Use of Methods of Linear Algebra in Climate Diagnostics

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Methods that I have used

- Empirical orthogonal function (EOF) analysis
  - Rotated EOF (REOF) analysis
  - EOT analysis
- SVD of the covariance matrix (MCA)
- Canonical correlation analysis (CCA)
  - Hybrid MCA/CCA (PMCA)
- Partial Least squares (PLS)

Methods that I have used

Empirical orthogonal function (**EOF)** analysis

Rotated EOF (REOF) analysis

EOT analysis (van den Dool et al. 2000)

SVD of the covariance matrix (**MCA**)

Canonical correlation analysis (CCA)

Hybrid MCA/CCA (PMCA)

Partial Least squares (**PLS**)

El Niño - Southern Oscillation (ENSO)

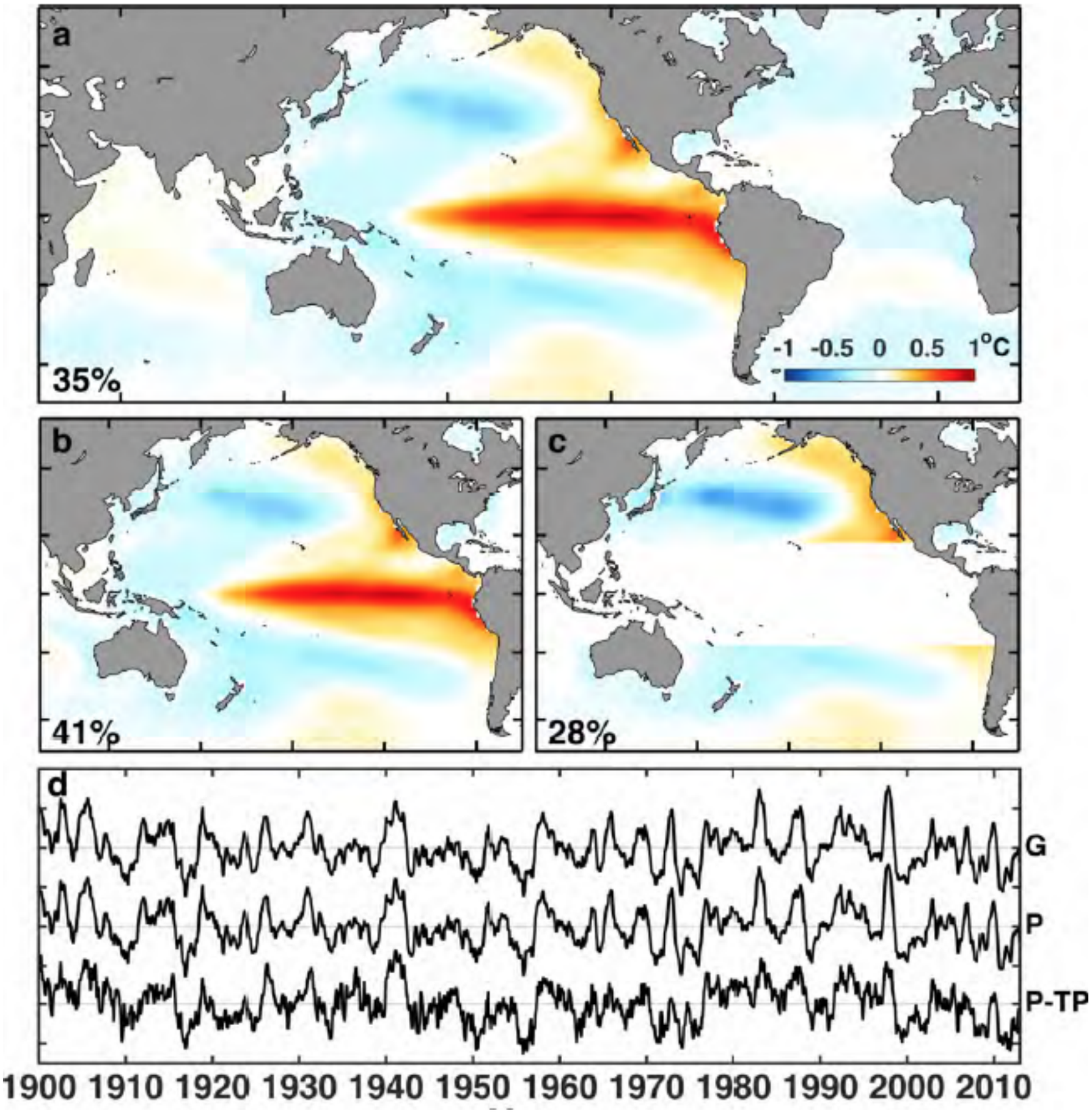
Gilbert Walker

Jacob Bjerknes

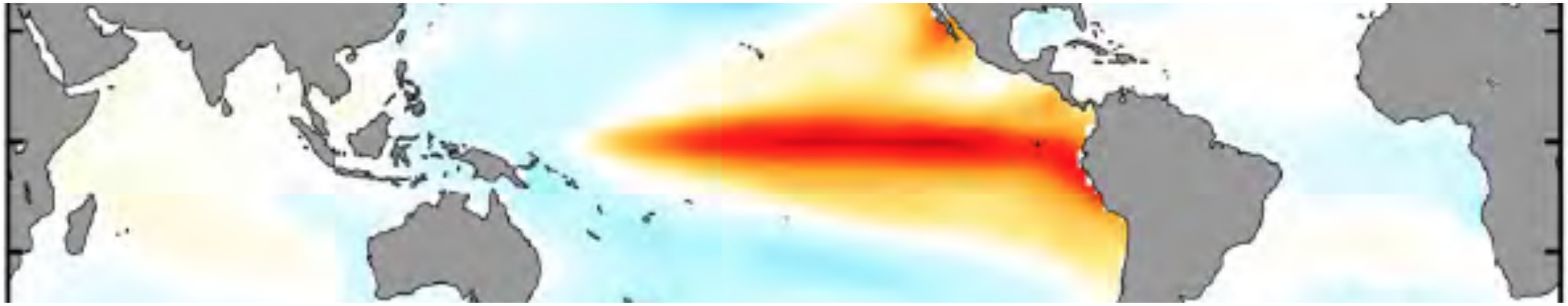
Klaus Wyrtki

Eugene Rasmusson

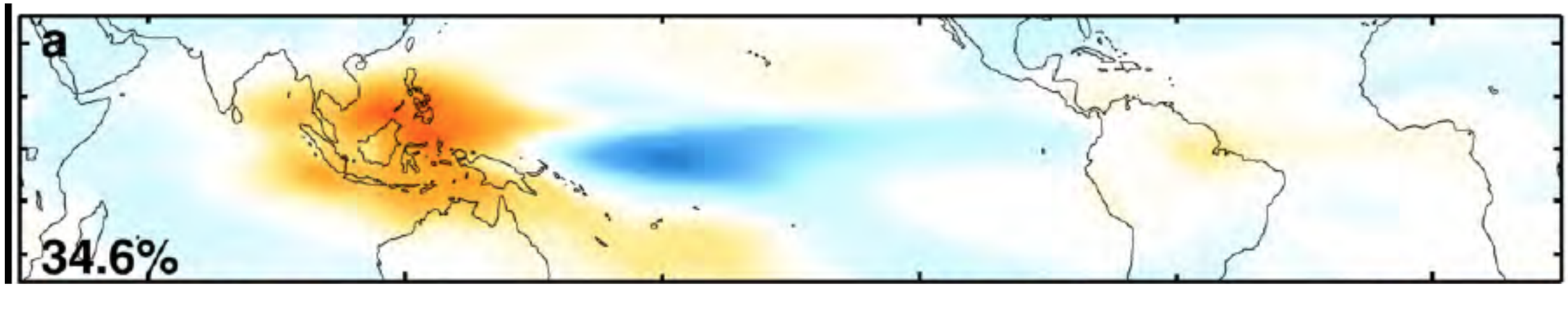
Dominant pattern of atmosphere - ocean variability on seasonal to interannual time scale


a
35%
-1 -0.5 0 0.5 1°C
b
41%
c
28%
d
G
P
P-TP
1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010

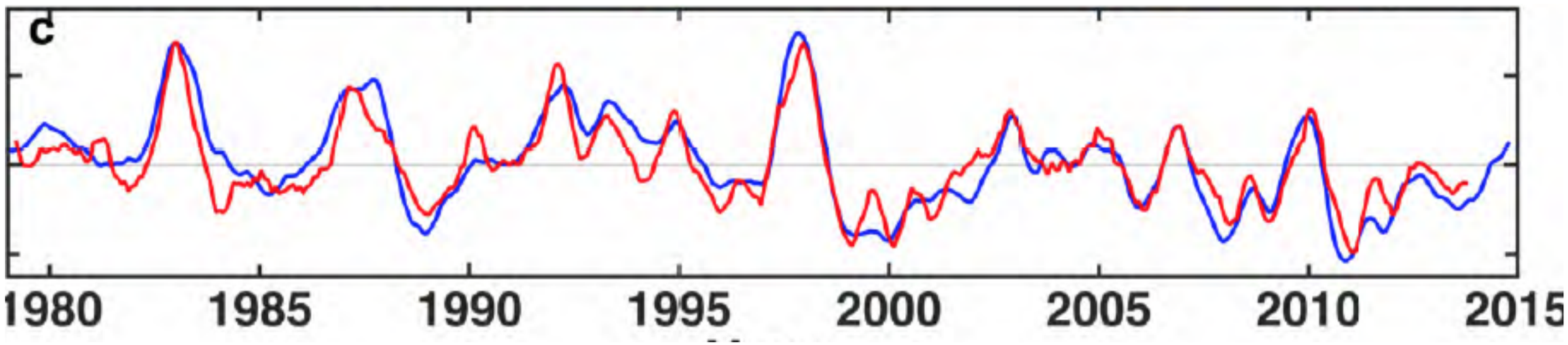
SST



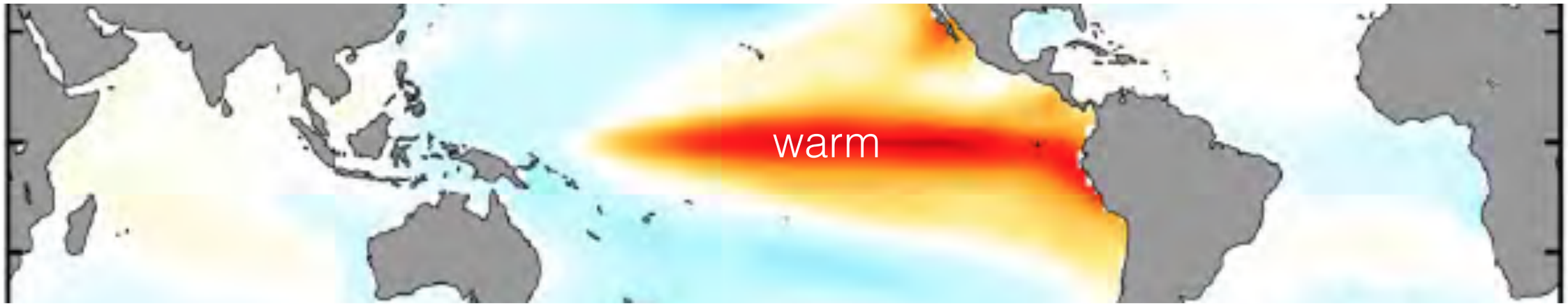
OLR



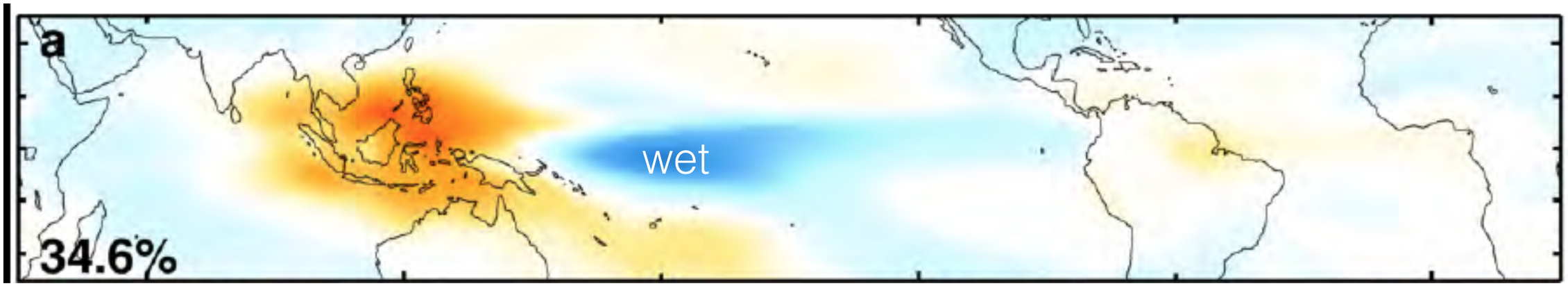
PCs



SST



OLR



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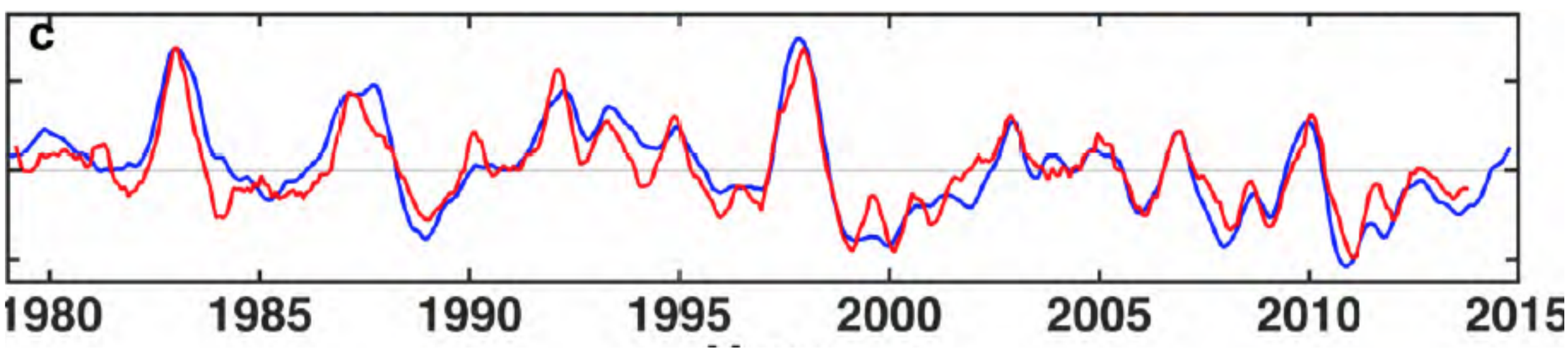
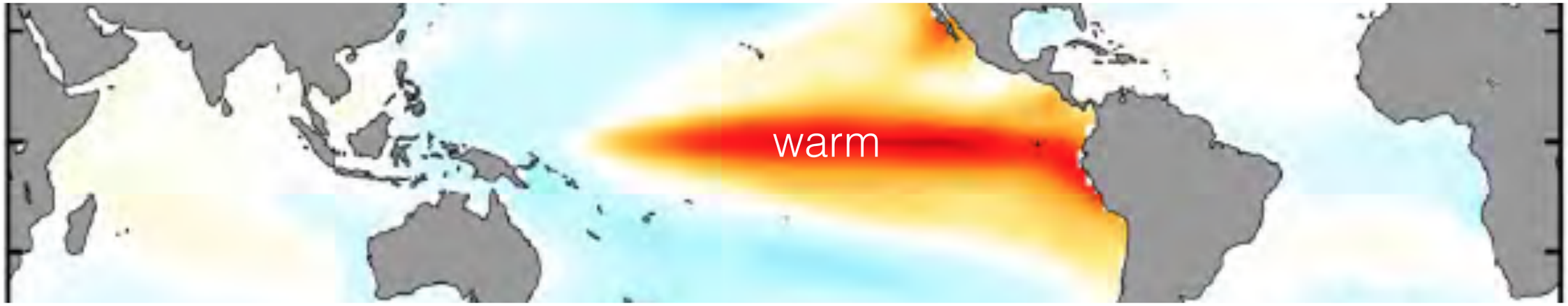
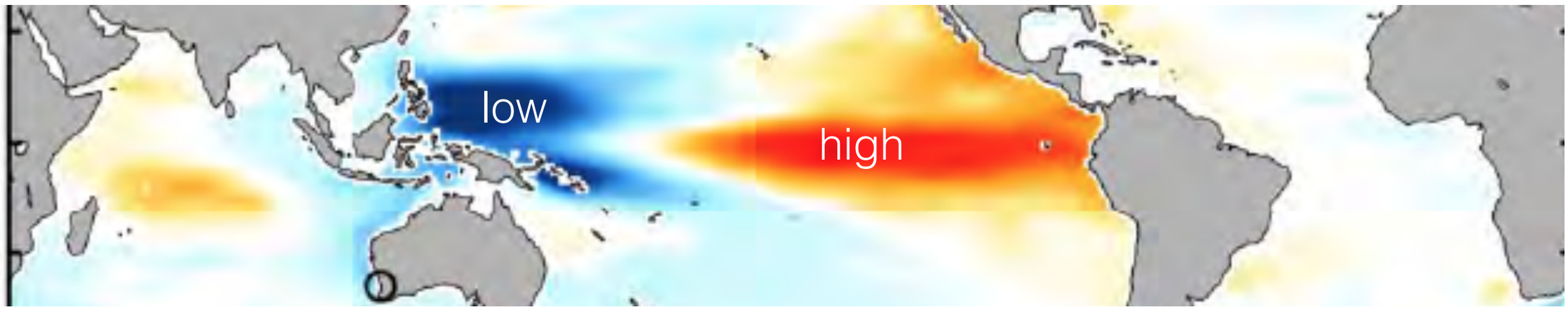


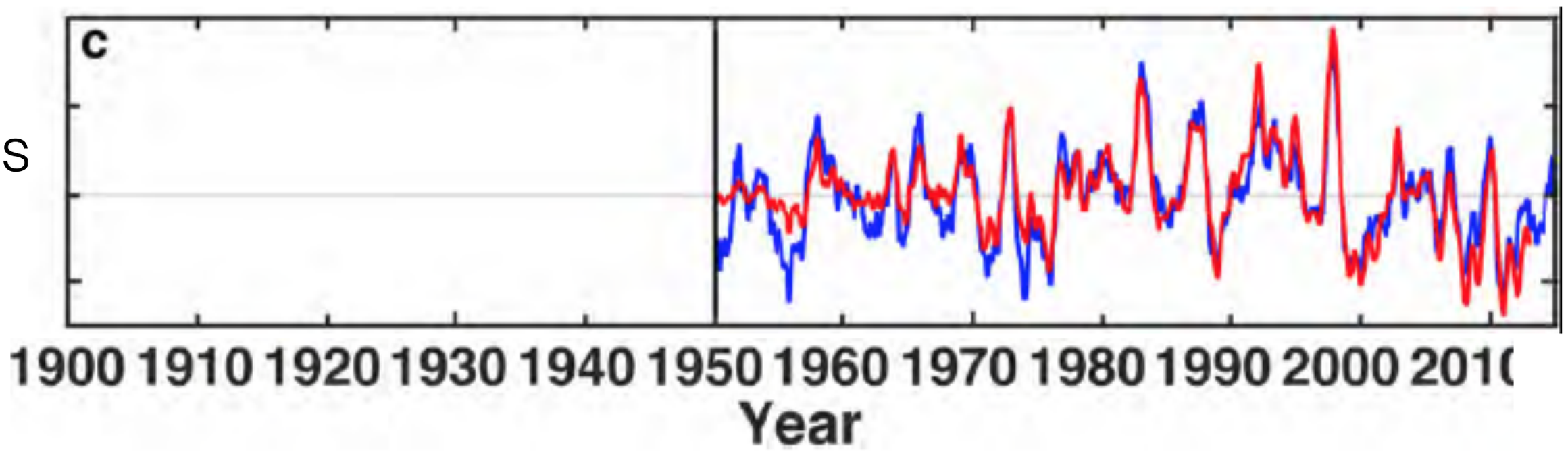
SST


warm

SSL

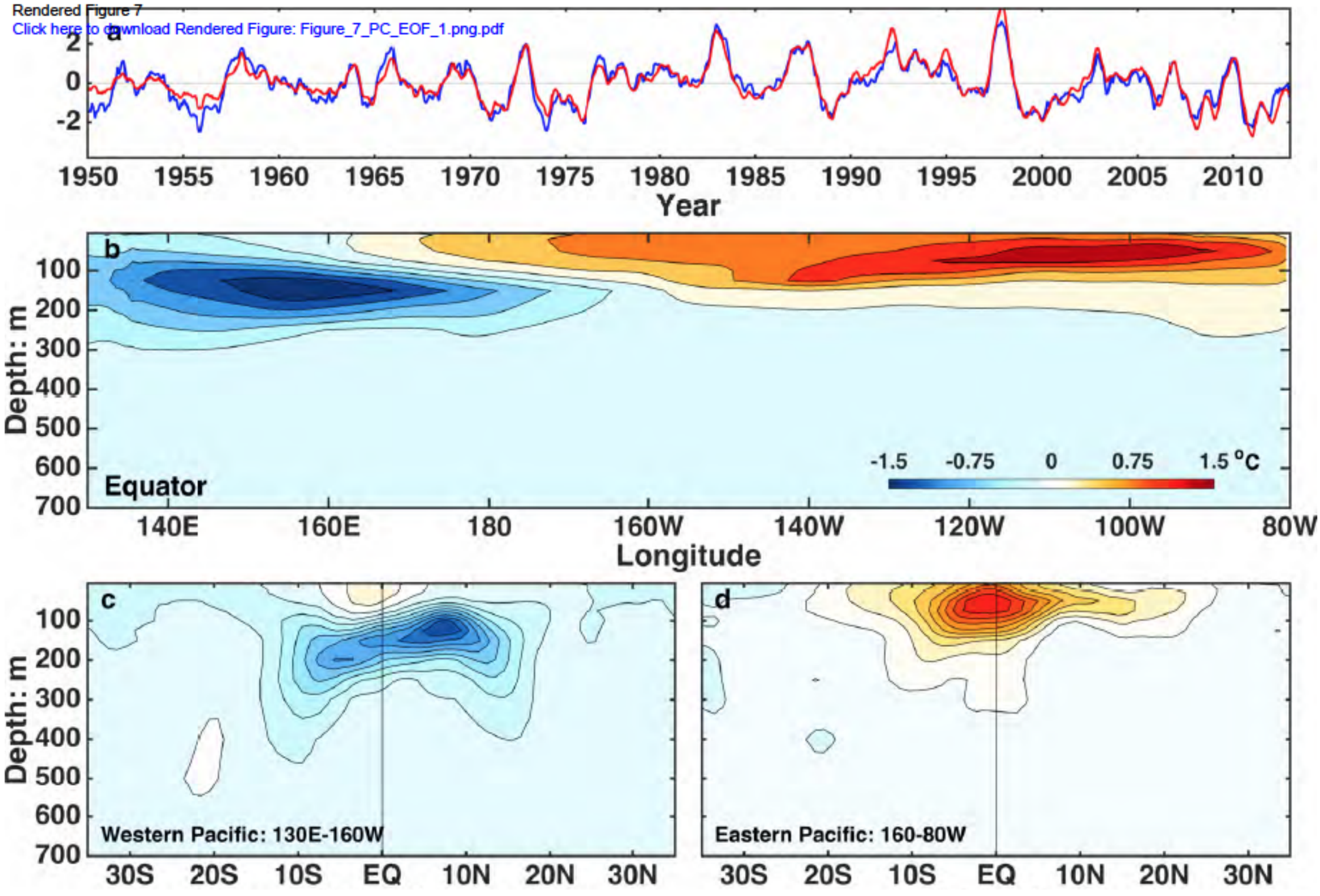

low
high

PCs

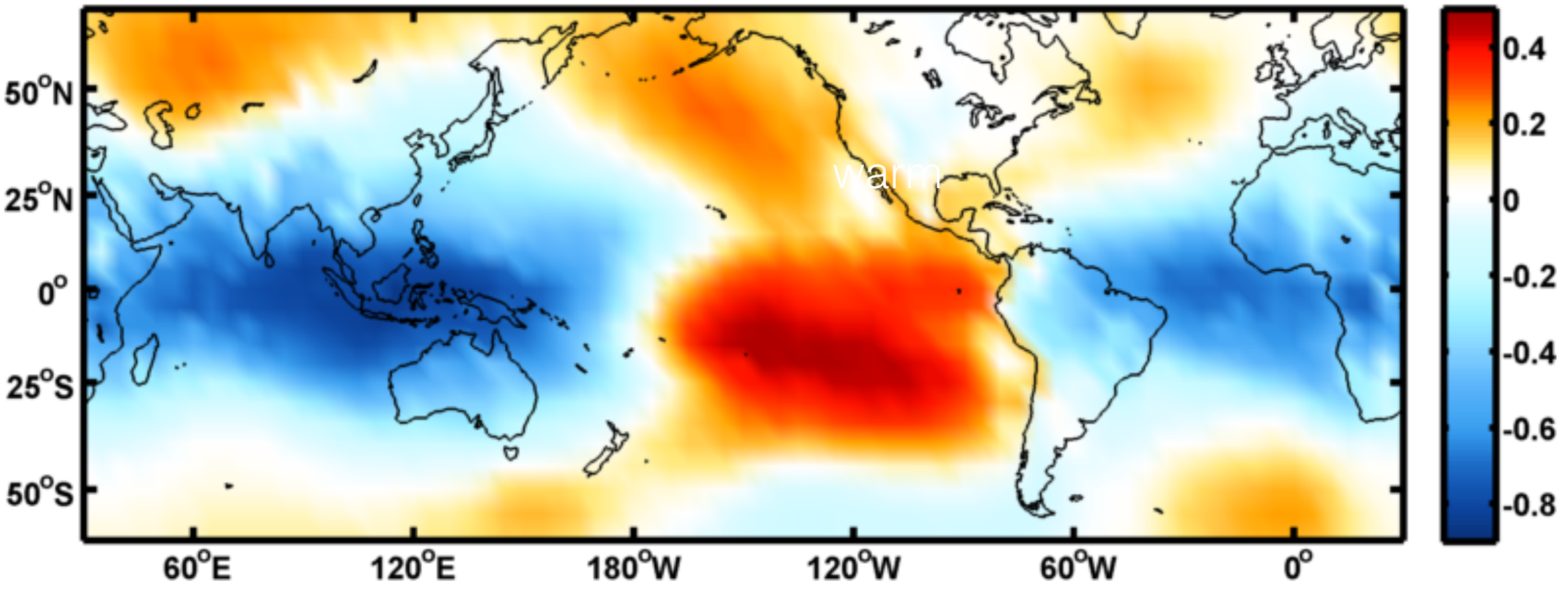

c
1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 201(
Year

Rendered Figure 7

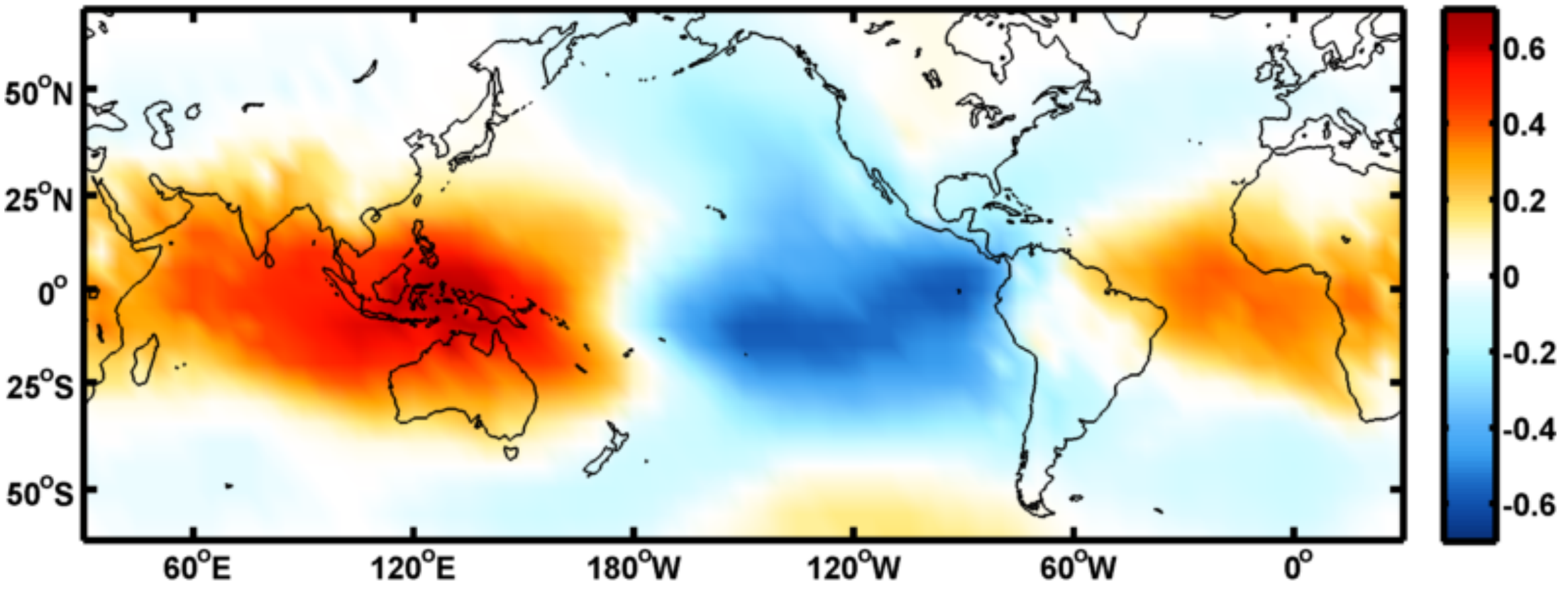
Click here to download Rendered Figure: Figure_7_PC_EOF_1.png.pdf



EOF1 of Global Standardized SLP

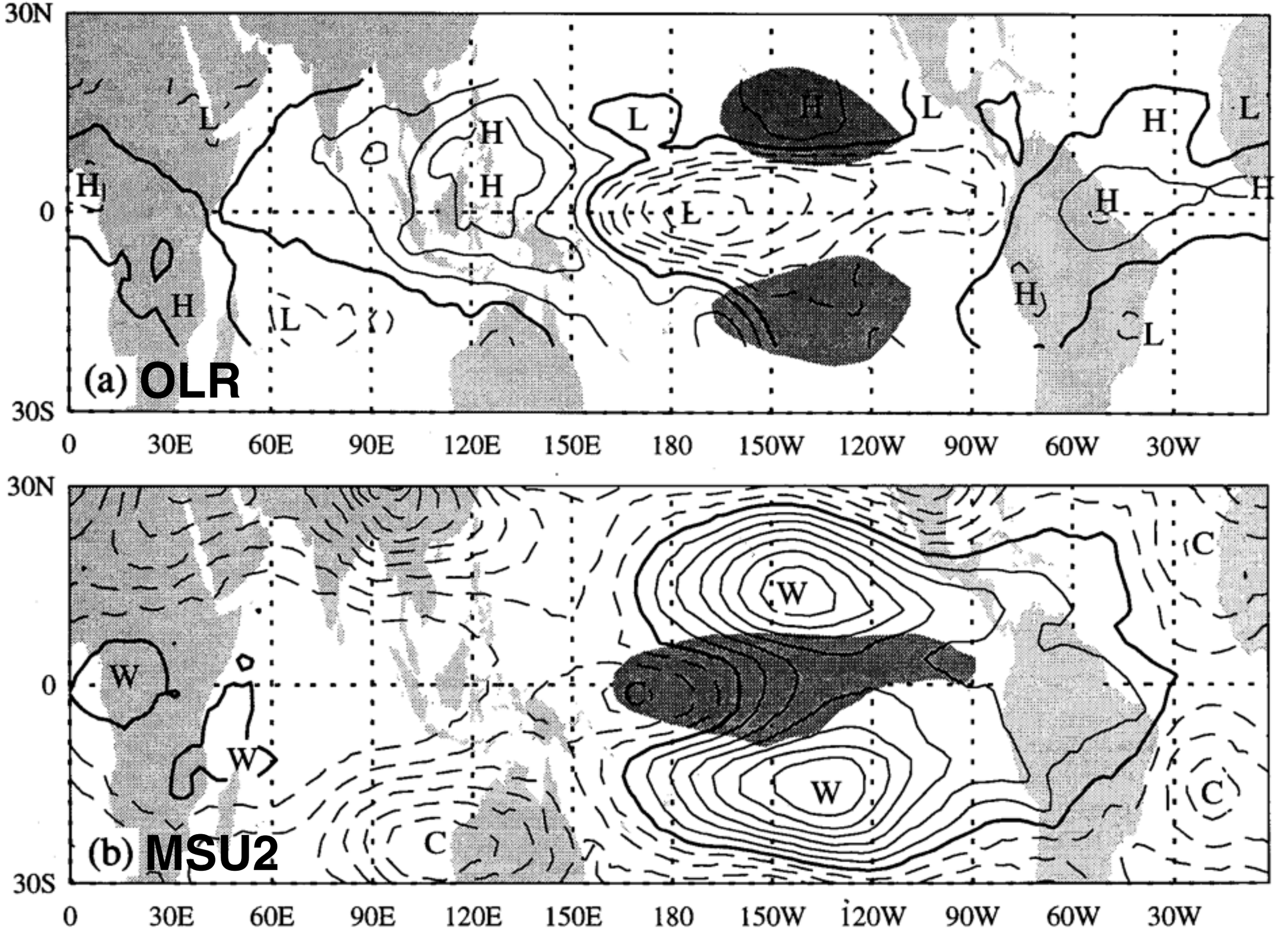


Regression of Normalized SLP on PC1 of SST*



MCA

Yulaeva and Wallace 1994 SCF = 79% ***r*** = 0.83



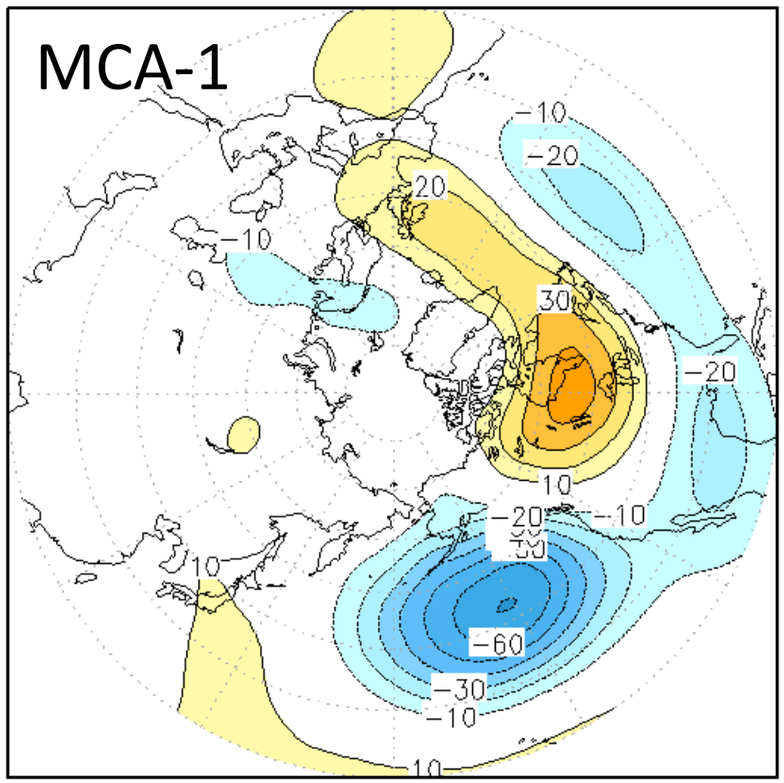
PMCA

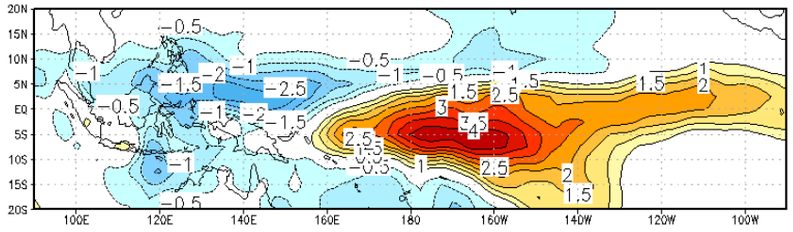
Continuum Power CCA: A Unified Approach for Isolating Coupled Modes

Erik Swenson *

APEC Climate Center, Busan, Korea

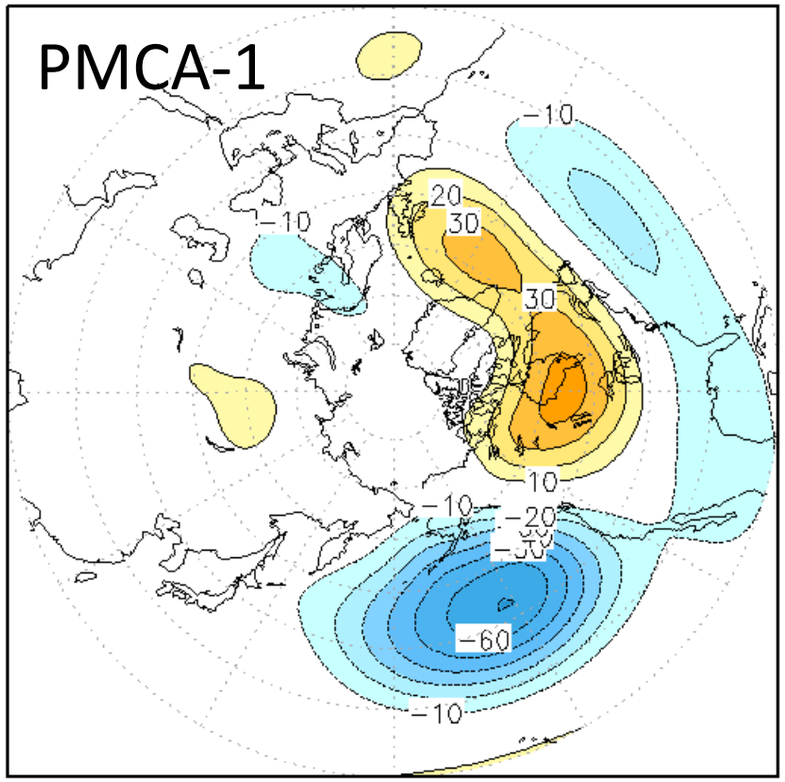
FM PREC - JF Z_{500}

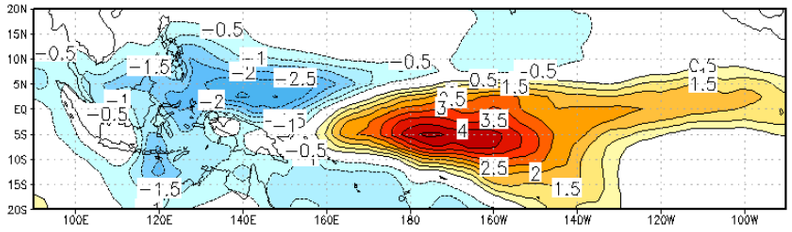




r = 0.77, 0.60

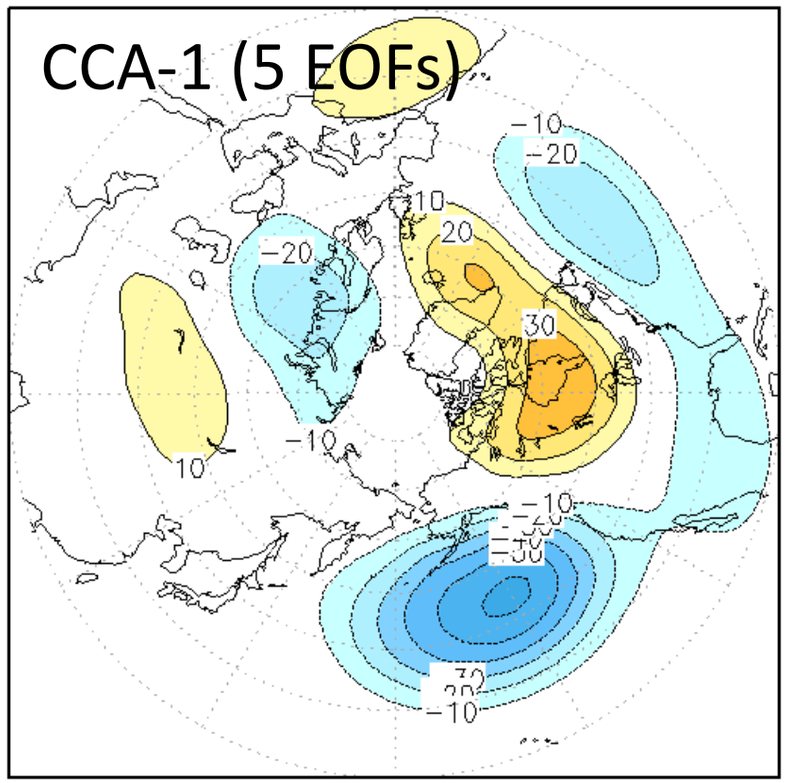
SC = 61%, 45%

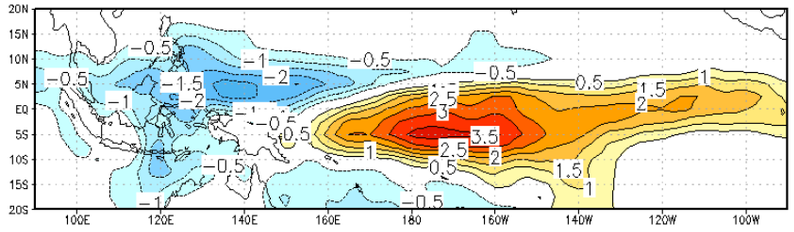




r = 0.93, 0.72

SC = 52%, 47%

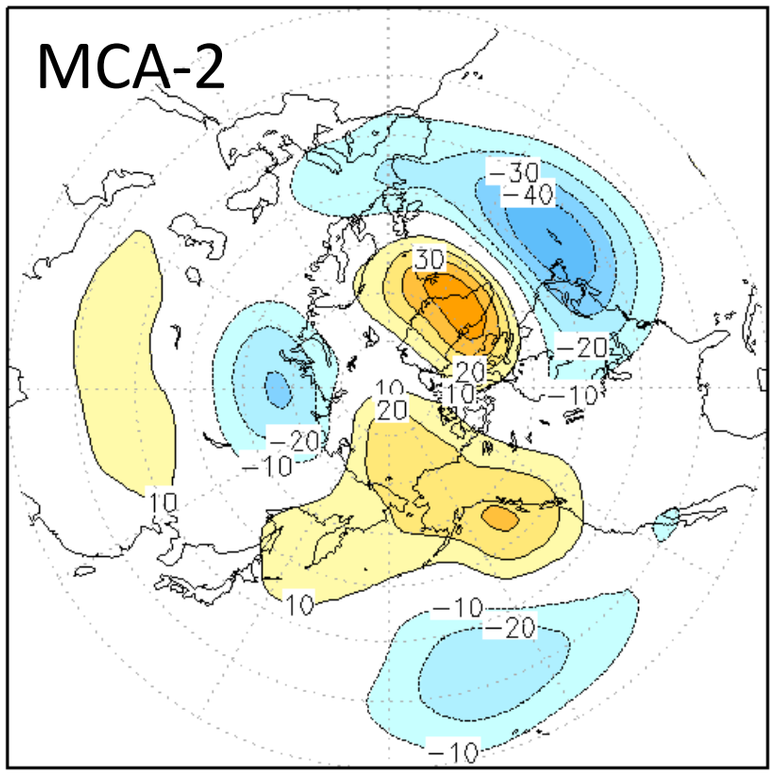


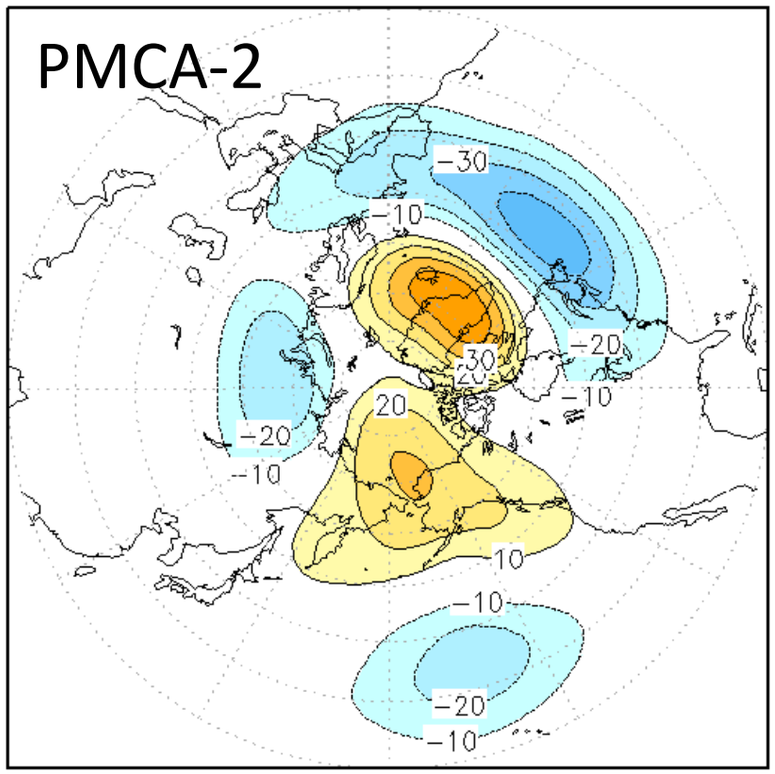


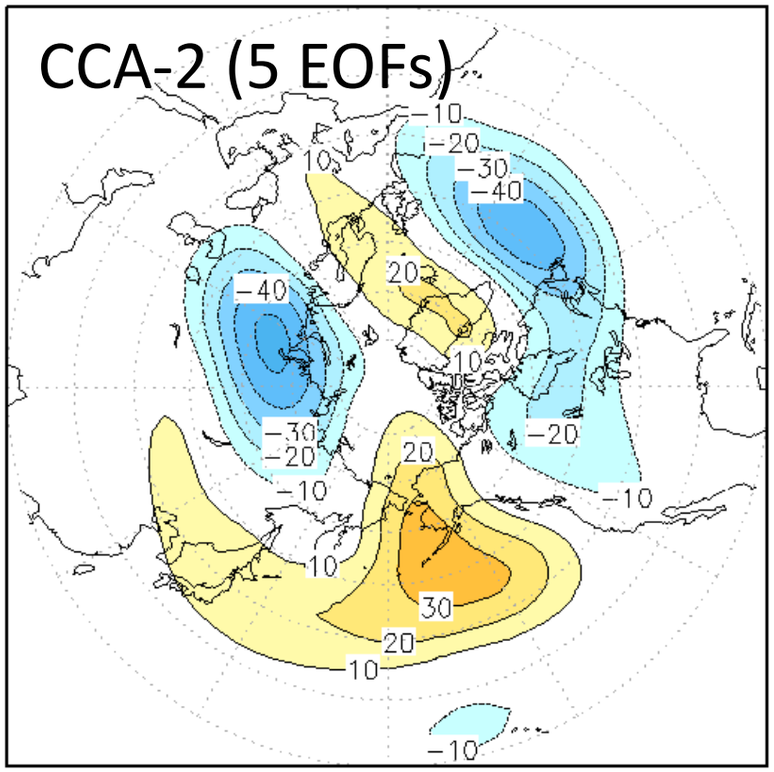
r = 0.84, 0.62

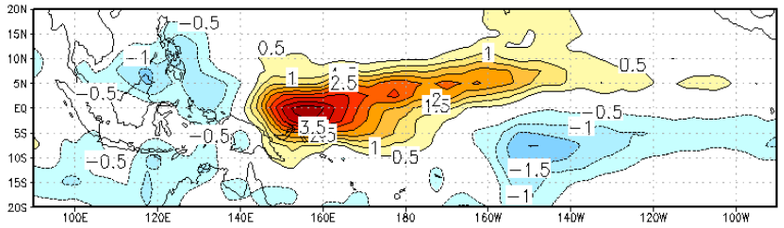
SC = 52%, 34%

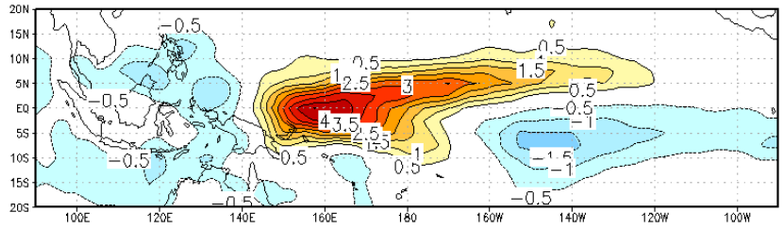
FM PREC - JF Z_{500}

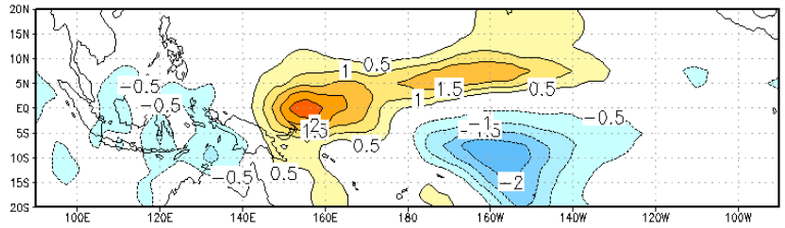












r = 0.70, 0.51
SC = 21%, 17%

r = 0.94, 0.70
SC = 14%, 18%

r = 0.77, 0.59
SC = 15%, 15%

PLS

If the predictand is a field

PLS is one of four possible approaches

Maximal Covariance Analysis	Canonical Correlation Analysis Principal Component Regression
Partial Least Squares	Redundancy Analysis Procrustean Target Analysis

symmetric

Maximal Covariance Analysis

Canonical Correlation Analysis
Principal Component Regression

asymmetric

Partial Least Squares

Redundancy Analysis
Procrustean Target Analysis

one operation

truncation needed

Maximal Covariance Analysis

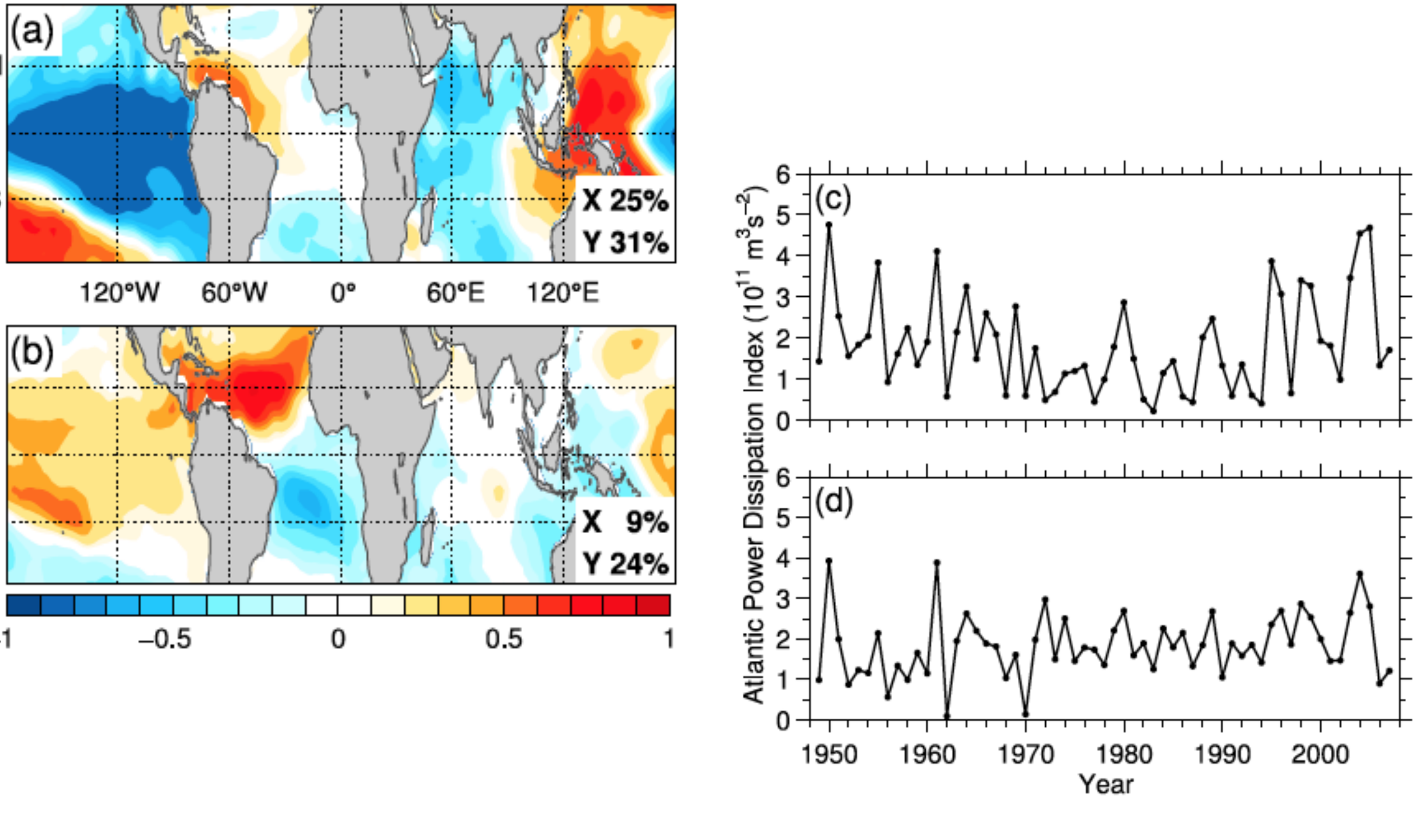
Canonical Correlation Analysis
Principal Component Regression

Partial Least Squares

Redundancy Analysis
Procrustean Target Analysis

Application to a scalar predictand

Atlantic hurricane (Power Dissipation Index) time series



What I have learned

Necessary to test methods by applying them to data

Useful for isolating phenomena, not just compressing data

When signal is strong, EOF analysis may be better

When signal is weak, covariance analysis may be better

Swenson's method (PMCA) looks promising

PLS (Wold) works well for scalar predictands