

On the Influence of Variability in the North Pacific and Tropical West Pacific on ENSO

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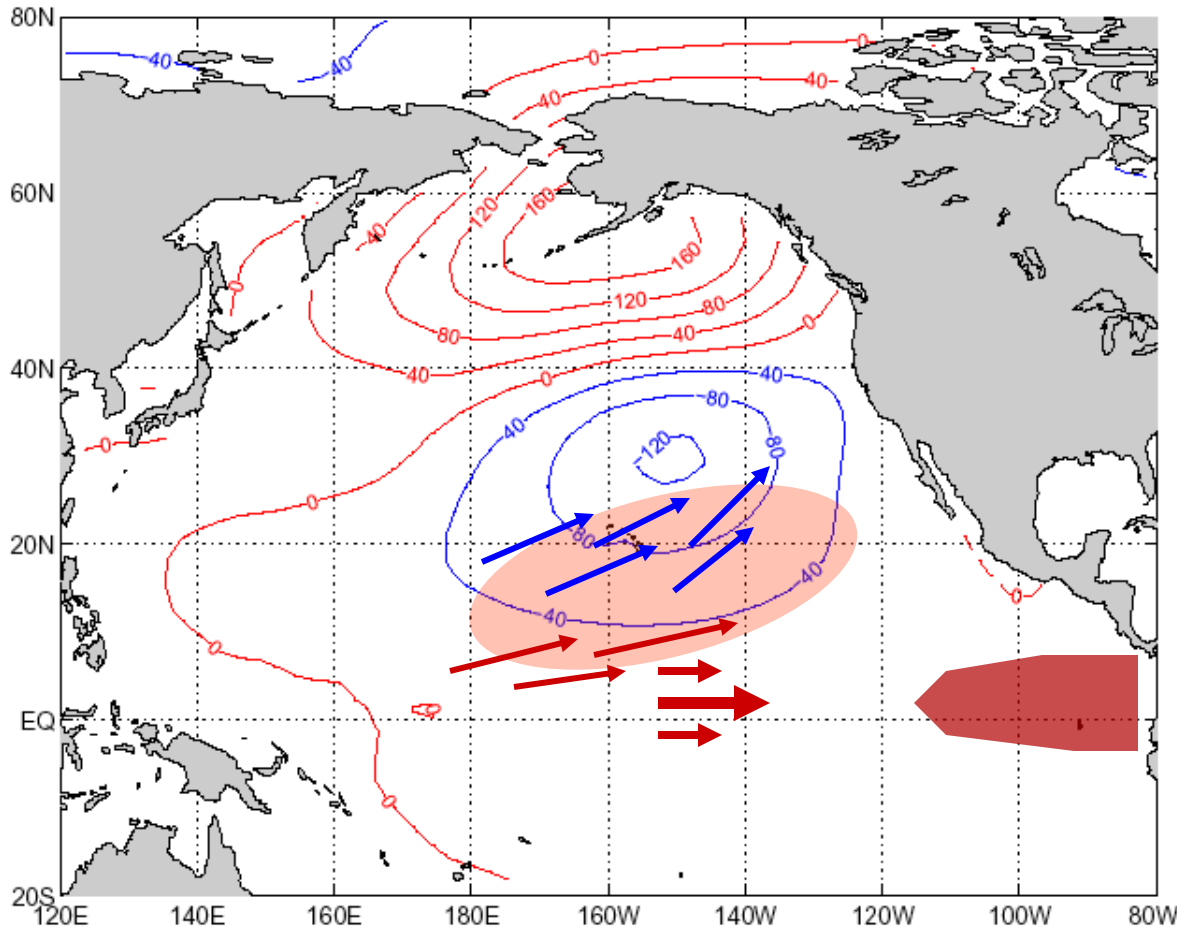
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Extratropical and Tropical ENSO Precursors

- Extratropical
 - “Seasonal Footprinting Mechanism (SFM)”
 - North Pacific SLP anomalies in previous winter impact the subtropical SSTs spring/summer and ENSO in the next winter
 - Vimont et al (2001, 2003), Anderson (2007)
 - Explore potential for SFM => ENSO
- Tropical West Pacific
 - Depth of thermocline on equator 12-18 month before ENSO event
 - Anderson (2007)
- NCEP Reanalysis (1948-2009)
- NCAR’s CCSM4: 500 year control integration

What is the Seasonal Foot Printing Mechanism (SFM)?



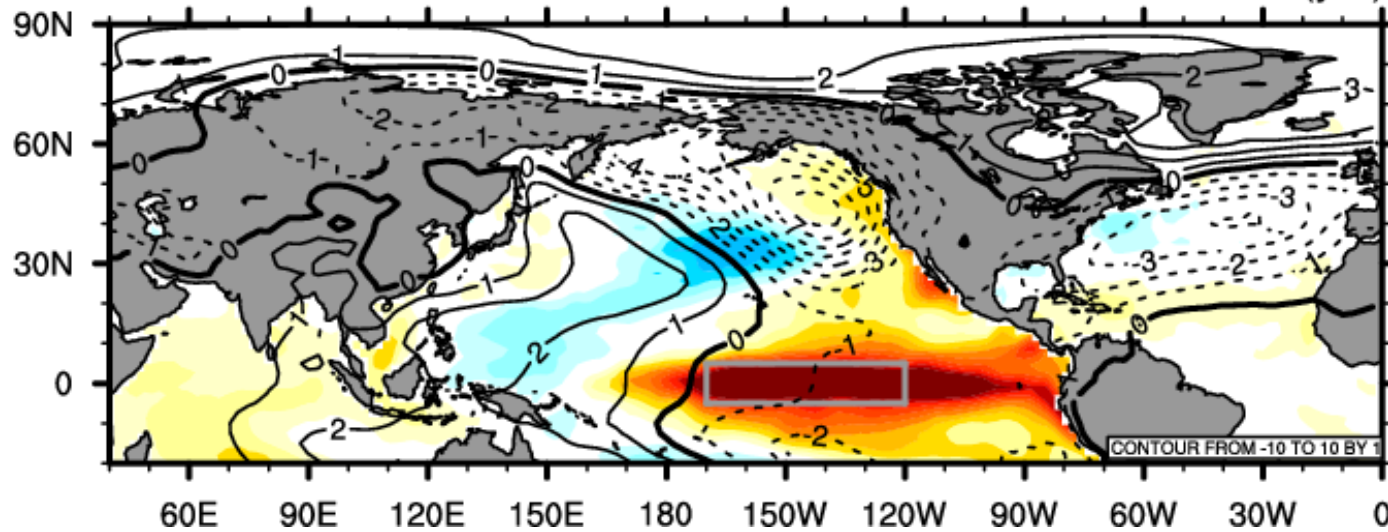
- *NPO in NDJ (-1)*
↓
- *Winds & Heat Flux*
↓
- *SST in FMA (0)*
↓
- *Tropical Winds*
- *Feedback (e.g. WES)*
JJAS(0)
↓
- *El Nino in NDJ(0)*

Vimont et al. 2001, GRL; 2003a&b, J. Climate

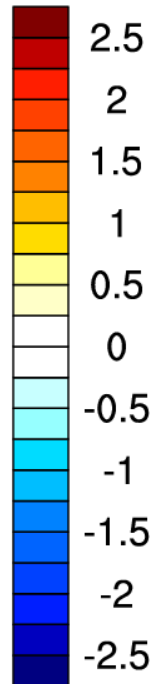
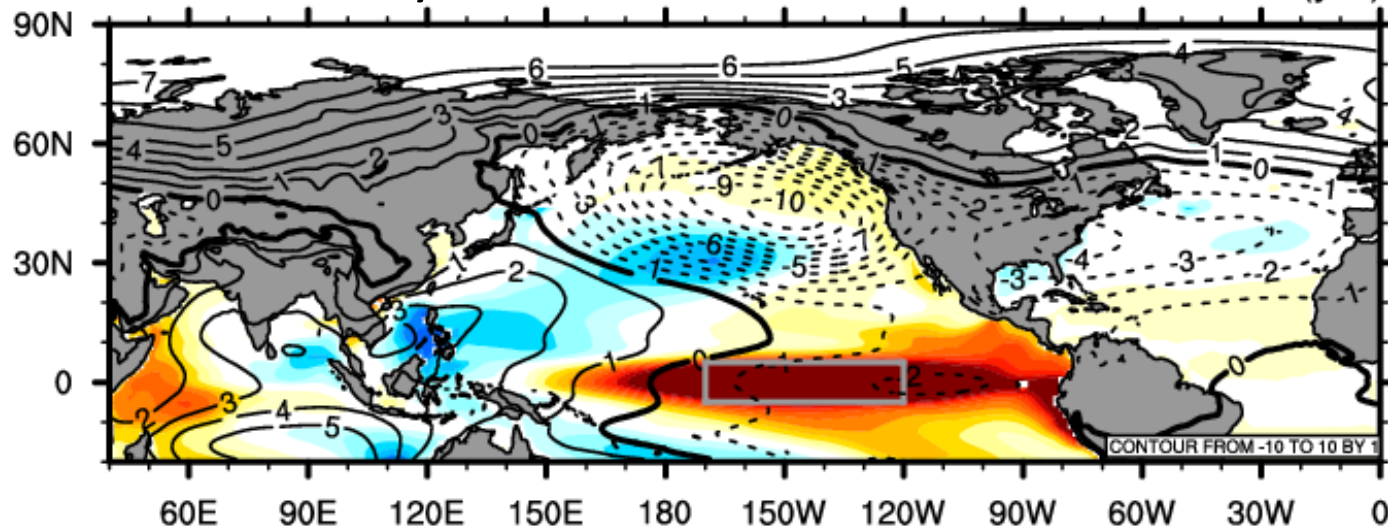
Niño-Niña SST/SLP Composite DJF(0/1)

based on Niño3.4 index +/- one stddev

NCEP R1 1948-2009



CCSM4 500 years



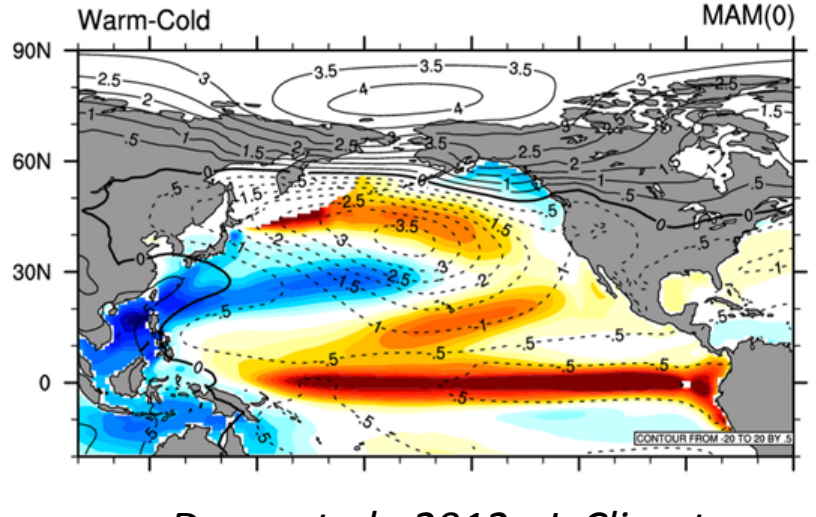
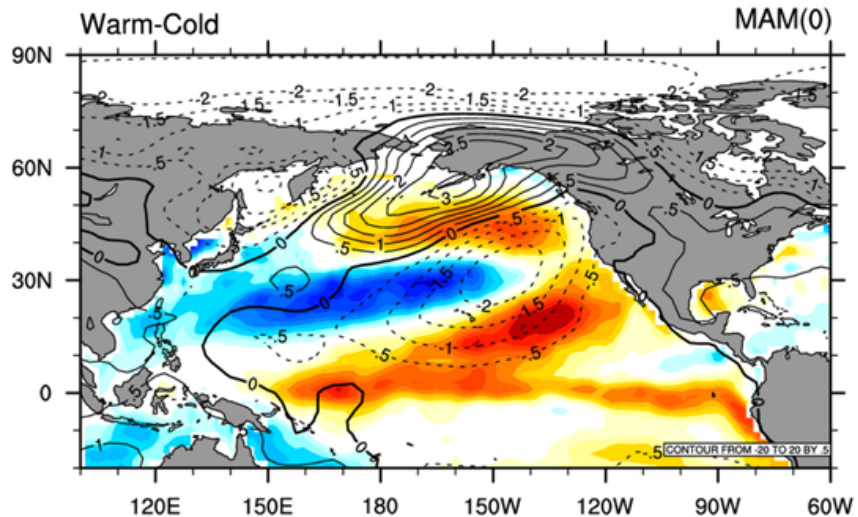
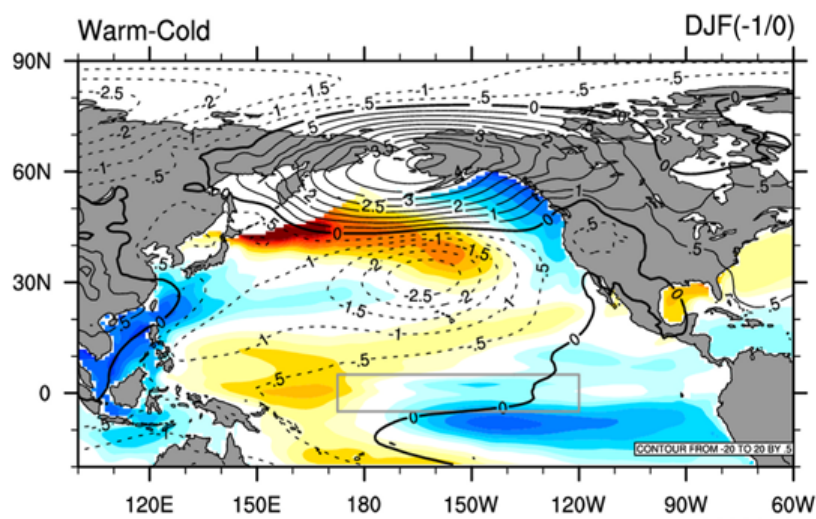
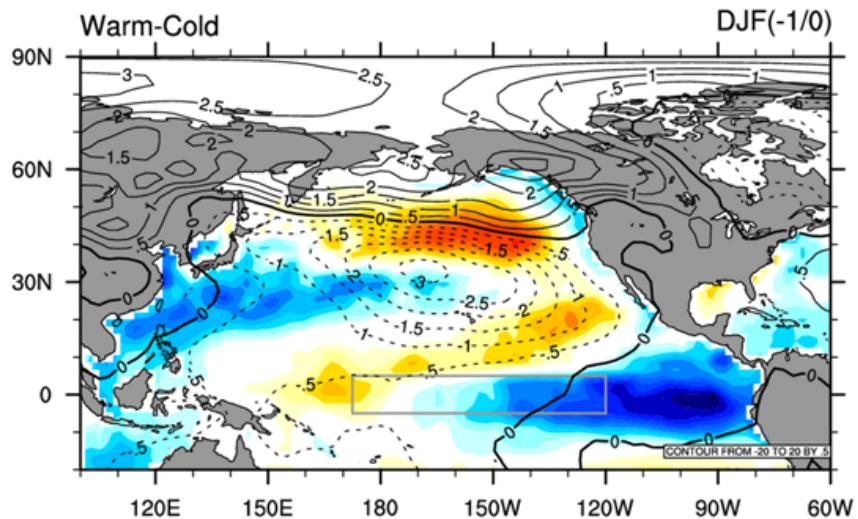
Niño-Niña SST/SLP Composite DJF(-1/0)-JJA(0)

based on NDJ Nino3.4 index +/- one stddev

SST ($^{\circ}$ C) Shaded SLP (mb, contoured)

NCEP R1 1948-2009

CCSM4

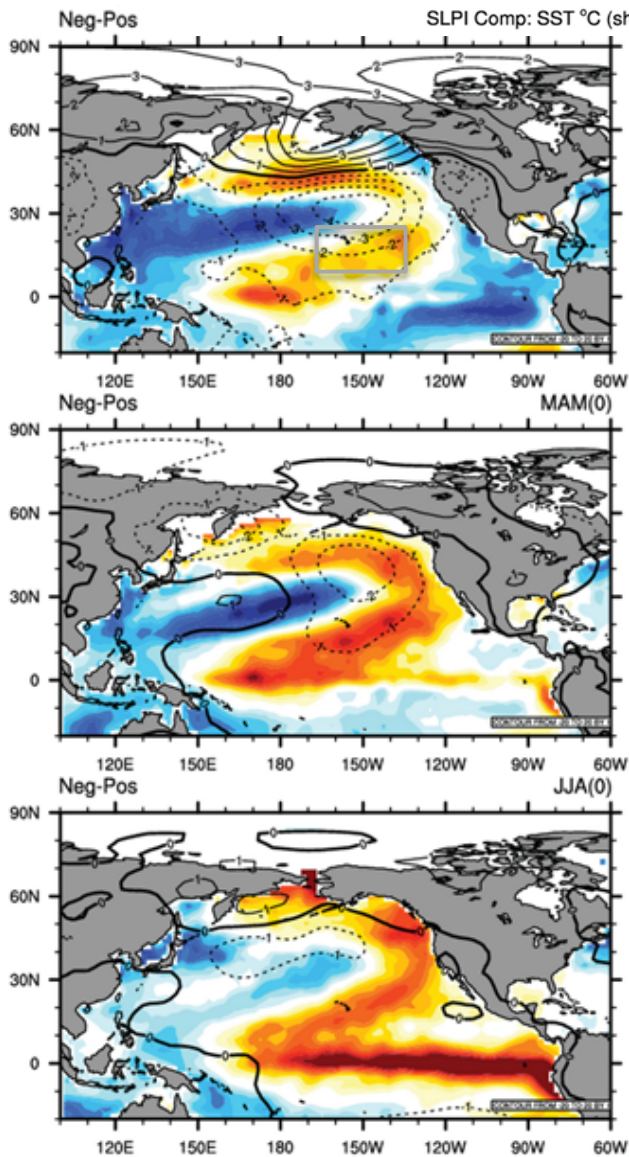


Deser et al., 2012, J. Climate

SLP Index SST/SLP composite DJF(0)-JJA(0)

NDJFM(-1/0) SLP Index (175W-140W, 10N-25N) Composites (Neg-Pos)

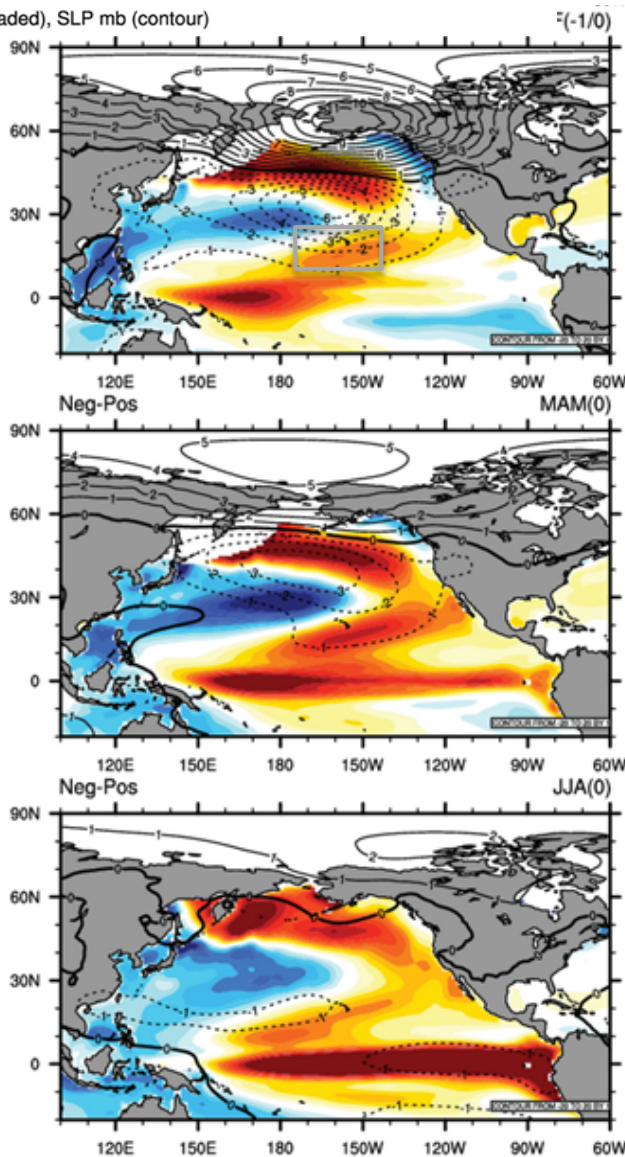
NCEP
Reanalysis



CCSM4

Correlation
between SLPI
and Niño3.4 SST
Index in JFM(1)
is 0.61 in nature
(Anderson
2007) and 0.59
in the model

*Deser et al.,
2012*

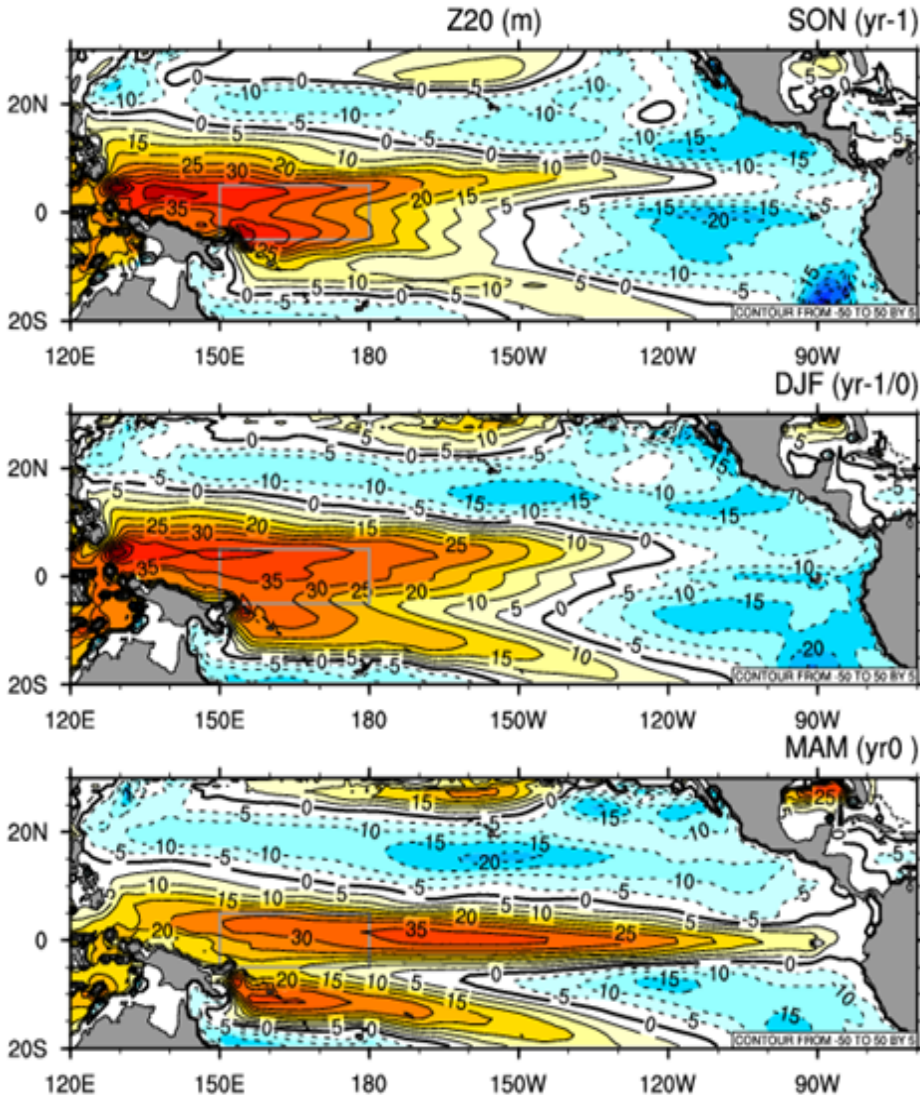


Second Index

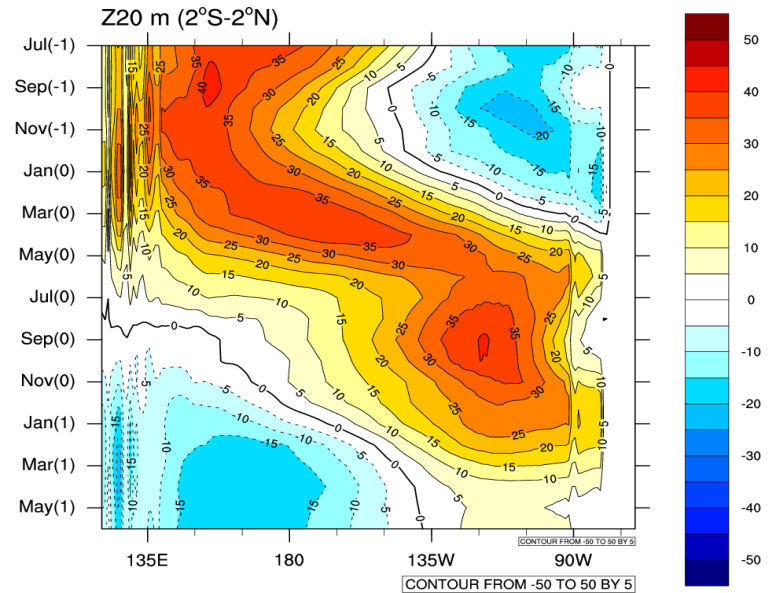
Depth of thermocline in the
Equatorial West Pacific

Z20 evolution

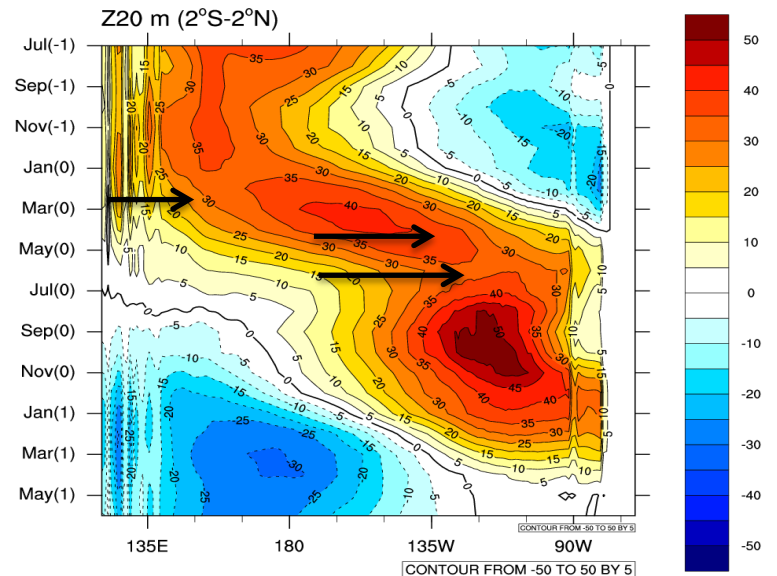
WP Z20 index (pos-neg)



WP Z20 index (pos-neg)

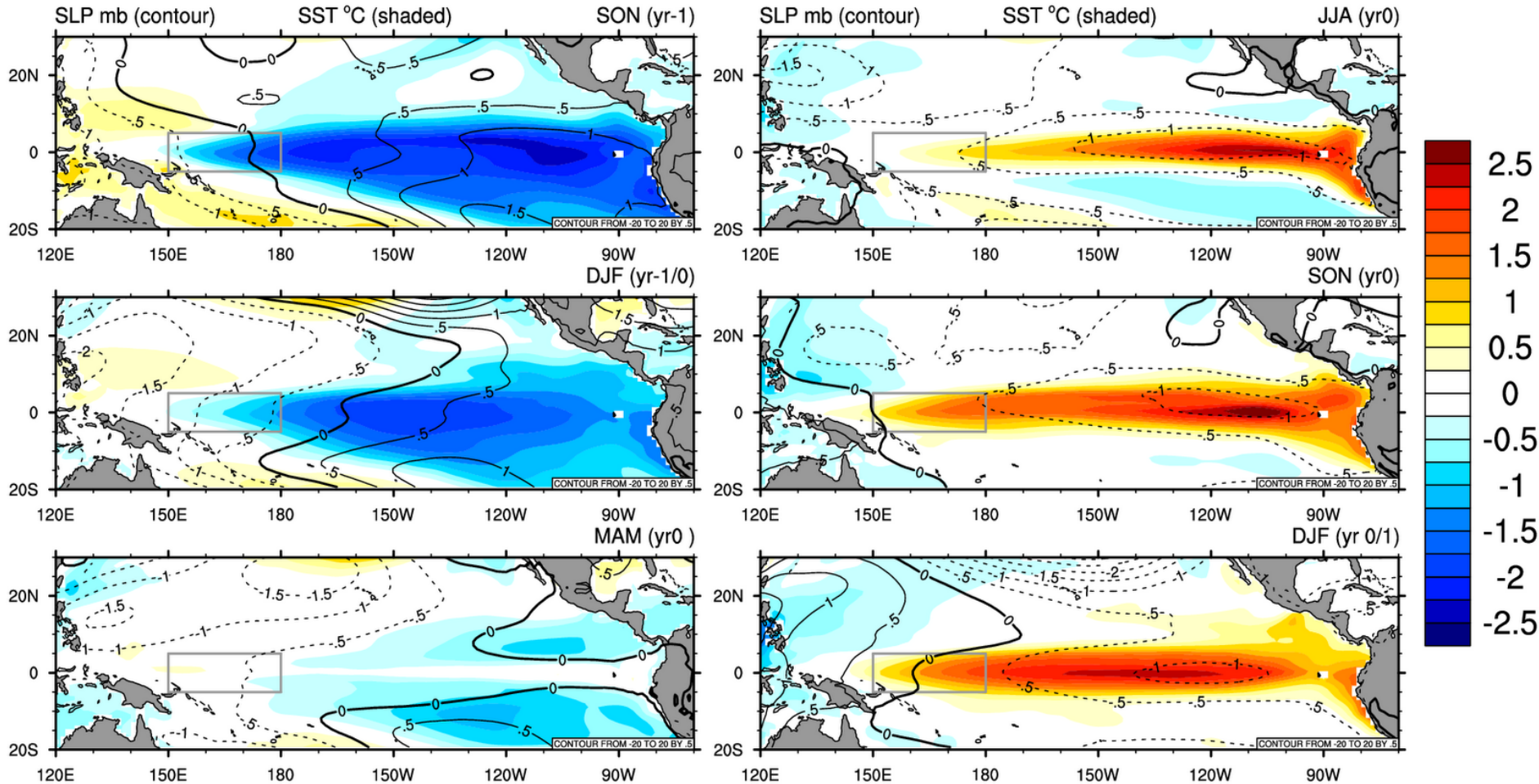


WP Z20 & SLP index (pos-neg)



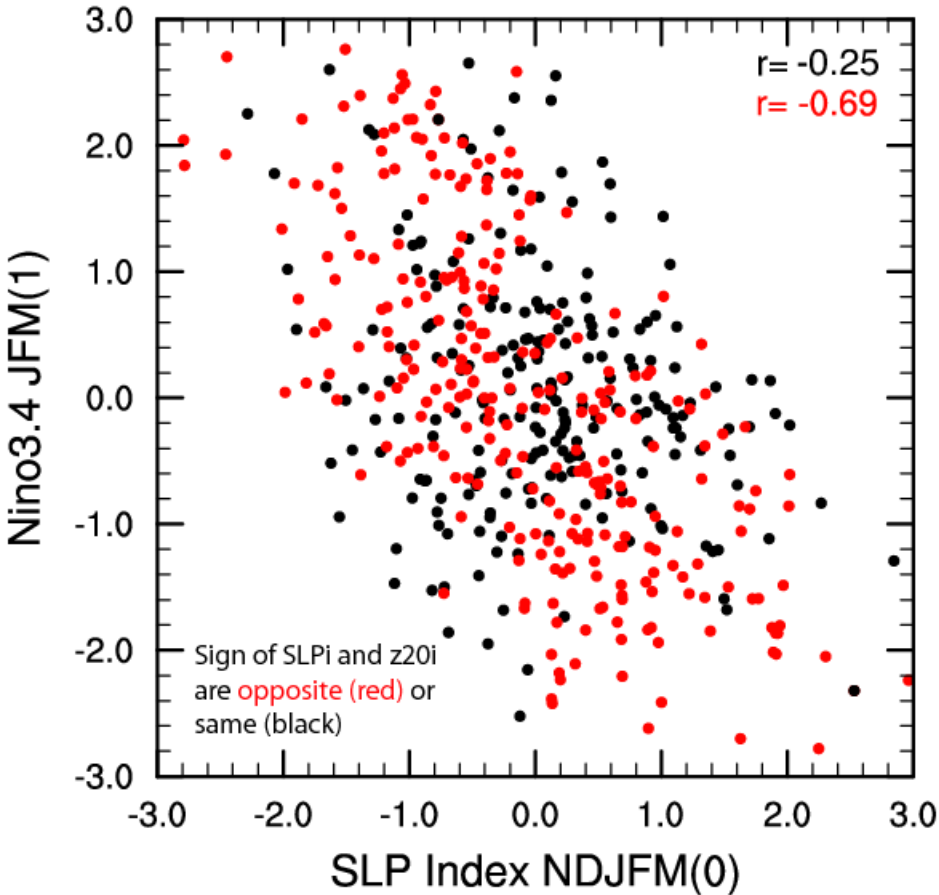
Composites based on West Pacific Z20 precursor: Positive-Negative Z20 Jun-Oct(-1) (5N-5S, 150E-180W)

CCSM4 500yrs HSTI JJASO(-1) (5°S-5°N,150-180°E) (pos-neg)



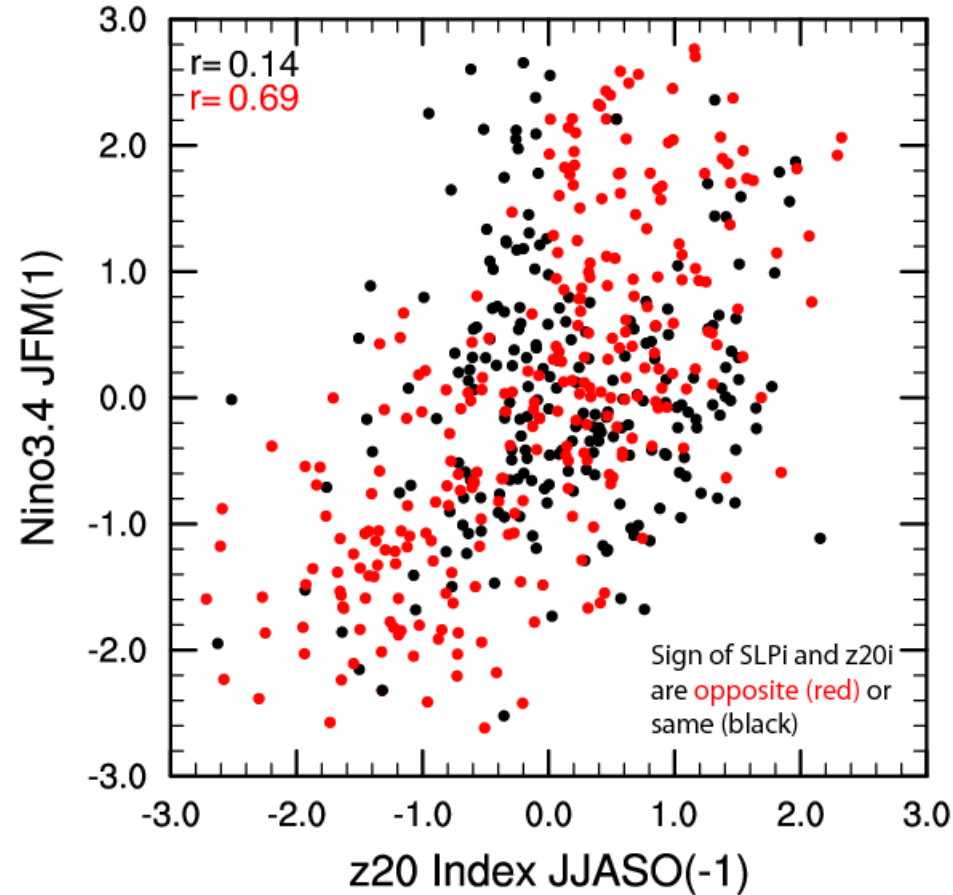
Nino 3.4 SST vs SLP and Z20 Index

CCSM4 Nino3.4 vs SLP Index (500yrs)



Anderson 2007 Obs: $r = -0.72$; $r = -0.37$

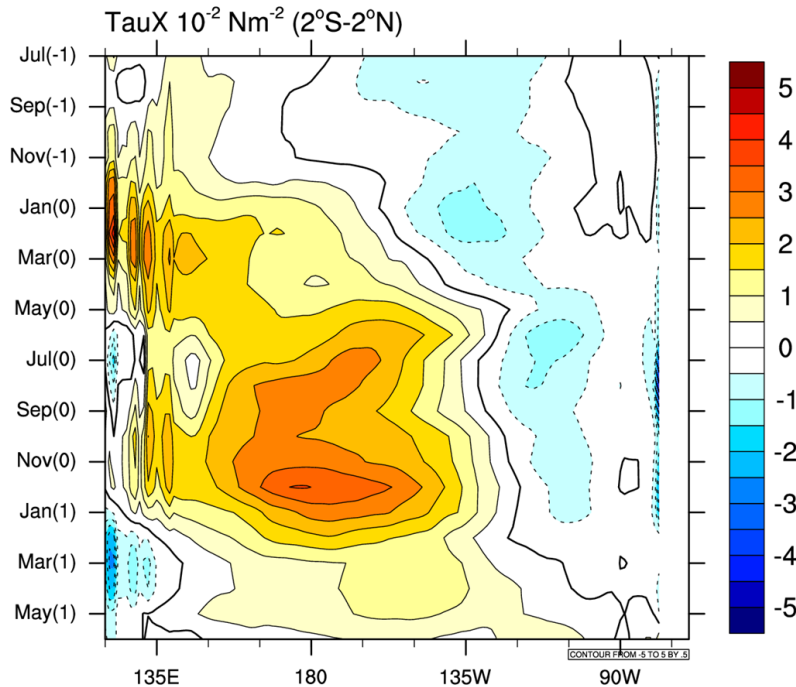
CCSM4 Nino3.4 vs z20 Index (500yrs)



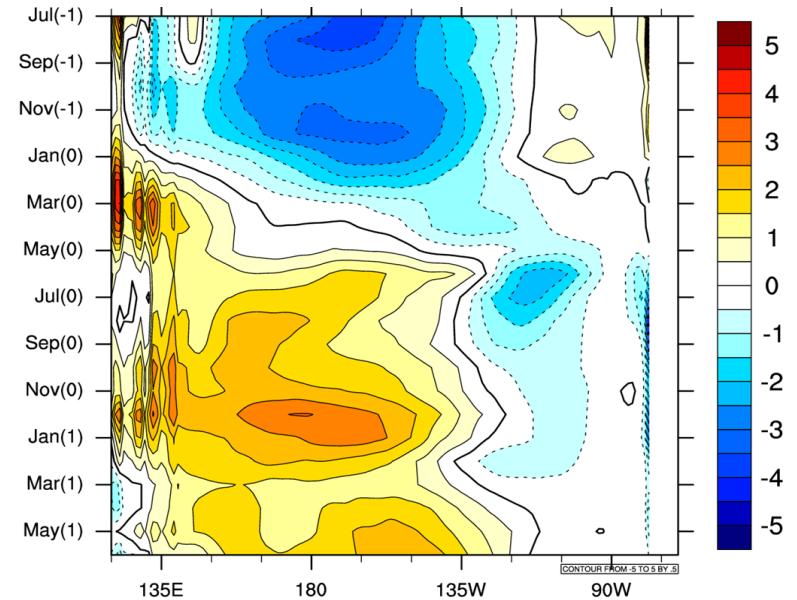
Obs: $r = 0.69$; $r = -0.06$

Hovmöller of composite zonal wind stress 2N-2S

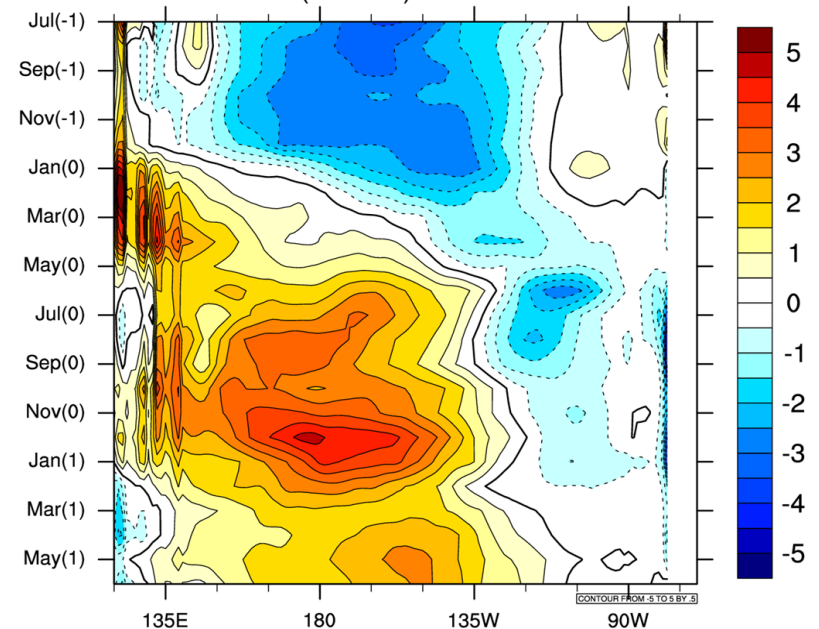
SLP Index (neg-pos)



Z20 Index (pos-neg)

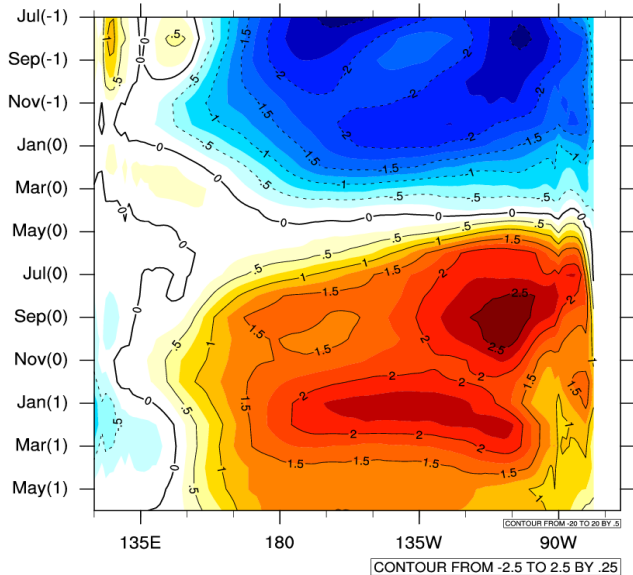


Z20 & SLP Index (pos-neg)

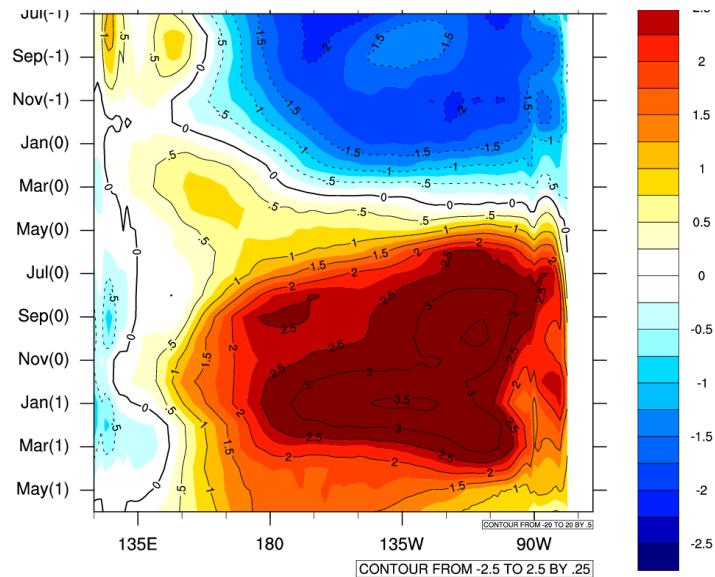


Hovmöller of SST composites 2°N-2°S

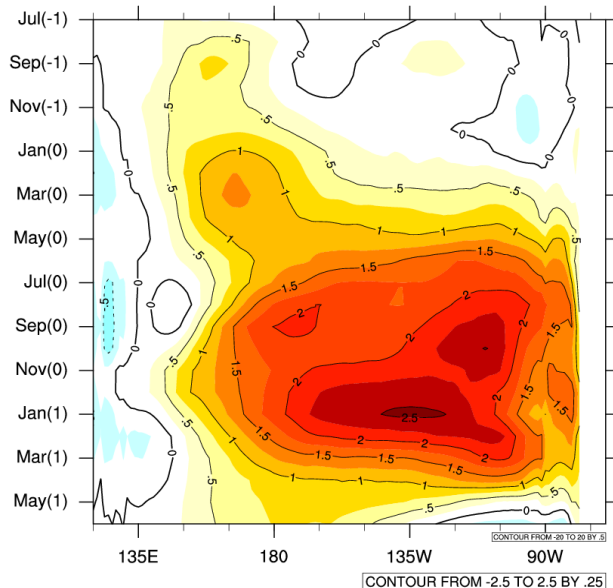
Z20 index (pos-neg)



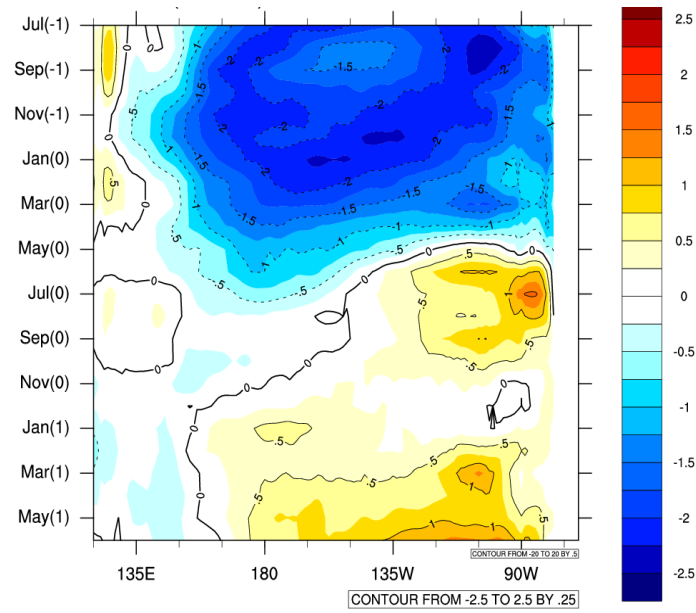
Combined:
Z20(+)/SLP(-)
minus
Z20(-)/SLP(+)



SLP index (neg-pos)



Combined:
Z20(+)/SLP(+)
minus
Z20(-)/SLP(-)



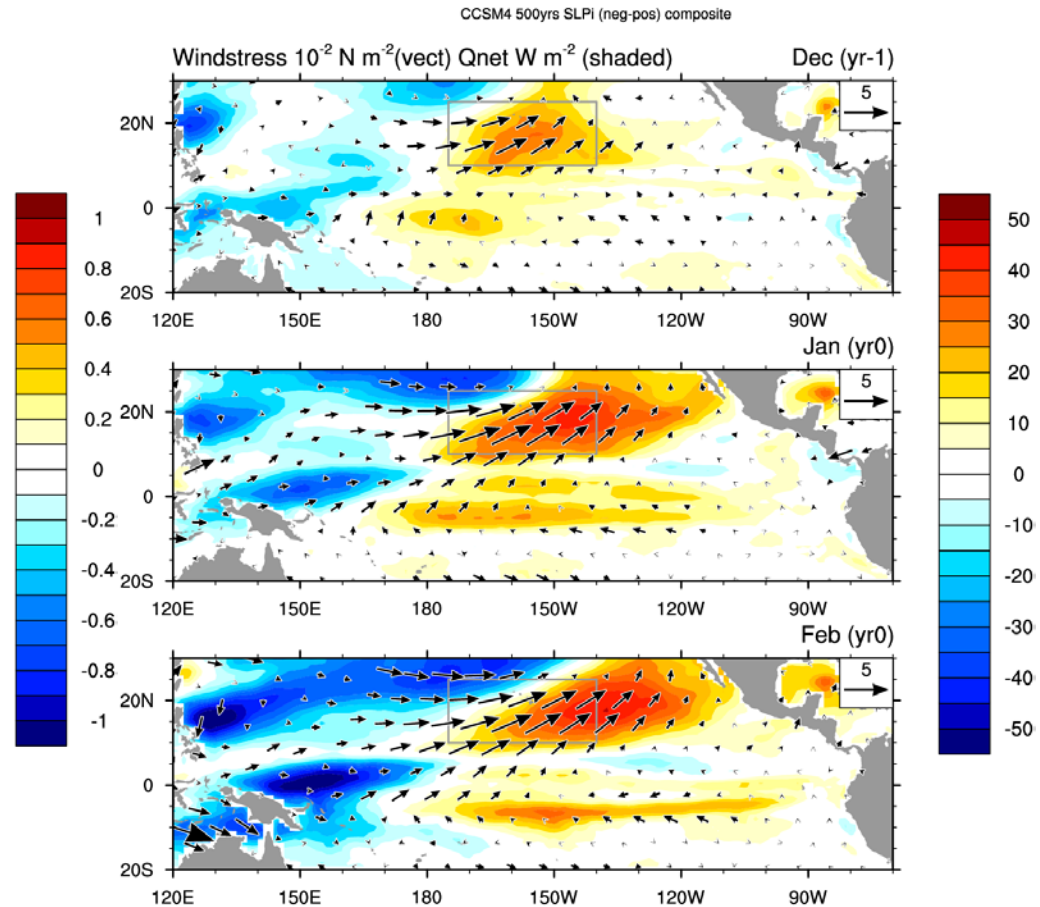
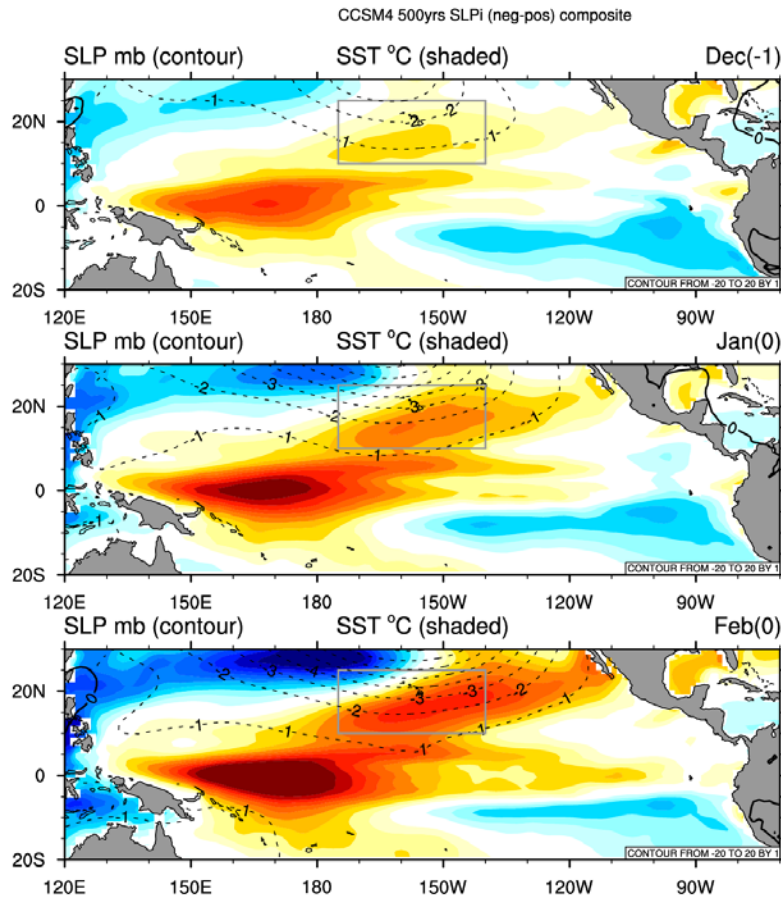
Subtropical => Tropical Connection

- Wind Evaporation SST (WES) feedback
 - In SFM: Vimont et al. 2009, Alexander et al. 2010
- Rossby wave excitation $\sim 5^{\circ}\text{N}$ and reflection off western boundary
 - Alexander et al. 2010(J. Climate)
- Recharge-discharge ENSO paradigm

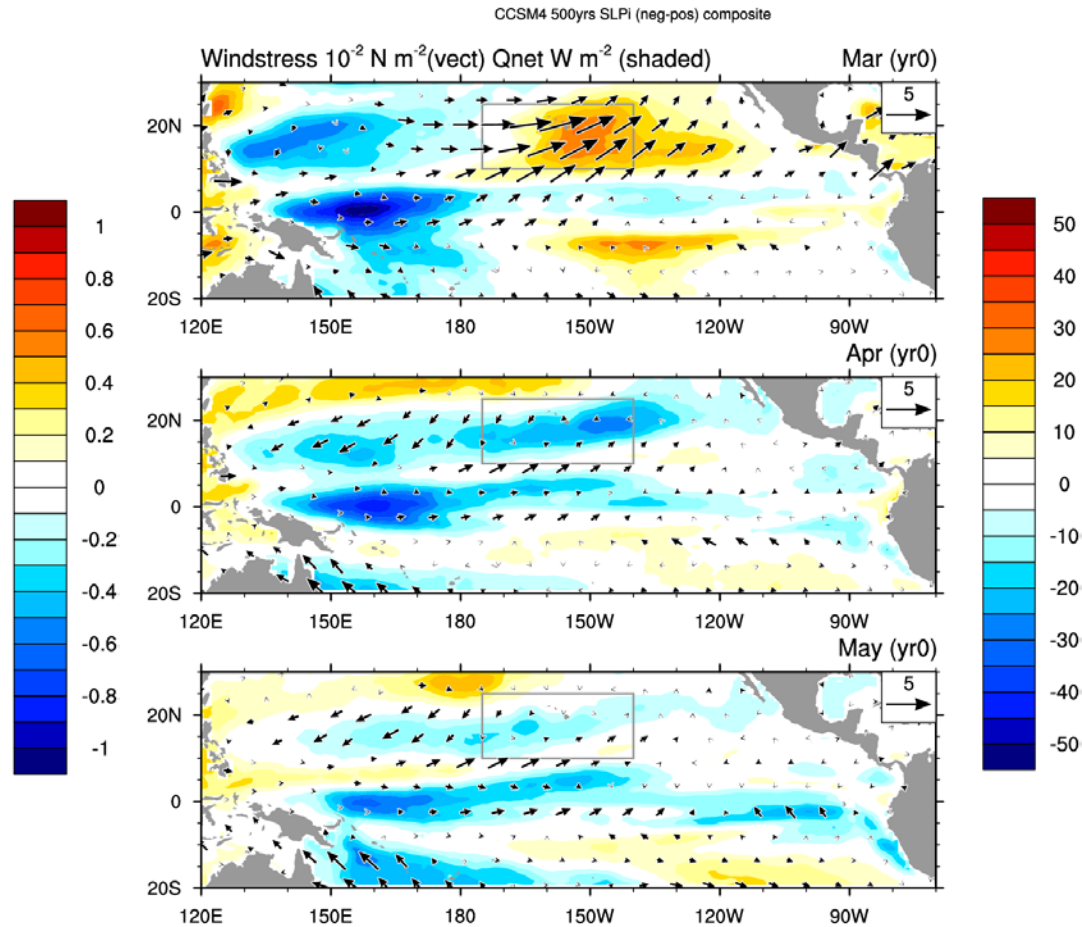
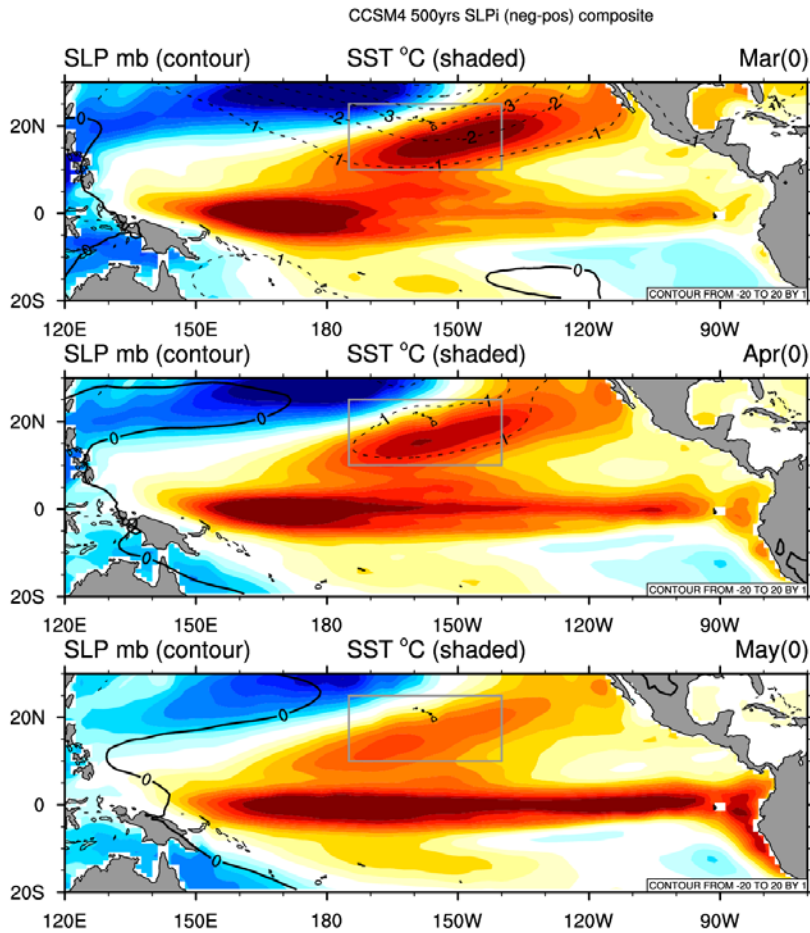
Others:

- Solar radiation
- Influence on the meridional mode (MM)
 - North-south dipole in precipitation (SST & wind signature) in the tropics
 - Also shown to be an ENSO precursor

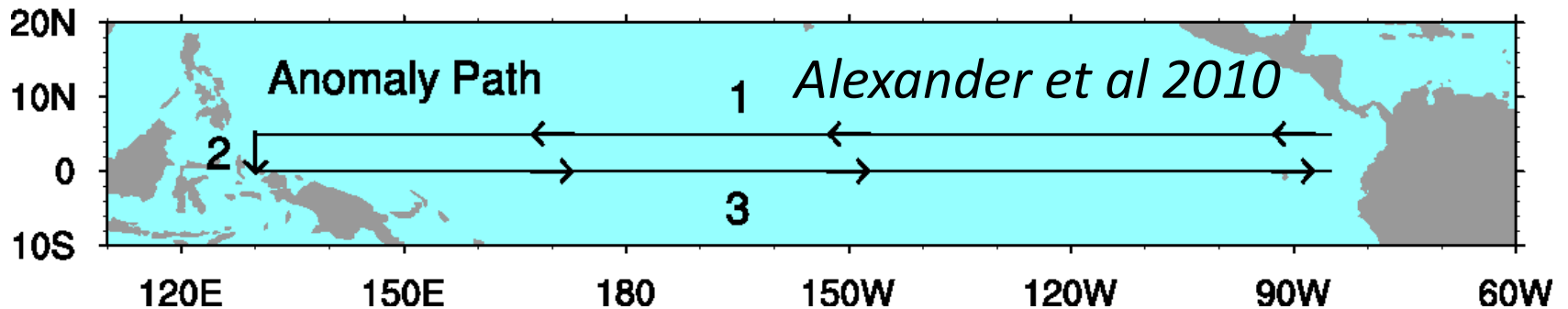
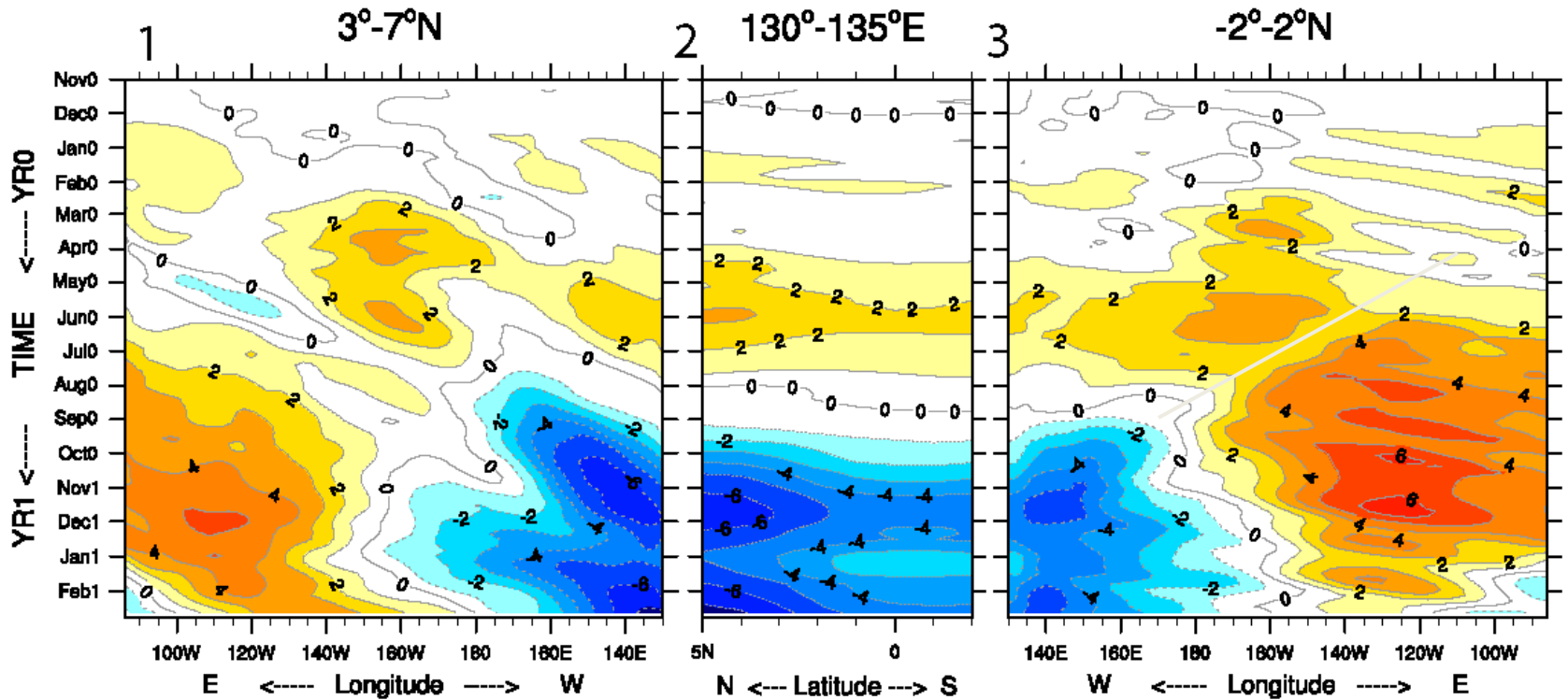
SLP Index Monthly SST/SLP & Winds/Qnet Dec(-1), Jan(0), Feb(0)



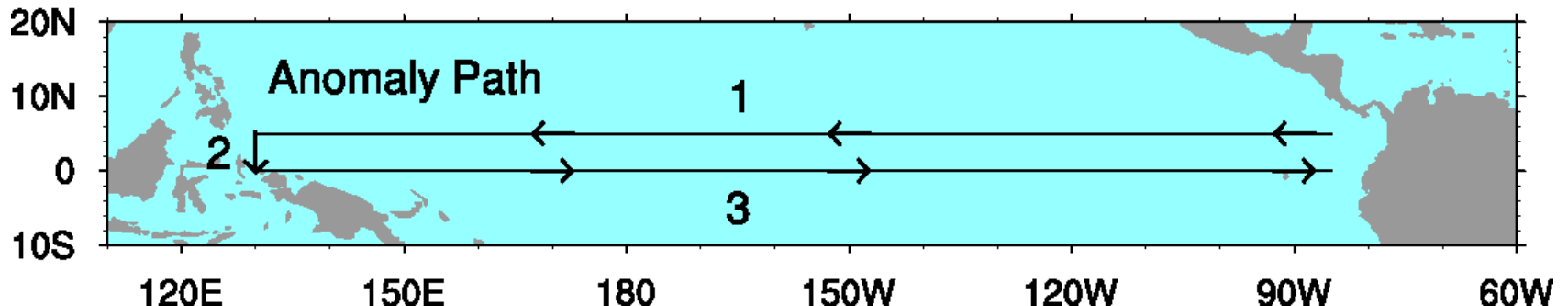
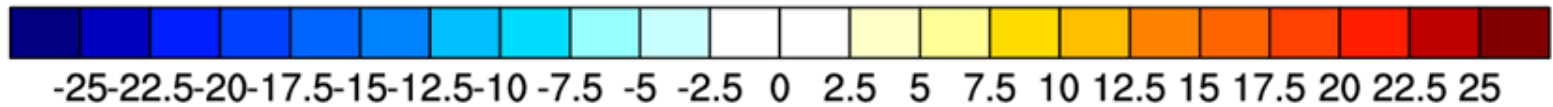
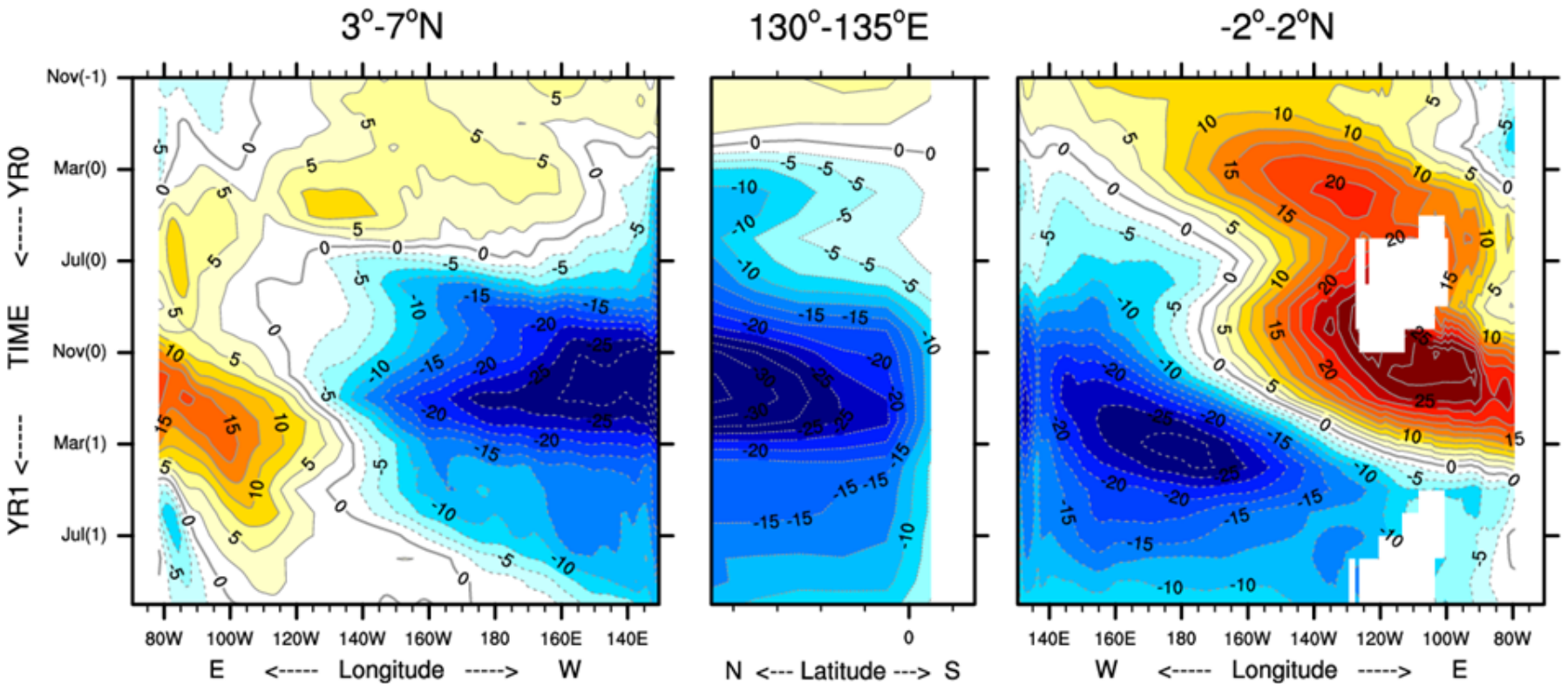
SLP Index Monthly SST/SLP & Winds/Qnet Mar(0), Apr(0), May(0)



h(m) Exp-Cntl 5-day Hövmöller: Western Boundary

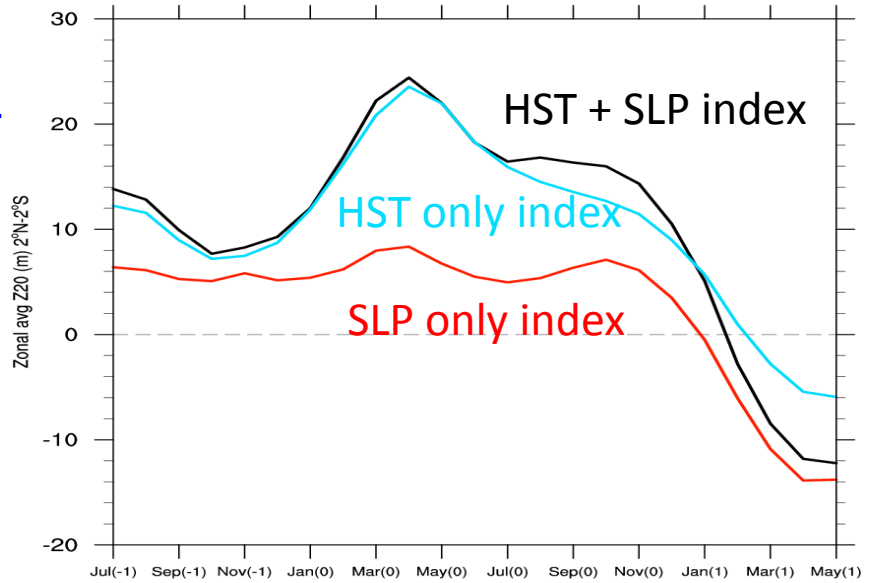


Z20(m) Hovmoller based on SLPI composite (neg-pos)



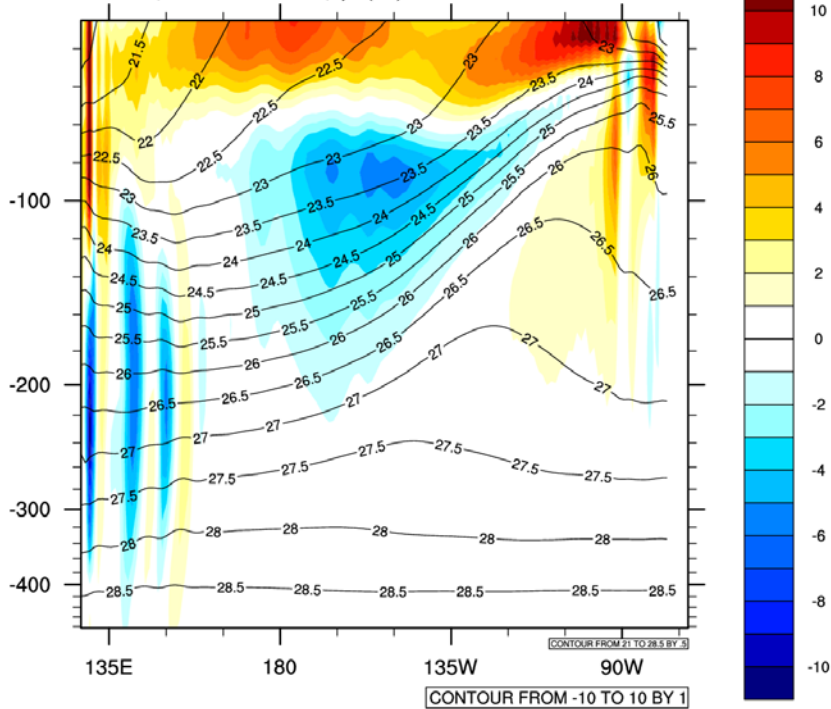
Zonal Average Z20 2°N-2°S CCSM4

v and density at 2N



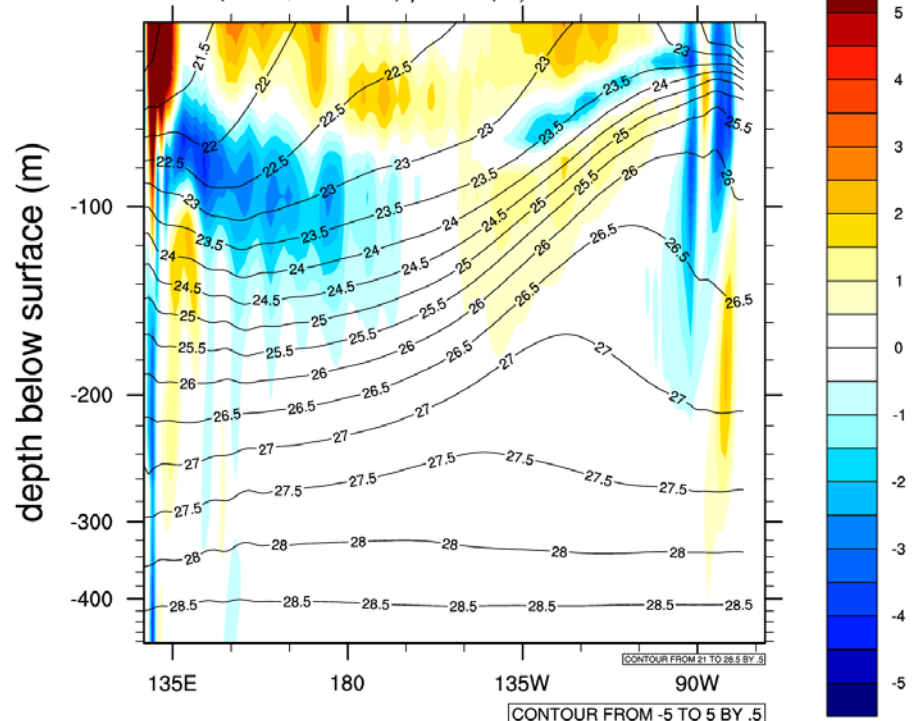
CCSM4 500yrs Clim (MAM) @2N

VVEL(cm/s, shaded) $\rho(\sigma)$

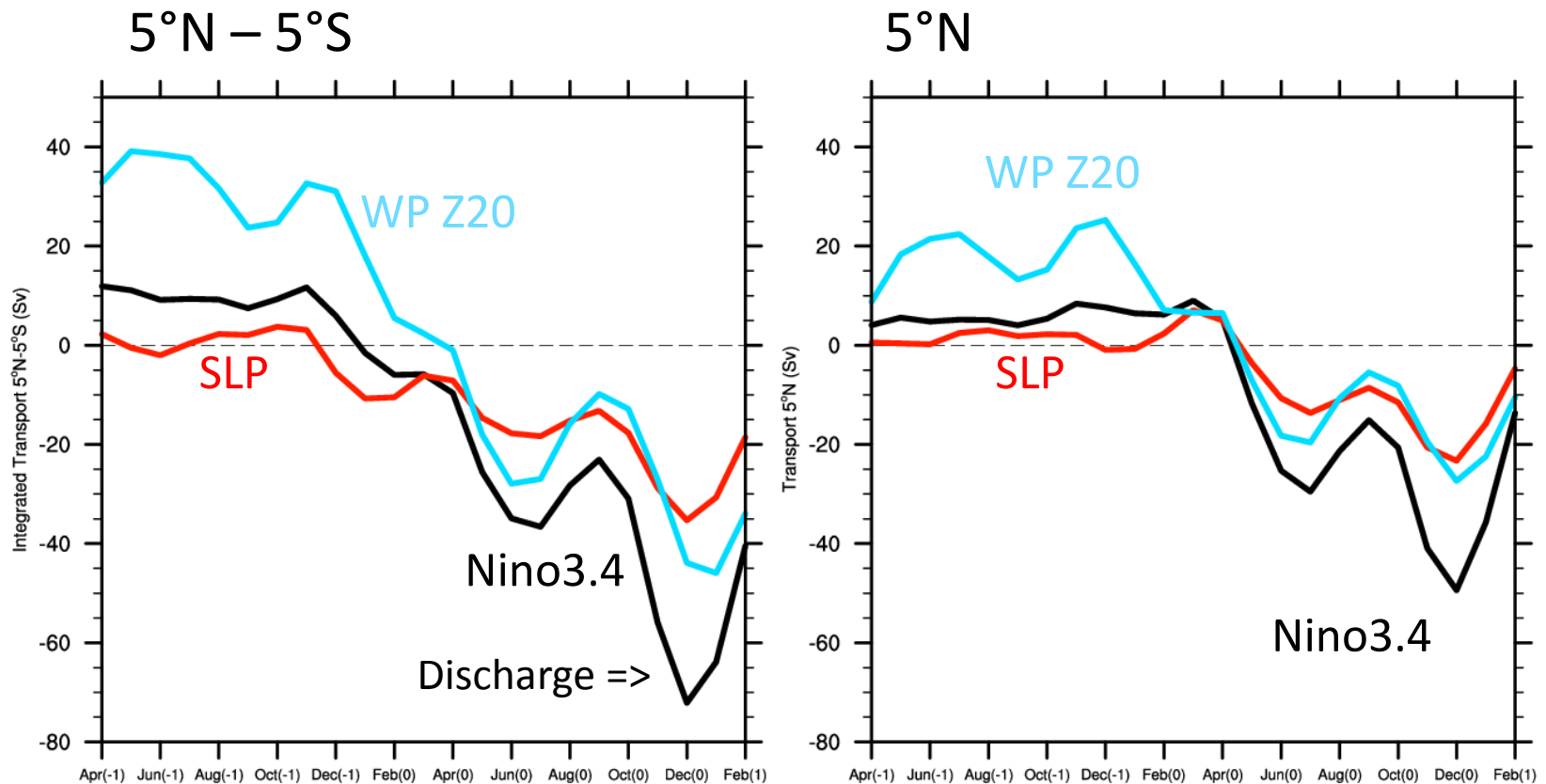


CCSM4 500yrs SLPi (neg-pos) Comp (MAM) @2N

VVEL(cm/s, shaded) ρ Clim(σ)



Zonally Integrated Sverdrup Transport Composites Nino3.4, SLP, Z20 Indices



Following Clarke et al. 2007 JPO

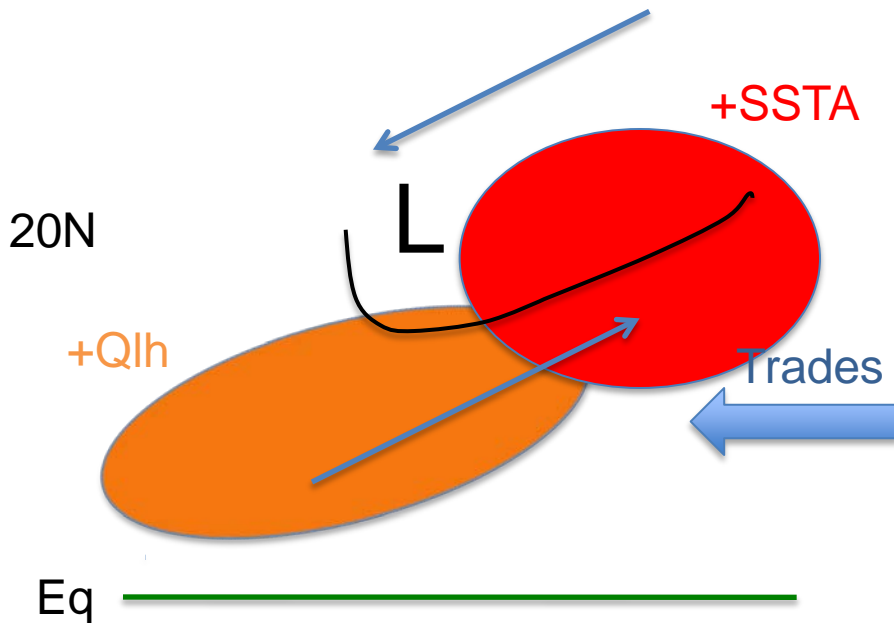
Summary & Conclusions

- SFM (- like) mechanism appears to be operating in nature (reanalysis) and CCSM4
 - Although some aspects deviate from
 - E.g. SST anomalies on the Eq. in Jan(0)
- Z20 in west equatorial Pacific good predictor for ENSO 12-18 month later

Hypothesis:

- z20 index measure of ENSO cycle: La Niña, deep thermocline in the west ~18 month prior to El Nino
- SFM is a way to enhance, kick start or even disrupt the cycle.
- Open question – What processes are key for communicating SFM information from the subtropics to the equator and when. Can it be understood via the recharge-discharge mechanism

Wind Evaporation SST (WES) Feedback



- Trough west of warm SSTs
- Southwest winds to the southwest of the +SSTA oppose trades
- Anomalous latent heat flux into the ocean
- Warm SSTs
- southwest propagation of Q_{lh} & SST

$$Q_{lh} \sim \rho c_e (\underline{u}(q'_s - q'_a) + \underline{u}'(q_s - q_a))$$

Theoretical underpinning WES: Chang et al., 1997; Xie 1997, 1999; equatorward & westward propagation: Vimont 2010