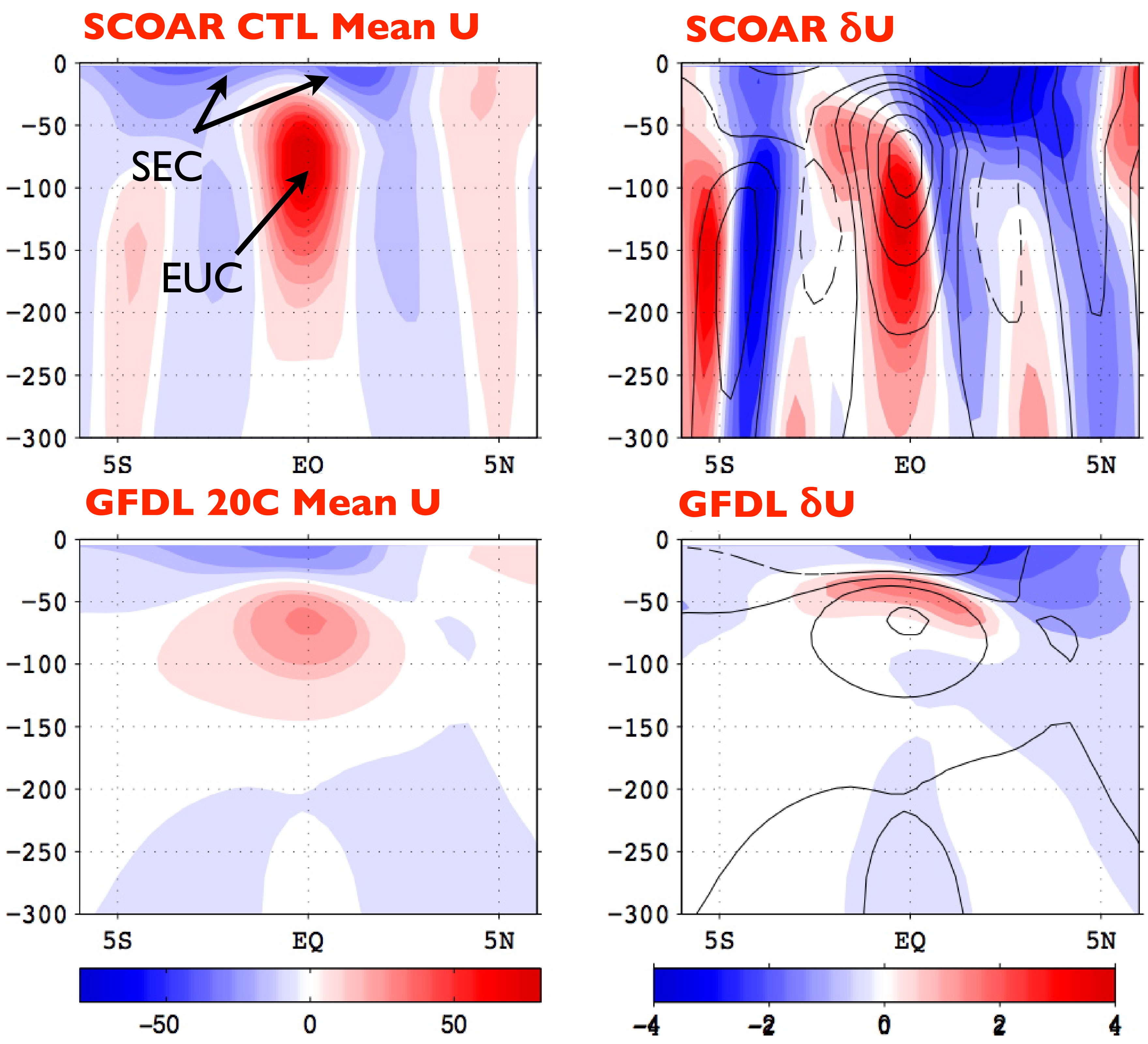
GW response



- Reduced warming in the equator
- Intensified cross-equatorial meridional winds

Change in equatorial zonal currents and equatorial instability



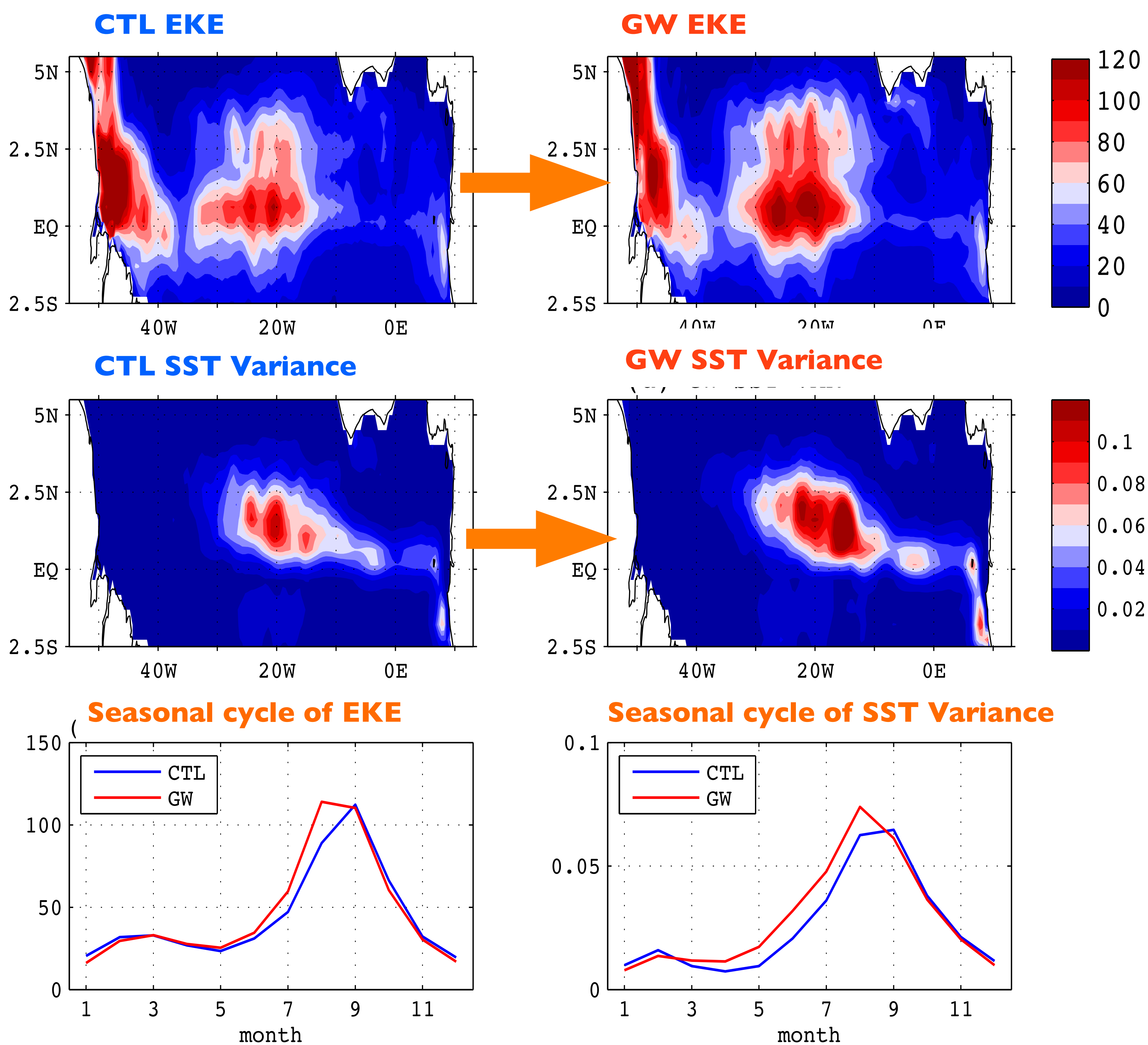
- EUC is more realistic (stronger) in SCOAR.
- Stronger cross-equatorial wind

➡ Stronger EUC (*Philander and Delecluse, 1983*)

➡ Enhanced Barotropic and baroclinic instability

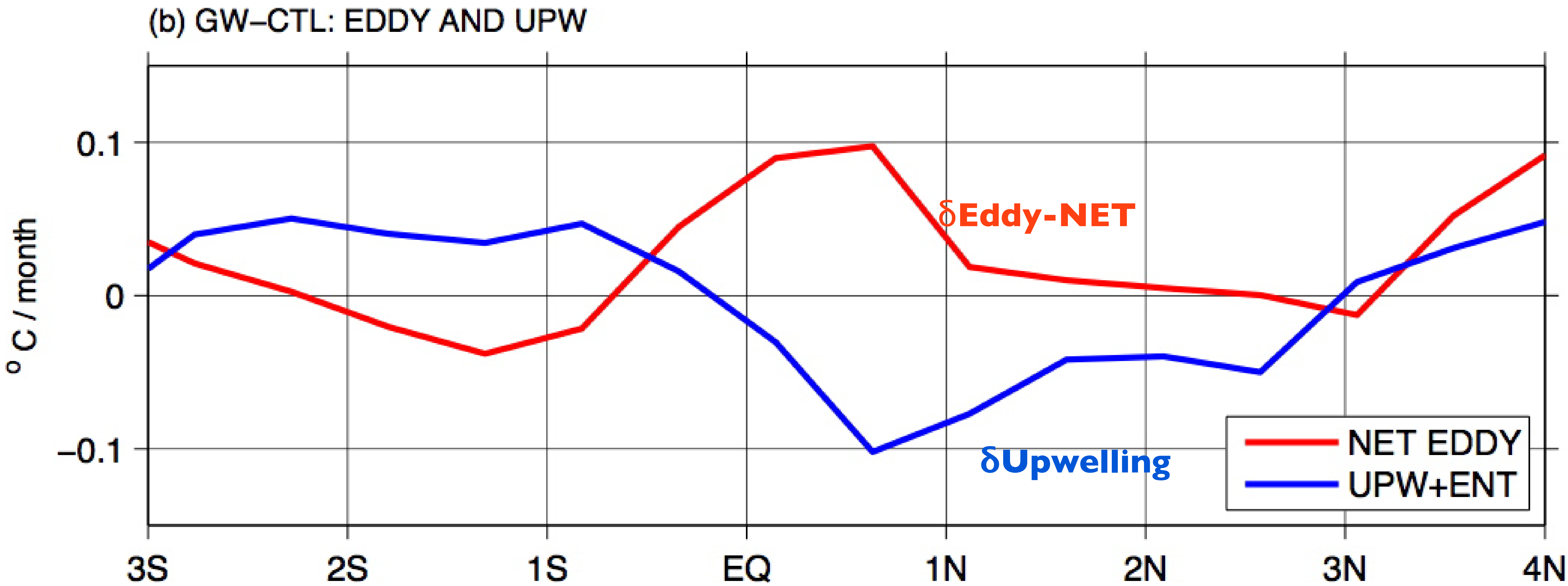
➡ Stronger TIWs

Strengthening of TIWs (20-40 day band-pass filtered EKE and SST variance)



- EKE and TIW-SST variance all become stronger during the cold season.

Annual mean mixed layer ocean heat budget (30W-10W)



- Equatorial upwelling (cooling) increases
    - Increased w' acting on climatological dT/dz >> Climatological <w> acting on dT'/dz due to radiative forcing.
- Net eddy heat flux (warming) increases, damping the effect of upwelling.

Conclusion and Discussion

- Downscaling is also important for study of oceanic role in weather and climate.
- Advantages: Better capture equatorial currents and mesoscale variabilities
- *Exploratory* research: Coupled downscaling of the IPCC climate change scenarios
- Upwelling increases. TIWs increase. Impact the mean state.
- Need to monitor TIW heat flux(zonal) for detection of warming signal.
- Need to resolve high-freq. processes in the model for global warming research.

Thanks!