The seasonal burden of Dimethyl sulphide-derived aerosols in the Arctic and the impact on global warming

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Global climate changes have led to remarkable environmental changes in the Arctic. On the other hand, Dimethyl sulphide (DMS) emission in Arctic Ocean plays an important role for the global warming. The ice cover as the special feature of Arctic Ocean has significant effect on regulation of the large distribution of phytoplankton production. Chlorophyll-a (CHL), as the primary production of phytoplankton, has its strong relationship with DMS derived aerosol in the ocean surface.
Arctic Ocean

North Pole
The sunlight goes some way towards heating the Arctic, but heat also comes from the south with ocean currents and airstreams. One branch of the Gulf Stream, called the North Atlantic Current, flows along the coast of Norway and continues all the way to the Arctic Ocean.

The area of the Barents Sea where the cold, relatively fresh, Arctic water meets the warm, saline Atlantic water is called the **polar front**. The polar front does not lie in a specific geographical position, but may move somewhat from year to year.
Study region: Barents Sea, 30-35E, 70-80N

Three Cruises collected DMSP data from Biglow Laboratory for Ocean Sciences, ME, USA
Study region: 30-35E, 70-80N
The comparisons for the calibrated model results and the original SeaWiFS data for 1998. Due to the fitness function is calculated by using negative value with maximum optimization rule applied, hence, the closer to zero, the better the fitness.

Year 1998 had its best fitness of -2.6758, while the 5 years mean (from year 1998 to 2002) also achieved quite high fitness (-4.4098).
CHL and DMS in 1999 in the study region

CHL and DMS in 2000 in the study region

CHL and DMS in 2001 in the study region
CHL and DMS in 1998
(5 days later than the first DMS bloom, 45 days to the peak DMS)

CHL and DMS in 2002
(4 days later than the first DMS bloom and 68 days to the peak DMS)
The spring blooms of phytoplankton (CHL peaks) were gradually shifted ahead from 17th May to 5th May during the 5 years. This is due to the increased SST and the earlier ice melting each year happened in the study region. The time lags between the CHL blooms and DMS peak blooms are increased from 45 days to 68 days in the 5 years. It is interesting to see that year 1998 had its DMS first blooms in spring a few days before CHL bloom while in other years, DMS had its first bloom a few days after the CHL spring bloom. The reason could be that the higher ice cover in year 1998 in south part of the study region could generate more and earlier DMS from the ice algal when ice started melting in spring.
Before the transit climate data prediction, another CHL GA calibration was carried out using average CHL SeaWiFS data in zonal 70-80N during the 5 years period: 1998-2002. The excellent fitness value (-0.7598) gives better model parameter values.

There was a second smaller bloom in September due to the shallower MLD and increased wind speed from August to September.
The transit climate data from GCM simulations for the period of 1960-1970 (pre-industry level: 1CO2) and 2078-2086 (tripled equivalent CO2: 3CO2) were obtained in the zonal 70-80N.
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<table>
<thead>
<tr>
<th></th>
<th>SST</th>
<th>Wind Speed</th>
<th>Cloud Cover</th>
<th>Ice Cover</th>
<th>MLD</th>
<th>DMS</th>
<th>DMS Flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>1CO2</td>
<td>-0.24</td>
<td>4.2</td>
<td>82.1%</td>
<td>68.8%</td>
<td>41.8</td>
<td>12.1</td>
<td>0.8</td>
</tr>
<tr>
<td>3CO2</td>
<td>0.71</td>
<td>4.5</td>
<td>74.7%</td>
<td>50.3%</td>
<td>35.3</td>
<td>13.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Increased</td>
<td>40%</td>
<td>3%</td>
<td>-9%</td>
<td>-27%</td>
<td>-13%</td>
<td>8%</td>
<td>117%</td>
</tr>
</tbody>
</table>
Annual mean ice cover in the study region during 1988-2002

Error bar is the Standard Error of the Mean

\[ y = -0.565x + 1156.4 \]

\[ R^2 = 0.3275 \]

Average ice cover in winter-spring (Nov.-Mar.) in southern 70-75N, 30-35E
We can conclude that the significant decrease of ice cover and increase of SST are the main reason of increasing DMS flux to more than 100% by year 2086. This significant change in the northern belt would cause large impact on global warming.