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

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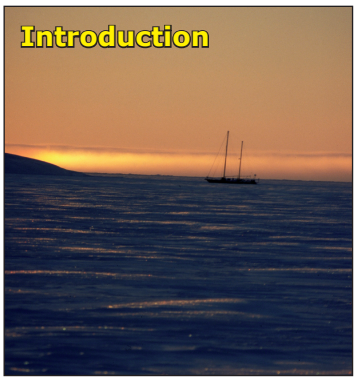
Introduction



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, N America, and Asia (*Hole et al., 2006, www.amap.no*). As for acidifying substances, the industrial areas of northern Europe and N Russia and the NE USA 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 (particularly in Russia) and diffuse sources (i.e., shipping) (Fig. 1). Emissions from natural sources within the Arctic (e.g., forest fires) are difficult to quantify and almost impossible to project. However, the frequency, severity, and duration of wild fires appear to be increasing.

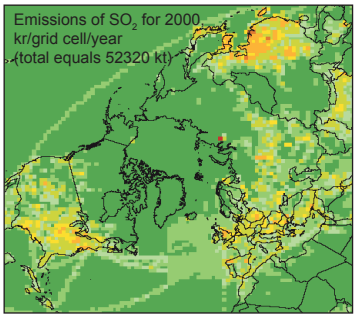


Figure 1. Estimated emissions of SO_2 and in 2000 (EDGAR database).

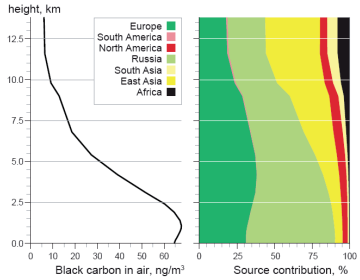


Figure 2. Concentration and origin profile of black carbon north of the Arctic Circle as calculated by the Danish Eulerian Hemispheric Model (DEHM). Average for 1991 to 2001.

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 acid atmospheric pollution at ground level in the Arctic (Fig. 2). Although there are 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 (the Danish Eulerian Hemispherical Model – DEHM) (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 could result in increasing wet deposition in the Arctic.

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

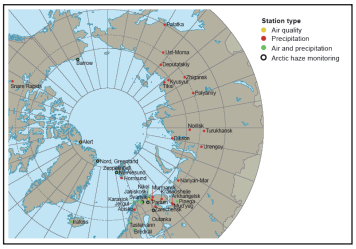


Figure 3: Arctic atmospheric monitoring stations.

Observed trends are supported by model results (Fig. 6). Models indicate that mean concentrations of sulphur oxides and total sulphur deposition within the Arctic almost halved between 1990 and 2000. The models also confirm earlier findings that emissions in Eurasia continue to make the greatest contribution to acid deposition within the Arctic.

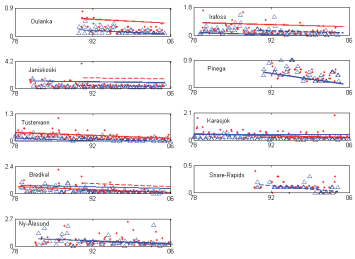


Figure 4: Summer and winter non-sea-salt sulfate trends in precipitation (mg S l^{-1}). Solid lines indicate significant trends 1980-2004 (2005), dashed lines trends after 1990.

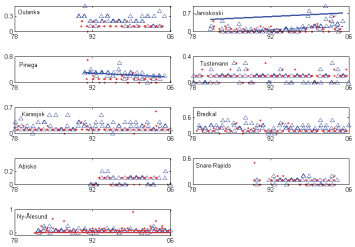


Figure 5: Same as Fig. 4, but for nitrate (mg N l^{-1}).

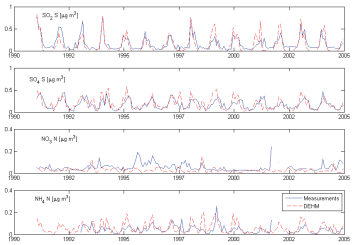


Figure 6. Measured and modeled monthly concentrations of sulphur dioxide, sulfate, nitrate and ammonium in air at Zeppelin (Ny-Ålesund, Svalbard).

Model projections based on future emissions scenarios indicate that 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).

Further recovery and continuing improvement in the acidification status of the Arctic 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.

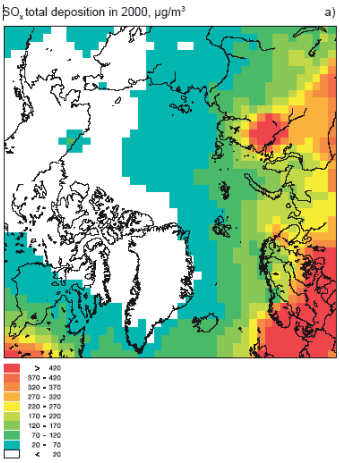


Figure 7. Total deposition of sulphur oxides (i.e., sulphur dioxide plus sulfate) in 2000 as estimated by DEHM.

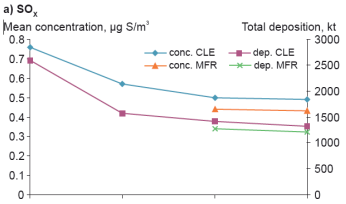


Figure 8. SO_x deposition and emission projections by DEHM for Current Legislation (CLE) and Most Feasible Reduction scenarios.

Reference

Hole, L.R., J. Christensen,V. A. Ginzburg, V. Makarov, A.I. Polishok, T. Ruoho-Airola, V. N. Vasilenko, *Concentrations and deposition of acidifying air pollutants.* AMAP assessment report 2006, chapter 3. *www.amap.no*

Acknowledgements

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