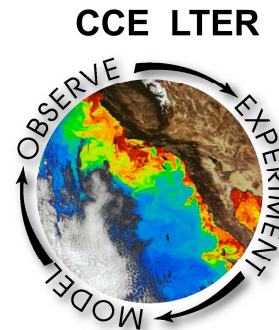


North Pacific Decadal Variability in the **FUTURE**

Di Lorenzo E.

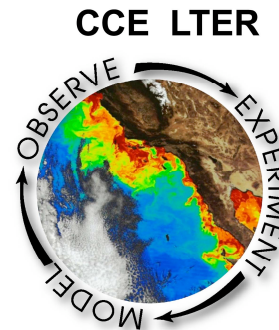
Collaborators: **Schneider** N., Furtado J., Bracco A.



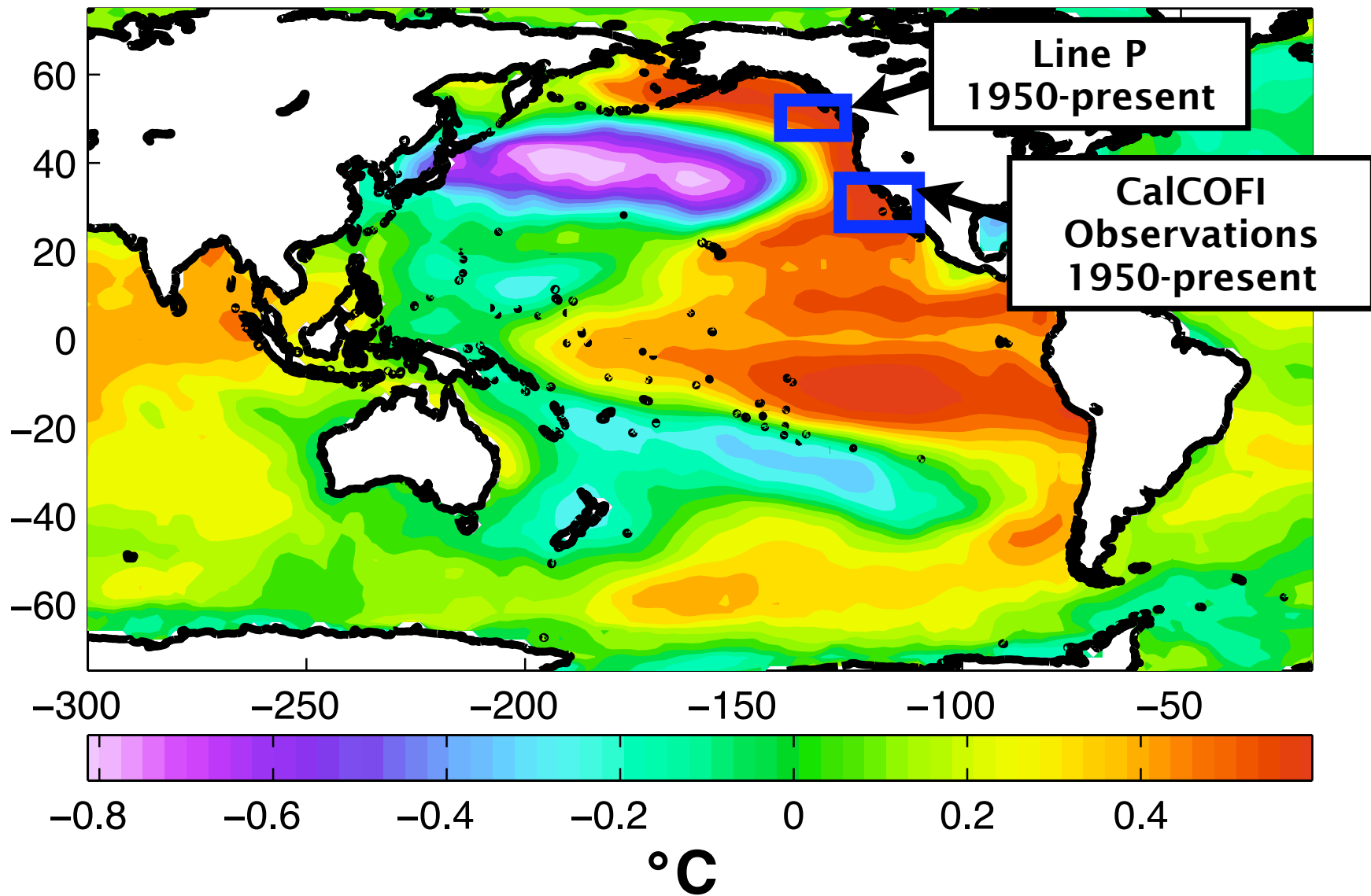
An improved conceptual framework for **Pacific Climate Variability**

Di Lorenzo E.

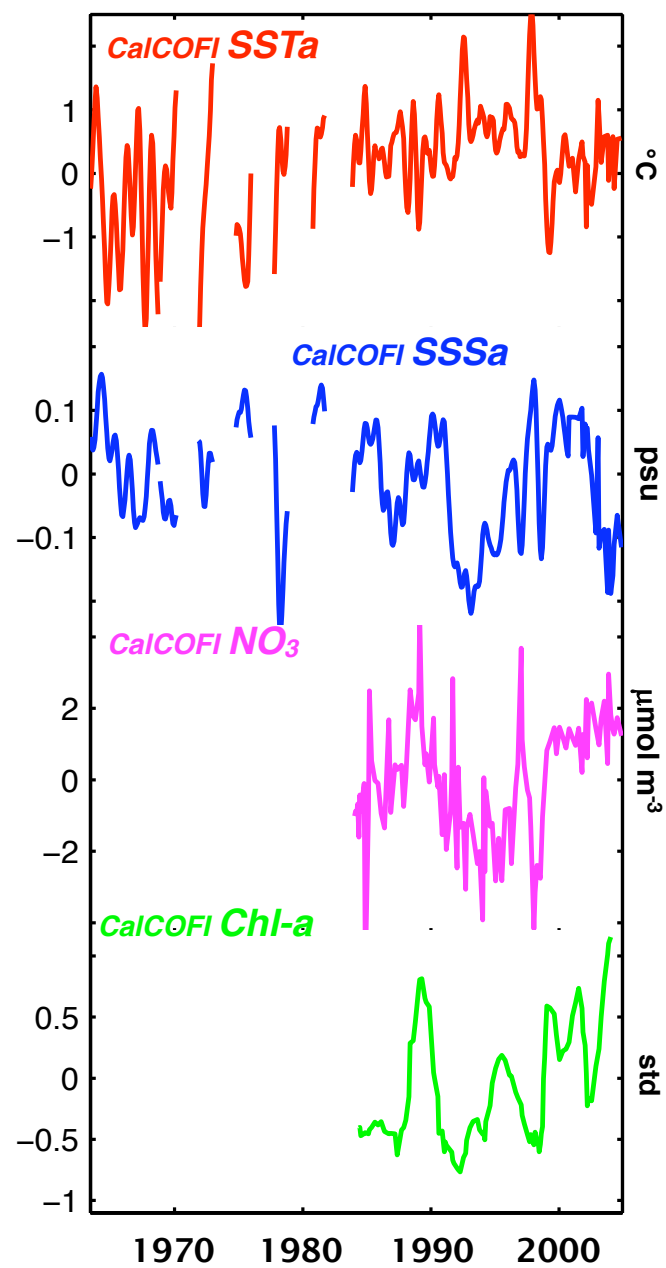
Collaborators: **Schneider** N., Furtado J., Bracco A.



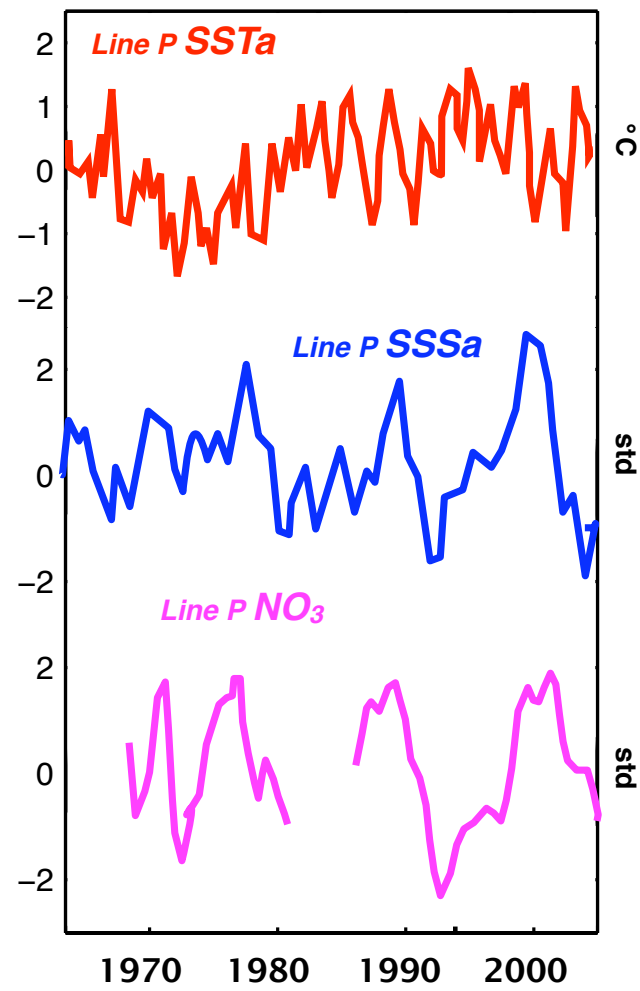
SSTa during Pacific Decadal Oscillation (PDO)



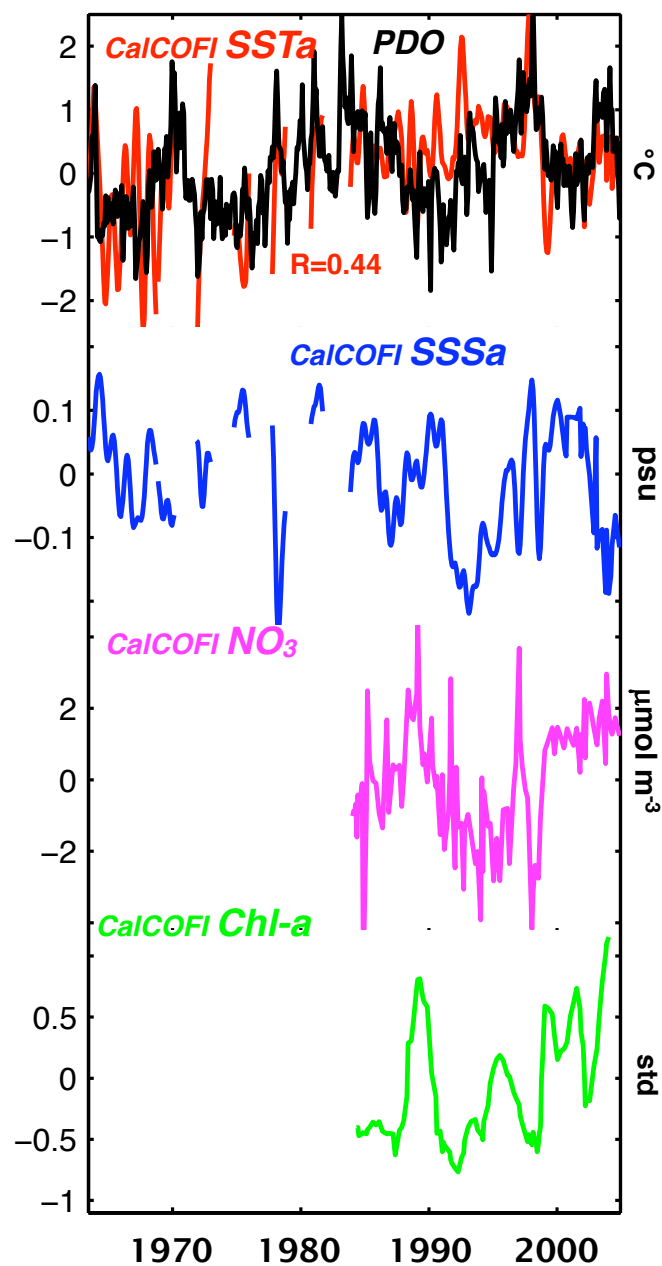
California Current - CalCOFI Observations



Gulf of Alaska - Line P Observations

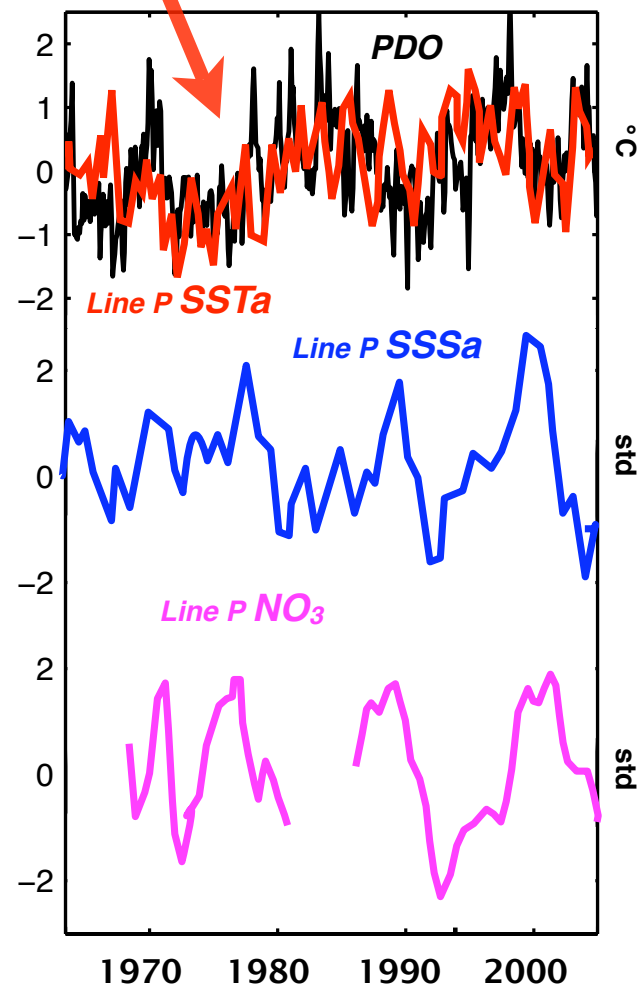


California Current - CalCOFI Observations

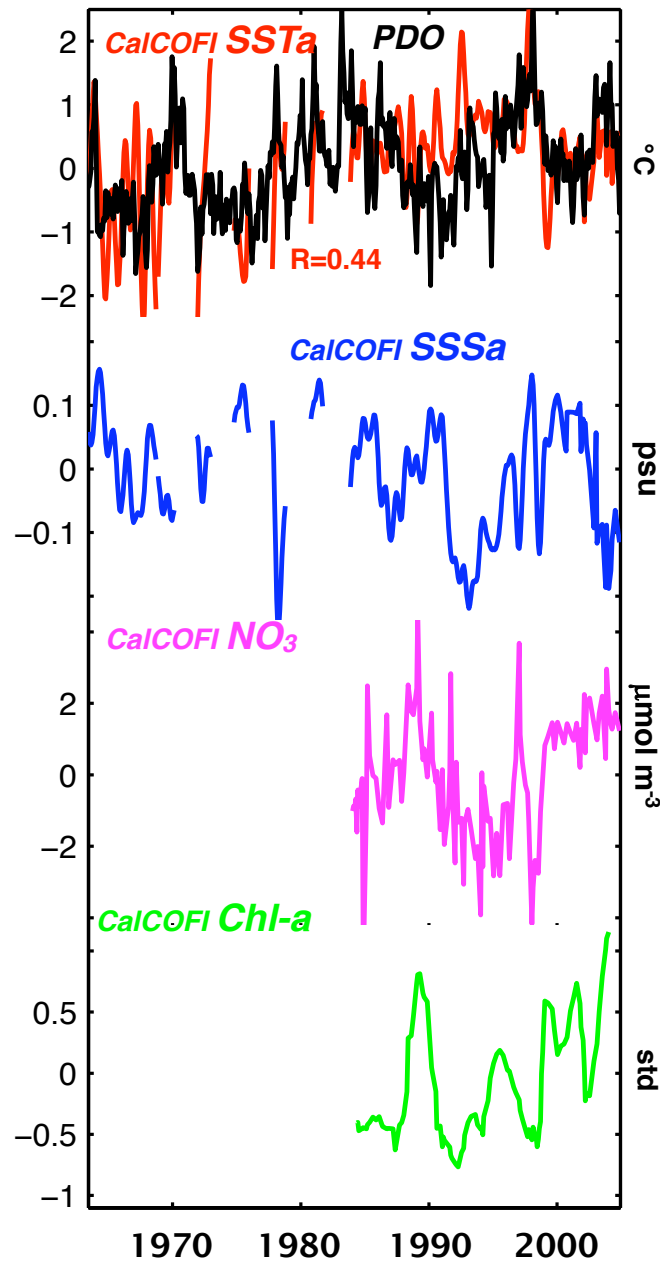


Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

Gulf of Alaska - Line P Observations



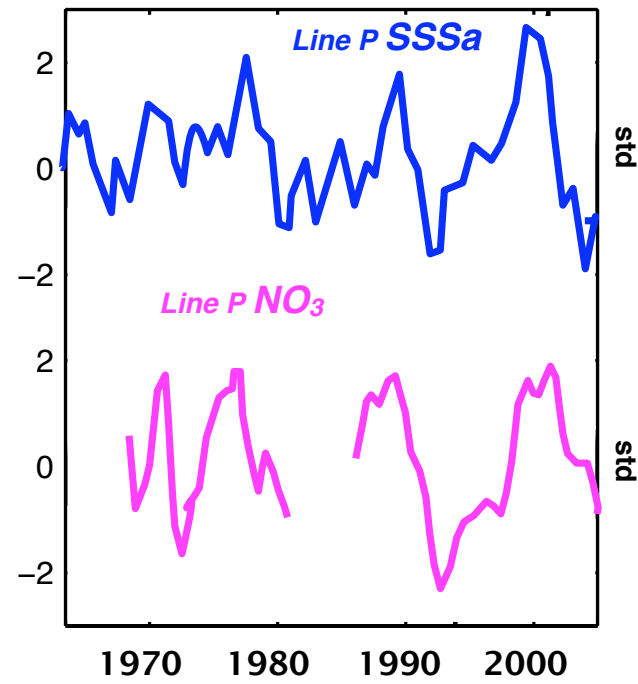
California Current - CalCOFI Observations



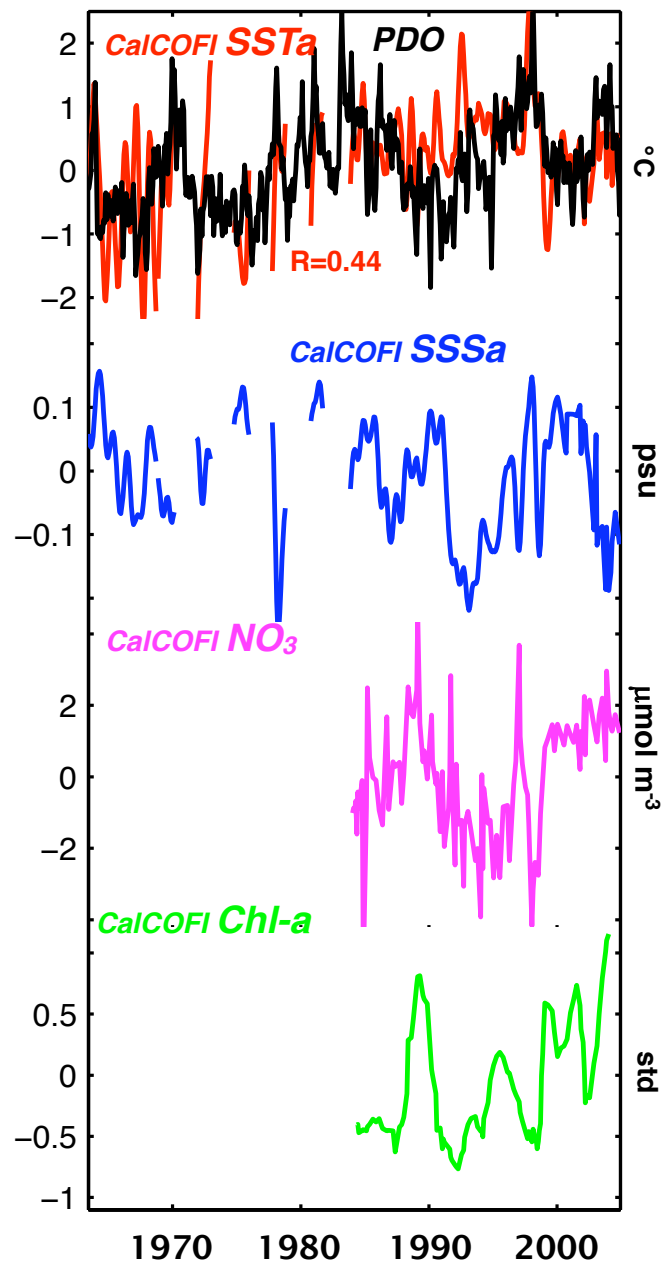
Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

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

Gulf of Alaska - Line P Observations



California Current - CalCOFI Observations

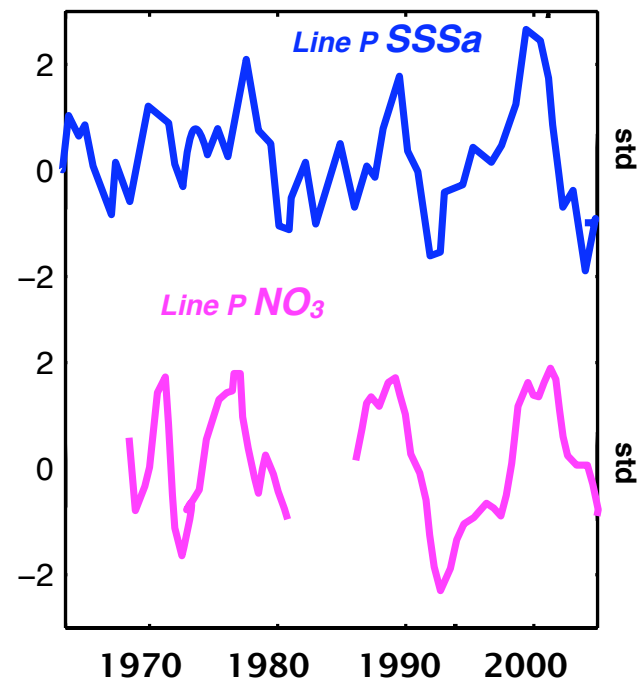


Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

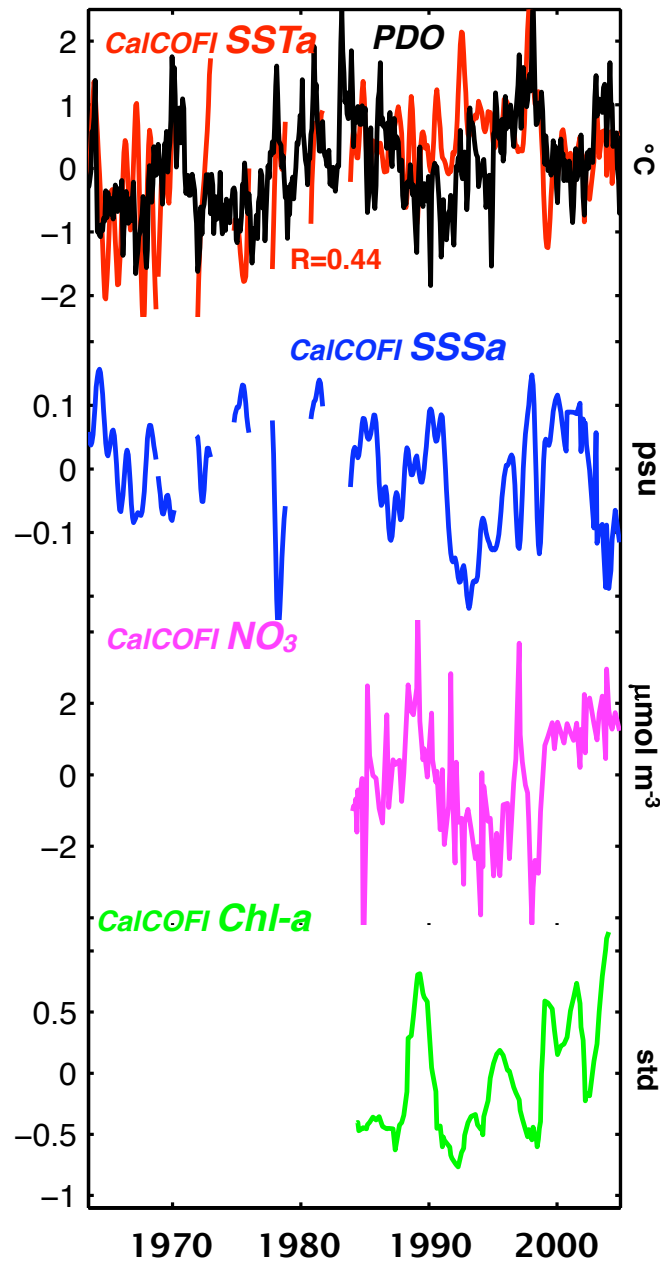
strengthening and weakening of the
sub-tropical and sub-polar gyres

EOF2 SSHa

Gulf of Alaska - Line P Observations



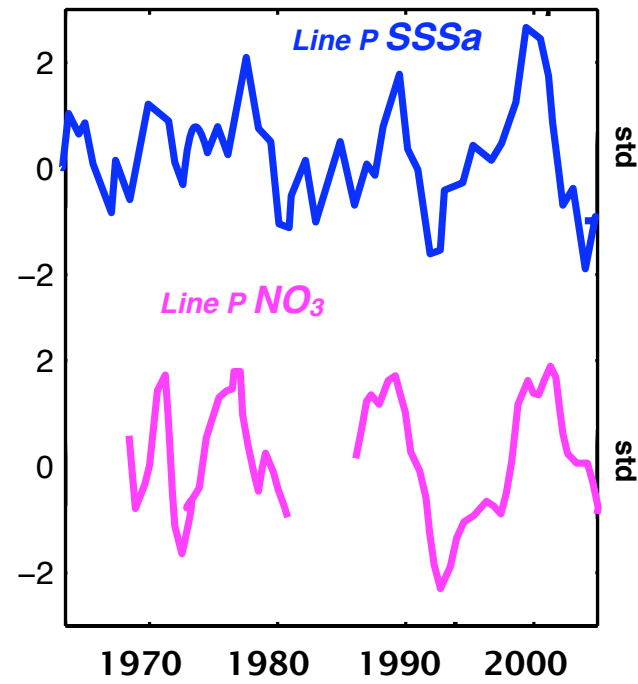
California Current - CalCOFI Observations



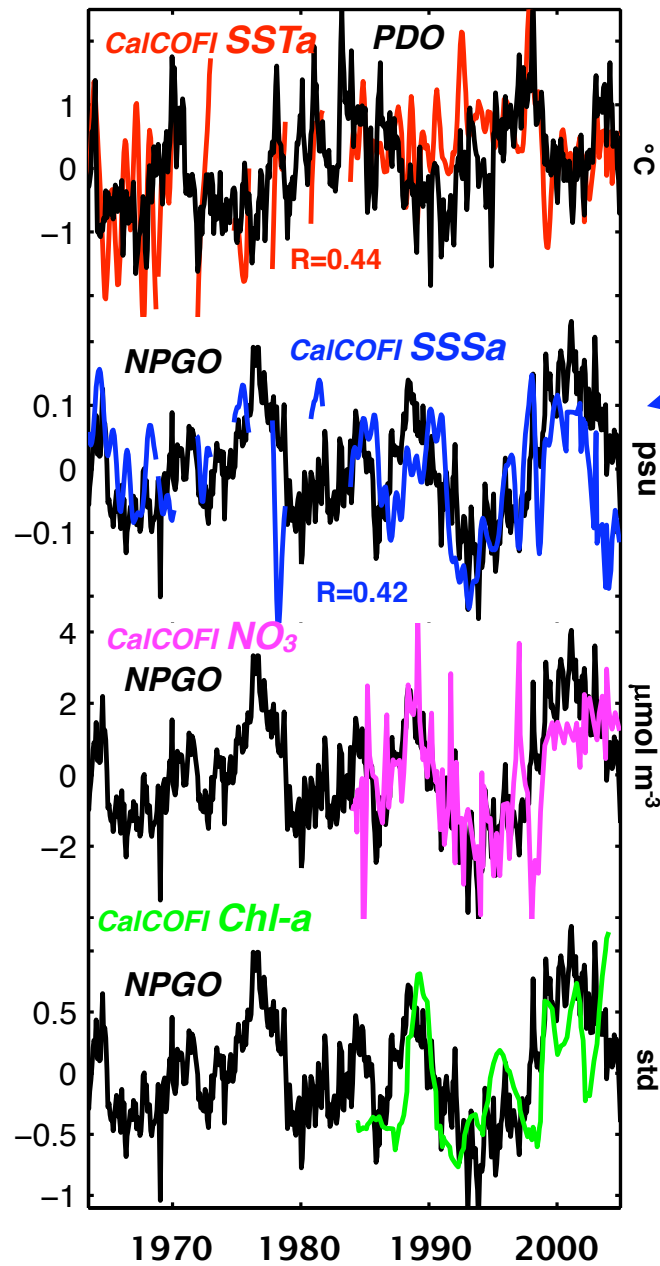
Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

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

Gulf of Alaska - Line P Observations



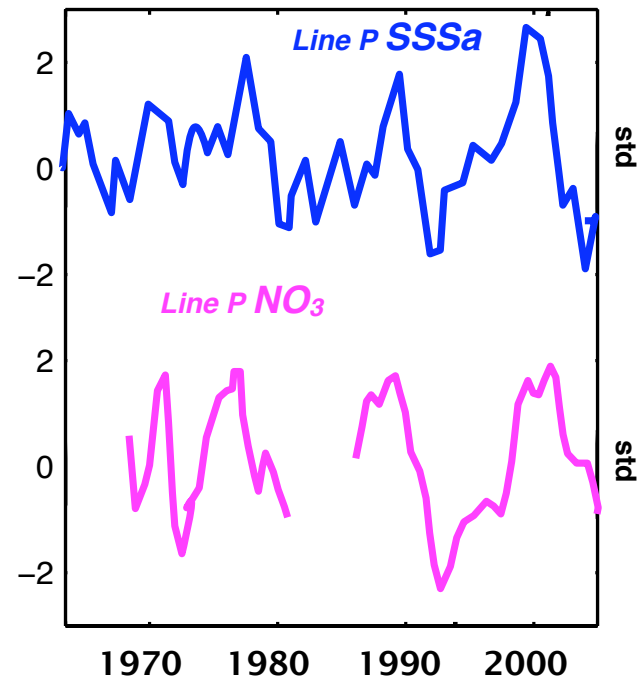
California Current - CalCOFI Observations



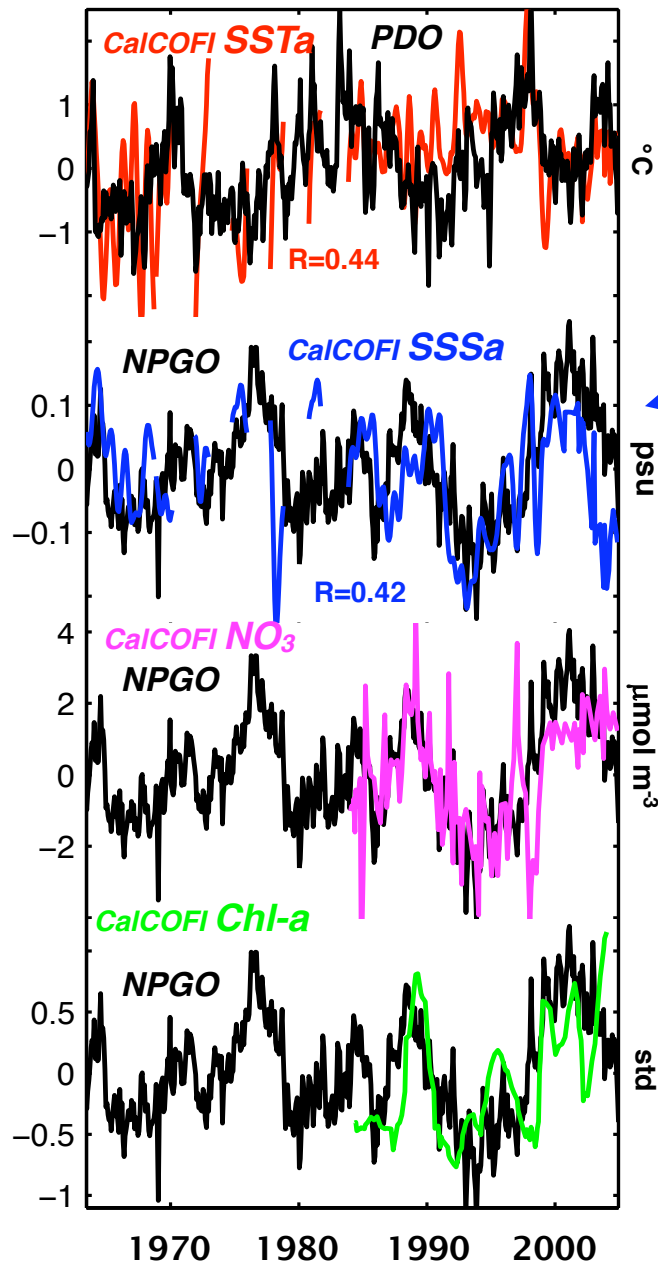
Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

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

Gulf of Alaska - Line P Observations



California Current - CalCOFI Observations

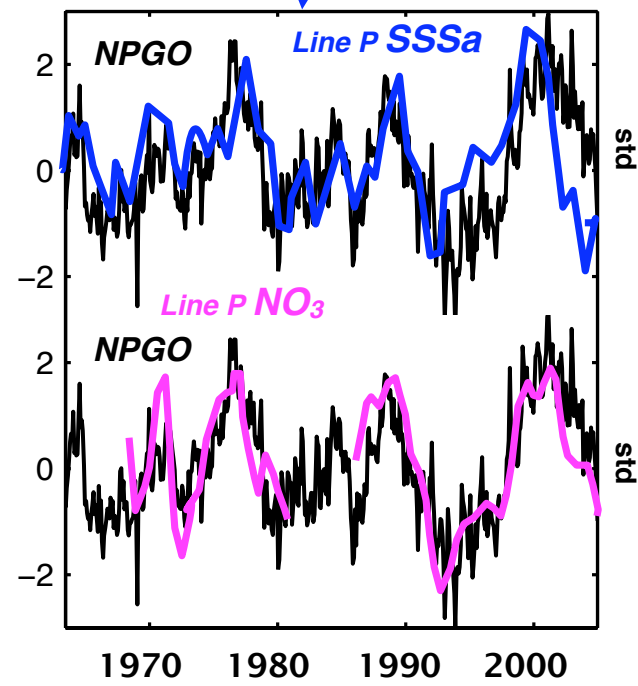


Pacific Decadal Oscillation (PDO)
(Mantua et al., 1997)
EOF1 SSTa

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)**

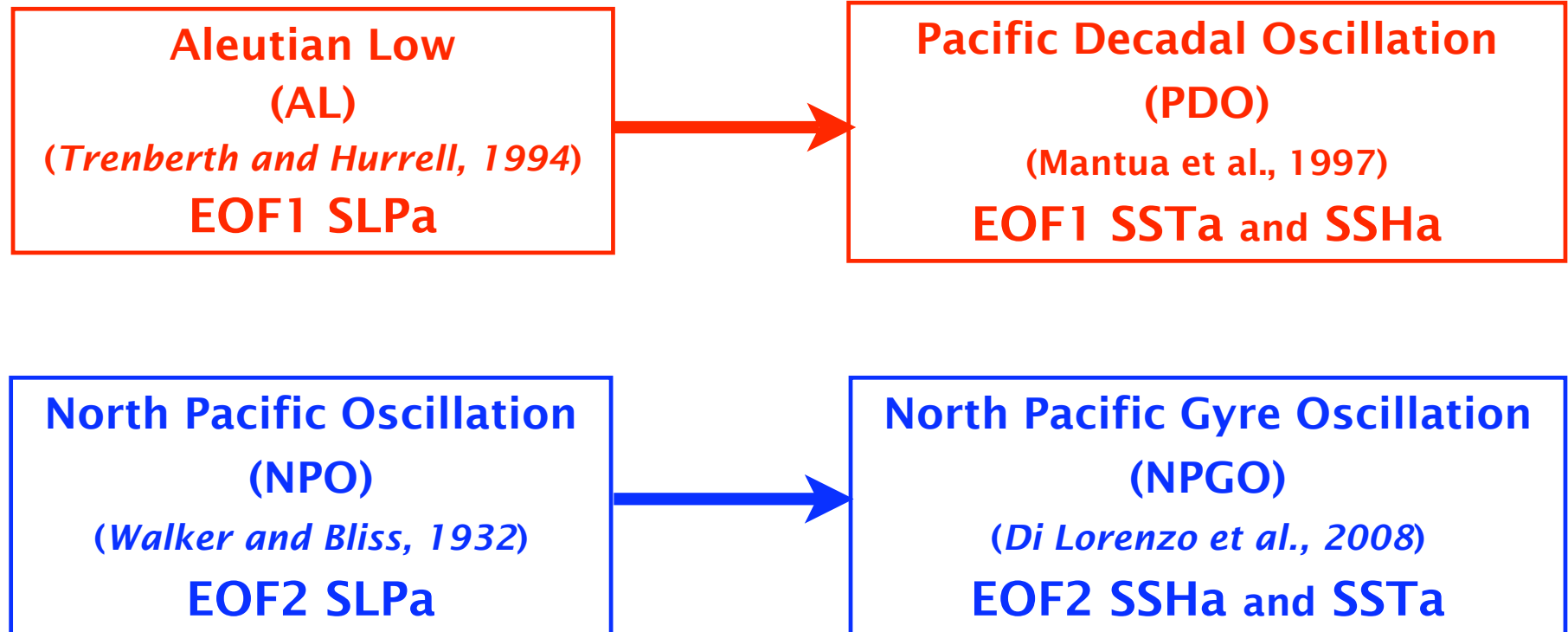
(Di Lorenzo et al., 2008)

EOF2 SSHa and SSTa



Atmosphere

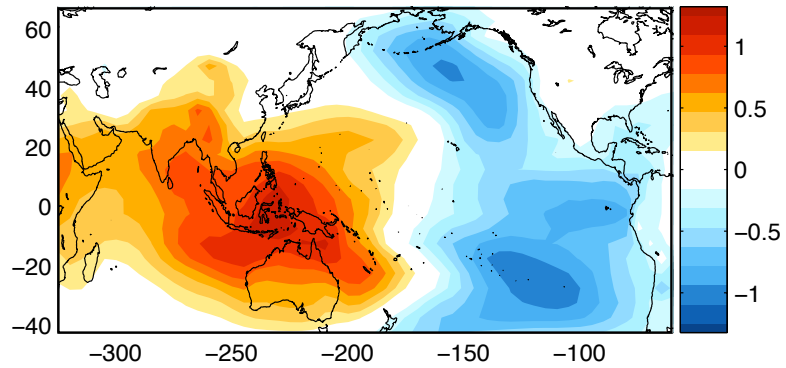
Ocean



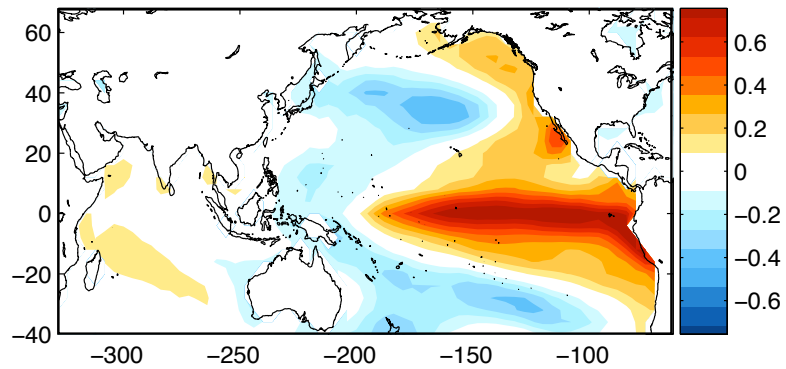
Connection to the tropics and ENSO?

Combined EOF
SLPa/SSTa
over the Pacific Ocean

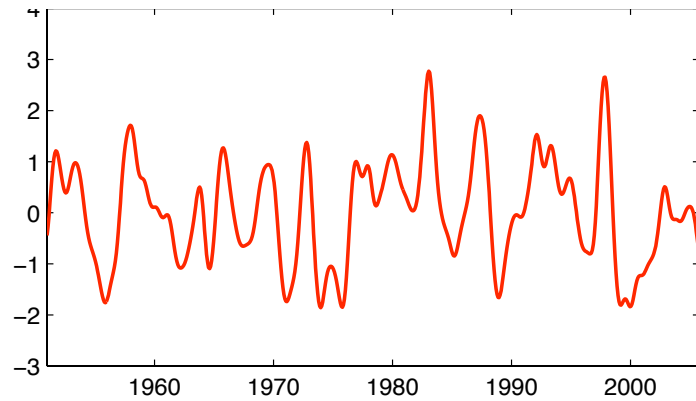
SLPa combined EOF 1



SSTa combined EOF 1

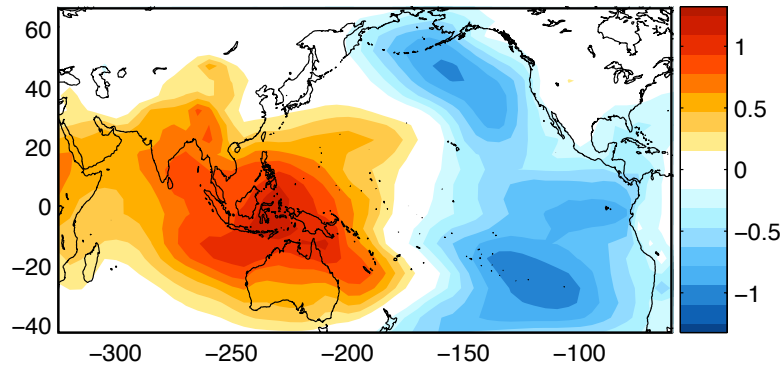


PC 1

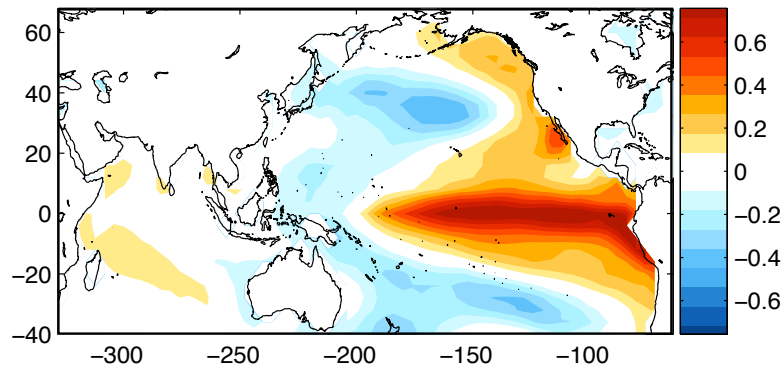


Combined EOF 1 SLPa/SSTa

SLPa combined EOF 1

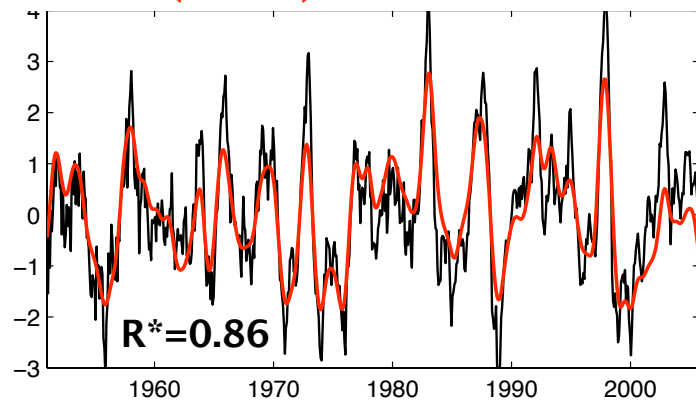


SSTa combined EOF 1



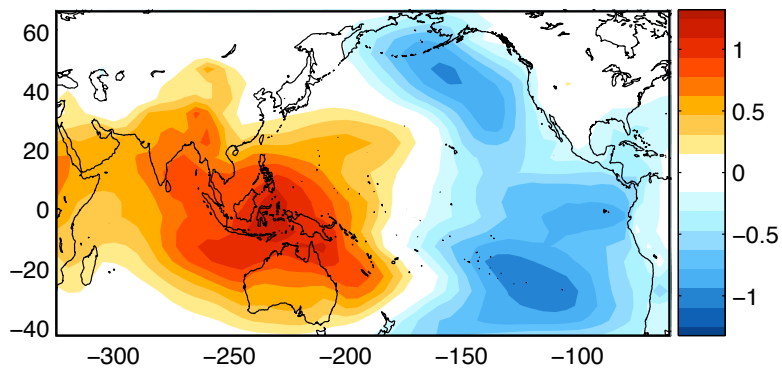
PC 1 (ENSO)

NINO 3.4 index

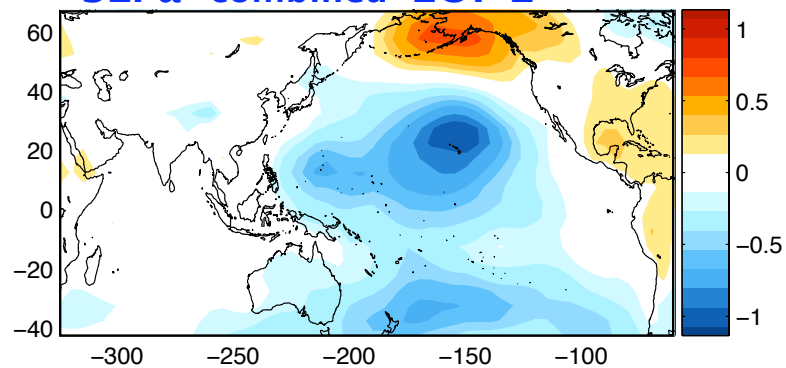


Combined EOF 1 SLPa/SSTa

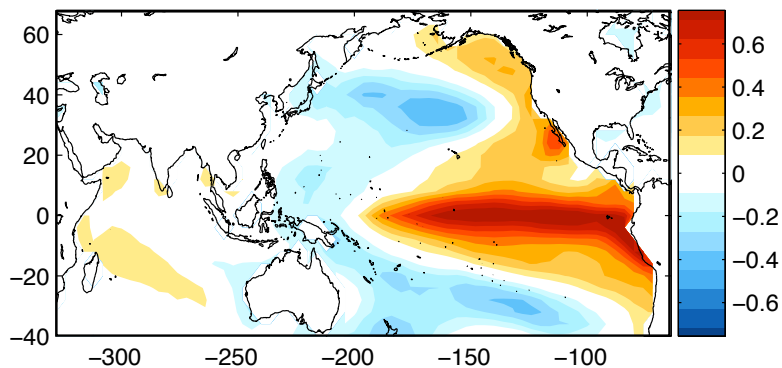
SLPa combined EOF 1



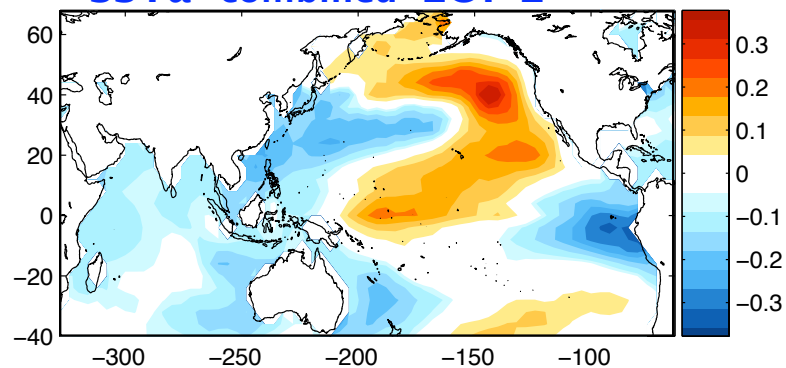
SLPa combined EOF 2



SSTa combined EOF 1

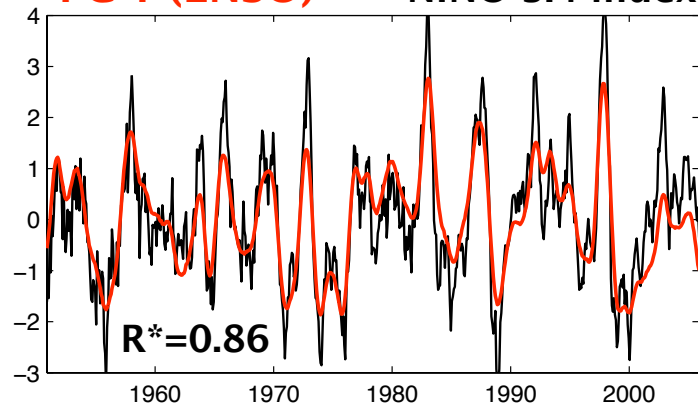


SSTa combined EOF 2

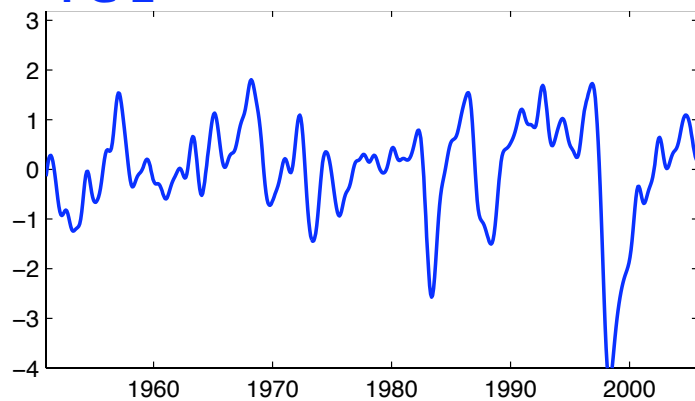


PC 1 (ENSO)

NINO 3.4 index

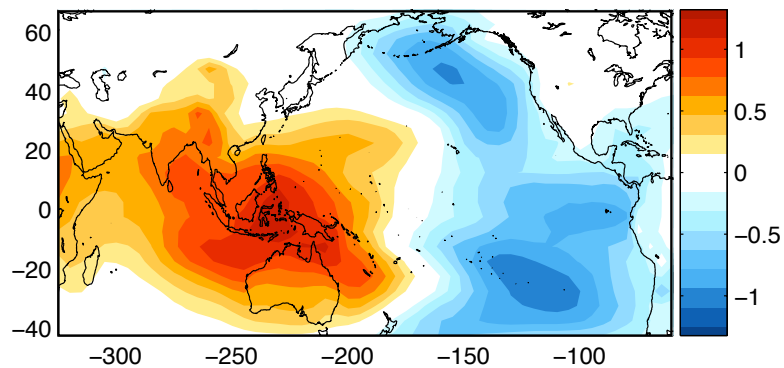


PC 2

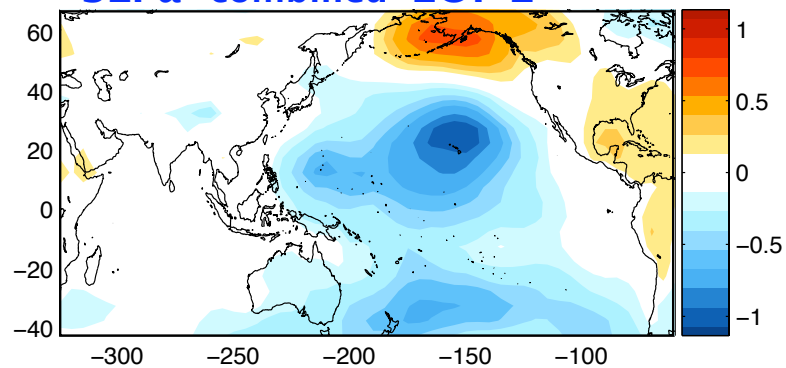


Di Lorenzo et al., in prep.

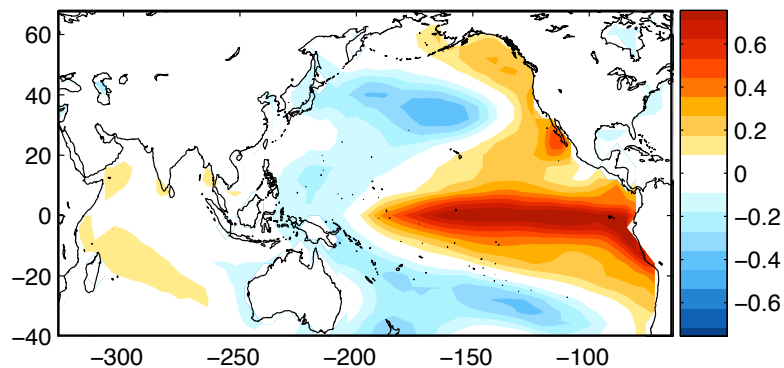
SLPa combined EOF 1



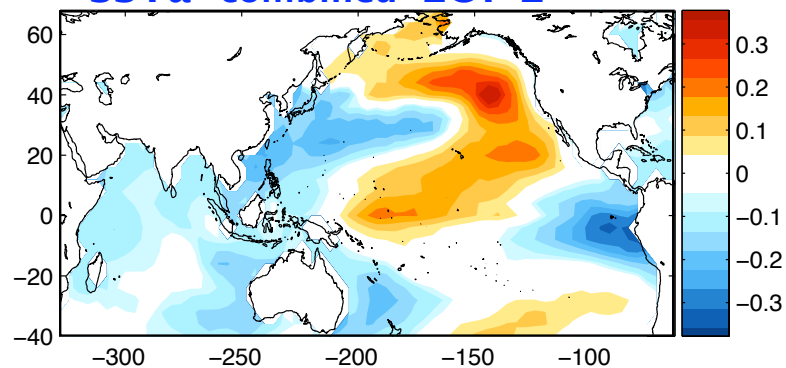
SLPa combined EOF 2



SSTa combined EOF 1

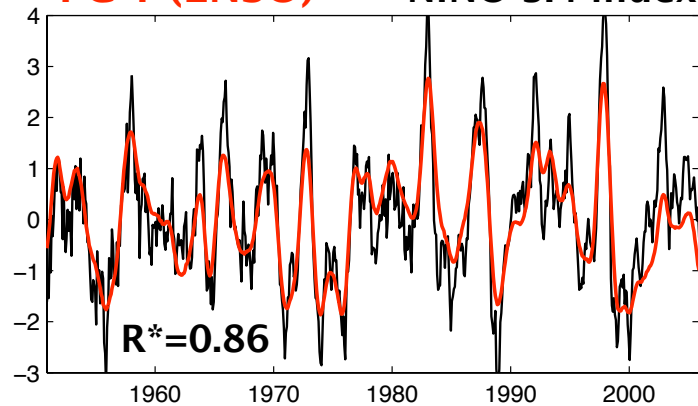


SSTa combined EOF 2



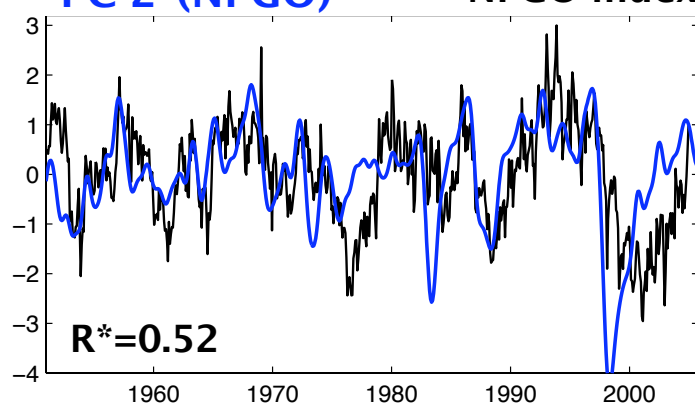
PC 1 (ENSO)

NINO 3.4 index



PC 2 (NPGO)

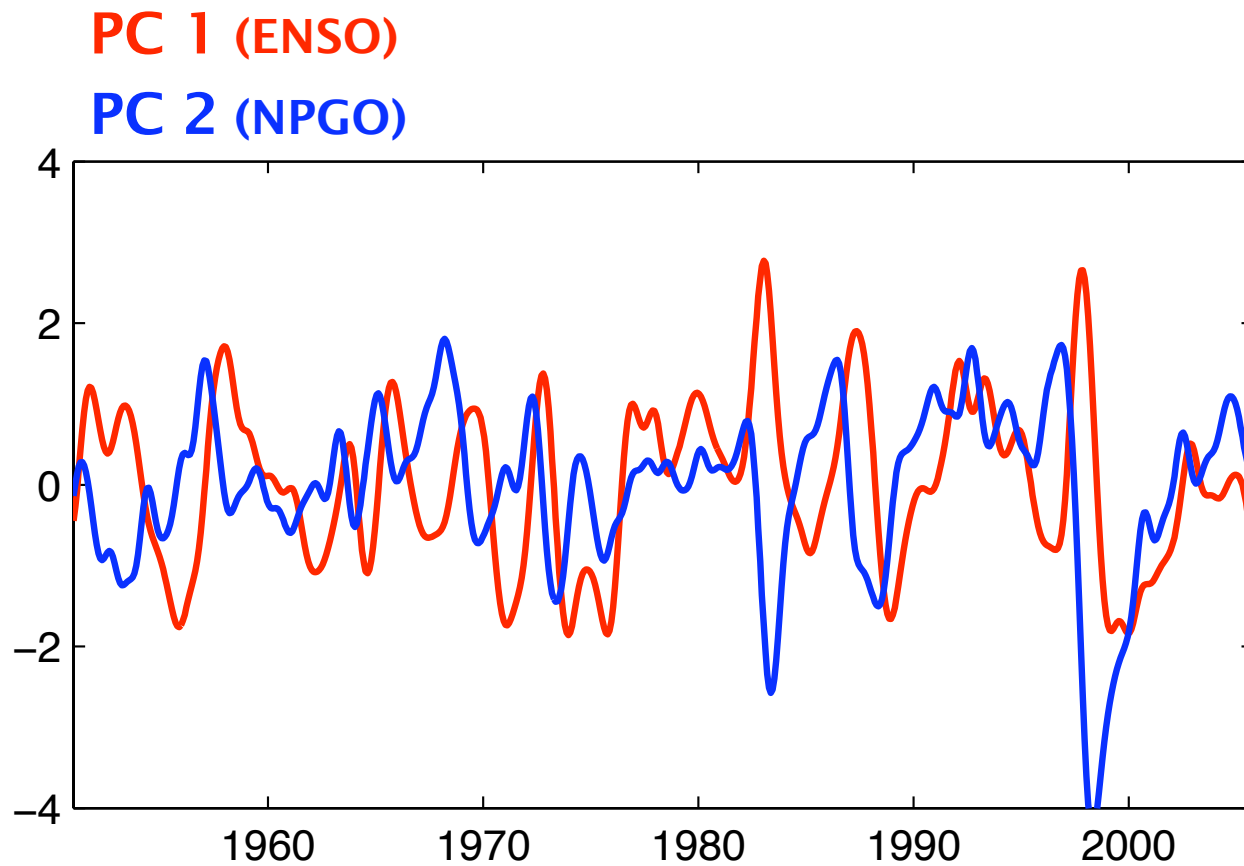
NPGO index



Di Lorenzo et al., in prep.

QUESTION:

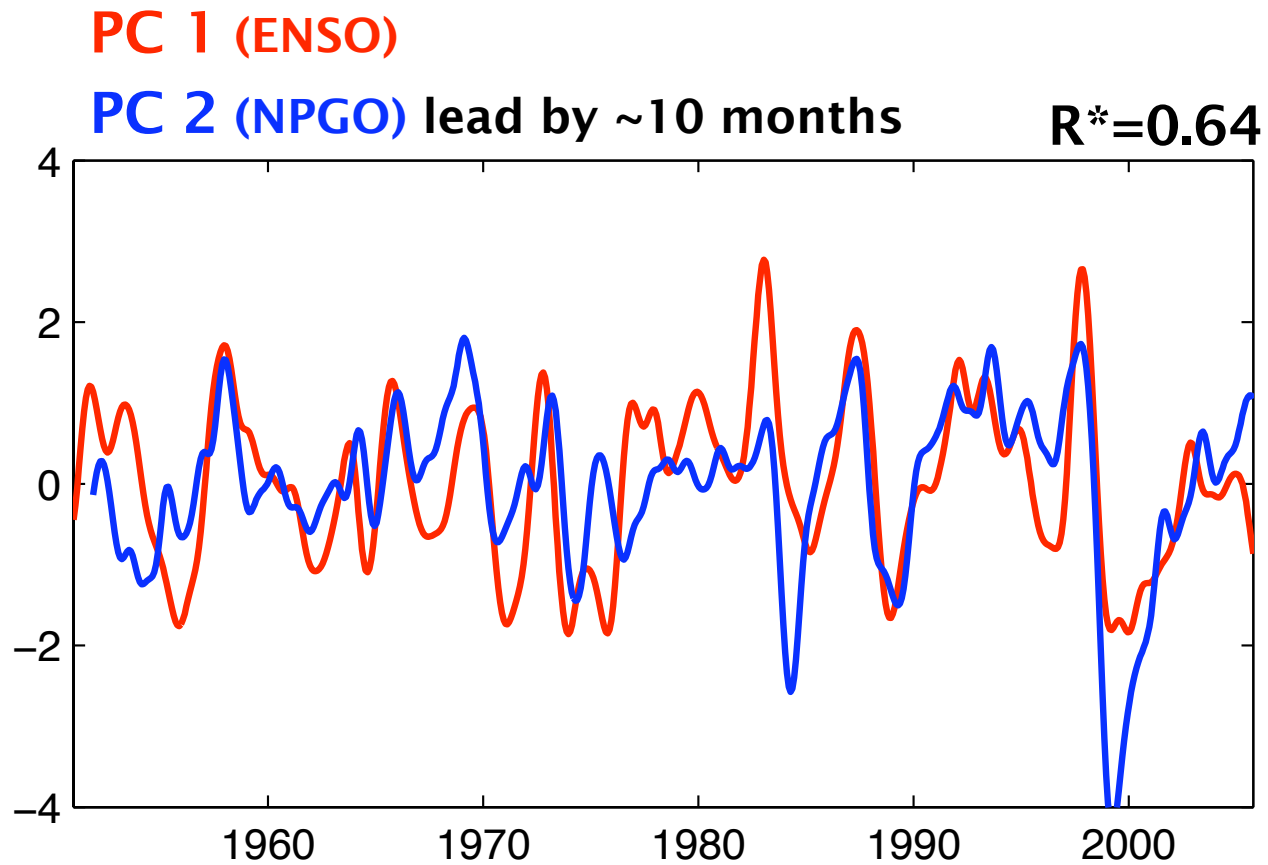
Is there a relationship between **ENSO** and **NPGO** mode?



Di Lorenzo et al., in prep.

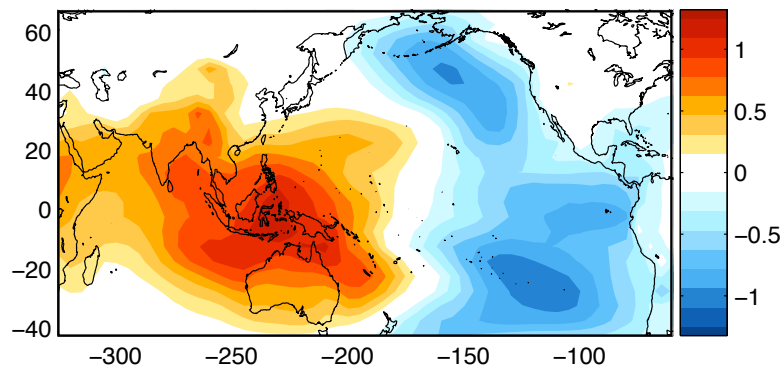
QUESTION:

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

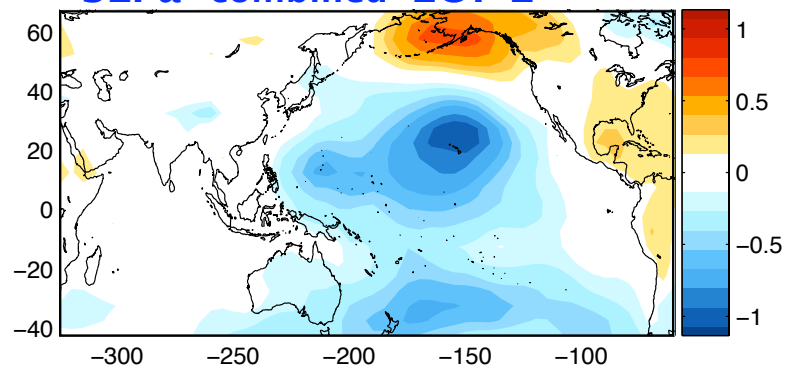


Di Lorenzo et al., in prep.

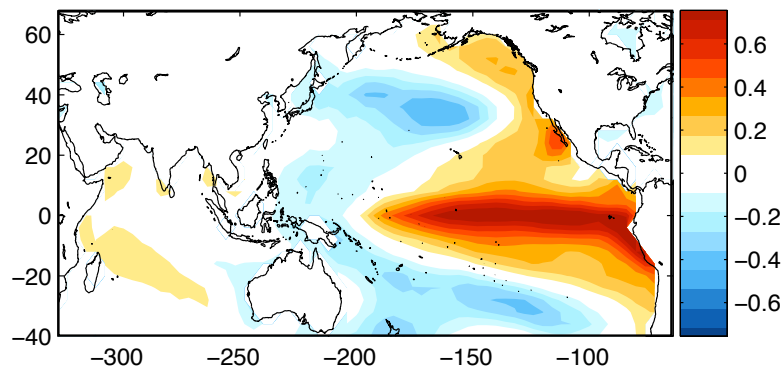
SLPa combined EOF 1



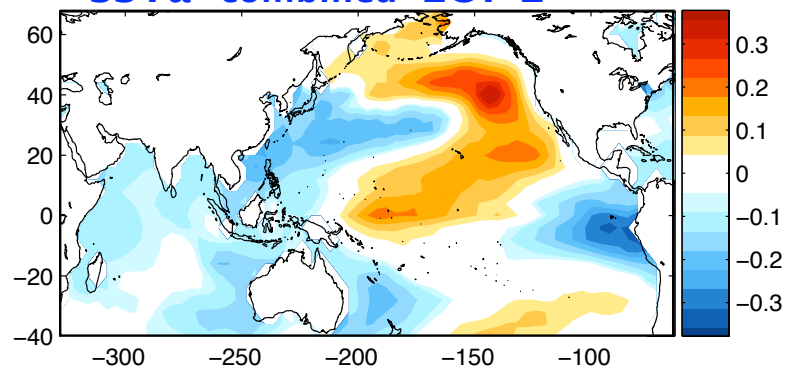
SLPa combined EOF 2



SSTa combined EOF 1

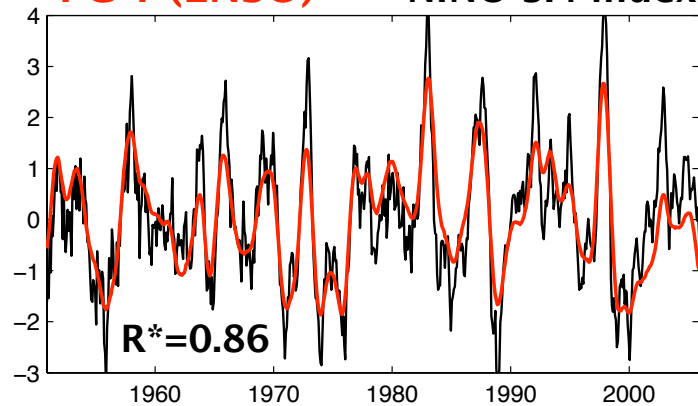


SSTa combined EOF 2



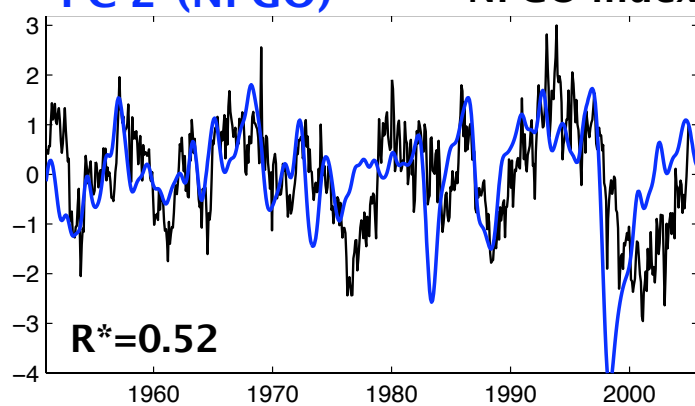
PC 1 (ENSO)

NINO 3.4 index



PC 2 (NPGO)

NPGO index

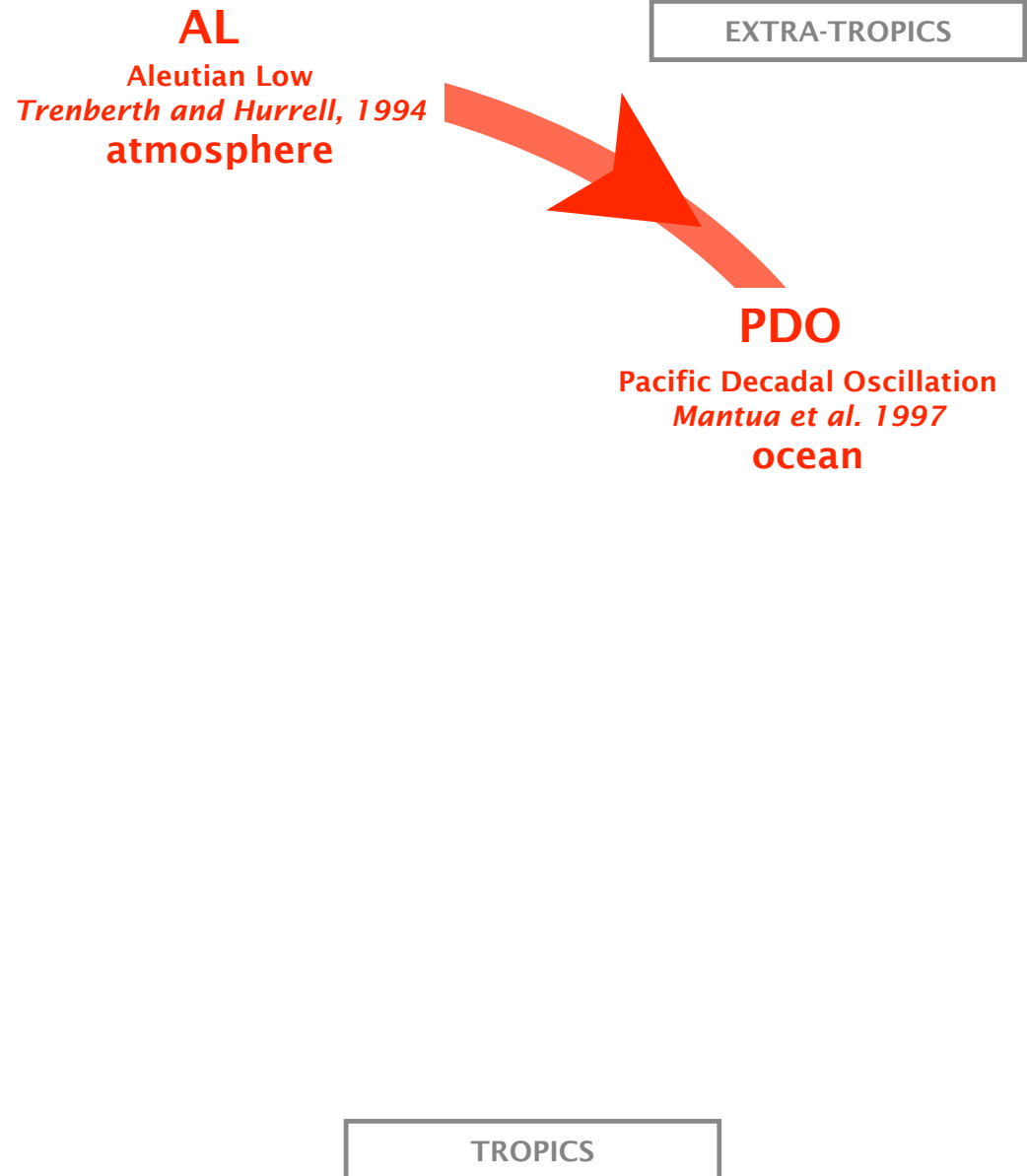


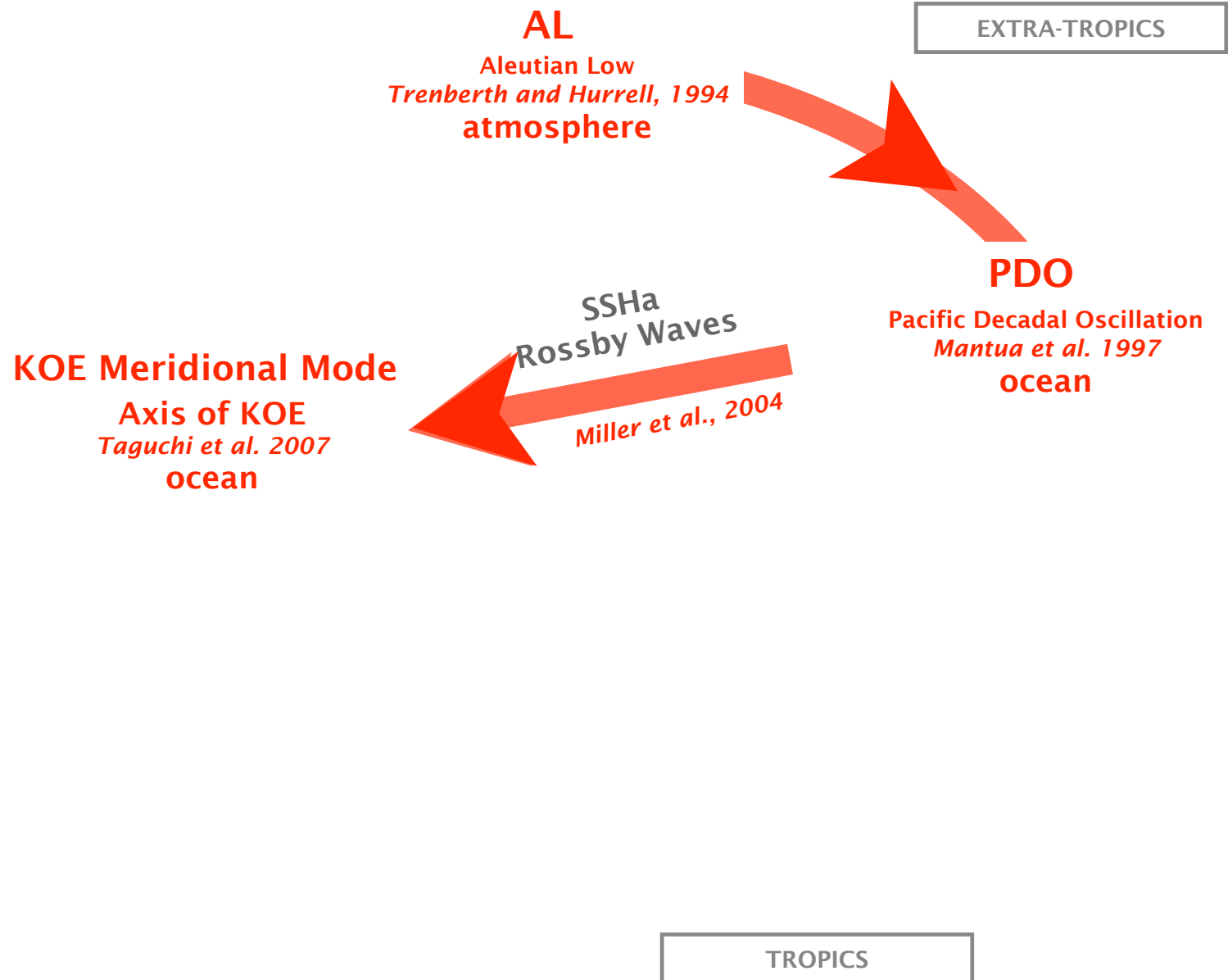
Di Lorenzo et al., in prep.

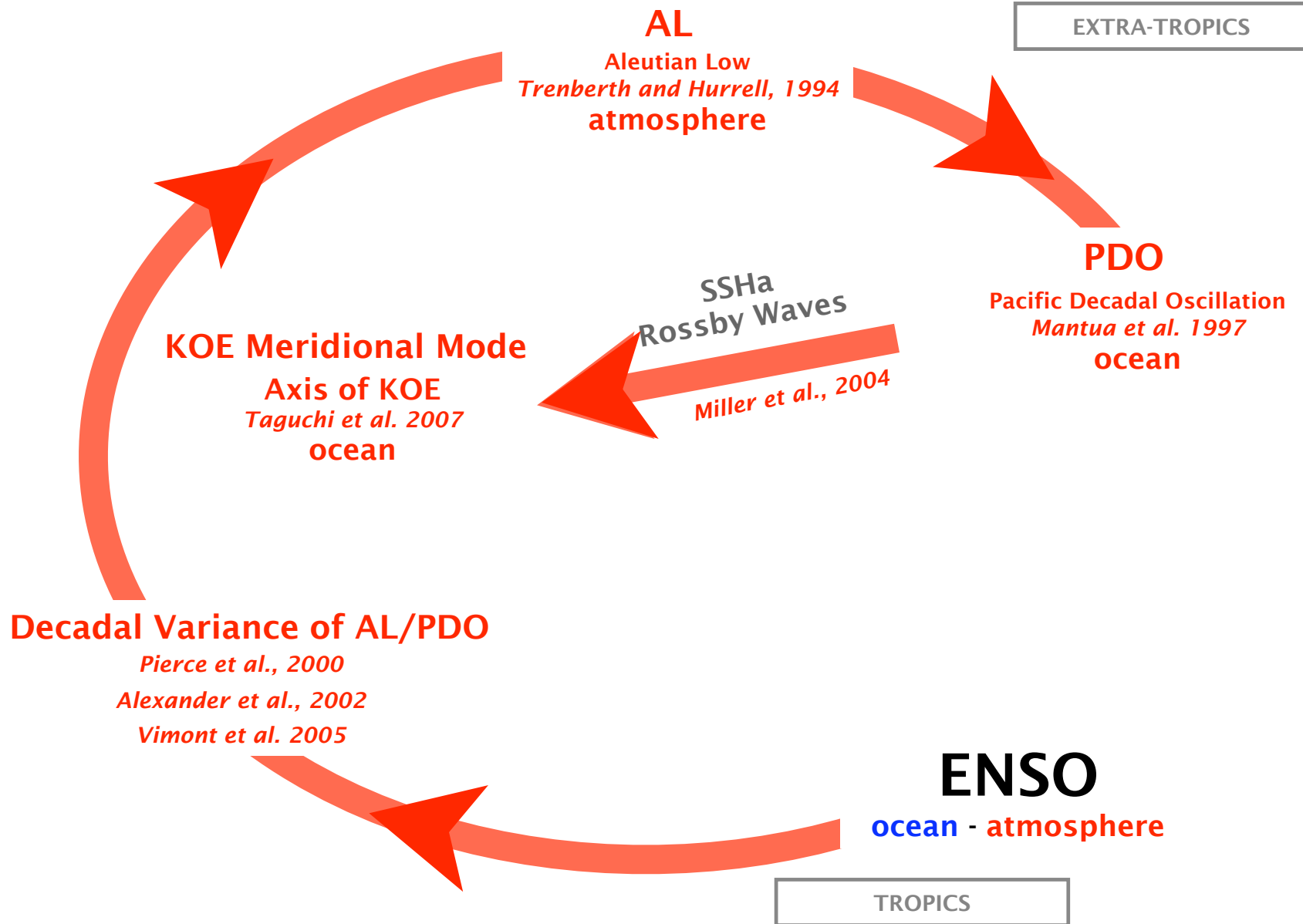
EXTRA-TROPICS

PDO
Pacific Decadal Oscillation
Mantua et al. 1997
ocean

TROPICS







NPO/NPGO dynamics

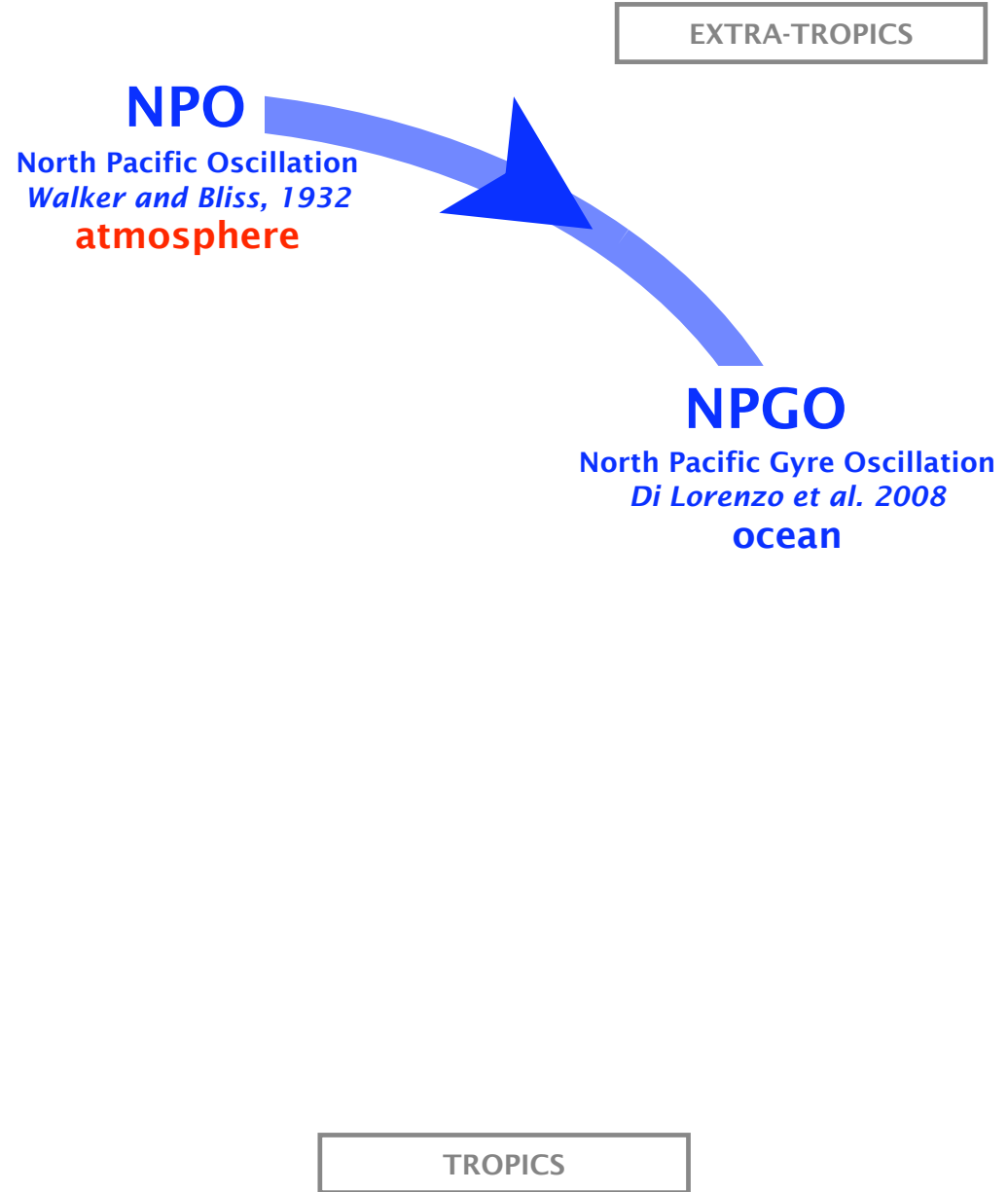
EXTRA-TROPICS

NPGO

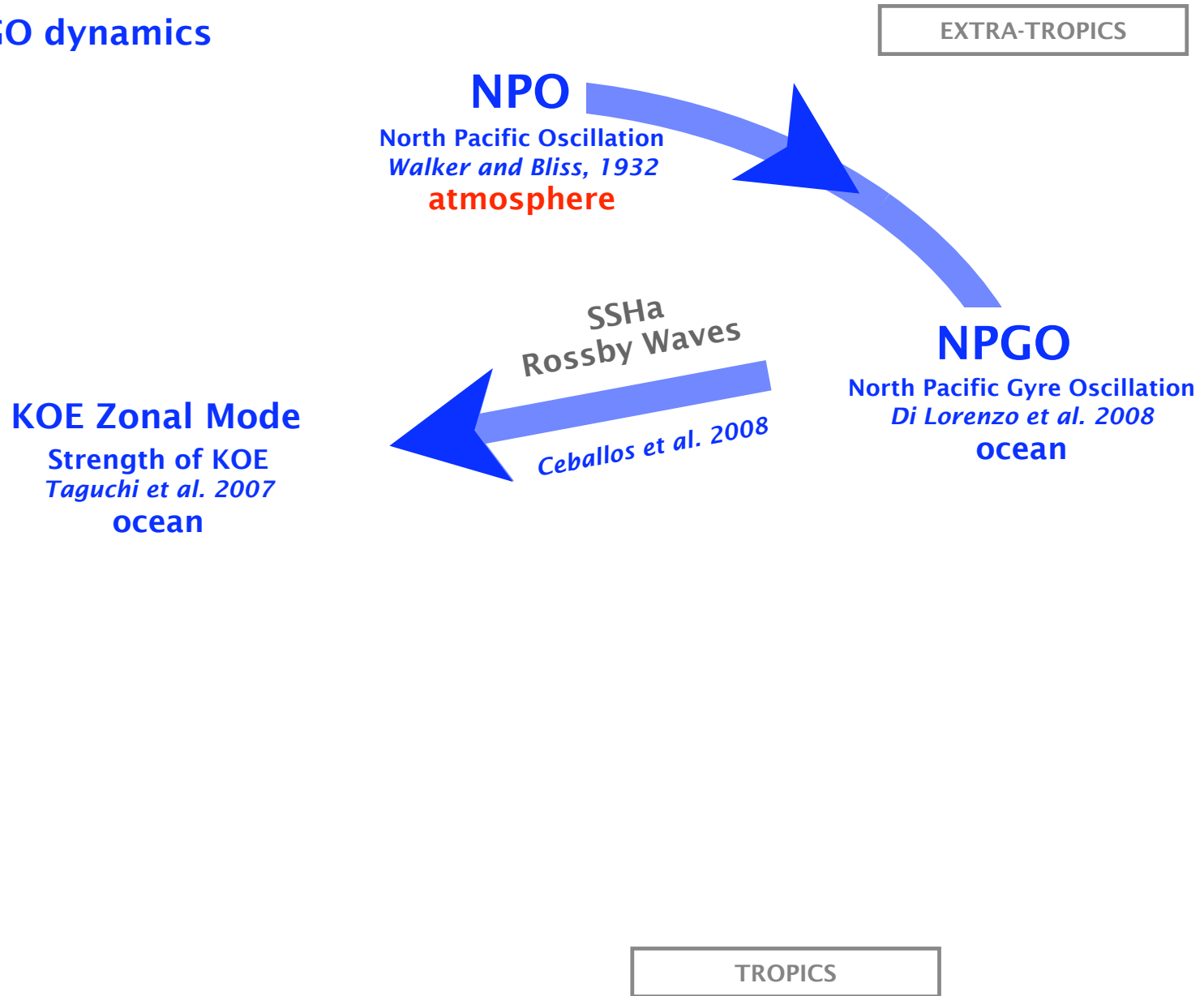
North Pacific Gyre Oscillation
Di Lorenzo et al. 2008
ocean

TROPICS

NPO/NPGO dynamics



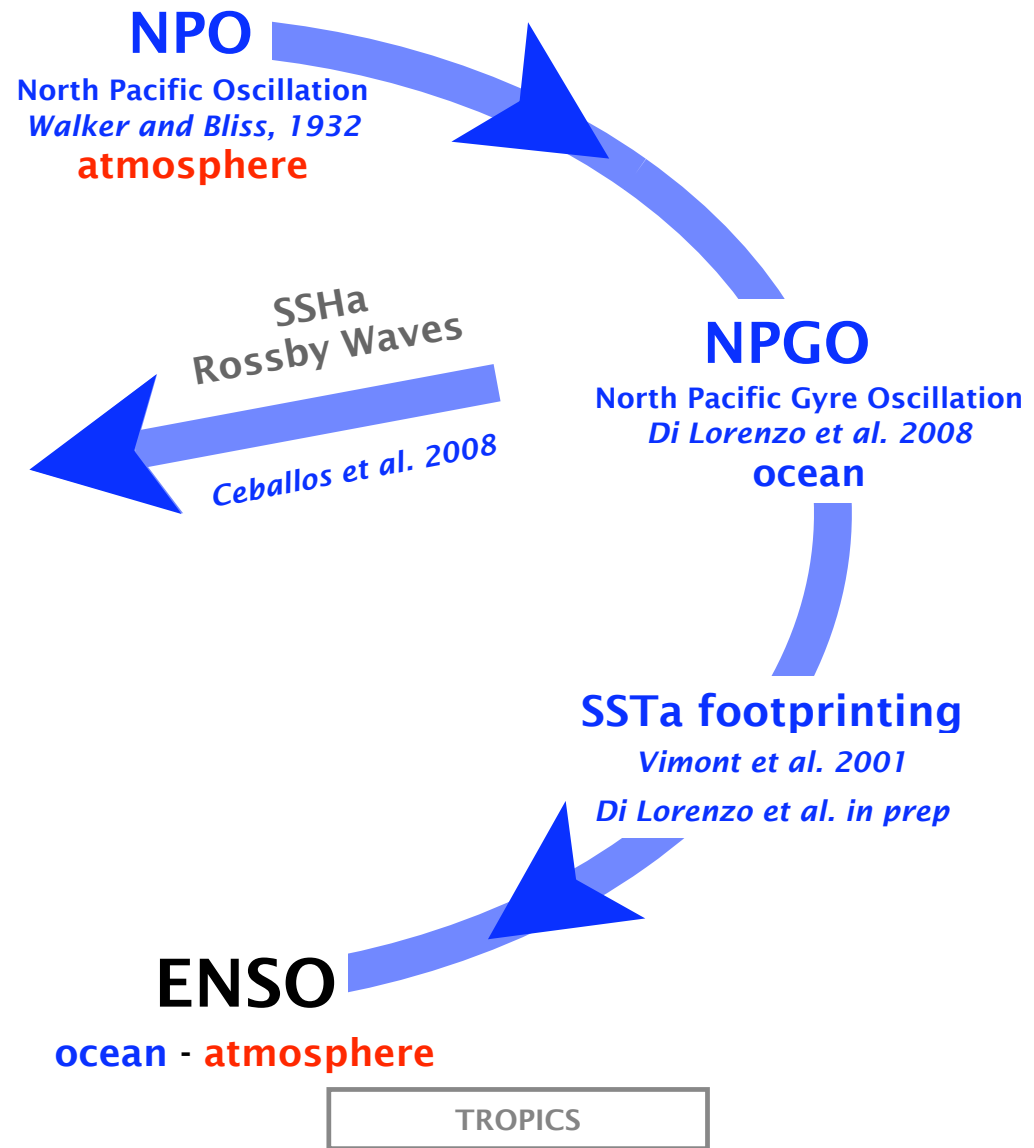
NPO/NPGO dynamics



NPO/NPGO dynamics

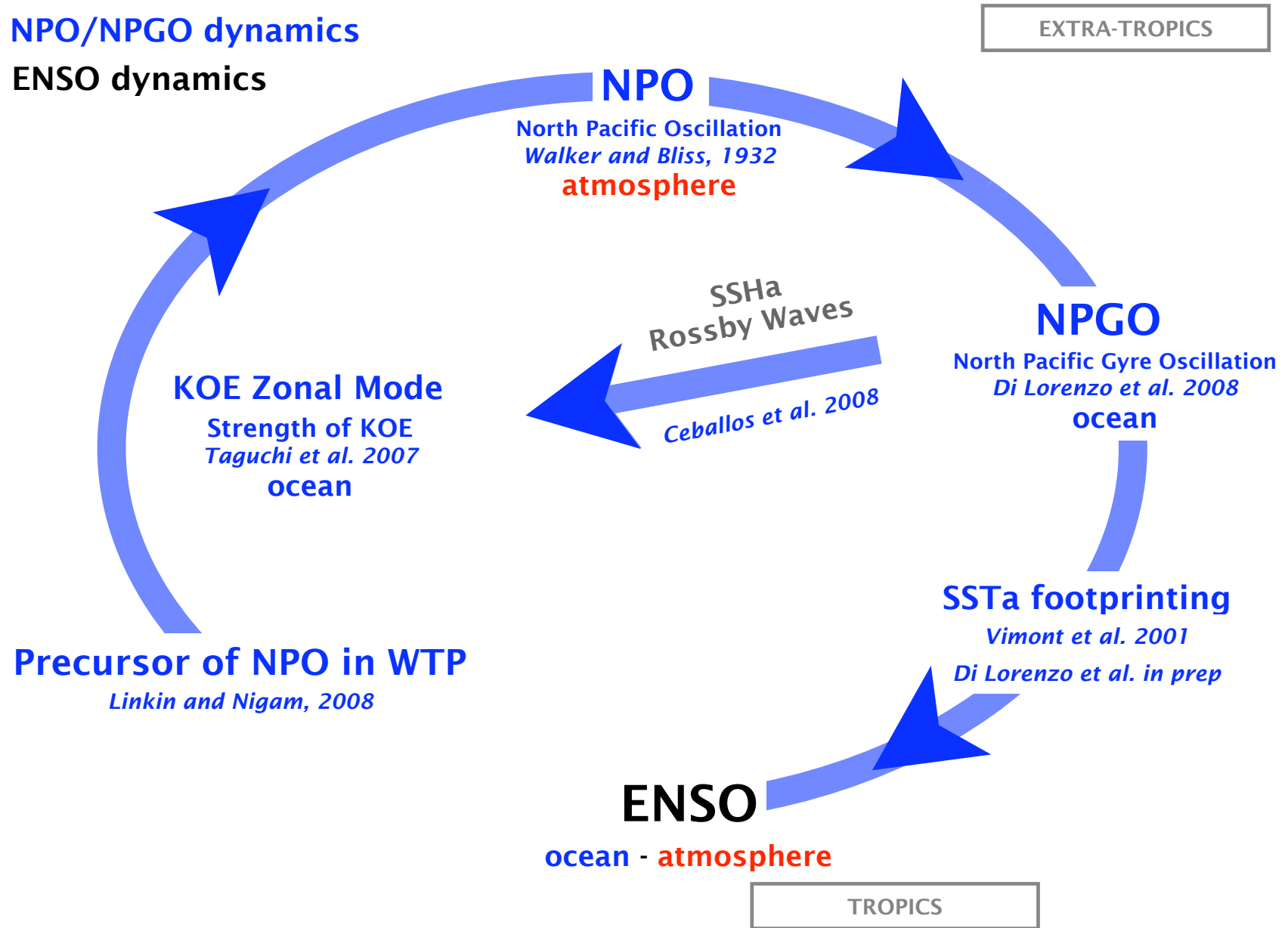
ENSO dynamics

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



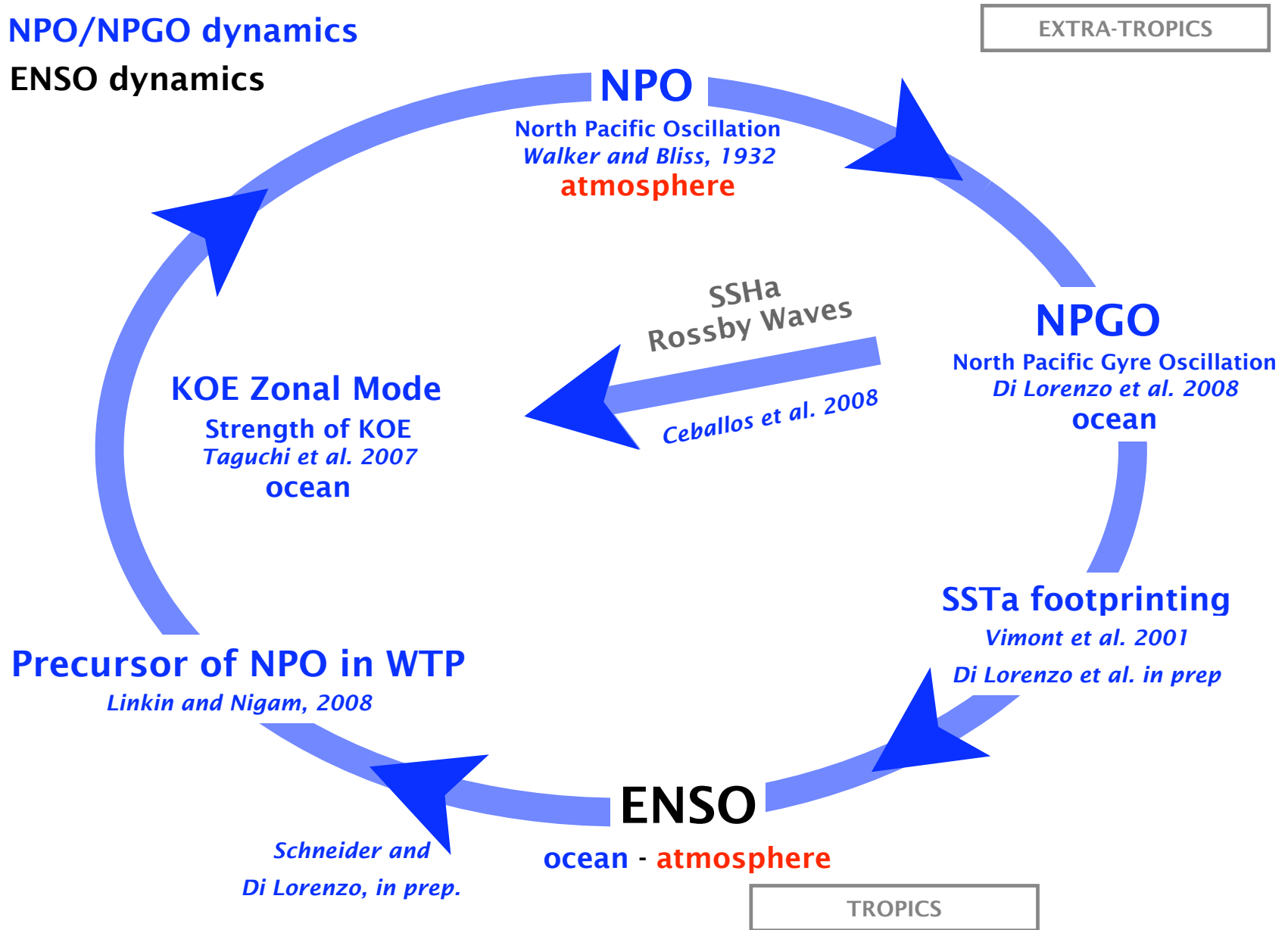
NPO/NPGO dynamics

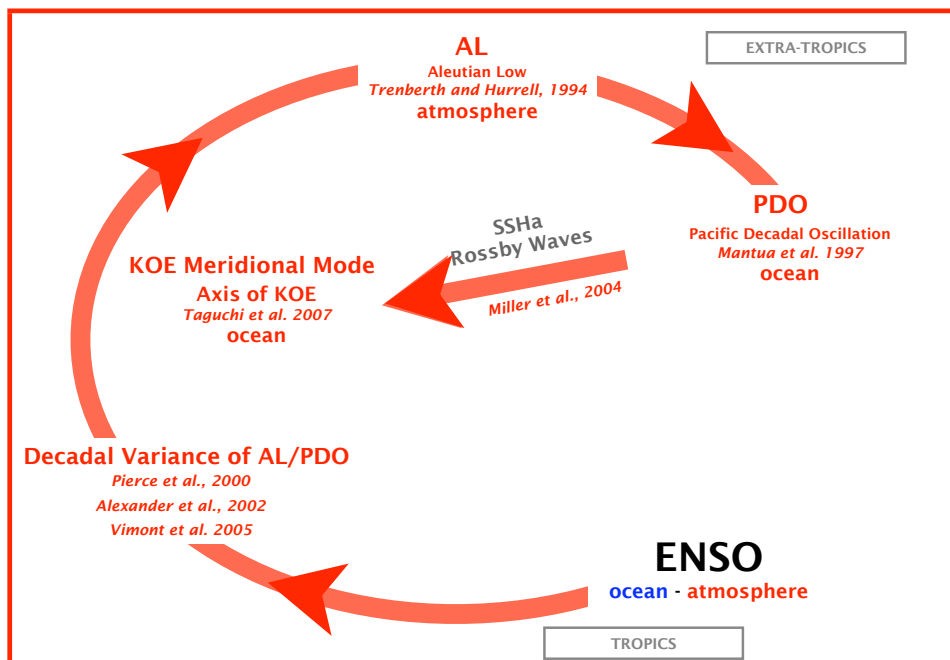
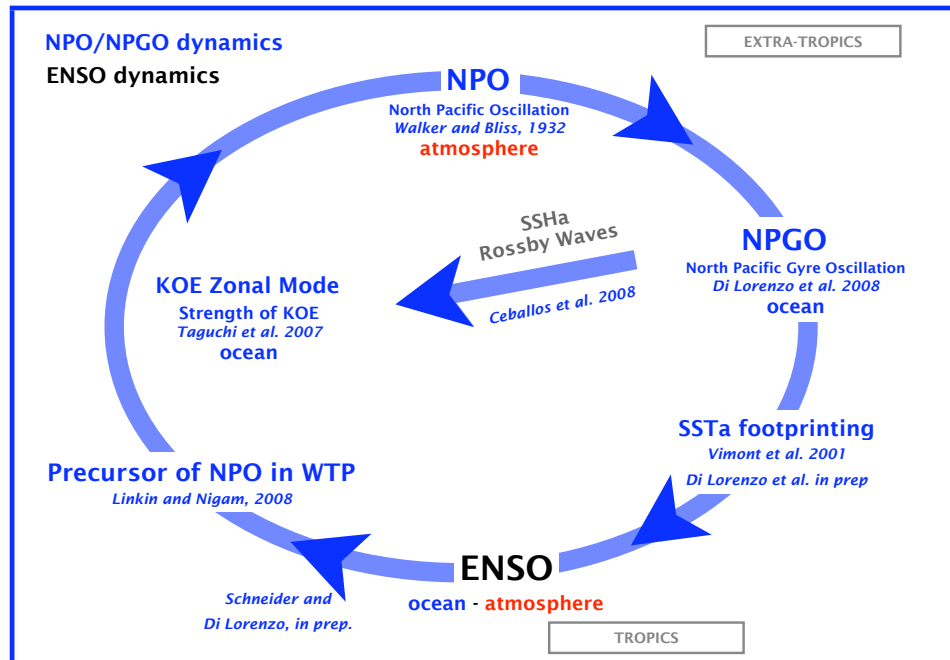
ENSO dynamics



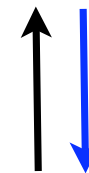
NPO/NPGO dynamics

ENSO dynamics





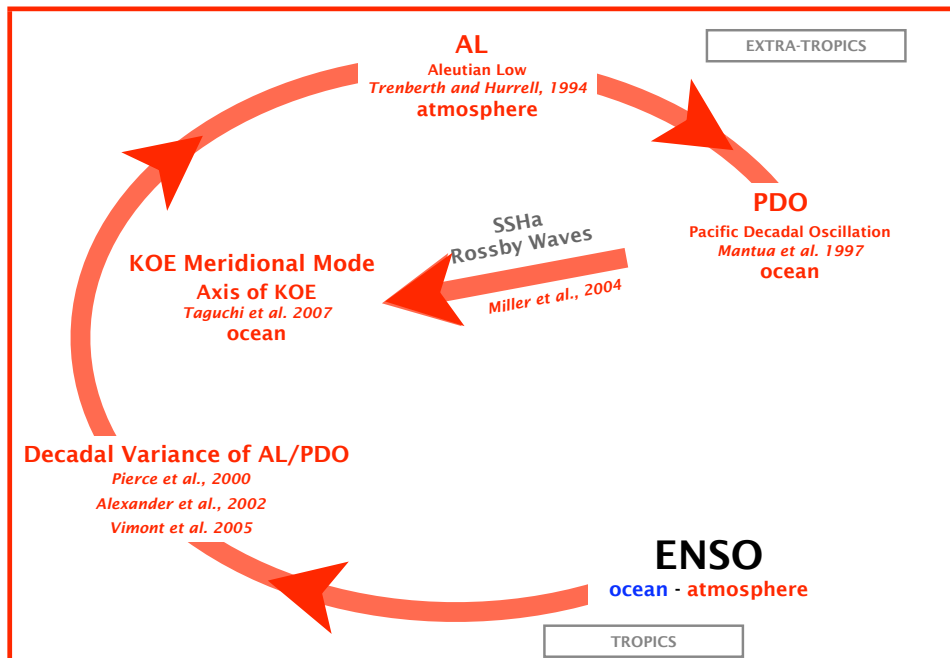
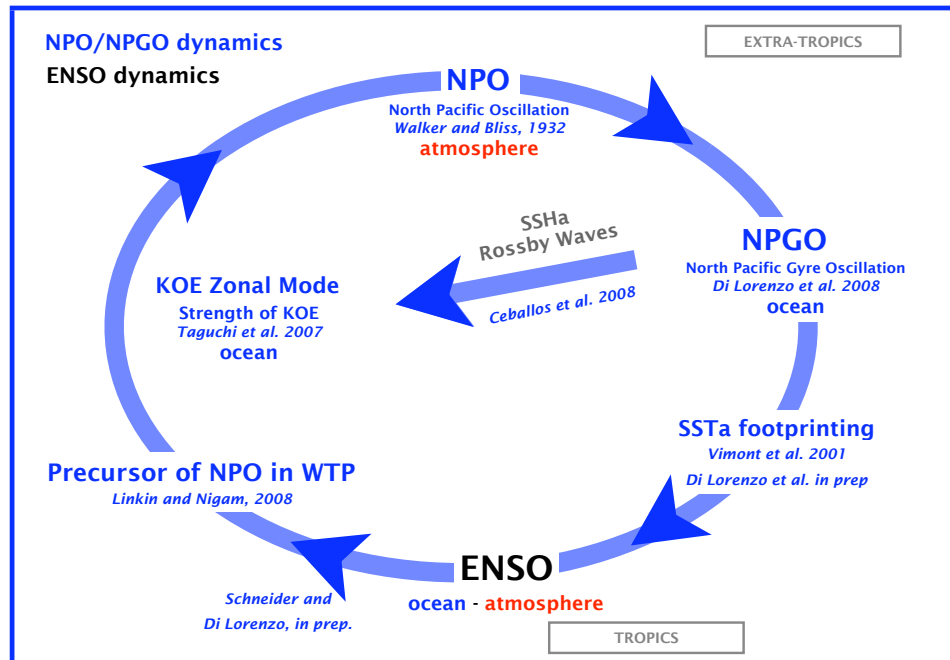
NPO/NPGO dynamics
Extra-Tropics



ENSO dynamics
Tropics

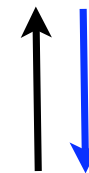


AL/PDO dynamics
Extra-Tropics



A “conceptual framework” for Pacific Climate Variability

NPO/NPGO dynamics
Extra-Tropics



ENSO dynamics
Tropics

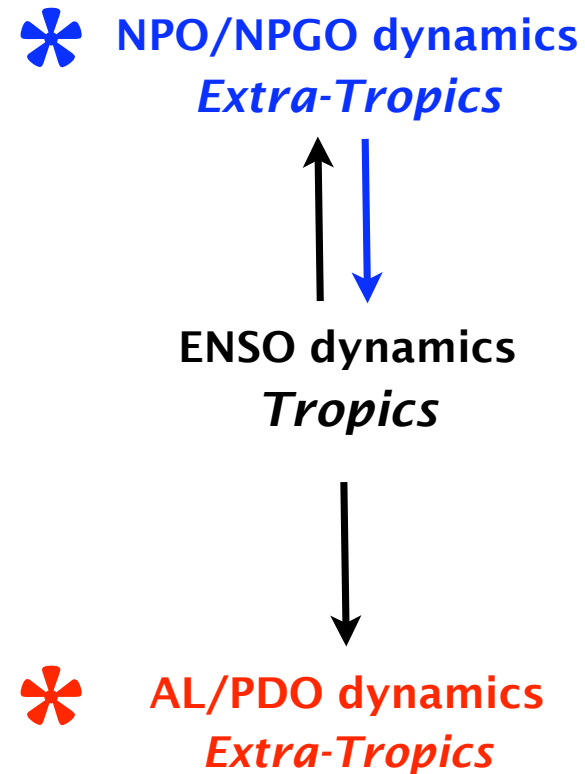


AL/PDO dynamics
Extra-Tropics

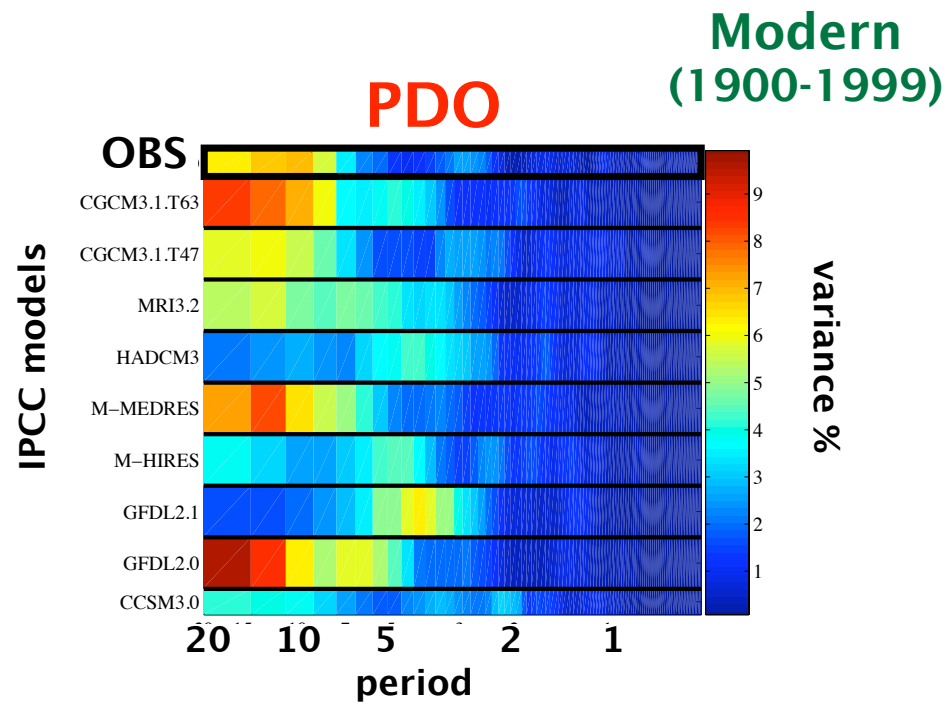
A “*conceptual framework*” for
Pacific Climate Variability

QUESTION:

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

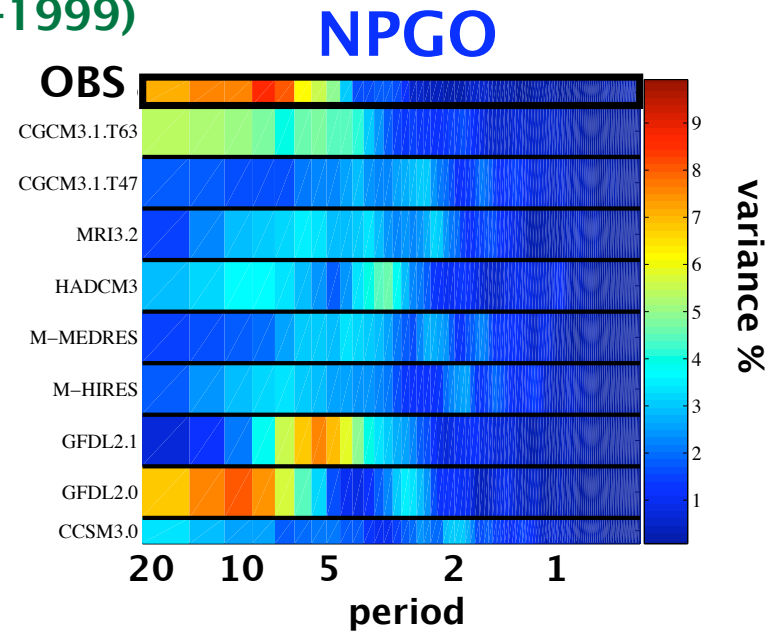
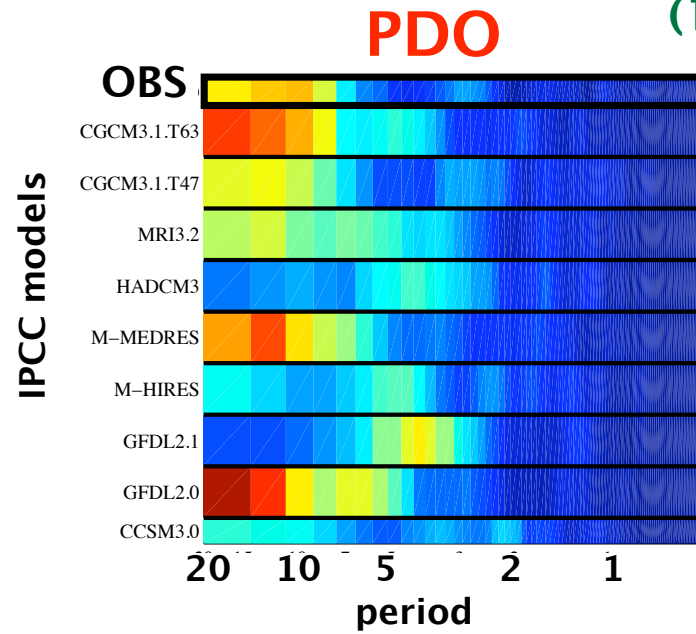


Power Spectra

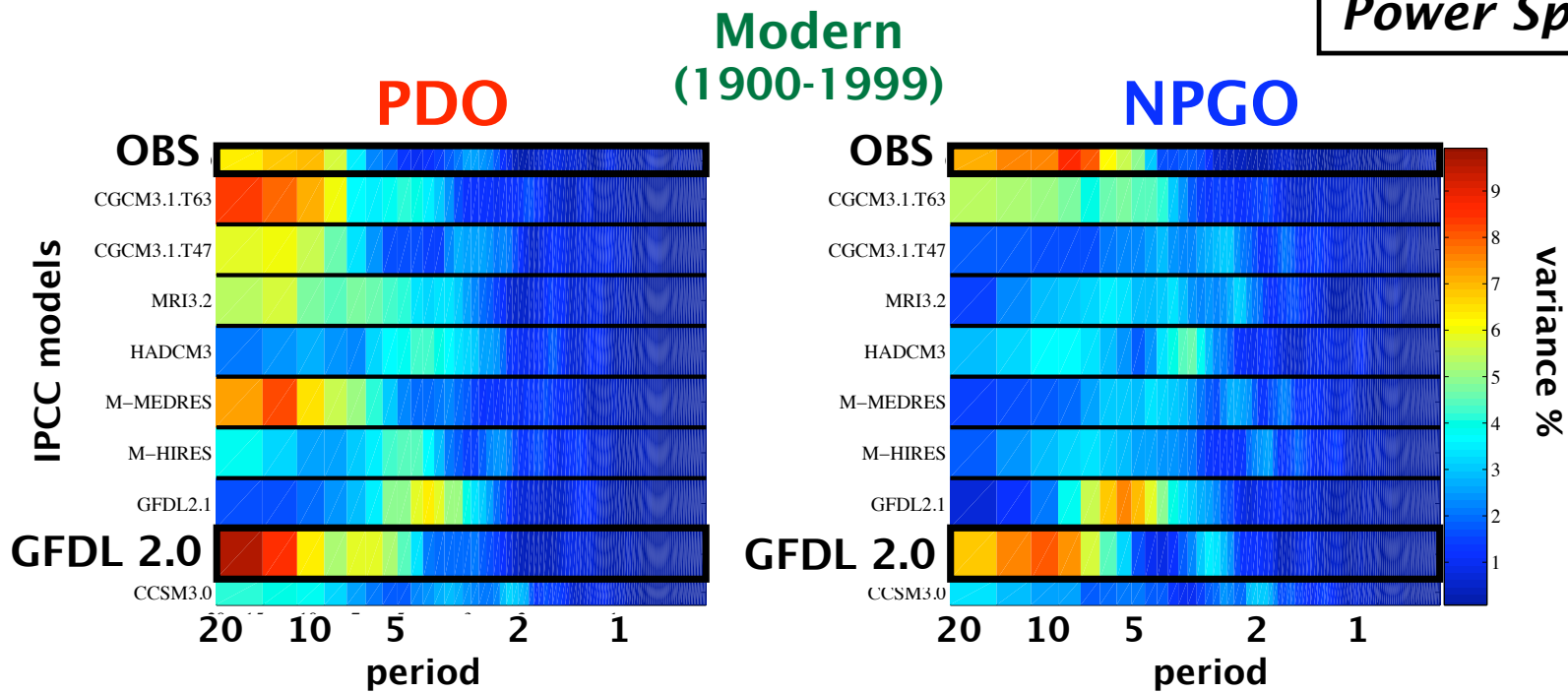


Power Spectra

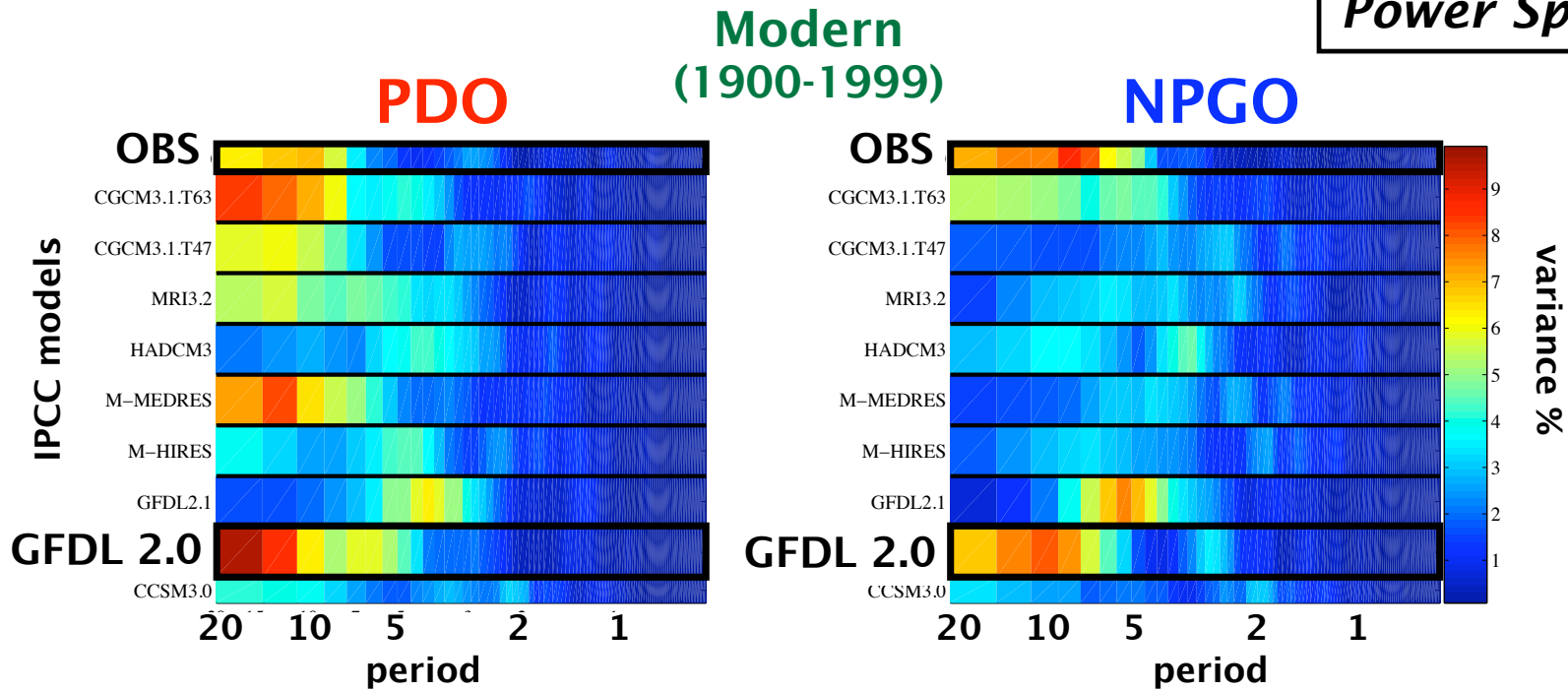
Modern
(1900-1999)



Power Spectra



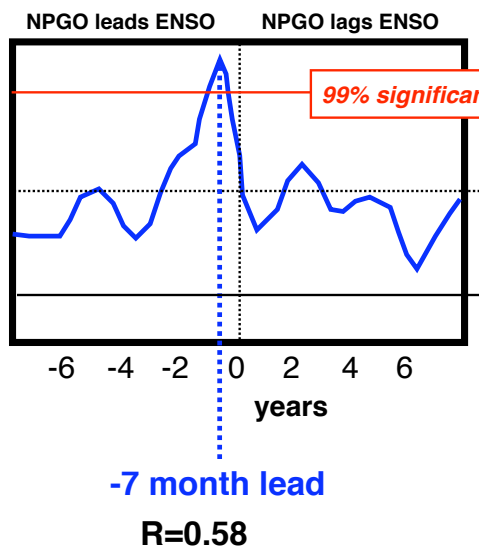
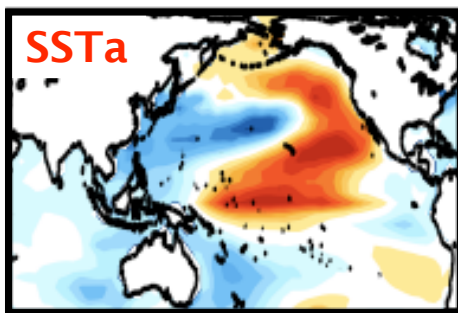
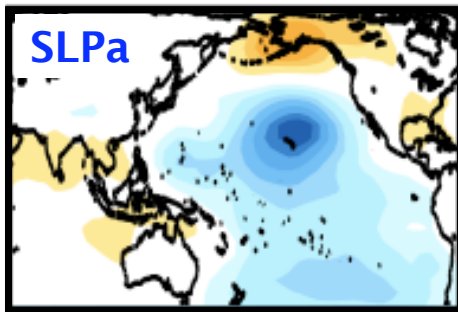
Power Spectra



QUESTION:

Do the IPCC climate model capture
NPGO/ENSO relationship?

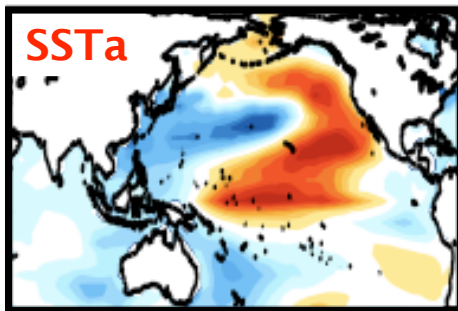
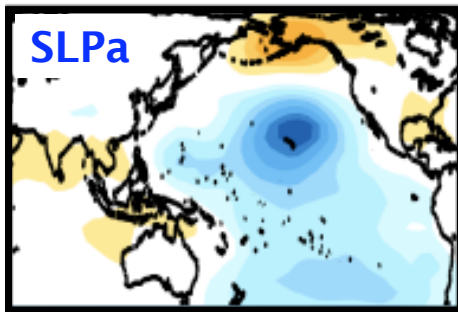
OBSERVATIONS



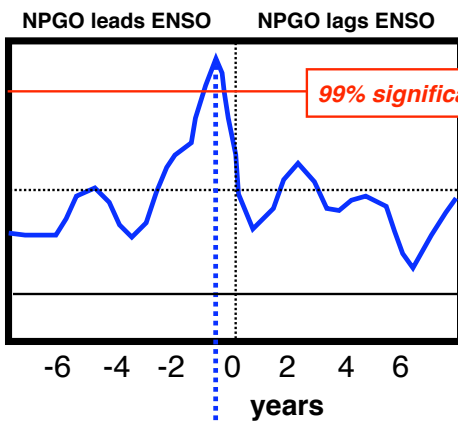
QUESTION:

Do the IPCC climate model capture
NPGO/ENSO relationship?

OBSERVATIONS



NPO/NPGO mode

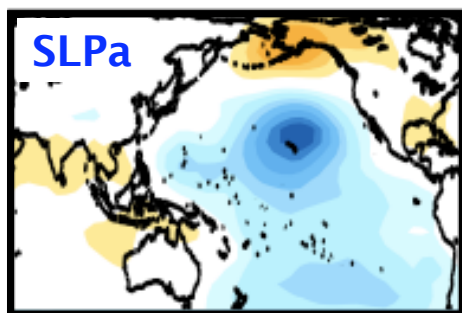


NPGO/ENSO lead-lag relationship

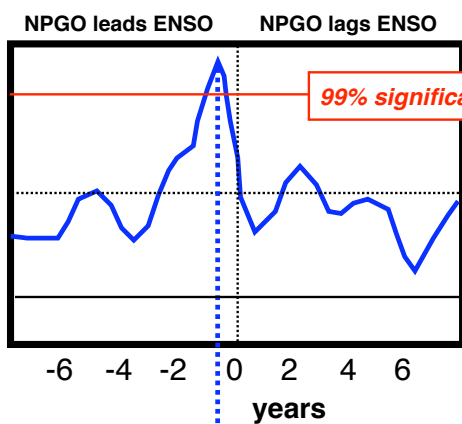
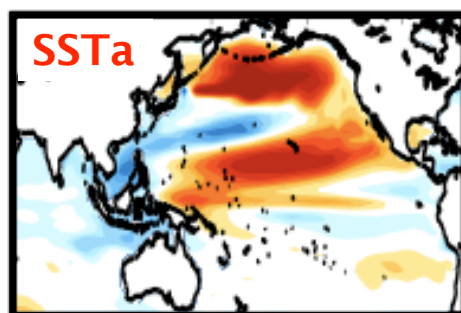
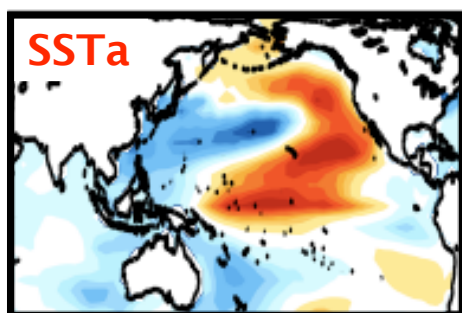
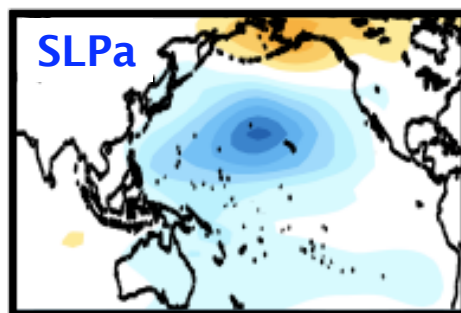
-7 month lead

R=0.58

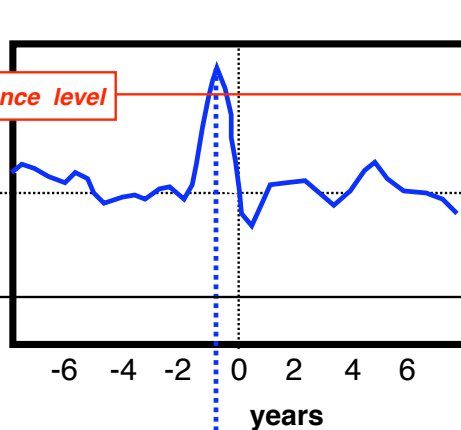
OBSERVATIONS



GFDL 2.0



-7 month lead
 $R=0.58$



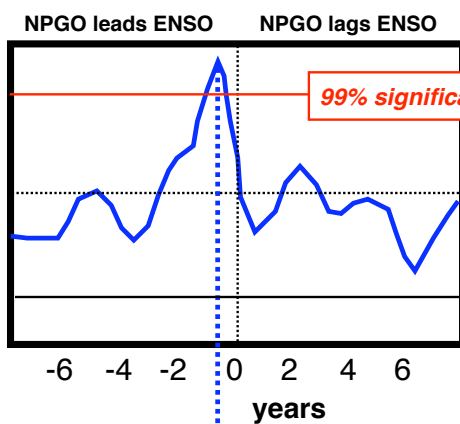
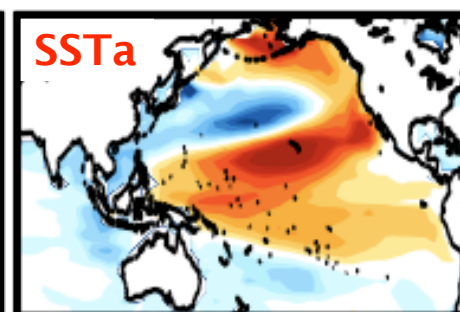
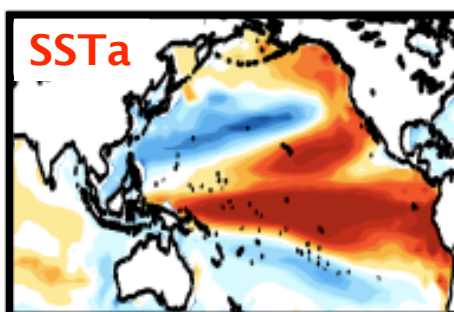
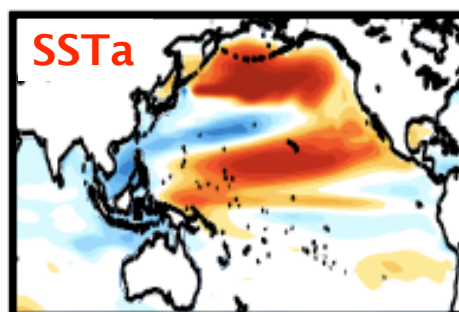
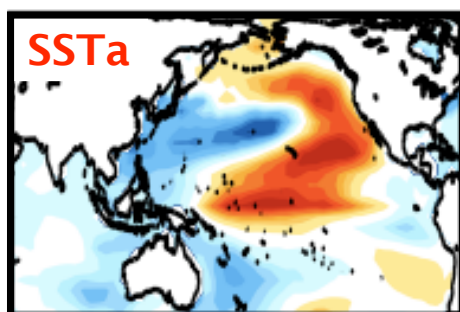
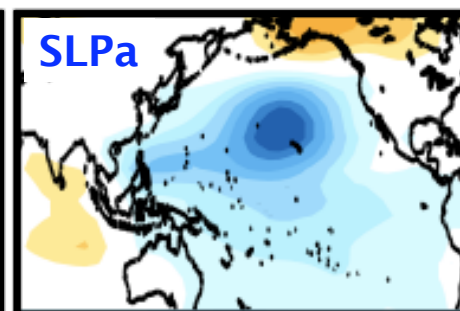
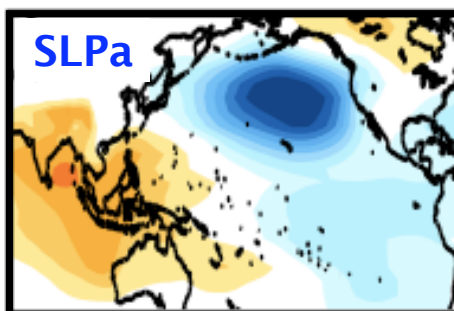
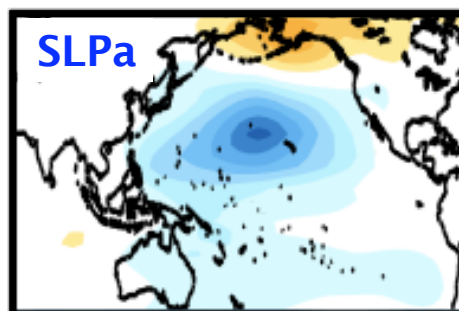
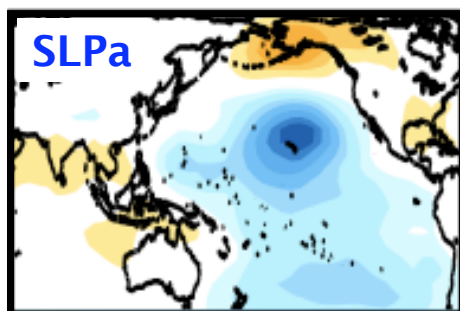
-8 month lead
 $R=0.52$

OBSERVATIONS

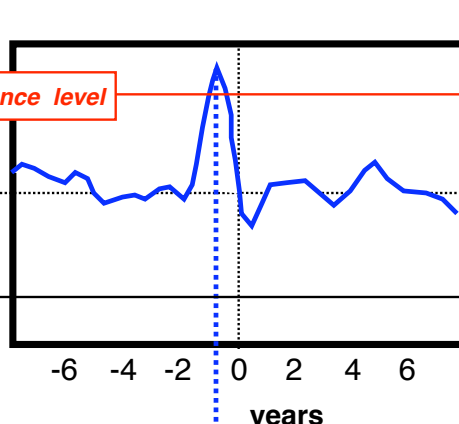
GFDL 2.0

HADCM3

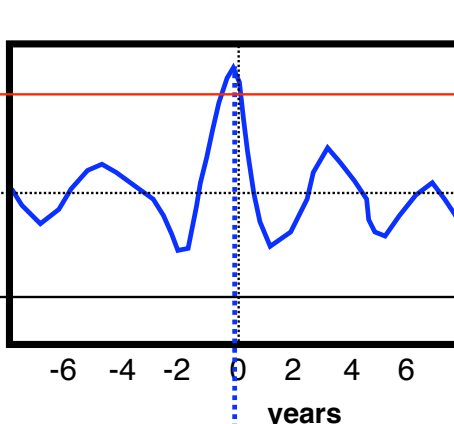
MIROC-MEDRES



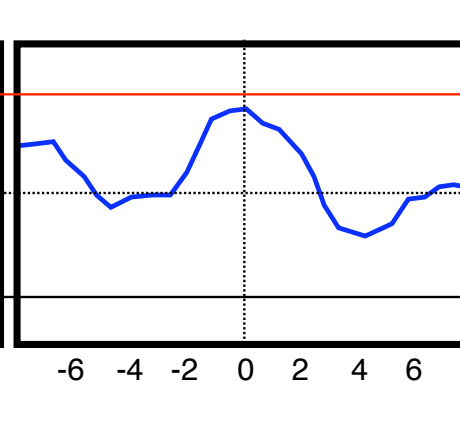
-7 month lead
R=0.58



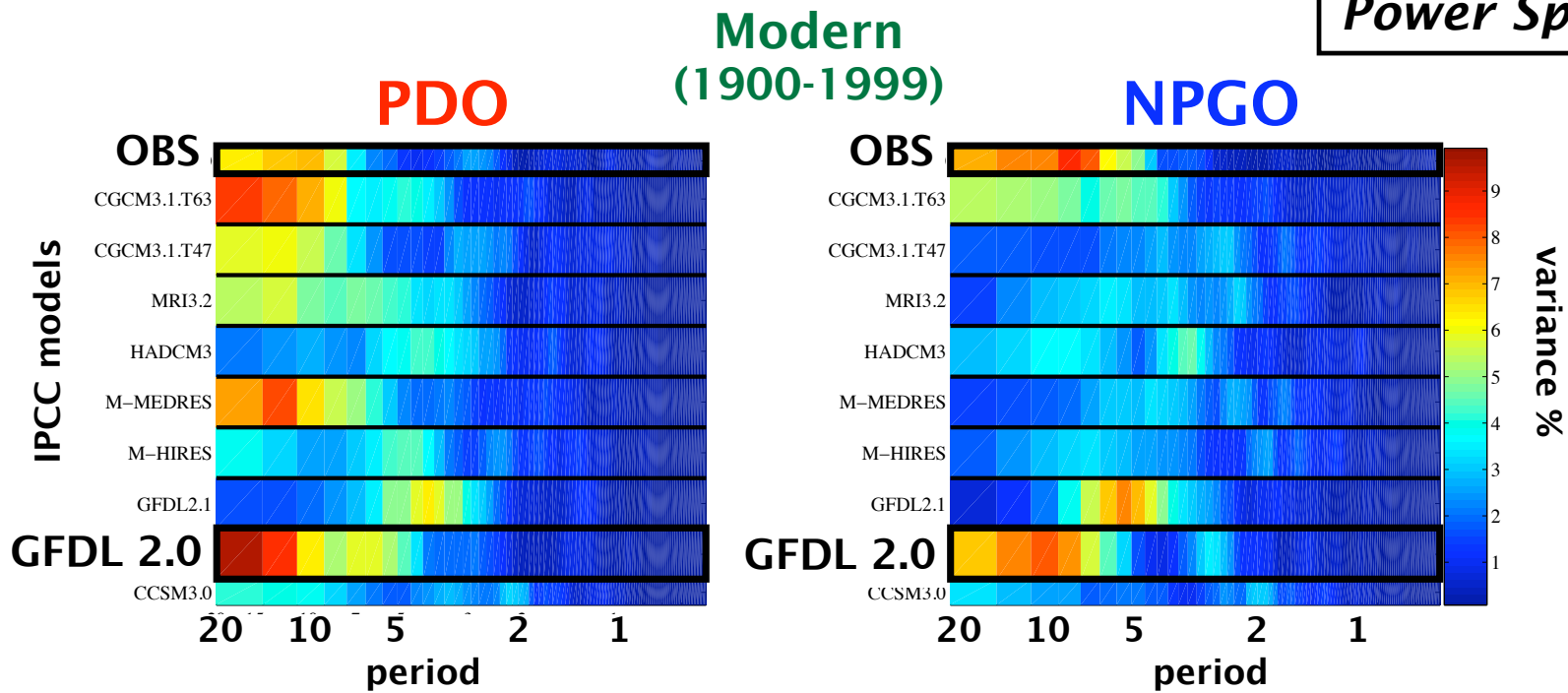
-8 month lead
R=0.52



-1 month lead
R=0.53

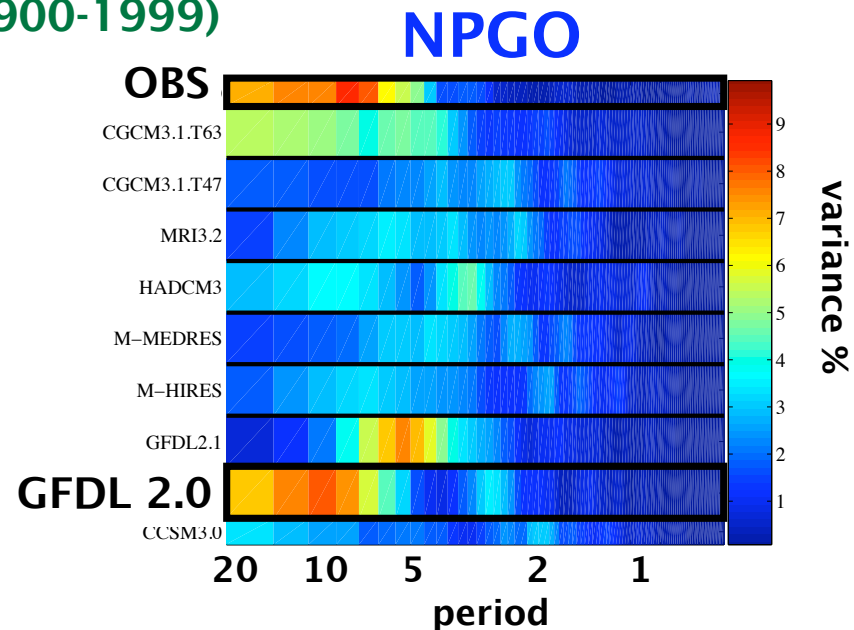
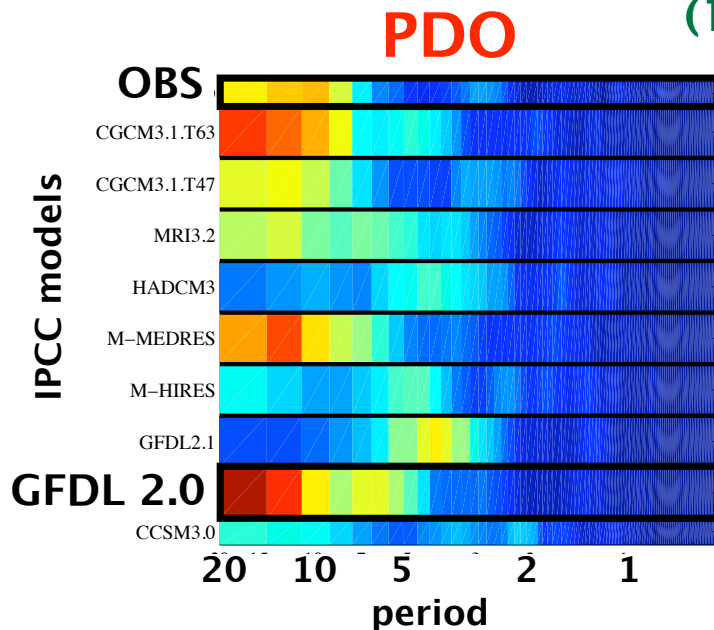


Power Spectra

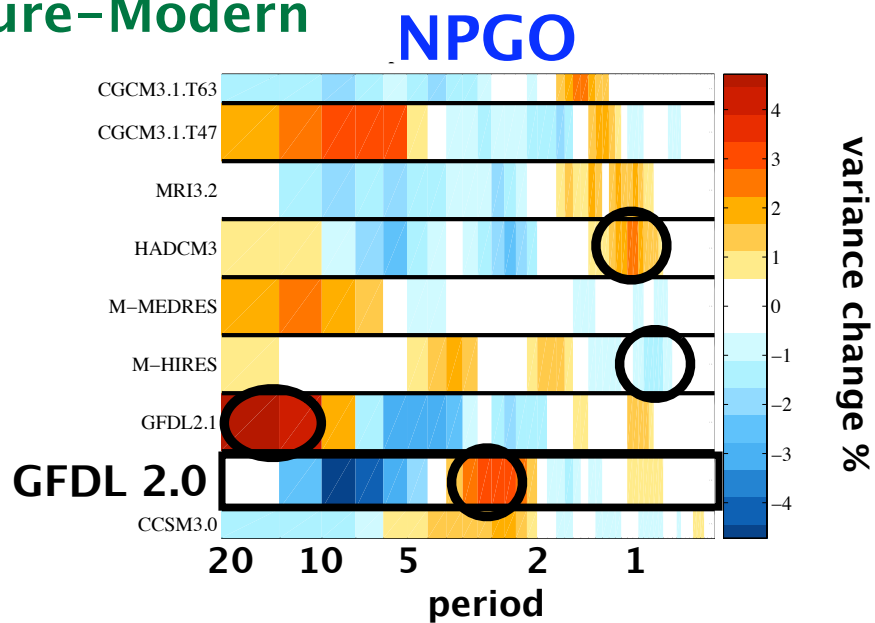
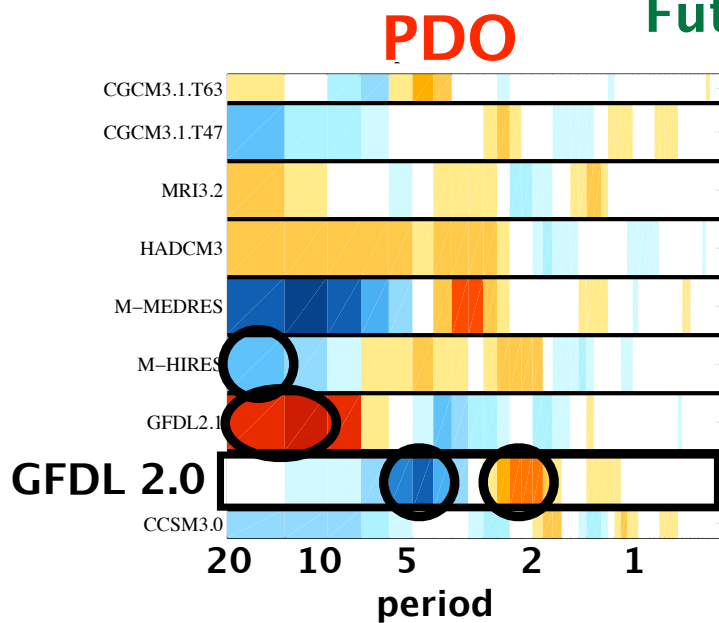


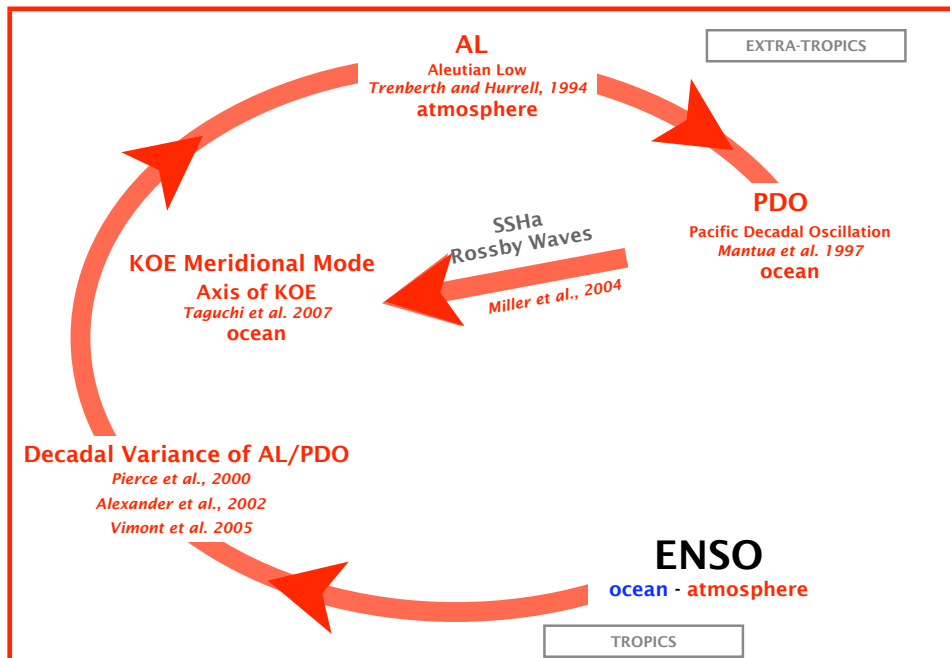
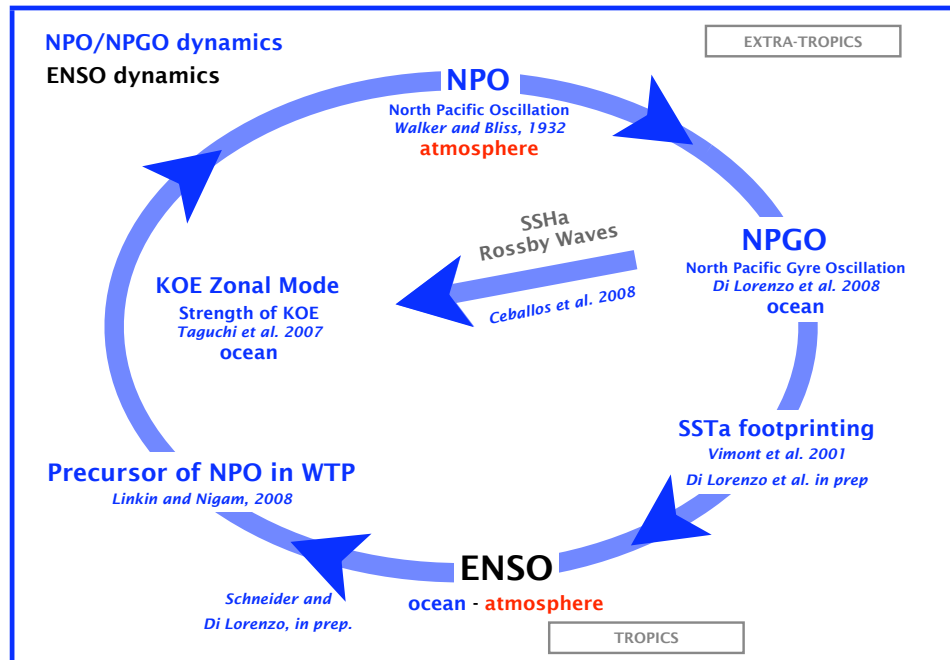
Power Spectra

Modern
(1900-1999)



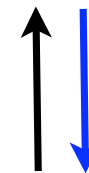
Future-Modern





A “conceptual framework” for Pacific Climate Variability

NPO/NPGO dynamics
Extra-Tropics



ENSO dynamics
Tropics



AL/PDO dynamics
Extra-Tropics