An Overview of Decadal Ocean Variability in the Indo-Pacific

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Sea Surface Temperature
Annual Mean Climatology

HadISST1
Rayner et al., 2003
1982-2008

Standard Deviation (non-seasonal variability)

W Boundary Current

Upwelling Zone
Non-seasonal variability:
< 10 years , > 10 years

1900-2009 detrended data (HadISST1)
Standard Deviation (1900-2009 trend removed)

Similar patterns

> 10 yrs

< 10 yrs
Standard Deviation (1900-2009 *trend removed*)

**Ratio**

- > 10 yr / < 10 yr

**Low/High**

**> 10 yrs**

Similar patterns

**< 10 yrs**
Standard Deviation (1900-2009 *trend removed*)

**Ratio**

> 10 yr / < 10 yr

> 10 yrs

< 10 yrs
Standard Deviation (1900-2009)

Ratio
> 10 yr / < 10 yr

Low-Pass SST std dev
> 10 yrs

High-Pass SST std dev
< 10 yrs

Northern Atlantic (detrended)
EOF Analysis: Patterns of Variability

HadISST
1900-2009 detrended
ENSO

Indo-Pacific EOF1

Nino3.4

(°C SD⁻¹)
Indo-Pacific EOF1

ENS0

Period (years)

Nino3.4

°C
Indo-Pacific EOF1

10 yr low-pass filter
Indo-Pacific EOF1
10 yr low-pass filter

North Pacific EOF1
Unfiltered

PDO/IPO/PDV

e.g., Mantua et al. 1997; Zhang et al. 1997
PDO/IPO/PDV

Power Spectrum
N. Pac PC1

North Pacific EOF1
Unfiltered

Period (years)

Power Spectrum
e.g., Mantua et al. 1997; Zhang et al. 1997
PC Dme series

10 yr low-pass filter

North Pacific EOF1

Unfiltered

Power Spectrum

N. Pac PC1

Period (years)

Nino3.4

Power Spectrum

Nino3.4

Power (°C)

Frequency (cycles month⁻¹)

SD

1900 1920 1940 1960 1980 2000
Climate Impacts

North Pacific EOF1
Unfiltered

Epochs

PDO/IPO/PDV
Epoch Differences

Winter Precipitation and SLP

North Pacific EOF1

Unfiltered

Deser et al., 2004

PDO/IPO/PDV
PDV Mechanisms

Alexander, 2009: Literature Review

Vimont, 2005: Spatial structure made up of ENSO lifecycle

Newman et al. 2003: ENSO + NPac ocean mixed layer memory (Shakun and Shaman, 2009: extension to S. Pac)

Schneider and Cornuelle, 2005: Newman et al. + N Pac dynamical ocean adjustment via baroclinic Rossby Waves

Clement et al., 2010: Thermodynamic tropical/extratropical air/sea interaction (independent of ENSO)

~ 50 year time scale ??
Indo-Pacific EOF1, 10 yr lowpass filter

**Observed**

**CAM4 + 50m slab ocean**

No preferred timescale (red noise)

Thermodynamic air-sea interaction (Clement et al. 2010)
North Pacific EOF2
Unfiltered

North Pacific EOF1
Unfiltered

NPGO/SFM
PDO/IPO/PDV

e.g., Vimont et al. 2001; Bond et al. 2003; DiLorenzo et al. 2008
Tropical SST Trends
1900-2009
SST Trends, 1900-2009

Missing data filled using optimal interpolation
Missing data not filled, no smoothing

Deser et al., GRL 2010
(see also Vecchi et al., 2008)

Independent evidence for warming trend in the E. Equatorial Pacific:
Bunge and Clarke, 2009; Deser et al., 2010; Tung et al., 2010
SST Trends, 1900-2009

Missing data filled using optimal interpolation

Missing data not filled, no smoothing

Contribution of ENSO to trend:
Compo and Sardeshmukh, 2009; Solomon and Newman, submitted
Uncertainty in Future Climate Projections: Insights from the 40-member CCSM3 A1B Ensemble, 2000-2060

Deser et al., submitted

Adam Phillips, Grant Branstator, Haiyan Teng, Jerry Meehl, Gary Strand, Vincent Bourdette, Lawrence Buja

CCSM3 response is very similar to the CMIP3 23-model mean response
Sea Level Pressure Trends 2005-2060 (A1B) DJF
Ensemble Members 10-20
Sea Level Pressure Trends 2005-2060 (A1B) DJF

40-member CCSM3
Mean response

Stippling: Ensemble mean response is 95% significant relative to spread within the 40-member ensemble

\[ N_{\text{min}} \approx \frac{8}{(\bar{X}/\sigma)^2} \]

Minimum # of ensemble members needed to detect a sig. response
Precipitation Trends 2005-2060 (A1B) DJF

40-member CCSM3
Mean response

Stippling: Ensemble mean response is 95% significant relative to spread within the 40-member ensemble

\[ N_{\text{min}} \approx \frac{8}{(X/\sigma)^2} \]

Minimum # of ensemble members needed to detect a sig. response
Air Temperature Trends 2005-2060 (A1B) DJF

40-member CCSM3
Mean response

Stippling: Ensemble mean response is 95% significant relative to spread within the 40-member ensemble

\[ N_{\text{min}} \approx \frac{8}{(\bar{X}/\sigma)^2} \]

Minimum # of ensemble members needed to detect a sig. response
Thank You
Sea Level Pressure Trends 2005-2060 (A1B) DJF

40 member CCSM3

21 AR4 models

Stippling: Ensemble mean response is 95% significant relative to spread within each ensemble
Precipitation Trends 2005-2060 (A1B) DJF

40 member CCSM3

21 AR4 models

Stippling: Ensemble mean response is 95% significant relative to spread within each ensemble
Air Temperature Trends 2005-2060 (A1B) DJF

40 member CCSM3

21 AR4 models

Stippling: Ensemble mean response is 95% significant relative to spread within each ensemble

CCSM3 and AR4 models also similar for the other seasons