

On the coupled interdecadal variations of the extra-tropical surface air temperature and the isentropic meridional air mass transport in Northern winter

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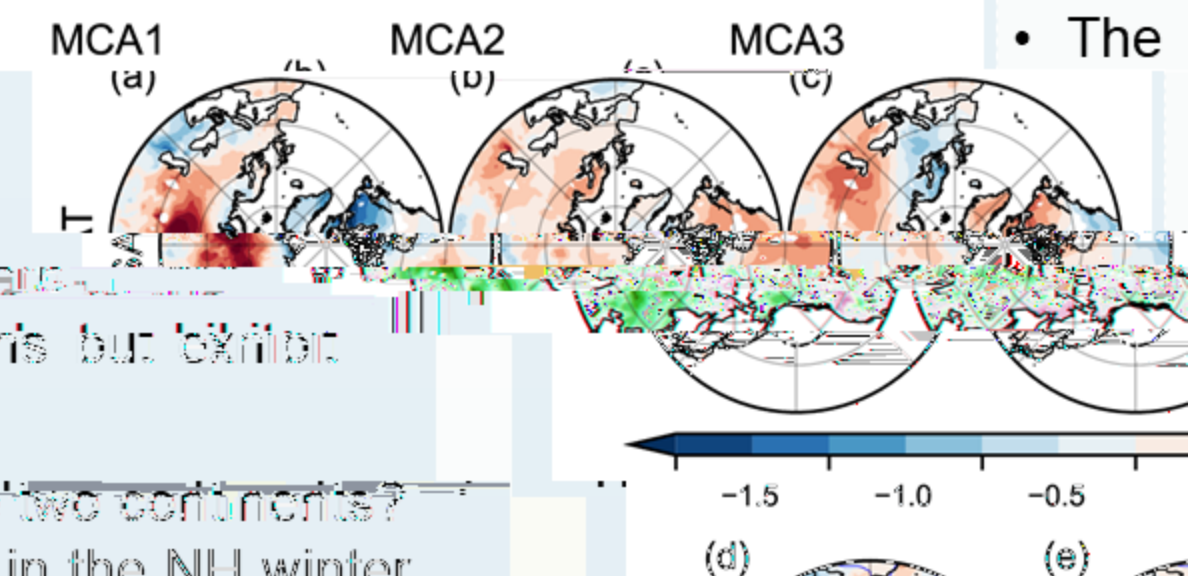
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Motivations

On top of the long-term global warming, the winter surface air temperature (SAT) exhibits significant interdecadal changes. Decadal changes of the winter continental SAT show

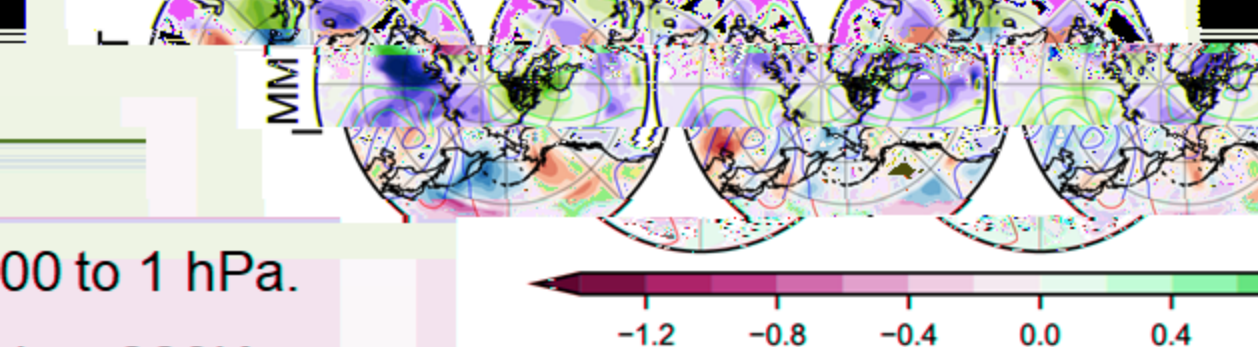
ambiguity: they may not always be in-phase between the two continental regions but exhibit complex zonal features.

- (1) What's the dominant interdecadal changes of the winter SAT between the two continents?
- (2) What's the coupled relationships between the winter SAT and the IMMT in the NH winter at decadal time scale? (3) Possible forcing of this coupled interdecadal variation?



The first three leading MCA modes explain 90.5% (respectively, 57.7%, 18.9% and 13.8%) of the cumulative squared covariance fraction,

and 0.95 for the MCA1, MCA2 and MCA3. MCA1 represents a 'out-of-phase' pattern between two continents, while MCA2 represents a 'in-phase' both continents.



1974 is a major transition point in the spectrum peak at the period of 33.1 years and exist significant lead-lag correlation (at -14 year and maximum at 12 year).

ERA5 (1950-2020): daily dataset at $1.5 \times 1.5^\circ$ grids and 37 pressure levels from 1000 to 1 hPa.

Isentropic-level Meridional Mass Transport (IMMT): meridional mass transport between two adjacent isentropic surfaces.

ENSO: the annually-interacted IMMT across the equator (SOI) with the ENSO.

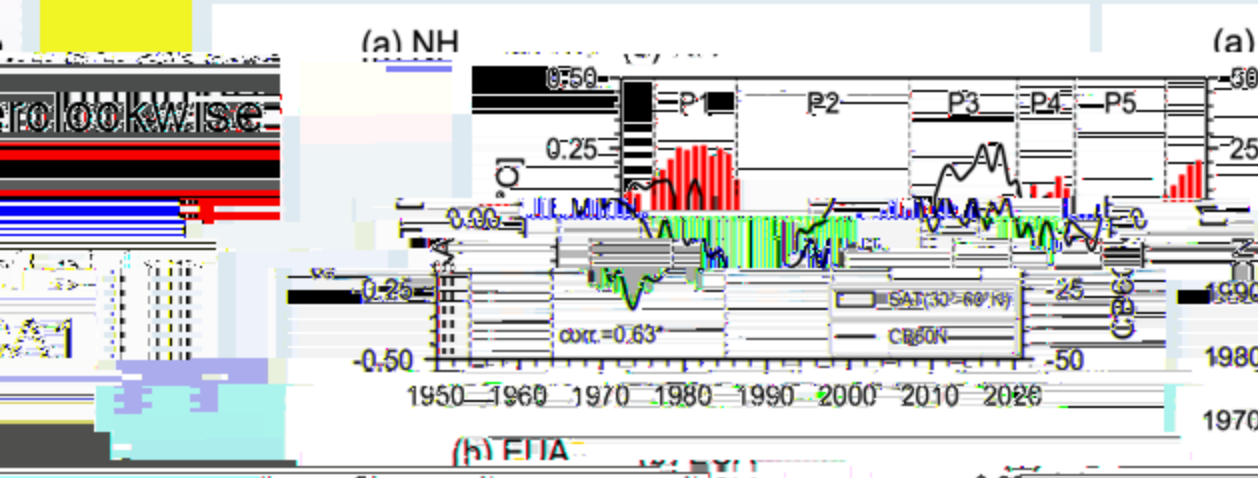
PDO index; AMO index.

Maximum Covariance Analysis (MCA).

Fig.5 The first three leading MCA patterns between the decadal evolution of SAT and IMMT.

Winter SAT dominated by changes

Interdecadal variation of the winter SAT



The state vector representing the evolution of the coupled T-MCA1 and T-MCA2 explains up to 45.5% of EUA-SAT, while MCA2-reconstructed SAT timeseries can explain up to 43.7% of NA-SAT (not shown).

The decadal SAT variations

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The phase variation against the coupled T-MCA1 and T-MCA2 evolves in a clockwise direction before 1974, but in a counterclockwise direction thereafter.

MCA1 before 1974, but the lag of the MCA1 is shorter.

Both cold and warm events are coupled.

This coupling basically indicates the dominant role of the dynamical transporting process.

overall SAT changes.

the PDO/AMO and T-MCA1 for the period of (a) 1950-1974 and (b) 1975-2020.

PDO/AMO and MCA1 in 1950-1974. (d-f) Are the same to (a-c) for the T-MCA2.

PDO and T-MCA1 are positively correlated with each other in general. PDO mainly lags the T-MCA1 in

the western Europe may always consistent SAT the Asian region and the

relationship between the AMO and PDO after 1975 probably further contributes

the PDO-regressed patterns

of the SAT and IMMT at a 0-lag resemble that of the MCA1 (EUA-warmer), while PDO-regressed patterns at a 14yr lag (12yr lead) resemble

the sub-route over Eurasia explain the not anomalies between Eurasian region

accompanied by low

mass centres

Summary

- The interdecadal variation of winter SAT is closely coupled with changes of the IMMT, which can be well represented by the first two leading MCA modes between SAT and IMMT.

- The MCA1 and MCA2 are significantly associated with the PDO which dominates the much-intensified MCA1 and the related 'EUA-warmer/colder' SAT pattern since 1975.

Fig.4 Composite anomalies of isentropic mass flux