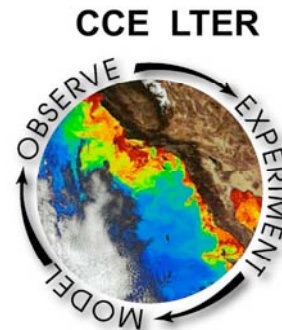


North Pacific Decadal Variability in the FUTURE

Di Lorenzo E.

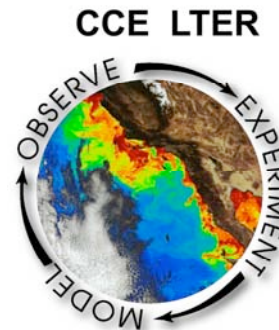
Collaborators: Schneider N., Furtado J., Bracco A.



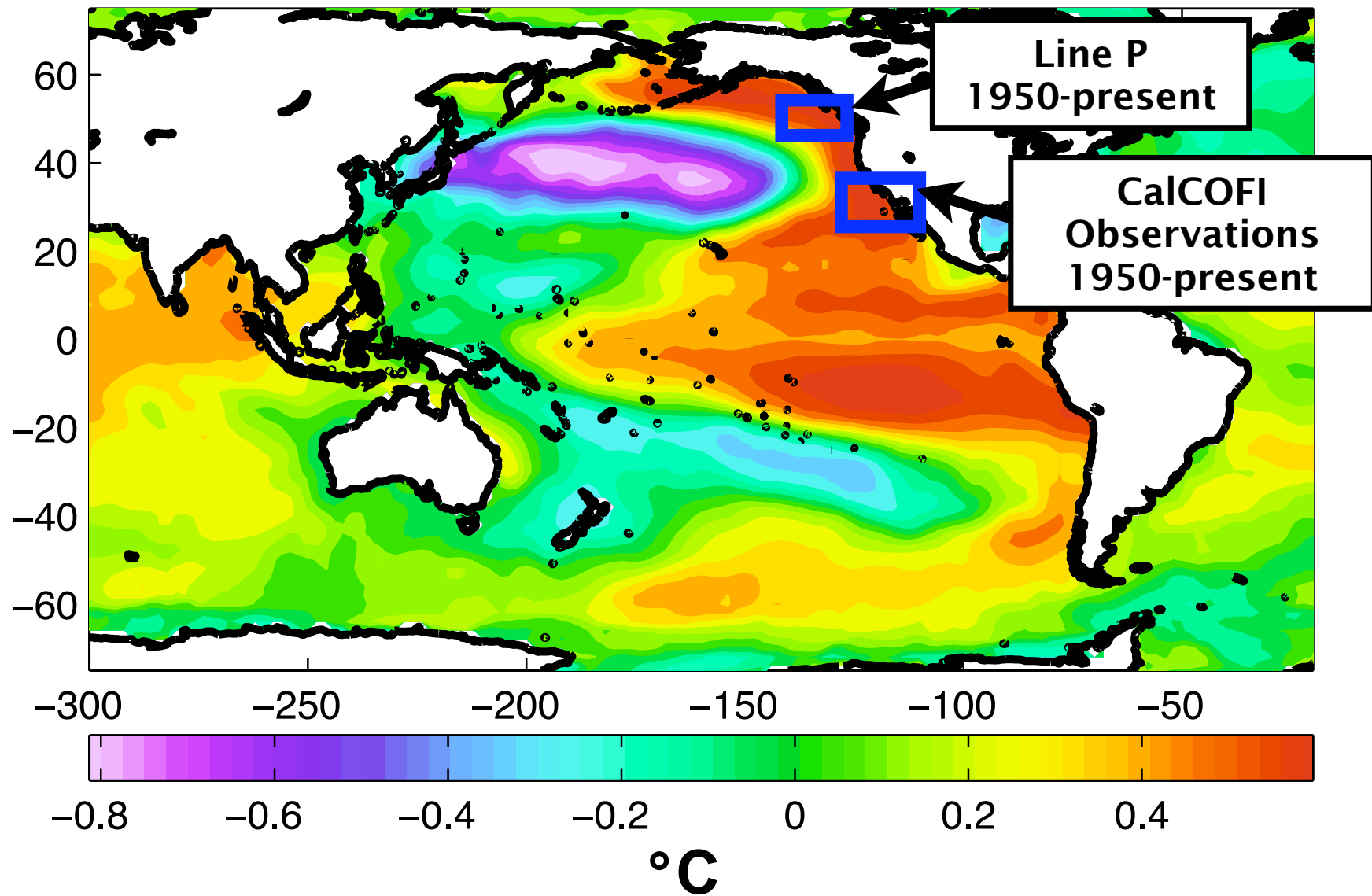
An improved conceptual framework for Pacific Climate Variability

Di Lorenzo E.

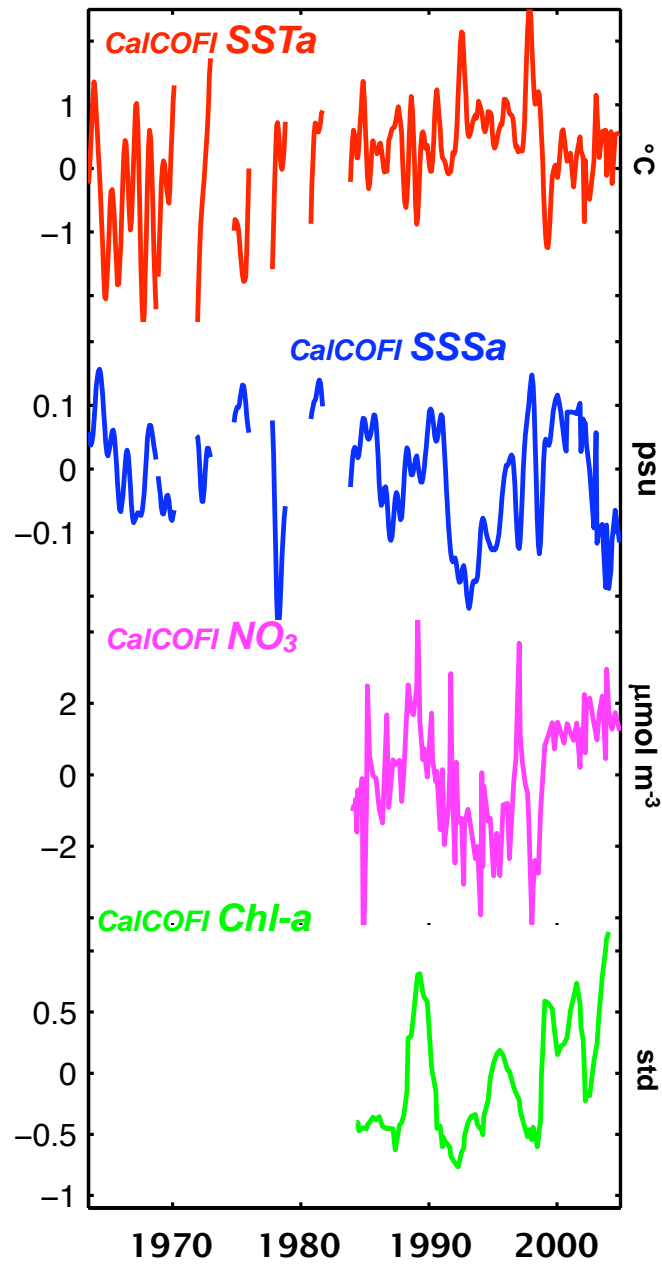
Collaborators: Schneider N., Furtado J., Bracco A.



SSTa during Pacific Decadal Oscillation (PDO)



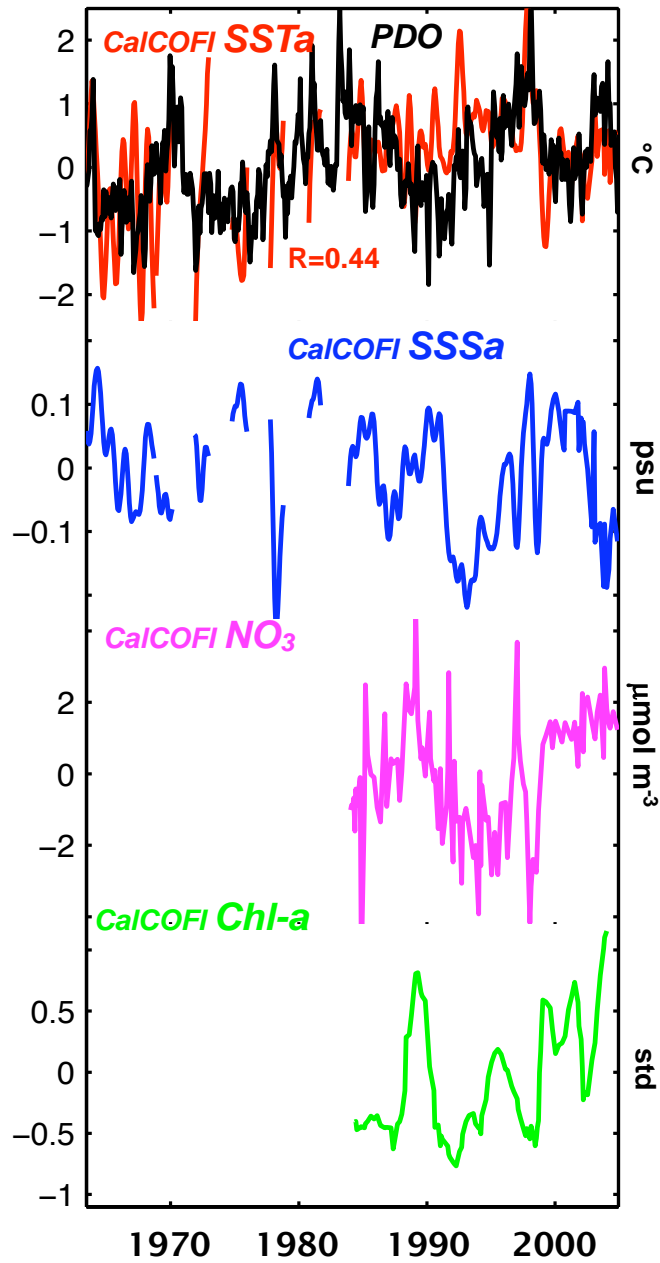
California Current - CalCOFI Observations



Gulf of Alaska - Line P Observations

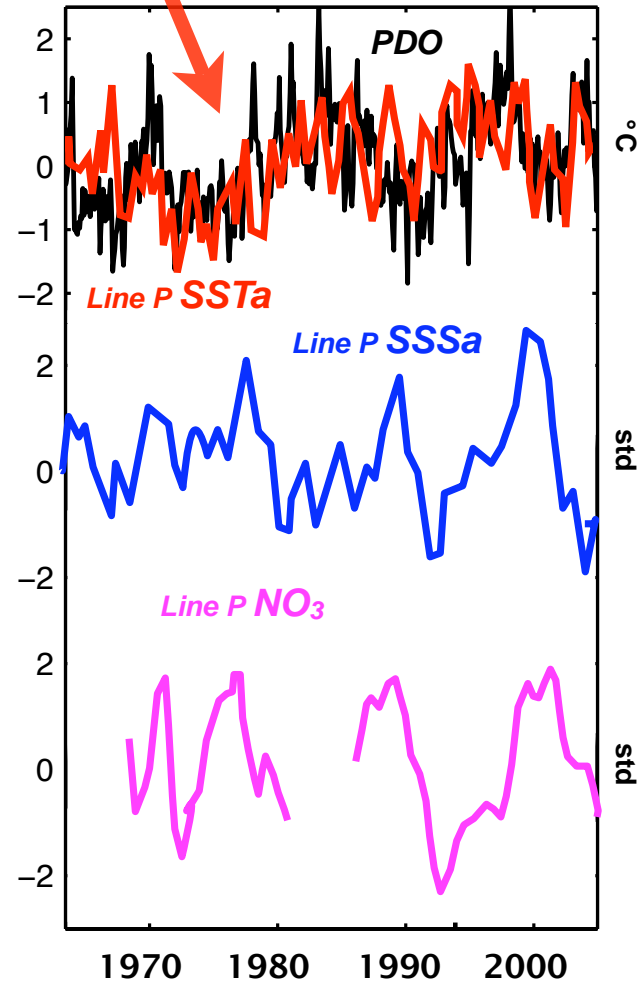


California Current - CalCOFI Observations

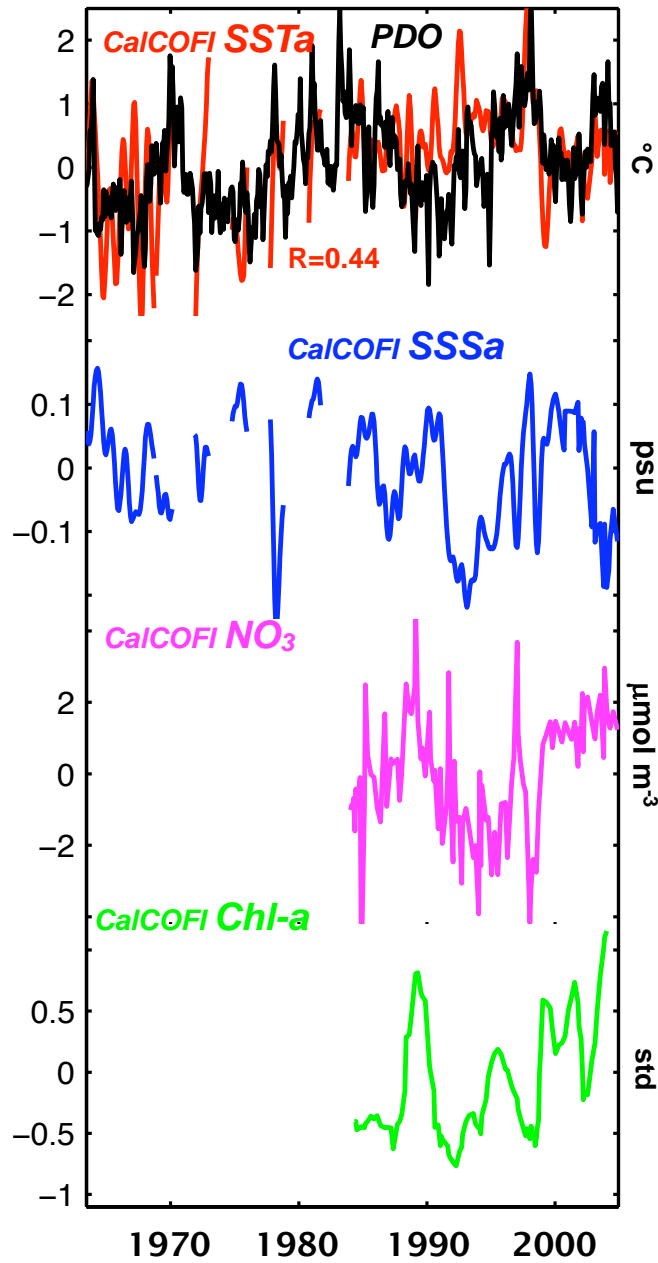


Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

Gulf of Alaska - Line P Observations



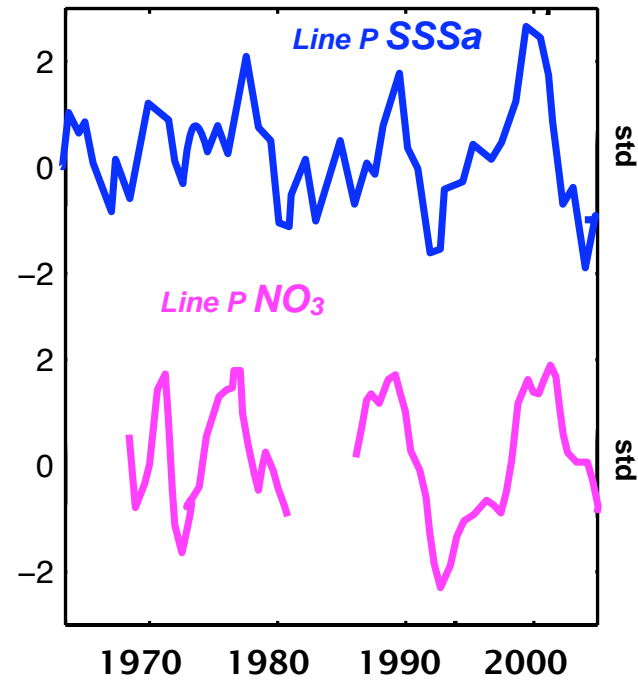
California Current - CalCOFI Observations



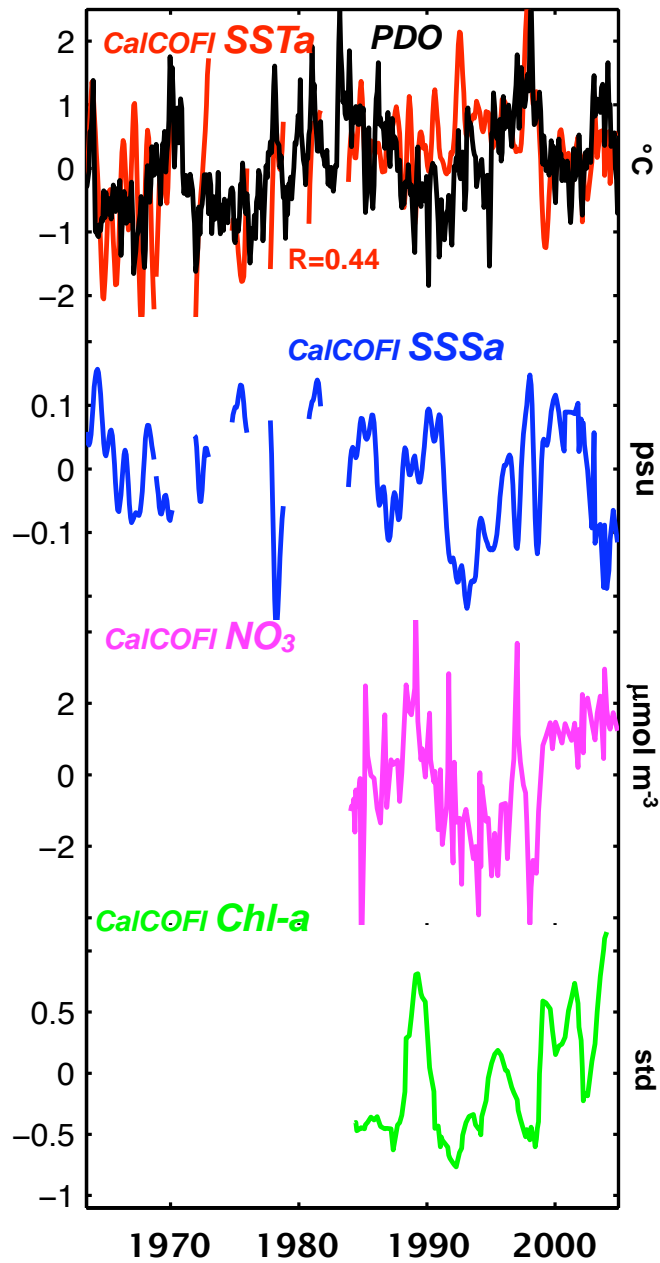
Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

Victoria Mode
(Bond et al., 2003)
EOF2 SSTa

Gulf of Alaska - Line P Observations



California Current - CalCOFI Observations

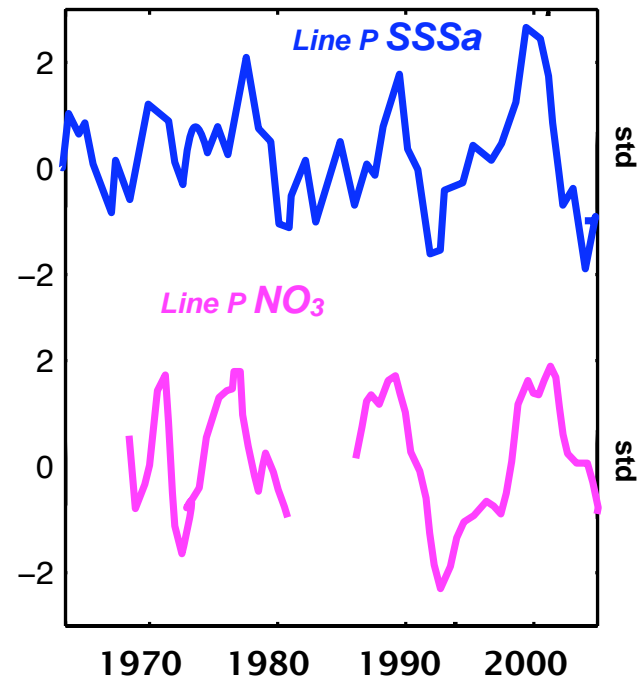


Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

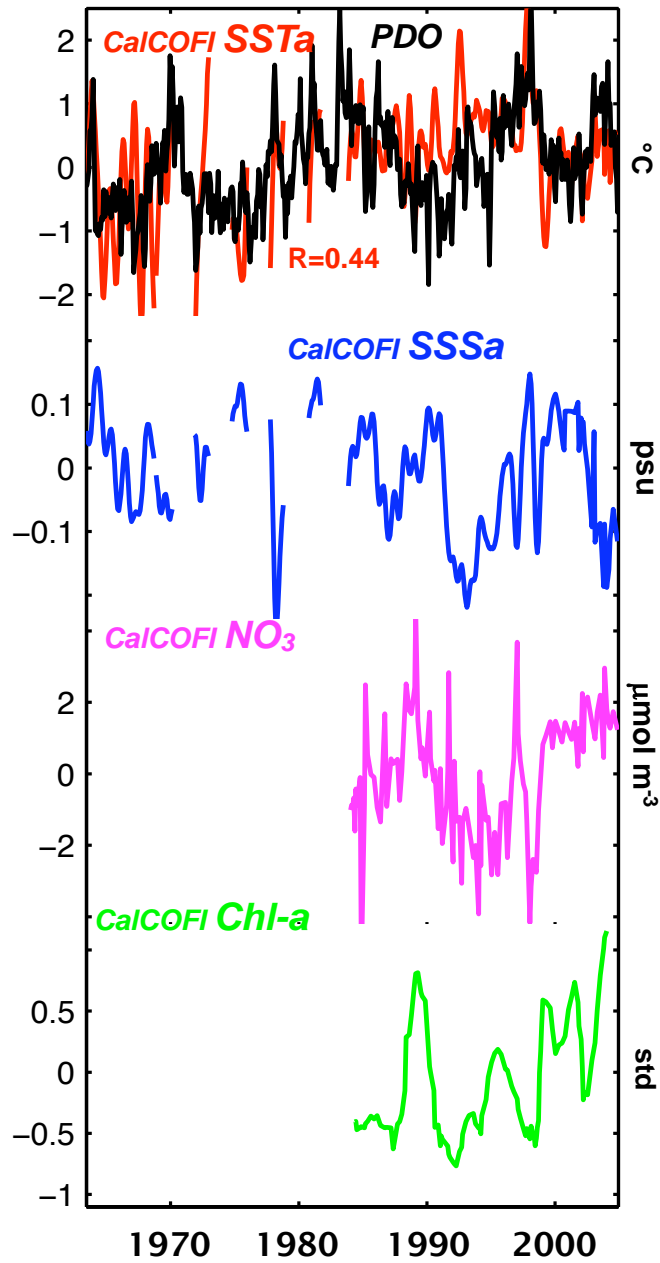
strengthening and weakening of the
sub-tropical and sub-polar gyres

EOF2 SSHa

Gulf of Alaska - Line P Observations



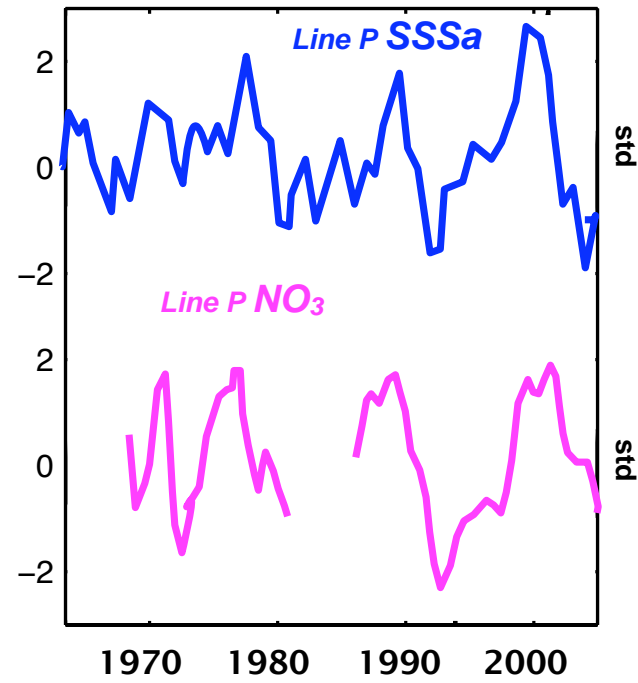
California Current - CalCOFI Observations



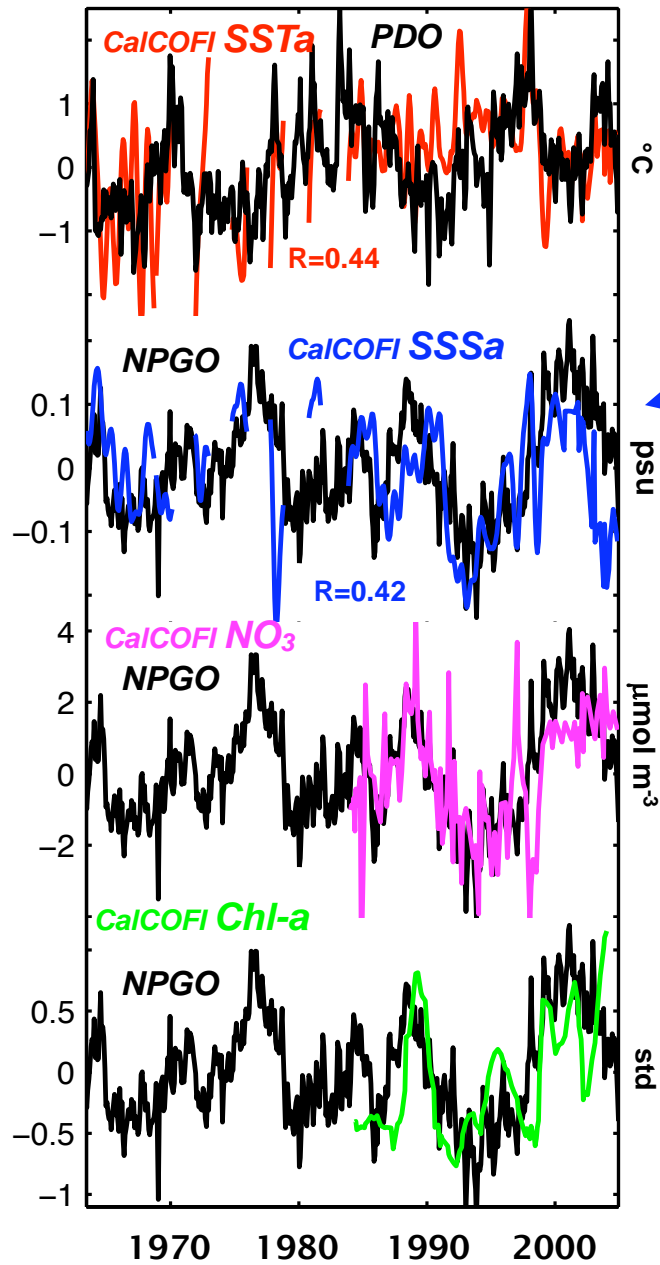
Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

North Pacific Gyre Oscillation (NPGO)
(Di Lorenzo et al., 2008)
EOF2 SSHa

Gulf of Alaska - Line P Observations



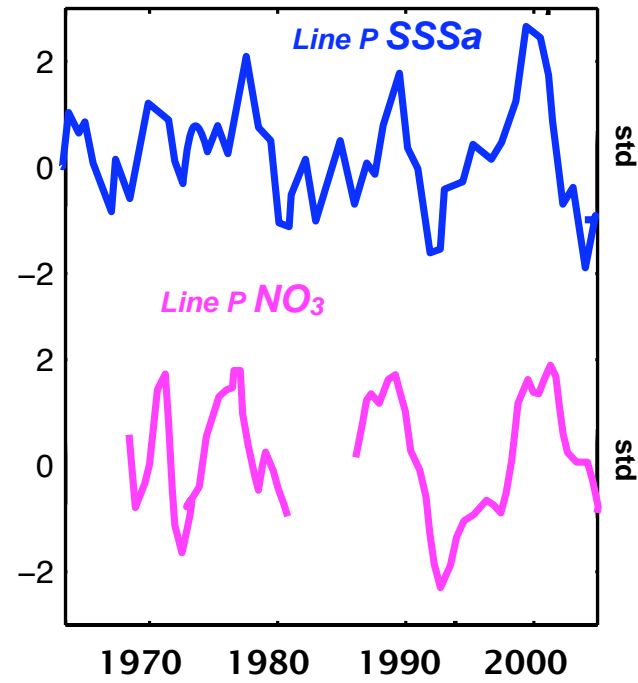
California Current - CalCOFI Observations



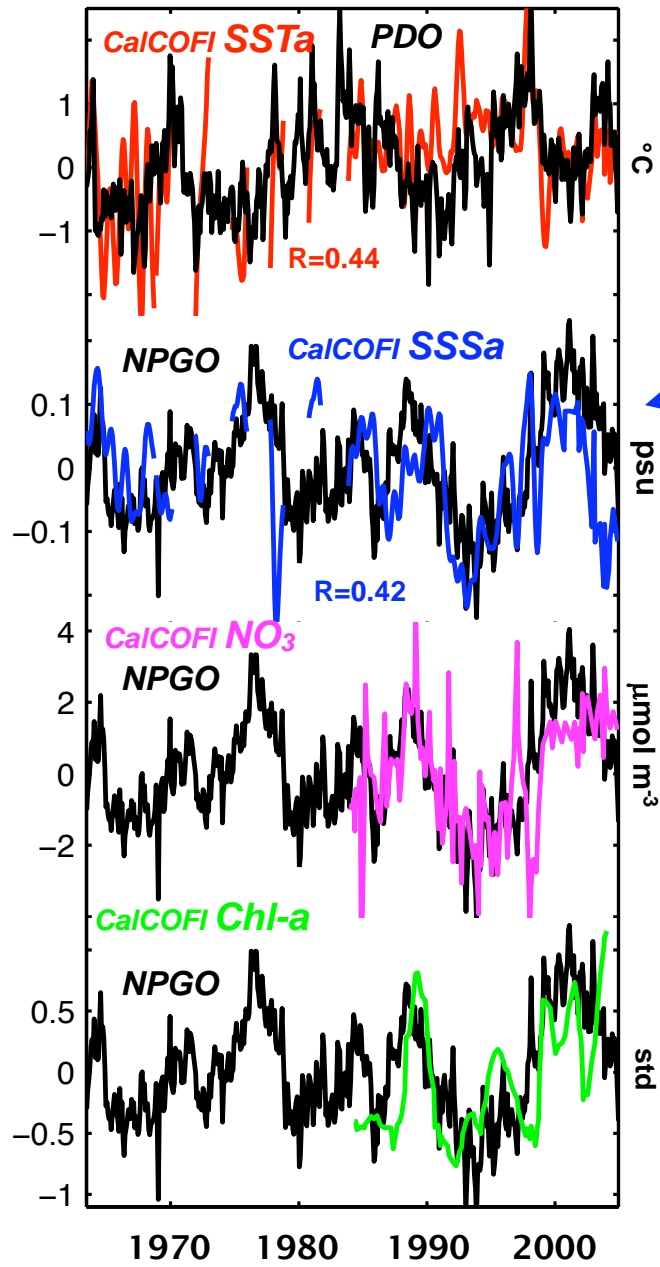
Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

North Pacific Gyre Oscillation (NPGO)
(Di Lorenzo et al., 2008)
EOF2 SSHa

Gulf of Alaska - Line P Observations



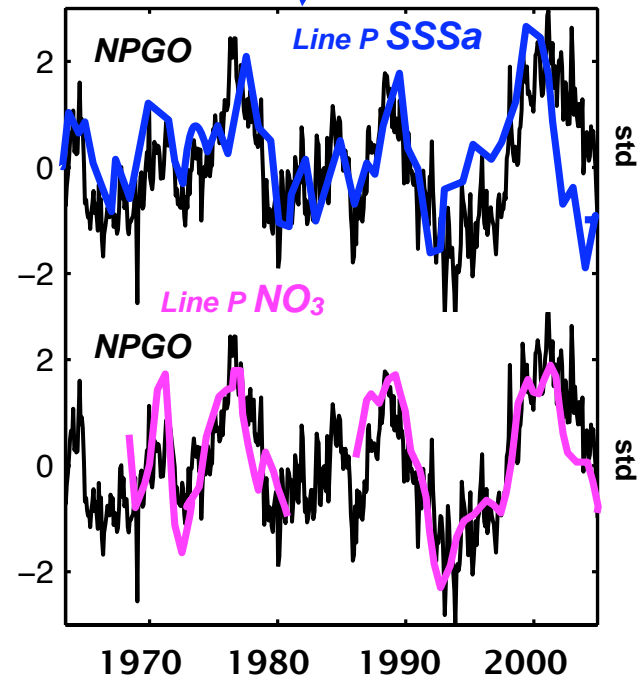
California Current - CalCOFI Observations



Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

North Pacific Gyre Oscillation (NPGO)
(Di Lorenzo et al., 2008)
EOF2 SSHa

Gulf of Alaska - Line P Observations



Ocean

*2 dominant modes of ocean
variability in the
North Pacific*

**Pacific Decadal Oscillation
(PDO)**

(Mantua et al., 1997)

EOF1 SSTa and SSHa

**North Pacific Gyre Oscillation
(NPGO)**

(Di Lorenzo et al., 2008)

EOF2 SSHa and SSTa

Atmosphere  *Ocean*

**Pacific Decadal Oscillation
(PDO)**

(Mantua et al., 1997)

EOF1 SSTa and SSHa

**North Pacific Gyre Oscillation
(NPGO)**

(Di Lorenzo et al., 2008)

EOF2 SSHa and SSTa

Atmosphere

**Aleutian Low
(AL)**

(Trenberth and Hurrell, 1994)

EOF1 SLPa



Ocean

**Pacific Decadal Oscillation
(PDO)**

(Mantua et al., 1997)

EOF1 SSTa and SSHa

**North Pacific Gyre Oscillation
(NPGO)**

(Di Lorenzo et al., 2008)

EOF2 SSHa and SSTa

Atmosphere

Ocean

**Aleutian Low
(AL)**
(Trenberth and Hurrell, 1994)
EOF1 SLPa



**Pacific Decadal Oscillation
(PDO)**
(Mantua et al., 1997)
EOF1 SSTa and SSHa

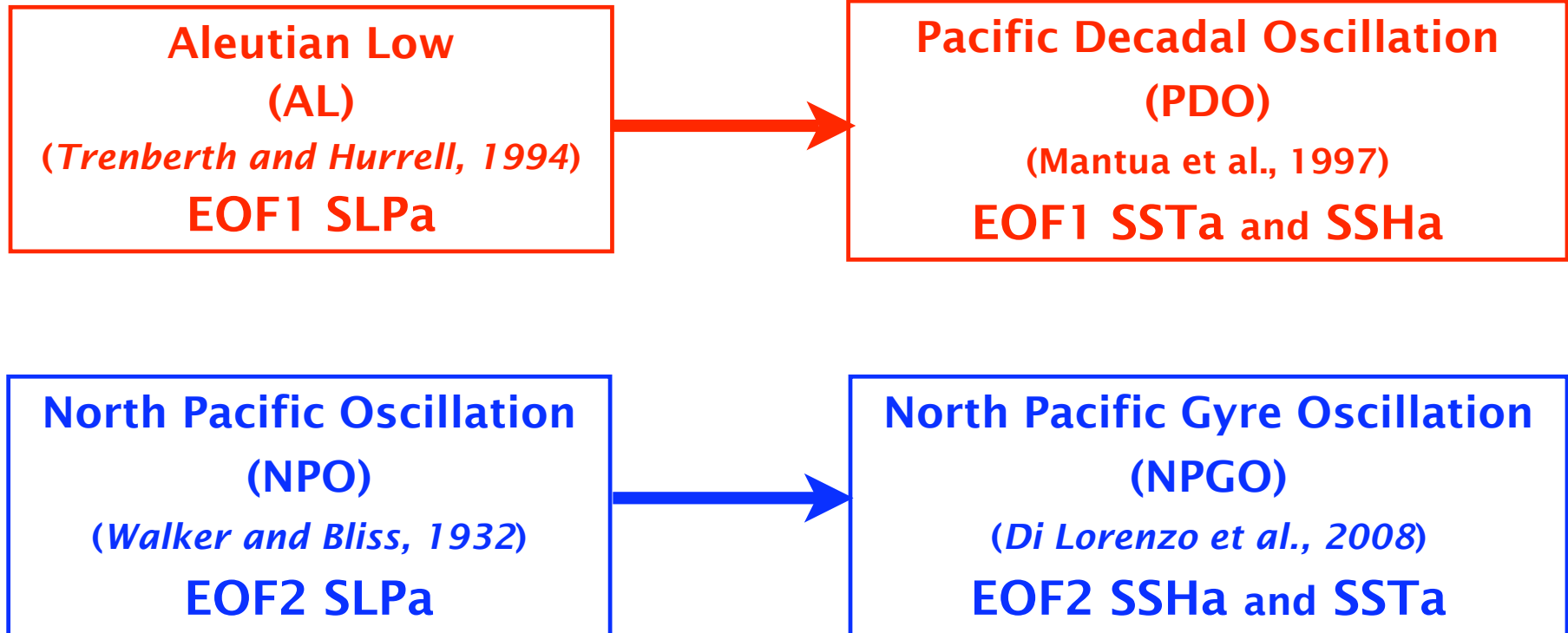
**North Pacific Oscillation
(NPO)**
(Walker and Bliss, 1932)
EOF2 SLPa



**North Pacific Gyre Oscillation
(NPGO)**
(Di Lorenzo et al., 2008)
EOF2 SSHa and SSTa

Atmosphere

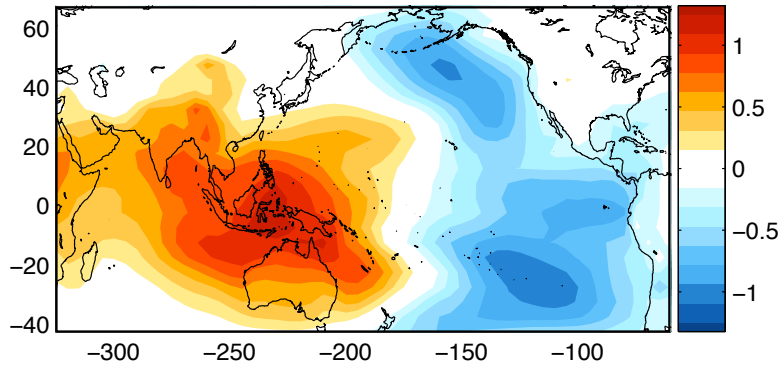
Ocean



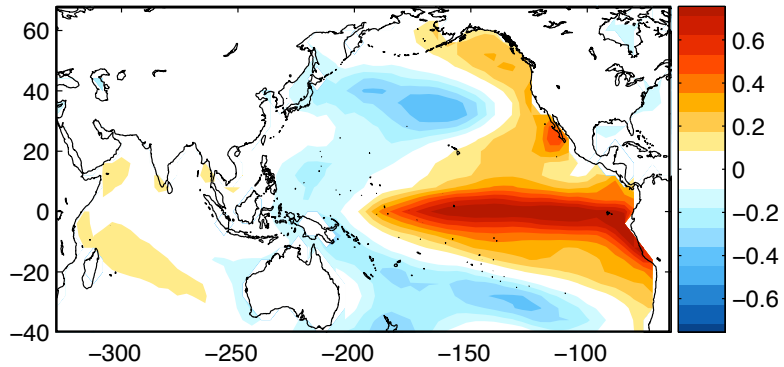
Connection to the tropics and ENSO?

Combined EOF
SLPa/SSTa
over the Pacific Ocean

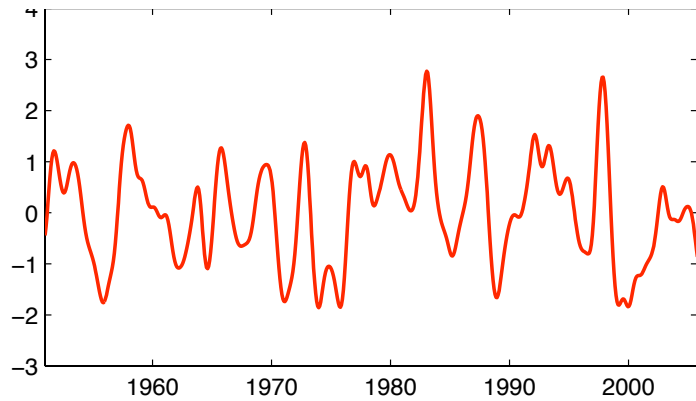
SLPa combined EOF 1



SSTa combined EOF 1

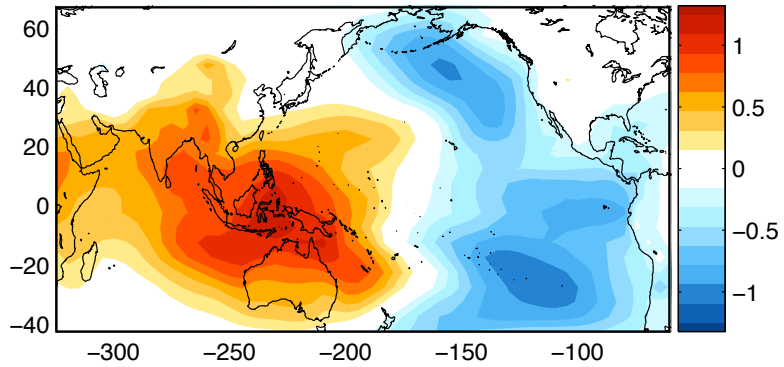


PC 1

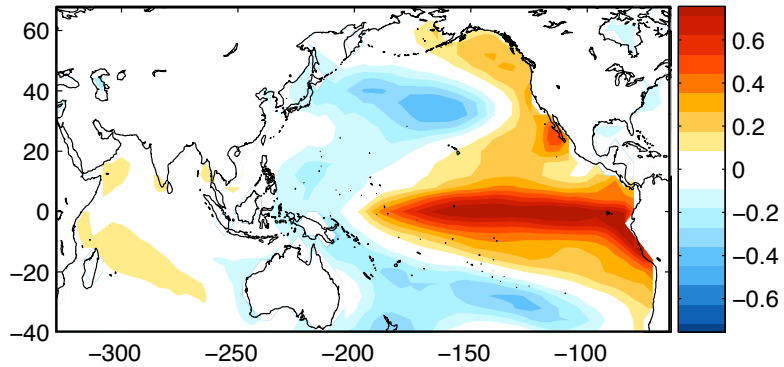


Combined EOF 1 SLPa/SSTa

SLPa combined EOF 1

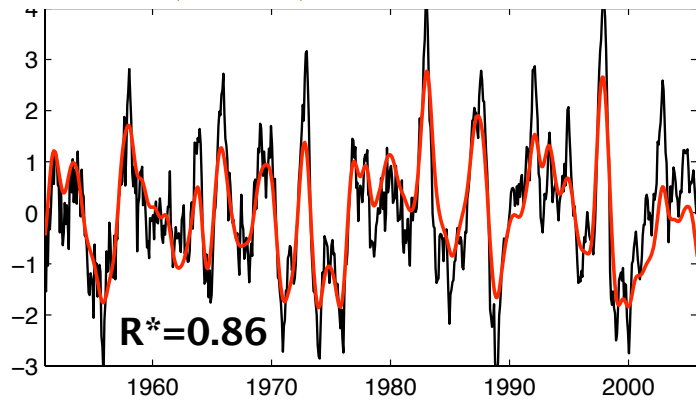


SSTa combined EOF 1



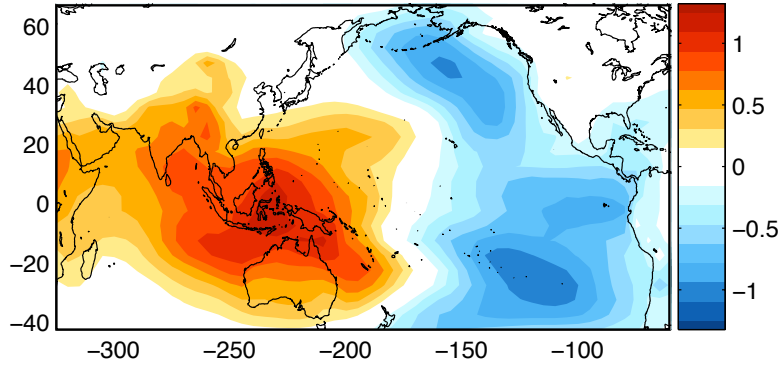
PC 1 (ENSO)

NINO 3.4 index

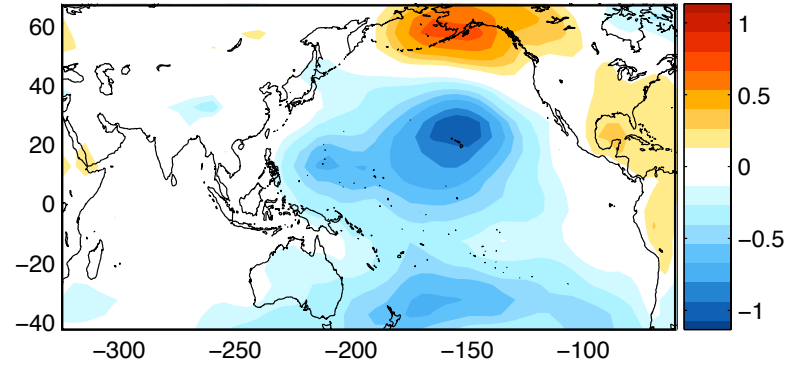


Combined EOF 1 SLPa/SSTa

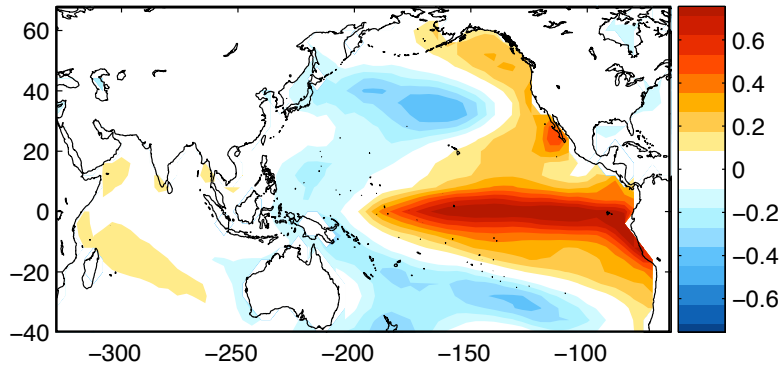
SLPa combined EOF 1



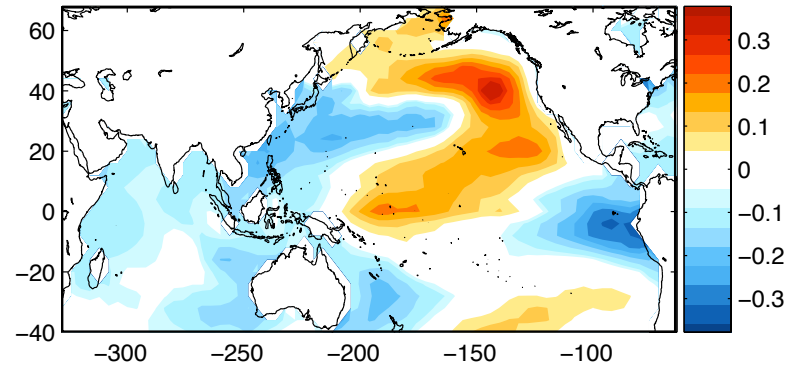
SLPa combined EOF 2



SSTa combined EOF 1

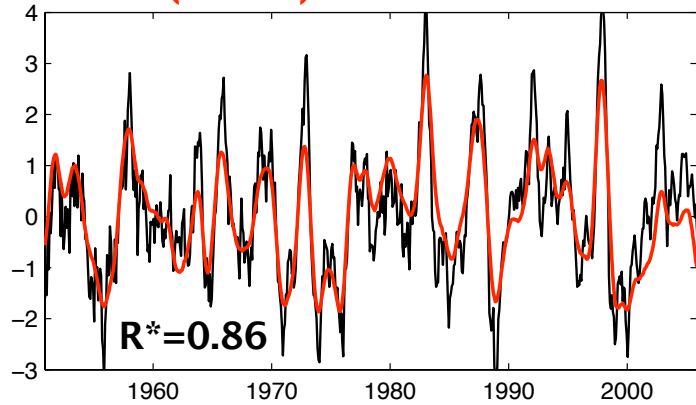


SSTa combined EOF 2

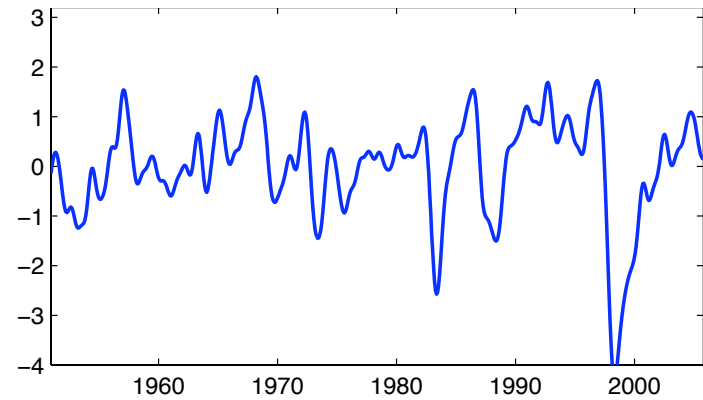


PC 1 (ENSO)

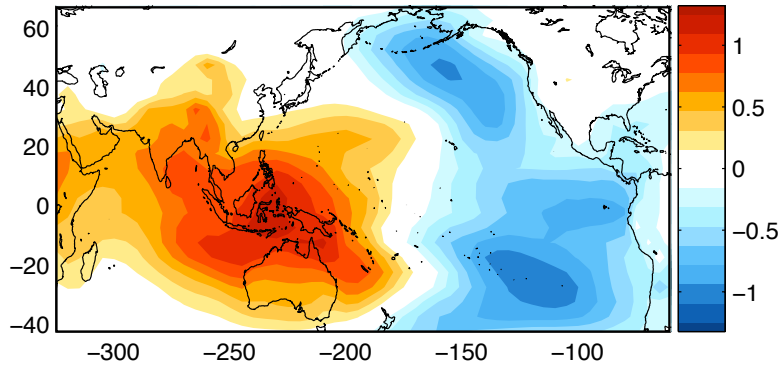
NINO 3.4 index



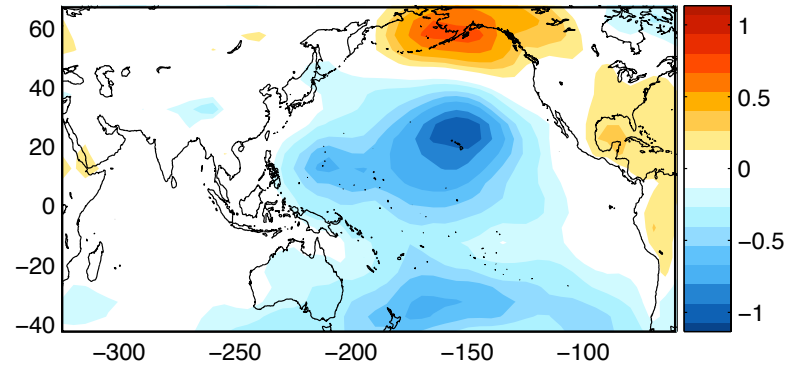
PC 2



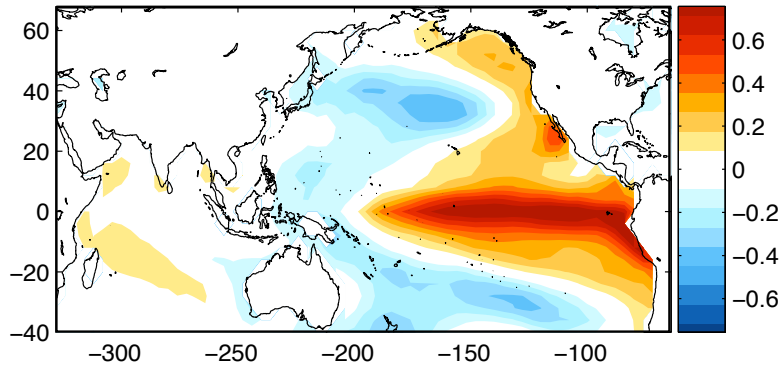
SLPa combined EOF 1



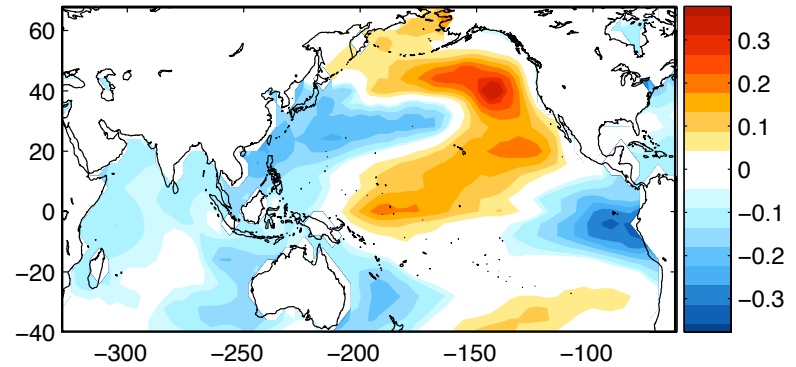
SLPa combined EOF 2



SSTa combined EOF 1

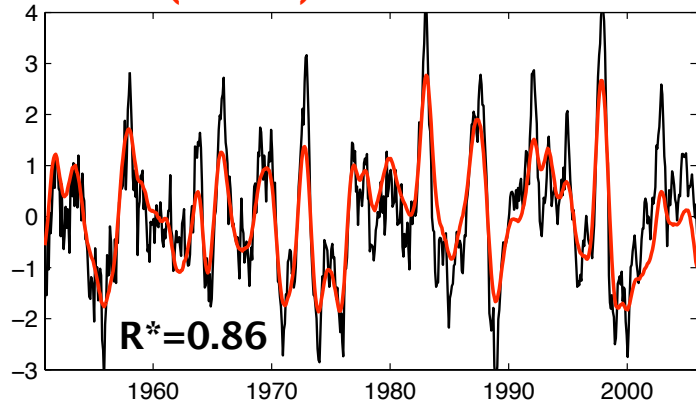


SSTa combined EOF 2



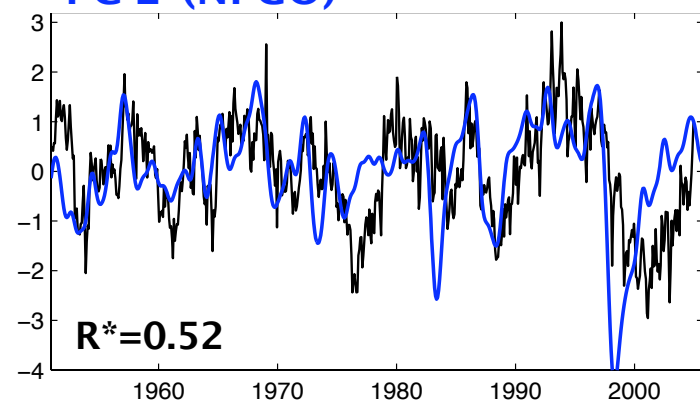
PC 1 (ENSO)

NINO 3.4 index



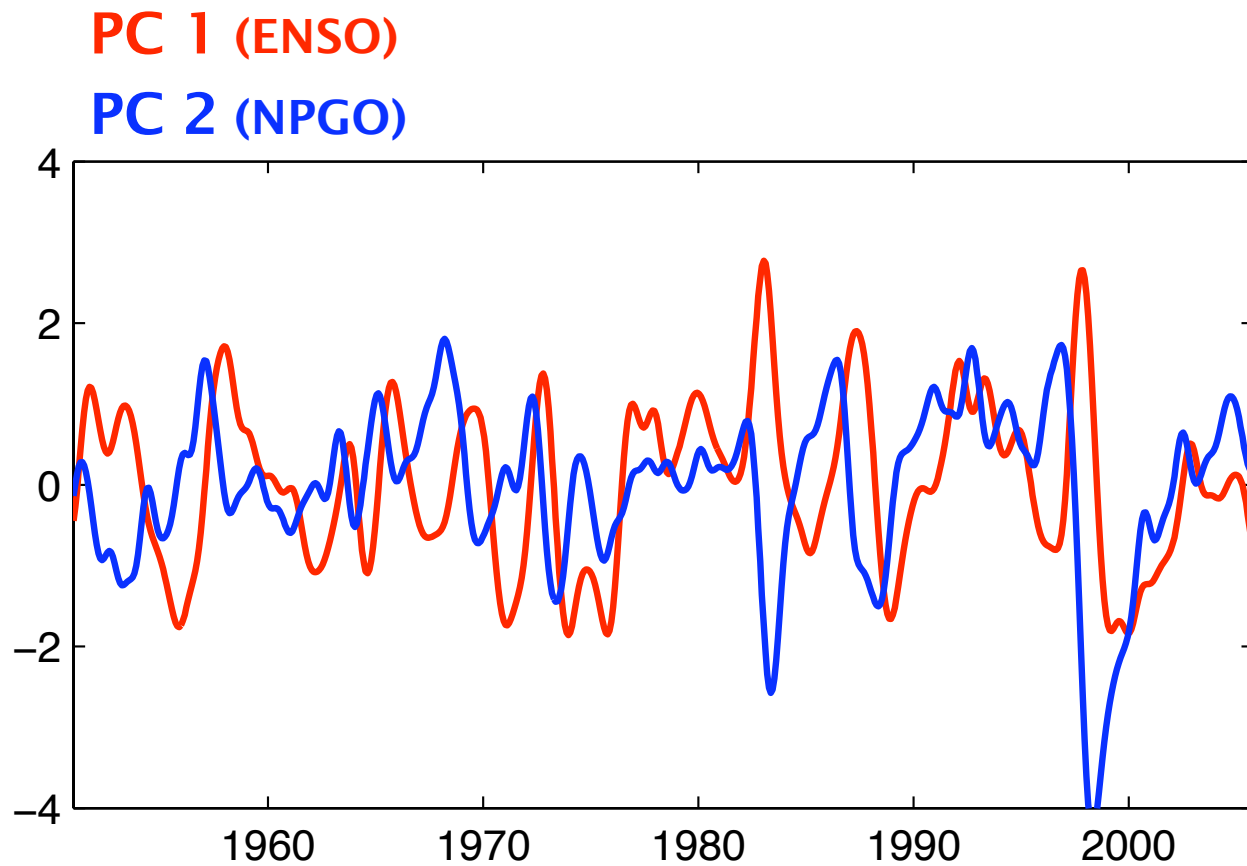
PC 2 (NPGO)

NPGO index



QUESTION:

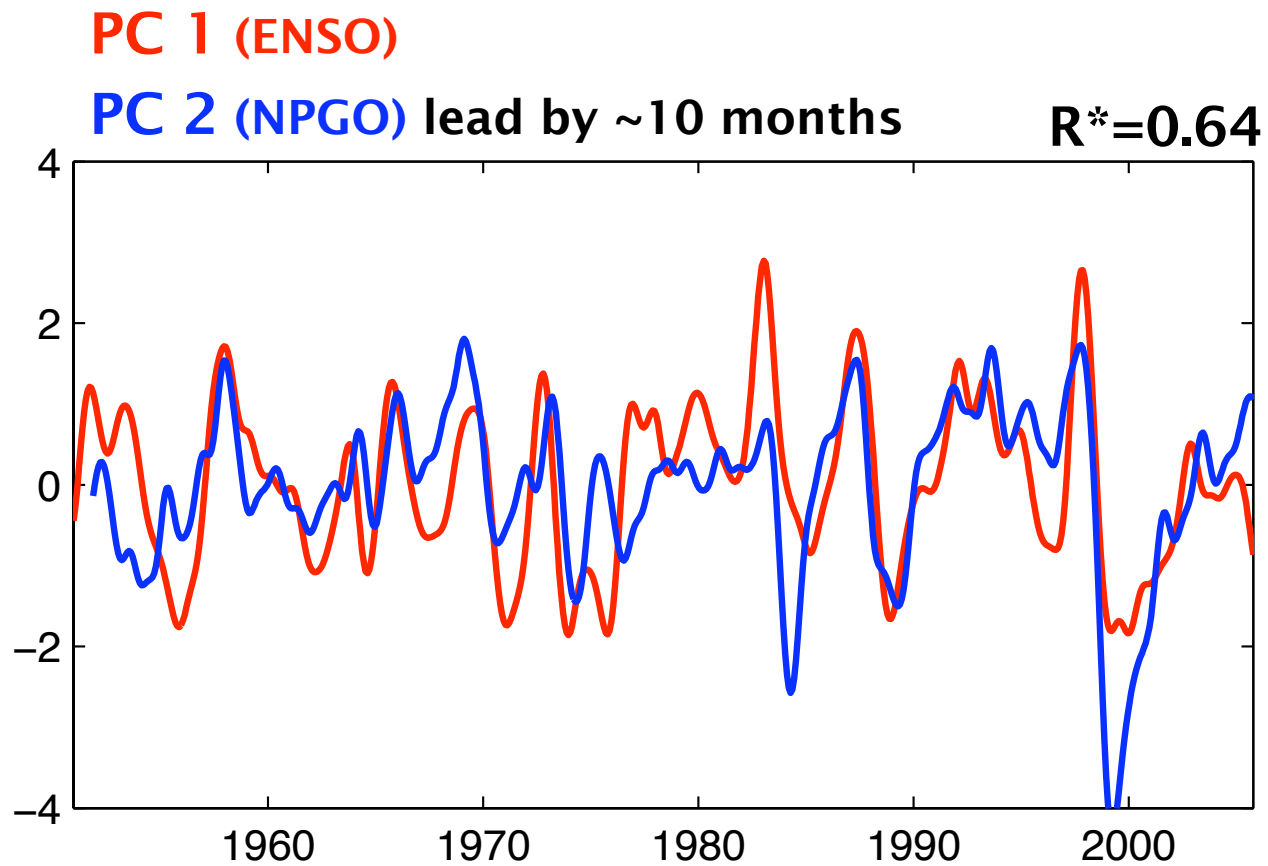
Is there a relationship between **ENSO** and **NPGO** mode?



Di Lorenzo et al., in prep.

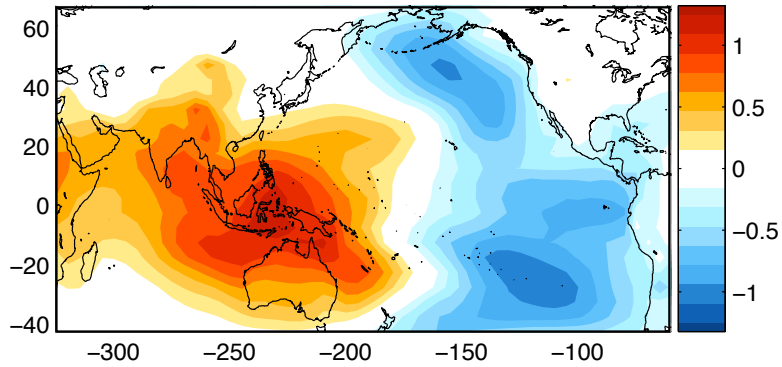
QUESTION:

Is there a relationship between **ENSO** and **NPGO** mode?

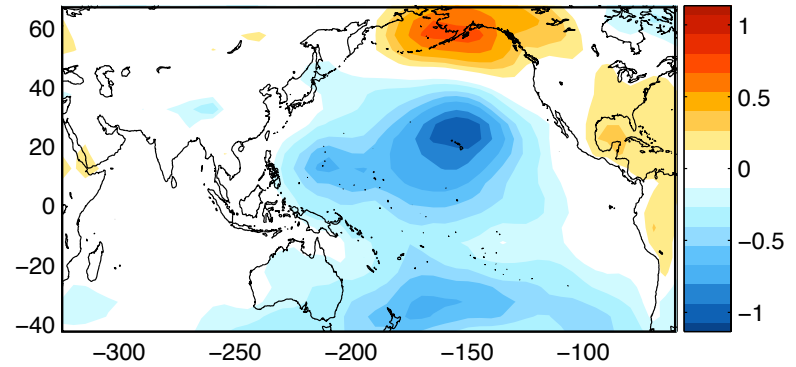


Di Lorenzo et al., in prep.

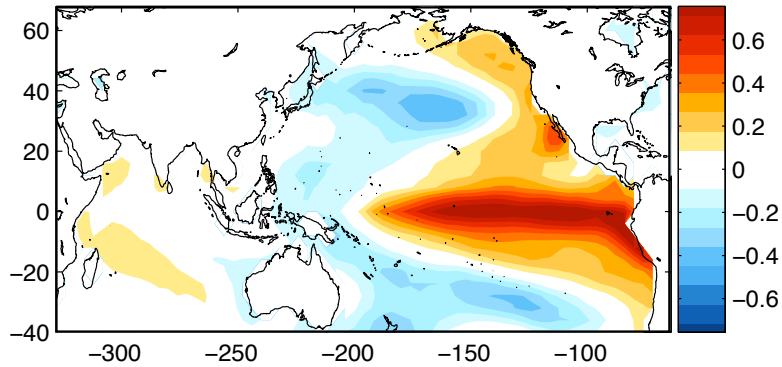
SLPa combined EOF 1



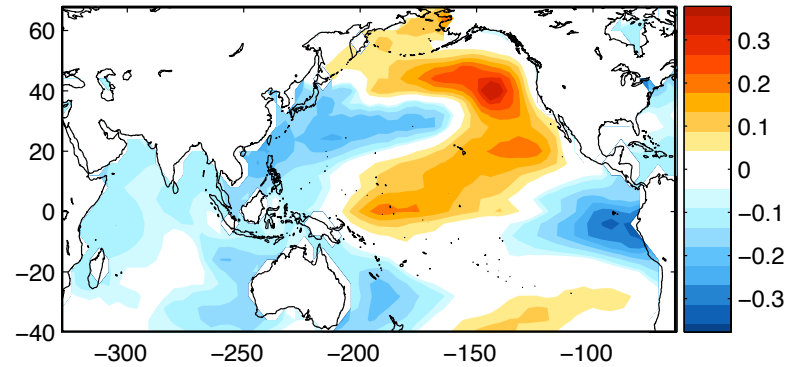
SLPa combined EOF 2



SSTa combined EOF 1

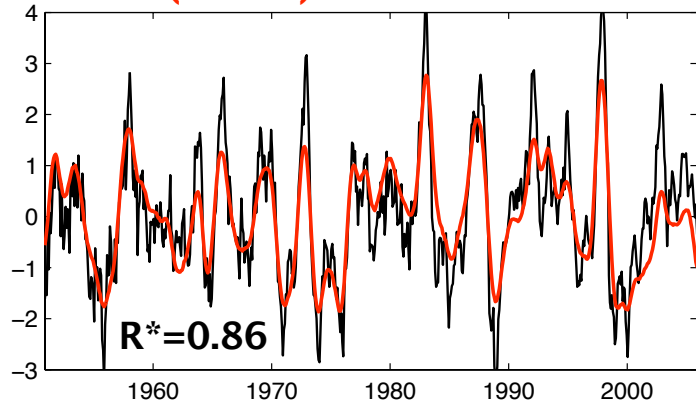


SSTa combined EOF 2



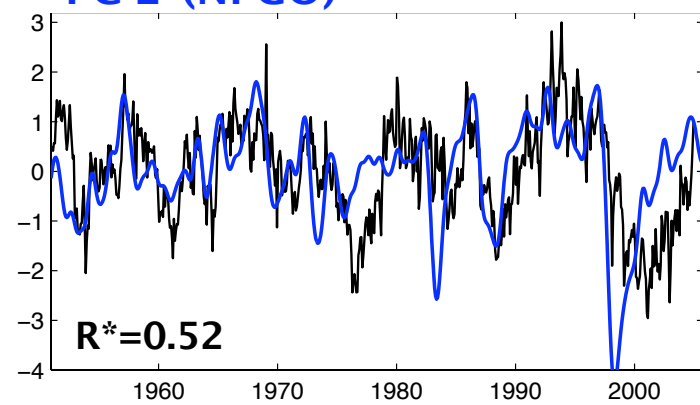
PC 1 (ENSO)

NINO 3.4 index



PC 2 (NPGO)

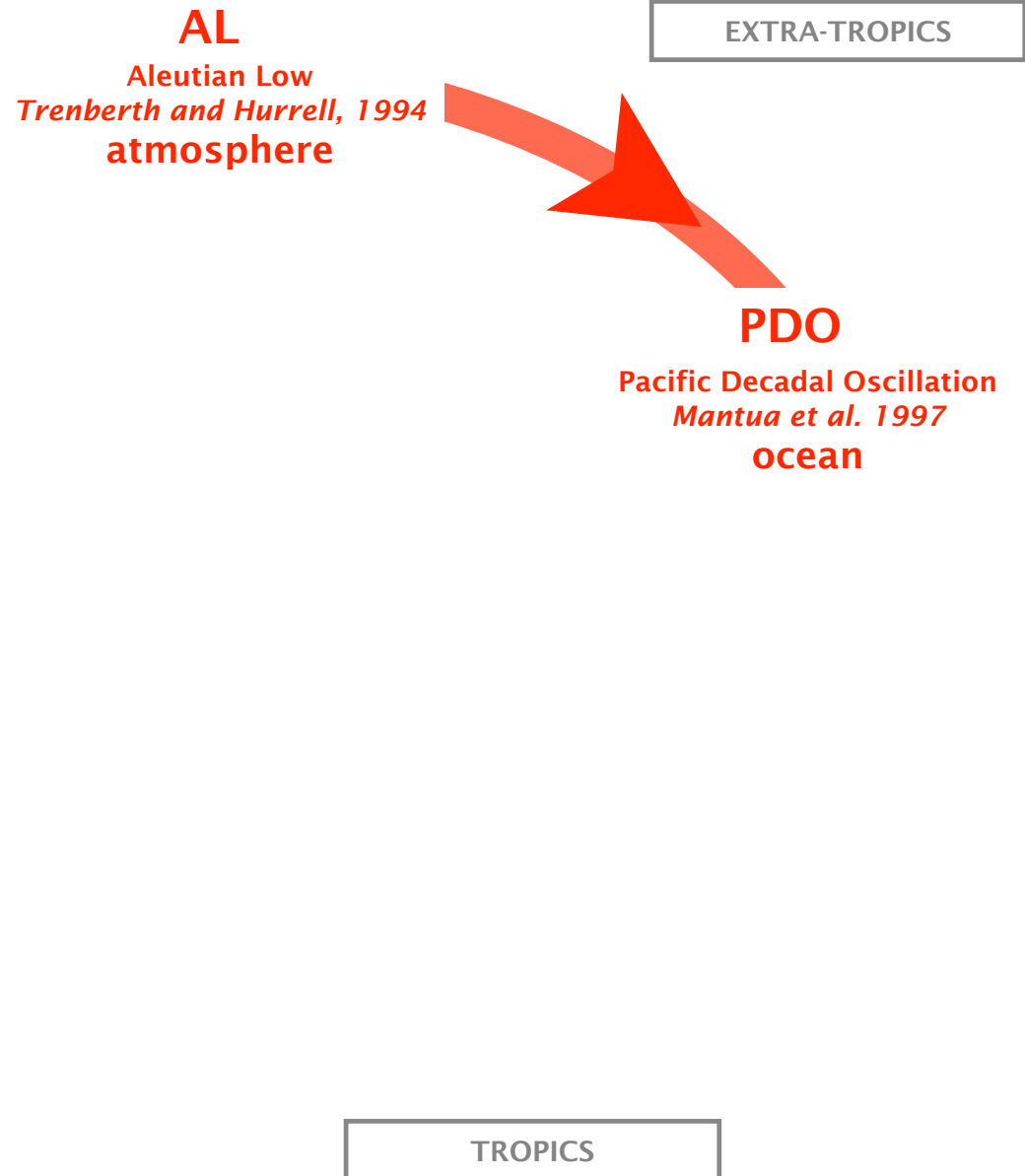
NPGO index

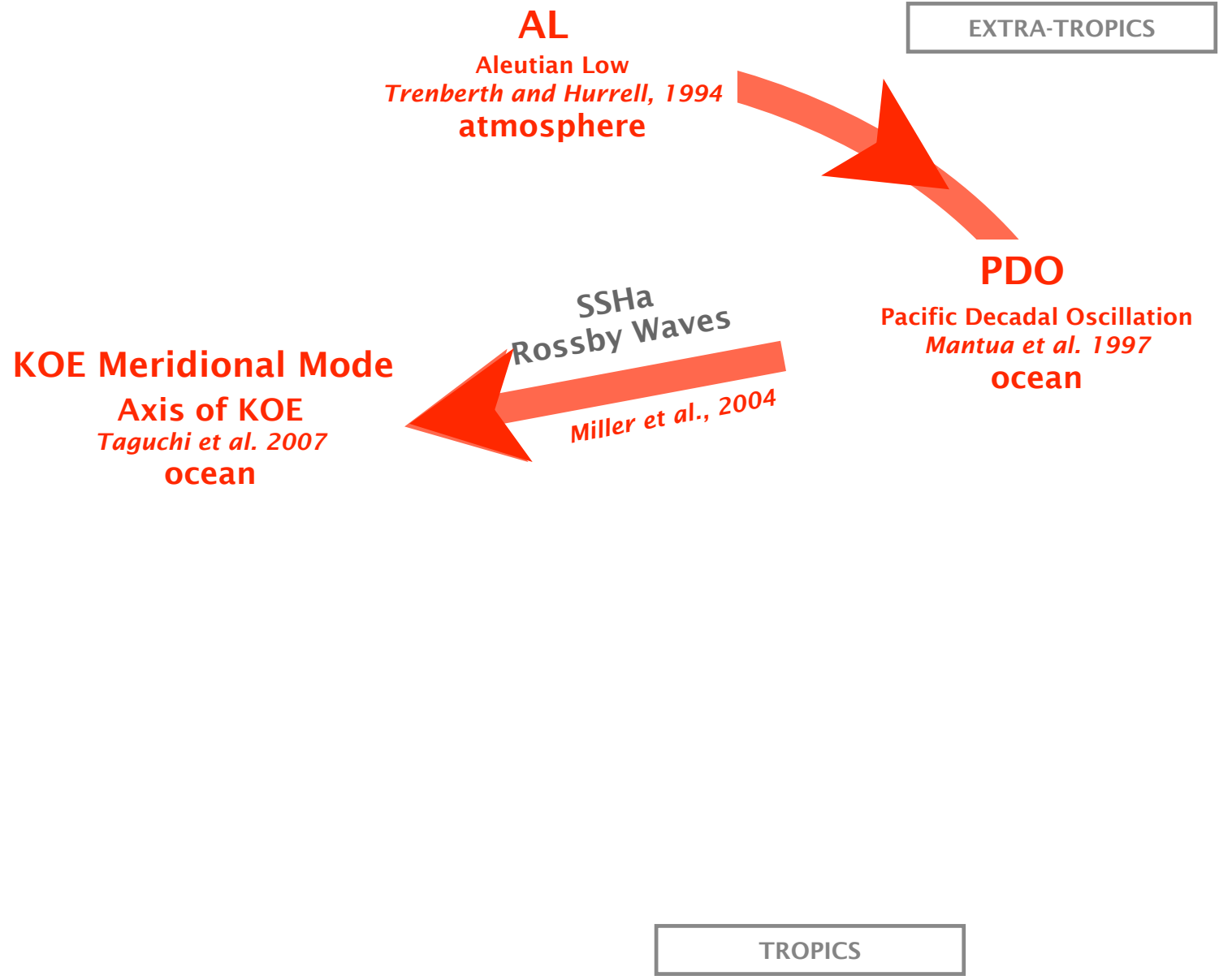


EXTRA-TROPICS

PDO
Pacific Decadal Oscillation
Mantua et al. 1997
ocean

TROPICS





EXTRA-TROPICS

AL

Aleutian Low
Trenberth and Hurrell, 1994
atmosphere

PDO

Pacific Decadal Oscillation
Mantua et al. 1997
ocean

SSHa
Rossby Waves

Miller et al., 2004

KOE Meridional Mode

Axis of KOE
Taguchi et al. 2007
ocean

Decadal Variance of AL/PDO

Pierce et al., 2000
Alexander et al., 2002
Vimont et al. 2005

ENSO

ocean - atmosphere

TROPICS

NPO/NPGO dynamics

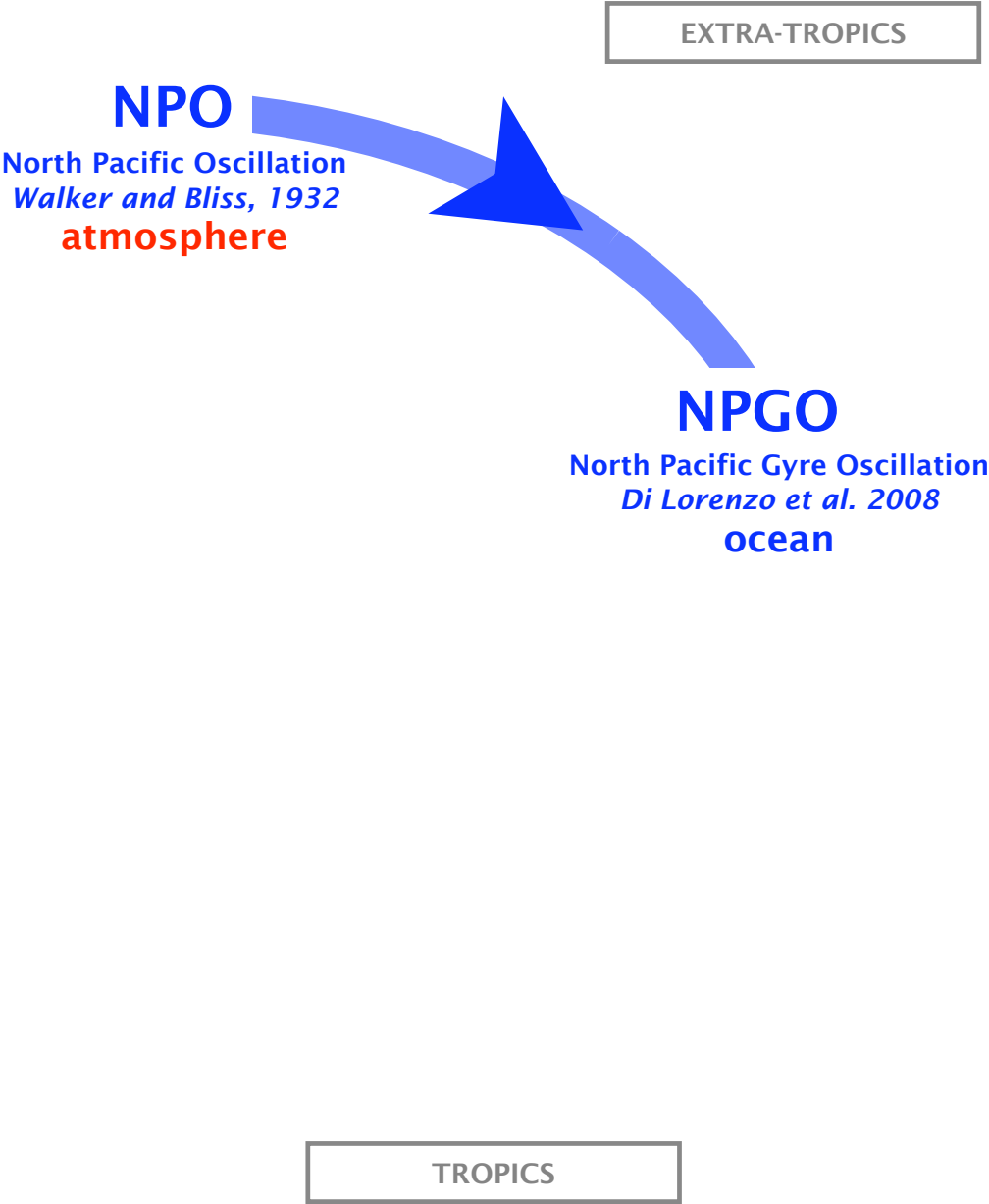
EXTRA-TROPICS

NPGO

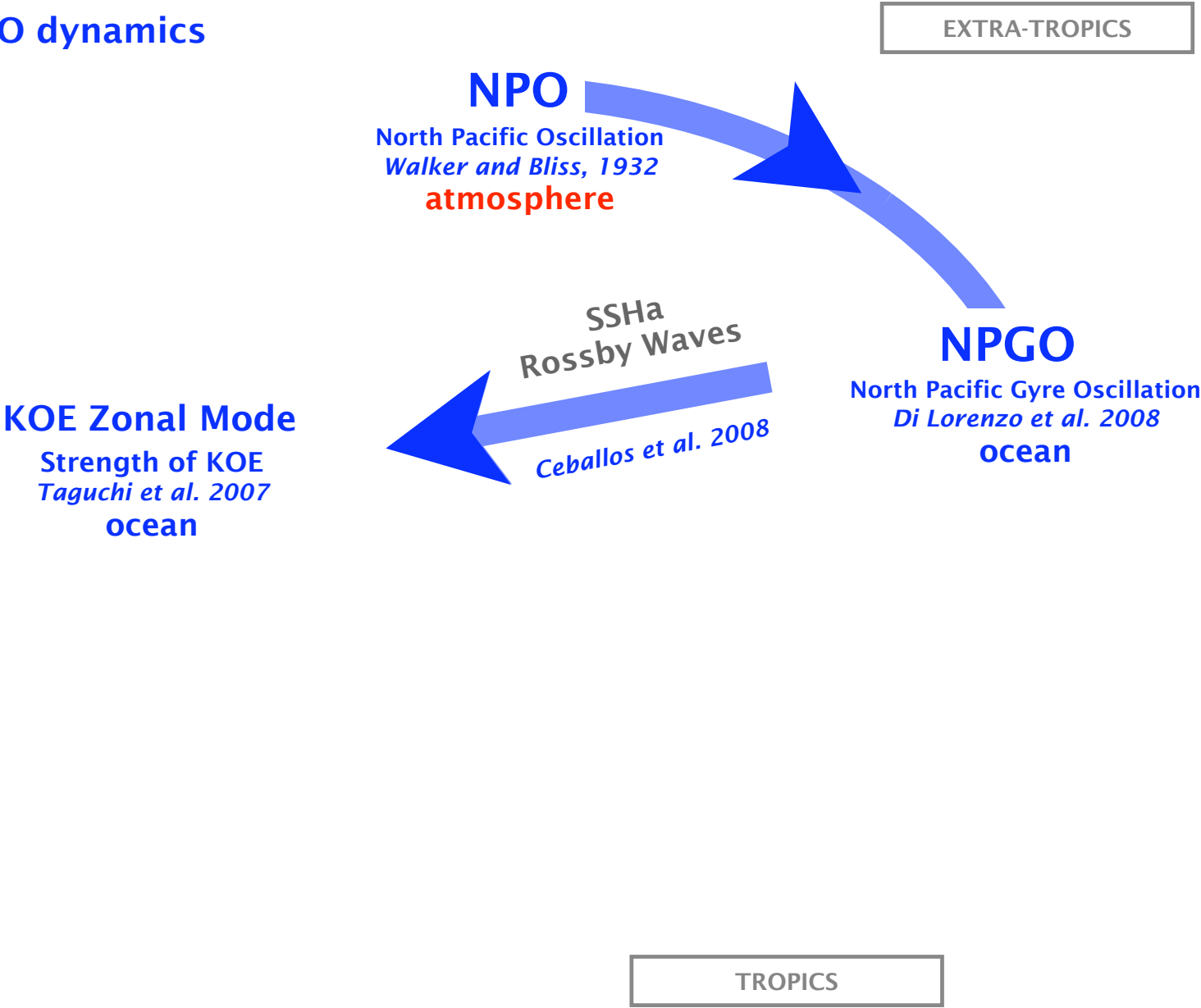
North Pacific Gyre Oscillation
Di Lorenzo et al. 2008
ocean

TROPICS

NPO/NPGO dynamics



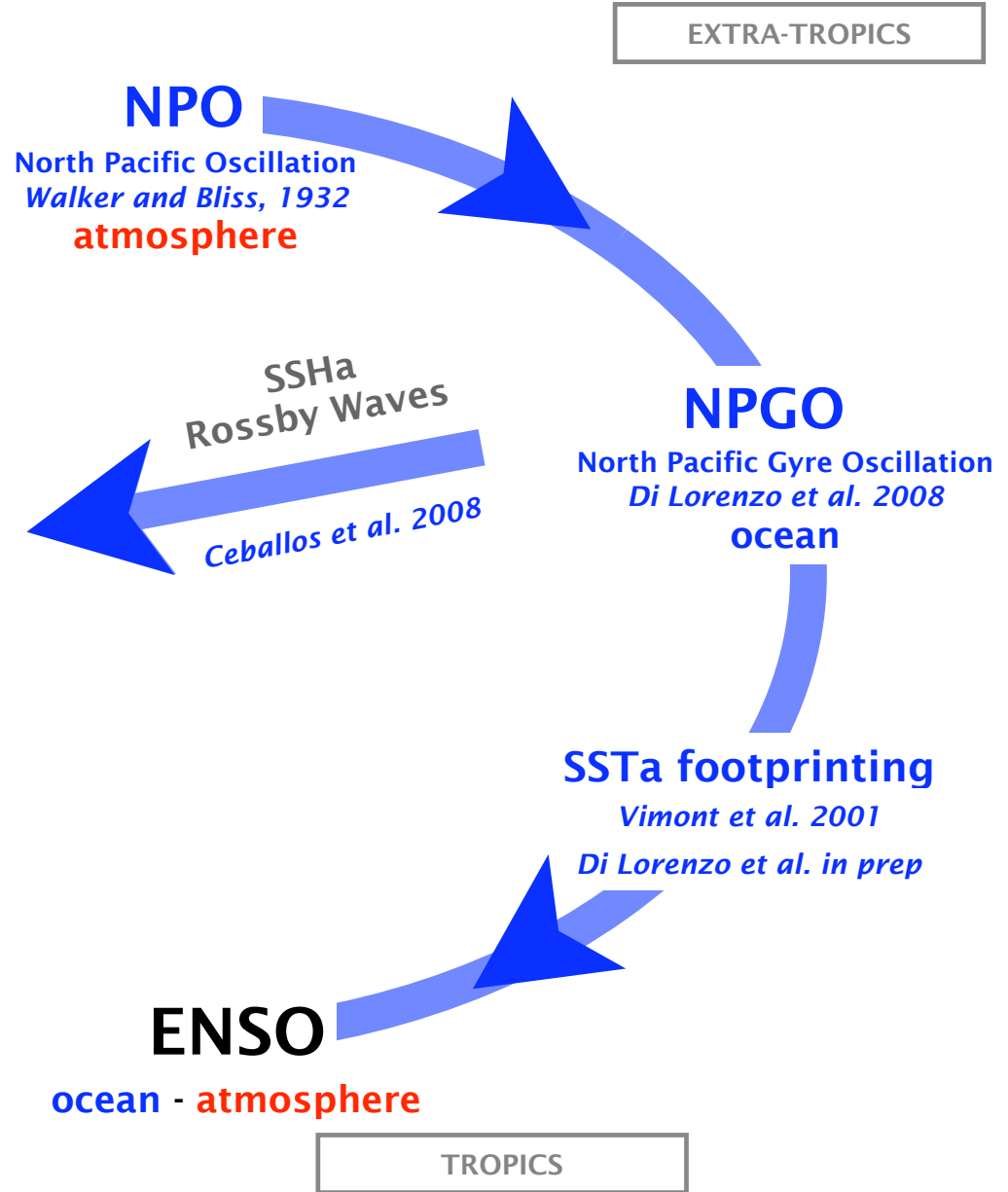
NPO/NPGO dynamics



NPO/NPGO dynamics

ENSO dynamics

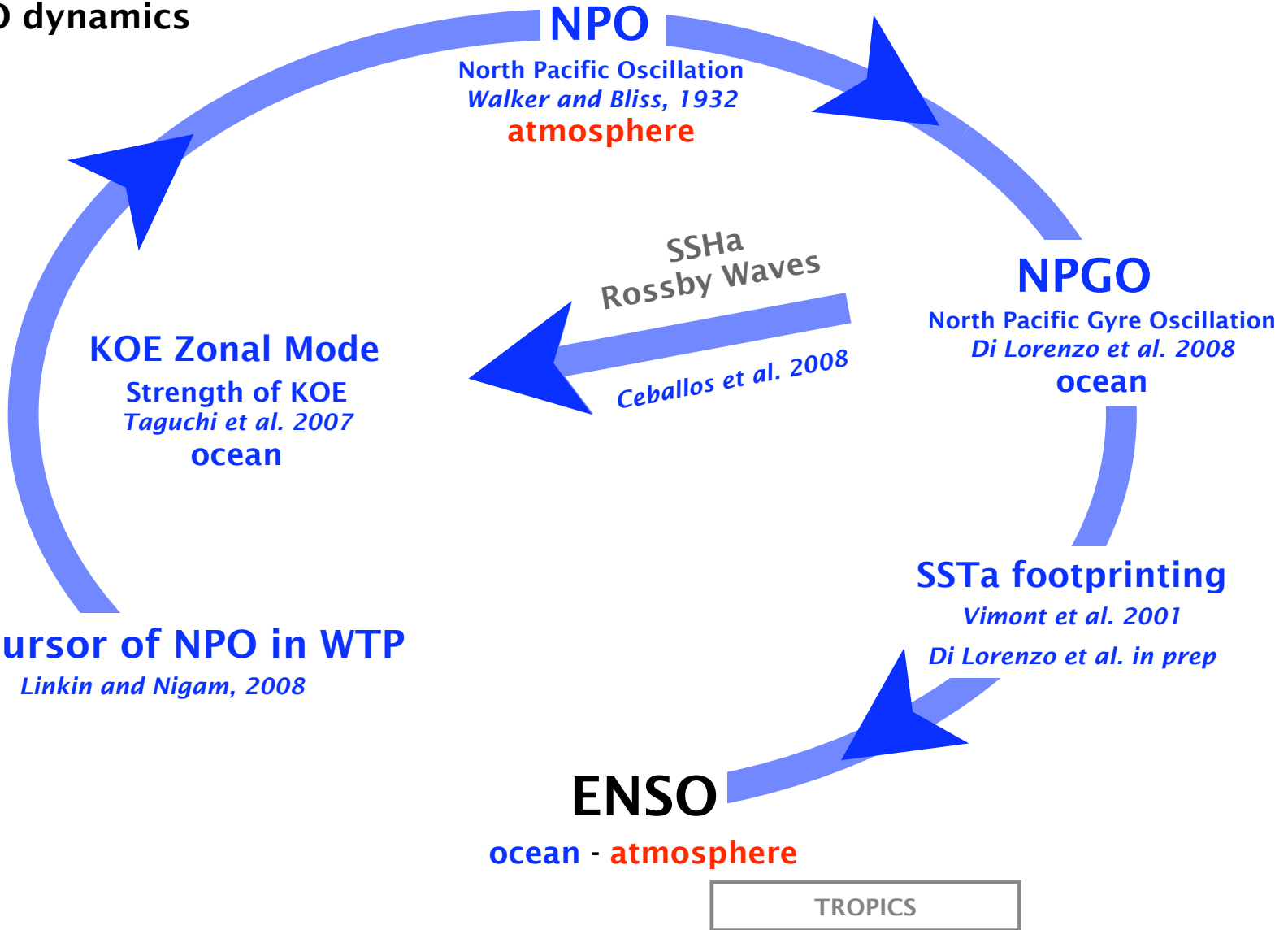
KOE Zonal Mode
Strength of KOE
Taguchi et al. 2007
ocean



NPO/NPGO dynamics

ENSO dynamics

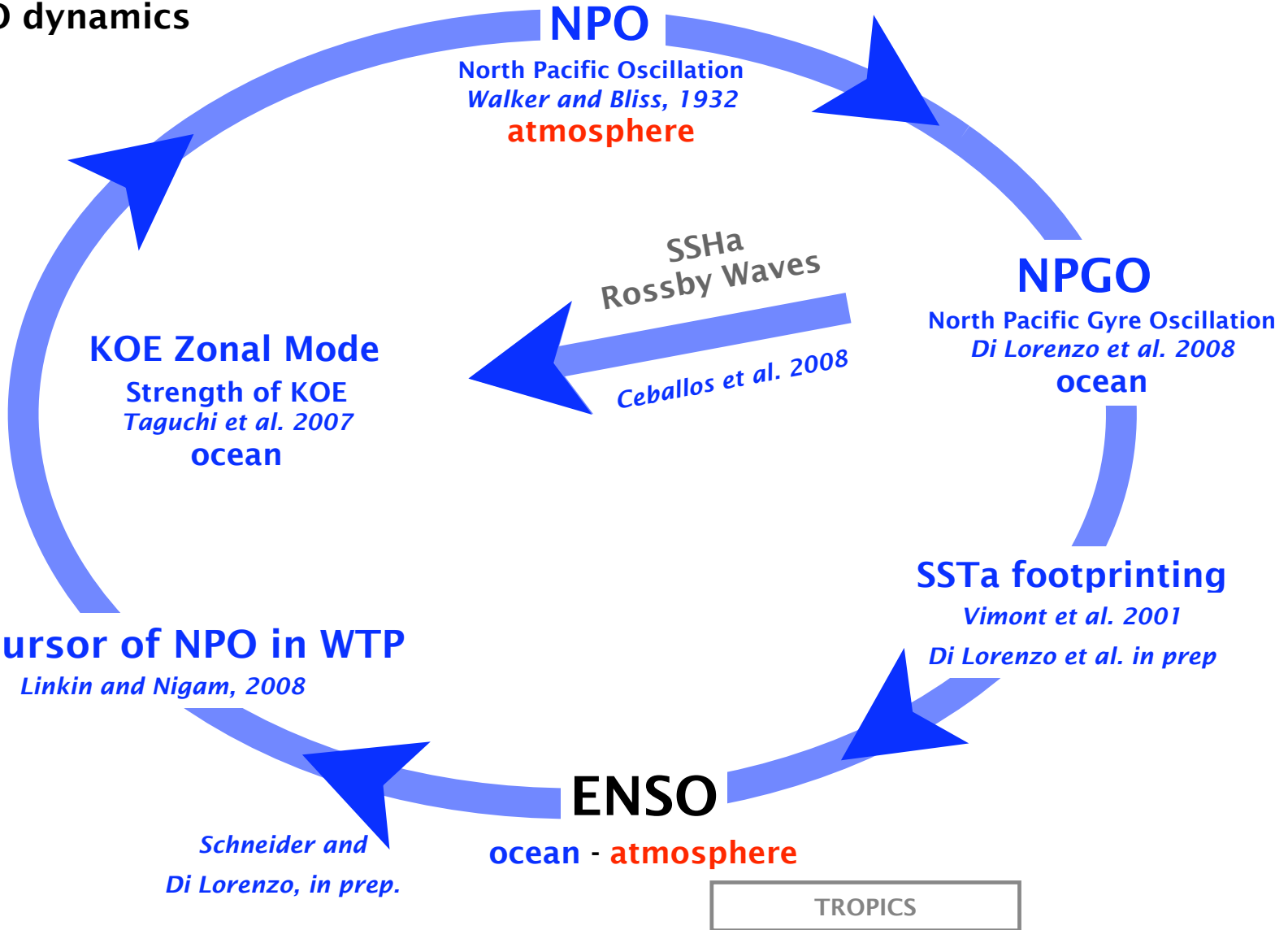
EXTRA-TROPICS



NPO/NPGO dynamics

ENSO dynamics

EXTRA-TROPICS



NPO

North Pacific Oscillation
Walker and Bliss, 1932
atmosphere

NPGO

North Pacific Gyre Oscillation
Di Lorenzo et al. 2008
ocean

ENSO

ocean - **atmosphere**

TROPICS

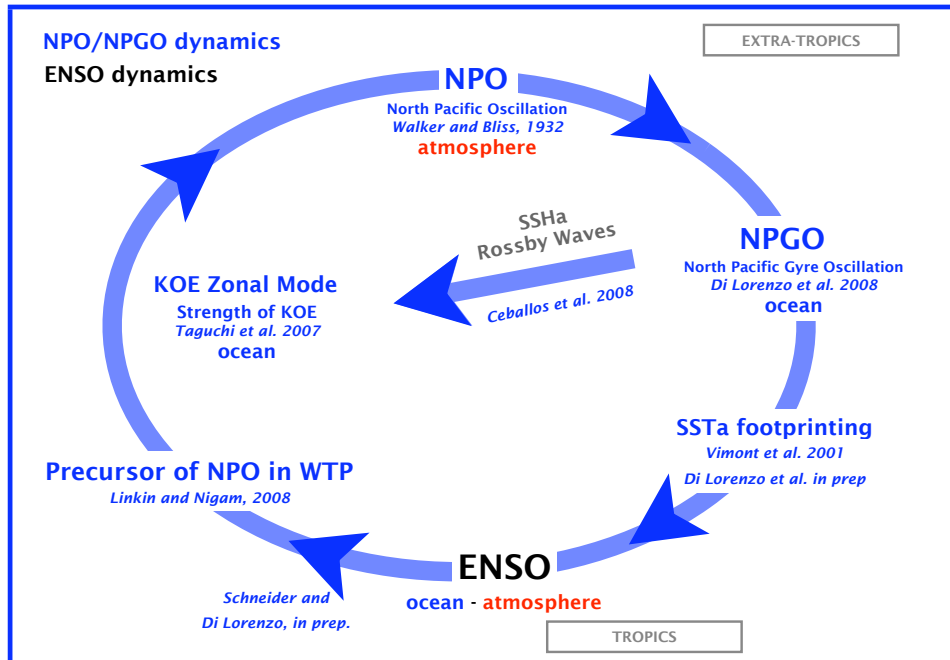
KOE Zonal Mode
Strength of KOE
Taguchi et al. 2007
ocean

Precursor of NPO in WTP
Linkin and Nigam, 2008

*Schneider and
Di Lorenzo, in prep.*

SSTa footprinting
Vimont et al. 2001
Di Lorenzo et al. in prep

SSHa
Rossby Waves
Ceballos et al. 2008



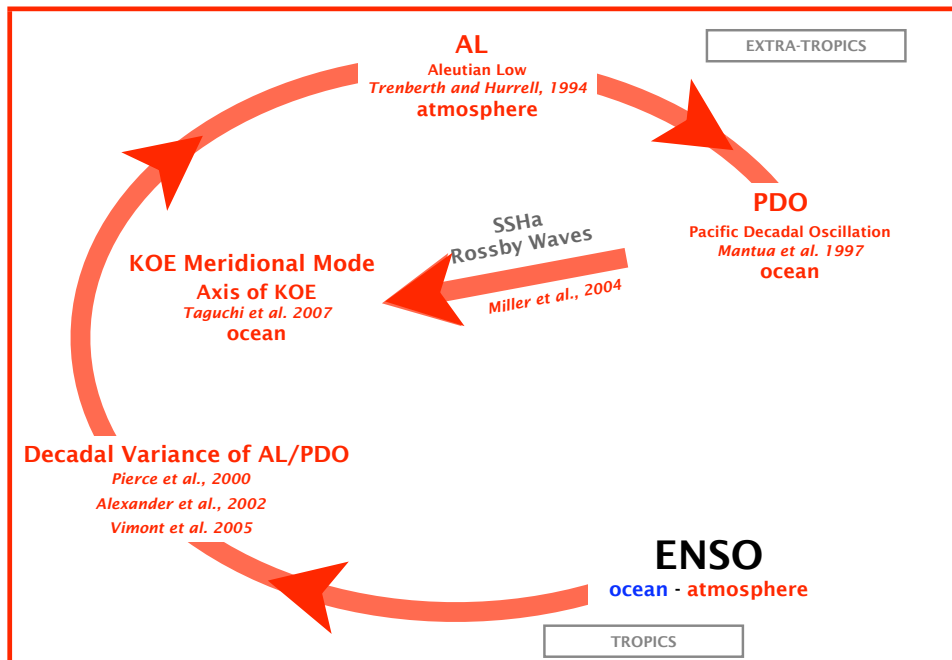
NPO/NPGO dynamics
Extra-Tropics

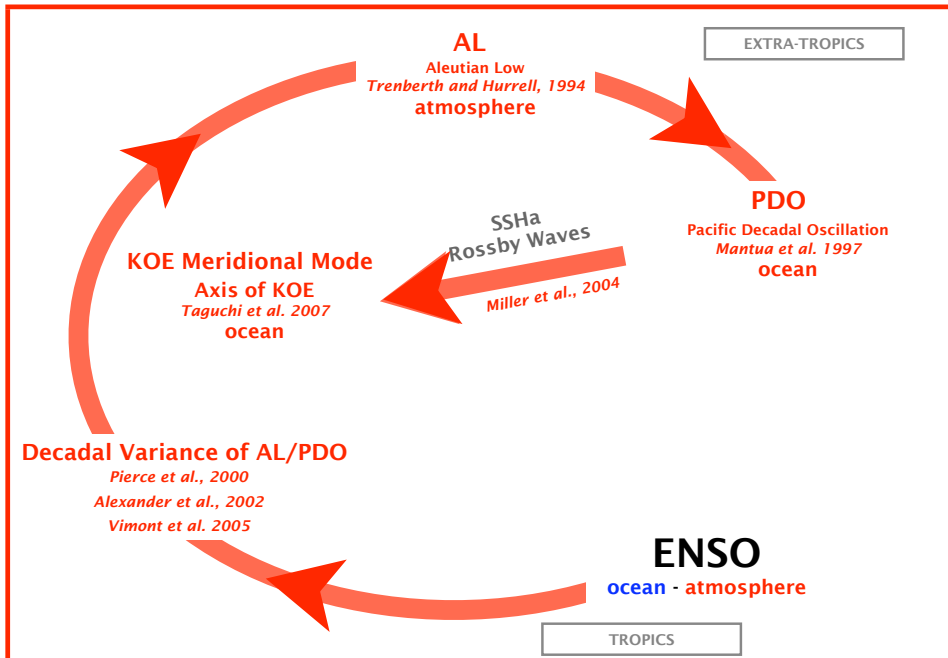
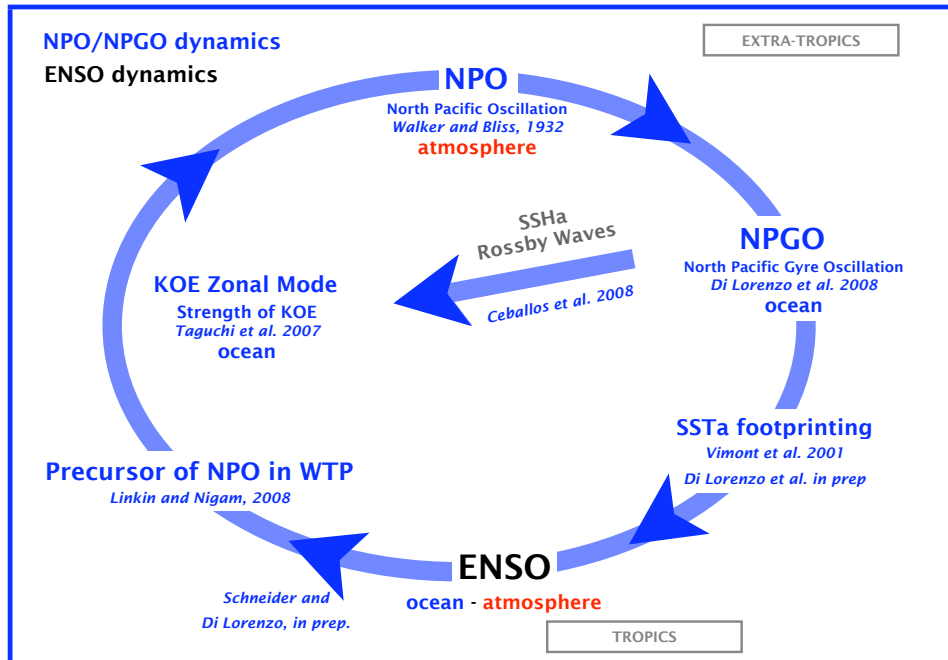


ENSO dynamics
Tropics



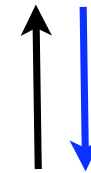
AL/PDO dynamics
Extra-Tropics





A “conceptual framework” for Pacific Climate Variability

NPO/NPGO dynamics
Extra-Tropics



ENSO dynamics
Tropics

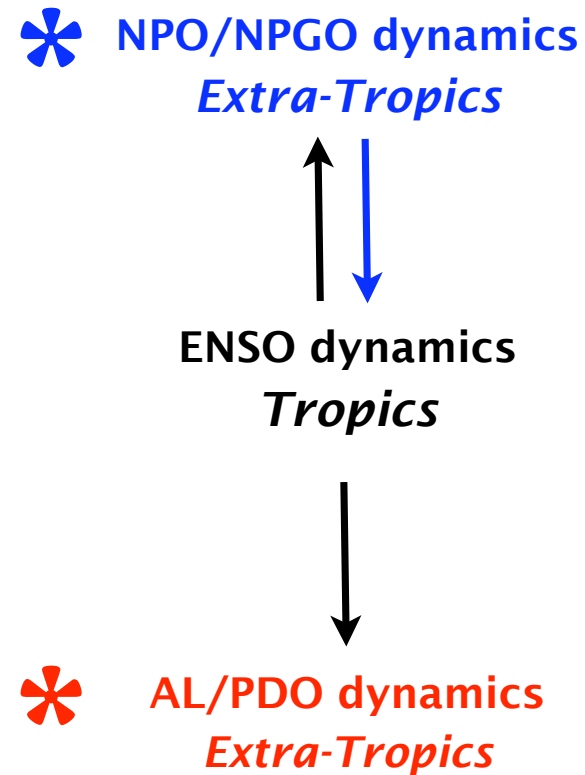


AL/PDO dynamics
Extra-Tropics

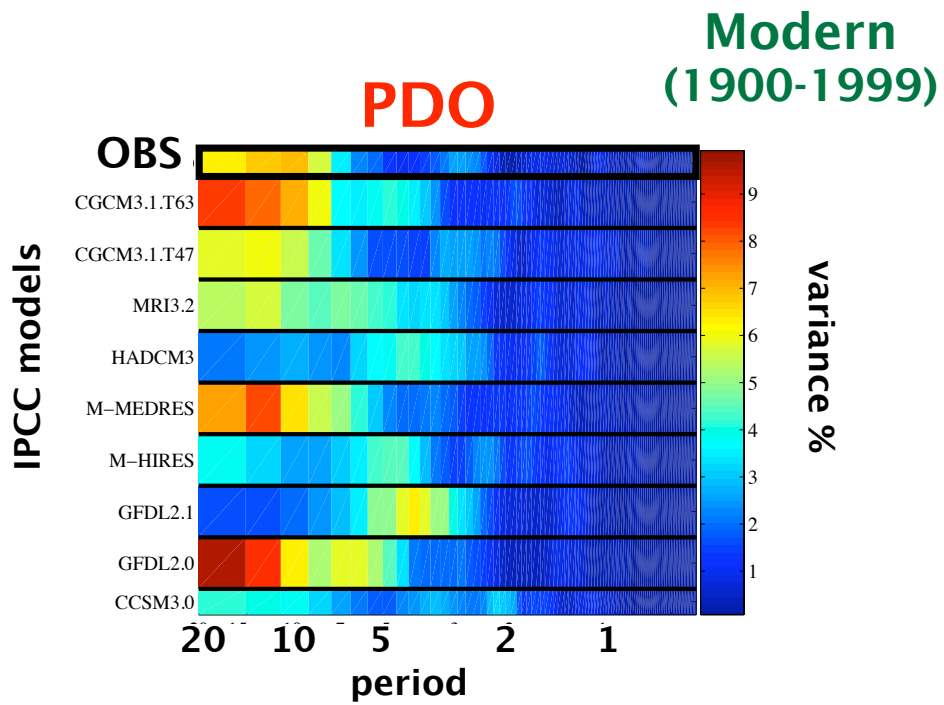
A “conceptual framework” for Pacific Climate Variability

QUESTION:

Do the IPCC climate model capture **PDO** and **NPGO**?



Power Spectra

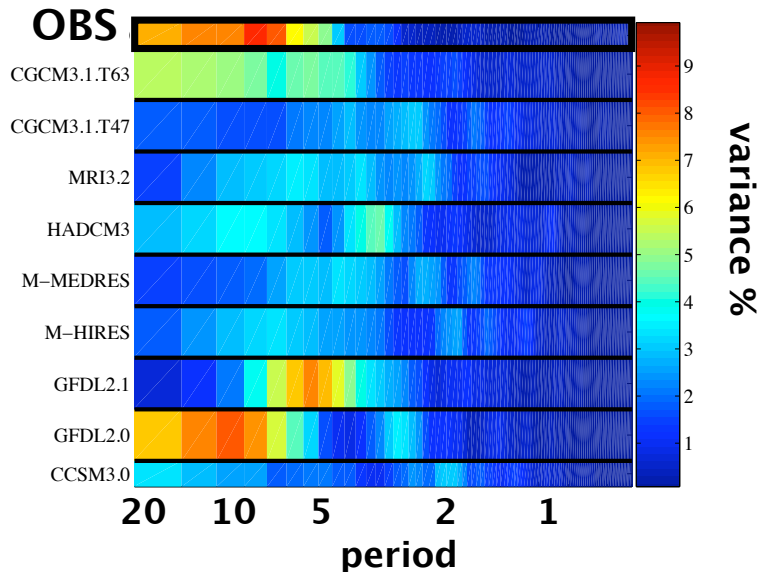
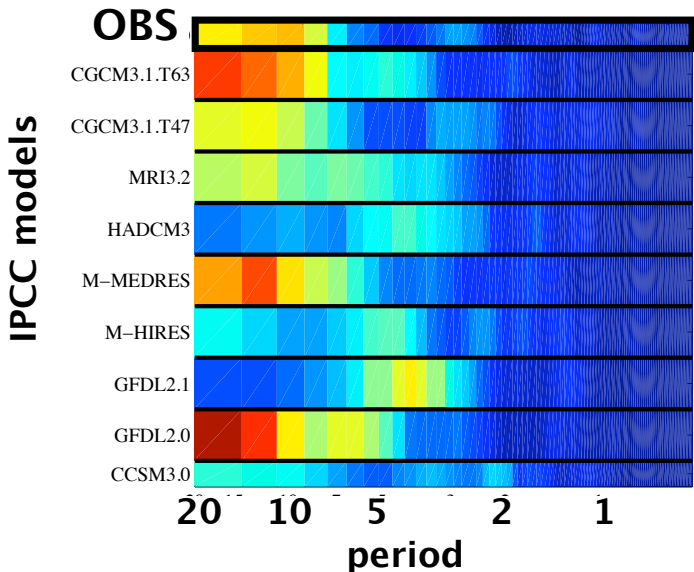


Power Spectra

**Modern
(1900-1999)**

PDO

NPGO

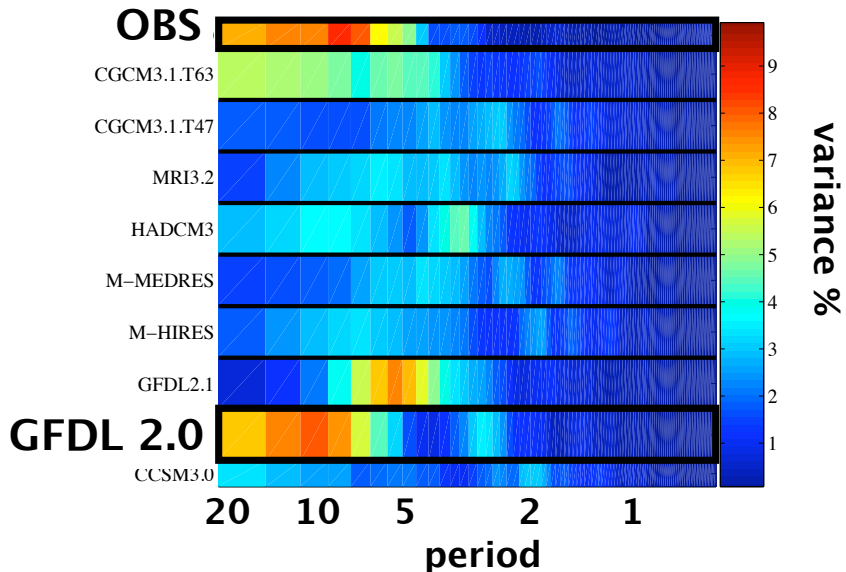
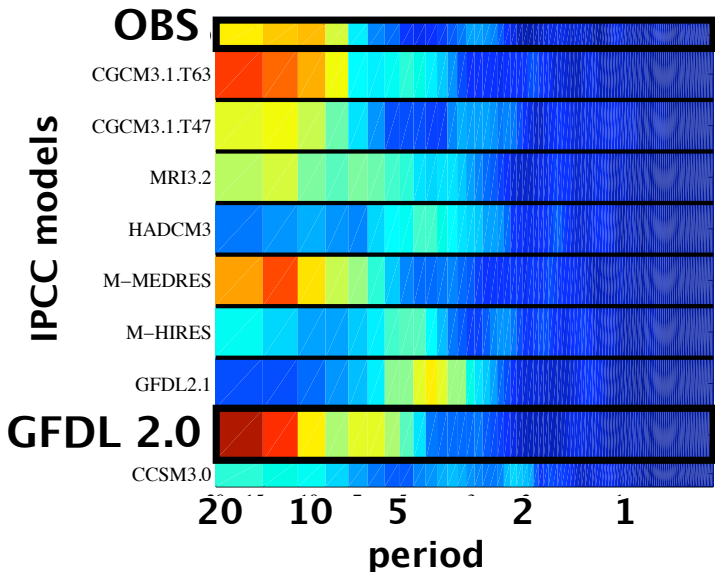


Power Spectra

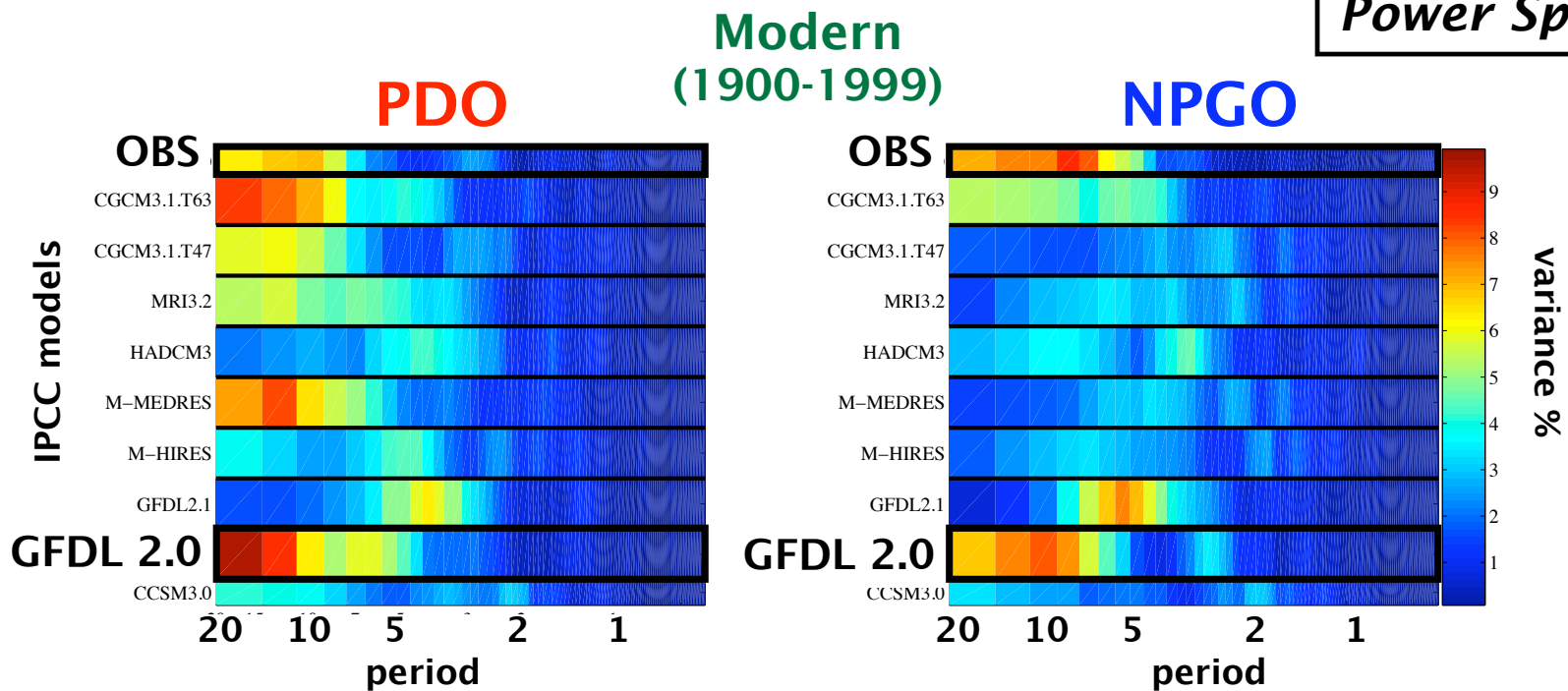
**Modern
(1900-1999)**

PDO

NPGO



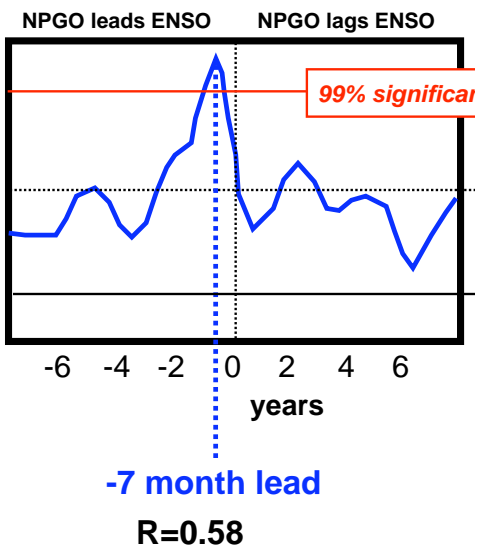
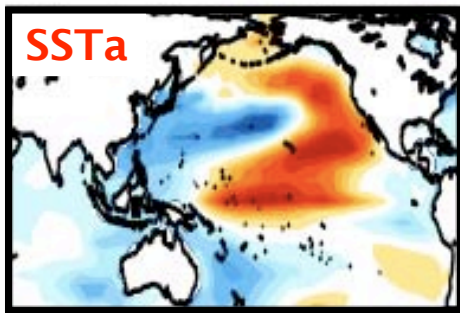
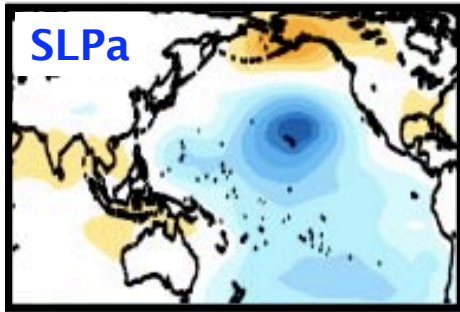
Power Spectra



QUESTION:

**Do the IPCC climate model capture
NPGO/ENSO relationship?**

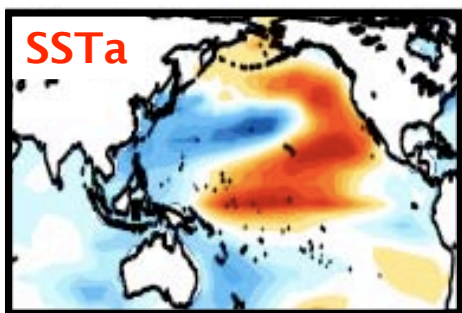
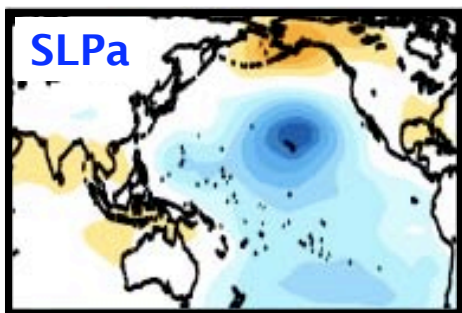
OBSERVATIONS



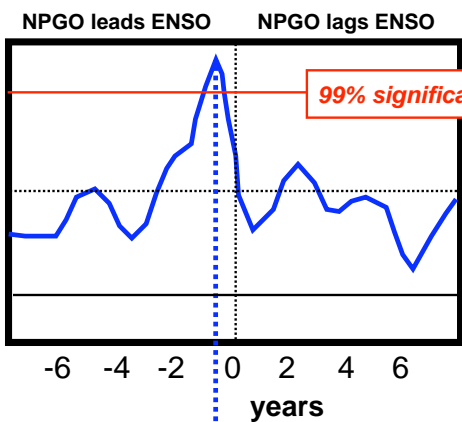
QUESTION:

Do the IPCC climate model capture
NPGO/ENSO relationship?

OBSERVATIONS



NPO/NPGO mode



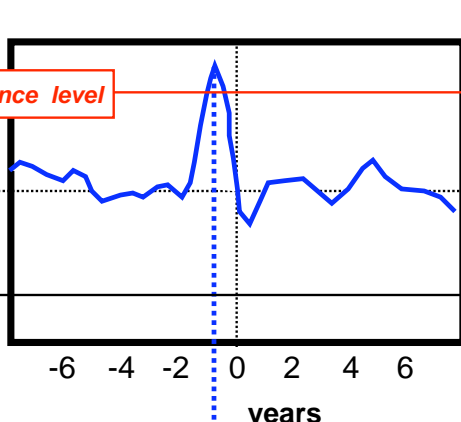
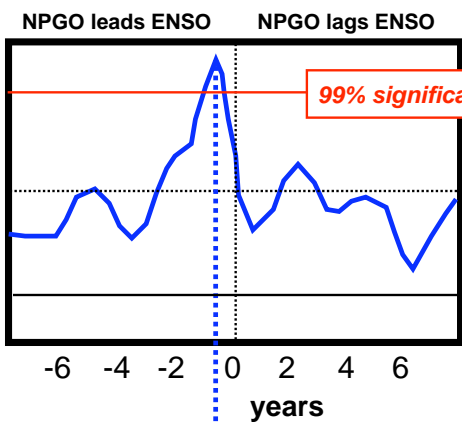
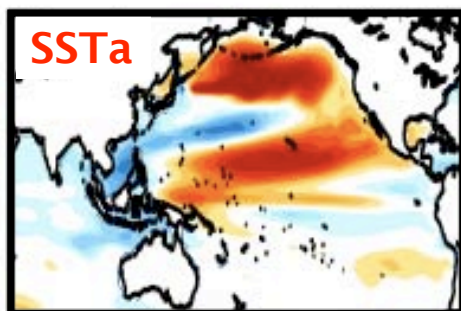
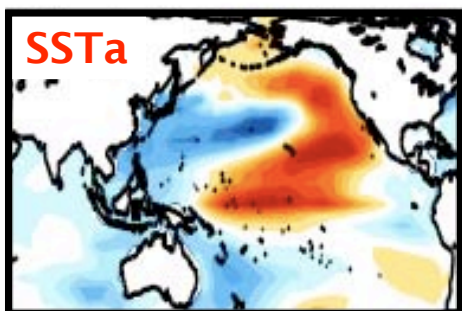
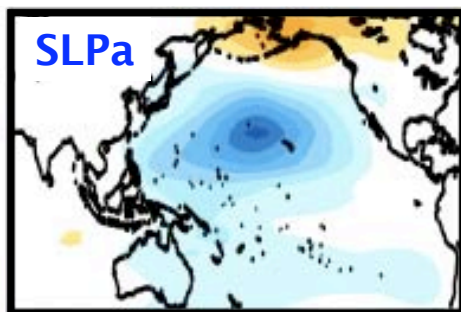
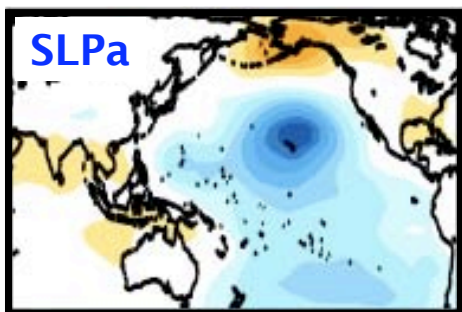
NPGO/ENSO lead-lag relationship

-7 month lead

R=0.58

OBSERVATIONS

GFDL 2.0



-7 month lead

R=0.58

-8 month lead

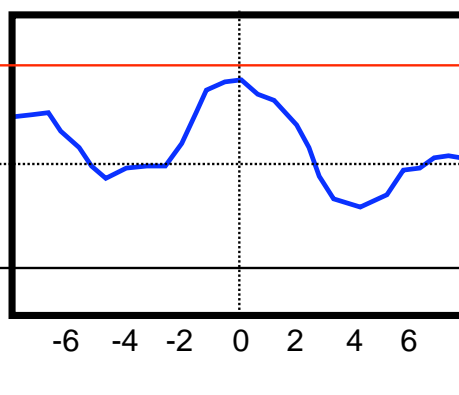
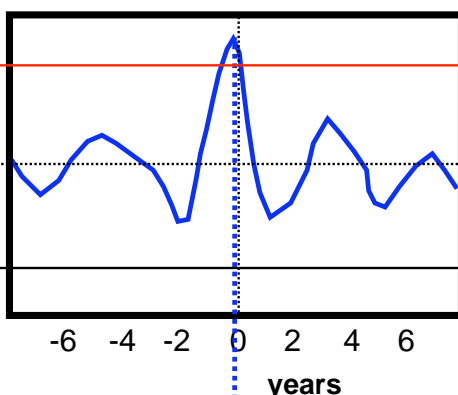
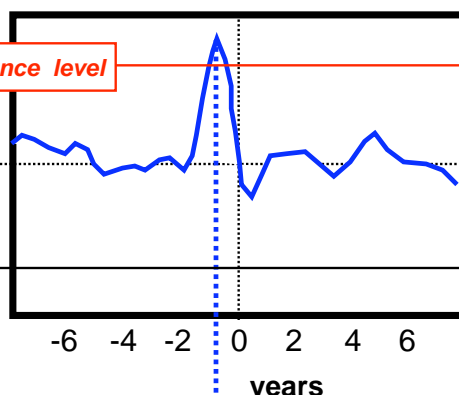
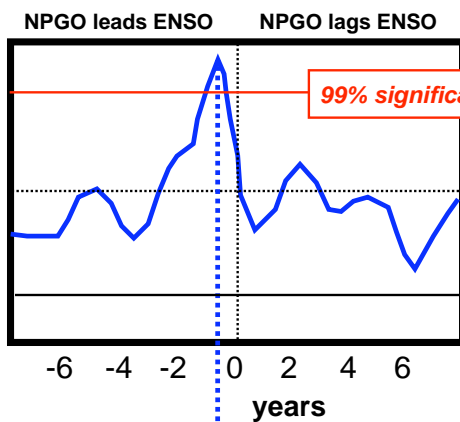
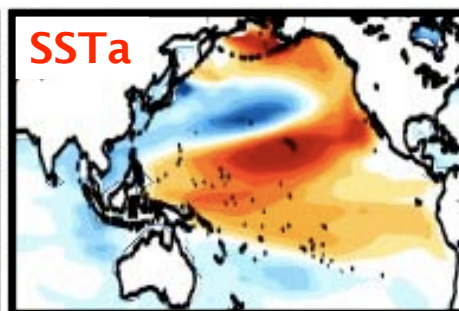
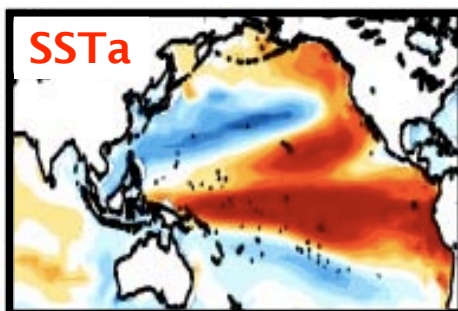
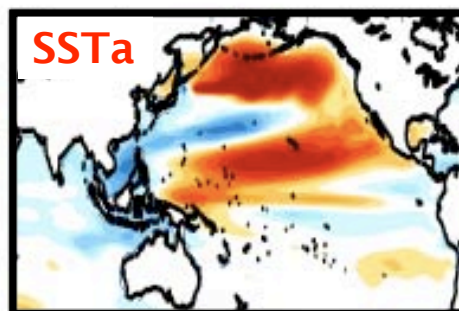
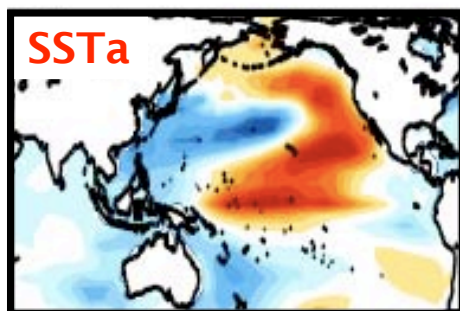
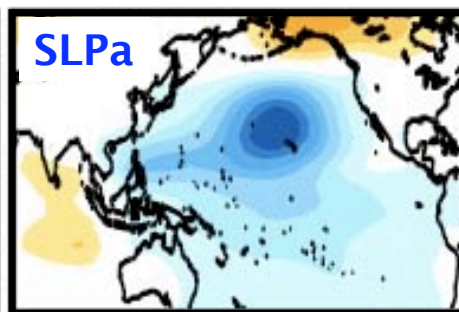
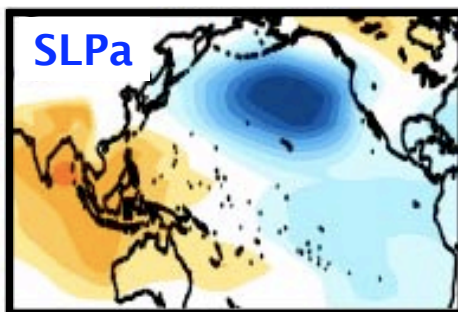
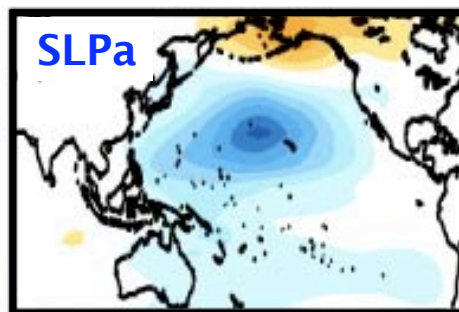
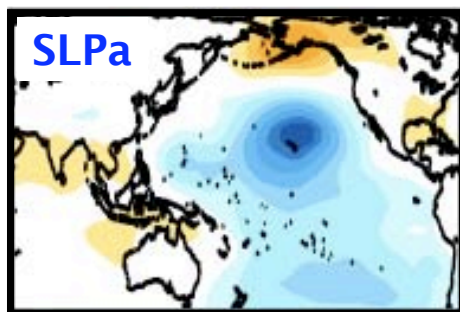
R=0.52

OBSERVATIONS

GFDL 2.0

HADCM3

MIROC-MEDRES

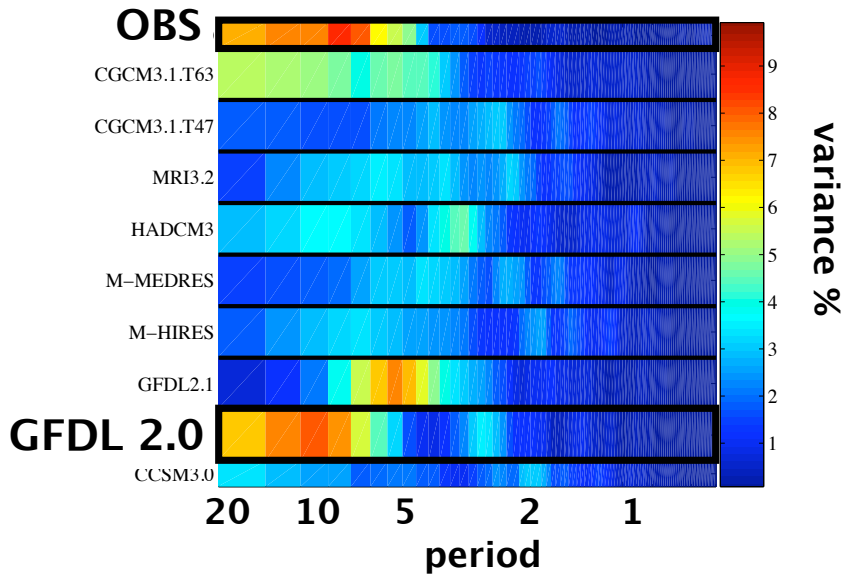
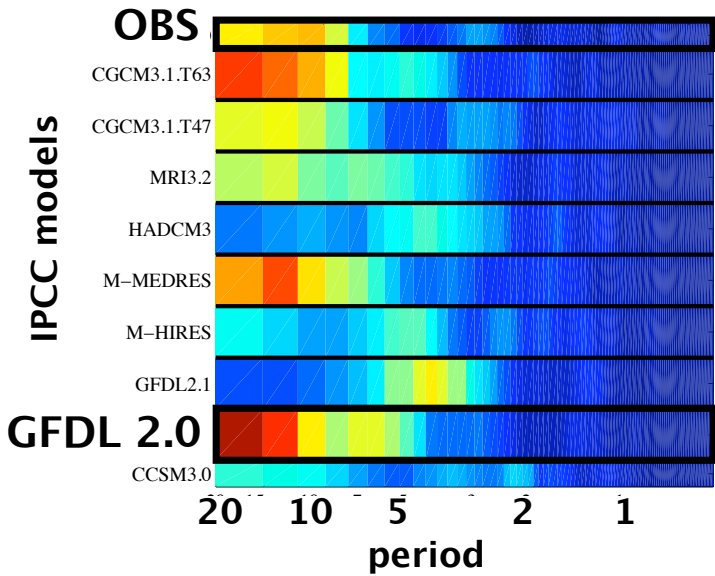


Power Spectra

**Modern
(1900-1999)**

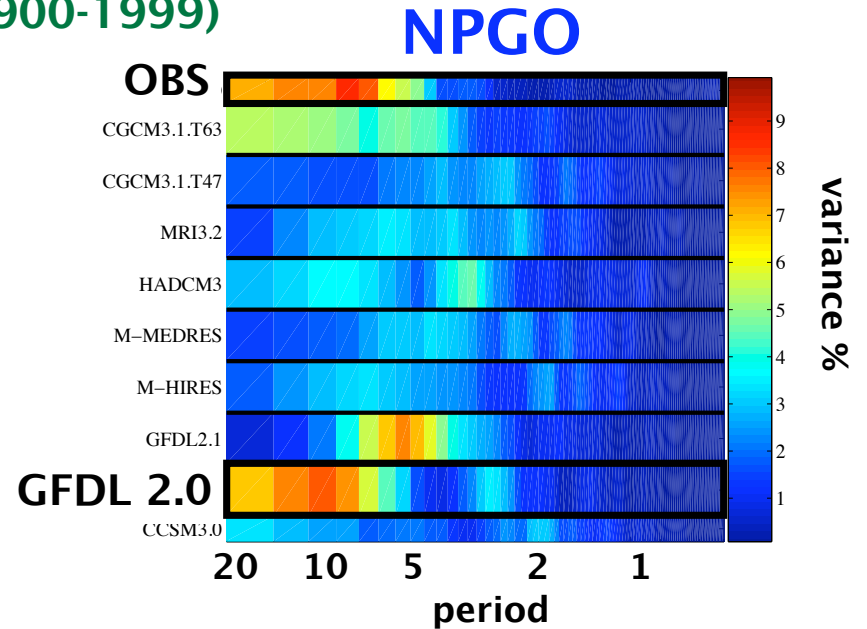
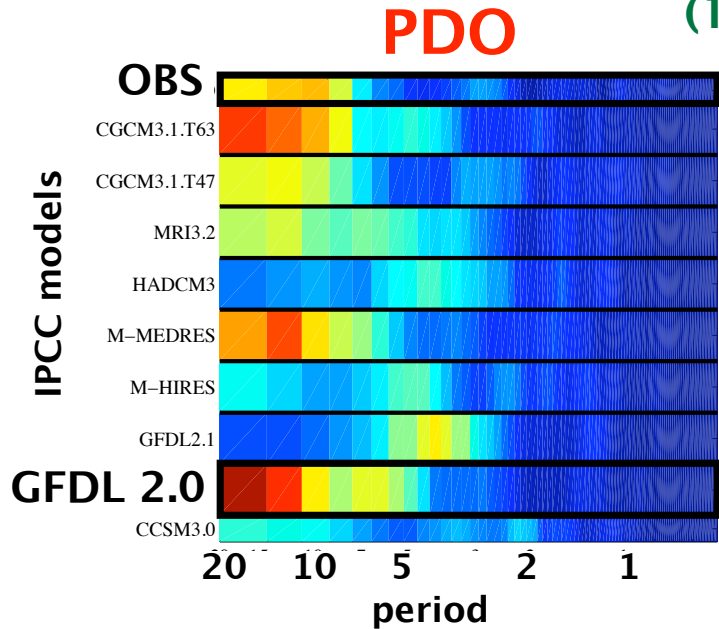
PDO

NPGO

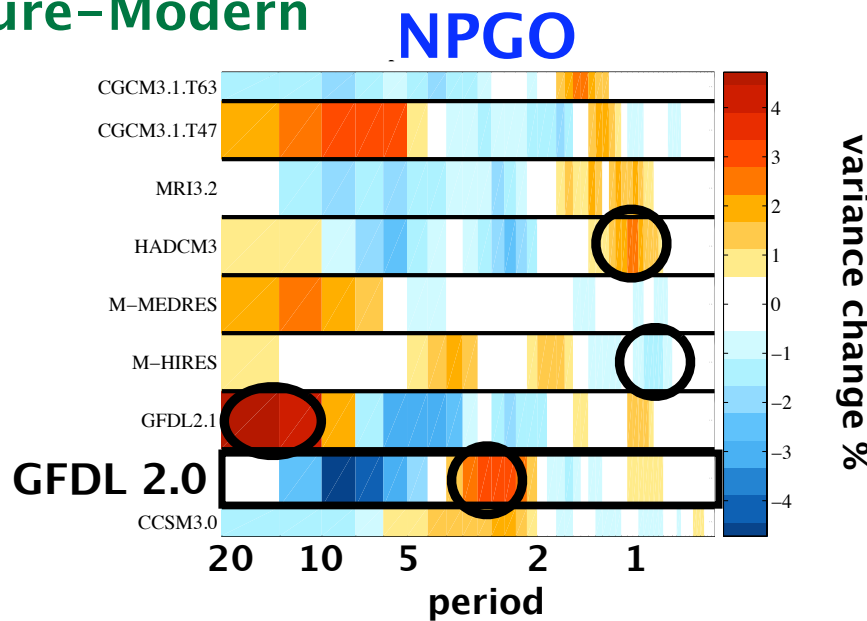
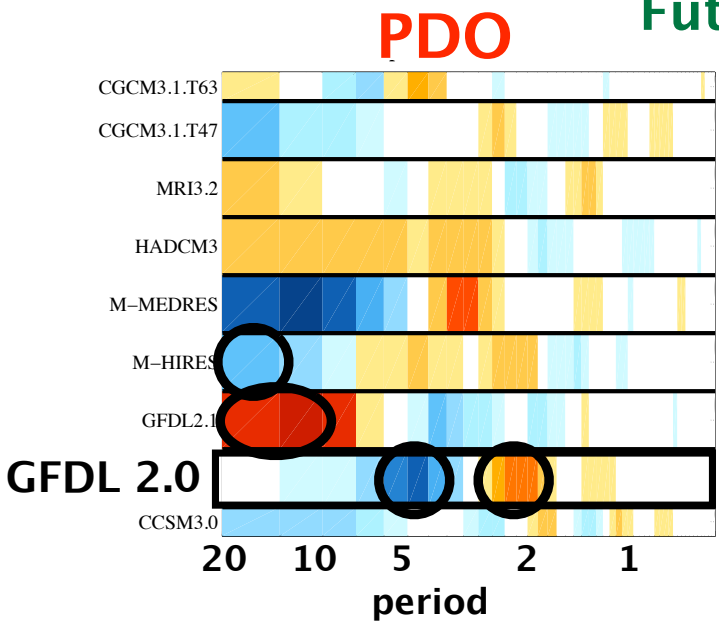


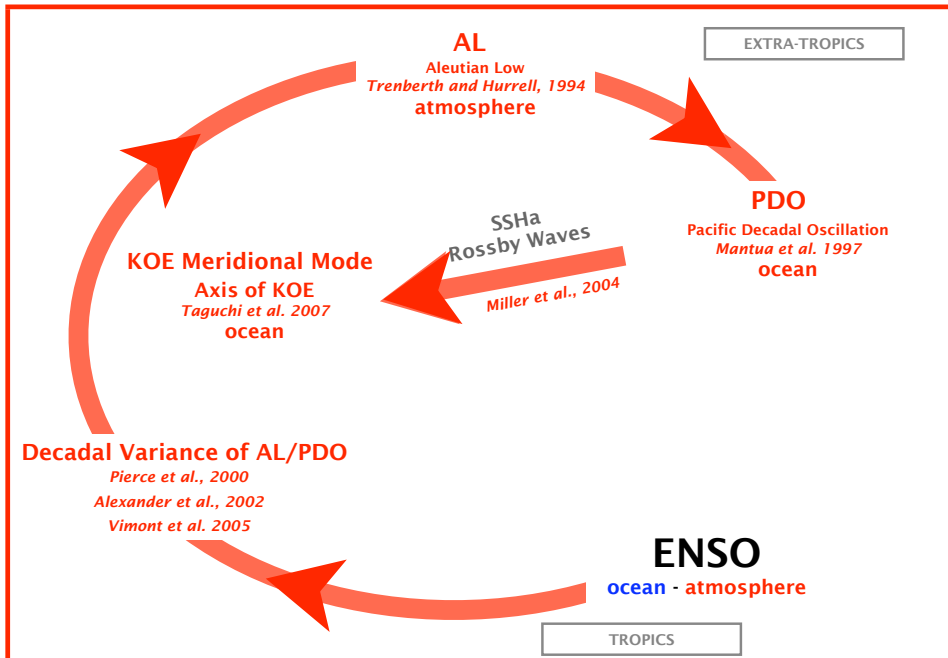
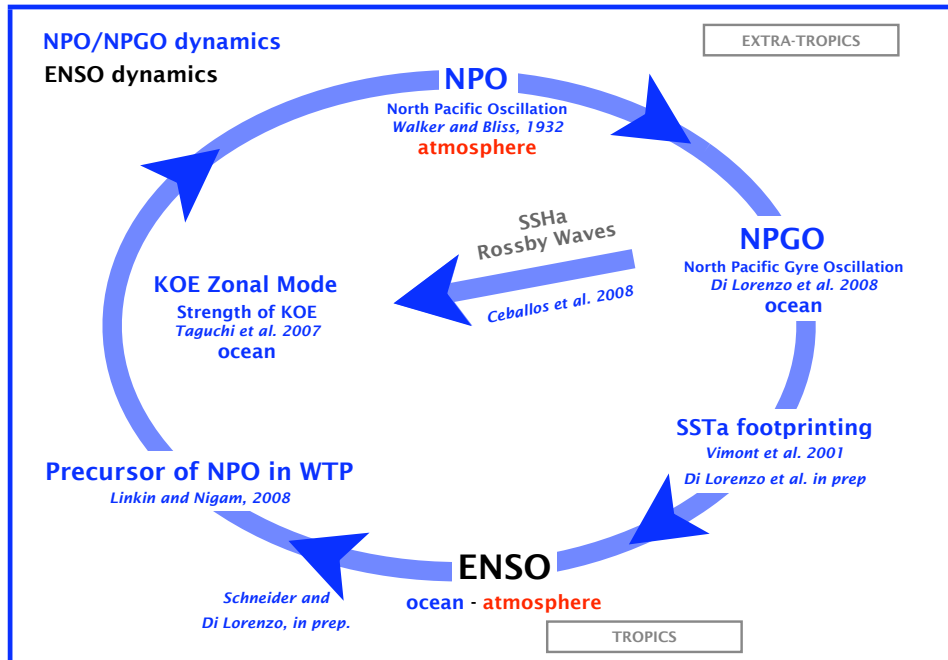
Power Spectra

**Modern
(1900-1999)**



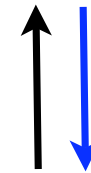
Future-Modern





A “conceptual framework” for Pacific Climate Variability

NPO/NPGO dynamics
Extra-Tropics



ENSO dynamics
Tropics



AL/PDO dynamics
Extra-Tropics