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)
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)
**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

Q Flux (Based on CCSM4)
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)

EOF1 (46%)
EOF2 (25%)

Relative frequency of El Nino and La Nina
PC1 > 0, more El Ninos
PC1 < 0, more La Ninas

ENSO amplitude (r~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 (°C), SLP (0.1 hPa) & Precipitation (Wet/Dry, 0.2 mm/day)

CCSM4

EOF1 (46%)

EOF2 (25%)

CAM4-SOM

EOF1 (38%)

EOF2 (18%)
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)

EOF1 (29%)
Pacific/North American (PNA) Pattern

EOF2 (26%)
North Pacific Oscillation (NPO)

EOF1 (30%)
Pacific/South American (PSA) Pattern

EOF2 (17%)
PSA2 Pattern
Role of Stochastic Atmospheric Forcing for TPDV

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

N Pacific

S Pacific

CAM4-SOM

PNA

NPO

PSA

PSA2
Role of Stochastic Atmospheric Forcing from the South Pacific

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

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

CAM4-SOM
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

Tropical Pacific Decadal Variability

North Pacific Atmospheric Variability

Atmospheric Rossby waves

Atmospheric Rossby waves

Thermodynamic air-sea interactions

South Pacific Atmospheric Variability

ENSO
Why Does the South Pacific Play More Important Role?

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