Modes of Indo-Pacific variability and predictability of East Asian climate

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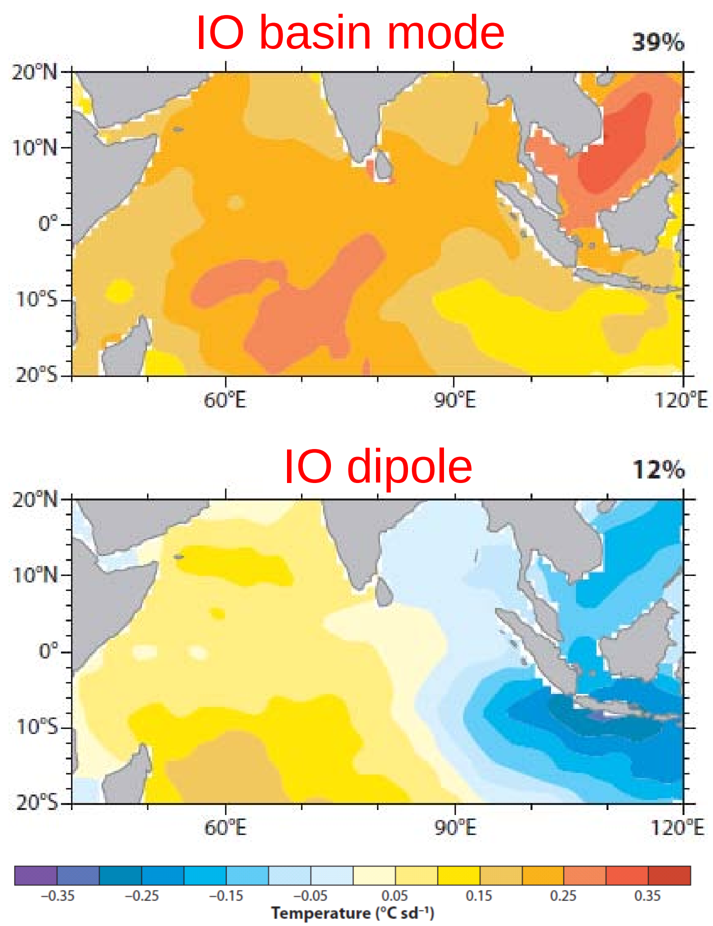
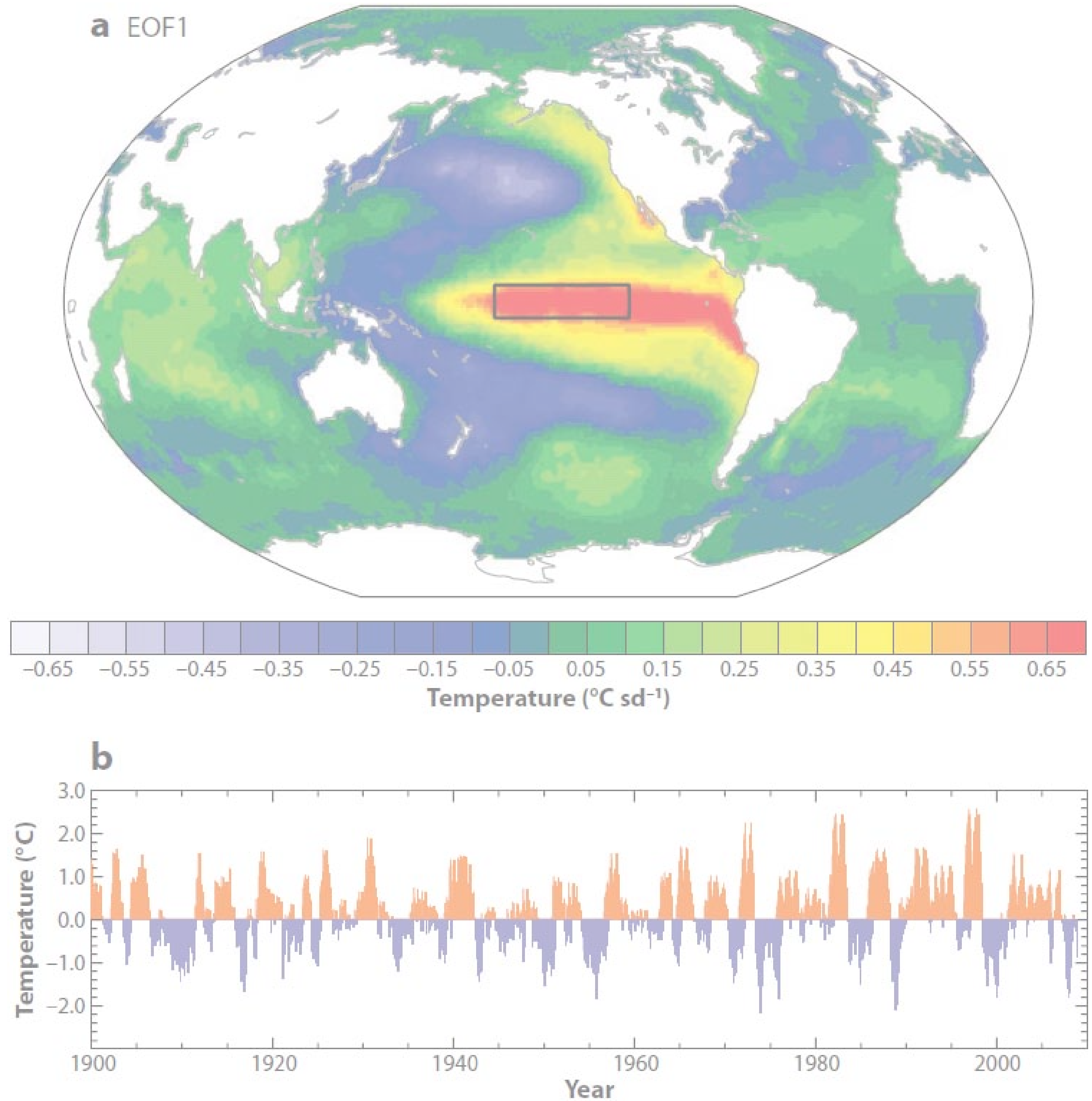
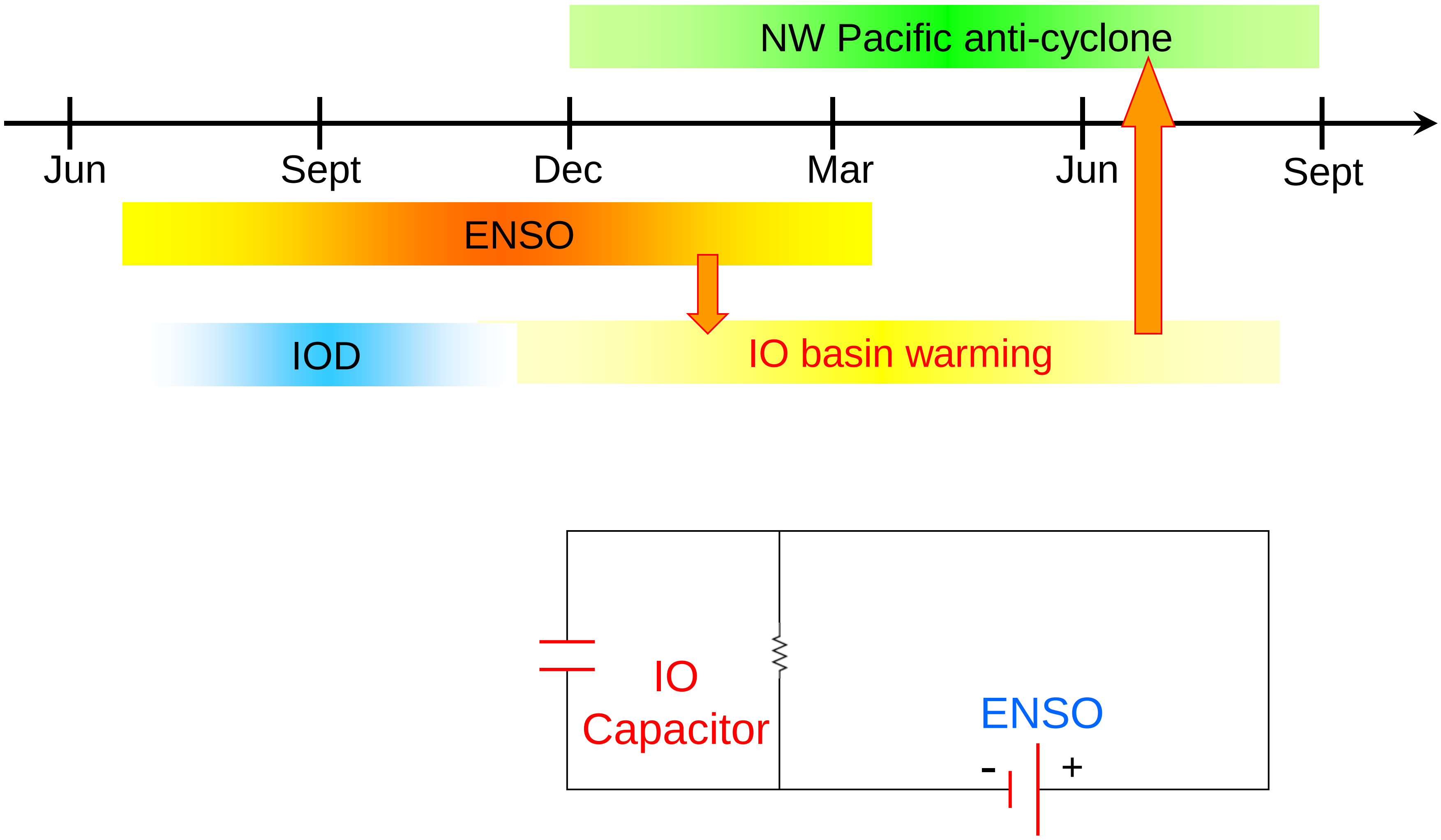
El Nino-Southern Oscillation (ENSO)





Deser et al. (2010, *Annu. Rev. Mar. Sci.*)

Major modes and phase locking



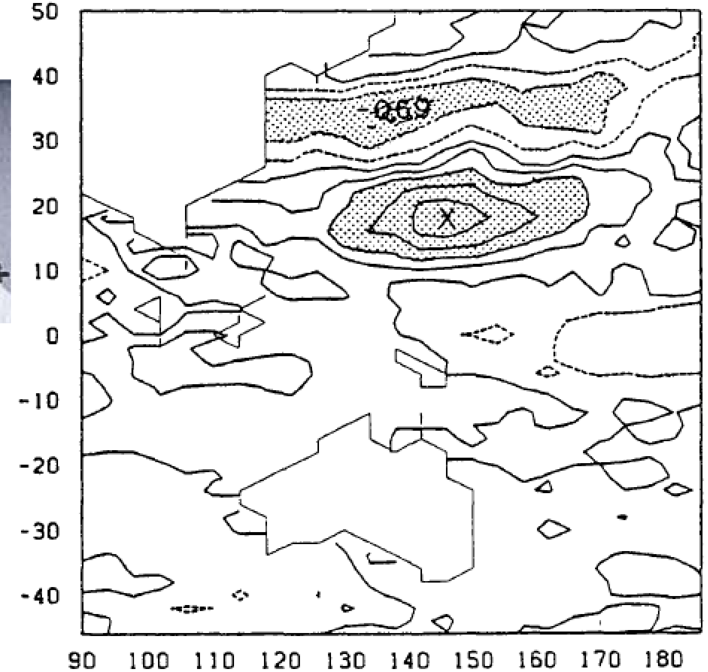
Important science questions

- What determines the spatio-temporal characteristics of summer rainbands over the NW Pacific and East Asia?
- What causes their year-to-year variability?
- How predictable is the variability?

Pacific-Japan pattern

(Nitta 1986, 1987, JMSJ)

But what anchors it?



One point correlation with high cloud amount at 146E, 18N for 1978-83. Nitta (1986)

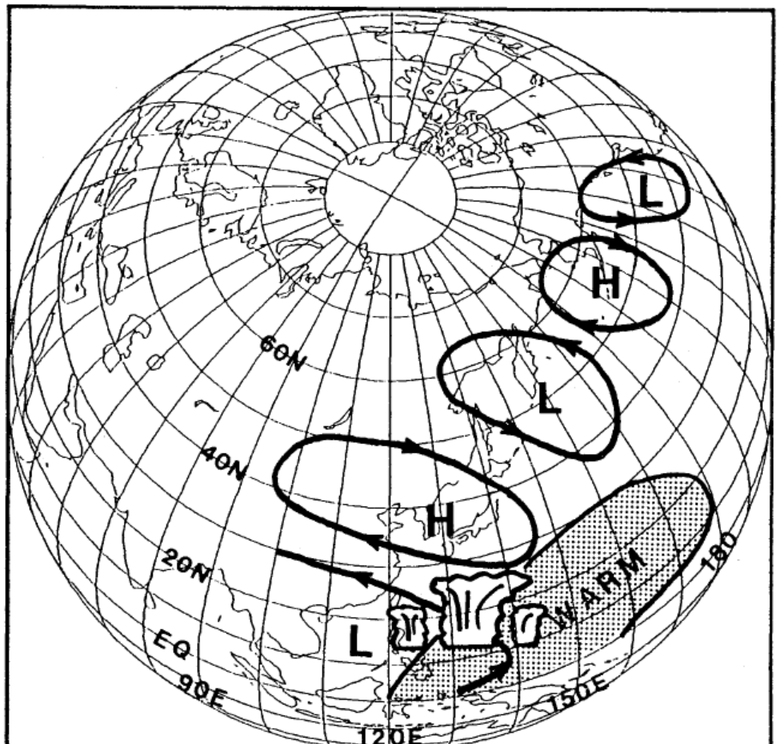


Fig. 18. Schematic pictures showing the relationships between SST anomalies, convective activities and atmospheric Rossby-wave trains.

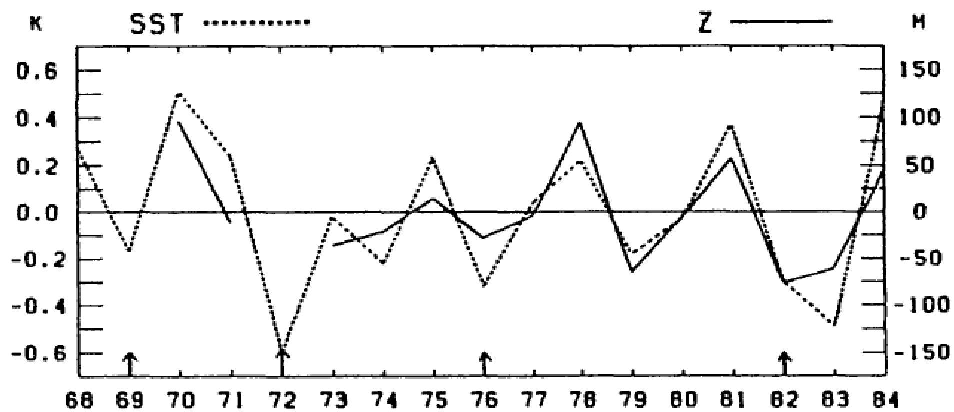
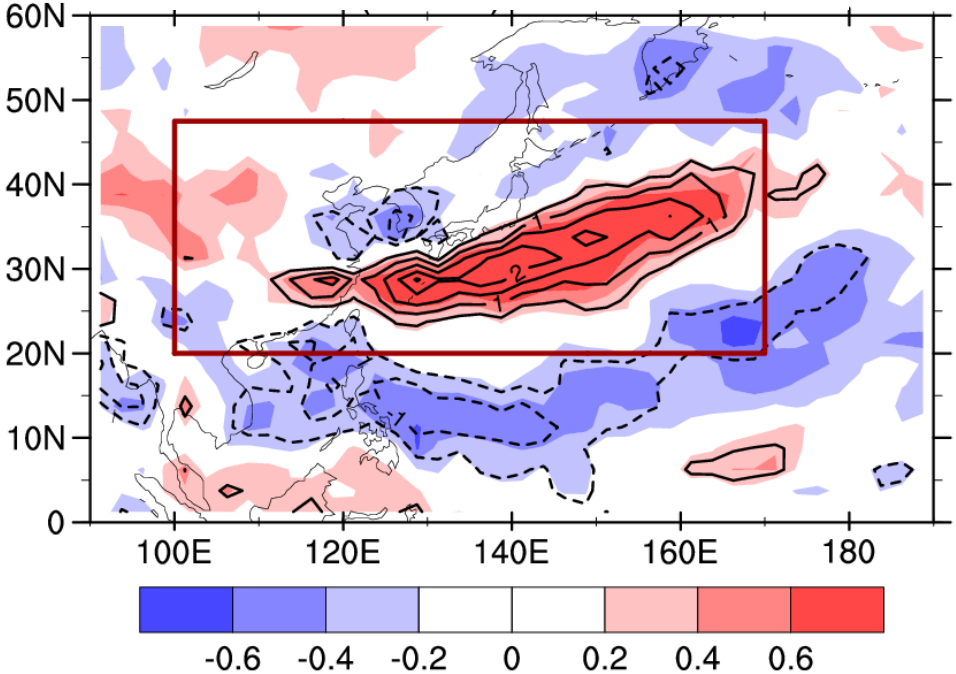
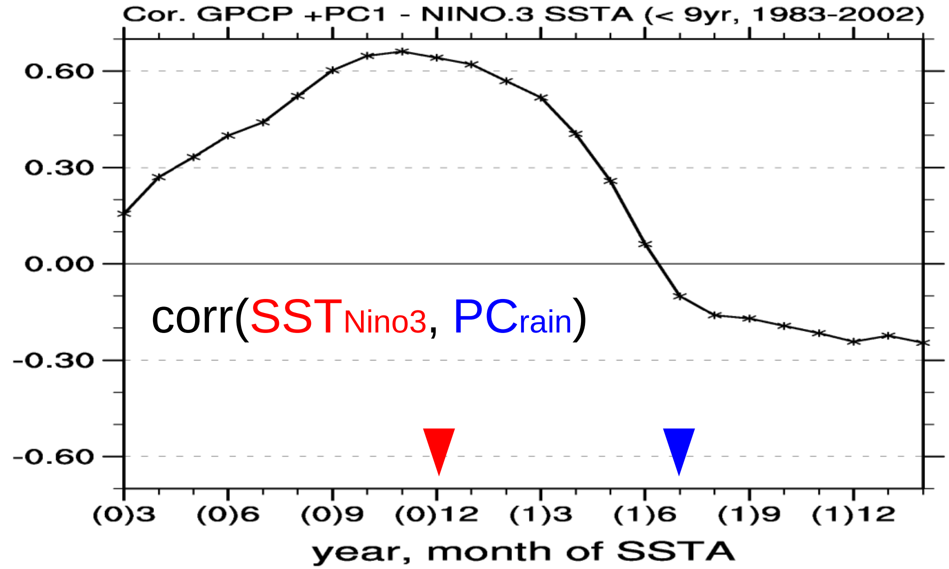


Fig. 19. Time series of SST anomalies in June averaged in the area of 10*N-20*N, 150*E-170*E (dashed line) and height anomalies at 300mb in July at 40*N, 150*E (solid line) for 17 years from 1968 to 1984. Arrows denote El Nino years.

Meiyu-Baiu rainfall EOF-1 (26.3%)



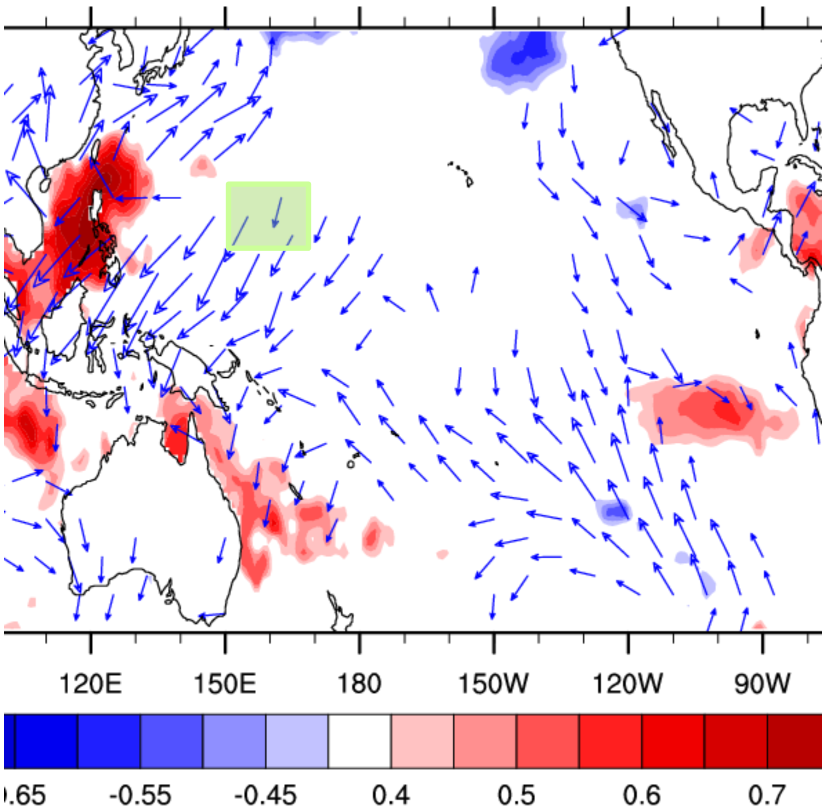
T. Sampe



- EOF-1 represents the PJ pattern.
- Correlated not with the concurrent Nino SST, but with Nino eight months ago.

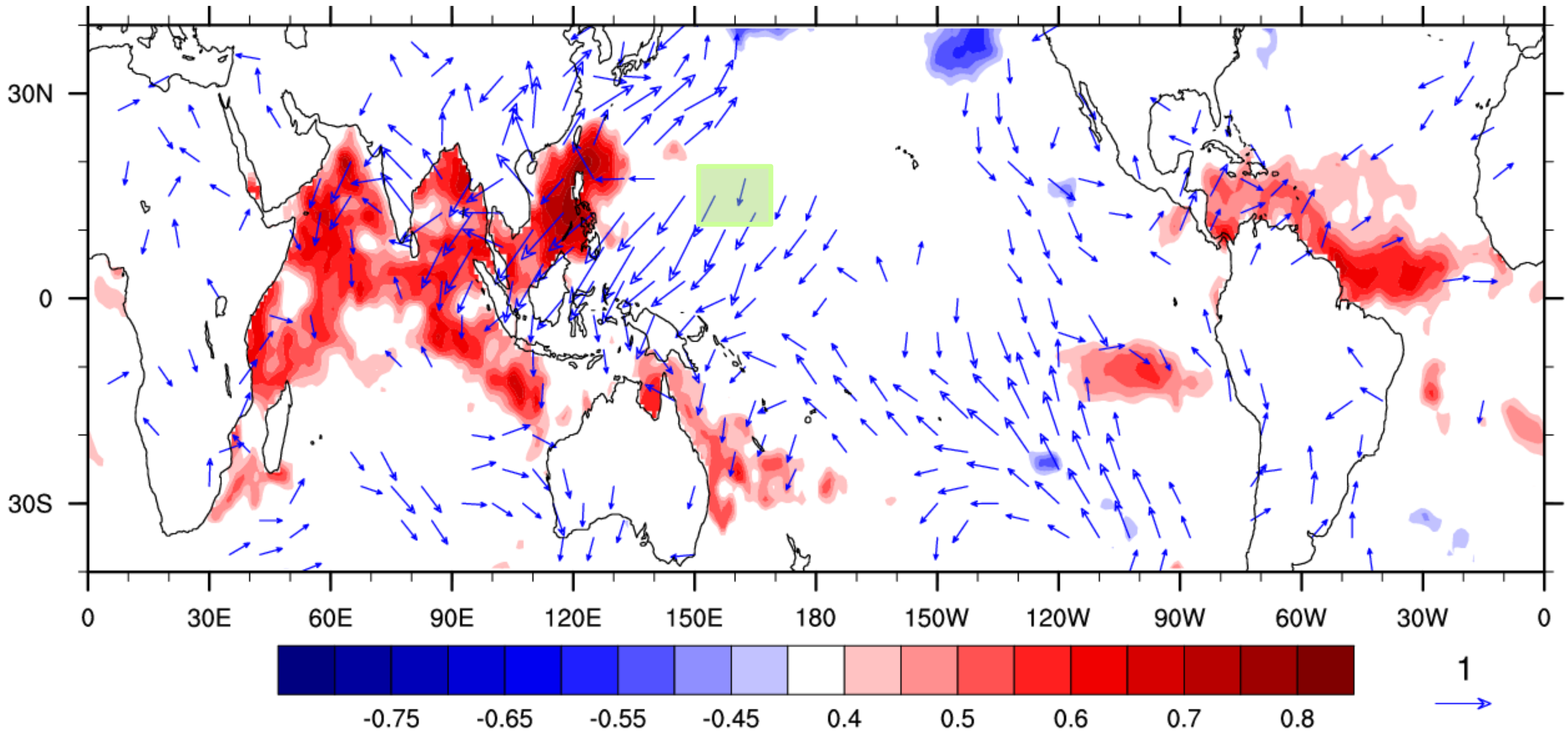
What SST anchors the anomalous anticyclone over NW Pacific?

Nitta's (1987) SST index



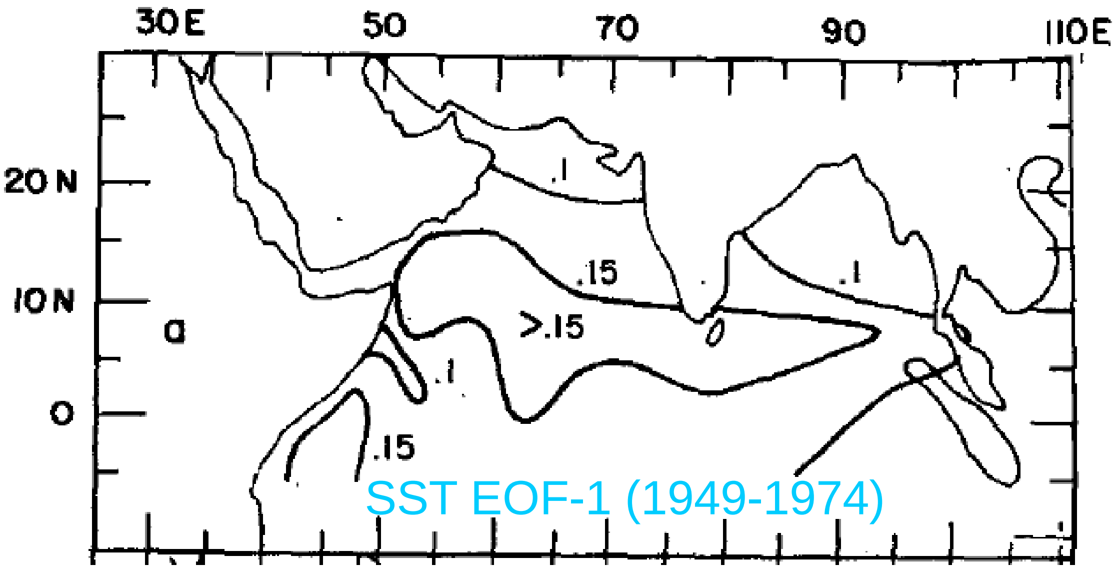
SST & surface wind correlation with the NWP monsoon index of B. Wang et al. (2001, JC) based on meridional shear

Highest SST correlation in North Indian Ocean & South China Sea, not in Pacific



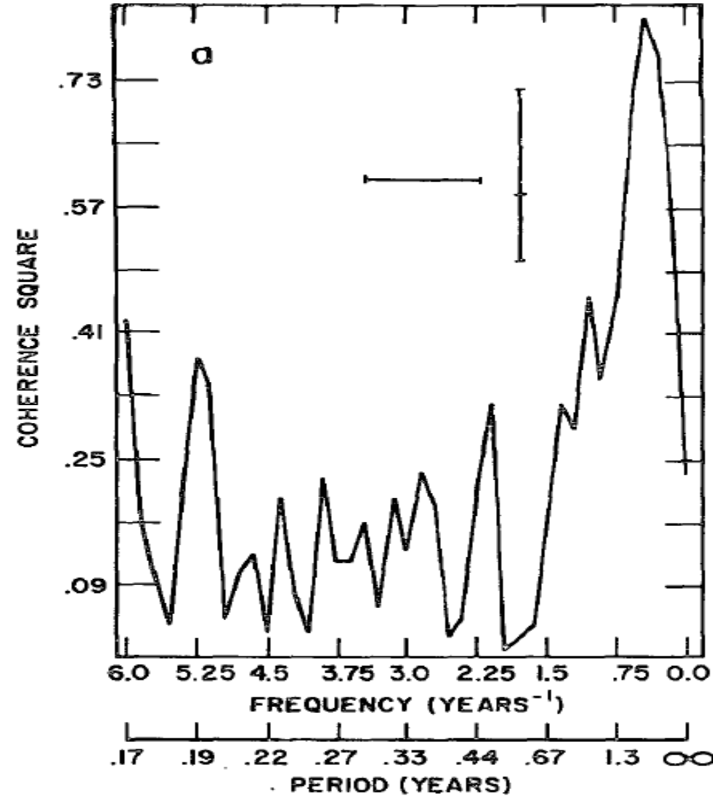
JJA SST & surface wind correlation with the NWP monsoon index of
B. Wang et al. (2001, JC) based on meridional shear

Courtesy of Xia Qu (IAP/CAS)



Pacific and Indian Ocean SST's are very coherent at periods near 3 years such that variations in the Pacific lead variations in the Indian by 1.2 ± 0.5 months (at the 95% significance level).

Weare (1979, JAS)

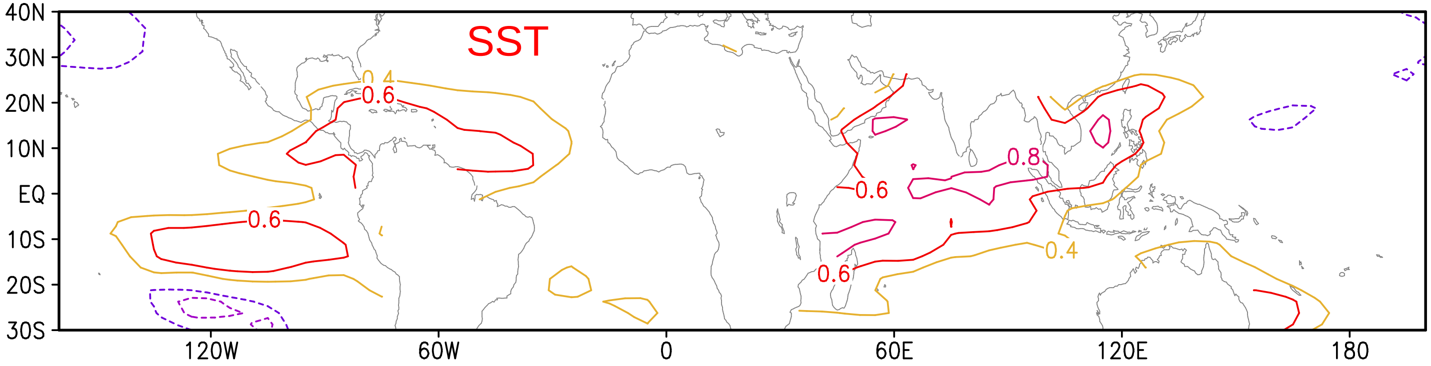


Coherence square b/w EOF-1 for IO and Pac

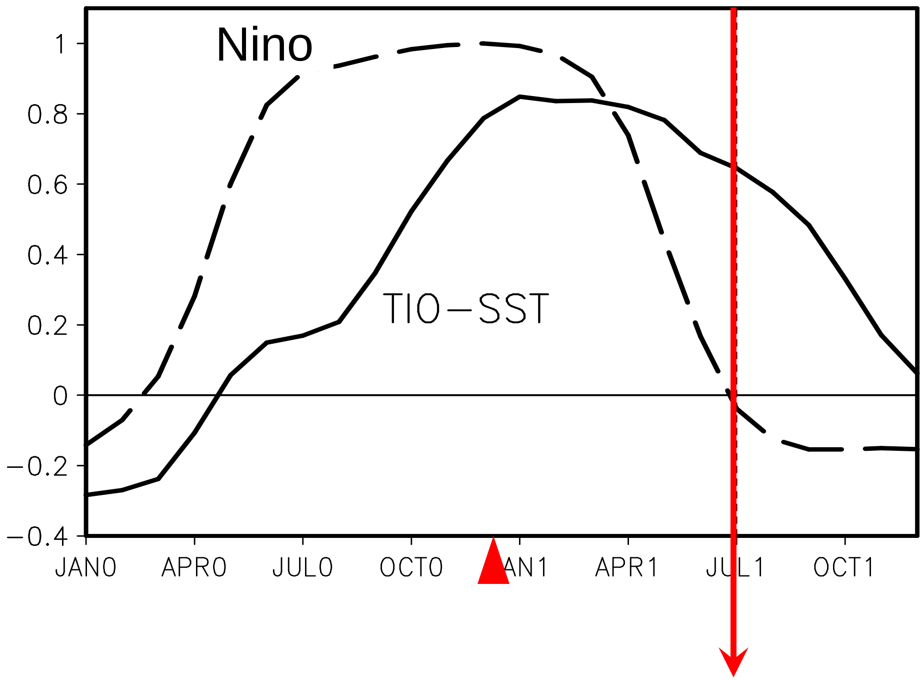
- IO SST warming has long been dismissed as passive on the ground that rainfall decreases there at the peak of El Nino.
- Does IO remain passive in the subsequent seasons?

Last echoes of ENSO, with most robust anomalies

- Ocean: Indian Ocean warming
- Lower-troposphere: Anticyclone & rainfall decrease over NW Pacific

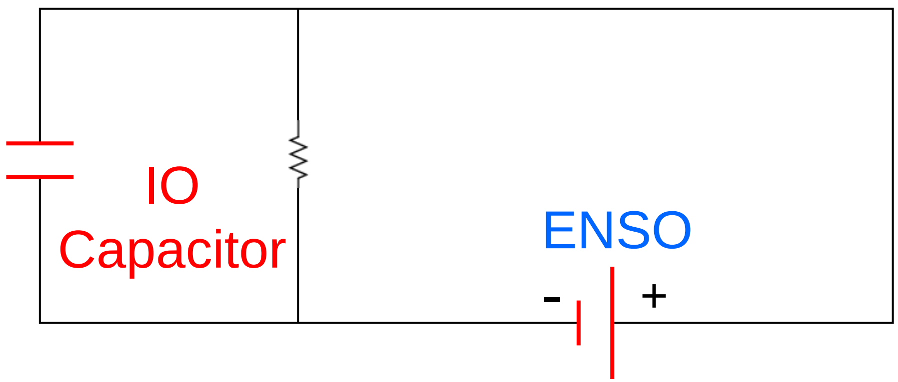


JJA(1) corr with NDJ(0) Nino SST



Tropical Indian Ocean warming persists through JJA(1), and could exert climatic influences after El Nino has dissipated.

But how?

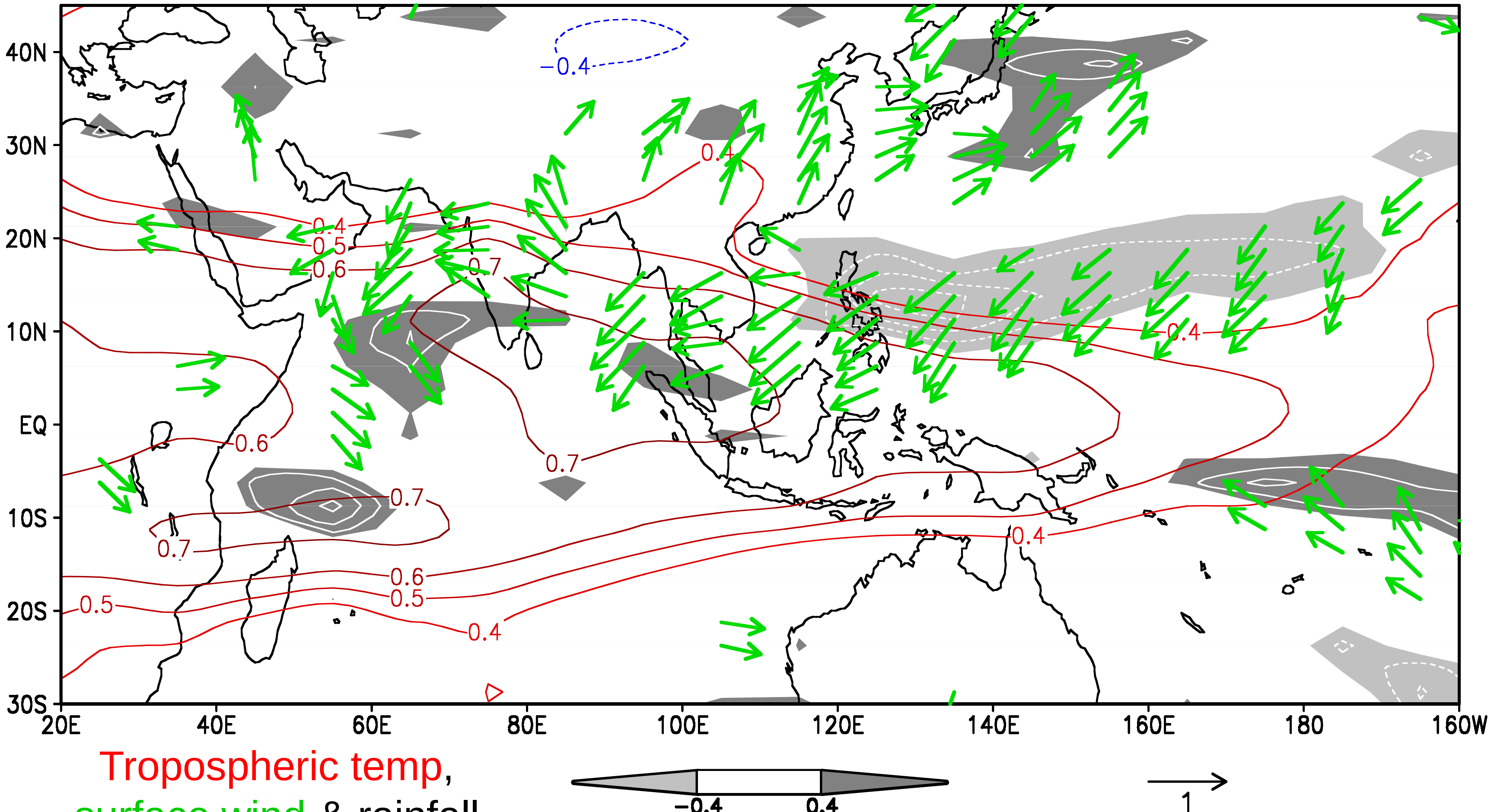


Yang, J., Q. Liu, S.-P. Xie, Z. Liu, and L. Wu, 2007: Impact of the Indian Ocean SST basin mode on the Asian summer monsoon. *Geophys. Res. Lett*., 34, L02708, doi: 10.1029/2006GL028571.

For non-summer seasons, Su et al. (2001, JGR-A); Watanabe &Jin (2003, JC); Annamalai et al. (2005, JC). See also Wu & Liu (1995, *Sci. Atmos. Sinica*)

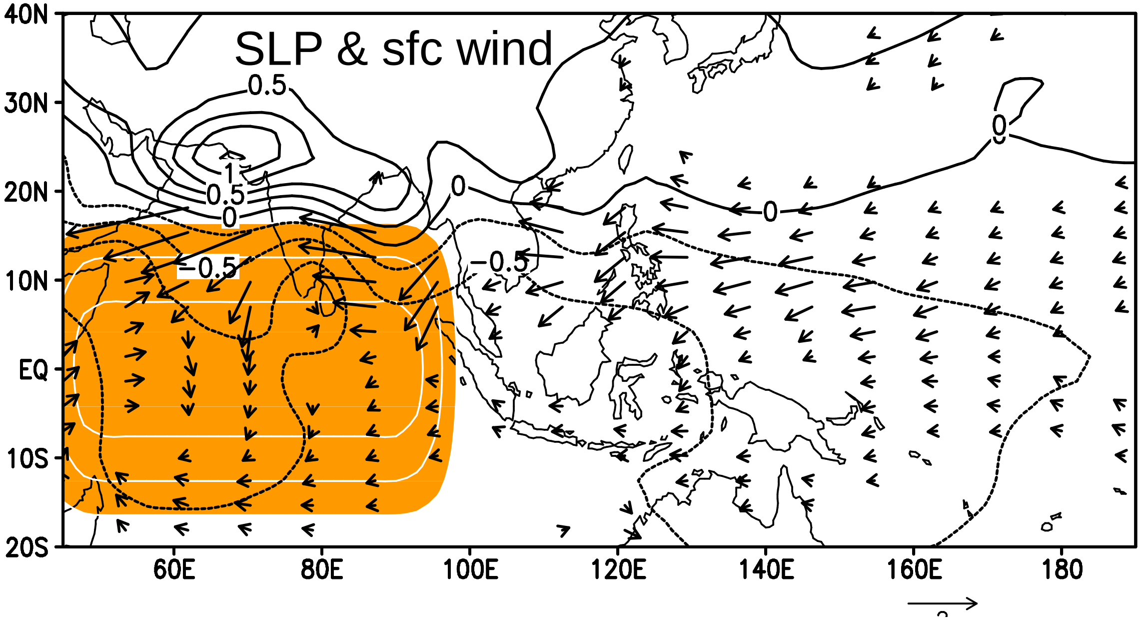
How does IO warming force NW Pacific anticyclone?

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

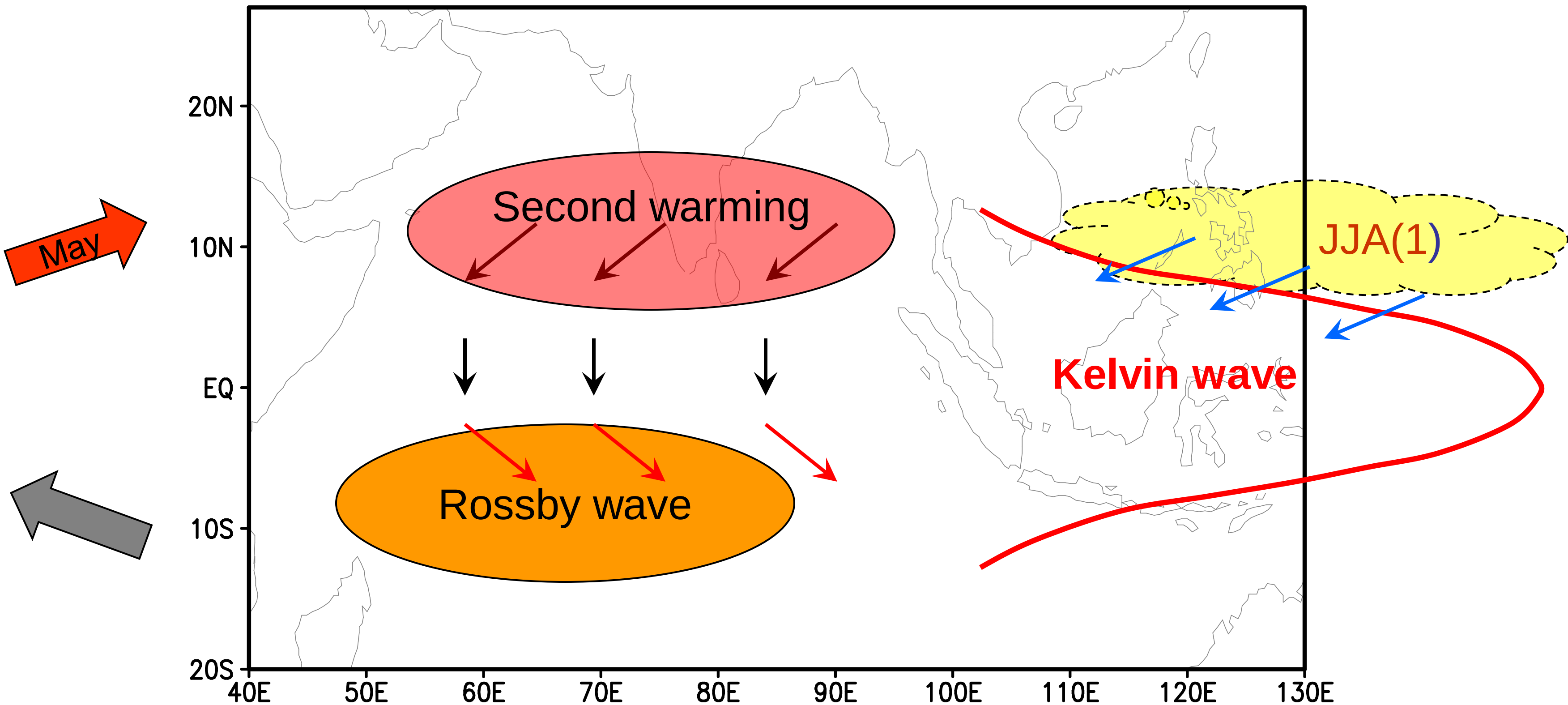
Linear atmospheric model response to TIO heating



TIO warming
→ Kelvin wave
→ NE wind in NW Pacific

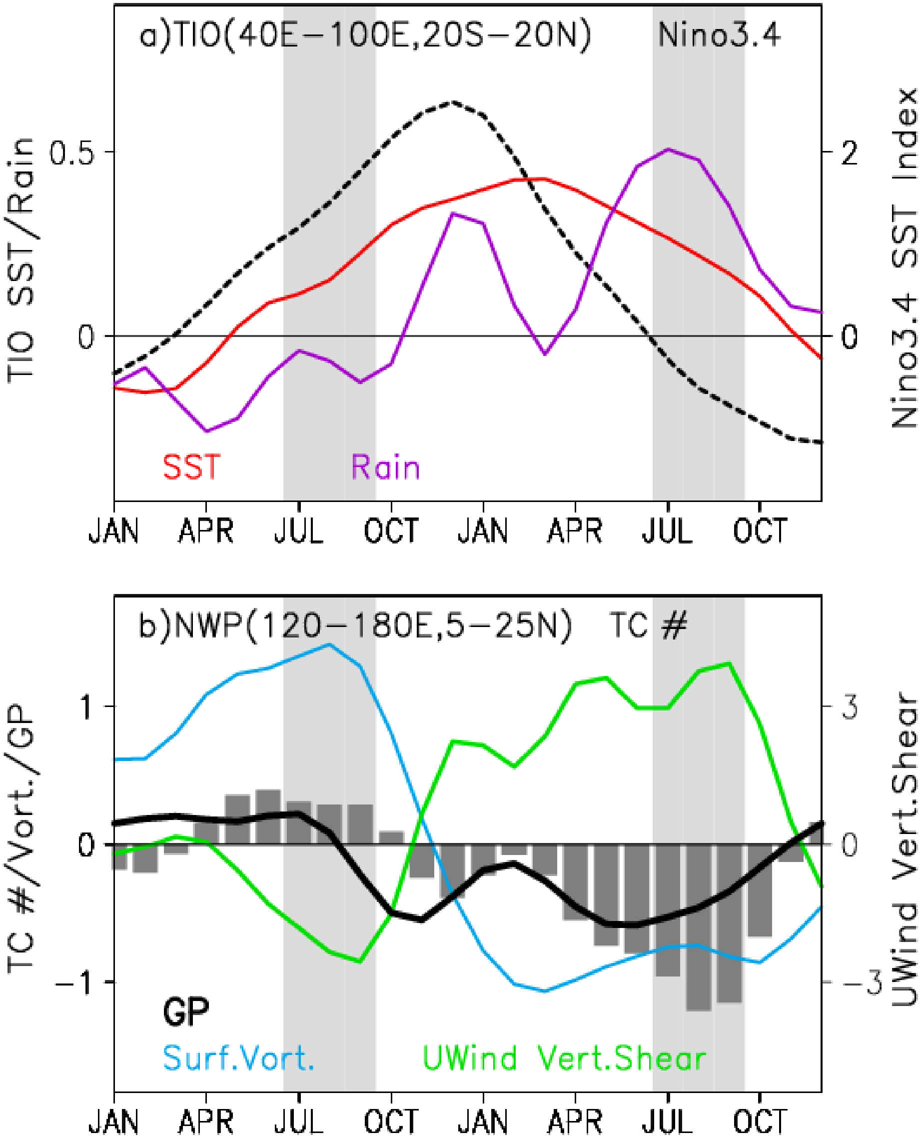
In NW Pacific, let
convective heating proportional
to sfc convergence

Summary



- ✓ IO-atmosphere interaction, anchored by SWIO Rossby wave, is key to the persistence of the IO basin warming through JJA(1).
- ✓ The IO warming, via Kelvin wave-induced Ekman divergence, reduces rainfall reduction and forces an anticyclone in NW Pacific.

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.



- TC count does not change much between El Nino and La Nina JAS(0) (B. Wang & Chan 2002)
- Fewer TCs in NW Pac in summers following El Nino JAS(1) ← suppressed convection & increased shear
- JAS TC count < 12 in 7 out of 39 years, all following El Nino except 1986 (climatology=14.2).

Du, Y., L. Yang, and S.-P. Xie, 2010: Tropical Indian Ocean influence on Northwest Pacific tropical cyclones in summer following strong El Nino. *J. Climate*, in press expedited.

Only one typhoon as of July 5, possible due to Indian Ocean warming

The Nikkei daily

73 (0), 75 (1), 83 (1), 10 (1)

H.22.7.05日経(夕) 14面

今年の台風 まだ1個

インド洋の高海水温、影響か

7月に入り夏本番も間近だが、今年は台風がまだ1個しか発生していない。気象庁によると、6月末現在で台風が1個以下だったのは1998年以来12年ぶりで、51年の統計開始以降、ほかには73年（0個）と75、83年（1個）だけだ。同庁は、インド洋の海面水温が高いことが原因の可能性があるとみており、北日本を中心とした冷夏など天候不順につながる恐れもあるという。

北日本で冷夏の恐れも

今年の台風は、3月24日に発生した1号のみ。6月末までの発生数の平年値は4・5個。

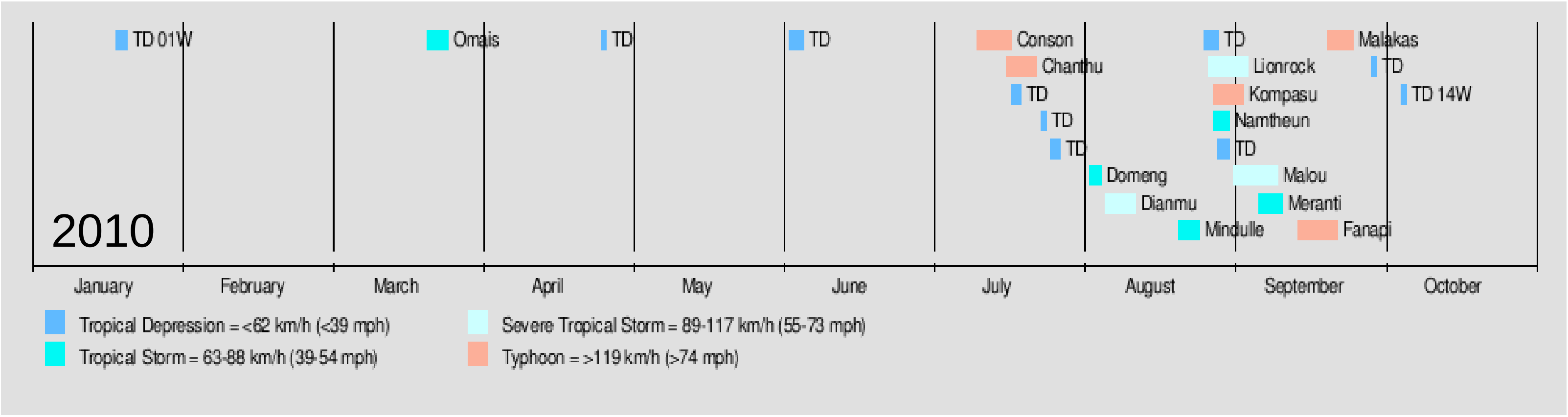
気象庁によると、今年はインド洋の海面水温が高く、大気の対流活動が活発化。逆にフィリピン近海は対流活動が弱く、台風が発生しにくい状態になっている。インド洋で上昇気流が盛んになる一方、フィリピン付近では下降気流が強まっているためとみられる。

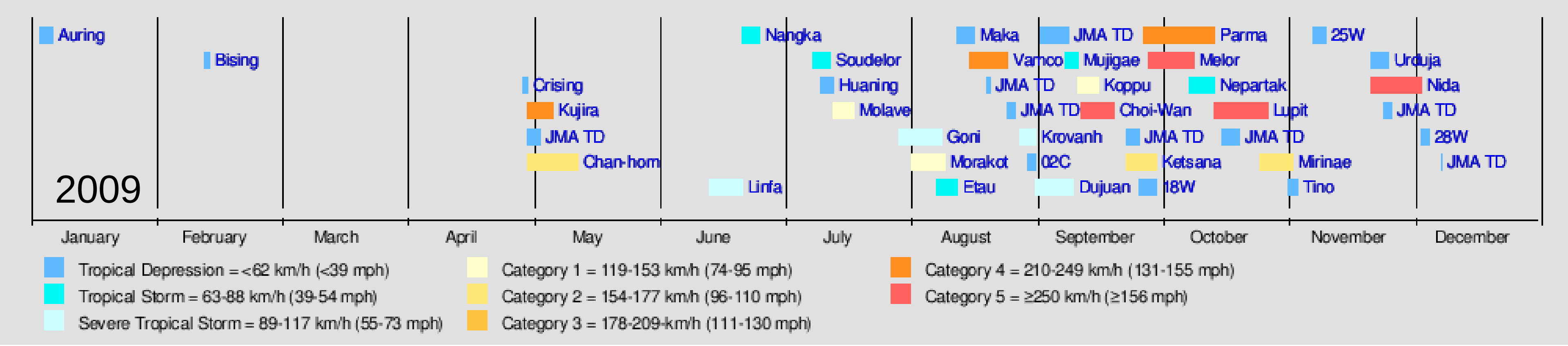
こうした状況は「エルニーニョ現象」終息直後によくみられるという。今年は春にエルニーニョが終息したばかりで、6月末までの台風が1個以下だった過去4回のうち、3回はエルニーニョが終息した年だった。

さらにフィリピン付近の対流活動が不活発だと、台風が少ないだけでなく、太平洋高気圧の北への張り出しが弱まり、西日本は暑いが北日本は気温が低い「北冷西暑」パターンになりやすいという。

同様に台風が少なかった83、98年夏は「北冷西暑」で、「大気の状況が今年と類似している」（気象庁気候情報課）という。73年は北日本で高温、75年はほぼ全国的に平年並みの暑さだったが、両年とも沖縄は低温傾向だった。今後の台風発生の可能性について同庁は「フィリピン沖の海面水温が上昇しつつあり、対流活動の活発化の兆しもあるが、予測は困難」としている。

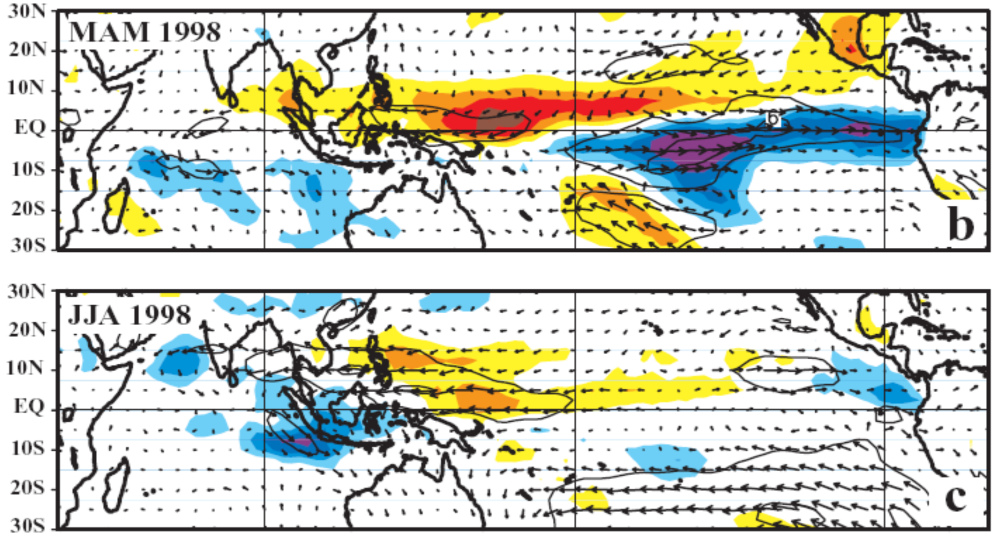
2010, a quite TC season (until late August)





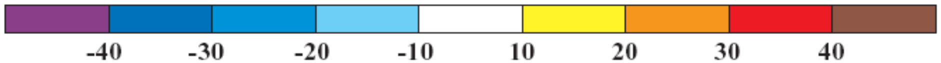
Are JJA(1) climate anomalies predictable?

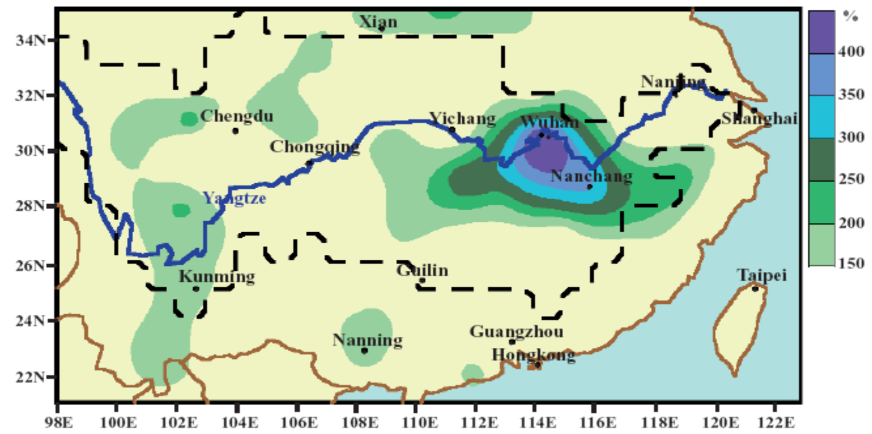
Great Yangtze Flood of 98



Bell et al. (1999, *BAMS*)

OLR & 850 mb wind

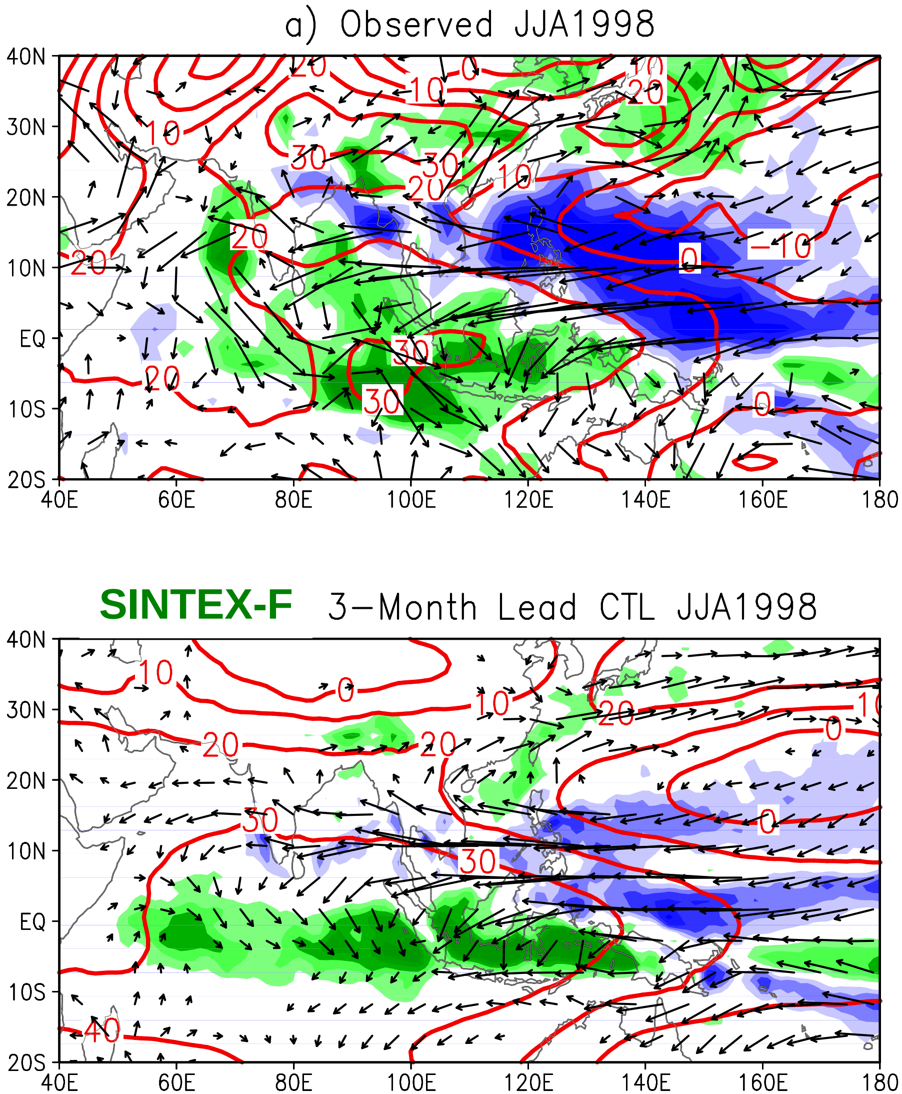




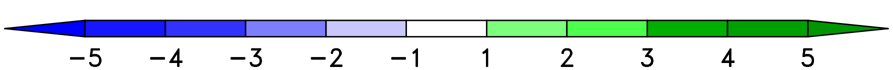
July 1998 rainfall anomalies in percentage

Great Yangtze Flood of 1998 summer

Chowdary et al. (2010, *Clim. Dyn.*)



(u,v) 850 hPa, Precip
temp (850-200 hPa)



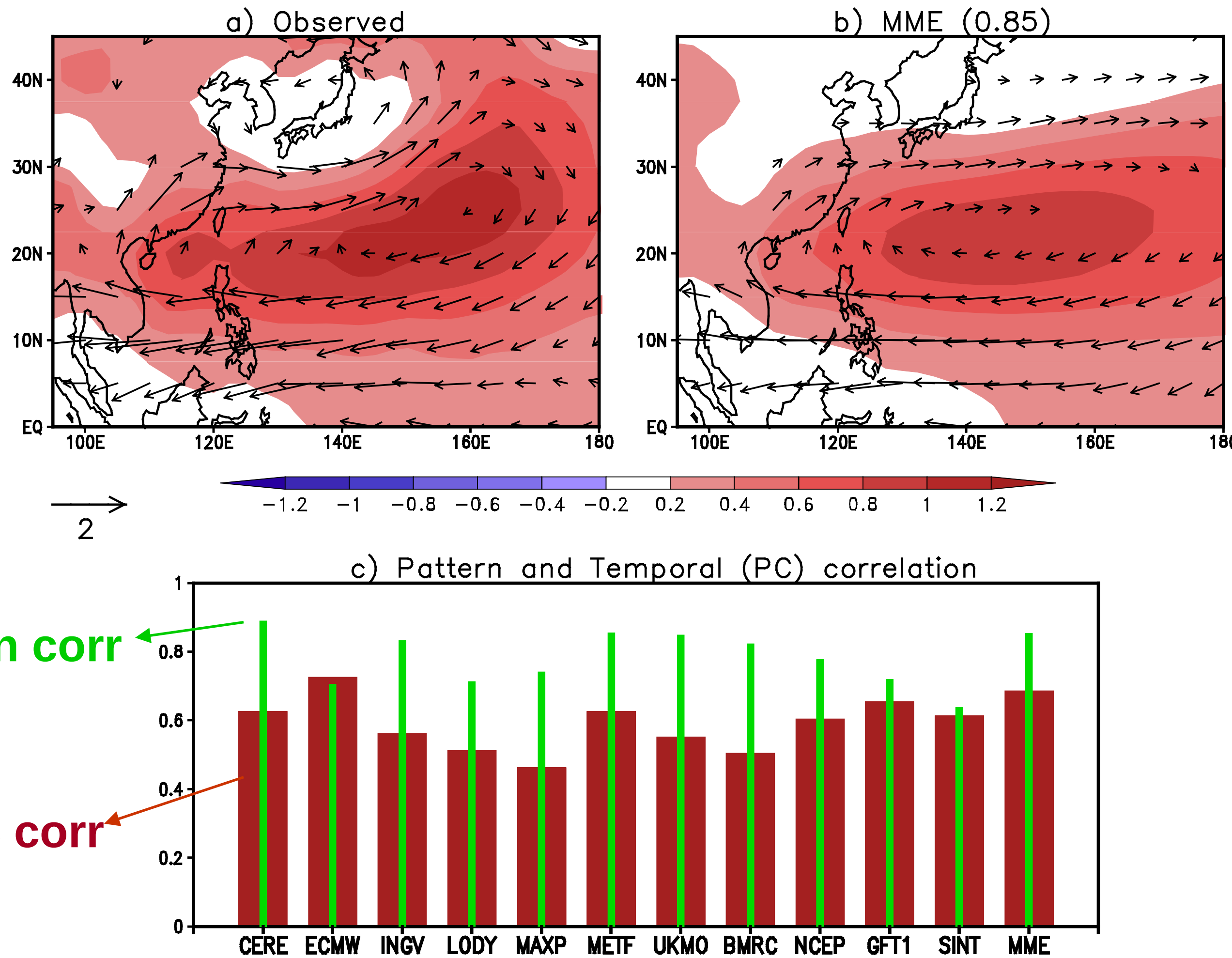
Multi-model forecast of JJA(1) climate, initialized on May 1

Chowdary et al. (2010, *JGR-Atmos*)

SLP EOF & 850 hPa wind

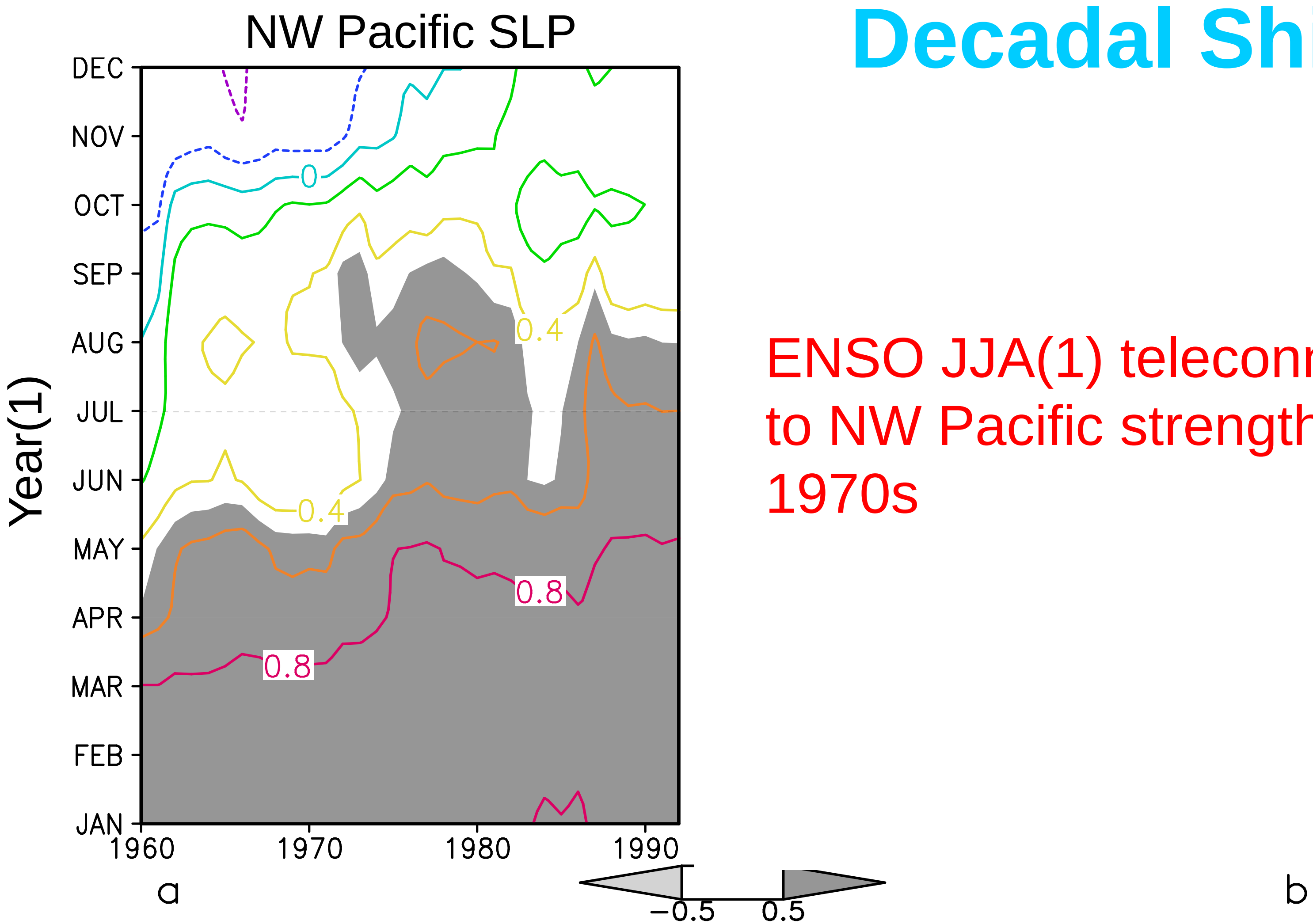
Pattern corr

PC corr



✓ **Many models and MME showed good skills in both pattern and temporal correlations than most of individual models.**

Decadal Shift

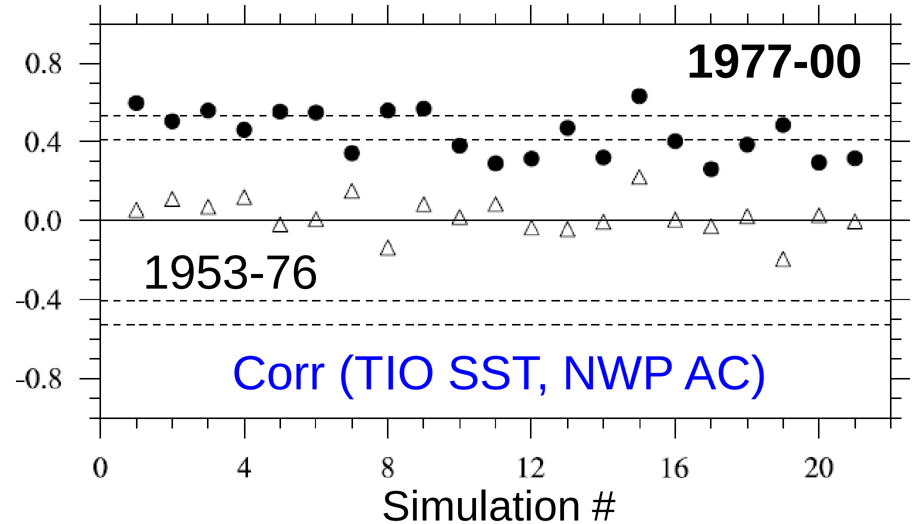


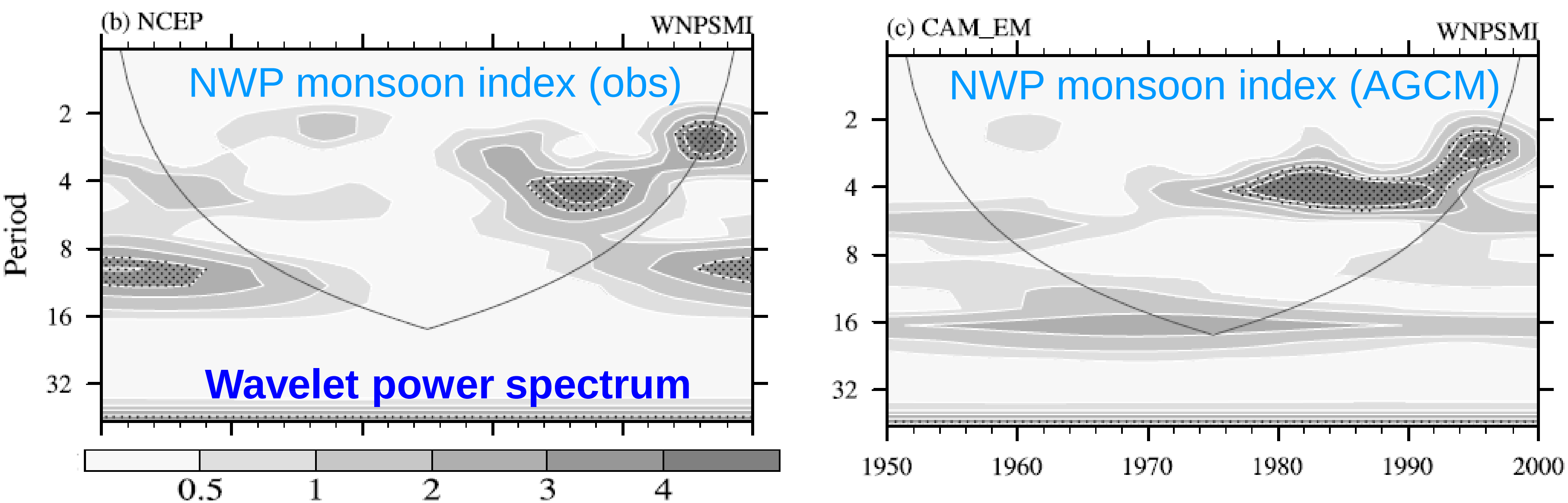
ENSO JJA(1) teleconnection to NW Pacific strengthened in 1970s

21-year running correlation with the NDJ(0) Nino3.4 SST for ENSO decay year

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

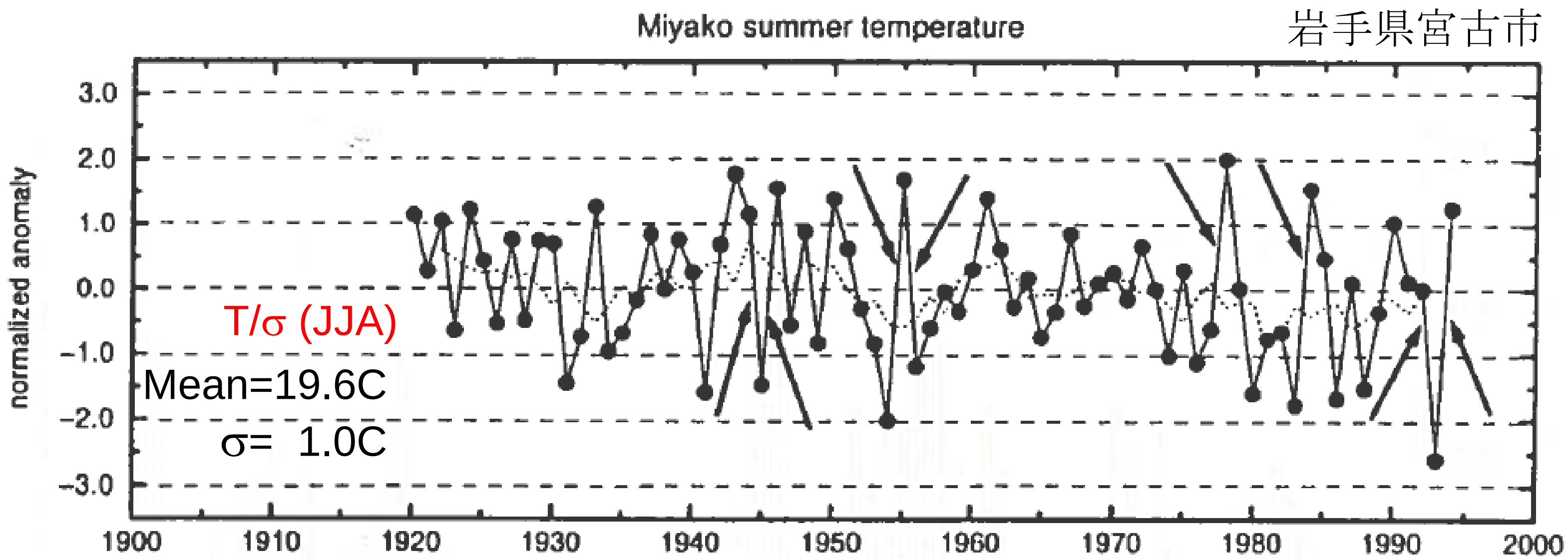
Has the TIO capacitor always been effective?

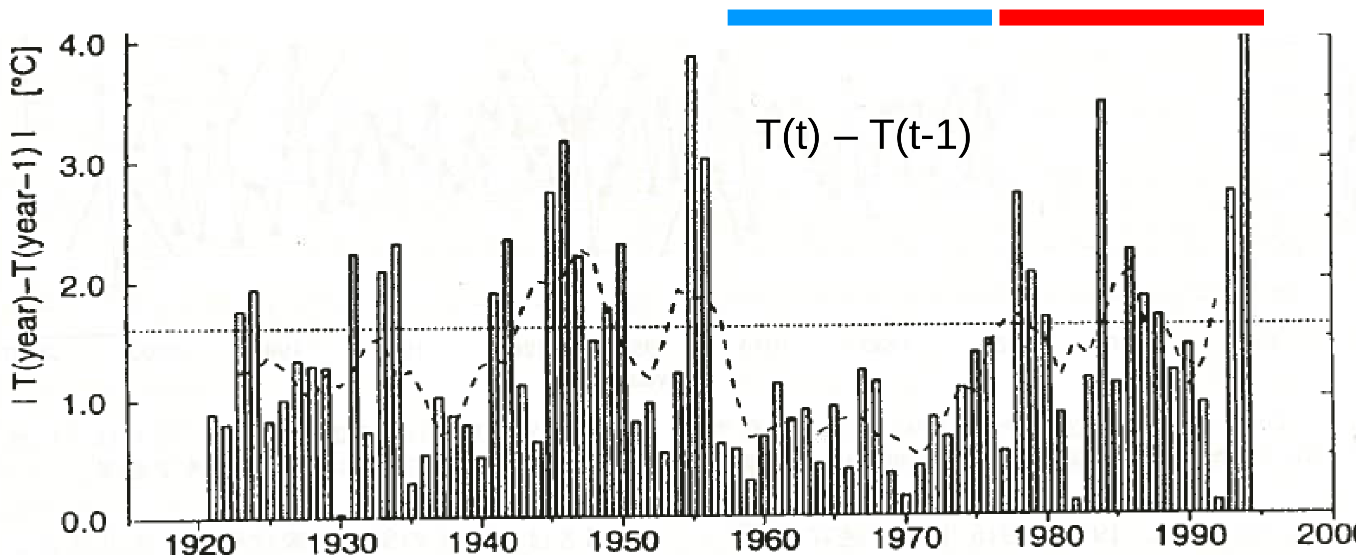




Huang, G., K. Hu, and S.-P. Xie, 2010: Strengthening of tropical Indian Ocean teleconnection to the Northwest Pacific since the mid-1970s: An atmospheric GCM study. *J. Climate*, in press.

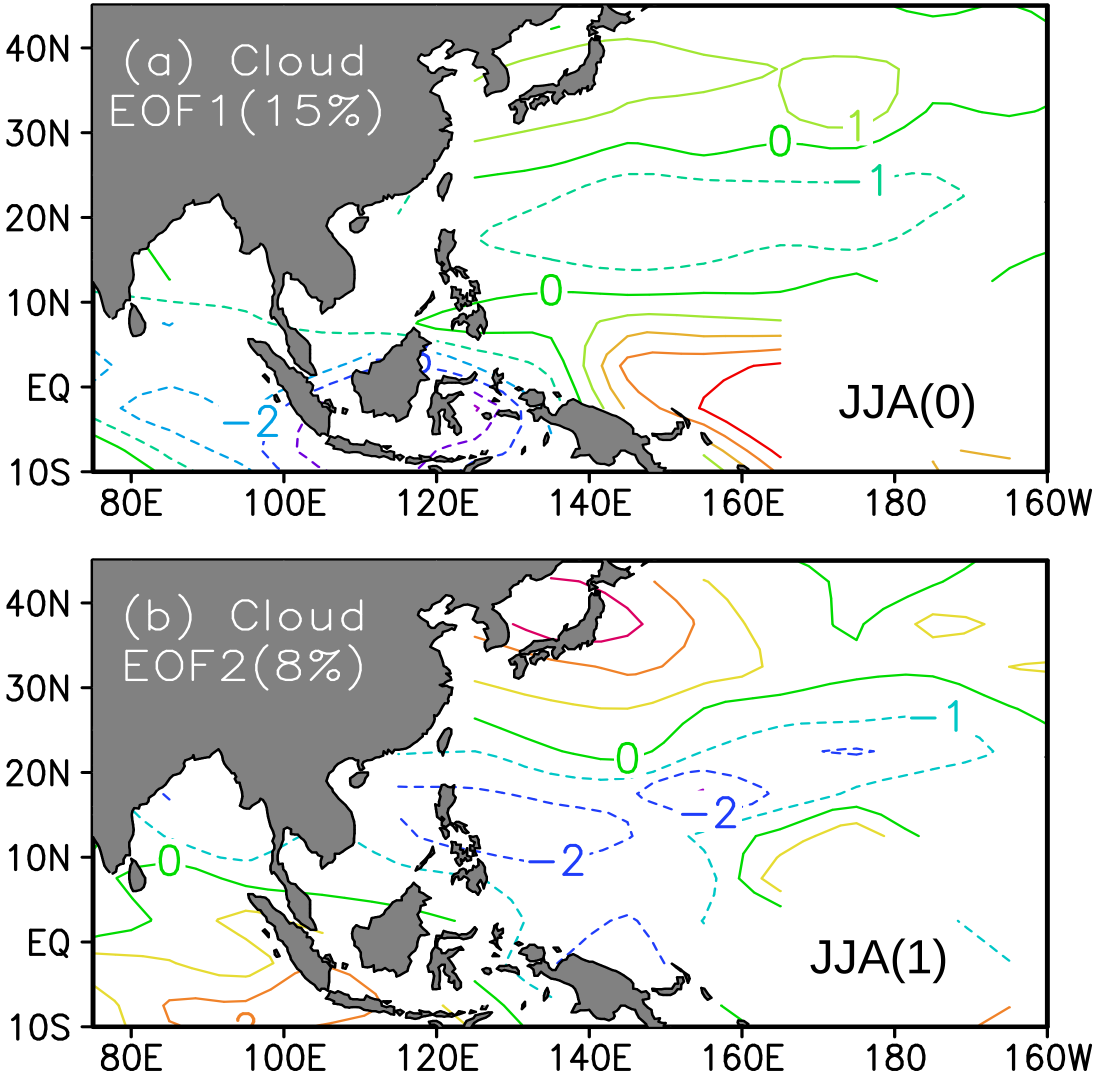
岩手県宮古市



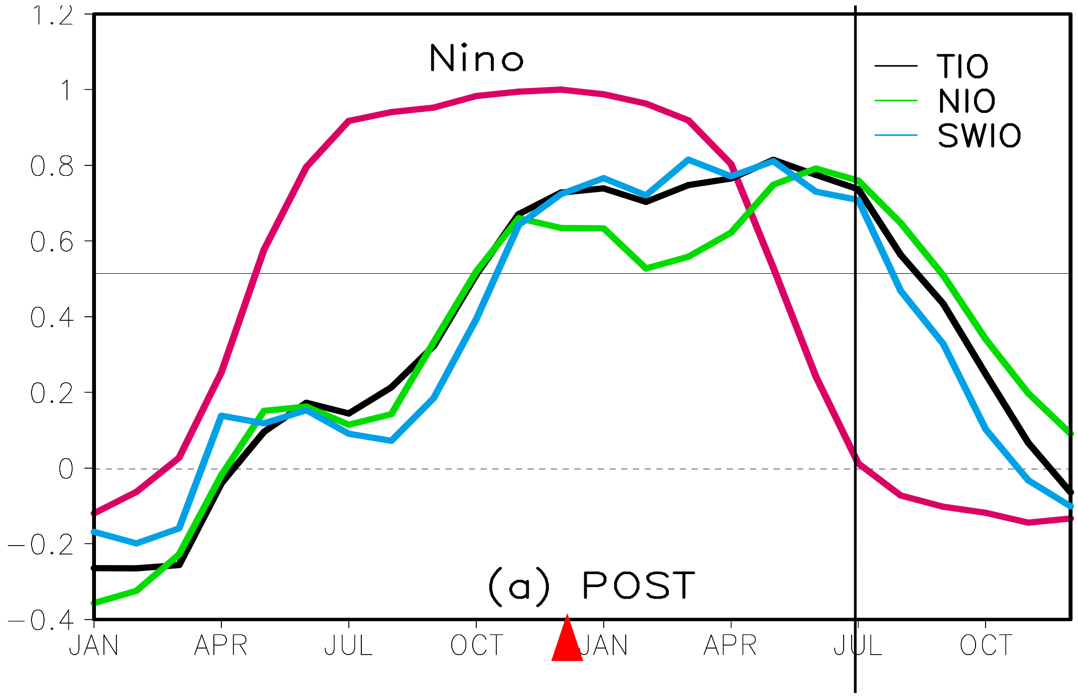


Hanawa (1997)
気象研究ノート

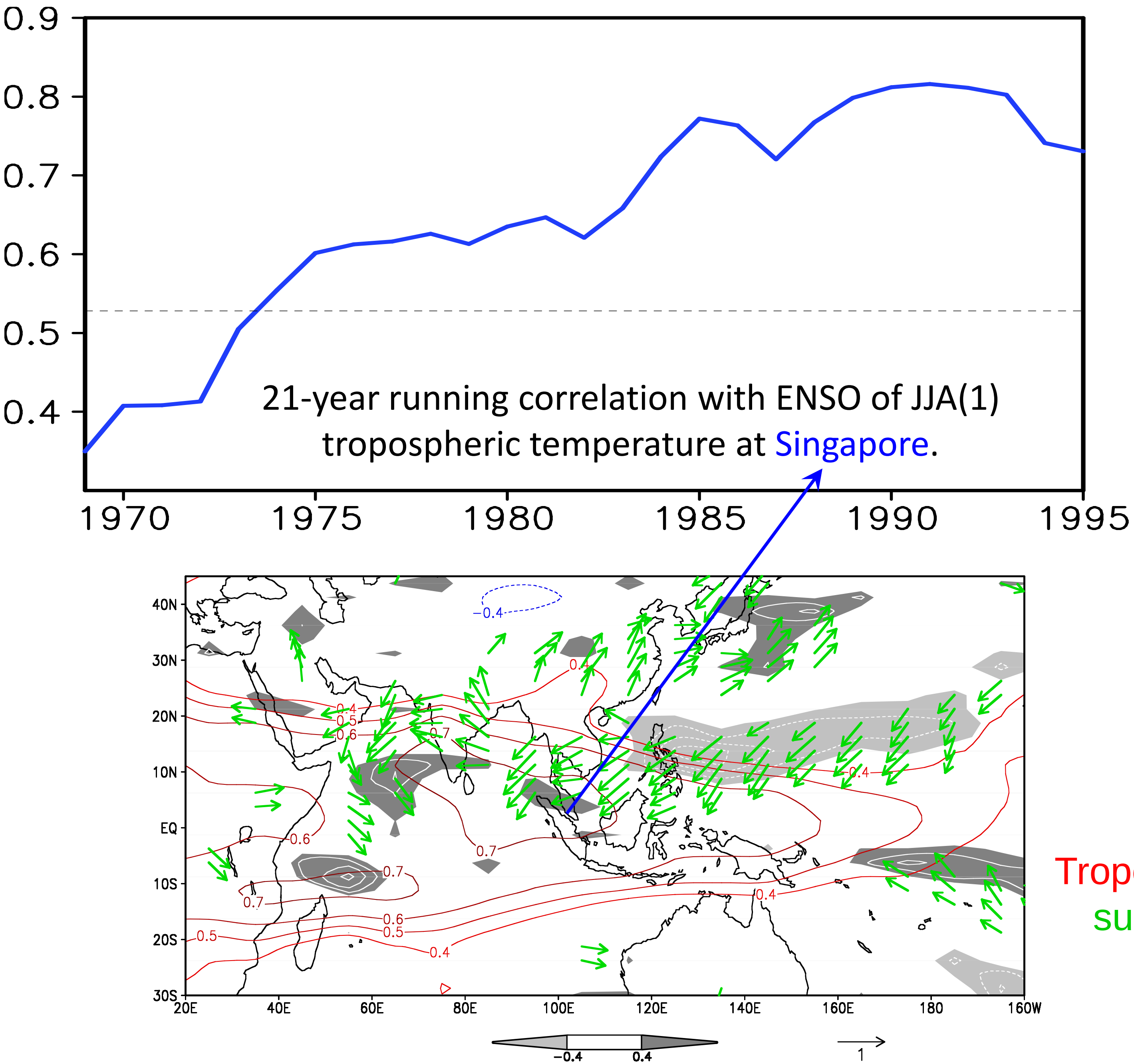
Summer cloudiness from iCOADS



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.



Correlation with
NDJ(0) Niño3.4 SST



Tropospheric temp, surface wind & rainfall

ENSO teleconnection to Indo-WP & East Asia has strengthened during decay phase since 1970s. Will it stay strong???

El Nino teleconnection (after 1970s)

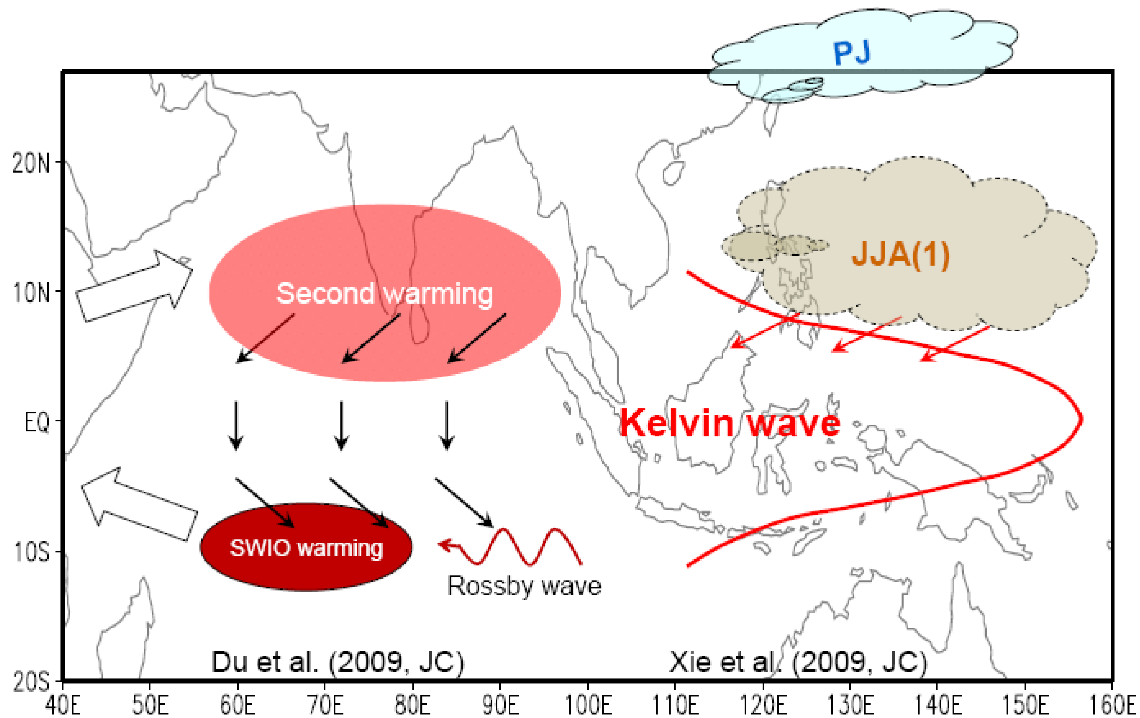
→ Ocean Rossby waves & persistent SST warming over SWIO (thermocline shoaling)

→ Anti-symmetric wind pattern & persistent North IO warming

→ Tropospheric Kelvin wave & frictional divergence

→ Convective feedback, and NW Pacific anticyclone

→ East Asian rainfall via PJ



Summary

- ✓ Tropical Indian Ocean warming anchors climatic anomalies over Northwest Pacific in JJA(1) summer, including anomalous anticyclone, suppressed convection, and reduced TC activity.
- ✓ The Indian Ocean capacitor is mediated by tropospheric Kelvin wave and amplified by convection-circulation feedback.
- ✓ Suppressed subtropical convection is associated with increased Meiyu/Baiu rainfall via the PJ pattern.
- ✓ Coupled models have good skills in predicting climate anomalies over the NW Pacific and East Asia at 1-4 months leads.
- ✓ The ENSO/TIO teleconnection to the NW Pacific has intensified since the mid-1970s, a change consistent with the Indian Ocean capacitor. (NWP anticyclone fails to develop when TIO warming is weak.)

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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.

Composites of summer following El Niño (1983, 92 & 98)