Snow Change over northern midaltitudes and its potential link to Arctic sea ice loss

Quan Liu

Motivation

- Since the late 1980s, parts of northern midlatitudes have recorded more frequent heavy snowfalls and upward trends of snow cover indices.
- Meanwhile, central Eurasian exhibited a cooling trend in winter, which is suggested to be remotely influenced by Arctic sea ice loss.
- However, a robust clarifying of snow cover change trend and its potential link to Arctic sea-ice loss is lacking.

Fast Multidimensional Ensemble Empirical Mode Decomposition (fast-MEEMD)

New data-driven approach to decompose spatial-temporal data into multi-waving-components and a time-varying trend.

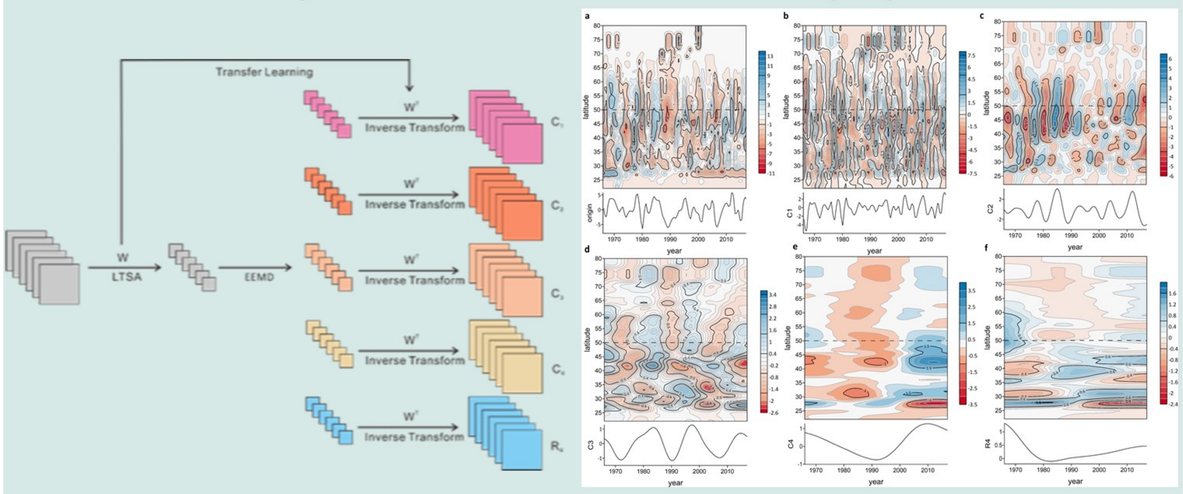


Fig 1. Flow chart of the proposed fast-MEEMD method (left). Zonally averaged outputs of fast-MEEMD upon snow cover frequency data (right)

Snow cover change

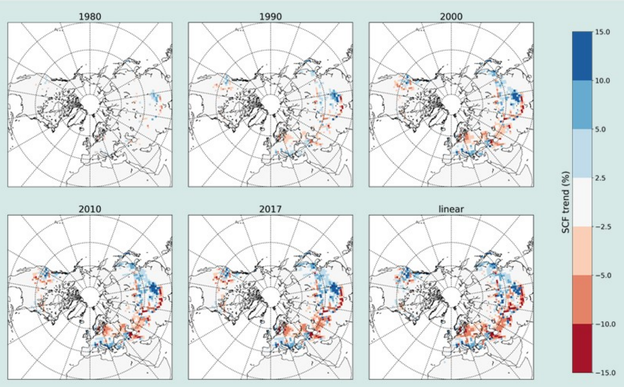


Fig 2. evolution of snow cover frequency change

- Increments over lower midlatitudes especially eastern Eurasian and southern Europe since 1990s.
- Decrements over higher latitudes and Ural regions.

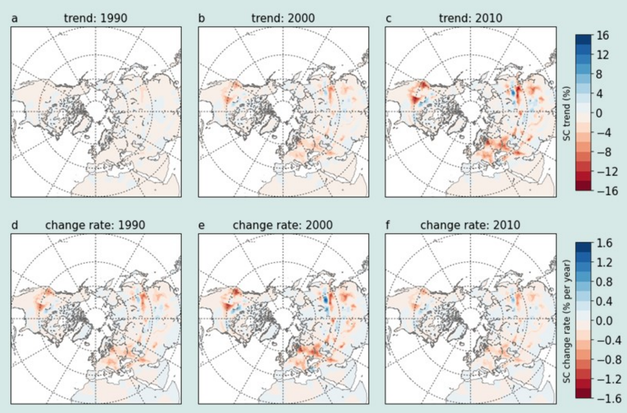


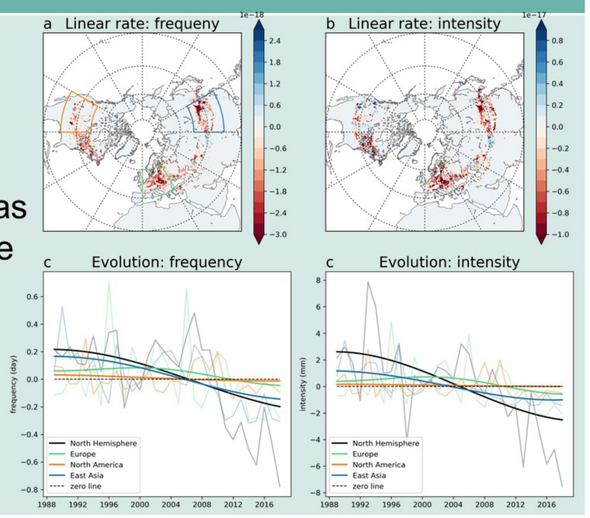
Fig 3. snow cover index trend (up-row) and changing rate (bottom-row)

- Increment over parts of eastern Asia and North America.
- Increasing rate reduced recently.

Extreme snowfall

Fig 4. linear and EEMD trends of extreme snow fall frequency (left column) and intensity (right column).

- Extreme snowfall event is defined as snow fall lasting for more than three days and exceeding its historical 90th percentile.
- Extreme snowfall over Europe increase since late 1980s and decrease after 2000s.



Temperature, moisture and sea-ice

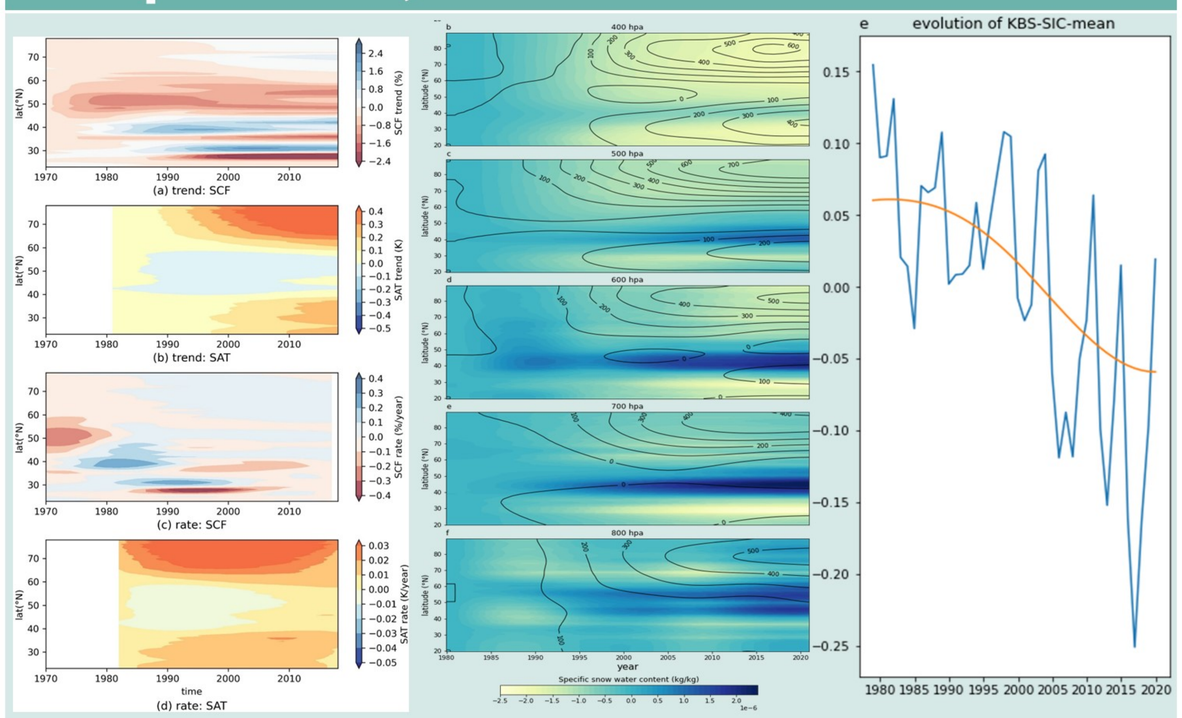


Fig 5. Zonally averaged trends of snow cover frequency and near surface air temperature (left), specific snow water content over different levels (middle). EEMD trend of sea-ice concentration over Kara Barents sea (right).

- Since 1980s, Snow cover frequency over lower midlatitudes increased; near surface cooled; Arctic sea-ice concentration started to rapidly decline.
- 1980-2000, obvious southward transport of moisture on 600hpa level.
- Decline of sea-ice concertation continues till today.

Causes of snow increments

- Previous works suggest that Arctic sea-ice loss induce weakening of polar vortex, leading to cold air outbreaks.
- Our work shows a high temporal coincidence of southward moisture transport, snow cover increment and weakening of polar vortex. But the sea-ice not.

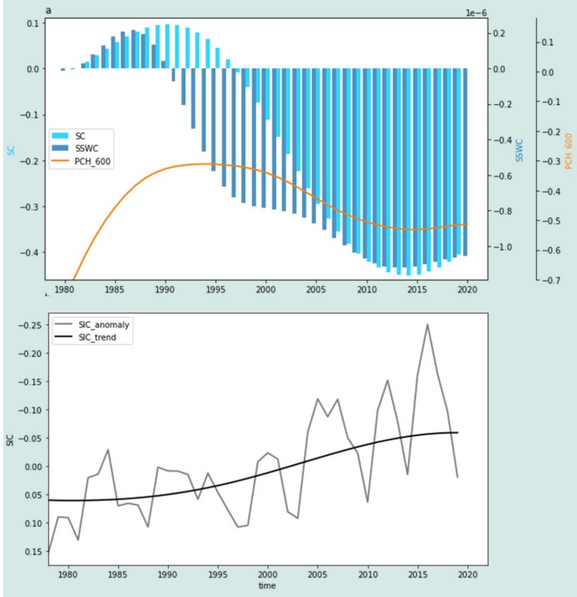


Fig 6. Relationship between snow cover frequency (light blue bars), moisture transfer (deep blue bars) and atmosphere circulation (orange).

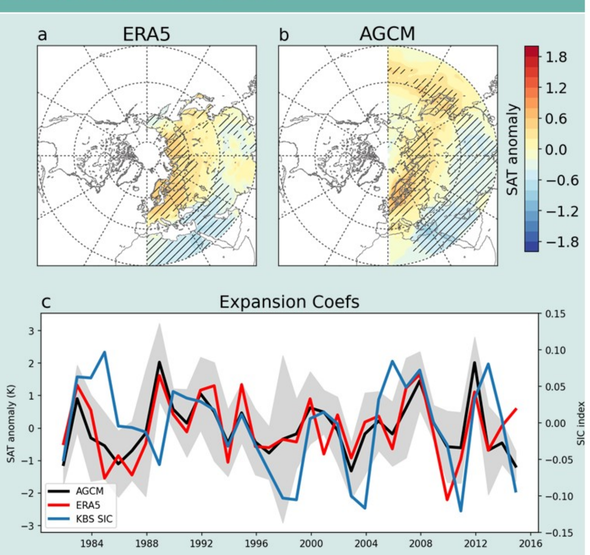


Fig 7. Response of near surface air temperature to sea-ice concentration change over Kara Barents sea

- Sea ice decline over Arctic can induce surface winter cooling in Eurasia, but the magnitude is quite small compared to observed records.
- Therefore, the cooling trend and the increments of snow cover indices over northern midlatitudes are not directly induced by sea-ice loss.

Conclusion

- Since late 1980s, parts of northern midlatitudes experienced snow cover increments, together with the cooling of the land surface and southward transport of moisture.
- Those anomalous snow change is not directly induced by rapid sea-ice loss decline. Rather, both are consequences of abnormal atmosphere circulation.

Max-Planck-Institut für Meteorologie

University of Chinese Academy of Sciences

IMPRS-ESM International Max Planck Research School on Earth System Modelling