Influences of the preceding winter Northern Hemisphere annular mode on spring extreme low temperature events in the north of eastern China

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1. Introduction

The Northern Hemisphere annular mode (NAM) is a major planetary-scale pattern of climate variability in the Northern Hemisphere, which is characterized by an out-of-phase relationship in the strength of the zonal flow along 65° N and 35 ° N (Li and Wang, 2003).

Much evidence demonstrates that the NAM has a broad and important influence on the climate of the Northern Hemisphere, as well as the atmospheric circulation in Asian (e.g. Thompson and Wallace, 2001; Ding and Li, 2005). However, less attention has been paid on the relationship between the NAM and extreme temperature events in China. Here we try to preliminarily interpret influences of the preceding boreal winter (December-February) NAM on spring extreme low temperature events in the north of eastern China (NEC).

2. Data and method

Four datasets are employed in this study: the homogenized 549 National Standard Stations (NSSs) dataset in China (Li and Yan, 2009), the NCEP/NCAR reanalysis monthly data, including geopotential height, wind field, vertical velocity and surface radiation, (Kalnay et al., 1996) of 1959-2008, continental snow cover areas for Eurasia calculated by Rutgers University Climate Lab and global monthly satellite-derived Snow Water Equivalent (SWE) data for period from 1978 to 2007. Correlation and composite analysis are adopted here.

➢The five extreme low temperature indices used here are based on the definitions of CLIVAR Expert Team:

a. Cold nights (**TN10p**): Percentage of days when daily minimum temperature (Tmin) < 10^{th} percentile

b. Cold days (**TX10p**): Percentage of days when daily maximum temperature (Tmax) < 10^{th} percentile

c. Minimum Tmin (**TNn**): Minimum value of daily Tmin

d. Minimum Tmax (**TXn**): Minimum value of daily Tmax

e. Number of frost days (**FD**): Monthly count of days when daily Tmin < 0°C

➢ The NAMI is defined as follows (Li and Wang, 2003):

$$\mathrm{NAMI} = [SLP]_{35^\circ\mathrm{N}} - [SLP]_{65^\circ\mathrm{N}}$$

[*SLP*]: Normalized zonal-mean sea level pressure anomaly

3. Relationship between the preceding winter NAM and spring extreme low temperature events

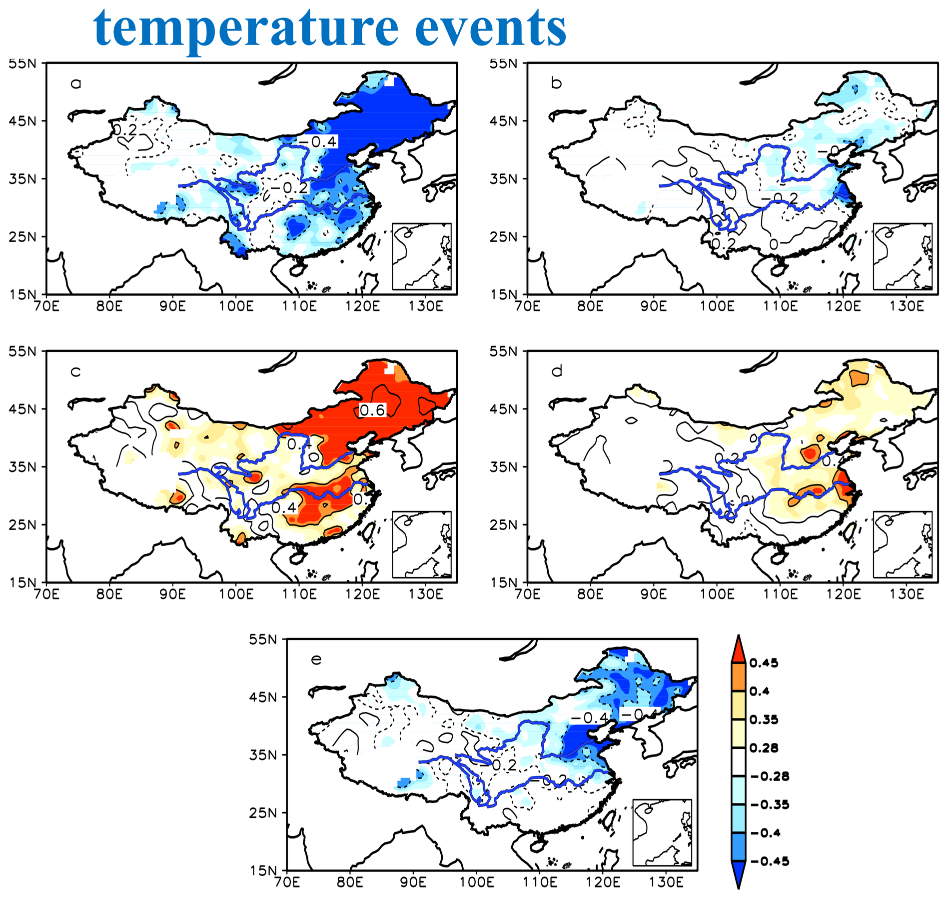


Fig.1 Correlation maps between the preceding winter NAMI and spring extreme low temperature indices in China: (a) TN10p, (b) TX10p, (c) TNn, (d) TXn and (e) FD. Shaded areas denote those correlation coefficients beyond the 95% confidence level.

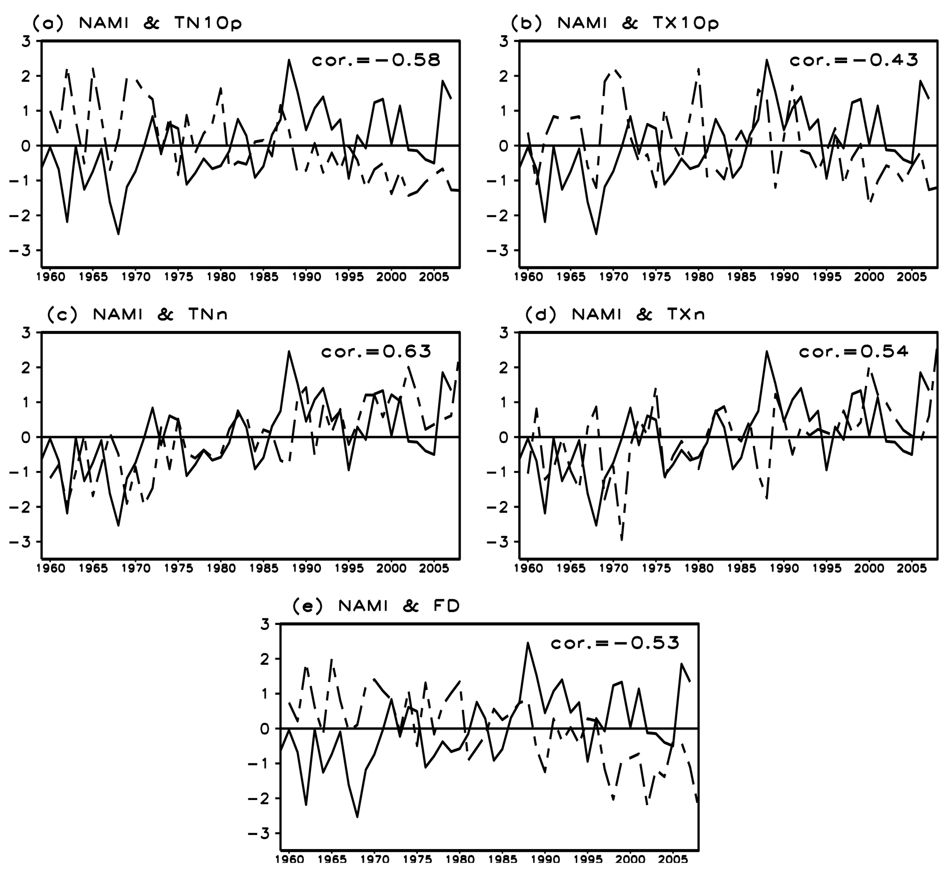


Fig.2 Normalized time series of NAMI (solid line) and the extreme low temperature indices (long-short dashed line) in the north of eastern China (30°–50° N, 110°–130° E).

4. Atmospheric circulation anomalies associated with the NAM, extreme low temperature events and Eurasian snow cover

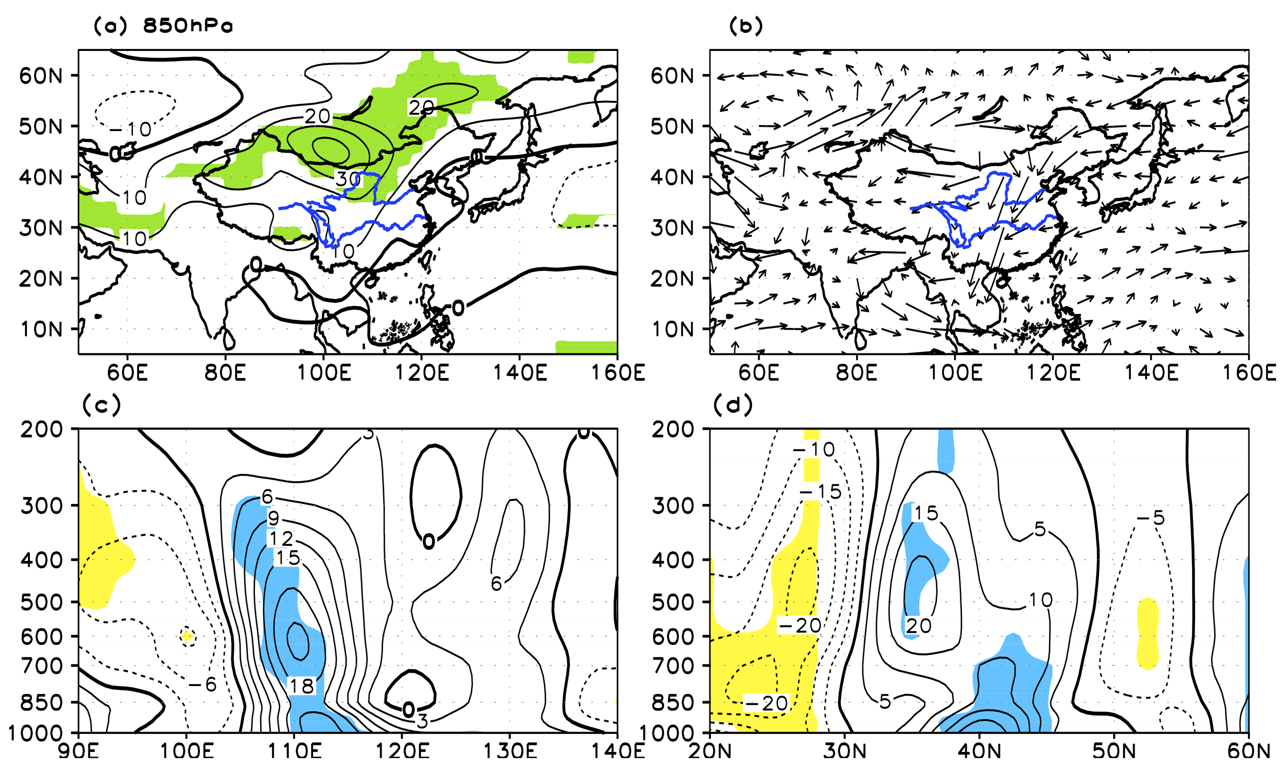


Fig.3 Composite differences of the spring 850 hPa (a) geopotential height (gpm), (b) horizontal wind field (m/s), (c) vertical velocity averaged between 30°–50°N and (d) vertical velocity averaged between 110°– 130° E (10^{-5} hPa/s) between high and low winter NAMI years.

When the preceding winter NAM is stronger, negative and positive geopotential height anomalies are associated in the upper (figure no shown) and lower level over NEC in the following spring, respectively. At the same time, there is anomalous sinking motion accompanied.

Previous studies (e.g. Saito et al., 2004; Bamzai, 2003) have shown that the winter NAM is closely related to the Eurasian snow cover in the following spring. We also find that there is a significant negative correlation between the winter NAM and SWE in 50°–70° N, 0°–120° E at the same time, and the snow anomalies in winter can persist to the following spring.

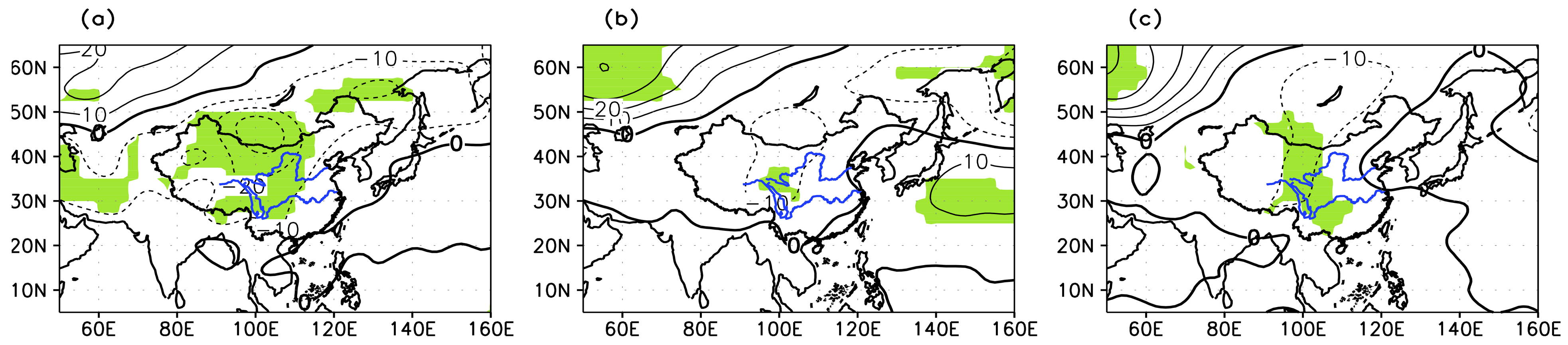


Fig.4 Same as Fig.3 (a), but for the spring (a) TN10p, (b) area of Eurasian snow extent and (c) SWE.

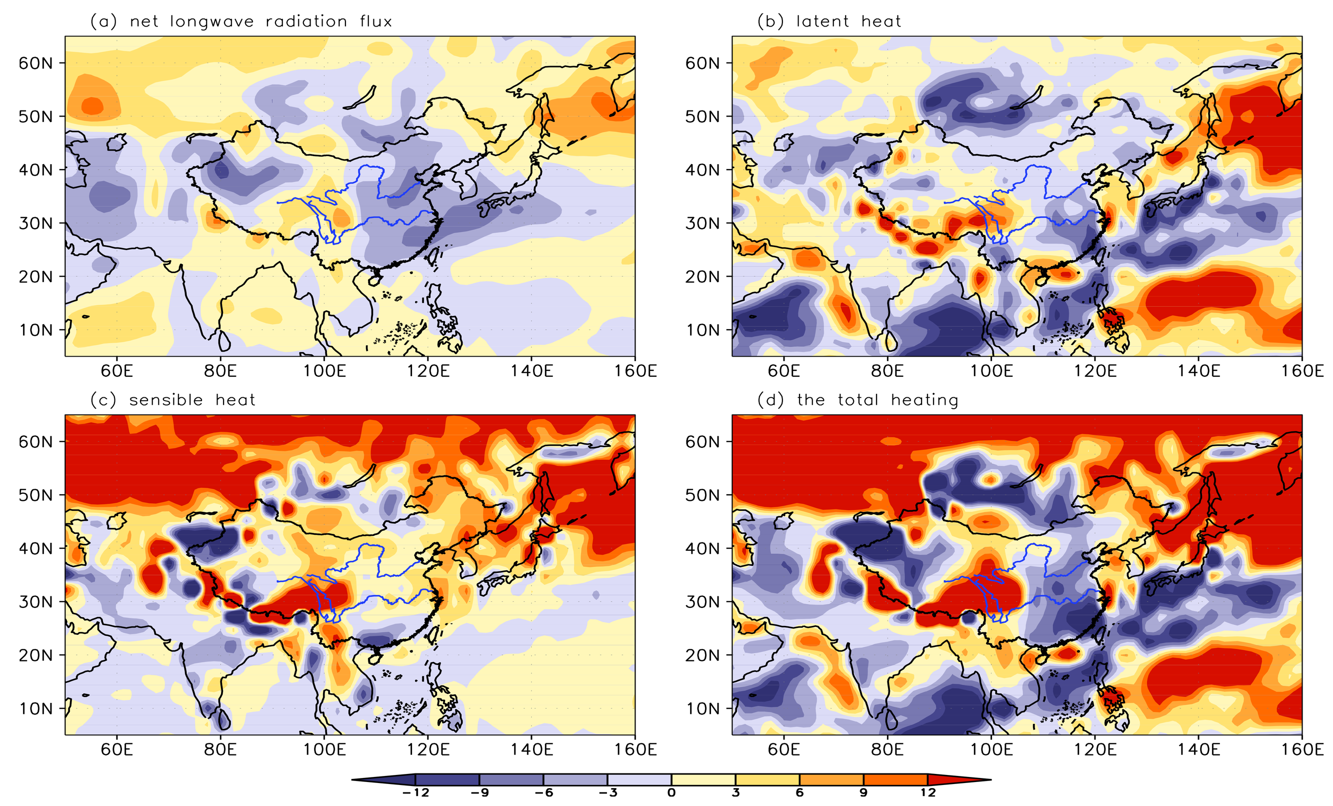
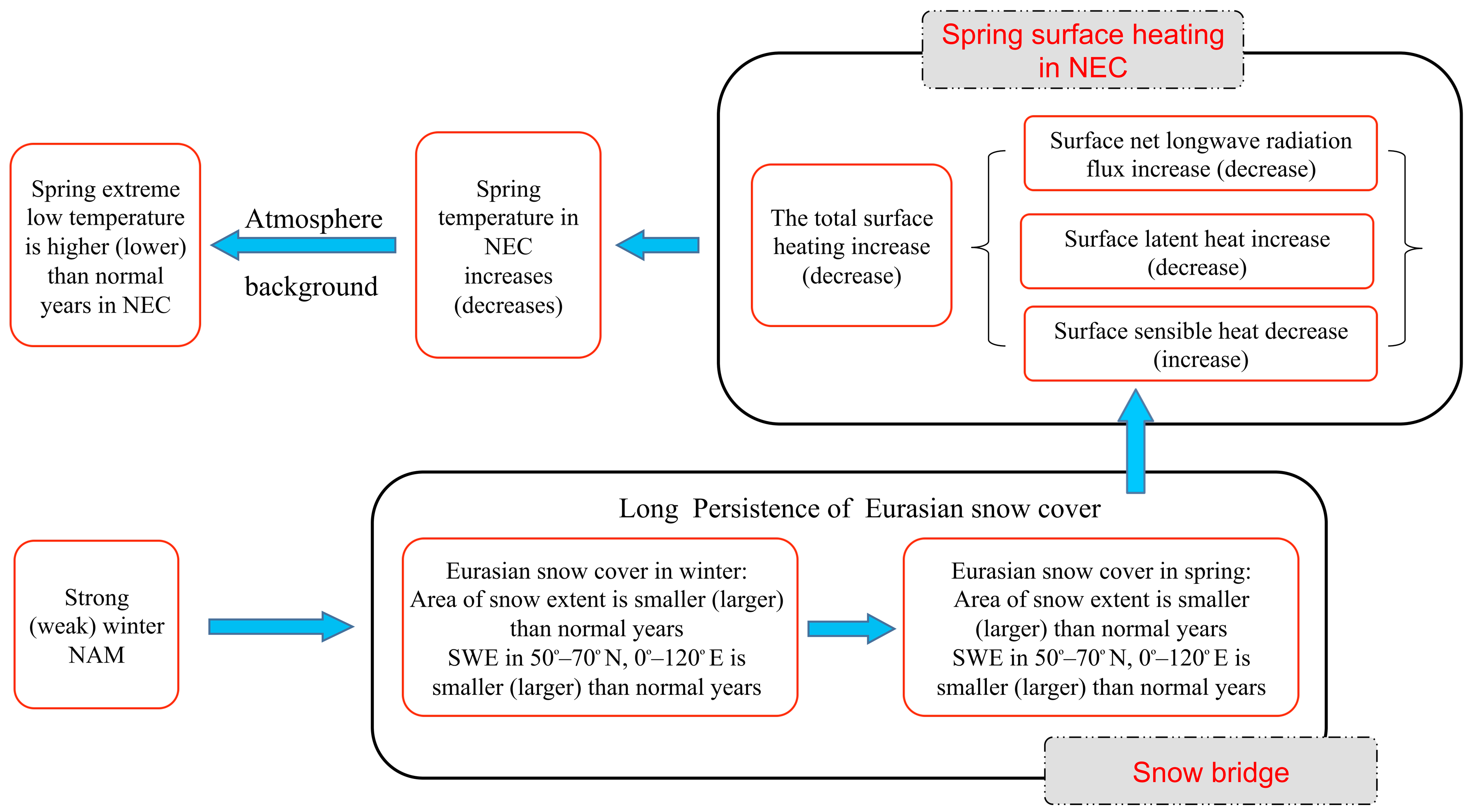


Fig.5 Composite differences of the spring (a) net longwave radiation flux, (b) latent heat, (c) sensible heat and (d) the total heating between large and small spring snow area years.

The results show that when the area of Eurasian snow extent is larger than normal years in spring, the total surface heating is less in NEC. So the air temperature on the ground is lower, and vice verse.

5. Conclusion

1) There exists a significantly inverse relationship between the preceding winter NAM and spring extreme low temperature events in NEC.
2) The pattern of atmospheric circulation in a weak NAM year in winter is similar to that when heavy Eurasian snow and extreme low temperature events in NEC occur in the following spring, vice versa.
3) It is argued that the Eurasian snow cover may be the potential bridge connecting the signals in winter and the following spring. However, it still needs further study on how it works.



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