Inter-annual Variations of Air Mass Transport to the Arctic

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January 8, 2007
Observed Temporal Variation for Sulphate

Measured aerosol sulphate at Alert (1980--1995)

(Sirois and Barrie, 1999)
How to model the seasonal changes and trends?

- Emissions surrounding the Arctic.
- Removal patterns – e.g. precipitation changes
- Transport patterns.
**Trajectory Calculations**

- **Trajectory Model:**
  - HYSPLIT4 (NOAA Air Resources Laboratory)

- **Trajectory duration:** 10-day backward

- **Arriving at Alert (Barrow):**
  - 82.31 N, 62.31 W (71.32 N, 156.6 W)
  - 1000 m above sea level

- **Clustering Technique**
  - Based on Dorling’s Algorithm (Dorling et al., 1992)
  - Modified to handle a large number of trajectories
Wintertime Transport Patterns for 1981-2000

- 2480 trajectories in total;
- Best grouped into 7 clusters;
- Clusters 1, 2, and 6 account for ~40% of the overall air mass transport;
- The interannual variability of transport patterns were obtained by counting the number of trajectories from each year.
Cluster-mean plots for the four mid-season

Jan

Apr

Jul

Oct
Inter-annual Variations for Jan.

---|---|---|---|---|---
% Contributions | 0 | 10 | 20 | 30 | 40
Cluster 1
Cluster 2
Cluster 6

Graph showing inter-annual variations for Jan. with lines representing clusters 1, 2, and 6.
Correlation between Transport Frequency and Black Carbon Concentration

\[ R_1 = 0.97 \quad R_2 = 0.61 \]
Transport Frequency ~ NAO/AO Indices at Alert

<table>
<thead>
<tr>
<th>Correlation (R)</th>
<th>AO</th>
<th>NAO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1</td>
<td>-0.545</td>
<td>-0.169</td>
</tr>
<tr>
<td>Cluster 2</td>
<td>-0.249</td>
<td>-0.301</td>
</tr>
<tr>
<td>Cluster 3</td>
<td>-0.485</td>
<td>-0.655</td>
</tr>
<tr>
<td>Cluster 4</td>
<td>0.429</td>
<td>0.287</td>
</tr>
<tr>
<td>Cluster 5</td>
<td>0.570</td>
<td>0.070</td>
</tr>
<tr>
<td>Clusters 1+2+3</td>
<td>-0.677</td>
<td>-0.626</td>
</tr>
<tr>
<td>Clusters 4+5</td>
<td>0.697</td>
<td>0.271</td>
</tr>
</tbody>
</table>

Map showing Alert at Alert, 0 o 60°E 75°N, with clusters labeled 1 to 5 and their respective percentages.
### Transport Frequency ~ NAO/AO Indices at Barrow

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<th>NAO</th>
</tr>
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<tr>
<td>Cluster 1</td>
<td>-0.718</td>
<td>-0.410</td>
</tr>
<tr>
<td>Cluster 2</td>
<td>-0.751</td>
<td>-0.906</td>
</tr>
<tr>
<td>Cluster 3</td>
<td>-0.482</td>
<td>0.110</td>
</tr>
<tr>
<td>Cluster 4</td>
<td>0.411</td>
<td>-0.900</td>
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<tr>
<td>Cluster 5</td>
<td>0.682</td>
<td>0.725</td>
</tr>
<tr>
<td>Cluster 6</td>
<td>0.307</td>
<td>0.433</td>
</tr>
<tr>
<td>Clusters 5+6</td>
<td>0.825</td>
<td>0.942</td>
</tr>
</tbody>
</table>
Variations in BC Emissions

Black Carbon, Canada

30%
Questions:

- Which is the dominant factor in modeling the observed spatial and temporal distributions of pollutants?
  - Transport variations
  - Removal processes
  - Emissions