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An analysis on observed and simulated PNA associated atmospheric diabatic heating

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An analysis on observed and simulated PNA associated atmospheric diabatic heating

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1. **Introduction**
2. **Data and Methods**
3. **Results**
   a. Diabatic heating
   b. Dynamical aspects
4. **Summary**

- **Excitation of the PNA by the atmospheric heating**

  - **Relating atmospheric heating to SST anomalies**

    (eg, Horel & Wallace, 1981; Wallace & Jiang, 1987; Renwick & Wallace, 1996; Trenberth etal., 1998; Held etal., 2002)

  - **ENSO related SST forcing**

    a. ENSO forcing can selectively amplify natural forms of internal variability but cannot generate new structures *(eg, Lau, 1997; Hoerling etal., 1997; Palmer,1999);*

    b. Climate variability on the PNA sector is not strongly related to ENSO *(eg, Deser & Blackmon, 1995; Zhang etal, 1996).*

    Particularly, ENSO forces a circulation pattern quite distinct from the internally generated PNA variability *(Straus & Shukla,2002).*

- **Maintenance of long-lived atmospheric anomalies**
  - **Interaction between the anomalies and the time-mean flow**
    (eg, Branstator, 1992; Hoskins & Karoly, 1981; Branstator, 1983; Simmons etal., 1983; Trenberth, 1986)
  - **Transient eddy feedbacks**
    (eg, Branstator, 1992; Hoskins etal., 1983; Lau, 1988; Nakamura & Wallace, 1990;Trenberth etal., 1998)

- **Objective**

  Analyze thermodynamic and dynamic aspects responsible for the PNA variability by linearly isolating the influence of ENSO.

- **Analysis data**

  a. NCEP/NCAR and ERA-40 reanalyses

  (Sept.1957-Aug.2002; Kistler etal., 2001; Uppala etal., 2005)

  b. CCCma's CGCM 1000-yr control simulation

  *(AGCM:3.75*3.75L10, OGCM: GFDL-MOM 1.8*1.8L29;*
  Flato etal.,2000; Boer etal., 2000)

- **Diagnostic methods**

  a. Diabatic heating

  ○ 3D diabatic heating *(e.g., Hoskins etal.,1989; Nigam,1994)*

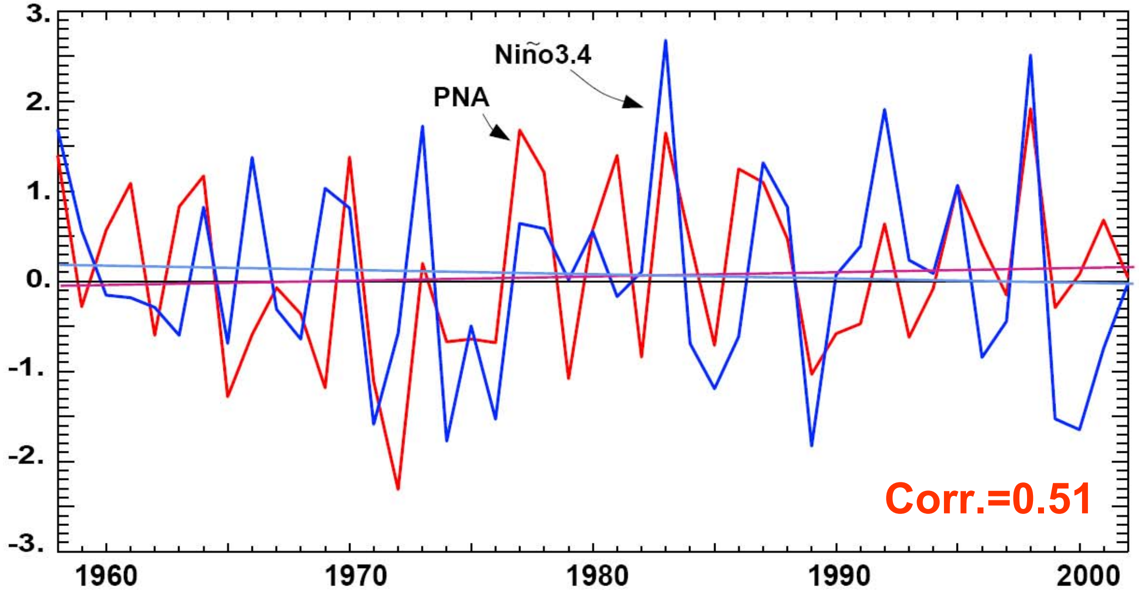
  ○ vertically integrated heating and energy transport
  (Boer,1986; Trenberth etal.,1994; Yu & Boer,2002)

  b. Dynamical aspects

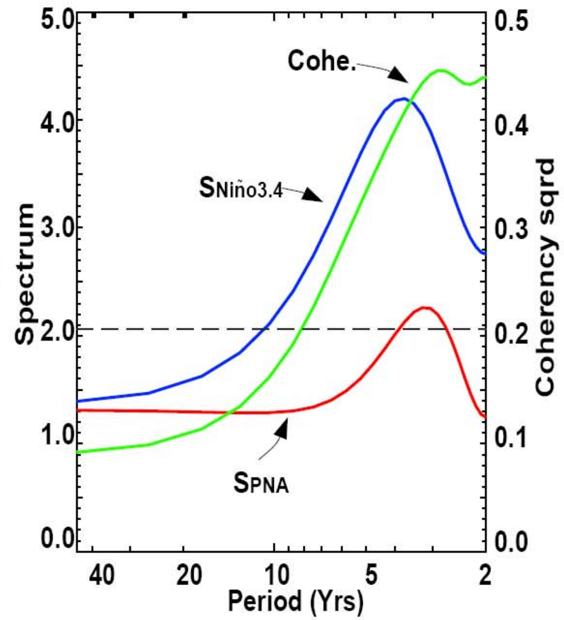
  ○ interaction between synoptic eddies and time-mean flow
  (e.g.,Hoskins etal., 1983; Trenberth, 1986; Lau, 1988)

  ○ Rossby wave source *(Sardesmukh & Hoskins,1988)*

Time series

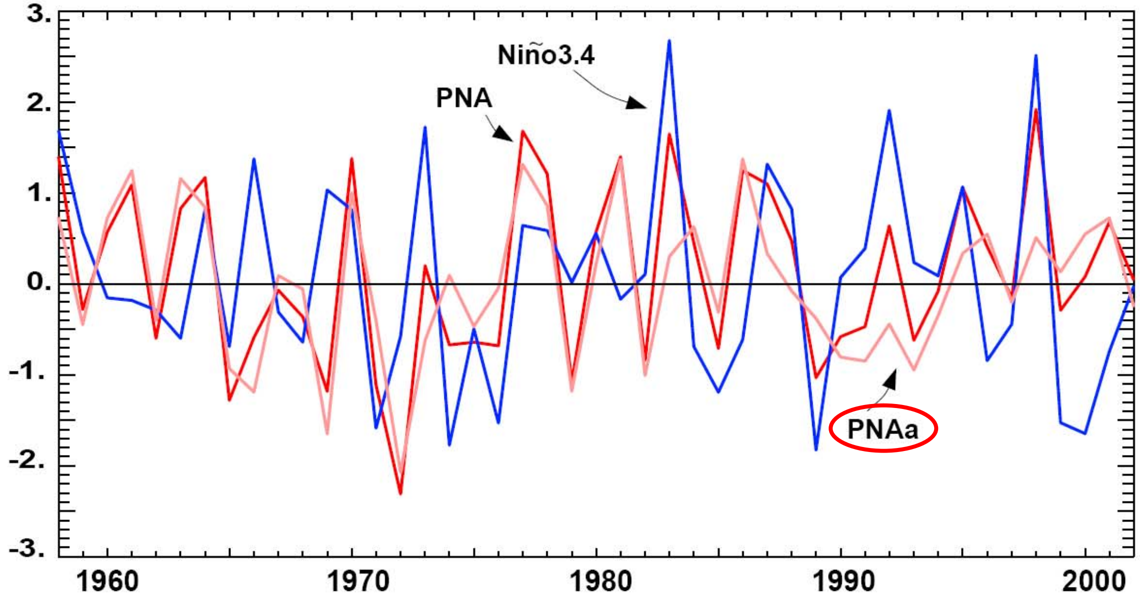


Spectra

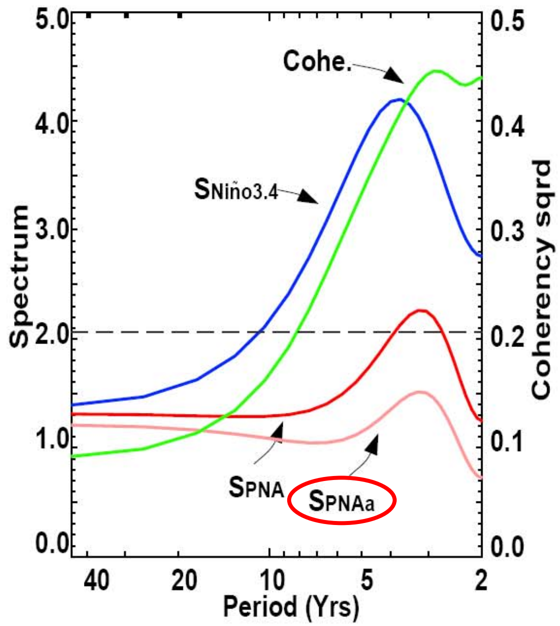


PNA: JISAO/NOAA,UW
Niño3.4: CPC/NCEP/NOAA

Time series



Spectra

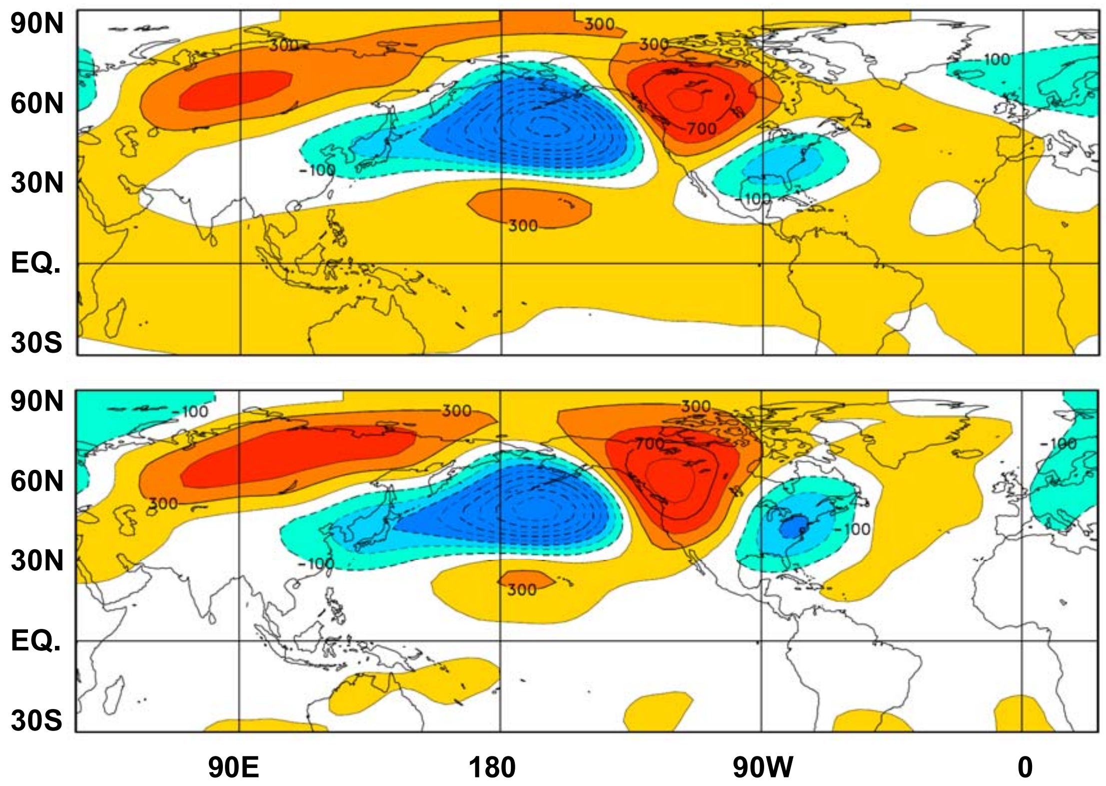


List of DJF winters for PNA and Niño3.4 composites

+PNA	1958 1961 1964 1970 1977 1978 1981 1983 1986 1998
-PNA	1965 1969 1971 1972 1979 1982 1989
+Niño3.4	1958 1966 1973 1983 1987 1992 1995 1998
-Niño3.4	1971 1974 1976 1985 1989 1999 2000
+PNAa	1961 1963 1964 1970 1977 1978 1981 1986
-PNAa	1965 1966 1969 1972 1979 1982 1991 1993

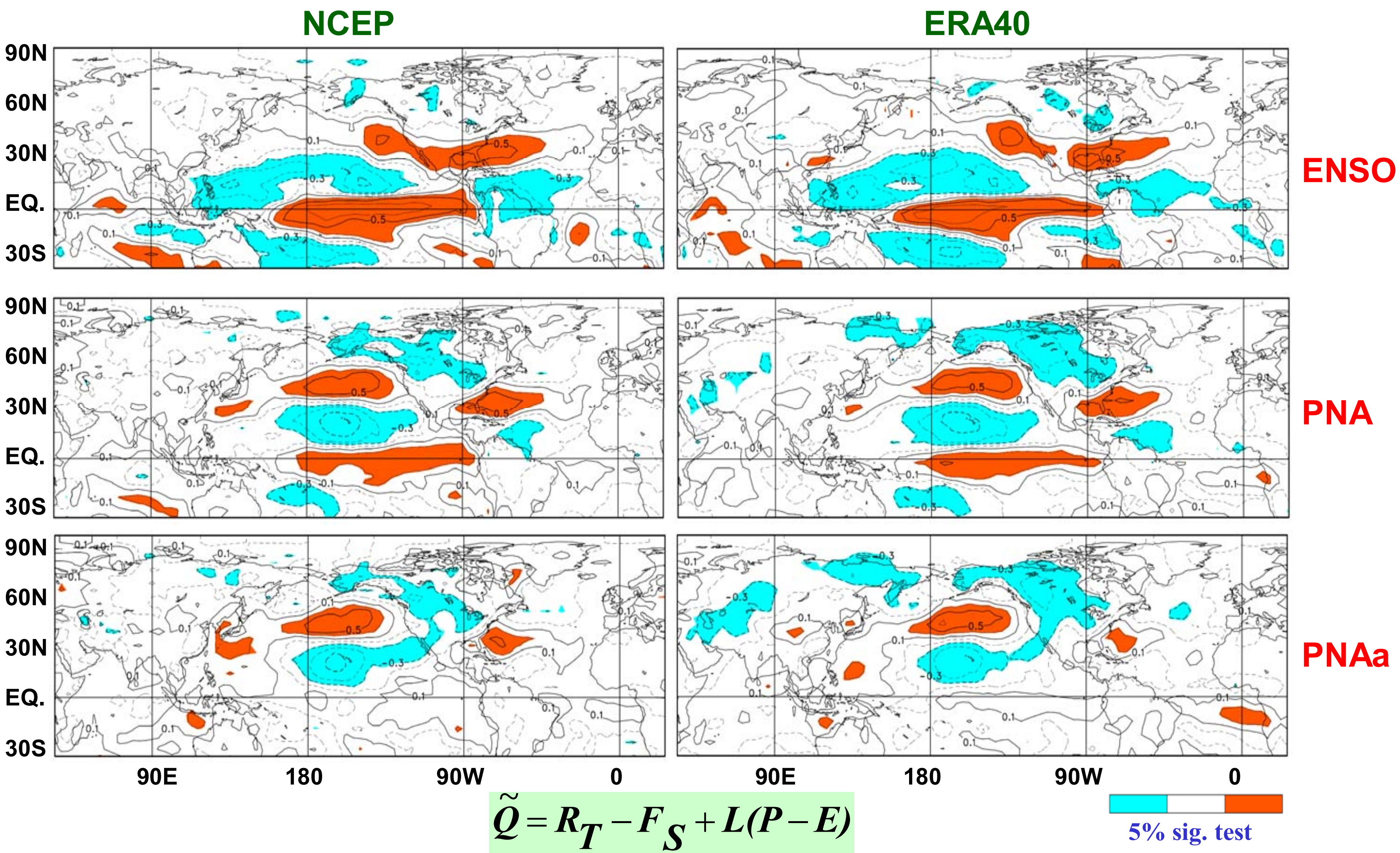
a) Years are labeled on January of the DJF winters.
b) PNAa indicates the index after removing the Niño3.4 contribution.

Φ_{500} anomalies (+PNA *minus* –PNA)



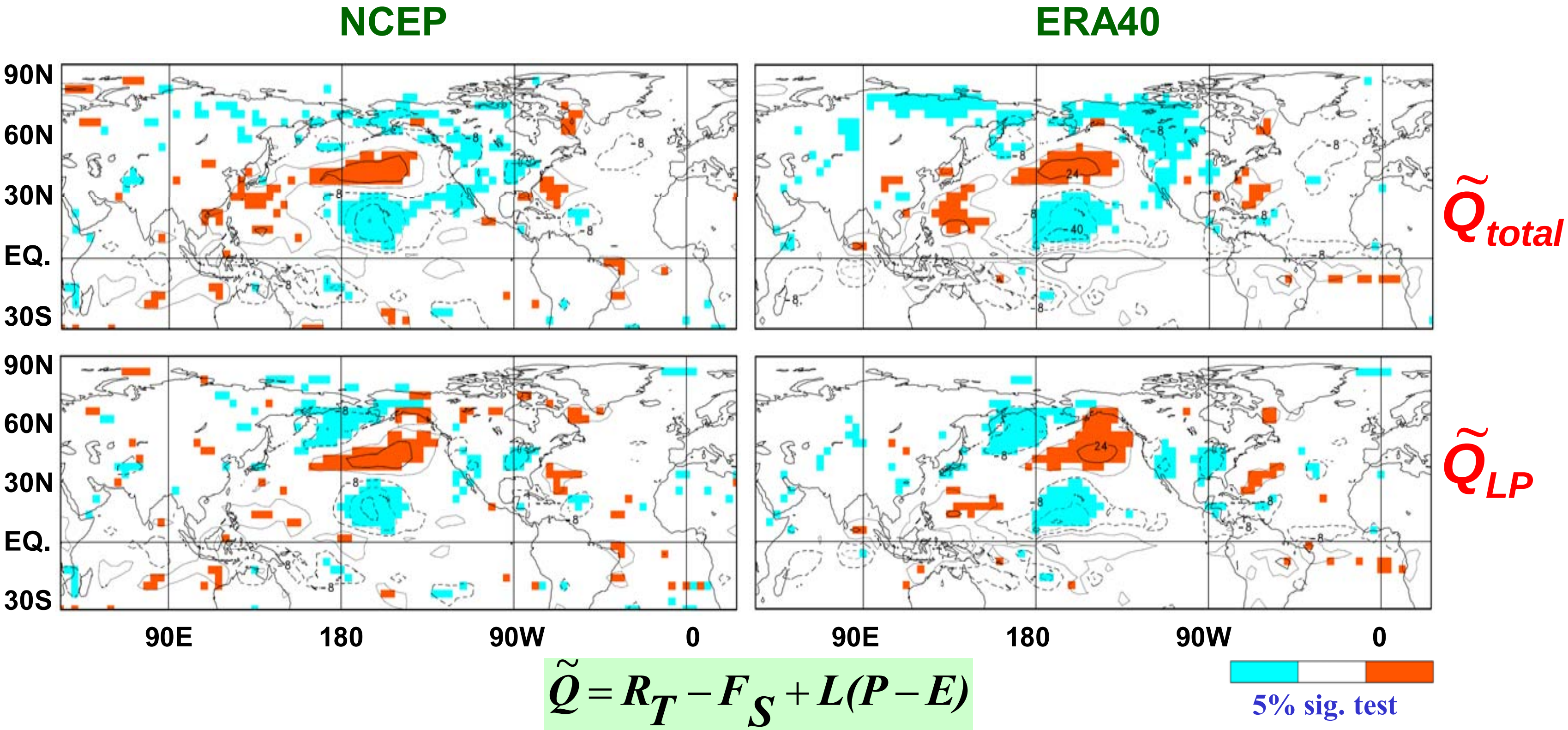
Removing ENSO

Correlations of vertically integrated heating $\widetilde{Q}$ with the indices



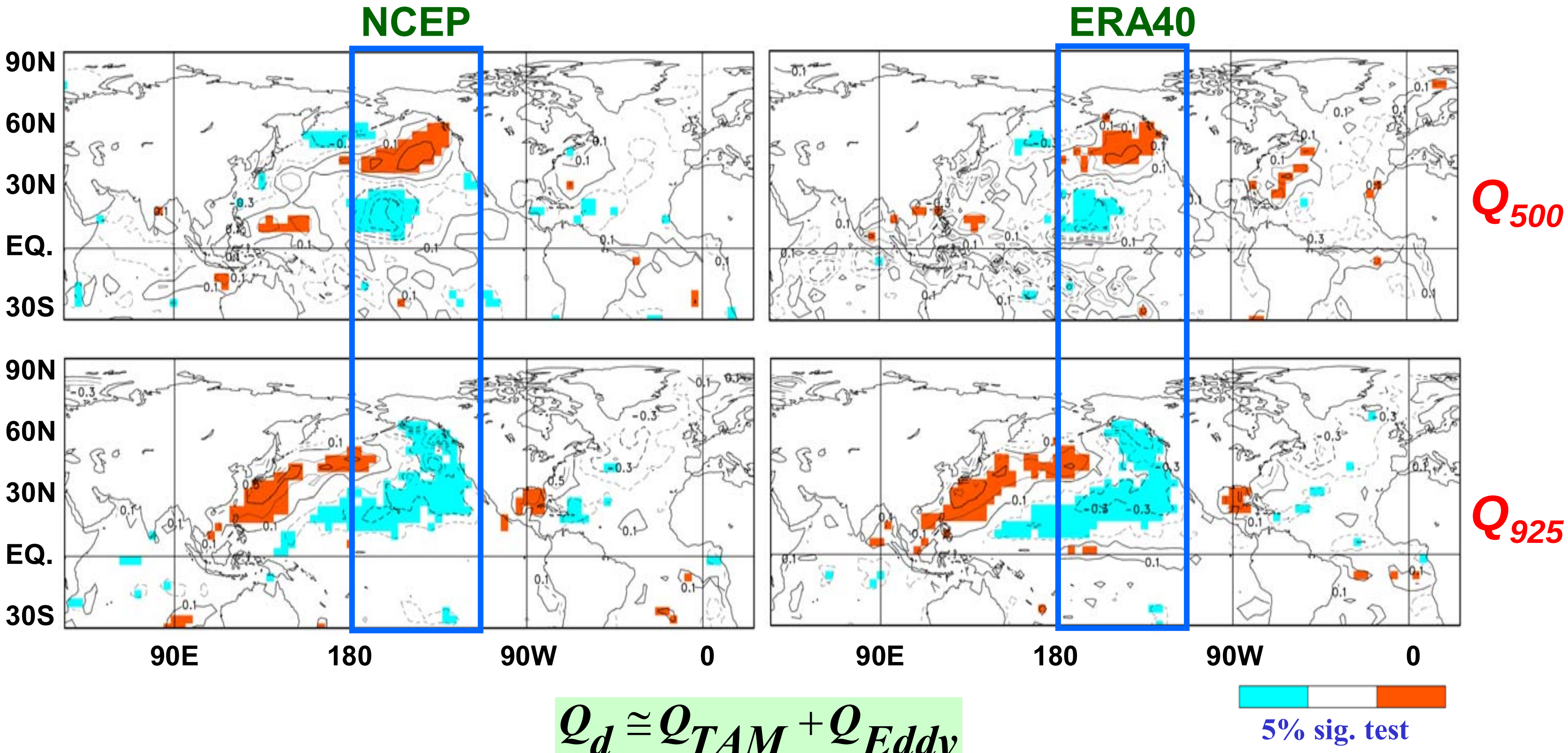
$$\widetilde{Q} = R_T - F_S + L(P - E)$$

Vertically integrated heating anomalies
(+PNAa *minus* –PNAa)



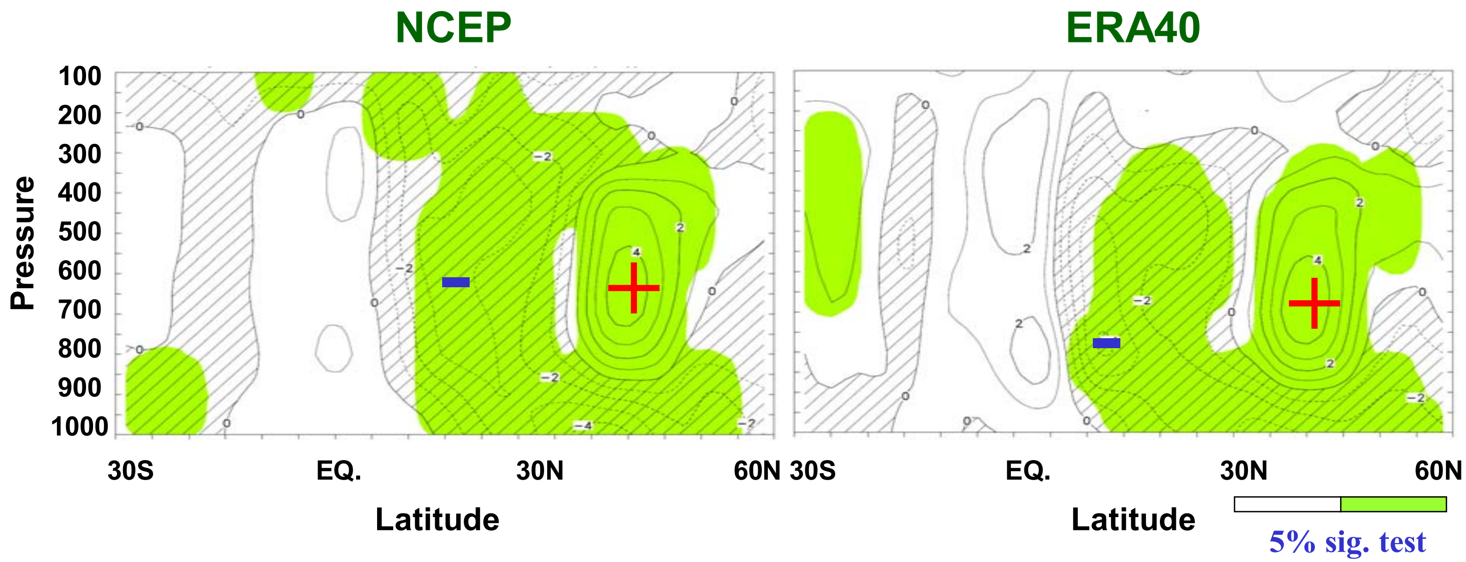
$$\tilde{Q} = R_T - F_S + L(P - E)$$

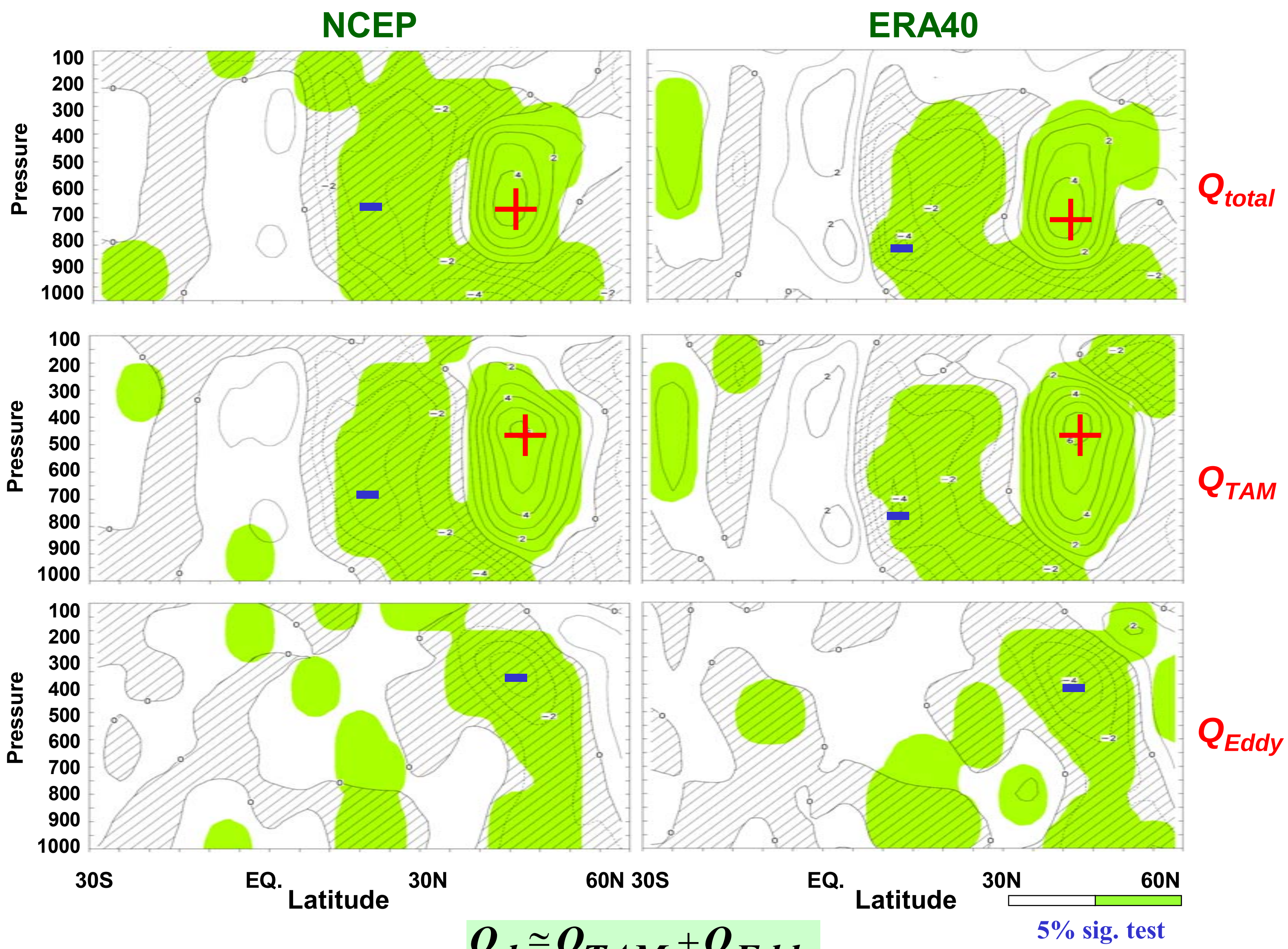
Diabatic heating anomalies
(+PNAa *minus* –PNAa)



$$Q_d \cong Q_{TAM} + Q_{Eddy}$$

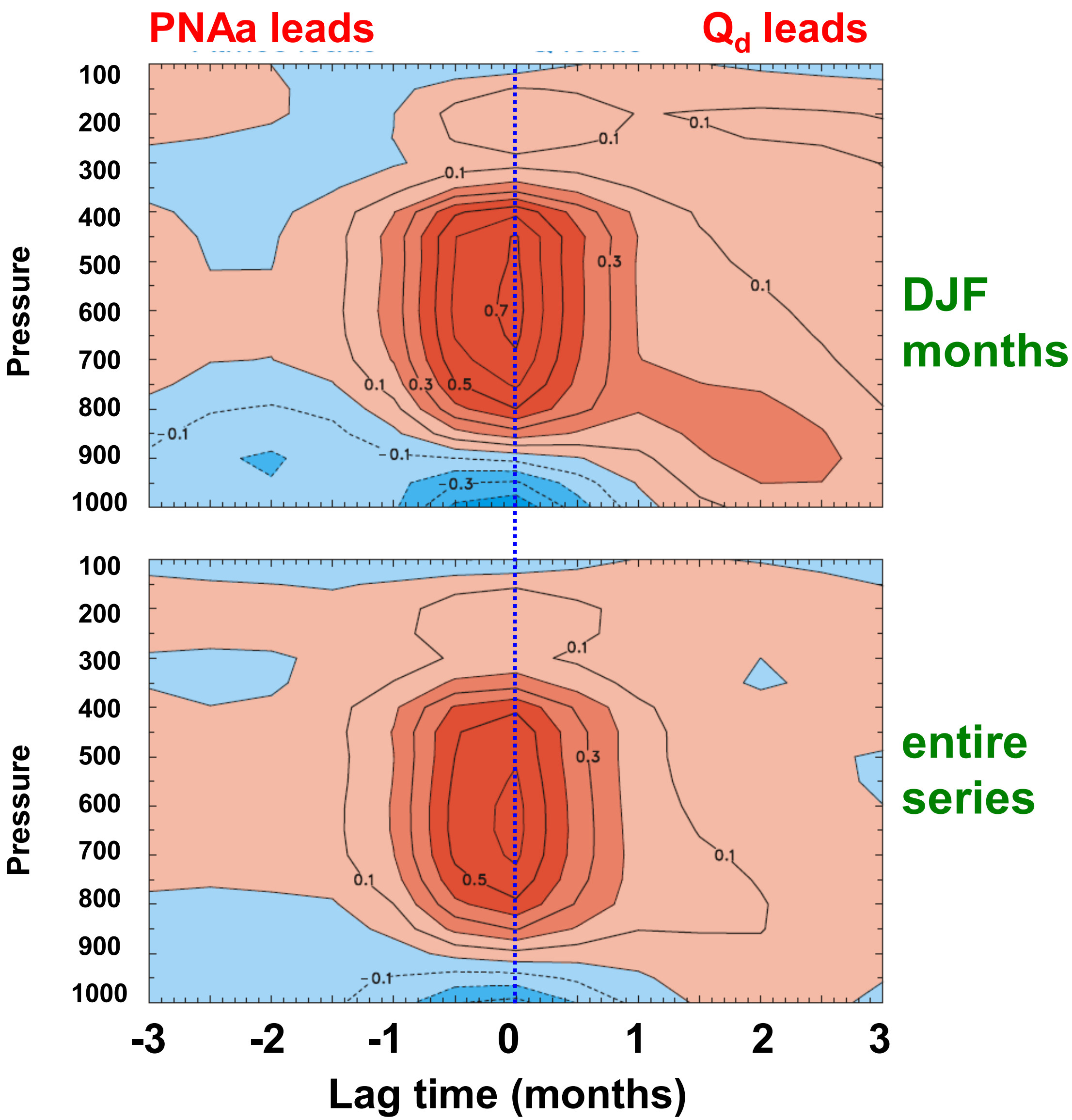
Vertical structure of heating anomalies (180-120W)
(+PNAa *minus* –PNAa)



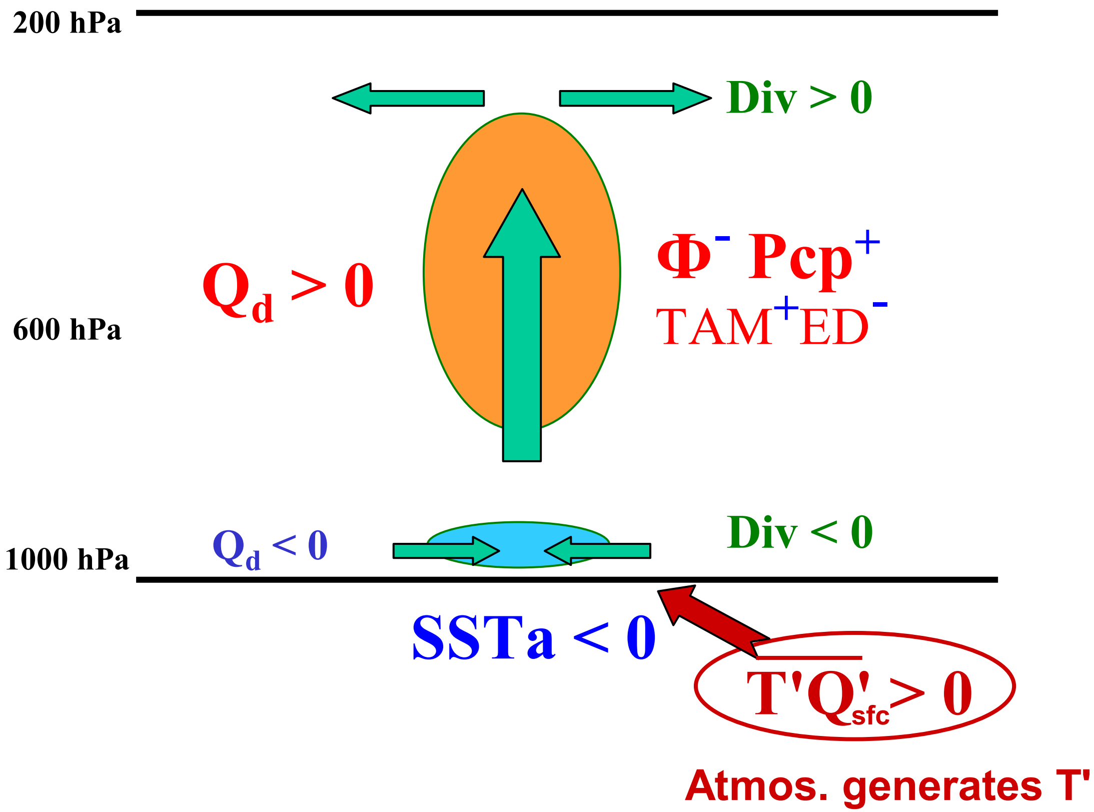


$$Q_d \cong Q_{TAM} + Q_{Eddy}$$

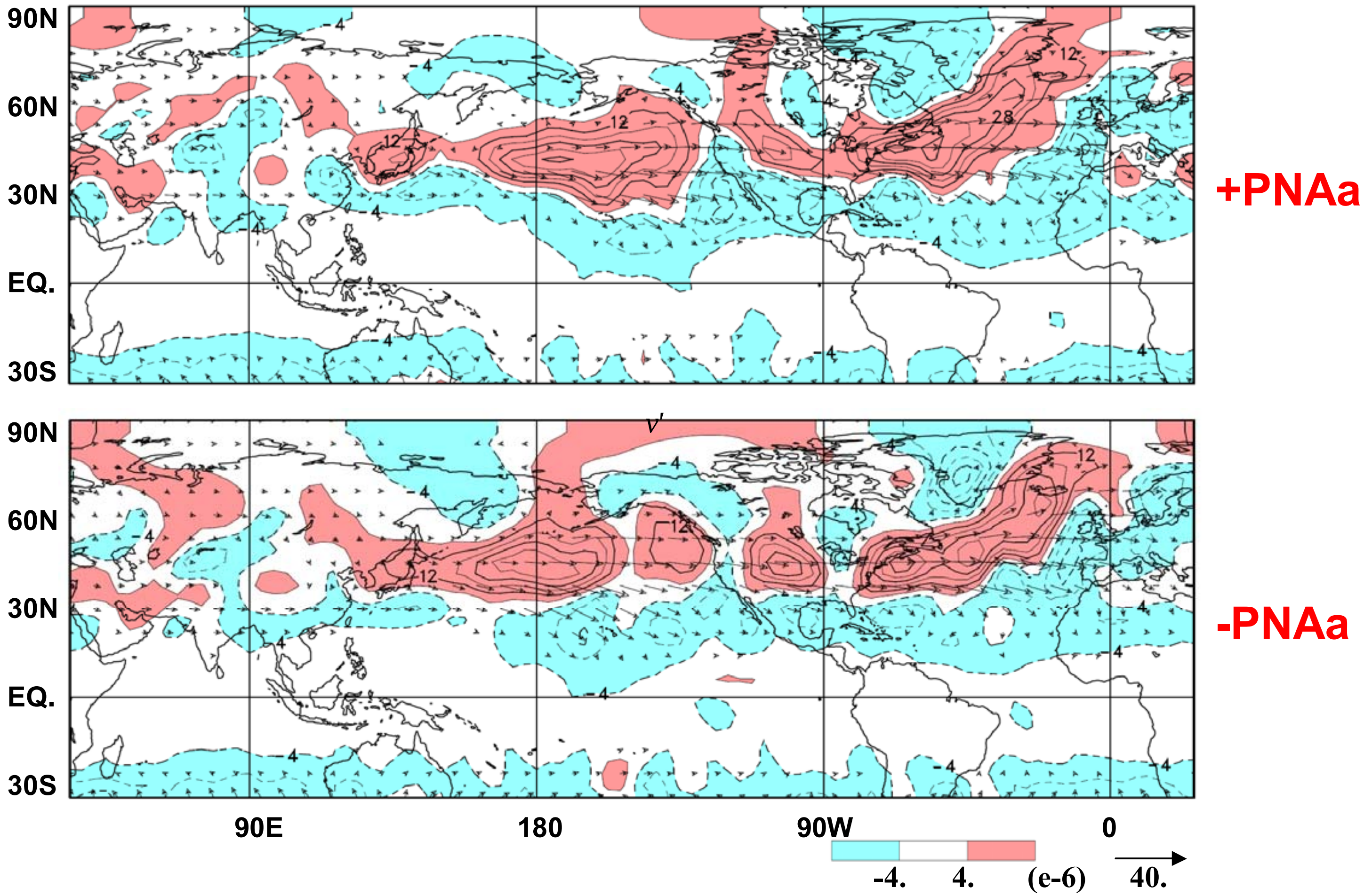
Lag-Corr. between PNAa and Q_d(35-45N,180-120W)



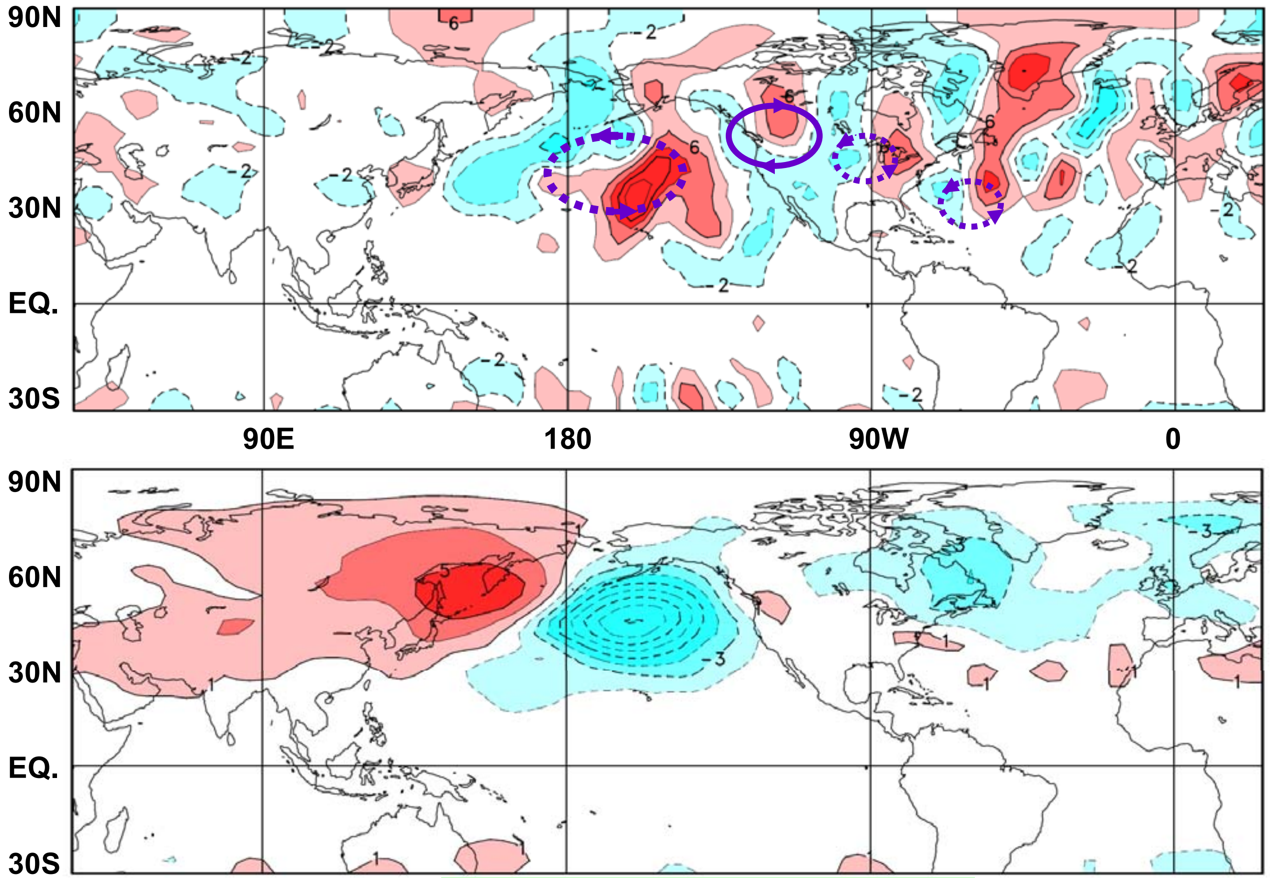
Positive phase of PNAa (Aleutian Low)



$\mathbf{E}=(\overline{v'^2-u'^2}, -\overline{u'v'})$ and $\nabla \cdot \mathbf{E}$ at 200hPa



Synoptic eddy feedbacks
(+PNAa *minus* -PNAa)

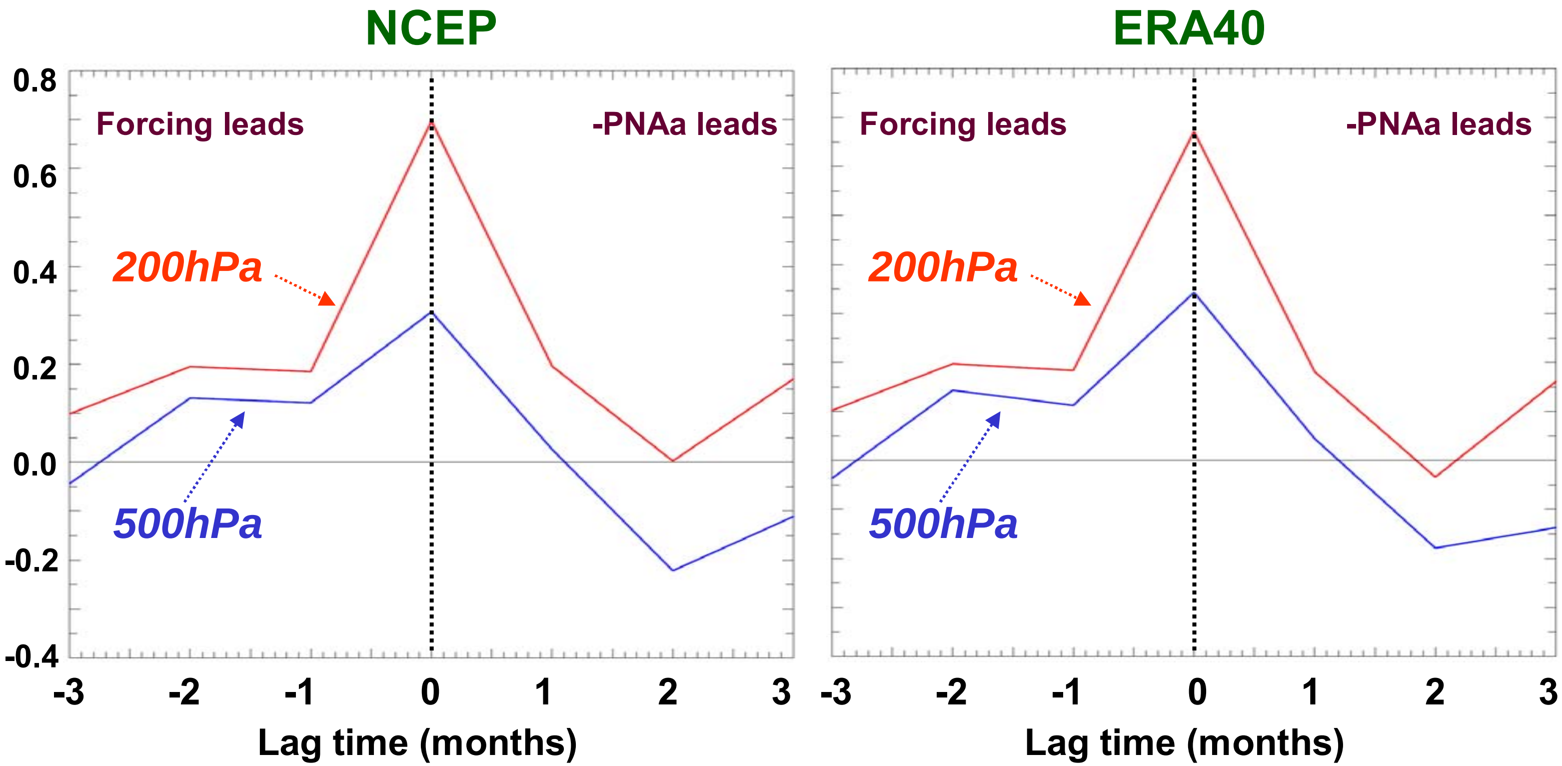


$\nabla \cdot \boldsymbol{E}$

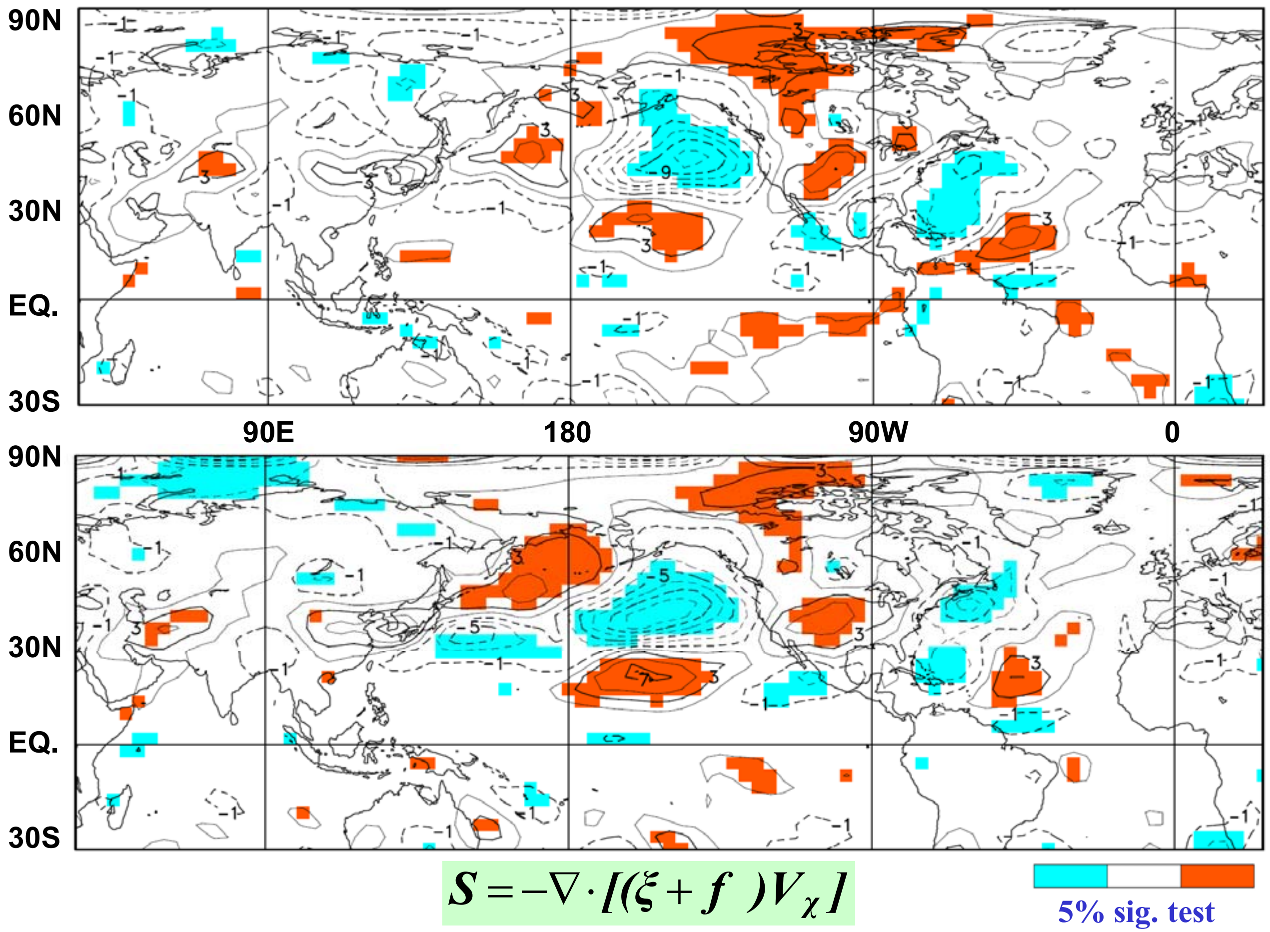
$\partial \overline{\Phi} / \partial t$

$$\partial \overline{\Phi} / \partial t \cong f \nabla^{-2} [-\nabla \cdot (\overline{u' \xi'})]$$

Lag-Corr. between -PNAa and HF-eddy forcing over (35-45N,180-120W)



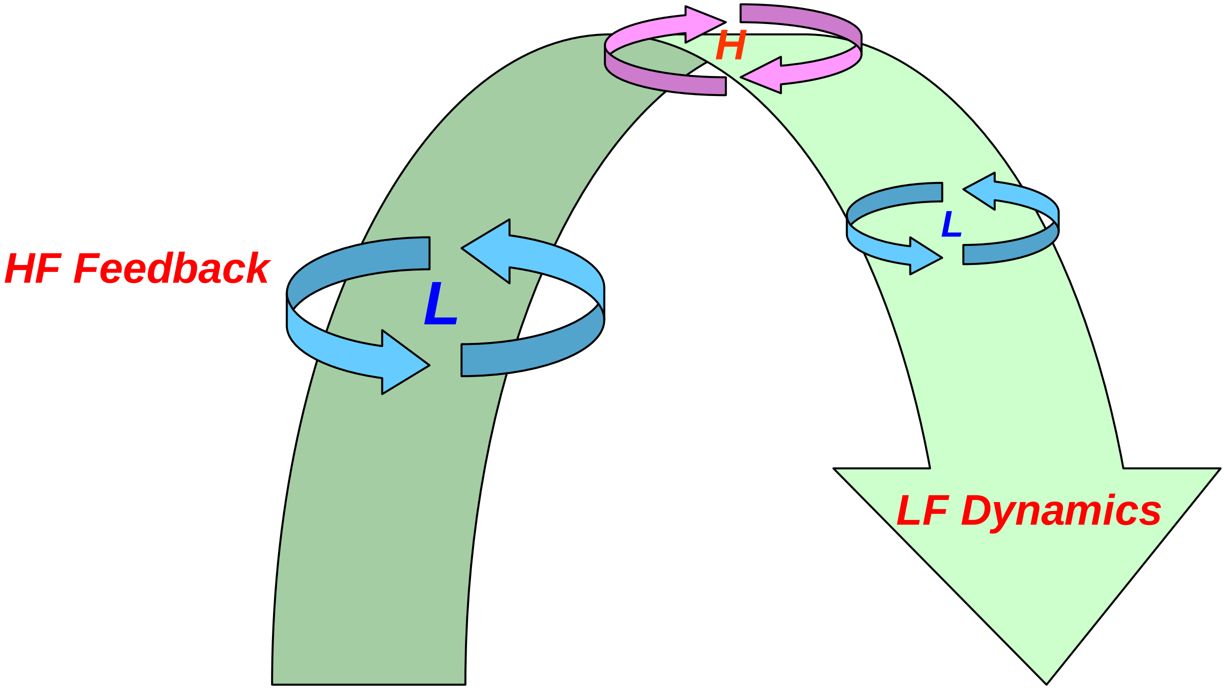
Rossby wave sources *(S)* at 200hPa
(+PNA *minus* -PNA)



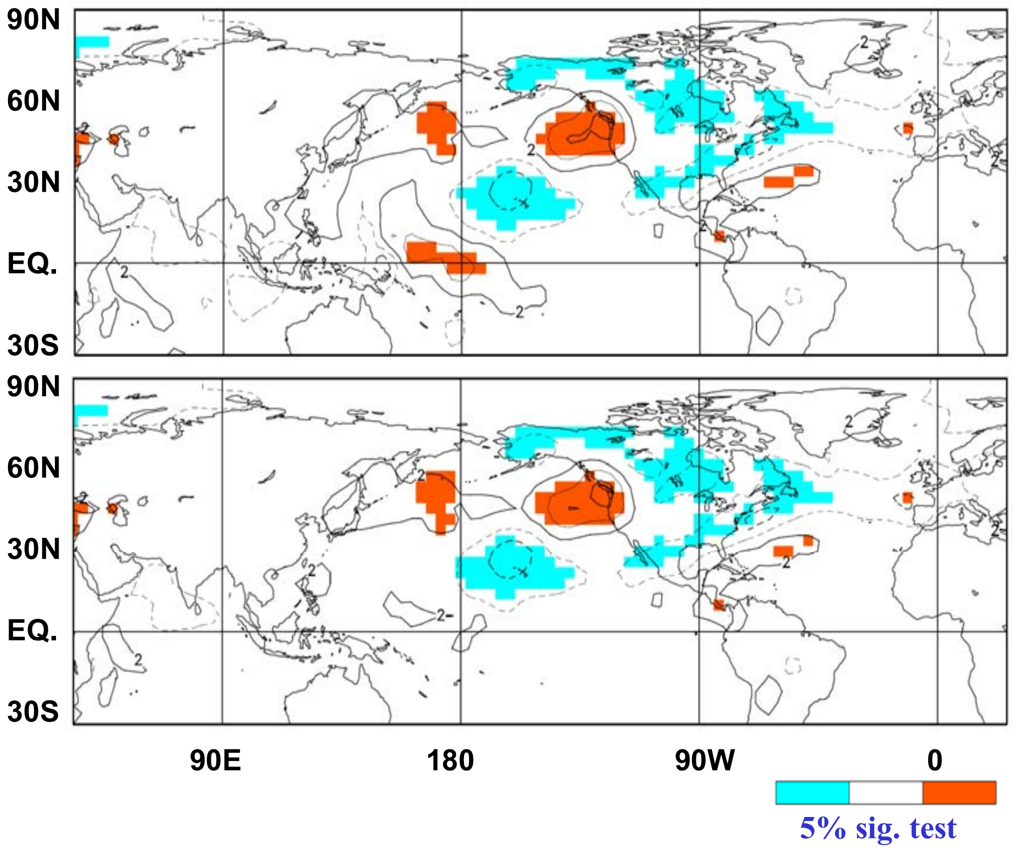
Removing ENSO

$$S = -\nabla \cdot [(\xi + f\ )V_{\chi}]$$

Positive phase of PNAa



Vertically integrated heating $\tilde{Q}$ anomalies



Removing ENSO

(based on a 1000yr-CGCM simulation, heating regressed on PNA)

Summary

a. PNA-related diabatic heating

- is dominated by a north-south dipole structure in the eastern Pacific.
- The heating anomalies change sign with height in mid-latitudes, and have the same sign throughout the troposphere in the subtropics.
- The independence of the PNA on ENSO from the heating viewpoint.

b. Over the North Pacific

- The mid-latitude depression leads to enhanced precipitation.
- The anomalous heating is supported by the anomalous advection of potential temperature by the time average motions.
- The atmospheric heating contributes a positive feedback to the PNA.

c. Rossby wave sources exhibit a PNA-like train of forcing anomalies.

The enhanced eddy activity over the NP is accompanied by eastward acceleration. The synoptic eddies feedback positively on the PNA centers of action.