Changes of interannual NAO variability in response to greenhouse gases forcing

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- **Motivation**
- **Further observational evidences**
- **Results from an atmospheric GCM (HadAM3)**
- **Summary**

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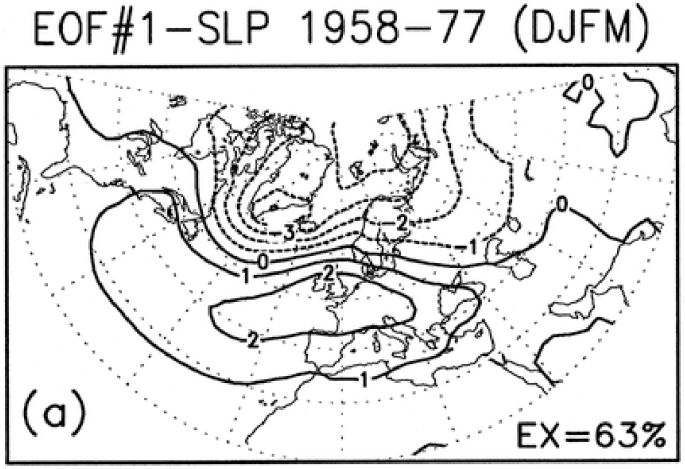
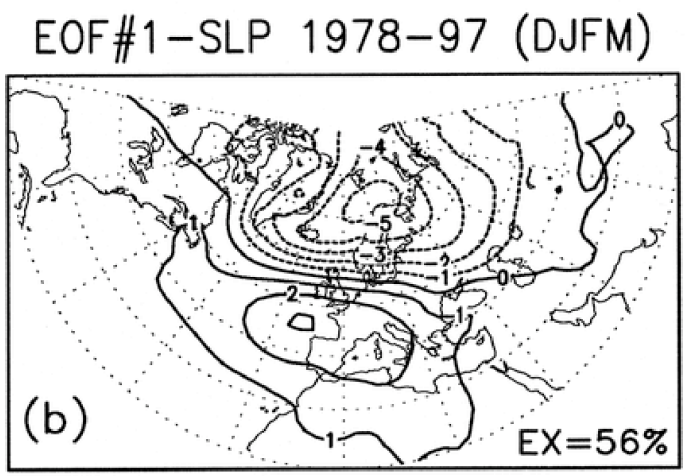
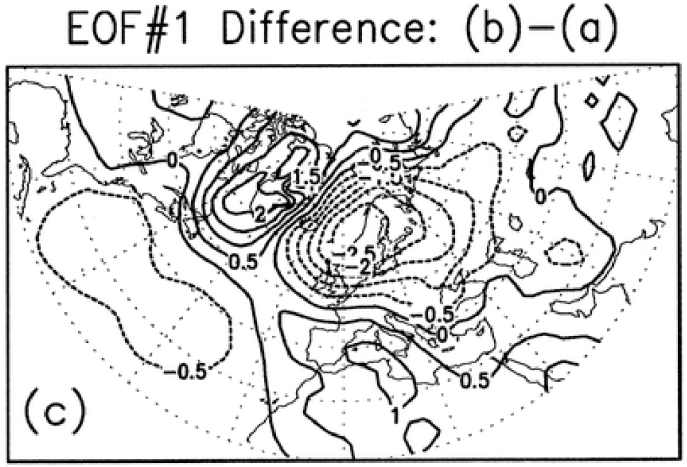
Motivation







(Jung et al. 2003) based on observations

There was change in interannual NAO variability in later 1970s. The change was characterized by an eastward shift of NAO action centres of interannual variability.

Questions

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1. **What is the change of the climatic impact associated with the eastward shift of interannual NAO variability?**

2. **What has caused this change in the interannual NAO variability. Previous studies using CGCMs (e.g., Ulbrich and Christoph 1999, Hu and Wu 2004) suggested that CO_2 change might have played a role.**

3. **What are the separate role of SST forcing and CO_2 forcing for the change in the pattern of NAO interannual variability?**

4. **What are the physical mechanisms responsible for this change?**

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Data used and model experiments

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Observations: HadSLP2 (1945-2004), NCEP analysis (1948-2004).

Model simulations: HadAM3, 2.5° in latitude and 3.75° in longitude and 19 vertical levels

Experiments	Forcings	Equilibrium
Control	1961-1990 mean monthly SSTs from HadISST. CO_2: 332 ppmv	2x25 years
CO_2 only	Same as control, CO_2: 664 ppmv	2x25 years
SSTA only	1961-1990 mean monthly SSTs plus the SST anomalies (derived from the HadCM3 simulation with 1% increase in CO_2 concentration at the time of CO_2 doubling). CO_2: 332 ppmv	2x25 years
CO_2 and SSTA	Combination of CO_2 only and SSTA only	2x25 years

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Change of interannual NAO variability (Observations)

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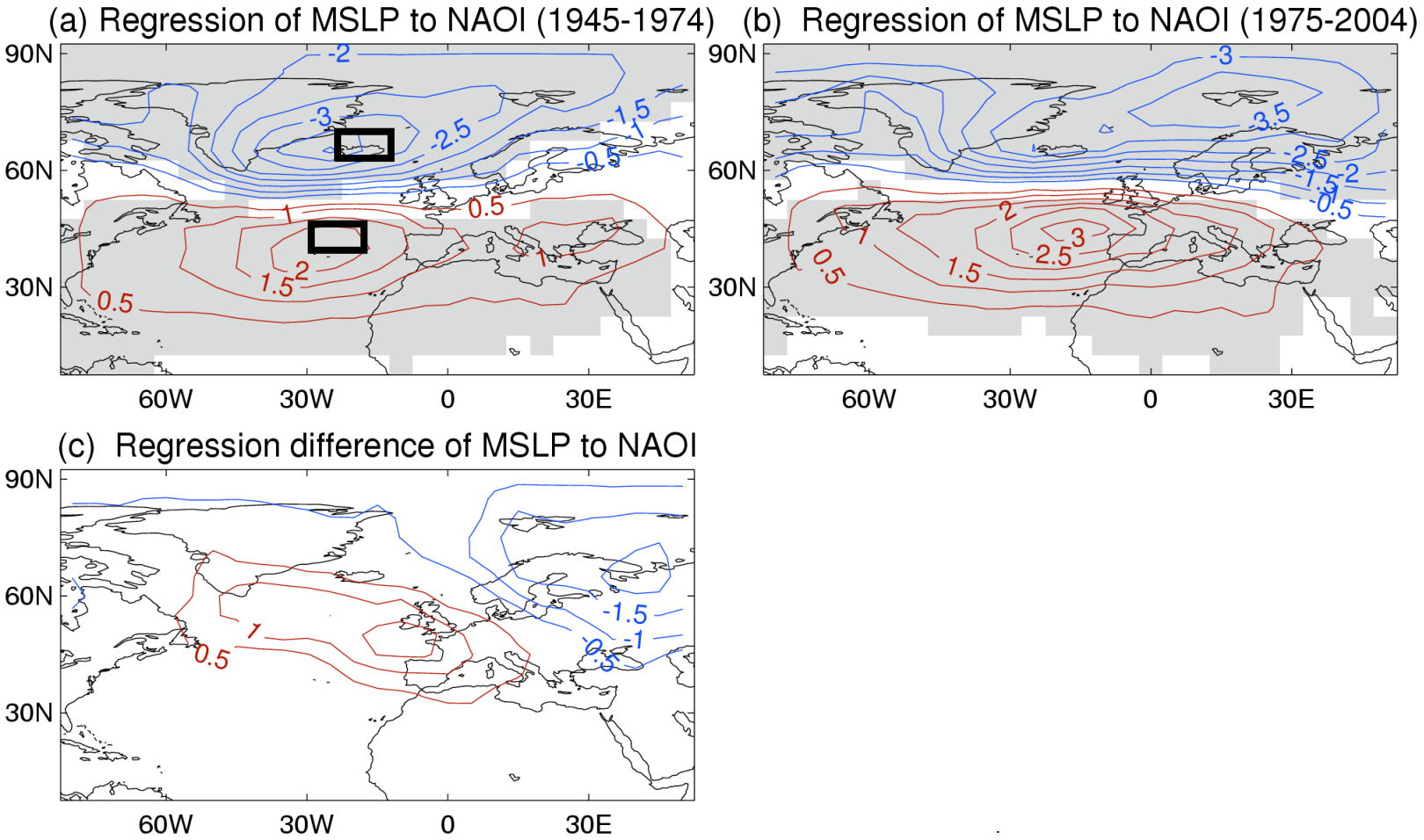

Observations show that centres of action of interannual variability of NAO were located farther eastward during the period 1975-2004 compared to the period 1945-1974 . Sdv (NAOI) =6.4 hPa and 5.9 hPa respectively.

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Changes of zonal wind at Atlantic associated with NAO during two periods (Observations)

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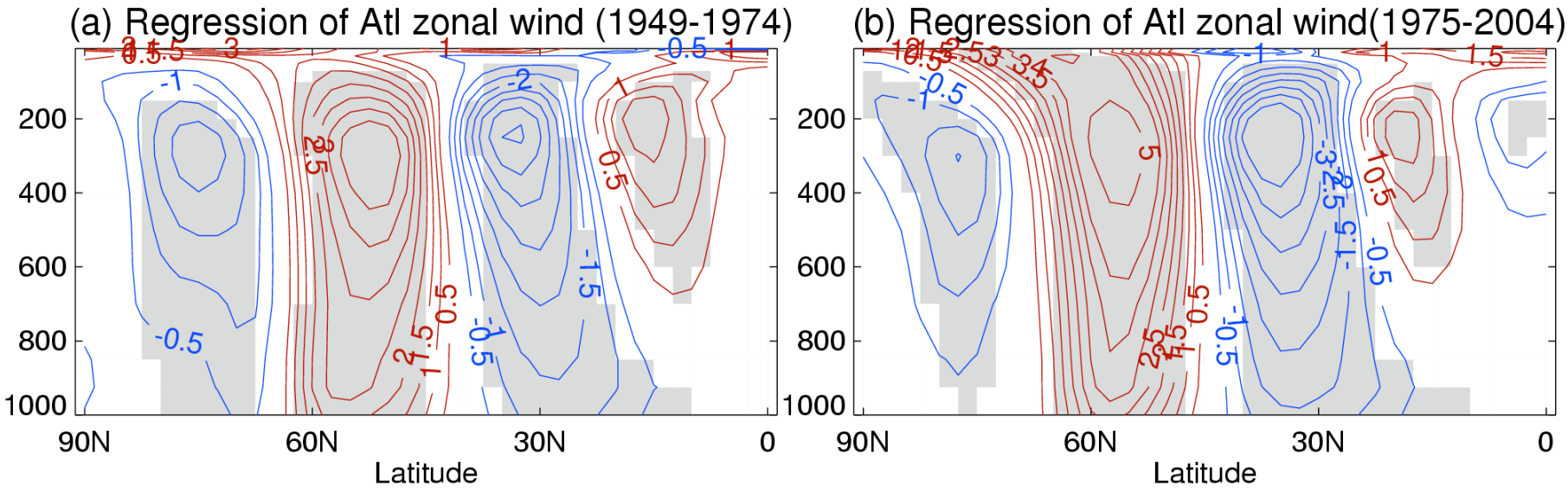

Zonal wind anomalies associated with NAO shifts poleward by about 5 latitudes in the later period relative to the period of 1949-1974. Another distinct feature in the later period is the large zonal wind anomalies in the stratosphere.

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Changes of surface air temperature associated with NAO during two periods (Observations)

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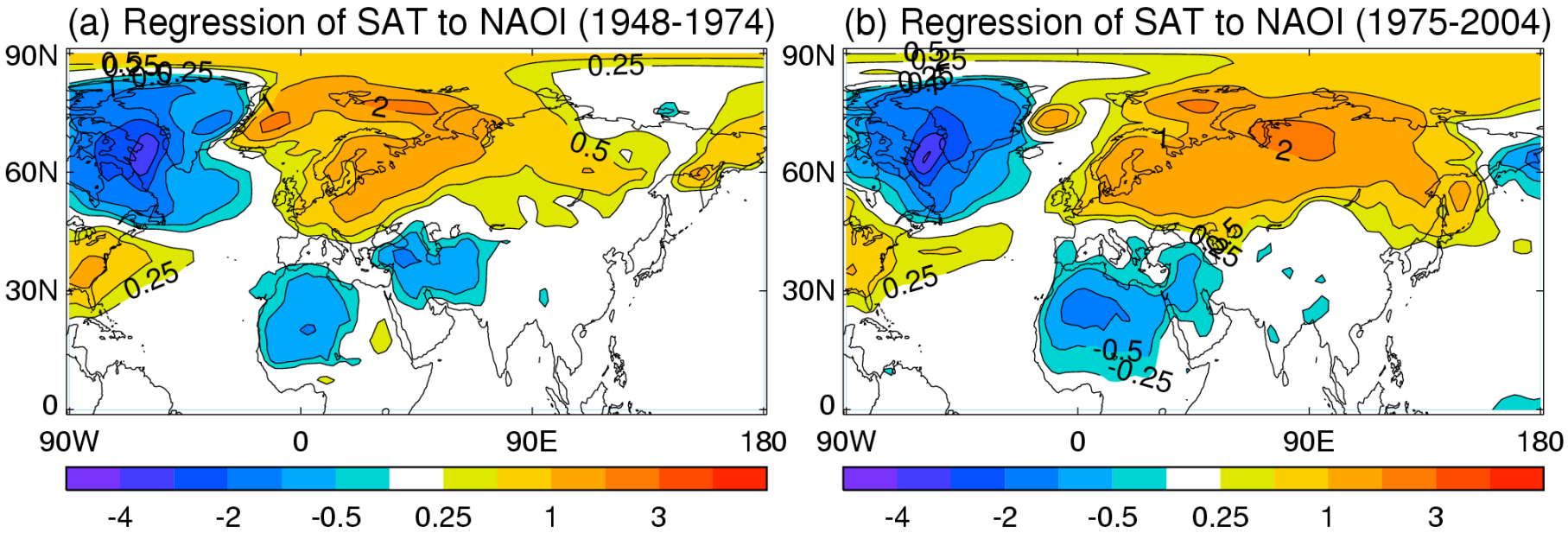

Eastward shift of surface air temperature anomalies associated with NAO during the period 1975-2004 compared to the period 1950-1975.

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Change of interannual NAO variability in response to different forcings

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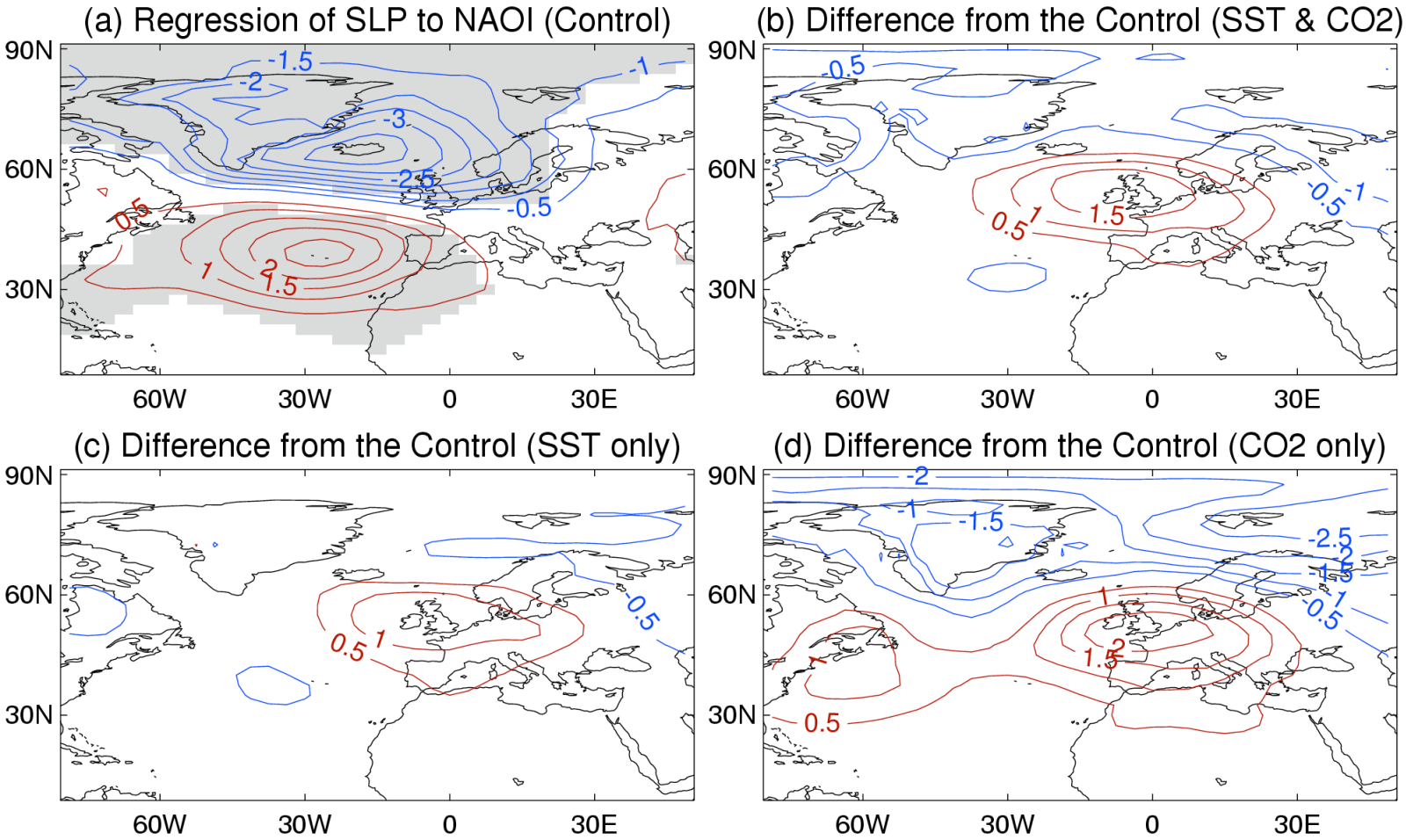

Both SST and CO_2 changes independently force an eastward shift in interannual NAO variability, similar to that seen in observations. Sdv (NAOI) = 6.4, 6.1, 5.8, and 7.8 hPa respectively.

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Changes of zonal wind at Atlantic associated with NAO in response to different forcings

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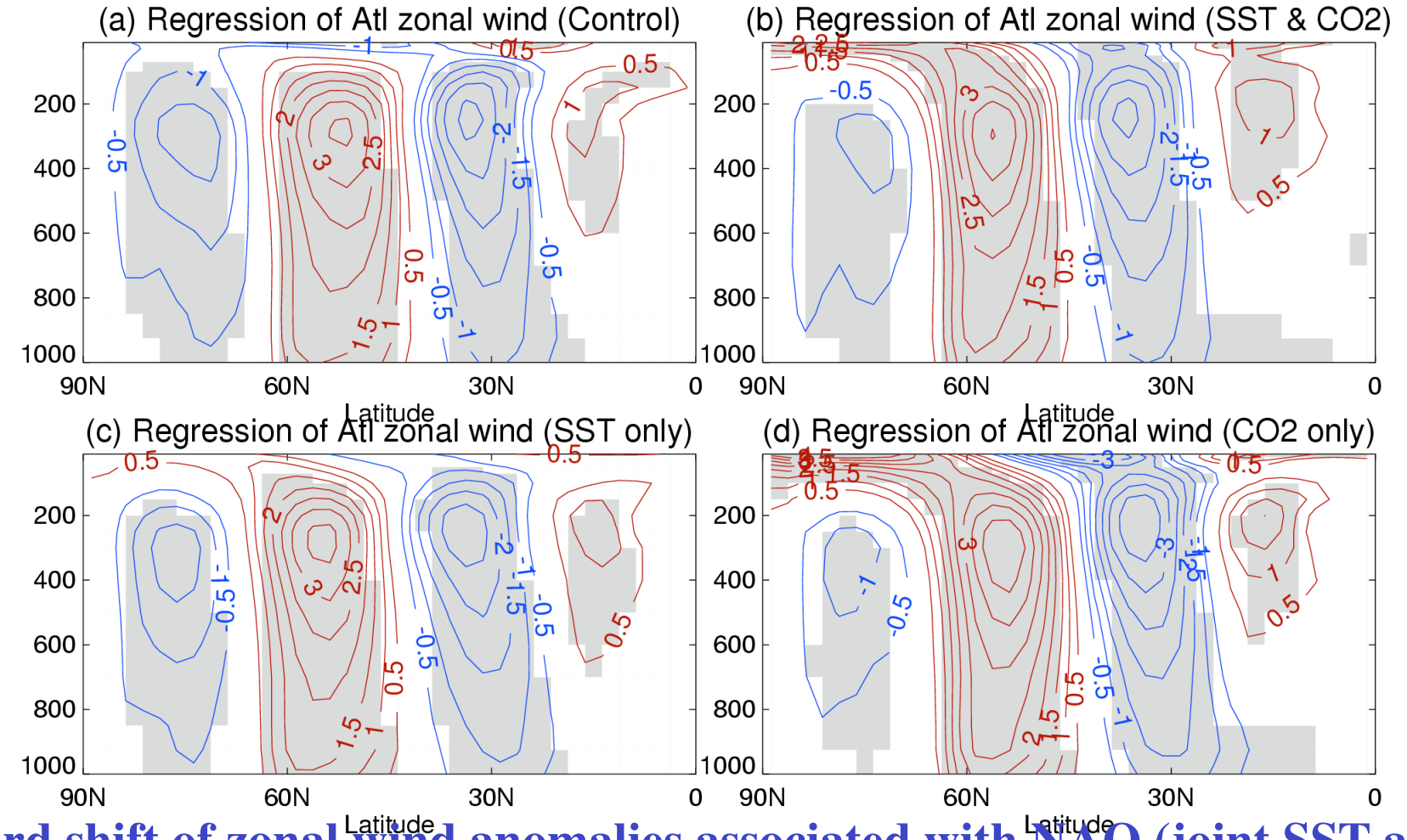

Poleward shift of zonal wind anomalies associated with NAO (joint SST and CO_2 change), similar to those based on observations. Poleward shift in the response to either SST change or CO_2 change. Strong connection with the stratosphere in response to CO_2 .

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Changes of surface air temperature associated with NAO in response to different forcings

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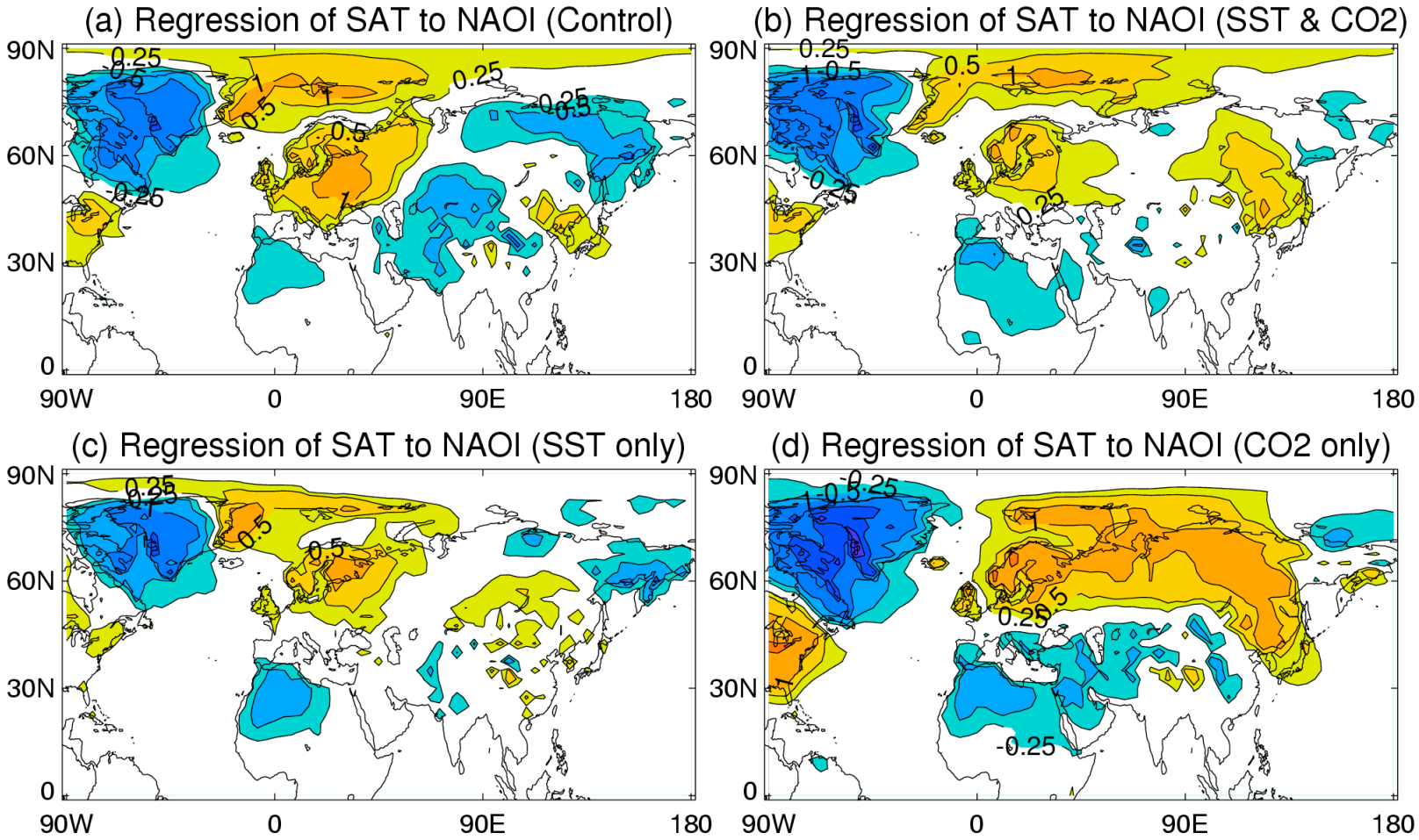

Eastward shift of surface air temperature anomalies associated with NAO in response to joint SST and CO_2 change, separate SST change, and CO_2 change.

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Understanding responses of interannual NAO variability in model experiments (mean responses)

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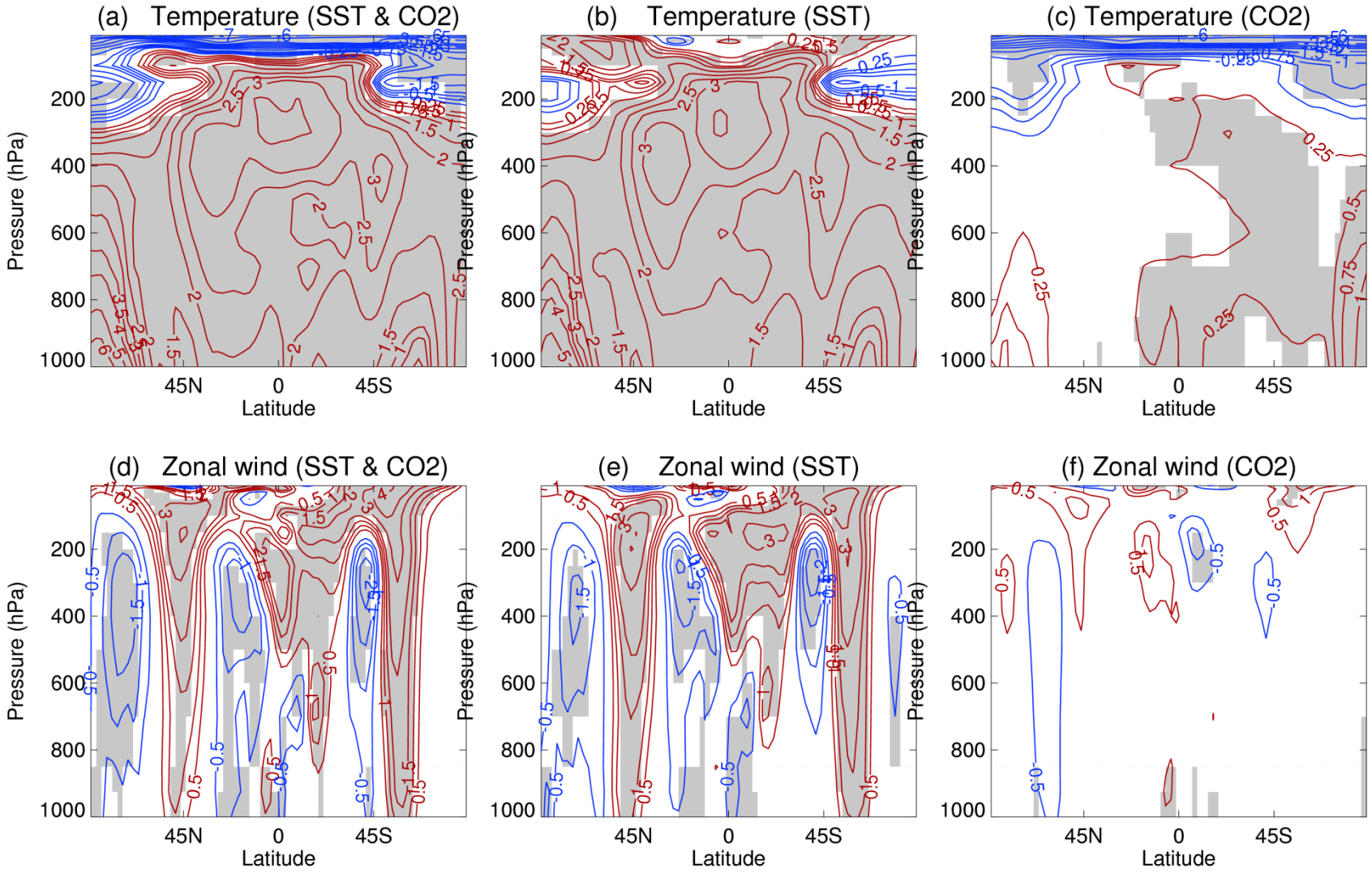

Large upper tropospheric warming in the tropics in response to SST change and enhanced polar vortex in the stratosphere in response to CO_2 change.

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Understanding responses of interannual NAO variability in model experiments (mean responses)

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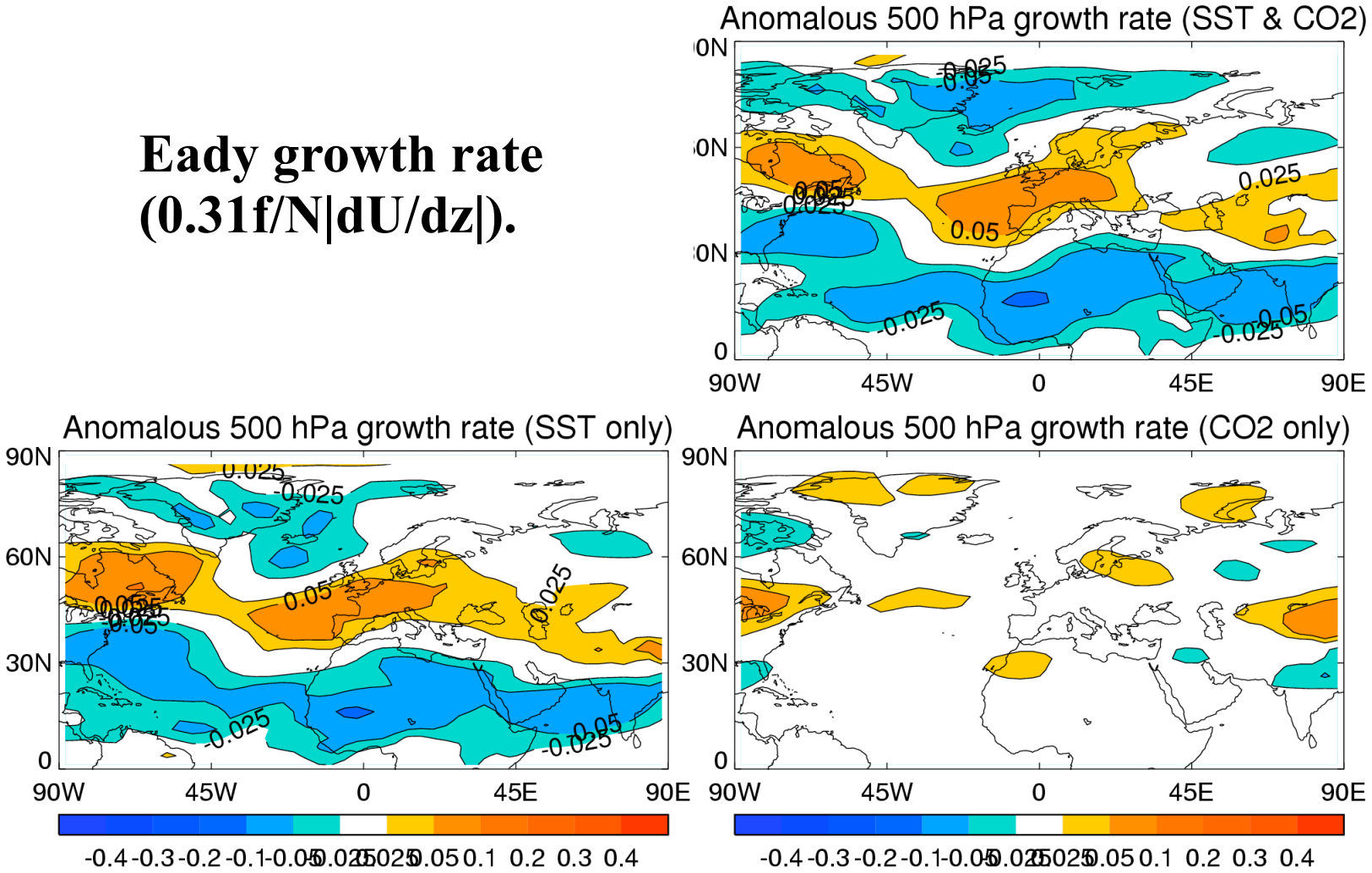
Eady growth rate (0.31f/N|dU/dz|).



Downstream extension of Eady growth rate in the mid-troposphere in response to SST change. Little change with CO_2 forcing.

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Summary

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- Observations show there was a change in interannual NAO variability in later 1970s. This change was characterized by an eastward shift of the NAO action centres and downstream extension of climate anomalies associated with NAO.
- Both SST and CO_2 changes independently force an eastward shift in interannual NAO variability, similar to that seen in observations.
- The effect of SST change can be understood in terms of mean changes in troposphere, especially Eady growth rate.
- The effect of CO_2 change can not be understood in terms of mean changes in troposphere. This implies that stratospheric change might play an important role in recent eastward shift in interannual NAO variability and related climate anomalies.

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