Role of Stochastic Atmospheric Forcing in Tropical Pacific Decadal Variability and ENSO Modulation

Tianyi Sun and Yuko Okumura

Institute for Geophysics, University of Texas at Austin

CESM Workshop 2017

TEXAS Geosciences
The University of Texas at Austin
Jackson School of Geosciences

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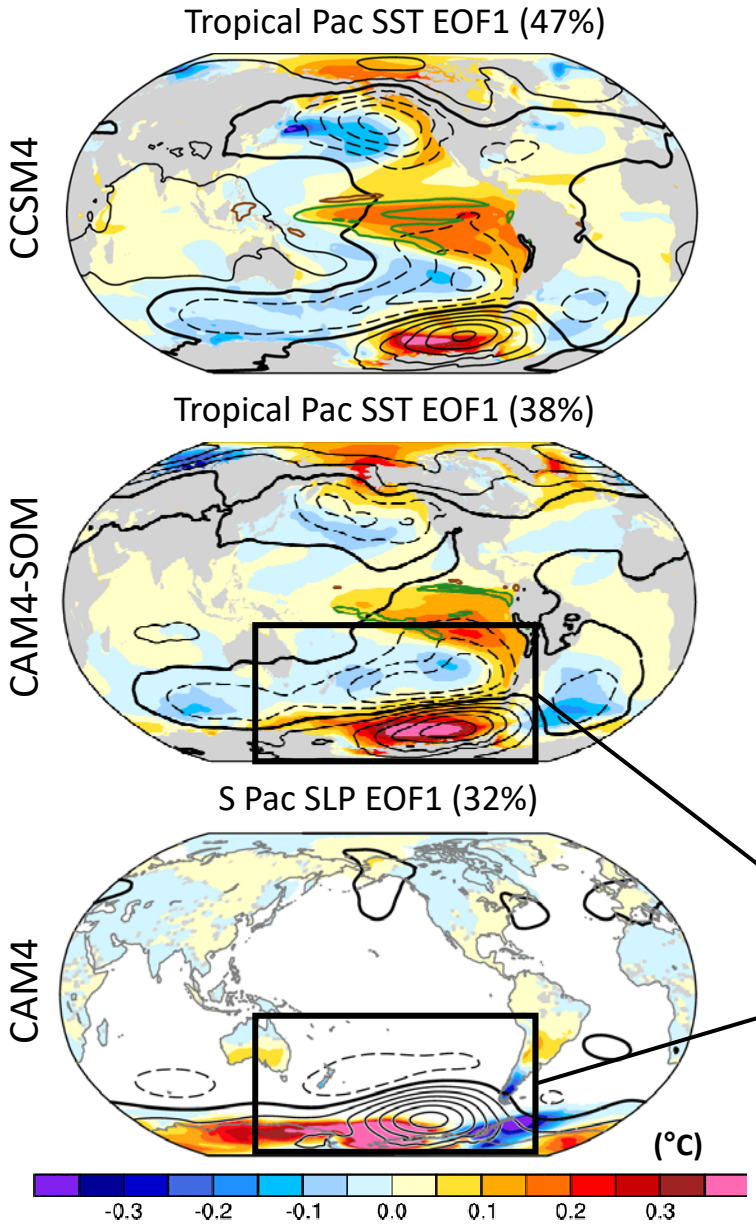
NSF

Motivation

Global Regression Patterns of Tropical Pacific Decadal Variability

SST, SLP (0.1hPa) and Rainfall (0.2mm/day)



Hypothesis

ENSO frequency & duration

↕

Tropical Pacific warming

↑

Pacific-South American (PSA)

– Okumura, Sun and Wu 2017

Methodology

Hypothesis

ENSO frequency & duration

↕

Tropical Pacific warming

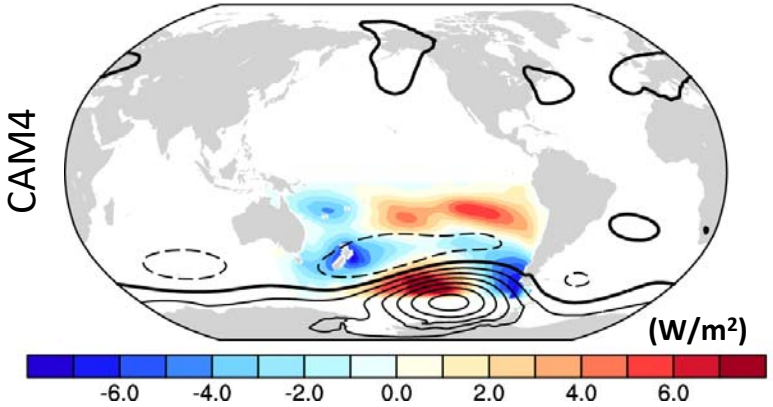
↑

Pacific-South American (PSA)

CCSM4

Atmosphere

Regression of Surface Heat Flux on S Pac SLP (0.1hPa) PC1
(>10yrs, 4 standard deviation)



\+ surface heat flux

Ocean

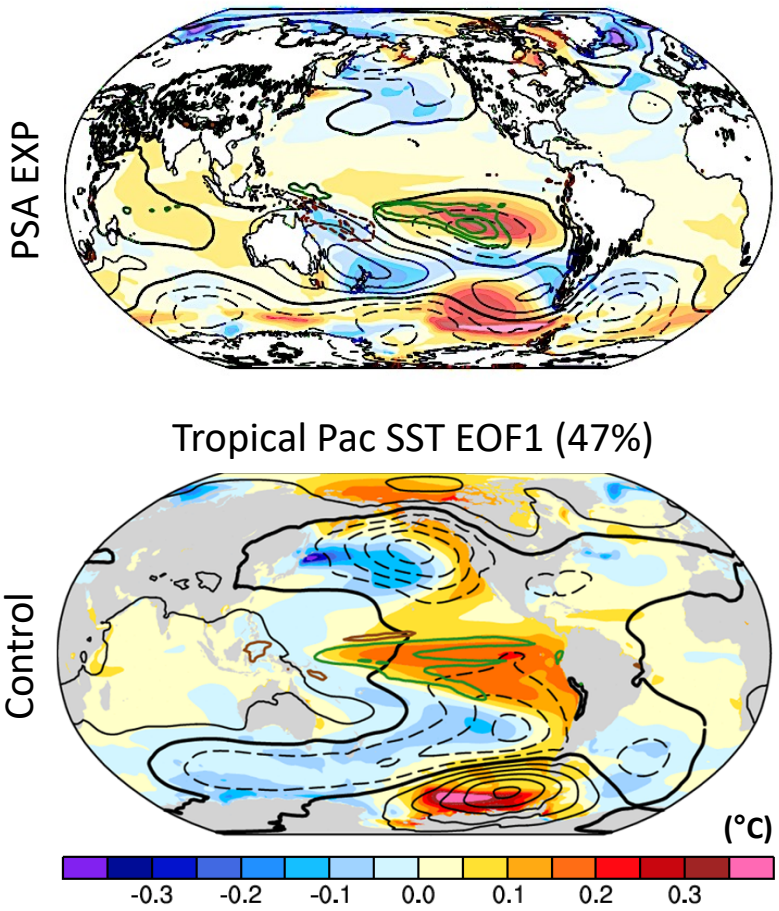
Control: year 800-1300 of CCSM4 pre-industrial simulation
PSA Experiments: 100yrs x 4 ensemble members

PSA_945
PSA_965
PSA_1045
PSA_1165

Time Mean Response

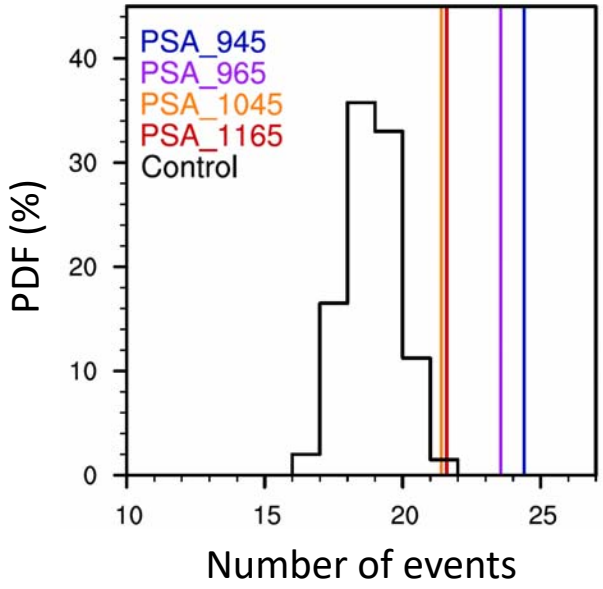
Ensemble Mean Response

SST, SLP (0.1hPa) and Rainfall (0.2mm/day)



El Niño Frequency

Number of El Niño events per 100 years



Q1: Why does the tropical Pacific warm less in PSA experiments compared to control run?

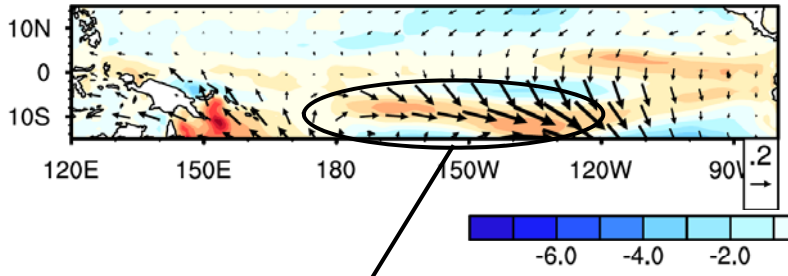
Q2: Why do El Niño events become more frequent in PSA experiments?

Time Mean Response

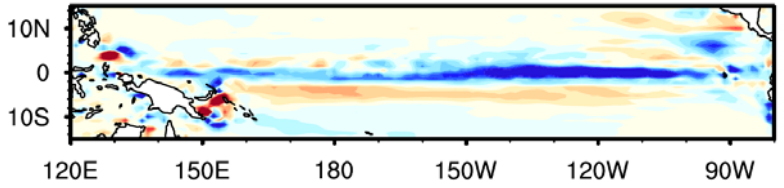
Q1: Why does the tropical Pacific warm less in PSA experiments compared to control run?

Ocean Mixed-layer Heat Budget Analysis

Latent Heat and Surface Wind



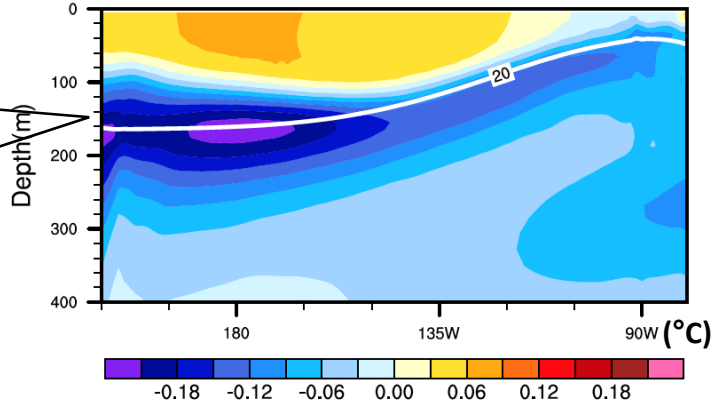
Vertical Advection (–w'dT/dz–wdT'/dz)



Wind stress curl -> Southward Sverdrup transport

Westerly wind anomaly -> Zonal momentum balance

Ocean temperature anomaly along the equatorial Pacific

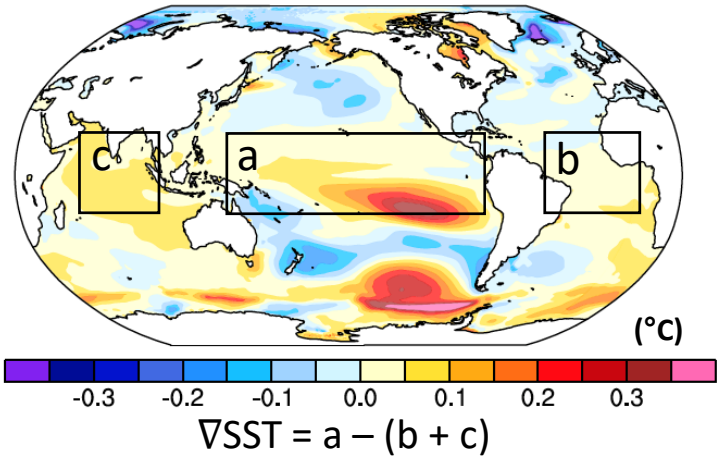


El Niño Frequency

Q2: Why do El Niño events become more frequent in PSA experiments?

Interbasin SST gradient (∇SST) <--> El Niño frequency (Okumura, Sun & Wu 2017)

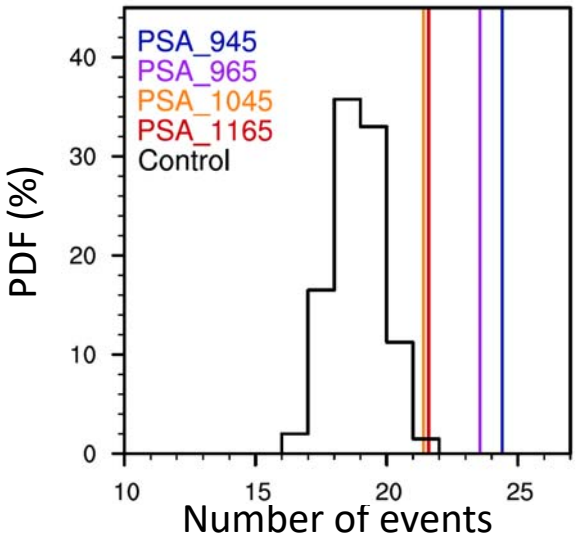
Ensemble Mean Feb-Apr SST Response

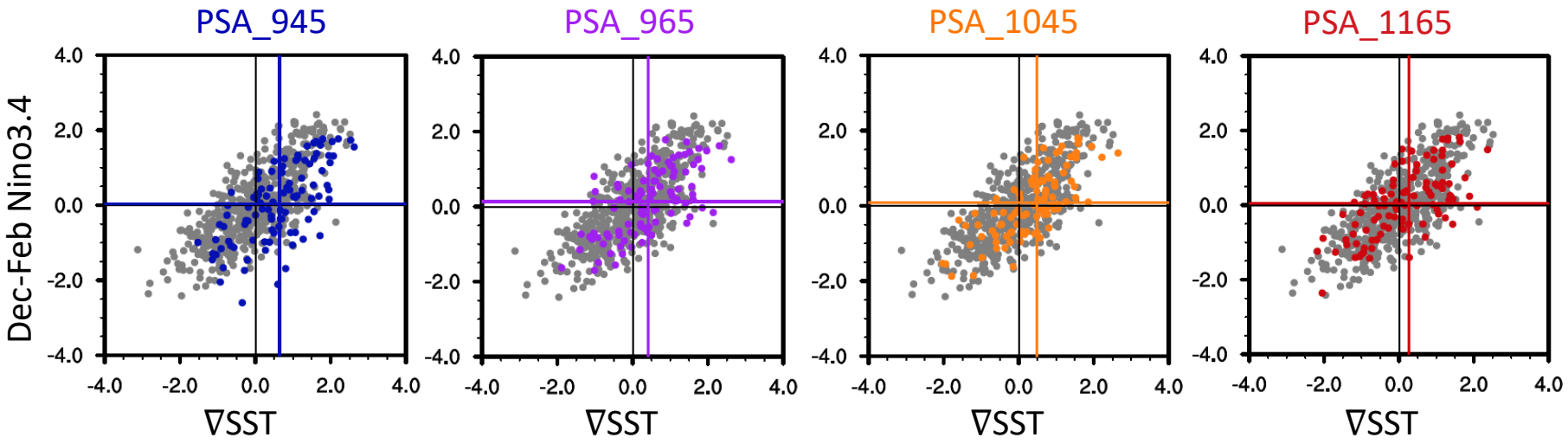


∇SST = a – (b + c)

(regression on previous Dec Nino3.4 index removed)

Number of El Niño events per 100 years





Summary

More El Niños

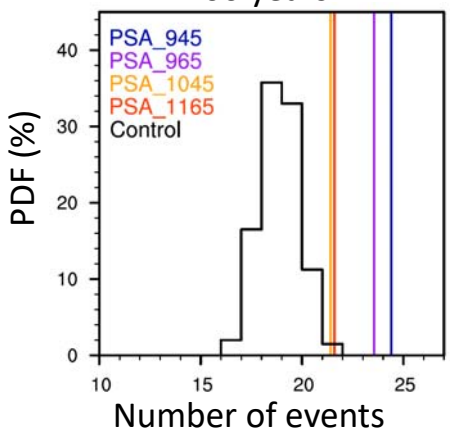
↑

Tropical Pacific warming
(weak equatorial warming)

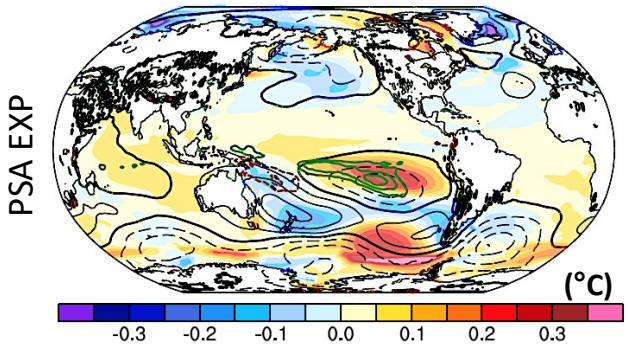
↑

Pacific-South American
(PSA)

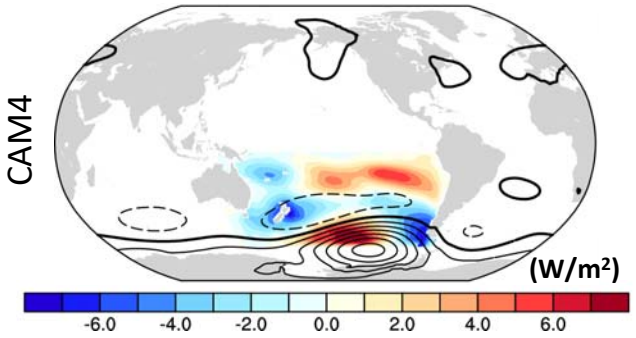
Number of El Niño events per 100 years



Ensemble Mean Response
SST, SLP (0.1hPa) and Rainfall (0.2mm/day)

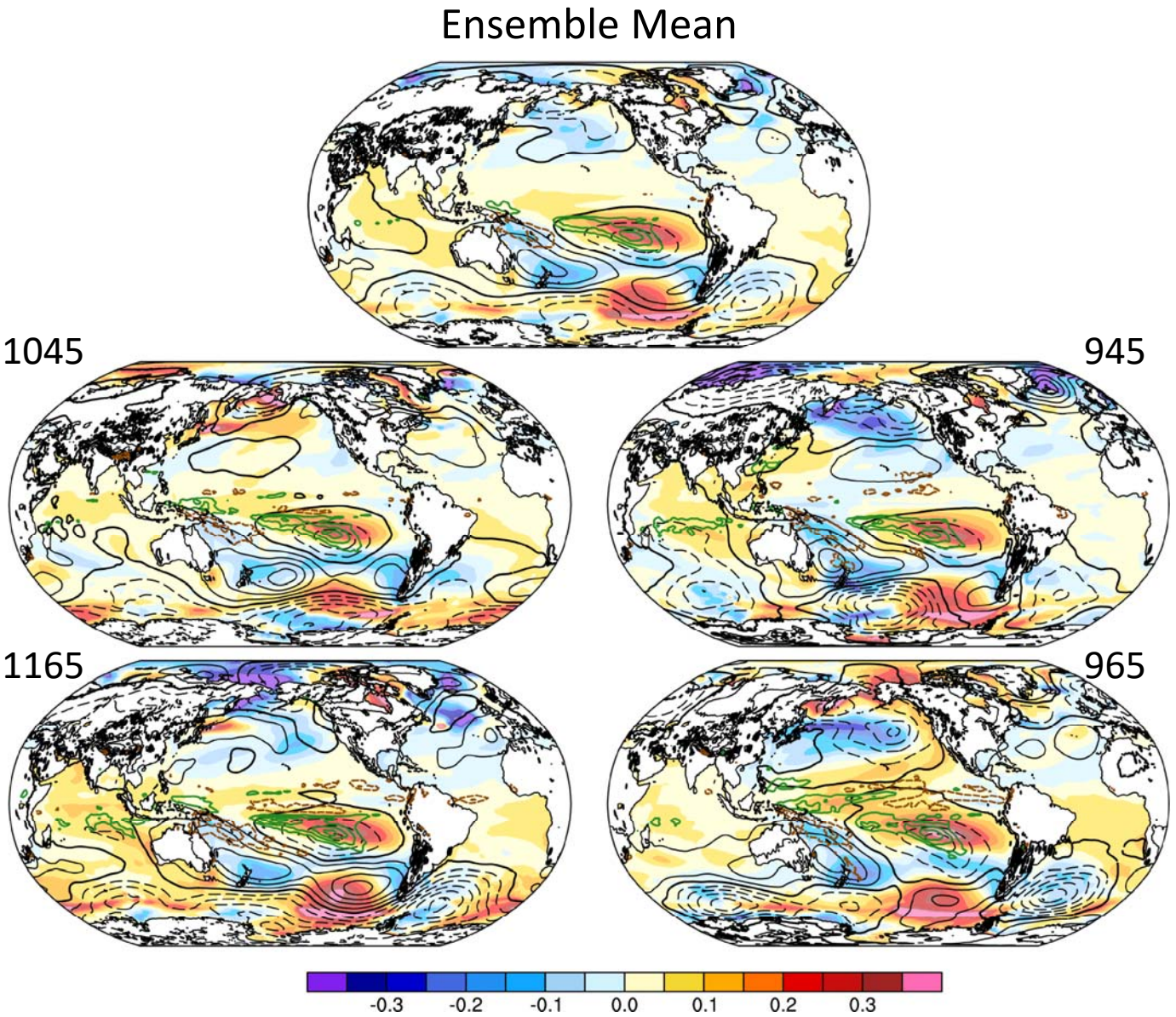


Regression of Surface Heat Flux on
S Pac SLP (0.1hPa) PC1

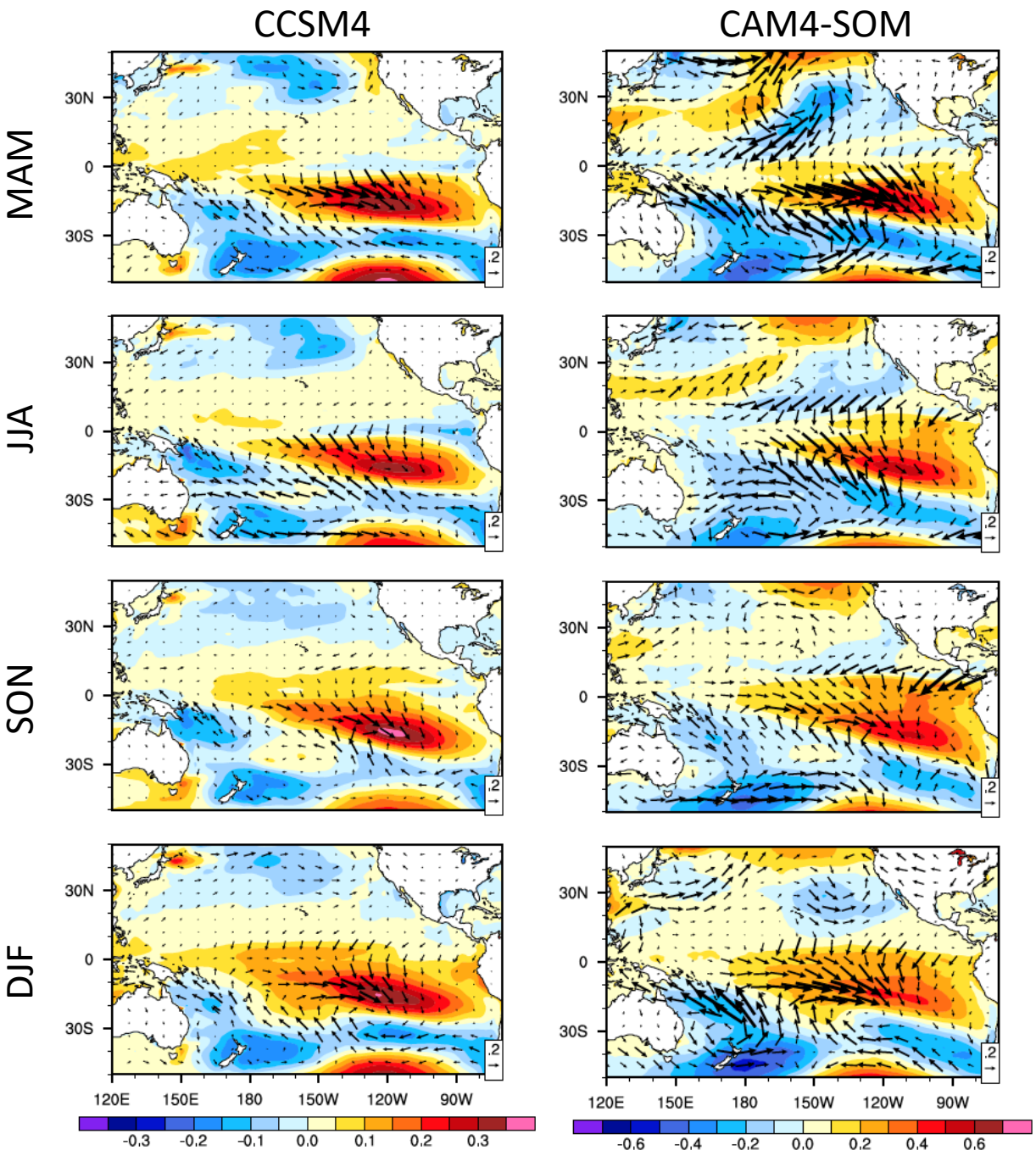


Back up slides

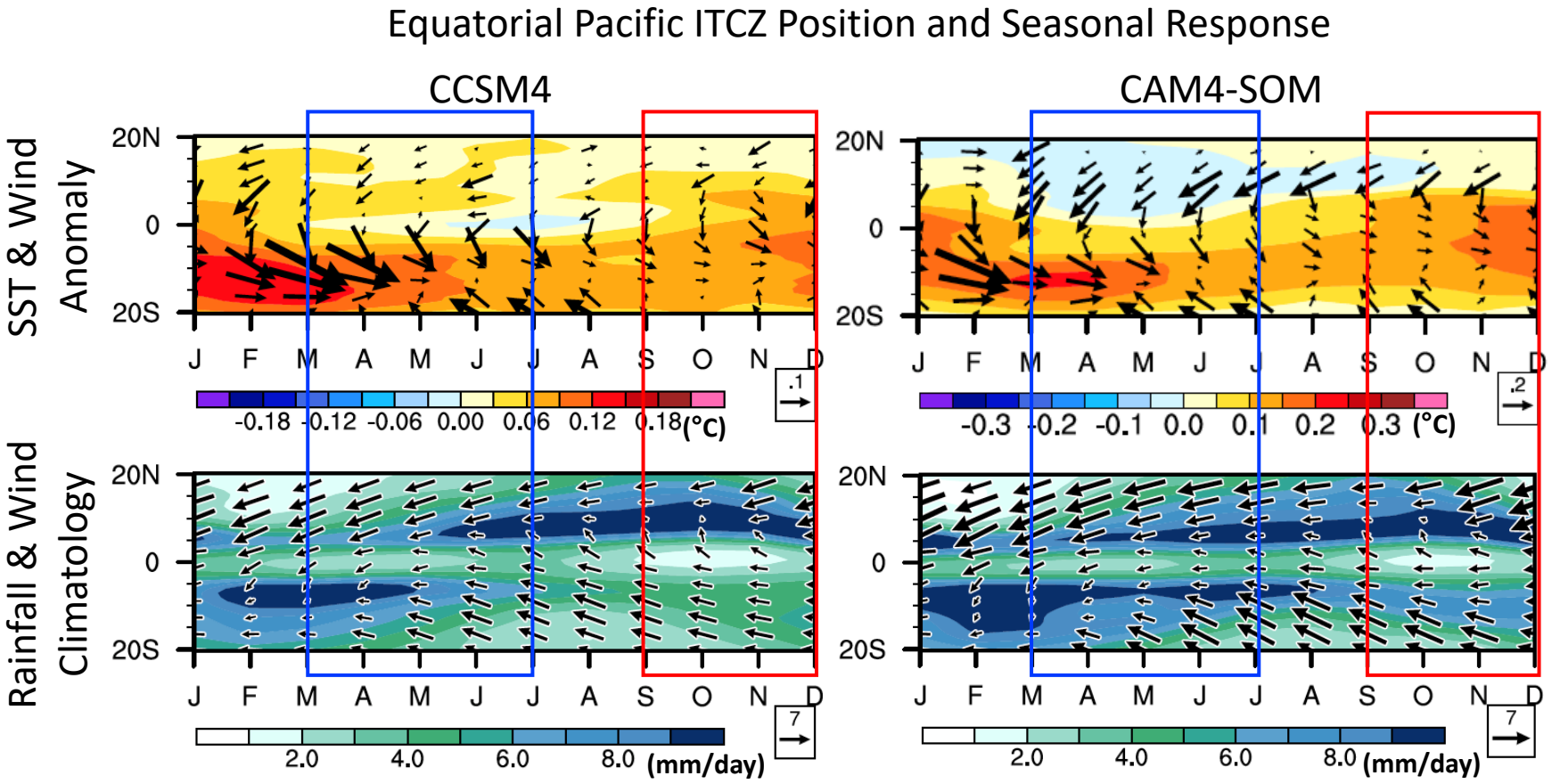
Time Mean Response (supp.)



Seasonal Mean Response of SST and Wind



Atmospheric forcing : seasonality of the WES feedback

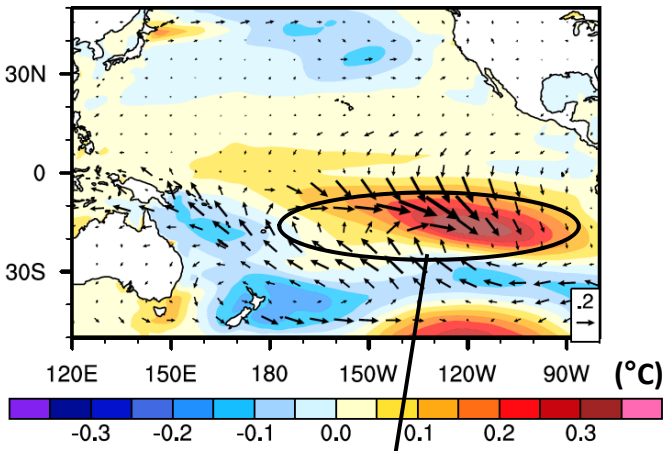


Seasonality of the WES feedback

- SOND: ITCZ north of equator -> warming extends to equatorial Pacific.
- MAMJJ: ITCZ south of equator -> cross-equatorial northerly wind induces cooling of the equatorial Pacific.

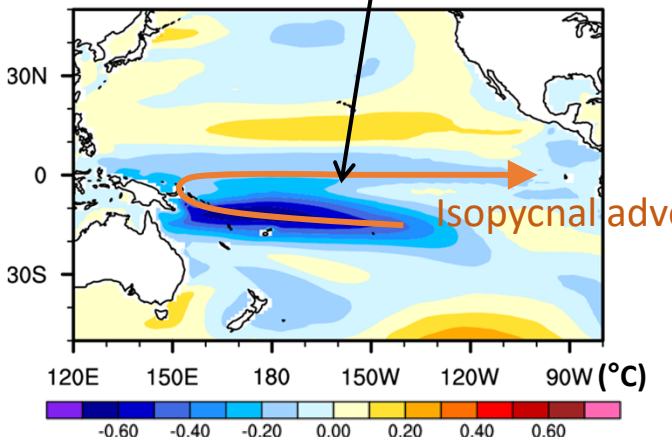
Oceanic Adjustments, CCSM4

SST and Wind



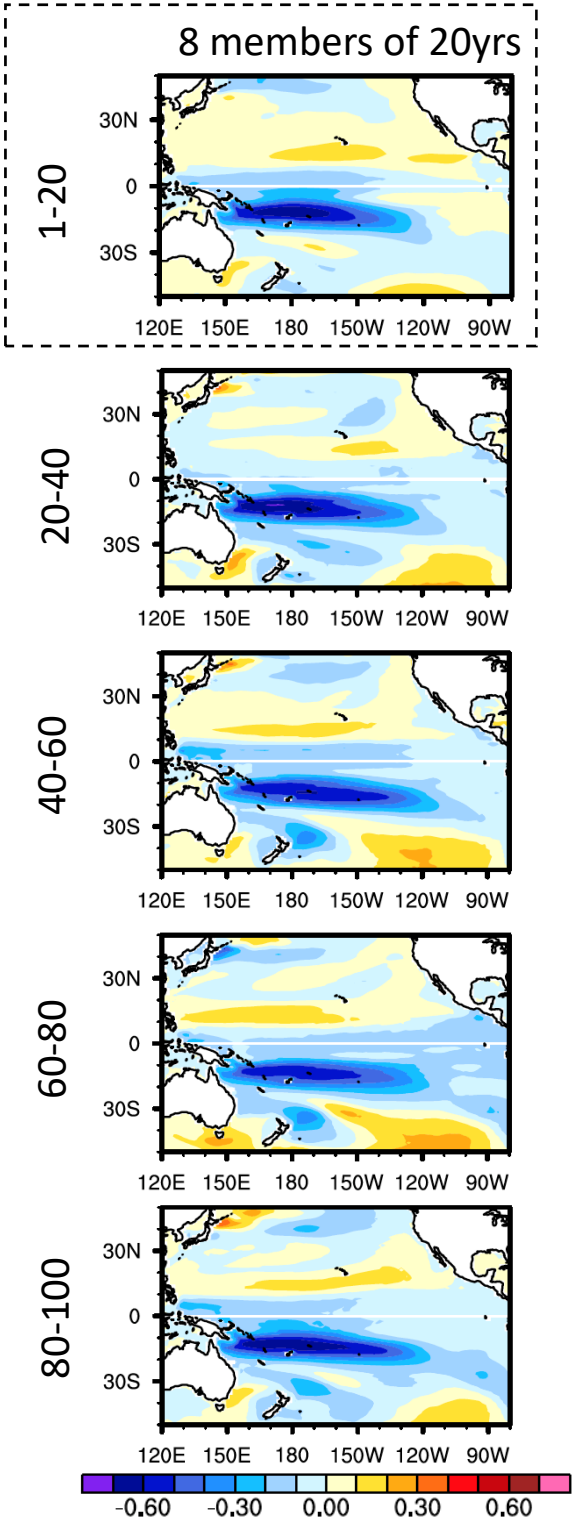
Ekman pumping

Westward Rossby Wave propagation



Isopycnal advection ?

Ocn temp along isopycnal 25-27



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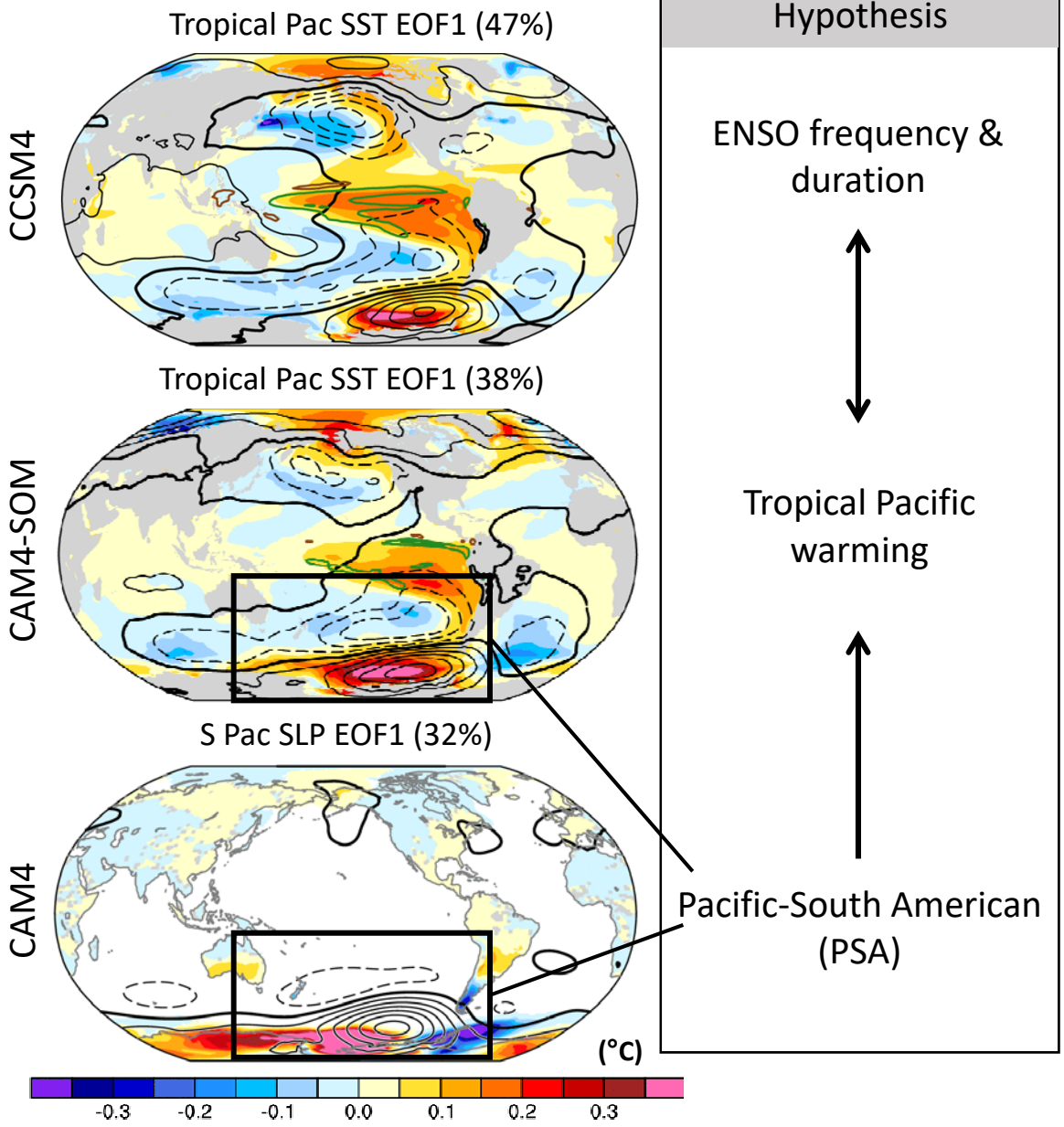


Hypothesis

ENSO frequency & duration

↕

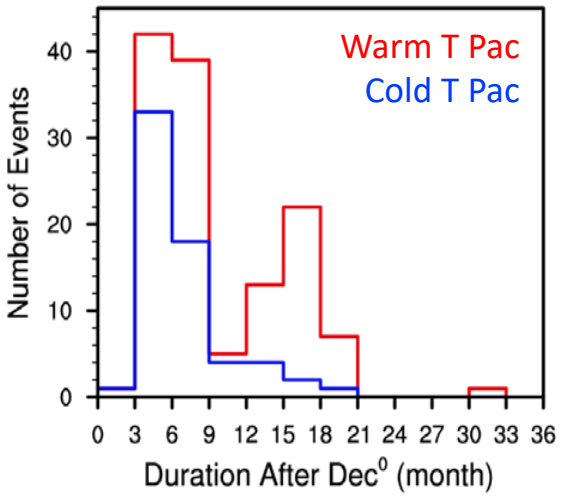
Tropical Pacific warming

↑

Pacific-South American (PSA)

Number of El Niño Events	
All Years	193()
Warm T Pac	130
Cold T Pac	63

El Niño Duration



– Okumura, Sun and Wu 2017

Time Mean Response

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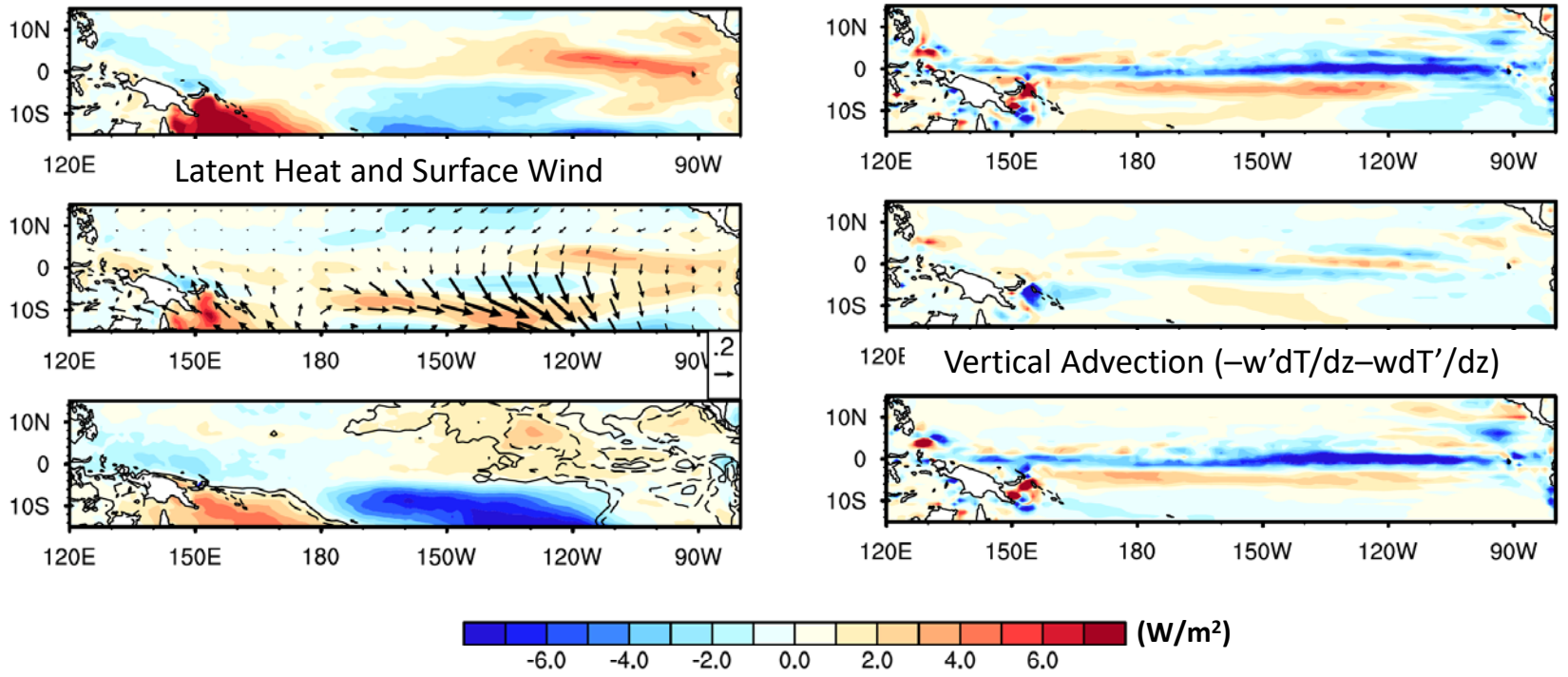
Ocean Mixed-layer Heat Budget Analysis