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

Eun-Pa Lim¹, Harry H. Hendon¹, Pandora Hope¹, Christine Chung¹ & Michael J McPhaden²

¹Bureau of Meteorology
²NOAA
- SAM refers to north/south shifts of the eddy driven jet
- SAM variations are the 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.

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?

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)

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)

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 1\textsuperscript{st}
Verified for **October-December mean**

\[ \textnormal{p} : \text{present climate} \]
\[ \textnormal{w} : \text{warmer climate} \]

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\textbf{2TR}: Doubling of the observed ocean T trends over 1960-2014

\[ \text{w} : \text{warmer climate} \]
Differences in climos  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 Nino3.4 region (top)

- Cooling on and below the thermocline at eq Pacific subsurface (middle)

- Reduced mean upwelling in equatorial eastern Pacific (bottom)
\[ \text{pElNino} - \text{pCLIM} = \text{pElNino}' \]

**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
• $w\text{ElNino}'$ is simulated to be $\sim 0.2^\circ\text{C}$ cooler in the eastern Pacific (significant at the 5% level)
Why is El Nino weaker in wCLIM?

- **Reduced thermocline feedback due to reduced mean upwelling** in the eastern Pacific

- **Reduced zonal advective feedbacks** in central Pacific
  - 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**
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

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

- 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