

# Origins of Tropical Pacific Decadal Variability: Role of Stochastic Atmospheric Forcing From the South Pacific

Yuko M. Okumura

*The University of Texas at Austin Institute for Geophysics (UTIG)*



**INSTITUTE FOR GEOPHYSICS**  
**JACKSON SCHOOL OF GEOSCIENCES**

# Motivation

**Extratropical  
Atmospheric Variability**

(e.g., *Barnett et al. 1999*;  
*Liu and Alexander 2007*)

Atmospheric Bridge  
(stochastic)

**Extratropical  
Oceanic Variability**

(e.g., *Gu and Philander 1997*;  
*Luo and Yamagata 2001*)

Oceanic Bridge  
(deterministic)

**Tropical Pacific Decadal Variability**

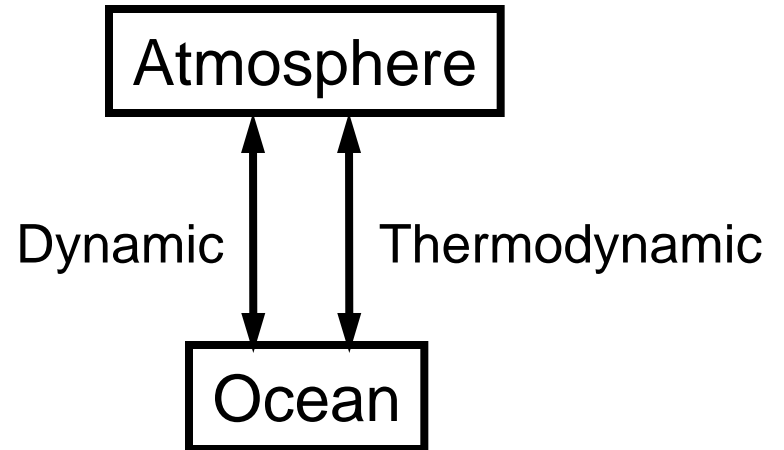
**Tropical Air-Sea Interactions/  
ENSO residuals**

(e.g., *Knutson and Manabe 1998*; *Newman et al. 2003*;  
*Rodgers et al. 2004*; *Vimont 2005*)

# Methods

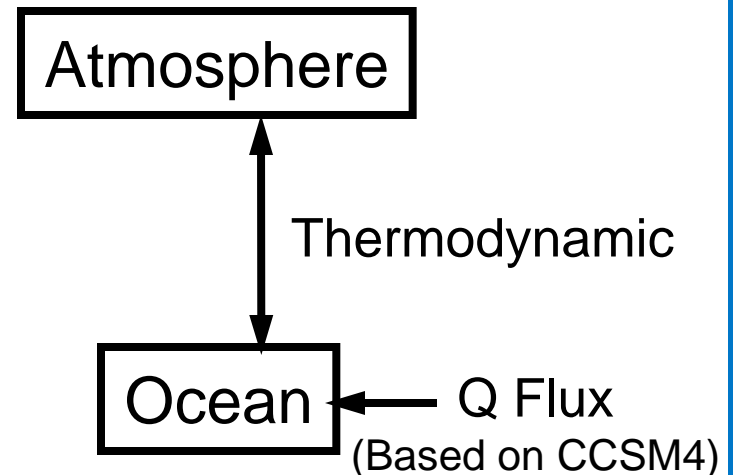
## CCSM4

**1300-year Control Run** of  
Community Climate System  
Model version 4



## CAM4-SOM

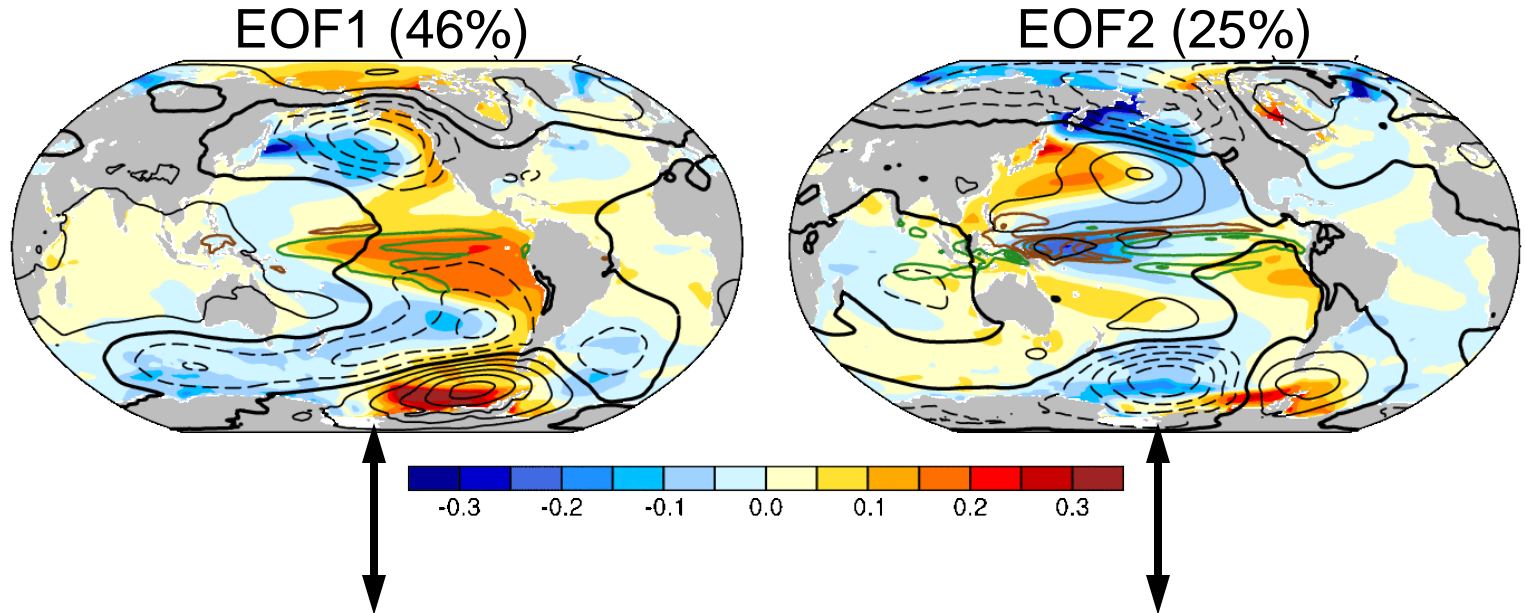
**500-year Control Run** of  
Community Atmosphere  
Model version 4 coupled to  
a slab ocean



# Tropical Pacific Decadal Variability in CCSM4

Tropical Pacific SST EOF (>10yr) → Global Regression  
SST (° C), SLP (0.1 hPa) & Precipitation (Wet/Dry, 0.2 mm/day)

CCSM4



Relative frequency of  
El Nino and La Nina

PC1 > 0, more El Ninos

PC1 < 0, more La Ninas

ENSO amplitude ( $r \sim 0.8$ )

PC2 > 0, stronger ENSO

PC2 < 0, weaker ENSO

# Are Ocean Dynamics and ENSO Necessary for TPDV?

**CCSM4**

**1300-year Control Run**



Tropical Pacific Decadal Variability  
SST EOF Analysis (>10yr)

**CAM4-SOM**

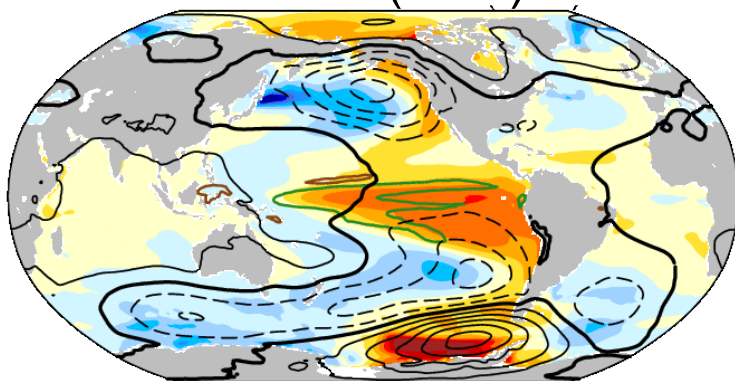
**500-year Control Run**

# Role of Ocean Dynamics in Tropical Pacific Decadal Variability

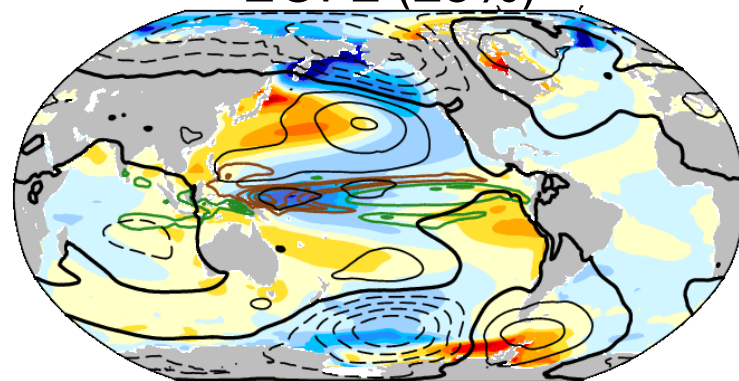
Tropical Pacific SST EOF (>10yr) → Global Regression  
SST ( $^{\circ}$  C), SLP (0.1 hPa) & Precipitation (Wet/Dry, 0.2 mm/day)

CCSM4

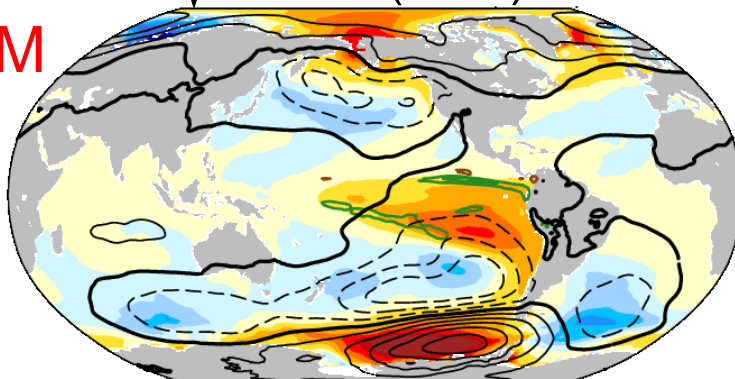
EOF1 (46%)



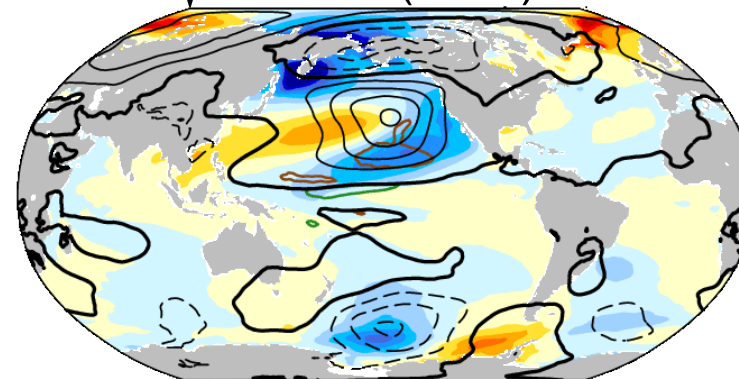
EOF2 (25%)



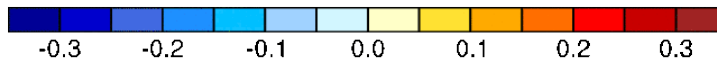
EOF1 (38%)



EOF2 (18%)

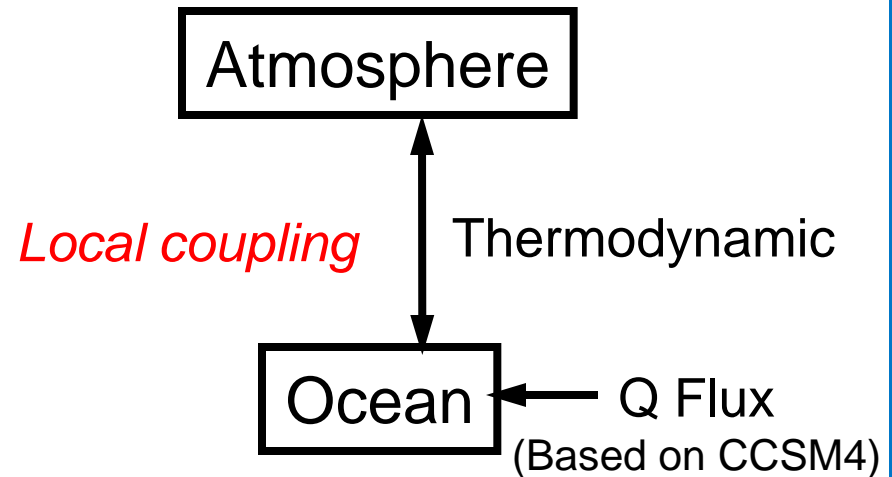


CAM4-SOM



# What Causes T Pacific Decadal Variability in CAM4-SOM?

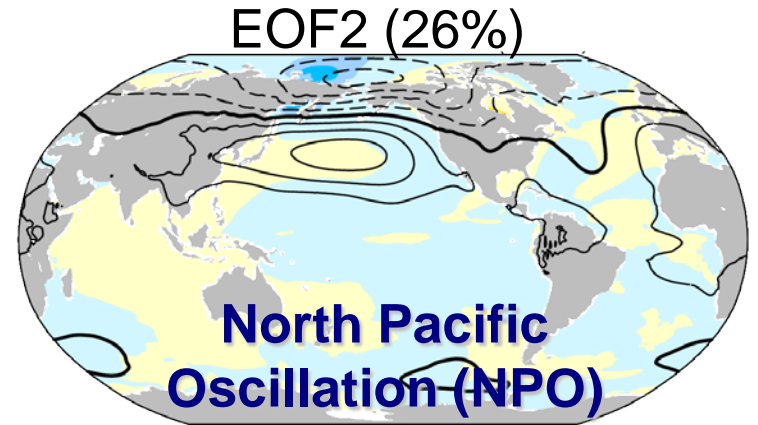
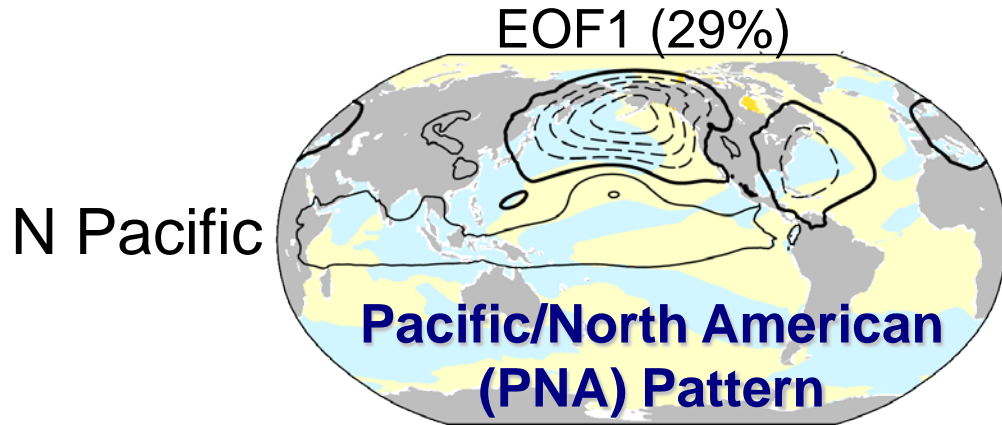
**CAM4-SOM**  
**500-year Control Run**



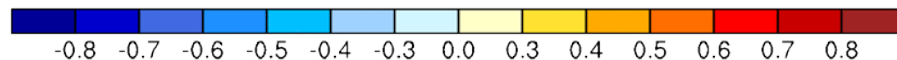
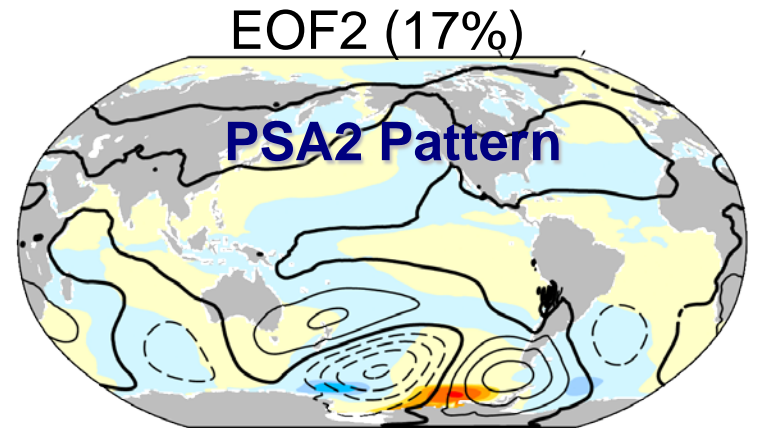
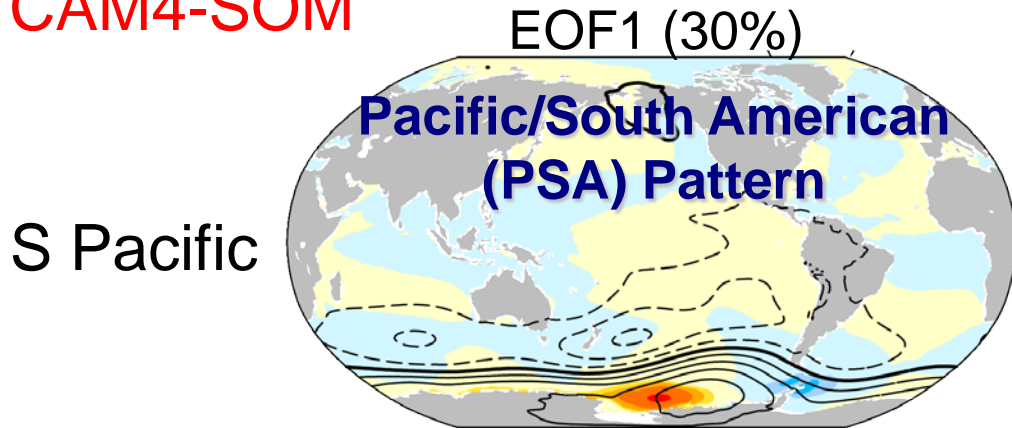
The spatial patterns of SST variability are likely determined by internal modes of atmospheric variability.

# Patterns of Internal Atmospheric Variability

**North/South Pacific SLP EOF (Monthly) → Global Correlation**  
SLP (0.2) & SST (0.1)



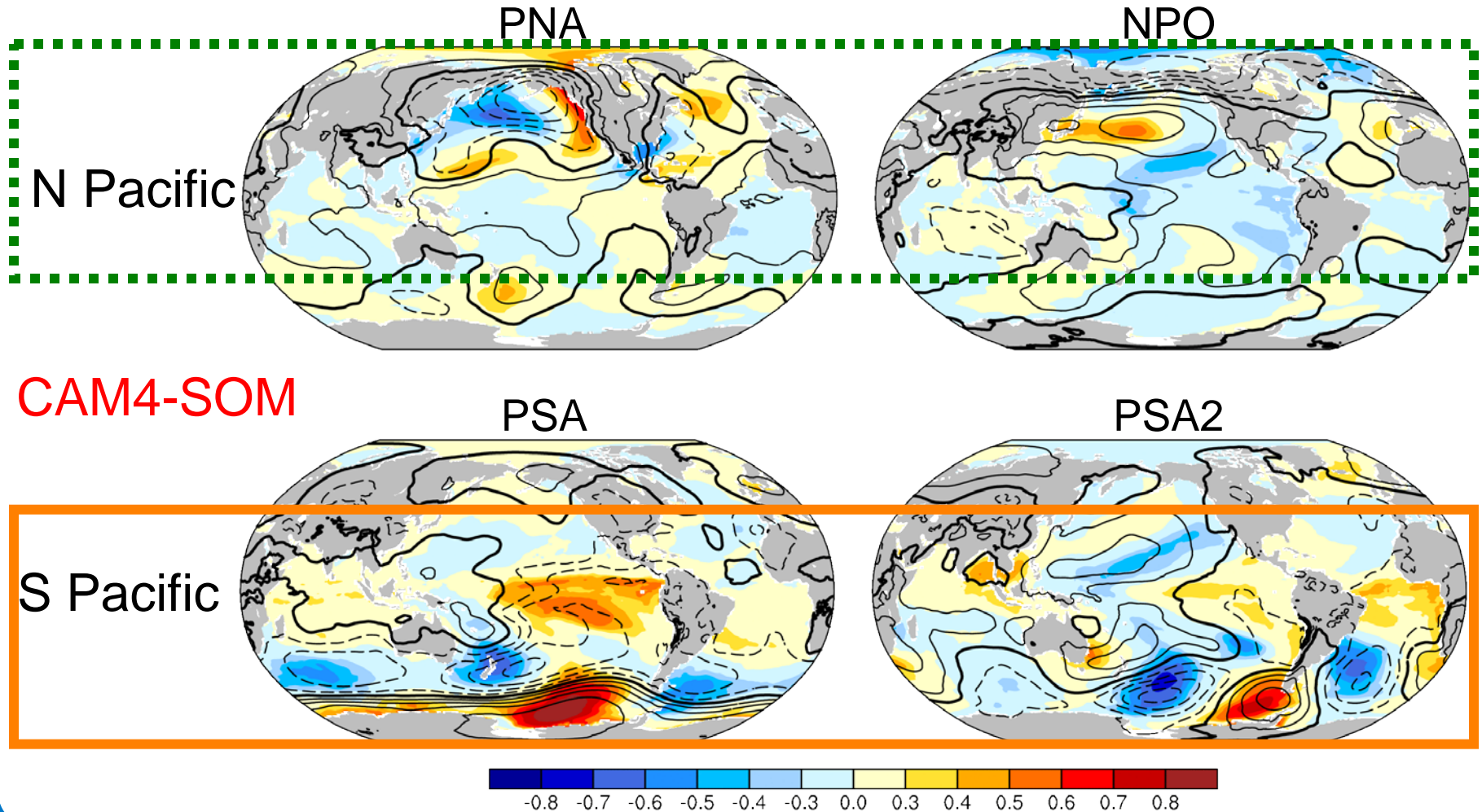
**CAM4-SOM**





# Role of Stochastic Atmospheric Forcing for TPDV

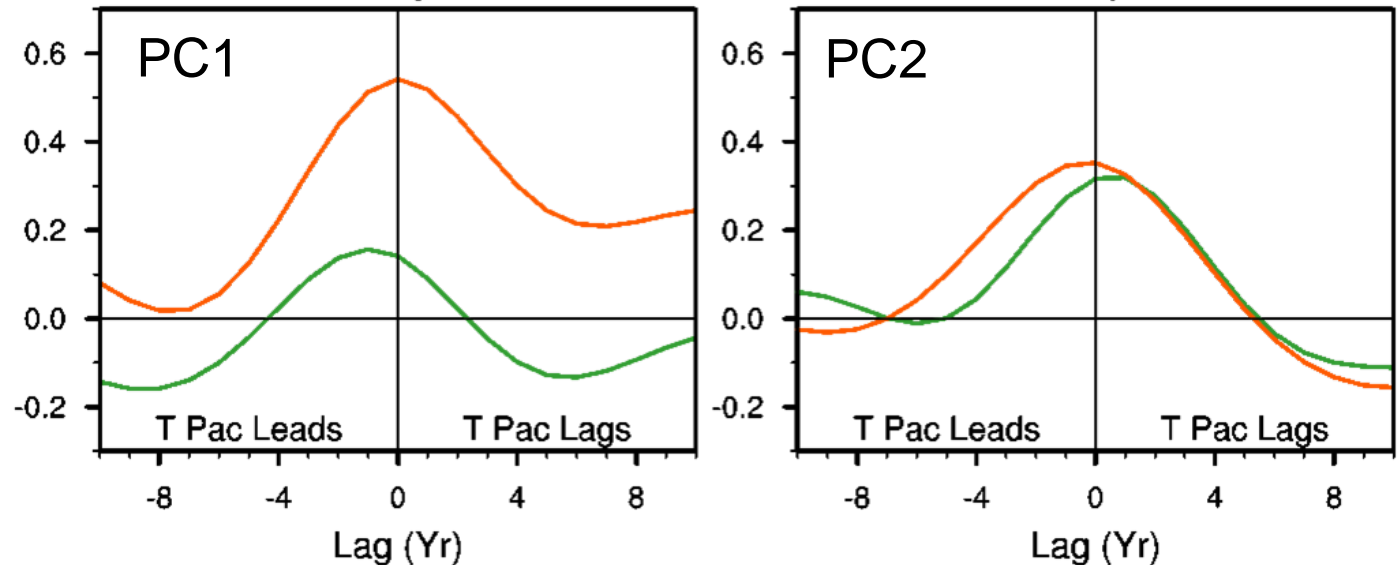
N/S Pacific SLP EOF (**Monthly** → **>10yr**) → Global Correlation  
SLP (0.2) & **SST** (0.1)



# Role of Stochastic Atmospheric Forcing from the South Pacific

Lag Correlation of Tropical Pacific SST PCs  
with **North** and **South** Pacific SLP PCs (>10yr)

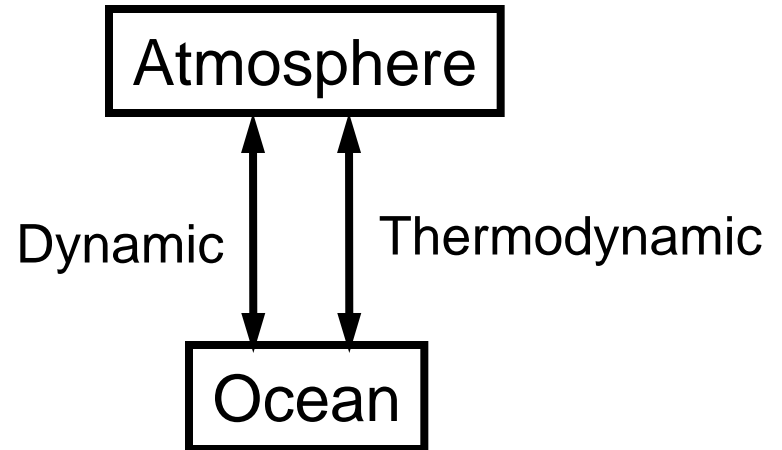
CAM4-SOM



- Important role of South Pacific atmospheric variability for the first mode (PDO/IPO)
- Two-way interactions between the tropics and extratropics

# What is the Role of Ocean Dynamics and ENSO?

**CCSM4**  
**1300-year Control Run**



How does the inclusion of dynamical air-sea interaction affect tropical Pacific decadal variability?

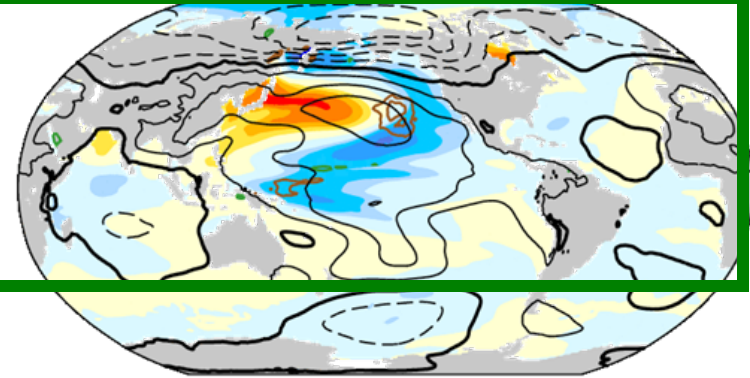
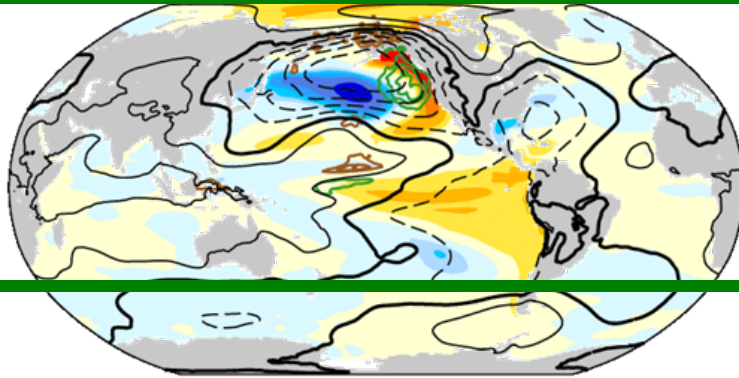
# Role of Ocean Dynamics and ENSO for TPDV

N/S Pacific SLP EOF (**Monthly** → **>10yr**) → Global Correlation  
SLP (0.2) & **SST (0.1)**

PNA

NPO

N Pacific

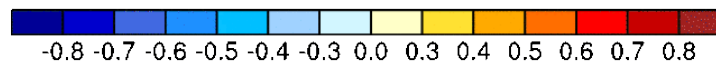
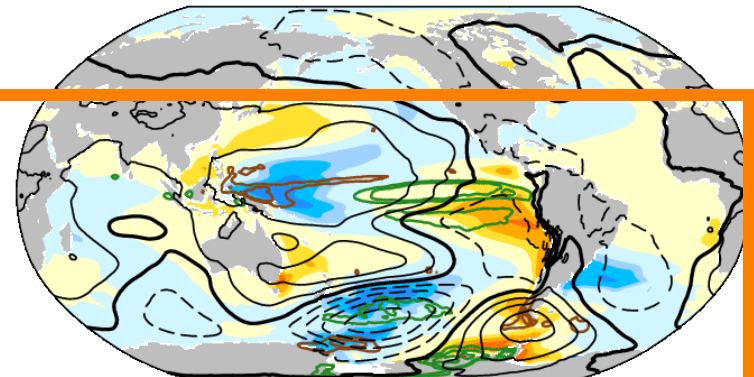
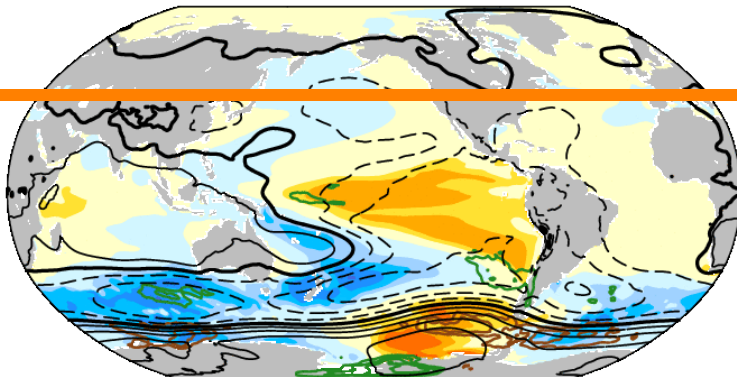


CCSM4

PSA

PSA2

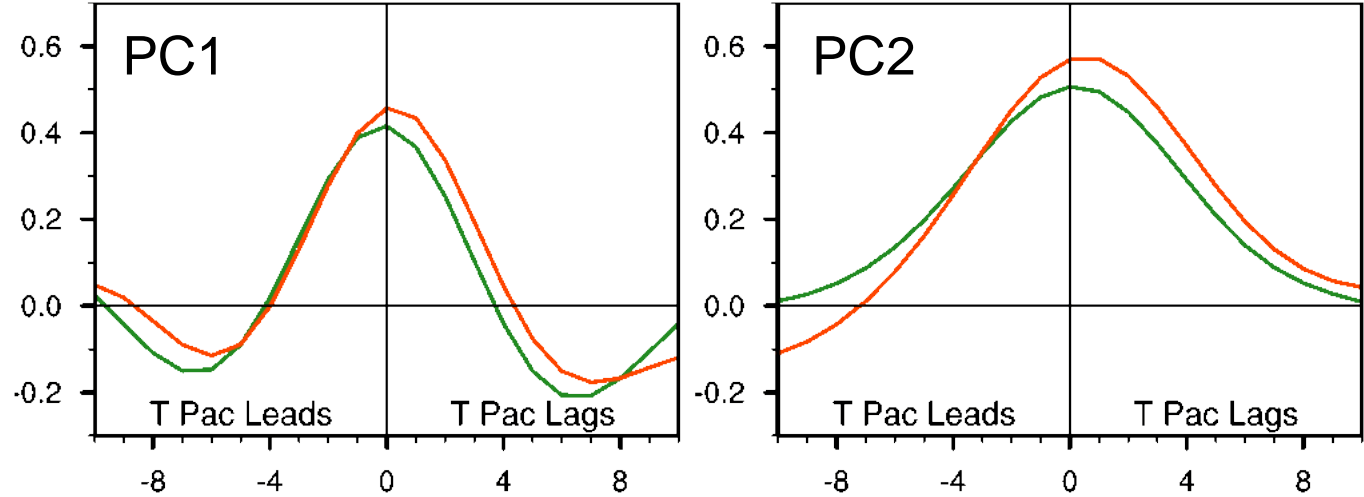
S Pacific



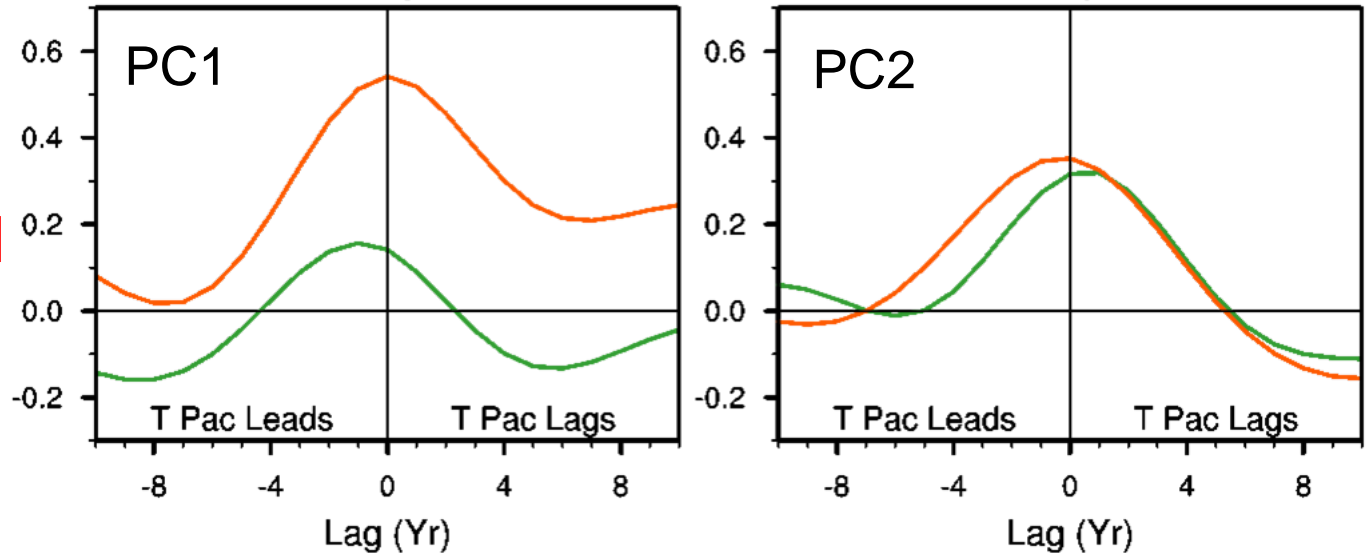
# Role of Stochastic Atmospheric Forcing and Ocean Dynamics

Lag Correlation of Tropical Pacific SST PCs  
with **North** and **South** Pacific SLP PCs (>10yr)

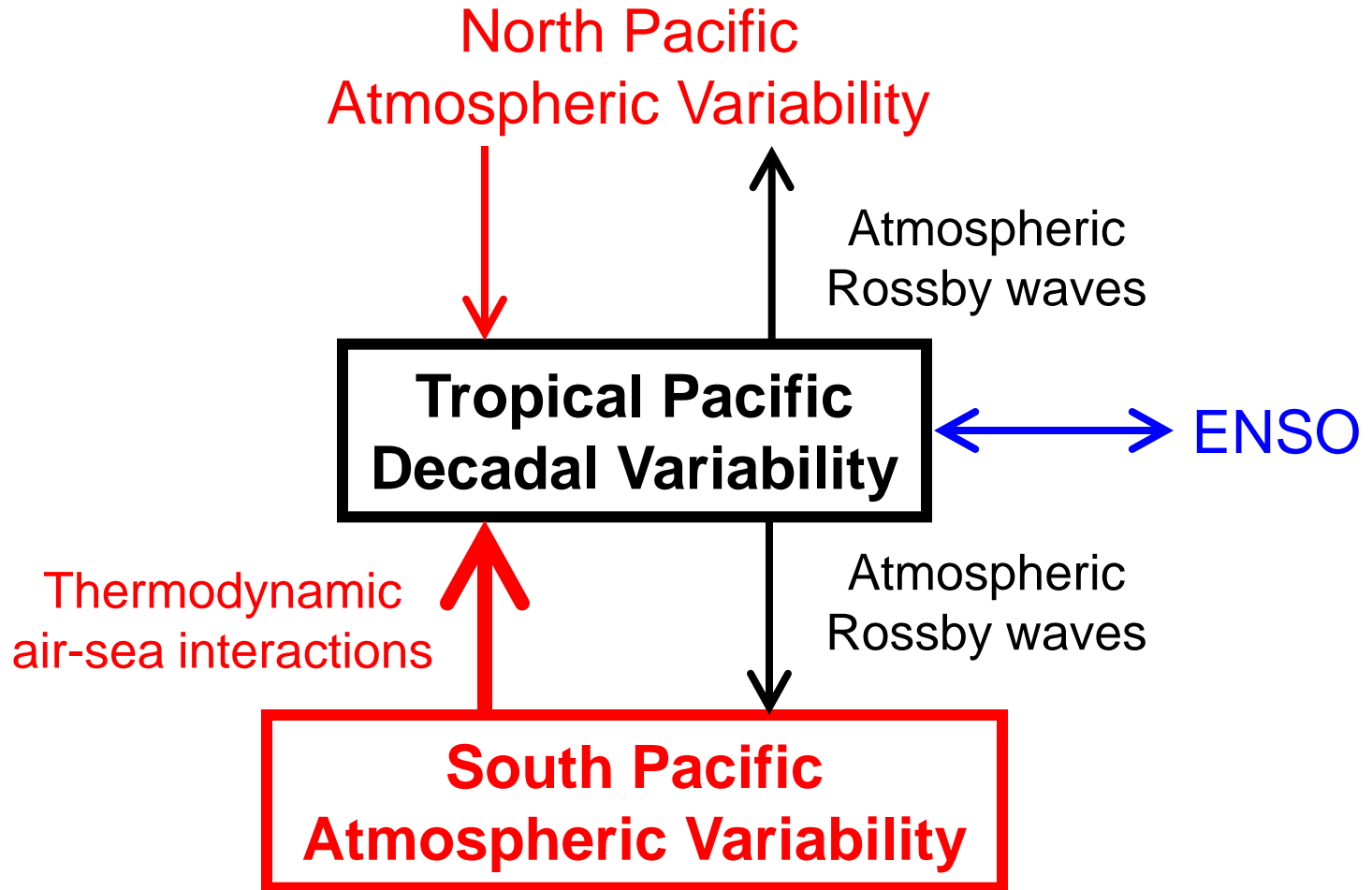
CCSM4



CAM4-SOM



# Summary

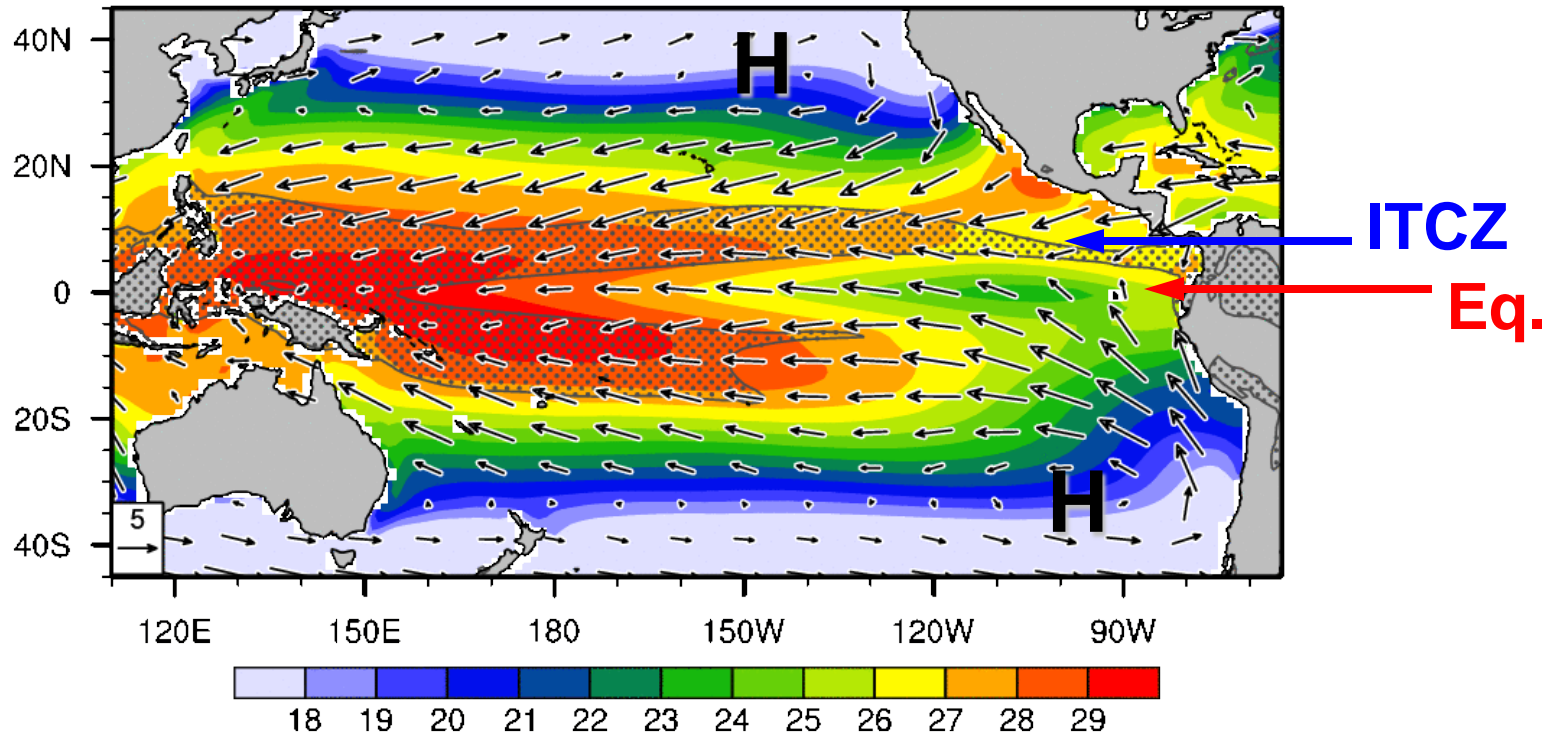




# Why Does the South Pacific Play More Important Role?

## Annual Climatology in CAM4-SOM

SST, Precipitation (>5mm/day) & Surface Wind

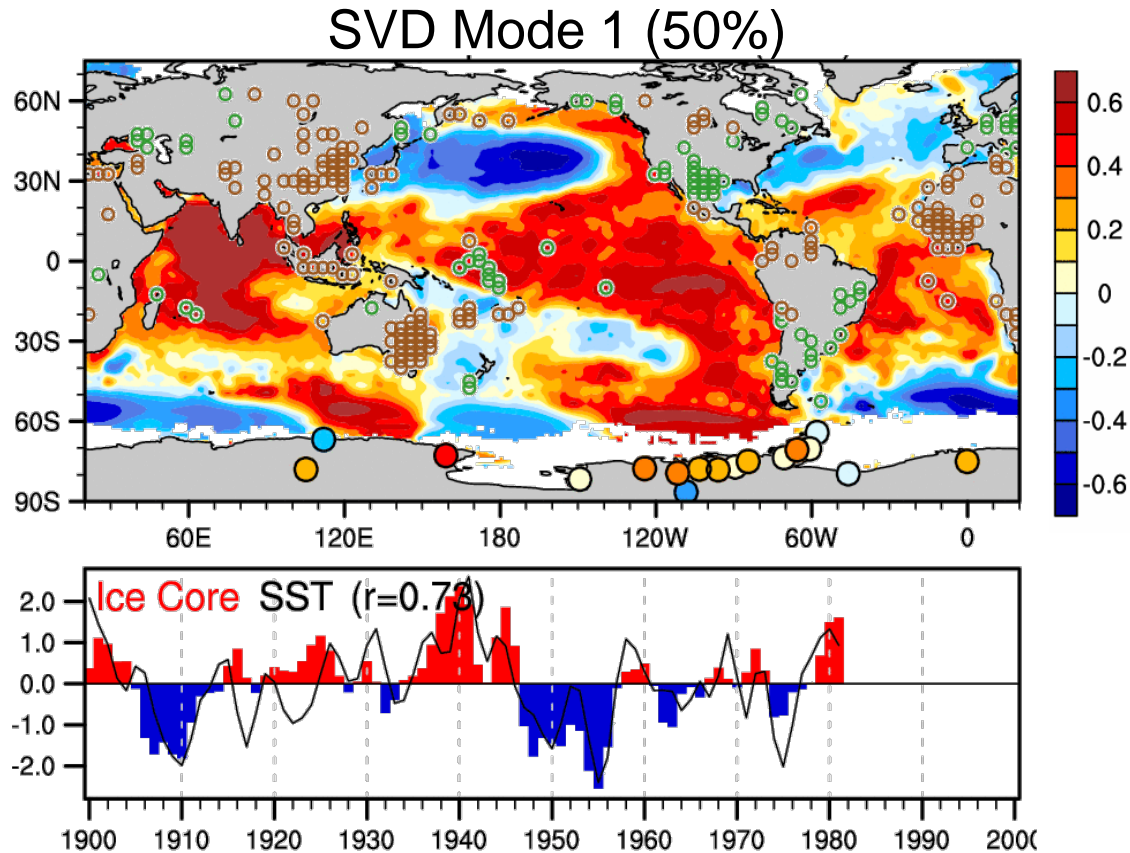


The role of South Pacific atmospheric variability in tropical Pacific interannual variability has been suggested by Trenberth and Shea (1987) and more recently by S. Minobe, H. Zhang and A. Clement (AGU2012).

# Implication for PDO/IPO Reconstruction

## SVD Analysis of Tropical SST & Antarctic Ice Core

→ Global Correlation: SST, Ice Core & Precipitation (Wet/Dry)

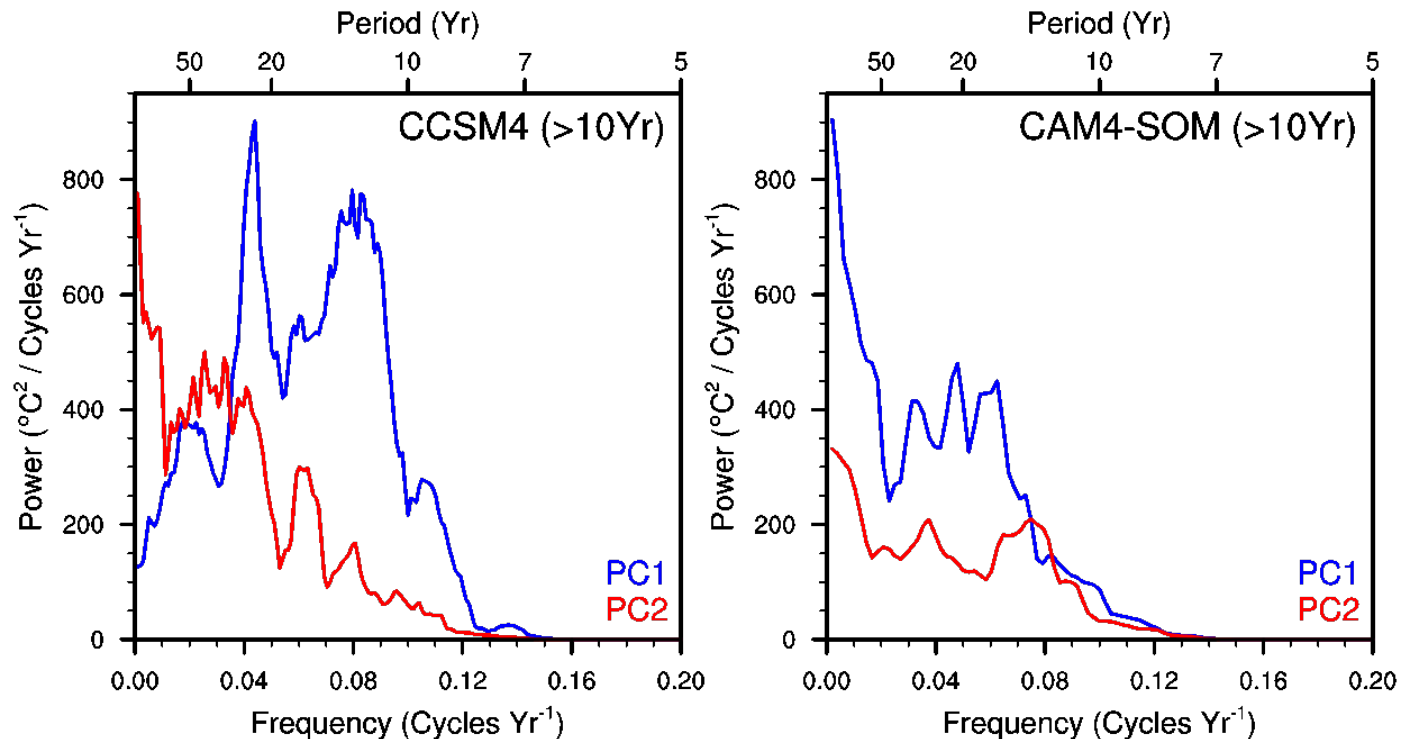


Okumura, Schneider, Deser and Wilson (*J. Climate*, 2012)



# Does the Ocean Set the Decadal Time Scales?

## Power Spectra of Tropical Pacific SST PCs (>10yr)



Strong oceanic linkages from the South Pacific to the tropical Pacific have been suggested by Wang and Liu (2000), Chang et al. (2001), Luo and Yamagata (2001), Giese et al. (2002), and Tatebe et al. (2013).

Thank you!



Blue Bonnet on the Pickle Research Campus, University of Texas at Austin