Dynamics of regional climate change

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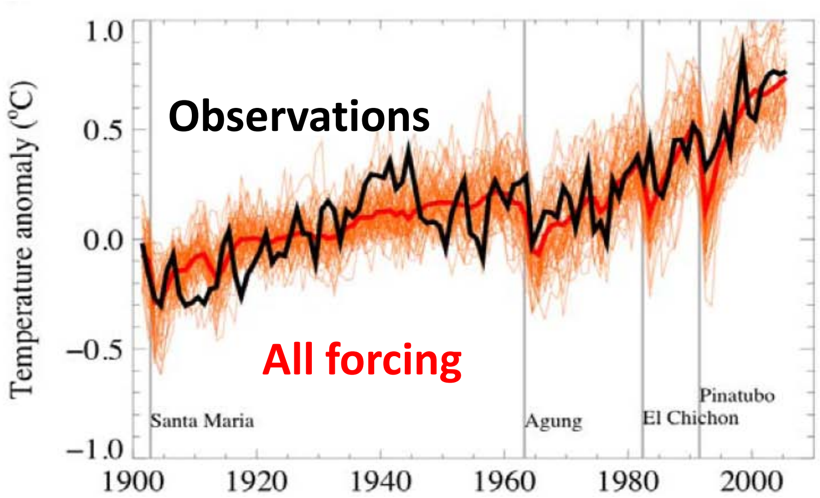
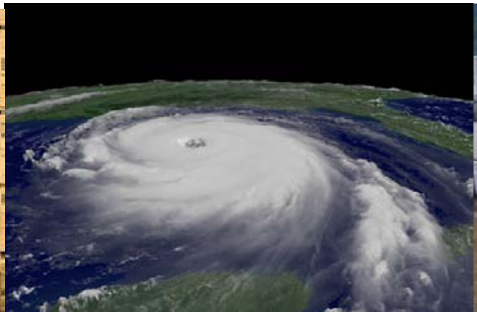
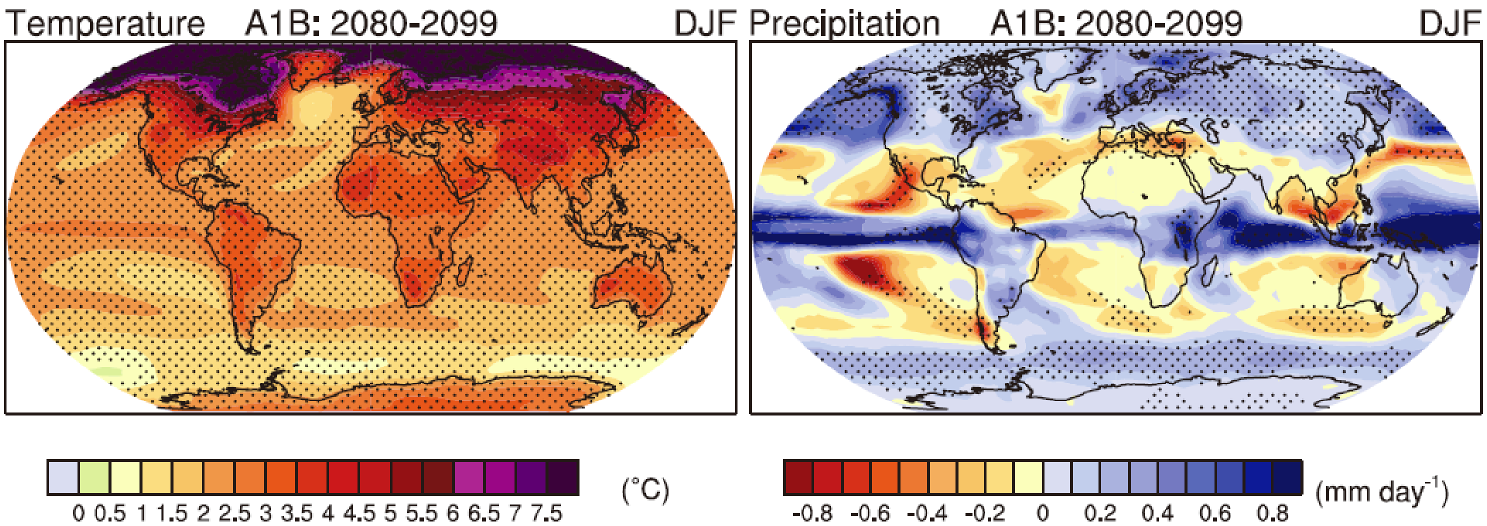


- SST patterns & rainfall change
- Changes in modes: IOD & IO capacitor

Ocean warming is not uniform;
precip change is even more variable in space.

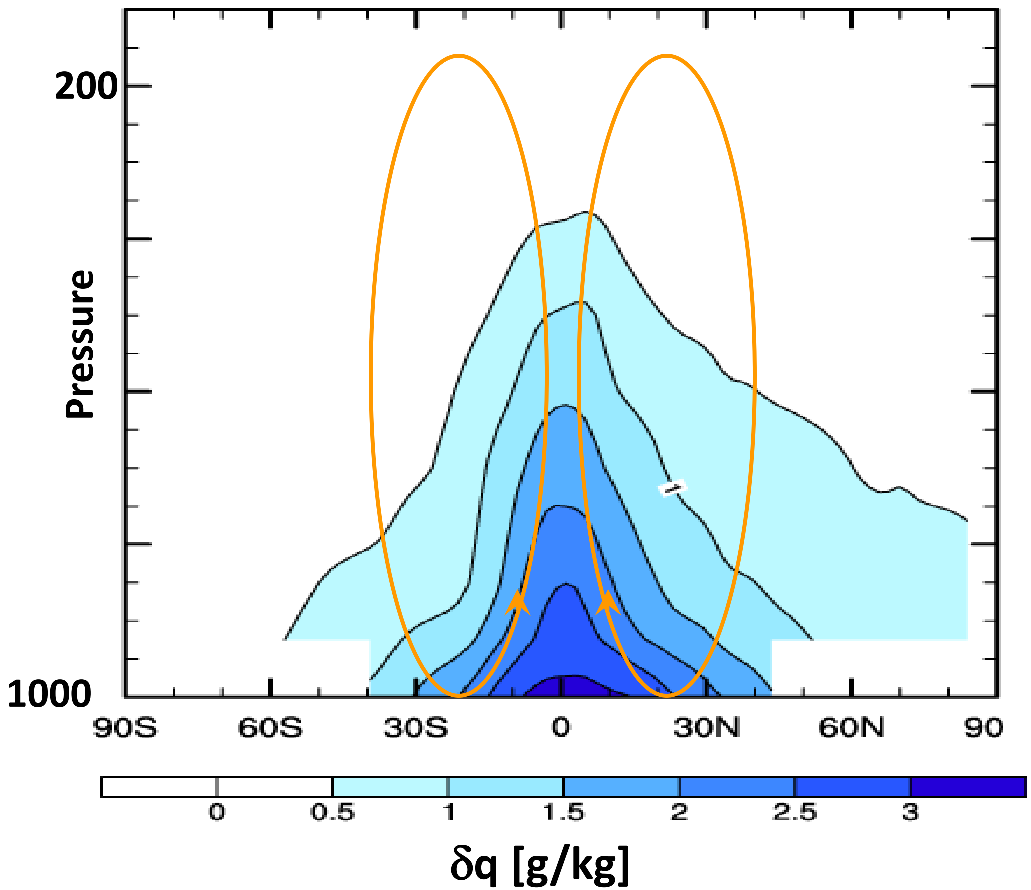
50-yr change	Air Temp	Precip
Global mean	1.16	1.48
Spatial σ	0.46	7.17



A1B multi-model ensemble mean (IPCC AR4, 2007)

Hypothesis 1: The wet gets wetter (e.g., Held & Soden 2006, JC)

(Precipitation increases in equatorial rain bands; decreases in subtropics; and increases in high-latitudes due to increase in moisture transport)



Zonal-mean change in specific humidity
Richter & Xie(2008, JGR)

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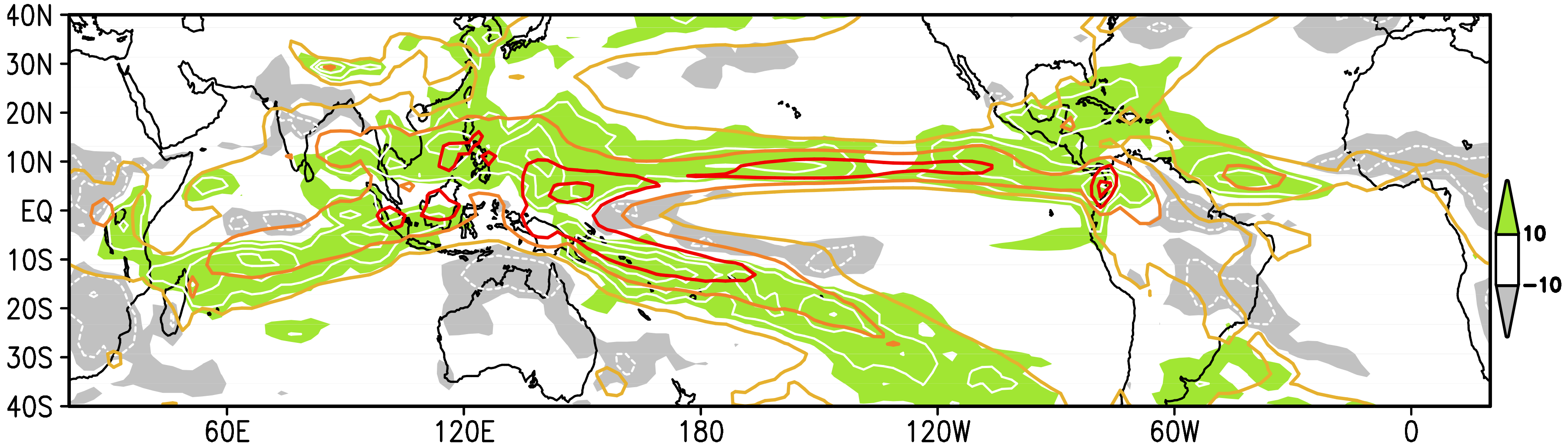
The wet-get-wetter pattern is realized in atmospheric response to a uniform SST warming in so-called Cess runs.

But what about in coupled simulations with δSST patterns?



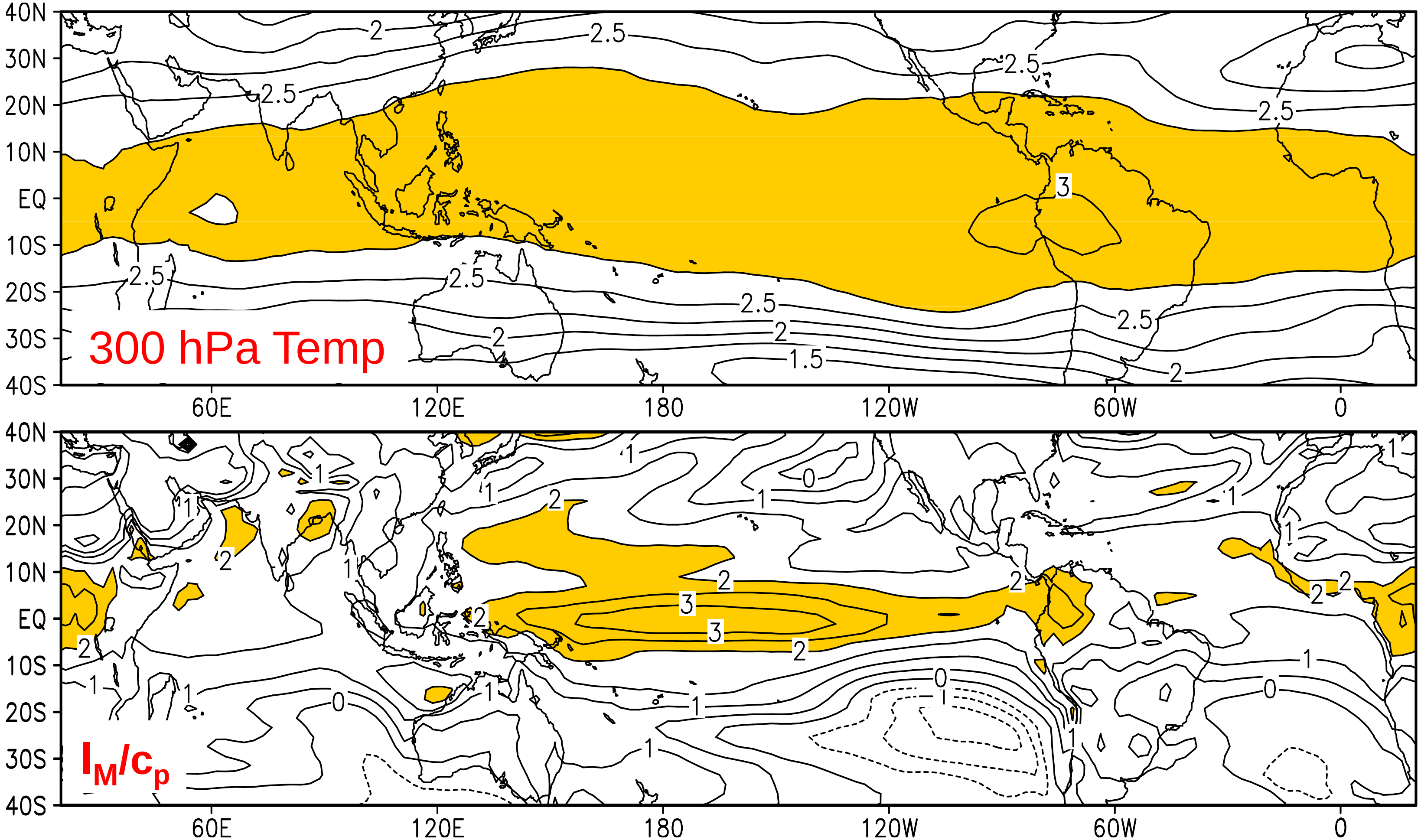
2K uniform SST warming: mean (contour) and change of precipitation

→ Wet-get-wetter pattern

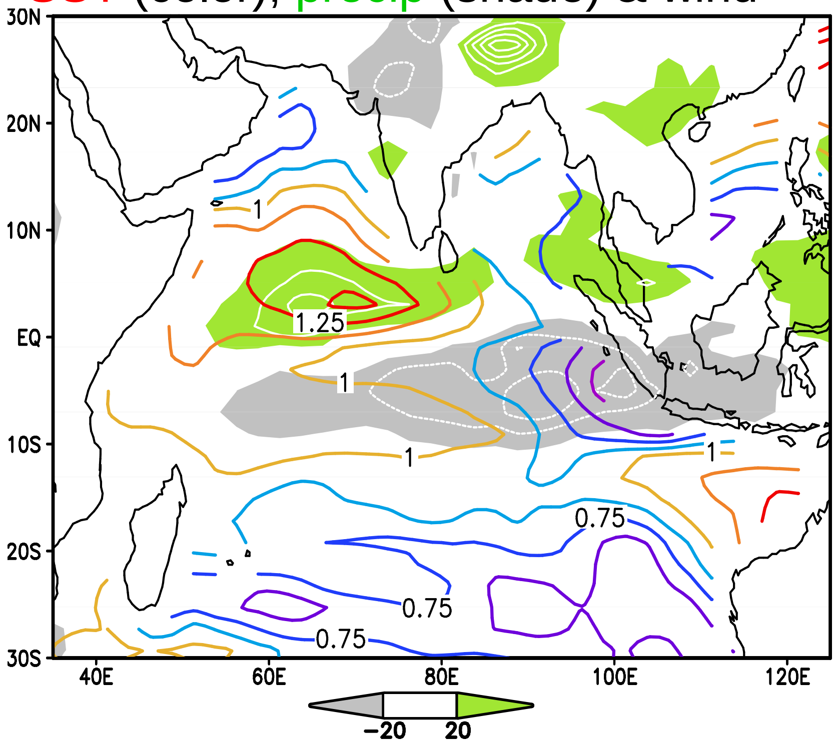
Hypothesis 2: Warmer get wetter (Xie et al. 2010, JC)

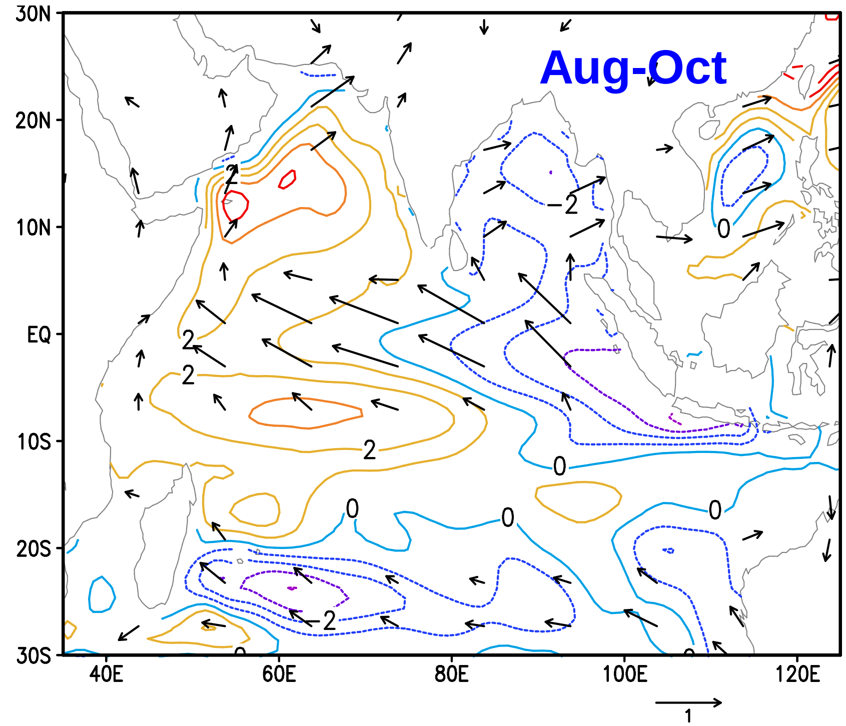
Convective Instability: $I_M = (c_p T + Lq)_{sfc} - (c_p T + Lq)_{300\ hPa}$

- Flat warming in upper troposphere ← equatorial waves
- I_M follows closely SST patterns

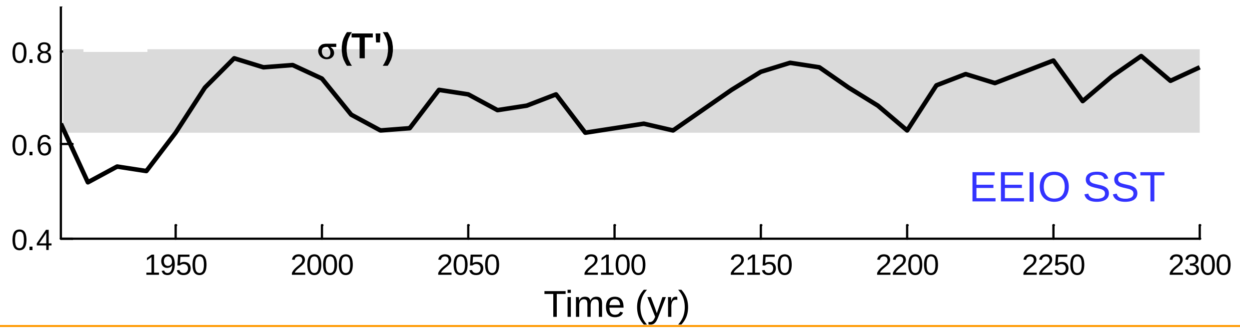


IOD-like change

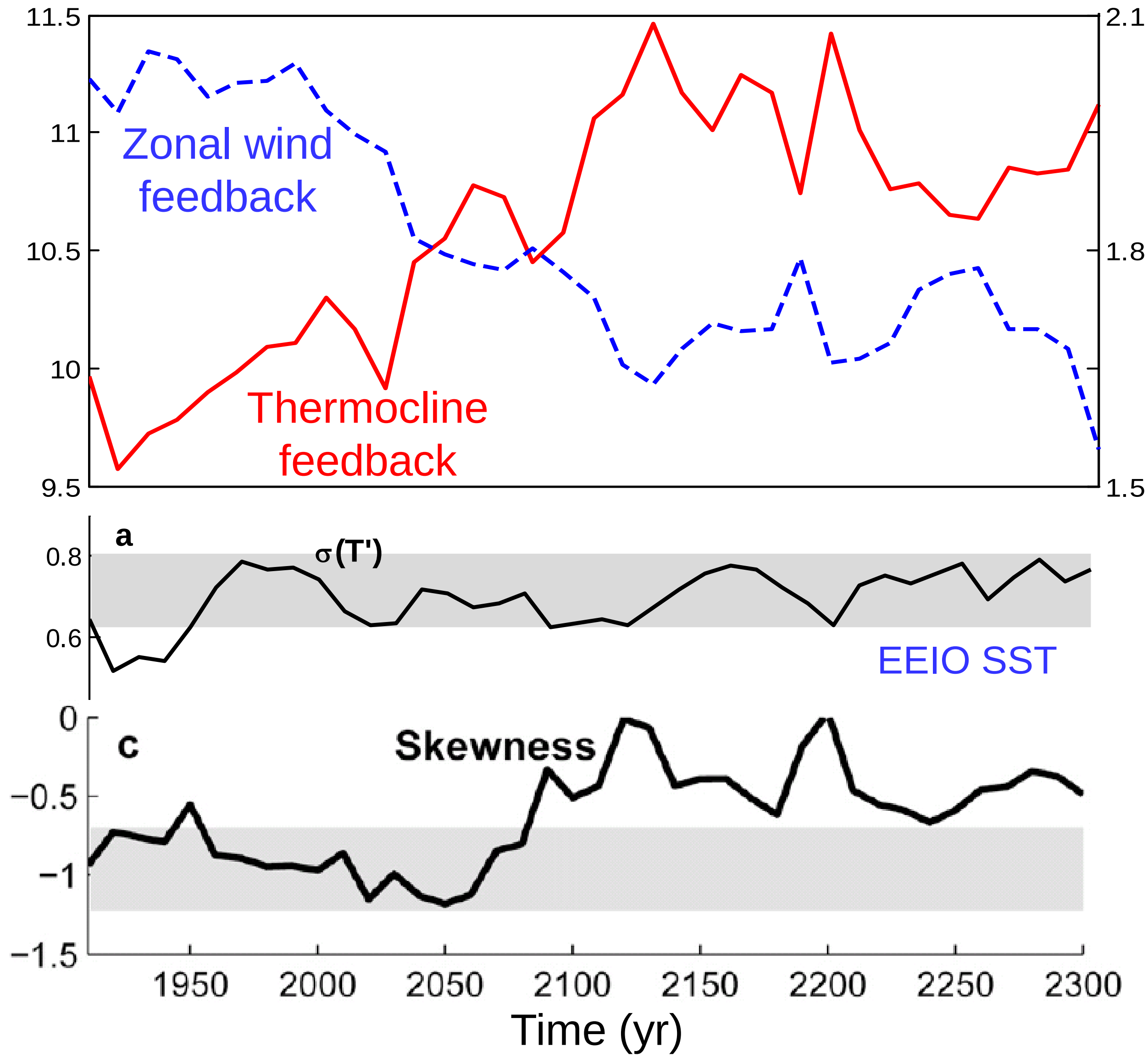


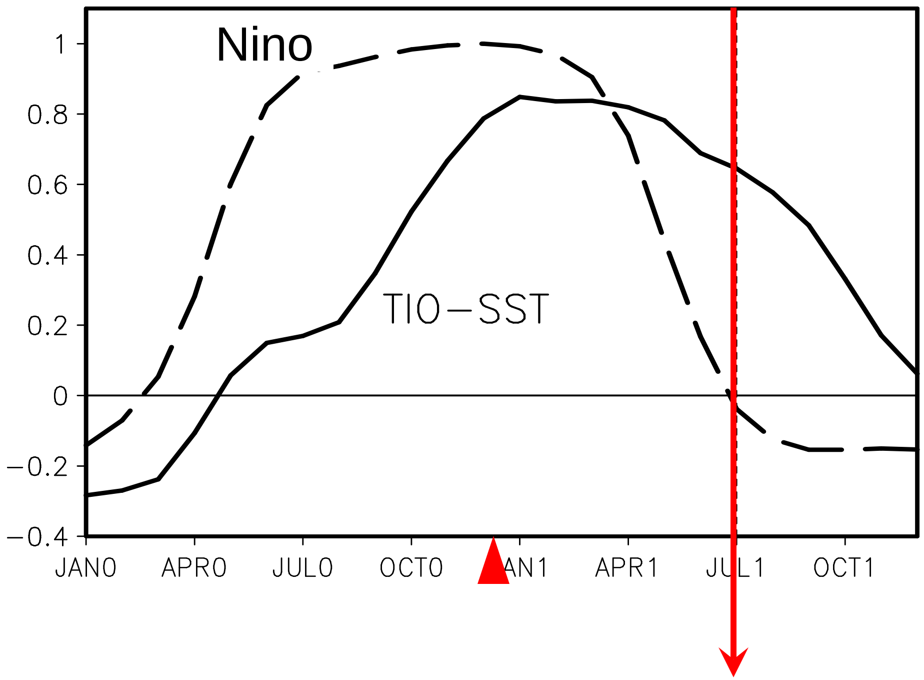


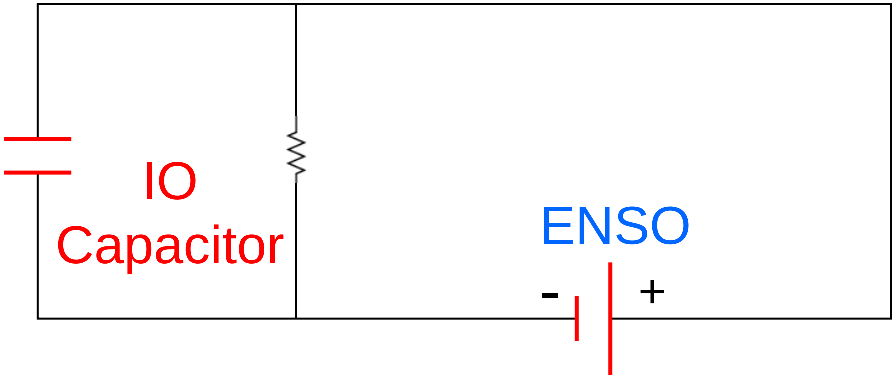
Interannual SST variance remains constant (Zheng et al. 2010 JC)



Thermocline feedback strengthens but wind feedback weakens → IOD variance remains constant but skewss weakens.







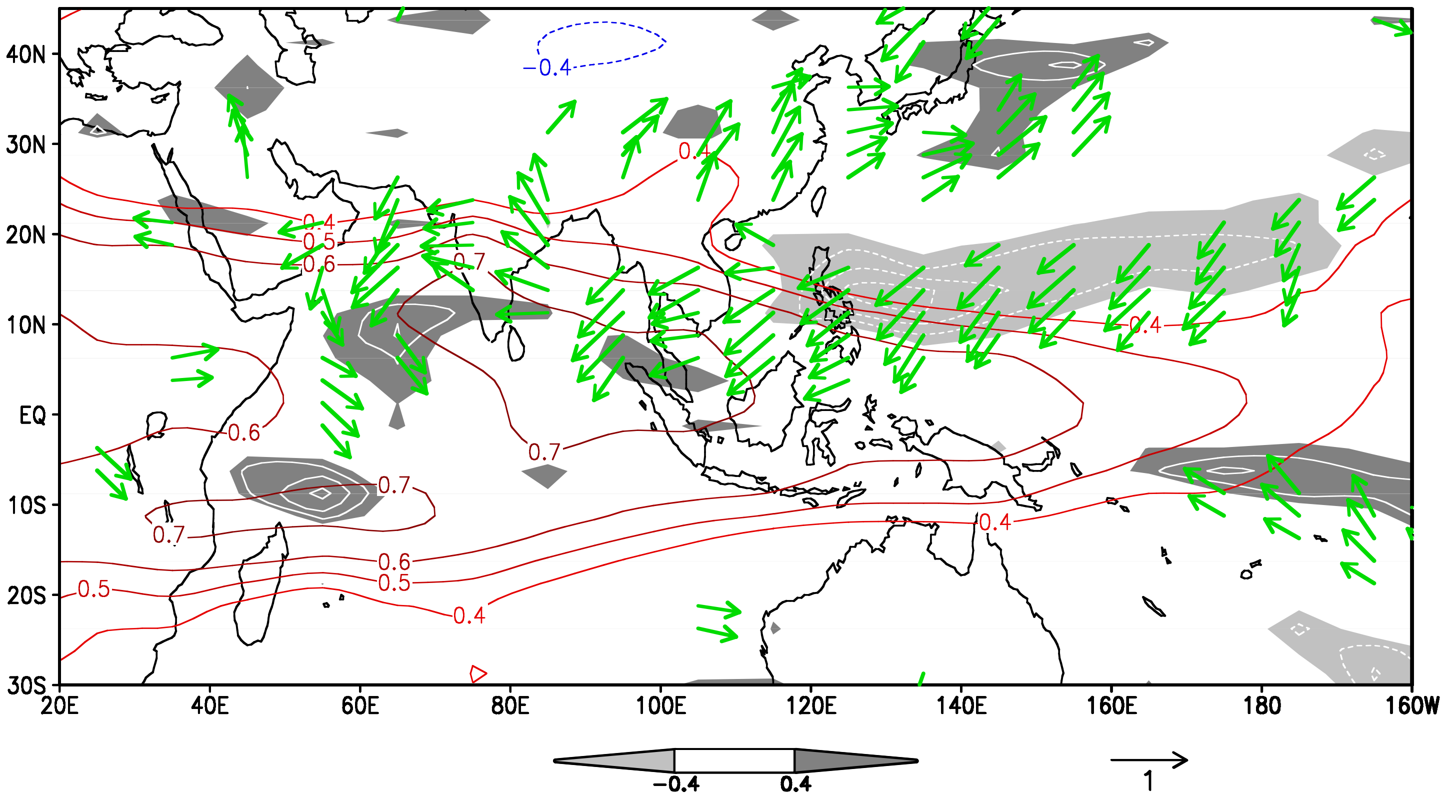
Indian Ocean Capacitor

SST warming persists through JJA(1), and exerts climatic influences after El Nino has dissipated.

Yang, J., Q. Liu, S.-P. Xie, Z. Liu, and L. Wu, 2007: Impact of the Indian Ocean SST basin mode on the Asian summer monsoon. *Geophys. Res. Lett.*, 34, L02708, doi: 10.1029/2006GL028571.

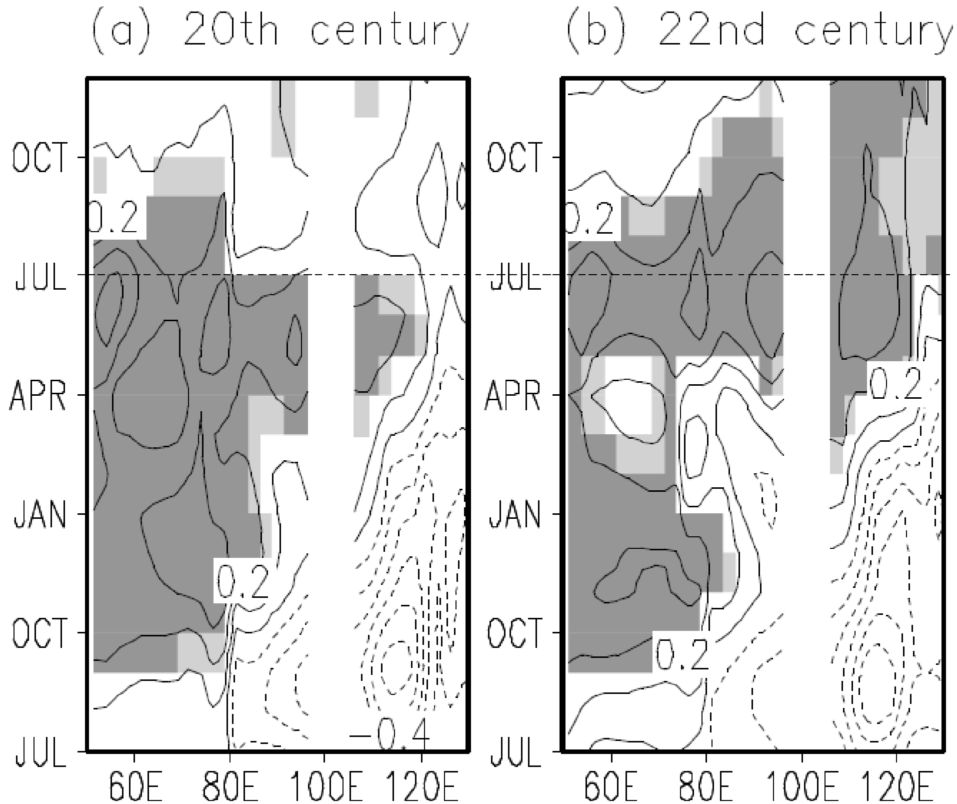
How does IO warming force NW Pacific anticyclone?

IO warming → Warm Kelvin wave into the WP
→ Northeasterly winds to the north under friction
→ Divergence over NW Pacific ←→ Suppressed convection



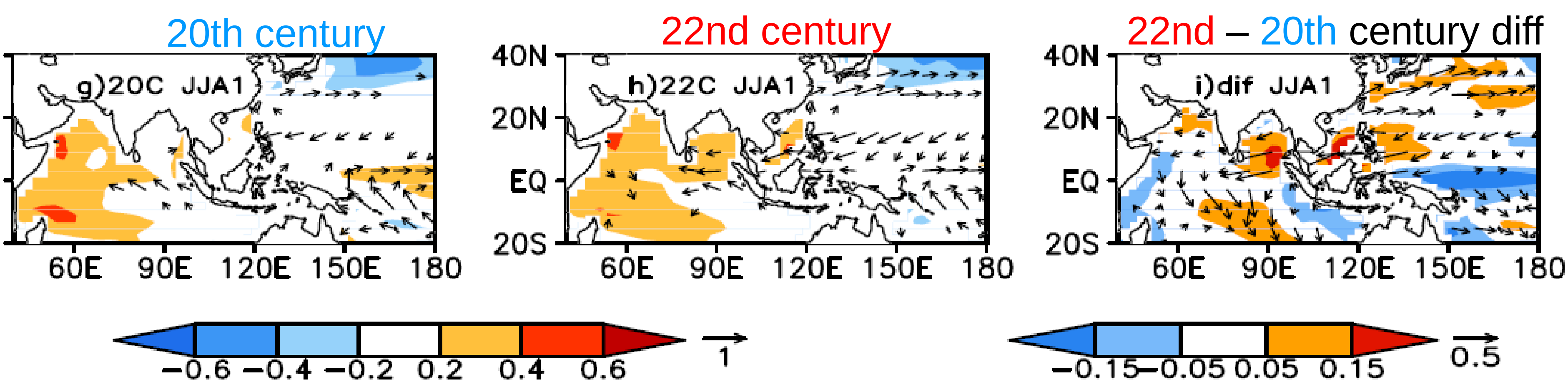
Tropospheric temp, surface wind & rainfall

Xie, S.-P., K. Hu, J. Hafner, H. Tokinaga, Y. Du, G. Huang, and T. Sampe, 2009: Indian Ocean capacitor effect on Indo-western Pacific climate during the summer following El Nino. *J. Climate*, 22, 730–747.



North Indian Ocean SST (5-15N) regression upon NDJ Nino3.4 SST

Zheng, X.-T., S.-P. Xie, and Q. Liu, 2011: Response of the Indian Ocean basin mode and its capacitor effect to global warming. *J. Climate*, in press.

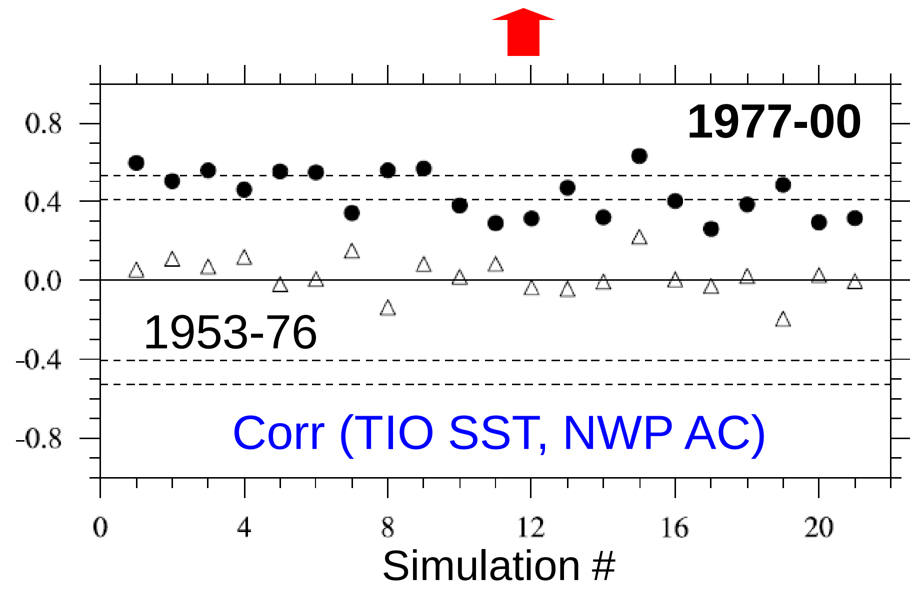


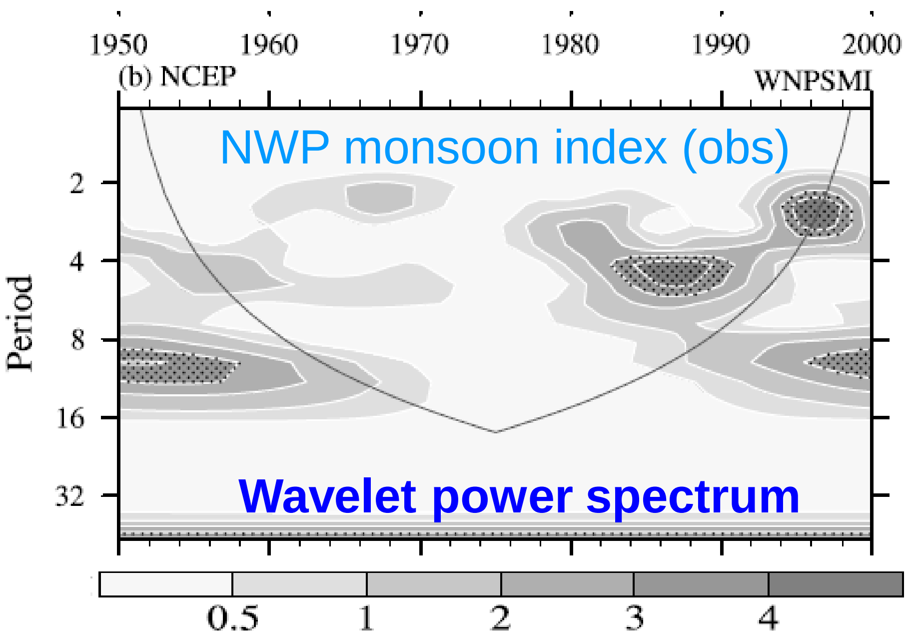
SST & surface wind regressions upon NDJ Nino3.4

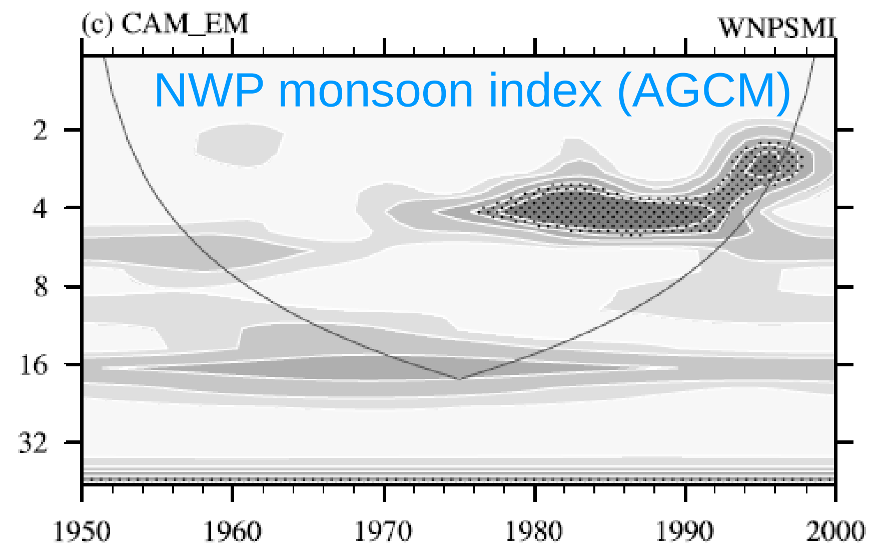
Enhanced variability in NW Pacific monsoon is due to intensified TIO SST variability.

Decadal Shift

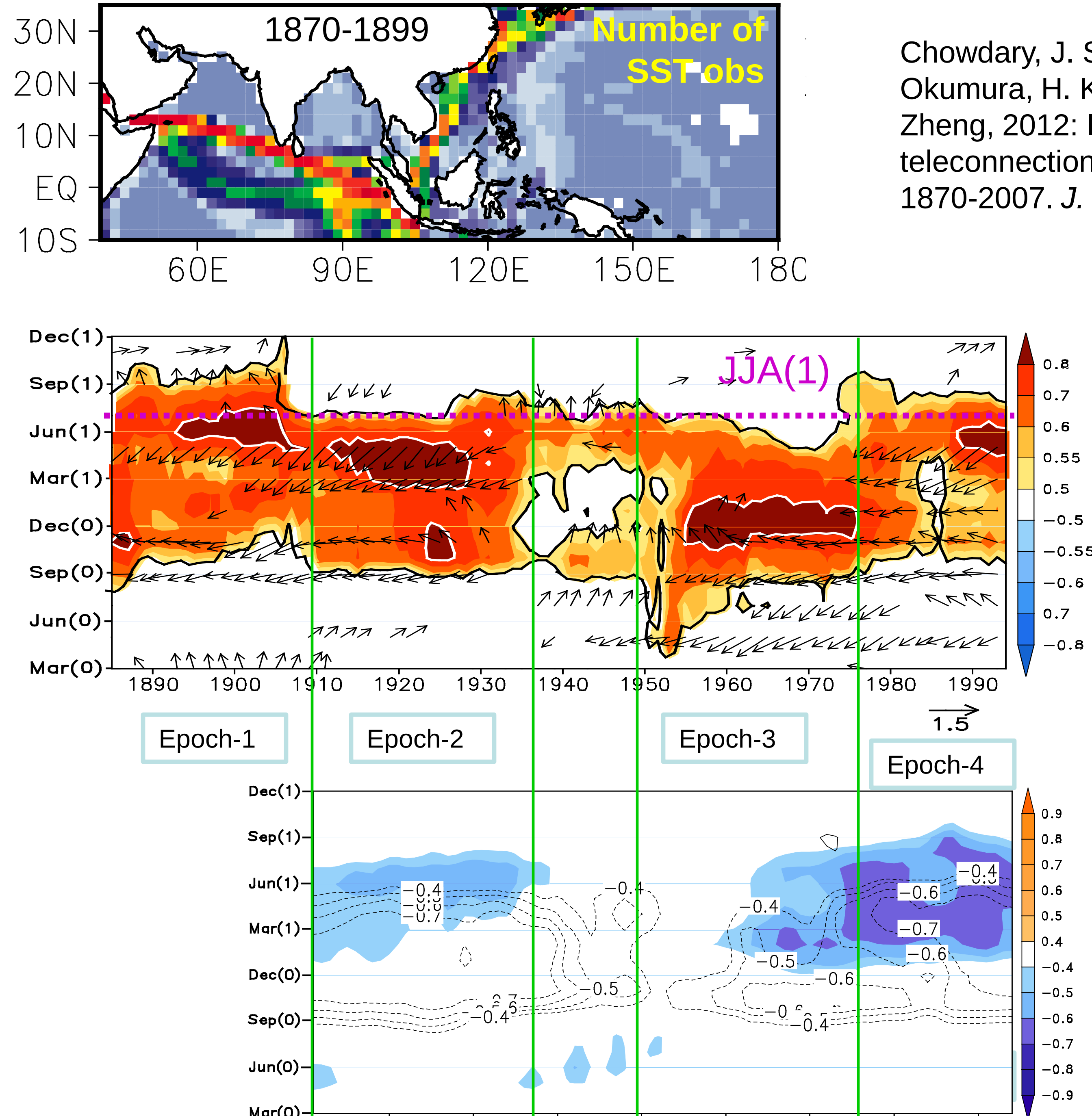
Has the TIO capacitor intensified?







Huang, G., K. Hu, and S.-P. Xie, 2010: Strengthening of tropical Indian Ocean teleconnection to the Northwest Pacific since the mid-1970s: An atmospheric GCM study. *J. Climate*, 23, 5294-5304 .

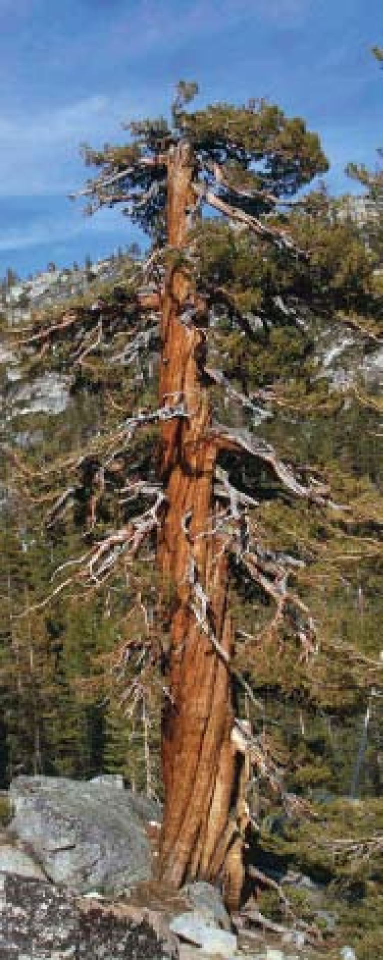


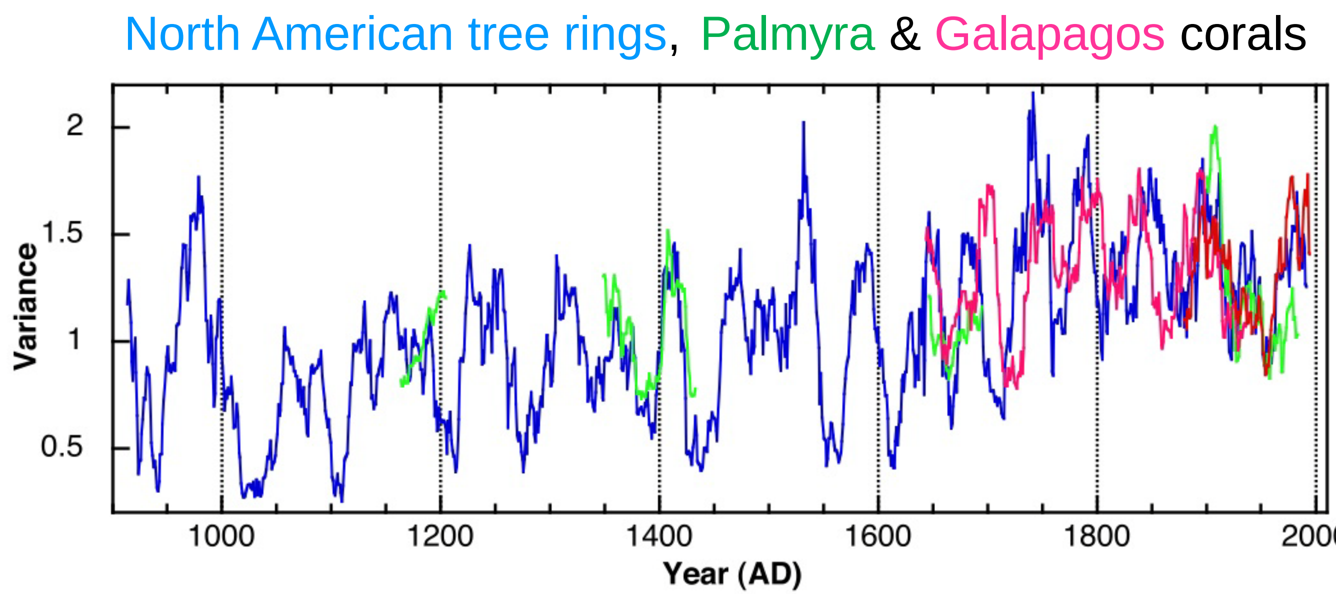
Chowdary, J. S., S.-P. Xie, H. Tokinaga, Y. M. Okumura, H. Kubota, N. C. Johnson, and X.-T. Zheng, 2012: Inter-decadal variations in ENSO teleconnection to the Indo-western Pacific for 1870-2007. *J. Climate*, in press.

21-yr running correlation of **NIO SST** and **wind** (on ship track) with NDJ Niño 3.4 SST.

Guam & Philippine rainfall correlations.

ENSO增幅在过去1100年的变化





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nature climate change

Interdecadal modulation of El Niño amplitude during the past millennium

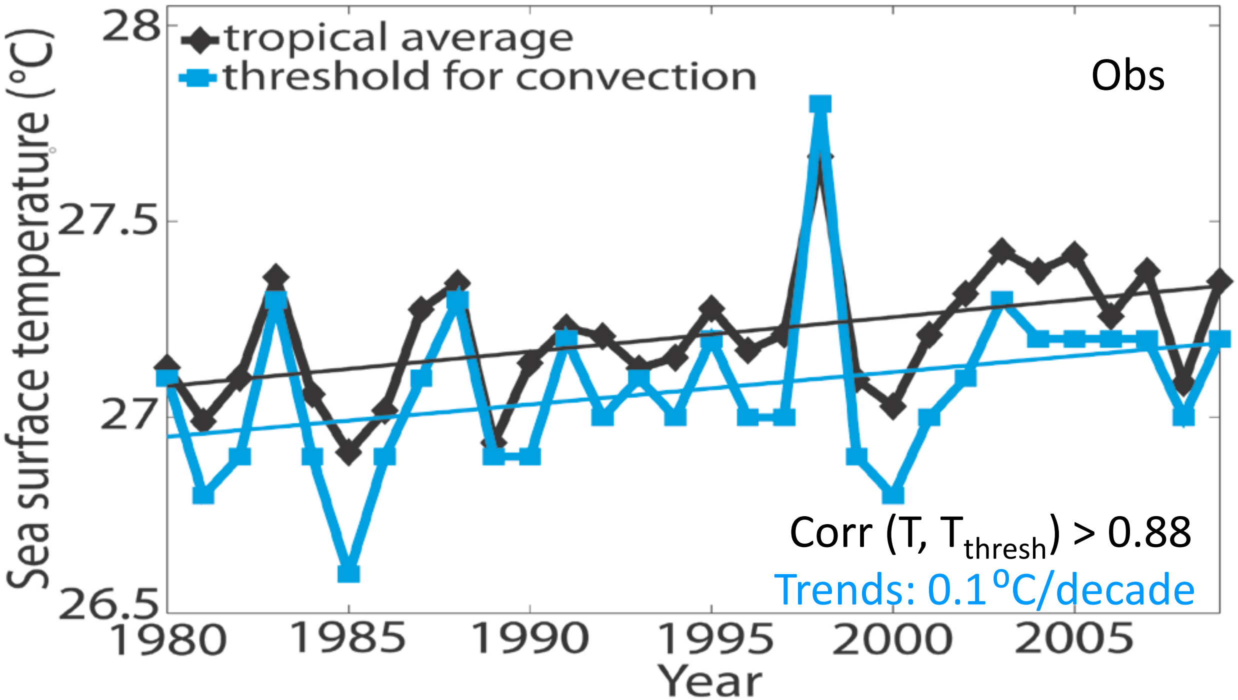
Jinbao Li[1,2]*, Shang-Ping Xie[1,3,4], Edward R. Cook[2], Gang Huang[5], Rosanne D'Arrigo[2], Fei Liu[1], Jian Ma[3] and Xiao-Tong Zheng[4]

Summary

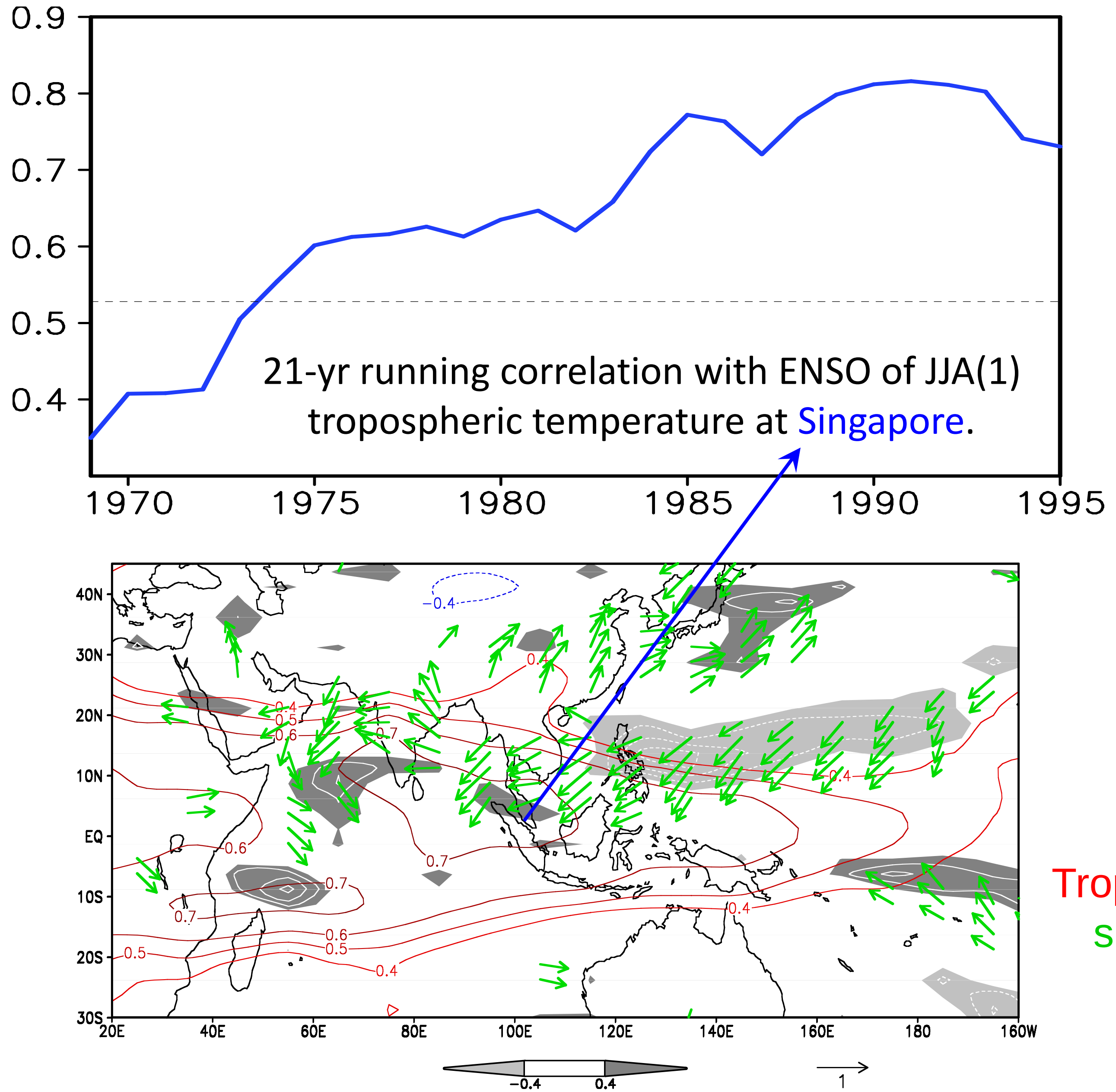
- Patterns of SST warming determine tropical rainfall change → Warmer get wetter.
- IOD-like warming pattern; IOD’s interannual variance remains unchanged but skewness weakens.
- Indian Ocean capacitor may intensify in the ENSO decay summer under global warming → increased predictability.
- IO capacitor was stronger around 1900 and after 1970s.
- It remains to be seen if the recent intensification of IO capacitor is part of natural variability or due to global warming.

Rising Sea Surface Temperature Threshold for Tropical Convection

N. Johnson and S.-P. Xie (2010, *Nature Geosc.*)



- Over the past 30 years, the convective threshold has risen in parallel with the tropical mean SST
- Consistent with the moist adiabatic lapse rate (MALR) adjustment of the tropical troposphere



Tropospheric temp, surface wind & rainfall

Xie, S.-P., Y. Du, G. Huang, X.-T. Zheng, H. Tokinaga, K. Hu, and Q. Liu, 2010: Decadal shift in El Nino influences on Indo-western Pacific and East Asian climate in the 1970s. *J. Climate*, 23, 3352-3368.