Is Recent Eurasian Winter Cooling Caused by Arctic Sea Ice Loss?

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1. Introduction

In recent decades, the Northern Hemisphere continent has undergone a significant cooling in the boreal winter. This cooling primarily appeared in central Eurasia and North America was sufficiently strong to weaken the annual-mean globally-averaged surface air temperature (SAT) trend, contributing to global warming. The relation between Eurasian cooling trend and SIC trend is not clear.

2. Data and method

# Data

monthly SAT in HadCRUT4 and ERA-Interim reanalysis from 1979 to 2013
monthly Sea Ice Concentration (SIC) in HadISST from 1979 to 2013

# Methods

1. Perron Yabu Procedure (linear trend with one time break) [Perron and Yabu (2009)]

\[ y_t = \beta_0 + \beta_1 t + \beta_2 D_{\text{trend}} + \gamma_x + \epsilon_t \]

2. Trend decomposition (linearity congruent component) [Thompson et al (2000)]

SAT = \alpha + SIC + \beta_1 \times \text{time}

\( \alpha \) is a regression coefficient
\( \beta_1 \) is a time trend
SAT = \alpha + SIC + \beta_1 \times \text{time} + \beta_2 \times \text{SIC} + \gamma_x + \epsilon_t

SIC = \text{linearly congruent component of SAT trend with SIC}
SIC = \text{residual component}

3. SAT trend in Observation

4. SAT trend associated with SIC

Table 1. Result of SST trend from CCA analysis based on singular vector decomposition with Arctic sea ice concentrations (SIC) and HadISST and DJF SAT trend in (a) 1979 to 1998 (left) and (b) 1999 to 2013 (right)

<table>
<thead>
<tr>
<th>Variables</th>
<th>SST trend (%)</th>
<th>SIC trend (%)</th>
<th>DJF SAT trend (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIC / SIC</td>
<td>75.5</td>
<td>40.9</td>
<td>26.3</td>
</tr>
<tr>
<td>SIC / DJF</td>
<td>77.8</td>
<td>44.9</td>
<td>27.2</td>
</tr>
<tr>
<td>DJF / SIC</td>
<td>64.4</td>
<td>39.7</td>
<td>24.4</td>
</tr>
<tr>
<td>DJF / DJF</td>
<td>63.4</td>
<td>38.7</td>
<td>23.3</td>
</tr>
</tbody>
</table>

5. Model configuration

We used the GFDL CM2.1, the fully coupled climate model developed by the Geophysical Fluid Dynamics Laboratory. The observed SST (ERSST v3) over the north of 70° N is restored to the pre-industrial simulation with 5 days timescale to give the only forcing of the sea ice loss in recent decades. 21 ensemble members are used. More details in Kug et al. (2015).

6. Coupled model experiments

The recent Eurasian winter cooling was not reproduced in coupled model simulation. But some ensemble members (7 in 21) show warm Arctic cold Eurasia (WACE) pattern and it is classified WACE cases.

The winter cooling over Eurasia represented in WACE cases are underestimated than observation (Fig. 6b)

WACE cases are accompanied with enhanced Ural blocking high, and the influenced Siberian high causes cold advection from Arctic.

7. Conclusions

In observation, the recent Eurasian winter cooling trend is mainly associated with late autumn sea ice loss. However, it is not well represented in polar restoring experiments in GFDL CM2.1. In the WACE cases, the enhancement of Ural blocking and the Siberian high seems the main causes. In further study, we will analyze the leading mechanisms for the blocking intensity and frequency to understand the leading mechanism.

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