

Continuation of Tropical Pacific Ocean trend will weaken linkage of SAM and extreme El Nino



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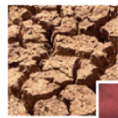
¹Bureau of Meteorology

²NOAA

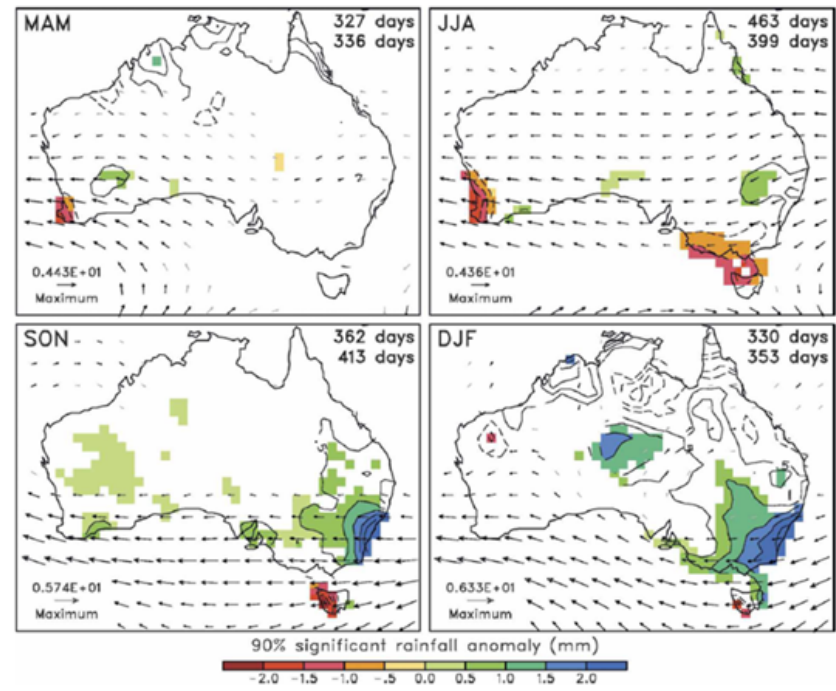
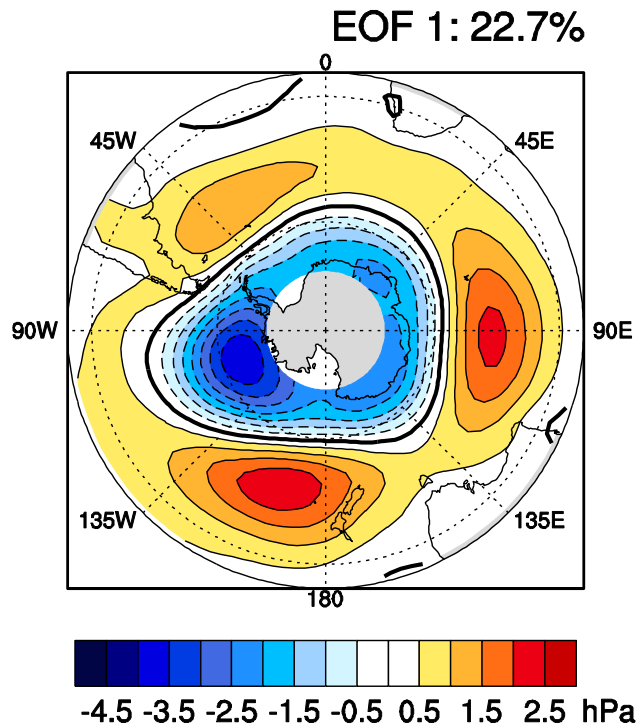


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SAM Background



- SAM refers to north/south shifts of the eddy driven jet
- SAM variations are source of Australian climate variability especially in south during winter and across large areas of east during spring/summer



Monthly ERAI MSLP

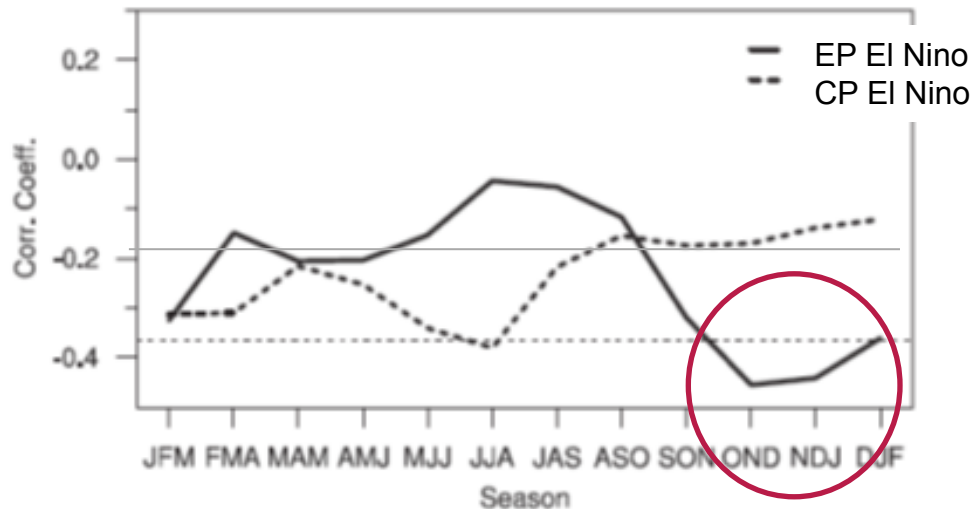


Predictability of SAM stemming from ENSO



- SAM is largely an internal atmospheric process (decorrelation time ~10 days), so largely unpredictable beyond 2 weeks
- But high SAM promoted by La Nina during late spring/summer

Correlation enso indices with SAM



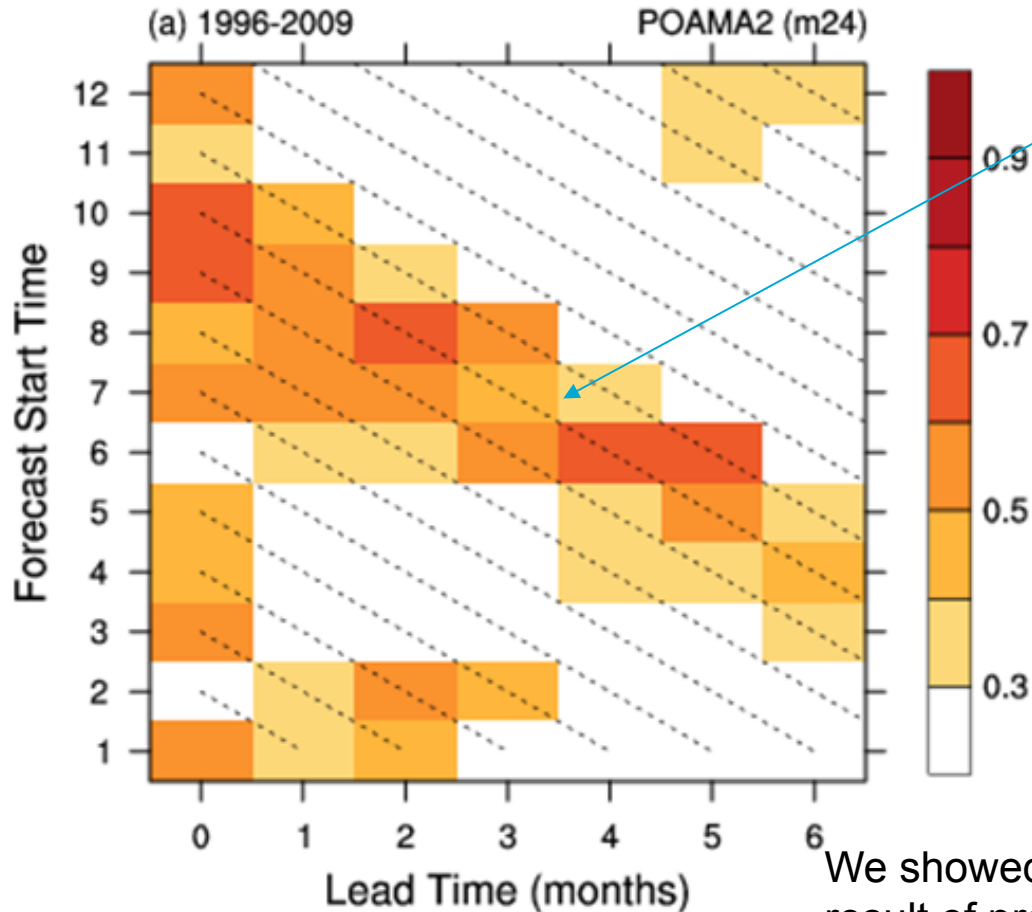
→ Long-lead predictability of SAM and associated surface climate variations as a result of long lead predictability of ENSO

Taken from Lim et al. (2013) their Fig 4



Monthly SAM largely only predictable for first month

Correlation (skill) monthly SAM



We showed this is largely the result of predicting ENSO and then correctly simulating the ENSO-SAM teleconnection

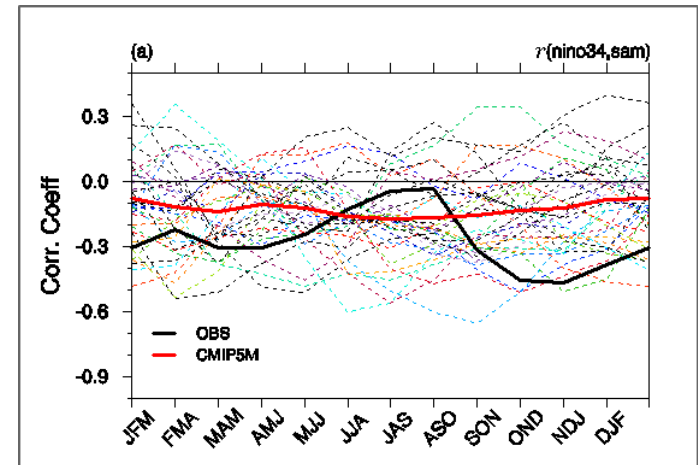
El Nino & SAM in a warmer climate?



- How will the relationship between *El Nino and negative SAM* change in a warmer climate?

- Not sure what we can learn from CMIP5: *can't simulate* the observed ENSO & SAM relationship in the present climate (model biases in ENSO and the EDJ/STJ?)

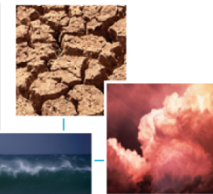
And, ENSO impacts in a warmer climate depend on pattern of SST warming: but consensus is and has been El Nino- like warming



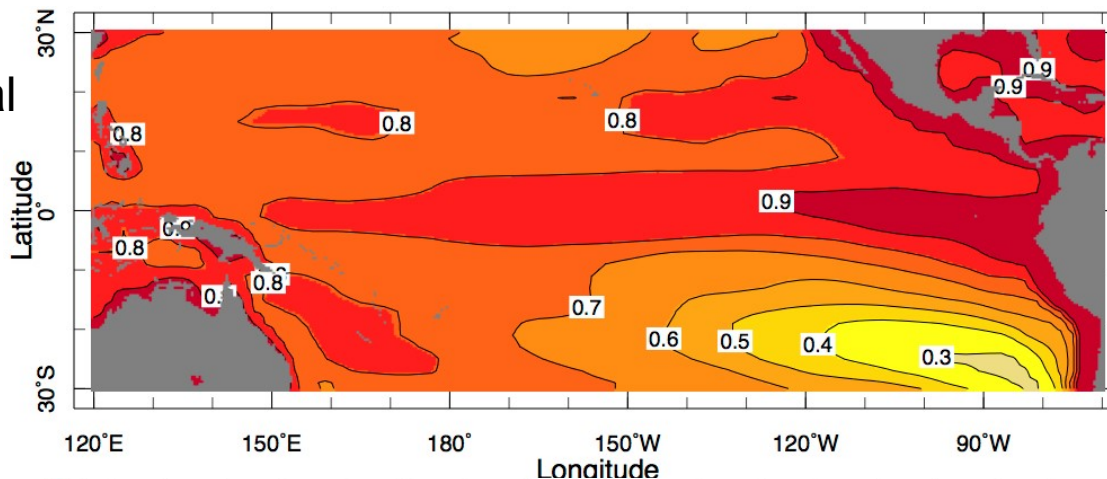
Lim et al. (2016)



Consensus is wrong?

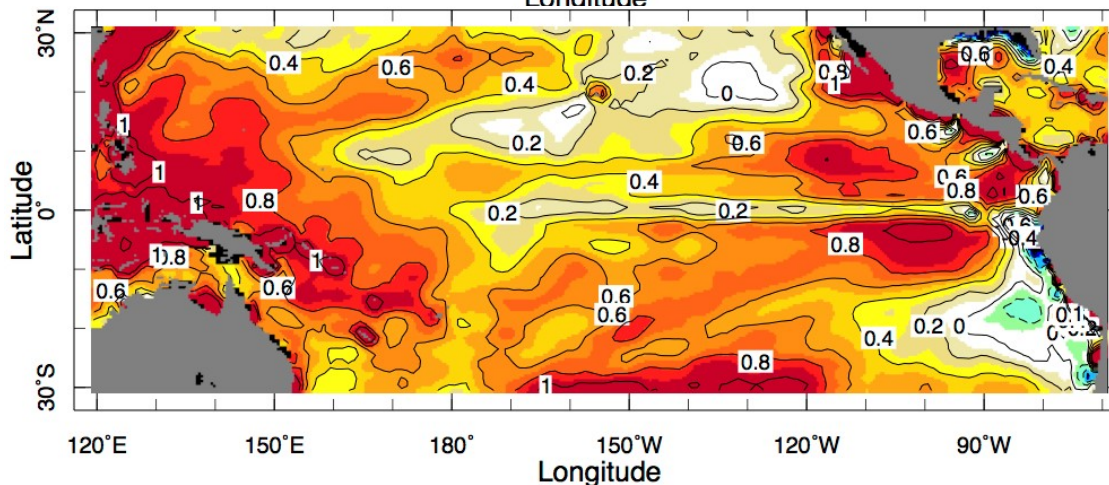


CMIP5 Historical runs SST trend



Seager et al 2019 argue this result reflects model biases (cold tongue too far west and warm to south that then makes cold tongue too sensitive to increasing GHG)

Observed trend

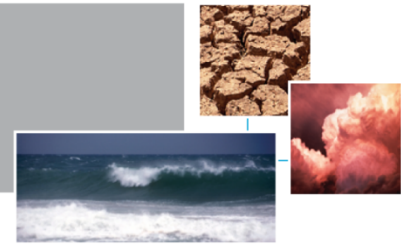


They argue observed trend reflects the "warmer get wetter", so stronger trades with weakest warming in the cold tongue Kohima and Hartmann 2017, Luo et al. 2017

* This work was begun with support from the World Surf League P.U.R.E. via the Center for Climate and Life at Columbia University and continued with National Science Foundation award OCE-1657209



Motivated to turn to a make believe world



What would happen if current observed trend simply continues into the future?

Address this with forecast sensitivity experiments using (old) POAMA system (T47,L17 atmos; 0.5/ 2 deg ocean)

Focus on 3 large (extreme El Ninos 1982, 1997, 2015):

What would happen if they felt a different ocean mean state, reflective of the ongoing trend?

Here we explore impact from imposing 2 x observed trend 1960- 2014 for T and S

Note we use PEODAS analyses (T, S) 1960- present

Design of experiments

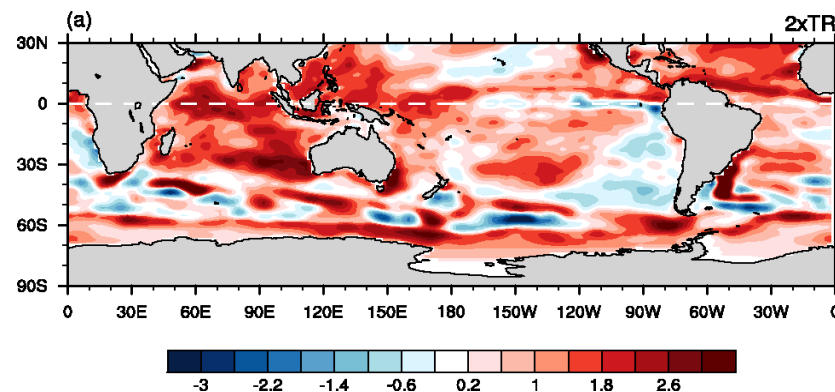
Four experiments

Initialised on September 1st

Verified for **October-December mean**

p : present climate
w : warmer climate

2TR: Doubling of the observed ocean T trends over 1960-2014



	Ocean Initial Conditions	Atmosphere & Land Initial Conditions	CO2	Ozone
pEINino	Obs 1982, 1997, 2015	Random select from 1981-2013	345 ppm (1980's level, POAMA hindcast default value)	Monthly climatology prescribed
wEINino	pEINino+2TR			
pCLIM	Climatology of 1981-2013			
wCLIM	pCLIM+2TR			

Differences in climos wClim – pClim

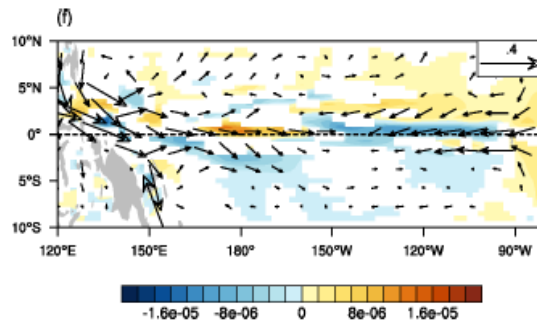
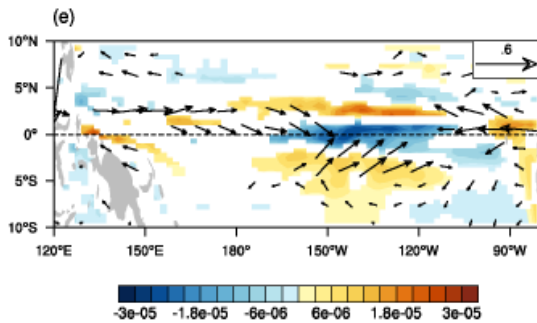
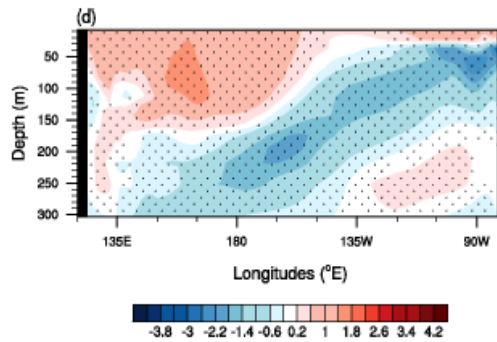
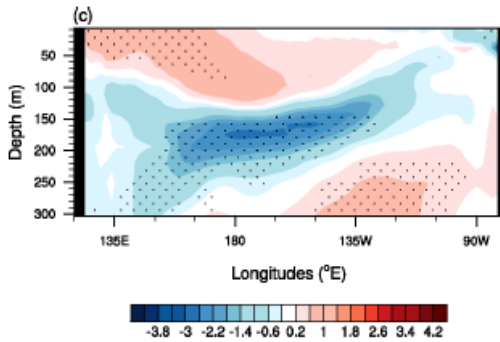
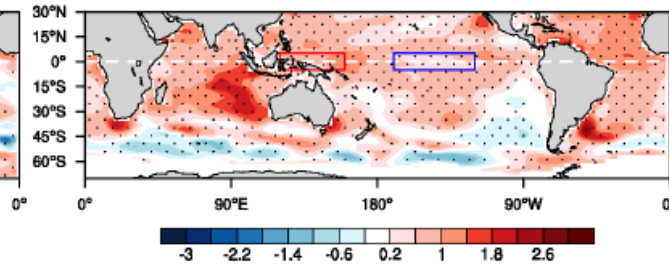
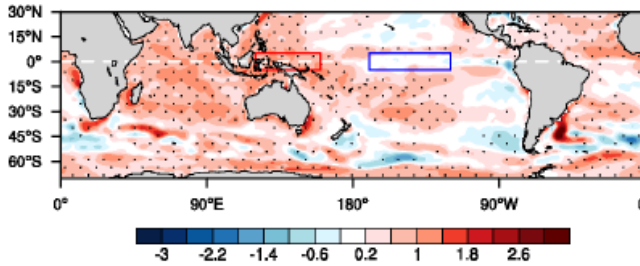


Observed

Forecast

Trend over 1960-2014

wClim - pClim



- wClim maintains the observed trend pattern well for Oct-Dec from Sep 1 initialisation
- Enhanced zonal SST gradient between the tropical WP and Niño3.4 region (top)
- Cooling on and below the thermocline at eq Pacific subsurface (middle)
- Reduced mean upwelling in equatorial eastern Pacific (bottom)

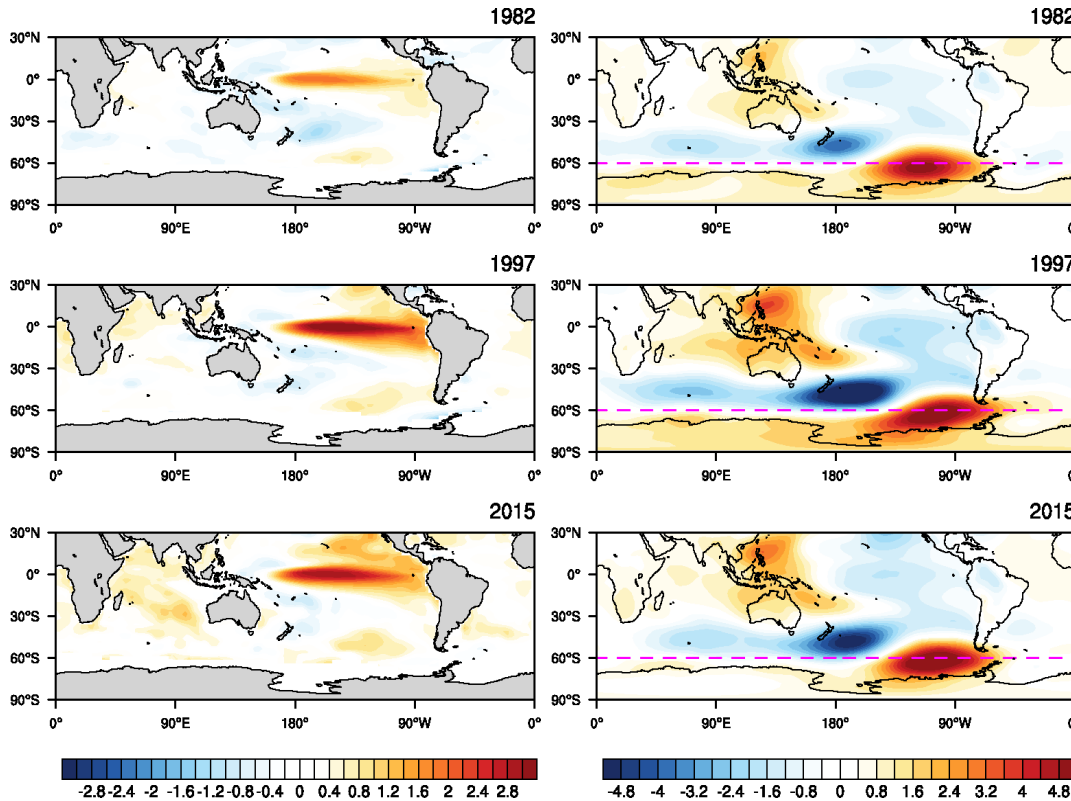


$$pElNino - pCLIM = pElNino'$$



SST

MSLP

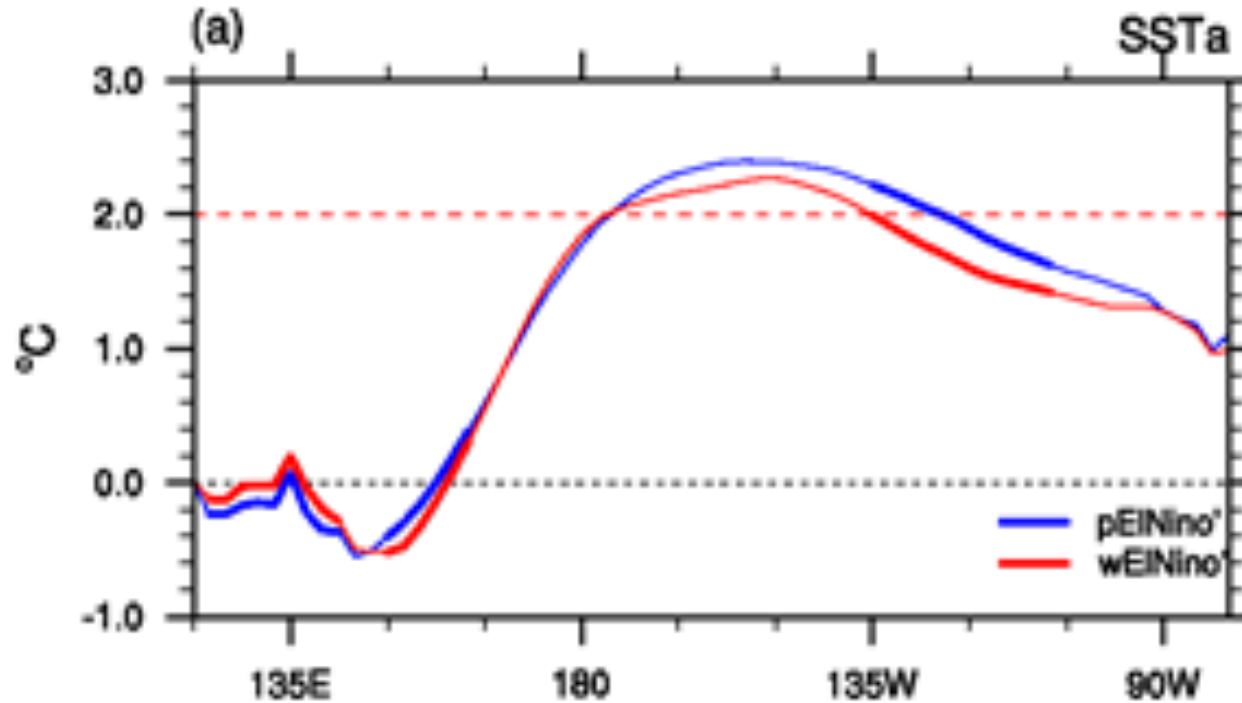


pElNino' reproduces

- strong El Nino of 82, 97, 15 – strength of 1982 El Nino is underpredicted
- PSA plus zonally symmetric negative SAM in all three El Nino forecasts
- Rossby wave propagation poleward & eastward from the Maritime Continent appears to amplify the strength of low SAM



$$w\text{ElNino} - w\text{CLIM} = w\text{ElNino}'$$



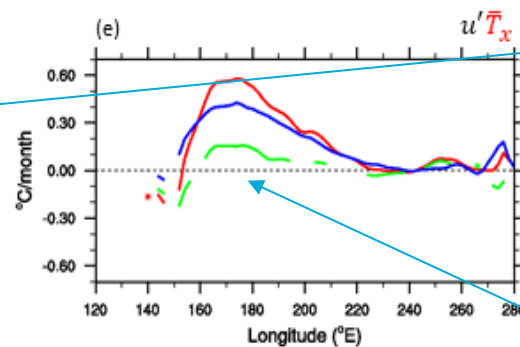
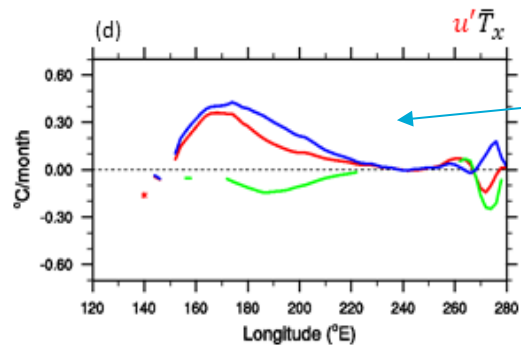
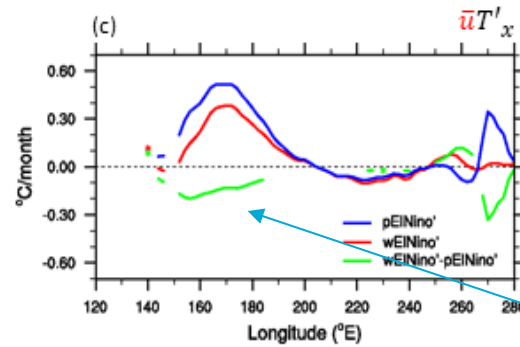
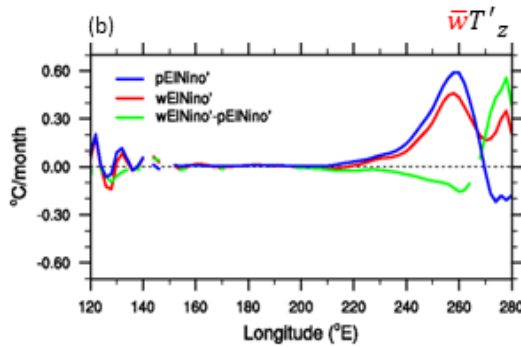
- $w\text{ElNino}'$ is simulated to be $\sim 0.2^\circ\text{C}$ cooler in the eastern Pacific (significant at the 5% level)



wElNino – wCLIM (wElNino')



Why is El Nino weaker in wCLIM?



in the eastern Pacific

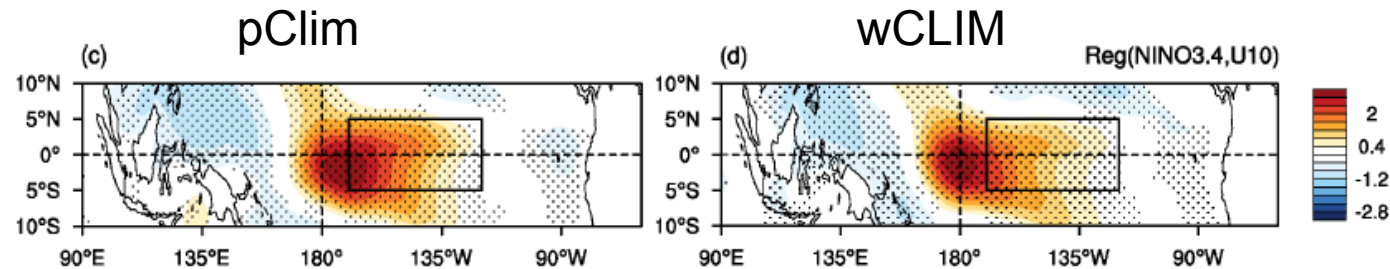
- Reduced thermocline feedback due to reduced mean upwelling

In central Pacific

- Reduced zonal advective feedbacks
 - by reduced mean westward currents
 - by reduced anomalous eastward currents during wElNino'
- But, increased zonal advective feedback by enhanced zonal T gradient in west Pac



Impact of wCLIM on coupled feedbacks

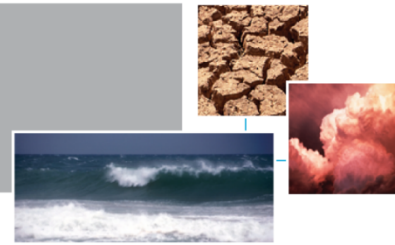


Regression of U10 anomalies onto the nino3.4 SST in OND

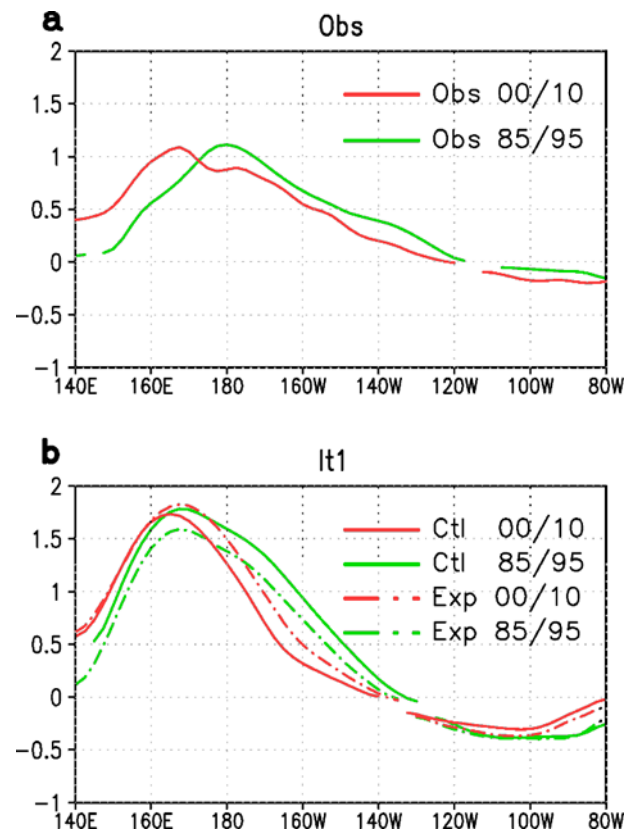
weaker and shifted to the west because of enhanced zonal SST gradient (harder to make it rain in the east from a SST anomaly when the mean SST is colder and Walker circulation is enhance)

Reduced thermocline feedback in east and reduced rainfall-wind-SST feedback are similar impact of swing to cold phase of the IPO since 2000 and previously used to argue why El Nino weakened from 1980-2000 to 2000-2015 (Zhao et al. 2016)





Zhao et al 2016 obtained similar results: swing to cold phase of IPO acts to weaken and shift west the zonal wind response to Nino3 SST anomaly



Regression of zonal wind onto Nino3 SST

Swapped mean state experiments

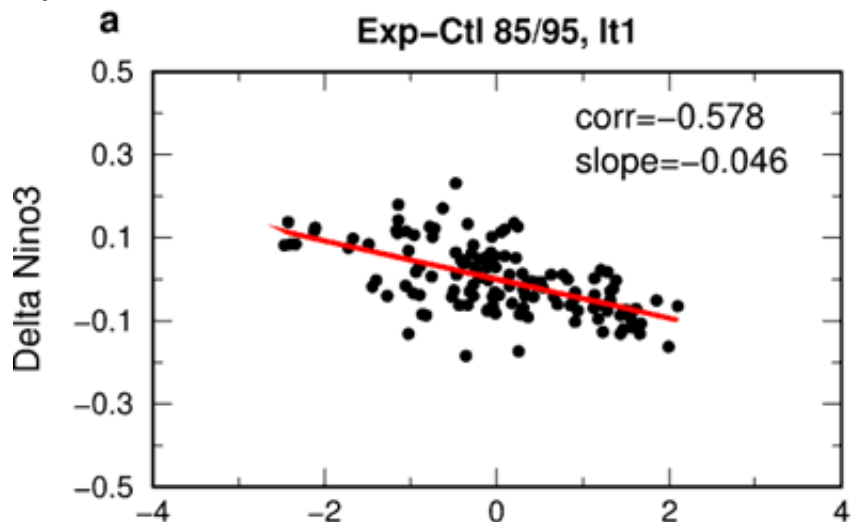




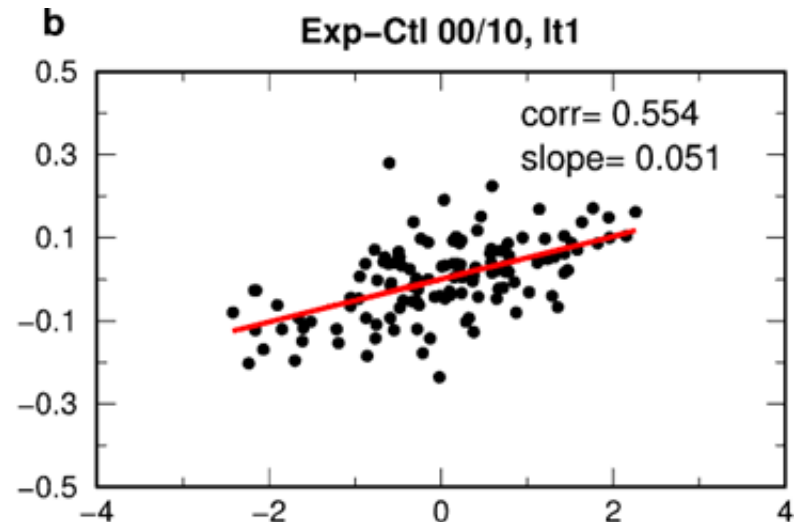
Also from Zhao et al, we expect impact of wCLIM to be linear: El Nino will weaken but so too will La Nina

Rerunning every **1985-95** forecast but initialized with mean state from 2000-2010 (ie , what is impact from a swing to **cold phase of IPO?**)

Rerunning every **2000-2010** forecast but initialized with mean state from 1985-1995 (ie , what is impact from a swing to **warm phase of IPO?**)



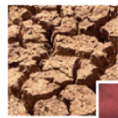
El Nino and La Nina weaken



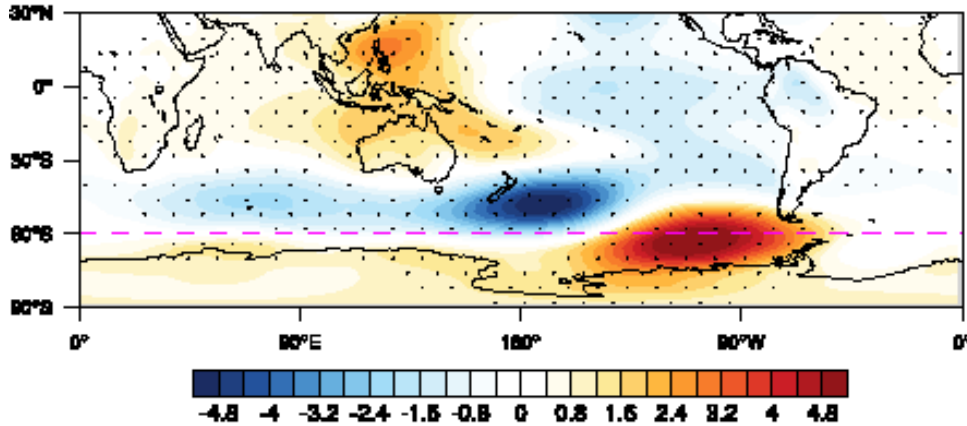
El Nino and La Nina strengthen



ENSO-SAM on the warmer mean state

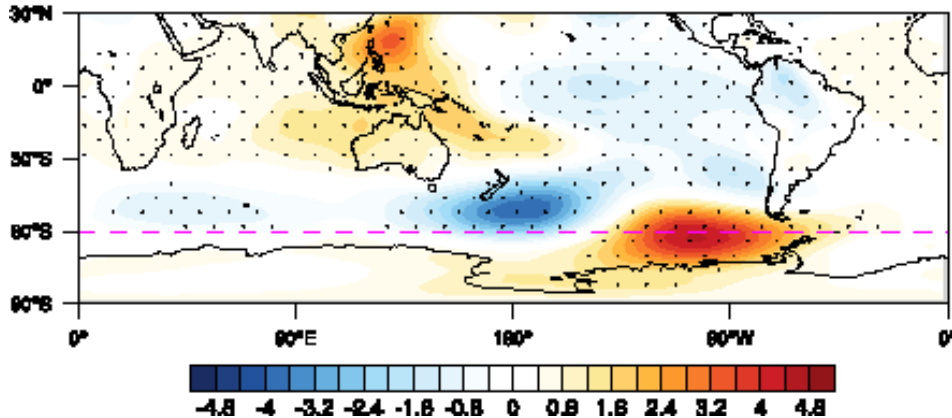


pElNino'

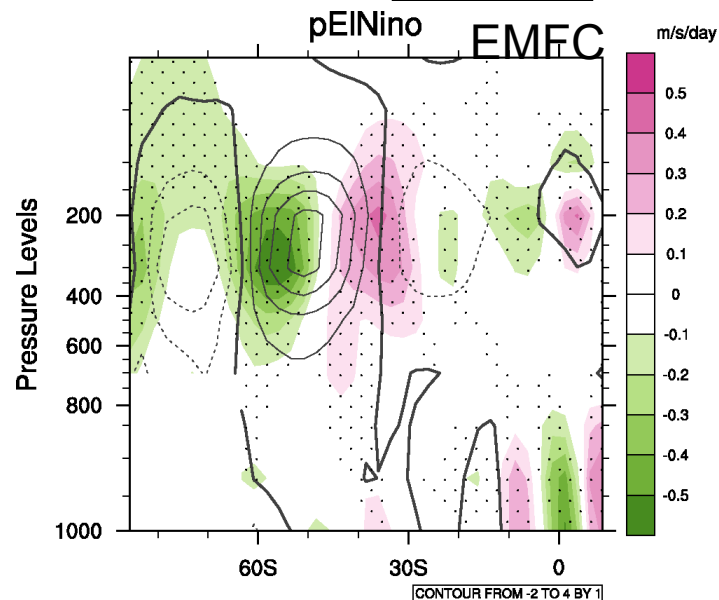
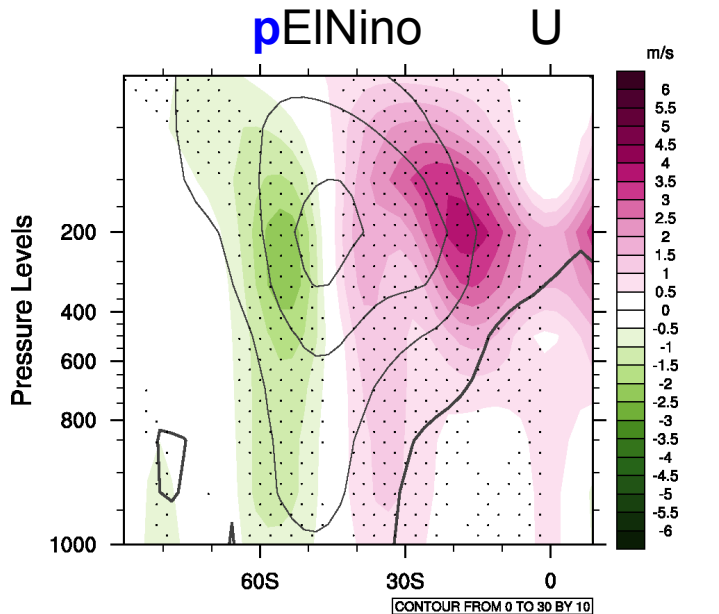
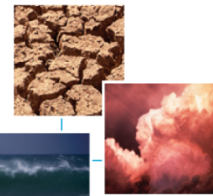


Weakened & westward shifted El Nino result in weaker Rossby wave train and weaker negative SAM

wElNino'



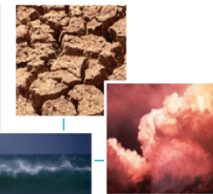
Mechanism of El Nino promoting negative SAM



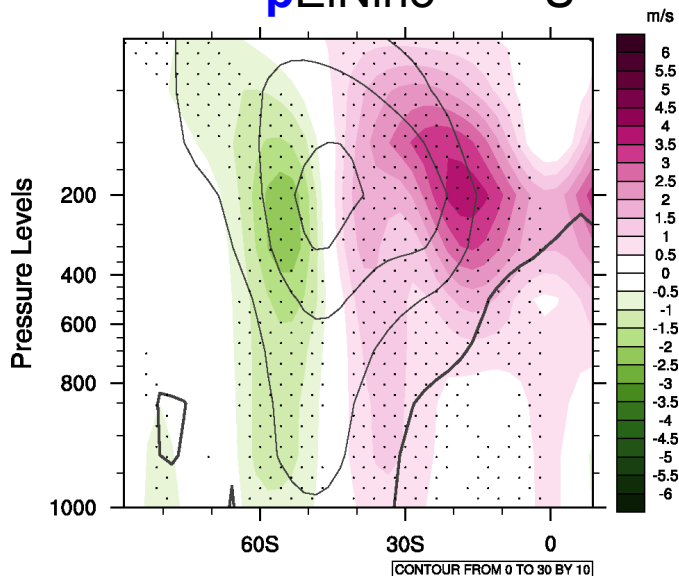
- El Nino acts to strengthen and narrow of the Hadley Cell with increased westerlies on the equatorward side of the climatological subtropical jet
 - Extratropical eddies thus travel deeper into the tropics before they reach critical line and break
 - Anomalous increases of eddy momentum flux convergence in the subtropical latitudes
 - Anomalous increases of eddy momentum flux divergence in the lower and higher latitudes
 - Equatorward shift of the eddy-driven jet
 - Equatorward shift of the maximum baroclinicity and associated storm track
 - Low pressure anomalies in the SH midlatitudes and high pressure anomalies in the SH high latitudes
- Negative SAM



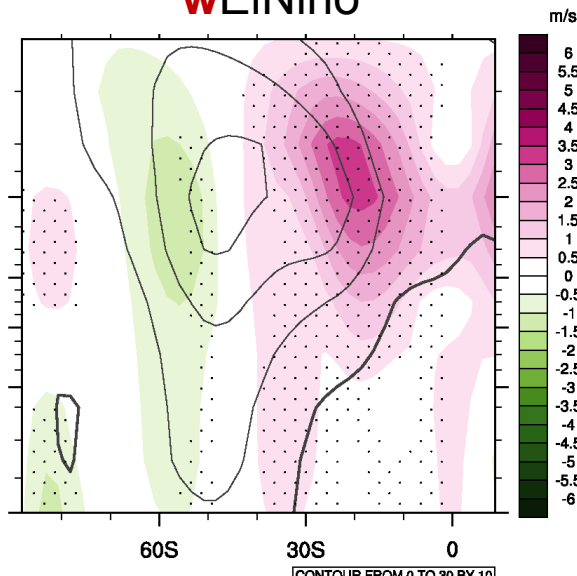
What about in wCLIM?



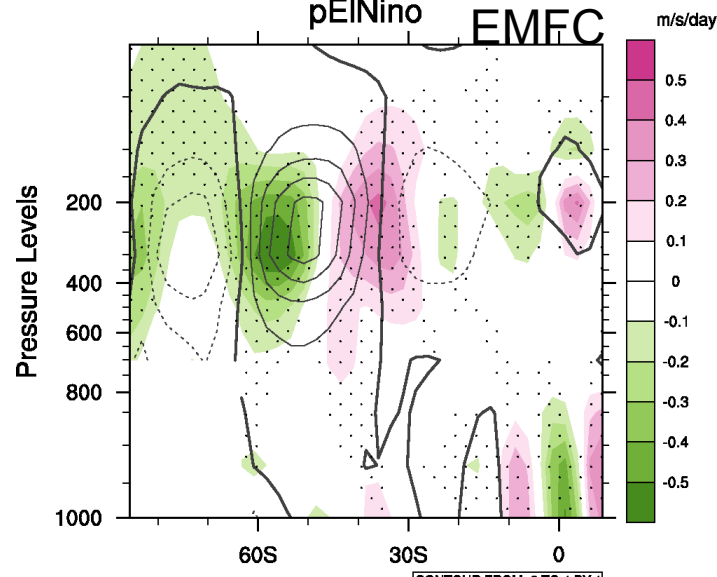
pElNino U



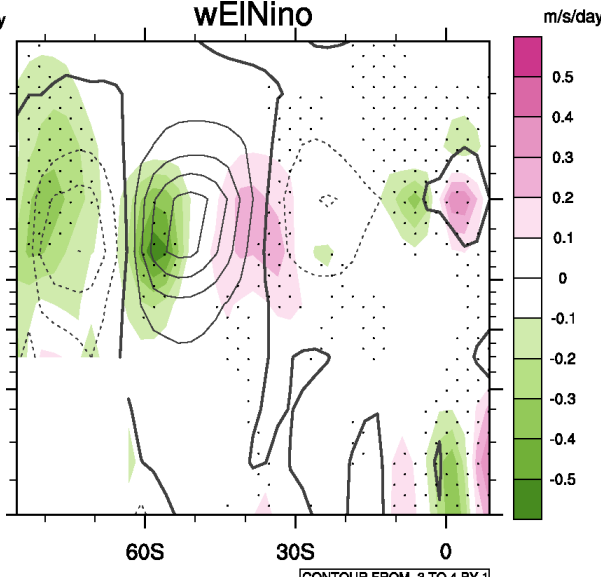
wElNino



pElNino EMFC



wElNino



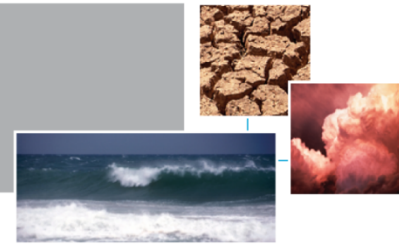
Weaker El Nino

→ Weaker westerlies on the equatorward side of the subtropical jet

→ Subsequent eddy-mean flow feedback weakens

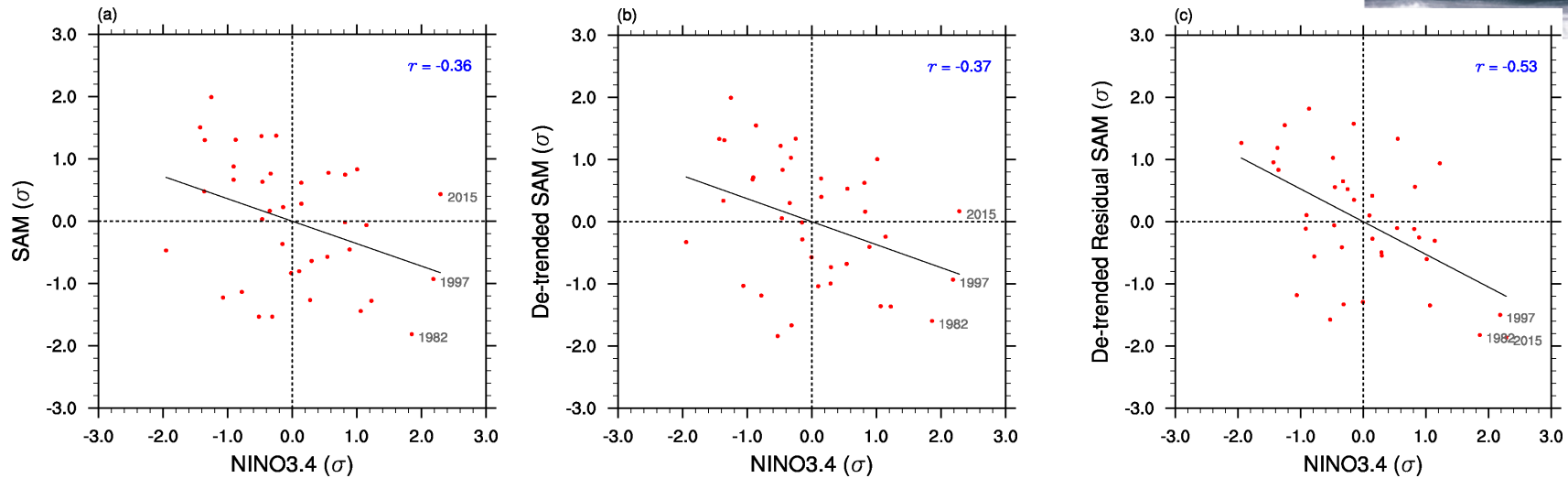
→ Weaker negative SAM

Summary



- pElNino experiment confirms the relationship between strong eastern Pacific El Nino and negative SAM in OND season
 - Under the scenario of the **doubling of the last 60-yr observed ocean temperature trend**
 - enhanced zonal SST gradient
 - weakening of upwelling in the equatorial eastern Pacific
- POAMA El Nino forecasts show
- **Weaker El Nino**
 - **Strength of El Nino & negative SAM connection weakens**
- Reduced predictability of SAM and associated surface climate conditions stemming from strong eastern Pacific El Nino
- *** Maloney (AMOS) also argues that enhanced upper tropospheric stabilization in future warmer climate will result in weaker teleconnection: for same ENSO rainfall anomaly, will need less w to balance the diabatic heating.**

The confounding influence on the SAM from the polar vortex



Nino34 versus (a) SAM, (b) de-trended SAM, and (c) de-trended residual SAM after removing the influence of the Antarctic stratospheric vortex

1979-2016 October-November-December (OND) data are displayed in each diagram

ENSO-SAM relationship is not sensitive to the de-trending, but strengthens when removing influence of stratospheric polar vortex

e.g. Neutral SAM was observed during strong 2015 El Nino due to the strengthening of the SH stratospheric polar vortex

In what follows, we remove the influence of polar vortex by linear regression