Effect of mid 1970's climate shift on the relationship between wintertime Ural blocking and East Asian winter climate

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BACKGROUND

Wintertime Ural blocking (UB) is very important for the East Asian winter climate

- Synoptically, it may cause the amplification of Siberian High (SH) and subsequent cooling over East Asia (*Ding and Krishnamurti 1987; Takaya and Nakamura 2005*)
- Climatologically, strong UB is a typical feature of strong East Asian winter monsoon (EAWM) (*Lau and Li 1984*)
- Therefore, to understand the East Asian climate requires a thorough investigation of the UB variability
- However, the interannual variations of UB in mid-winter has not been studied before.

Atmoshperic Circulation changed significantly around mid-1970s

- The deepening of the Aleutian Low (*Trenberth and Hurrell 1994*)
- The weakening of the SH (*Panagiotopoulos et al., 2005*)

PURPOSE OF THIS STUDY

1. Investigate the circulation patterns associated with UB as well as its relationship with the downstream East Asian winter climate in midwinter during the last four decades.
2. The mid-1970s climate shift on the UB-EA climate relationship.
3. Possible reasons for the UB-EA relationship change.

DATA AND METHODS

Data:

- Daily ERA40 reanalysis
  - to detect blocking events
- Monthly ERA40 reanalysis
  - to construct monthly and winter-mean blocking index

Methods:

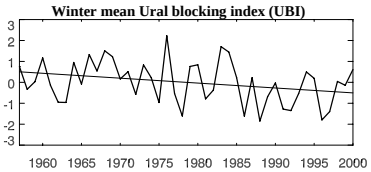
- Automatic blocking detection method (*Barriopedro et al. 2006*)
  - to detect blocking events at each grid point
- Definition of Ural blocking index (UBI) for winter mean condition

$$UBI = \frac{\langle \Delta Z_b, \Delta Z_m \rangle}{\langle \Delta Z_b, \Delta Z_b \rangle}$$

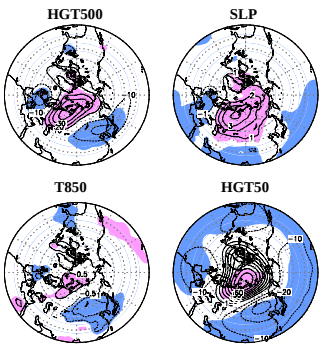
where the brackets denote a squared norm inner product (the normalized projection), and ΔZ_m (ΔZ_b) is the monthly (blocking) 500-hPa height anomaly composite over the Ural sector (30°E-90°E). The Blocking patterns are in turn obtained by compositing the 500-hPa height anomalies for all the days belonging to the Ural blocking episode using daily-mean geopotential height field.

- Therefore, positive UBI represents high frequency of blocking activities, and negative UBI represents strong zonal flow regime in the Ural region.

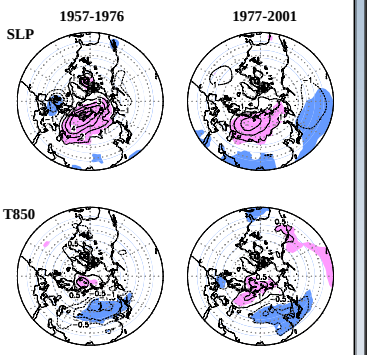
RESULTS



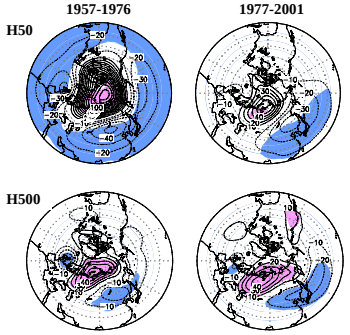
There is a large interannual variation of the blocking activity over the Urals, and a significant (confidence level above 99%) decrease of the frequency of blocking activity during the last four decades.



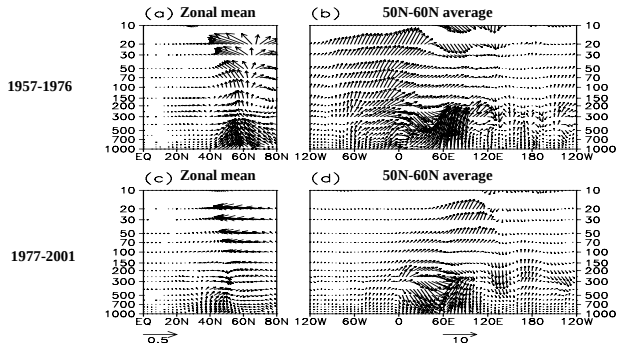
The circulation anomalies associated with high Ural blocking occurrence reveal a quasi-barotropic wave-train-like structure over the Eruasian continent extending from the surface to the lower stratosphere. It exerts a strong impact on the East Asian winter climate, namely, the drop of lower tropospheric air temperature over the East Asia, which results from the cold air advection downstream of the blocking high.



After mid-1970s climate shift, there is a clear eastward extension of Ural blocking signal.



It is associated with an oscillation of the UB signal between troposphere and stratosphere.
More S-signal → Less eastward T-signal
Less S-signal → More eastward T-signal



The stratospheric polar vortex is in its weak regime before 1976/77 (*Christiansen 2003*), which favors the upward propagation of planetary waves and the stratosphere-troposphere coupling. As a consequence, the Ural blocking signal tends to propagate more upward into the stratosphere and less eastward to East Asia, and UB is less related to the East Asian winter climate. After the regime shift, the upward propagation of planetary waves is suppressed due to the strong stratospheric polar vortex. Therefore, the eastward propagation is intensified, which leads to a closer UB-East Asian winter climate.

CONCLUSIONS

1. The interannual variation of Ural blocking activity is found to be strongly related to that of the East Asian winter climate.
2. The UB-East Asian winter climate relationship has been influenced much by the shift of mid 1970's climate change. After the mid 1970s, the Ural blocking signal propagates more eastward to East Asia and it tends to exert more influence on the East Asian winter climate. The stronger coupling between UB and SH amplifies the impact of Ural blocking on East Asia, which contributes to the higher frequency of warm winters in this region.
3. The stratospheric polar vortex and its modulation on the propagation of atmospheric stationary waves are likely responsible for this change, with the key area being located in the North Atlantic region.

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