Trends in nitrogen and sulphur compounds in the Arctic: Past and future

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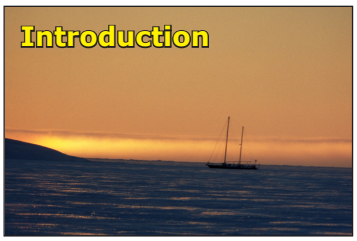
Introduction



AMAP assessments have clearly documented that air pollutants,including persistent organic pollutants, heavy metals such as mercury, and acidifying substances can reach the Arctic as a result of long-range transport from source regions in Europe, North America, and Asia (*www.amap.no*). In relation to acidifying substances, the industrial areas of northern Europe and parts of Russia and the northeastern United States are responsible for most of the pollution exported to the Arctic. There are also significant sources of acidifying substances within the Arctic, including industrial sources (the metallurgical industry, power plants, oil and gas related activities) particularly in Russia and diffuse sources associated with, for example, shipping (*Fig. 1*). Emissions from natural sources within the Arctic (volcanoes, marine algae, and forest fires) are very difficult to quantify and almost impossible to project. However, the frequency, severity, and duration of boreal forest fires do appear to be increasing, possibly related to the influence of changing climate.

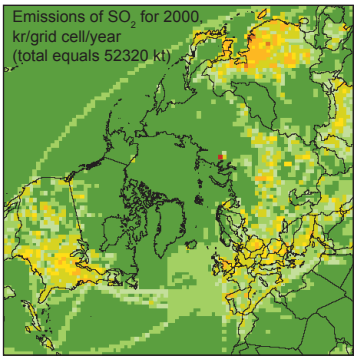


Figure 1. Estimated emissions of SO_2 and in 2000 (EDGAR database).

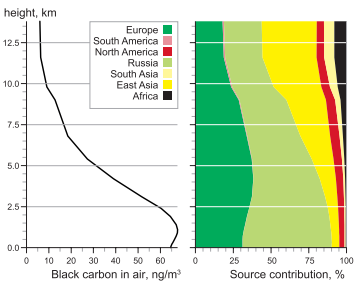


Figure 2. Concentration and origin profile of black carbon north of the Arctic Circle as calculated by the Danish Eulerian Hemispheric Model (DEHM). Average for 1991 to 2001.

Extreme transport event on Zeppelin, Ny-Ålesund, Svalbard May 2006. Climate change might affect pathways. Photos: Ann-Christine Engvall,Univ. Stockholm.

Results

Asia is not likely to be a major source of acidification-related atmospheric pollution at ground level in the Arctic (*Fig. 2*). Although there are relatively few and unevenly distributed background stations within the Arctic (*Fig. 3*), most record a decrease in concentrations since the 1990s (*Figs. 4-5*). These observations are supported by modeling results (Fig. 6). There are few signs of significant trends in precipitation for the period studied. However, expected future occurrence of rain events in both summer and winter will result in increasing wet deposition in the Arctic.

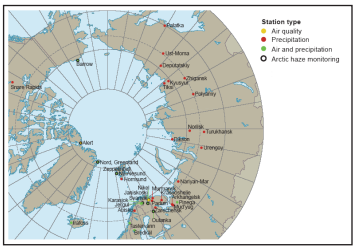


Figure 3: Arctic atmospheric monitoring stations.

For nitrate and ammonia the pattern is unclear, with increases at some stations and decreases at others. The increasing trends in nitrate are particularly apparent in recent years indicating a decoupling between the trends in sulfur and nitrogen (*Figs. 4-5*). Time series of sulfur and nitrogen concentrations in precipitation at Norilsk since 1990 do not show any significant trends.

In general, sulfur deposited originates from local point sources and long-range transport. In the AMAP region, high levels of deposition only occur close to large point sources in the vicinity of the Nikel and Monchegorsk smelters on the Kola Peninsula and in Norilsk in NW Siberia (*Fig. 7*).

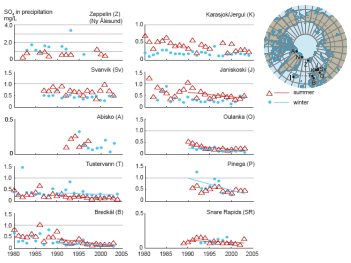


Figure 4: Summer and winter sulfate trends in precipitation within the Arctic. Solid lines indicate significant trends 1990-2003.

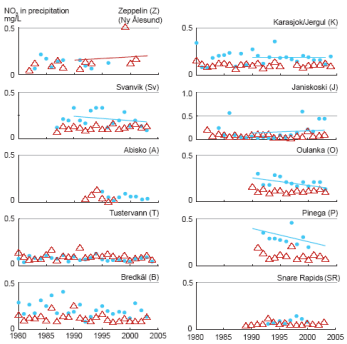


Figure 5: Summer and winter nitrate trends in precipitation within the Arctic. Solid lines indicate significant trends 1990-2003.

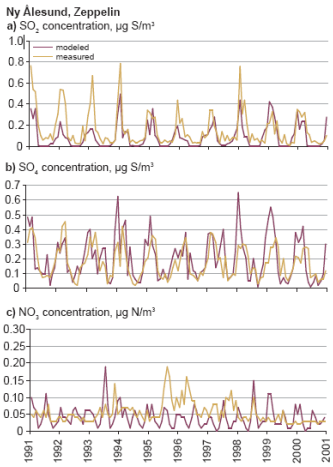


Figure 6. Time series comparing measured and modeled monthly concentrations of sulfur dioxide, sulfate, and nitrate at Zeppelin (Ny-Ålesund, Spitsbergen).

Decreasing trends in levels of acidifying pollutants observed at many sites throughout the Arctic are supported by model results (*Fig. 6*). Models indicate that mean concentrations of sulfur oxides and total sulfur deposition within the Arctic almost halved between 1990 and 2000. The modeled results for airborne oxidized nitrogen are similar to those for sulfur. The models also confirm earlier findings that emissions in Eurasia continue to make the greatest contribution to acid deposition within the Arctic.

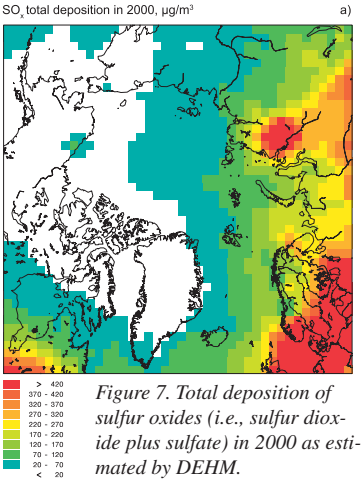


Figure 7. Total deposition of sulfur oxides (i.e., sulfur dioxide plus sulfate) in 2000 as estimated by DEHM.

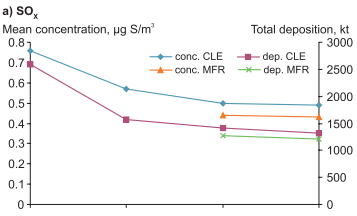


Figure 8. SOx deposition and emission projections by DEHM for Current Legislation (CLE) and Most Feasible Reduction scenarios (MFR).

Model projections based on future emissions scenarios indicate that the decreasing trends observed between 1990 and 2000 are likely to level off and that only small reductions in concentrations and deposition can be expected after 2020, even if maximum feasible reductions in emissions are achieved (*Fig. 8*).

Although further recovery and continuing improvement in the acidification status of the Arctic can be expected during the period until 2020, this is dependent on the implementation of existing international agreements to reduce emissions of acidifying substances. The Gothenburg Protocol is the most important agreement in this connection.

Acknowledgements

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