October Eurasian Snow and its Effects on Wintertime Atmospheric Parameters

Seyedarya Mohajerani 1, Paul Kushner2, Chris Derksen3
1. University of Toronto, Department of Physics 2. Climate Research Division, Environment Canada

1. Introduction
Eurasia is covered by a significant amount of snow in fall and winter, which also shows the greatest year-to-year variability. This large snow cover can affect the atmosphere through feedback effects such as the albedo of snow. It has been suggested that October snow cover in Eurasia can be used as a predictor for atmospheric circulation in the following winter. Here we examine this issue, as well as the reliability of different Eurasian snow datasets. The NOAA dataset shows an increase in snow cover in Eurasia over time. However, the apparent increase in snow cover might be the result of biases in the NOAA dataset, which requires an examination of the reliability of the NOAA snow data over time.

2. Datasets
The data used was in the form of monthly snow cover fraction (SCF). The five datasets examined are summarized in table 1.

<table>
<thead>
<tr>
<th>DATASET</th>
<th>MEAN SCF</th>
<th>Measurement Type</th>
<th>Monthly SCF Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>BROWN (ERA)</td>
<td>0.72</td>
<td>Reanalysis based on ERA-int temperature and precipitation (ERA-int snow depth is inconsistent)</td>
<td>% of days in a month with ≥2cm snow depth</td>
</tr>
<tr>
<td>MERRA</td>
<td>0.77</td>
<td>Reanalysis</td>
<td>% of days in a month with SWE ≥24mm</td>
</tr>
<tr>
<td>PMW</td>
<td>0.76</td>
<td>Passive Microwave Satellite Measurements</td>
<td>% of days in a month with SWE ≥7.5mm</td>
</tr>
<tr>
<td>NOAA</td>
<td>0.77</td>
<td>Visible Satellite Measurements</td>
<td>Percentages of days in month that a cell has more than 50% snow covered</td>
</tr>
<tr>
<td>RU</td>
<td>0.77</td>
<td>Ground Measurements of Snow Depth</td>
<td>% of days in a month with SWE ≥2 cm snow depth</td>
</tr>
</tbody>
</table>

Table 1. SCF datasets examined

3. Comparing SCF data
The RU dataset was treated as the “truth” dataset, because it was obtained from ground measurements. Comparing the other SCF datasets to RU, we found that MERRA has the best agreement with RU, while NOAA has the poorest agreement. Figure 1 shows the spatial correlation of the SCF value for all datasets with the RU dataset.

![Figure 1. Correlation of SCF values of corresponding grid cells of each dataset and the RU dataset](image)

4. Developing a snow index
In order to compare snow datasets and also compare them to other atmospheric parameters, we developed an index by finding the weighted average over all grid points and detrending the averages over time:

\[ S(t) = \frac{\sum SCF(t) \times \text{parameter}(t)}{\sum \text{parameter}(t)} \]

The truth map table for October with a snow presence threshold of SCF < 0.5% are shown for MERRA and NOAA in Figures 2 and 3. Note the datasets have a much better agreement when there is actually snow on the ground (according to RU). Once again, MERRA has a much better correlation with RU than NOAA does.

![Figure 2. MERRA “truth-table” map, with a threshold of 5.0%](image)

5. October snow and wintertime atmosphere
Other parameters are detrended at each grid cell, which is then correlated against the October snow index. The original claim about wintertime correlations might have been influenced by biases in the NOAA dataset. Figures 6 and 7 show correlation for sea level pressure and geopotential, respectively, for October and the following winter. While NOAA shows slightly higher correlations, MERRA still suggests a significant correlation, attesting to the original hypothesis.

![Figure 7. ERA-int geopotential (zonal average) correlated against NOAA-EU (left) and MERRA-EU (right) October Index for October (top) and December-February average (bottom) 1980 to 2011. Areas inside black contours are statistically significant at the 0.05 level.](image)

6. Conclusion
It is apparent that the NOAA dataset has serious disagreements with ground measurements that are known to be reliable (RU). The flaws in NOAA are responsible for the apparent increase in Eurasian snow cover over time. Furthermore, both reanalyses (MERRA, BROWN) agree very well with the RU dataset and so MERRA is taken as an extrapolation of the RU data over the entire Eurasian region. While the original suggestion about correlations between October Eurasian snow and wintertime atmospheric circulation might be partially influenced by NOAA (NOAA shows higher correlations), there is still significant evidence suggesting that October Eurasian snow can be used as in indicator for wintertime parameters. This issue is worth further examination.

7. Acknowledgements
I would like to thank the Center for Global Change Science and the Physics Department at the University of Toronto for giving me the opportunity to carry out this research. Furthermore, I would like to thank Professor Paul Kushner and Dr. Chris Derksen for their guidance and support throughout my project.

8. References