Investigation of mercury depletion events recorded during early and late spring 2003 at Zeppelin / Ny-Ålesund, Svalbard (Norway)

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Mercury in the polar environment

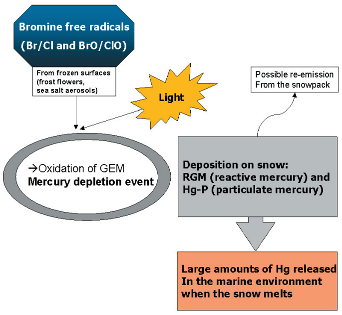

Fig.1: Simplified diagram for AMDEs.

Mercury (Hg) is a major pollutant of the arctic environment. High concentrations of Hg have been detected in arctic marine ecosystems as well as in the native populations of the arctic regions [1]. Atmospheric mercury depletion events (AMDEs), first observed in the spring 1995 at Alert, Canada [6], are likely to participate in the elevation of mercury concentrations in the Arctic.

During these depletion events, gaseous elemental mercury (GEM) is probably oxidised by bromine free radicals into less volatile species. Bromine radicals (Br) are produced through photolysis from molecular halogens emitted by aerosols, snow and frozen surfaces [5]. AMDEs have now been observed at several locations in the polar areas, they only occur during a three-month period following polar sunrise. Oxidised Hg species produced during AMDEs, reactive gaseous mercury (RGM) and particulate mercury (Hg-P), have a short atmospheric residence time and will deposit quickly, dramatically increasing the deposition flux of mercury.

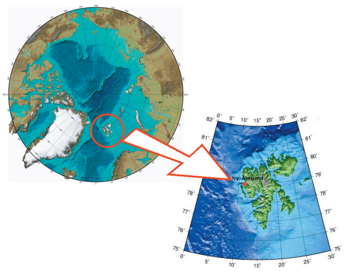

Fig. 2: Experiment location.

At the Zeppelin station, close to Ny-Ålesund, GEM has been continuously monitored since February 2000 using a Tekran Gas Phase Mercury Analyser. AMDEs were observed every spring in connection with Ozone depletion events (ODEs).

This study is focused on a period including the early and late spring 2003 (17/03 to 14/04 and 04/05 to 30/05). AMDEs were studied in this period and their characteristics were investigated. The origin of the depletion events (location where the reactions took place) was estimated using:

- Bromine maps and 4 day backward trajectories ending in Ny-Ålesund (Hysplit [3])
- Local meteorology and weather maps
- GEM decrease rates

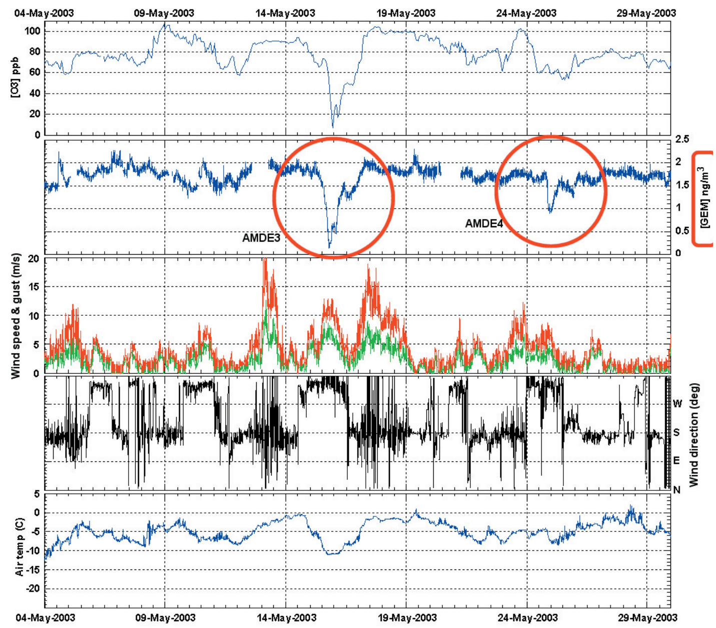

Fig 3: Time series of O_3, GEM and local meteorology for late spring 2003

Results

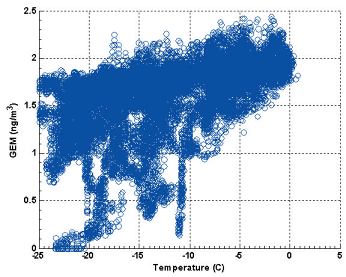

Fig. 4: Scatter plot of GEM and temperature for spring 2003 (Cold temperatures (-20/-10) are necessary to trigger a depletion event).

Four depletion events were identified during the period studied, two during early spring, and two during late spring. Figure 3 shows the time series of late spring for GEM and O_3 in connection with local meteorology. In total 8 separate depletion events were recorded in 2003, the 4 major events are reported in [4]. The annual mean concentration of GEM at Zeppelin is 1.60ng/m3 for 2003.

Research of the origin of AMDEs, Example of AMDE3 (16 May)

On the 15th and 16th of May, a low-pressure system was building up on the north east of Svalbard, bringing cold air from northwest, leading to a considerable temperature drop (figure 3). The shifting weather conditions and the fact that no high concentration of bromine seemed to be around Svalbard at this moment implies this AMDE probably results of transport chemistry.

Backtrajectories indicate that the air mass arriving on the 16th has travelled from Ellesmere Island trough northern Greenland (figure 5). On the 12th, this air mass has passed an area with significant concentration of bromine (figure 6), which probably triggered a depletion event, later recorded at Ny-Ålesund after 4 days of transport.

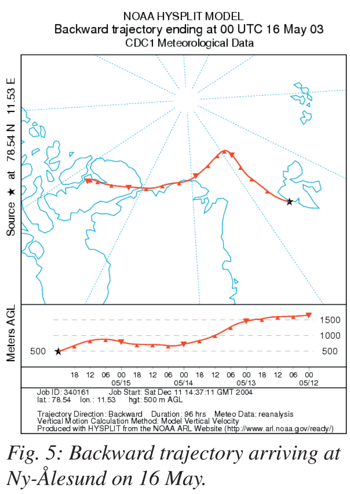

Fig. 5: Backward trajectory arriving at Ny-Ålesund on 16 May.

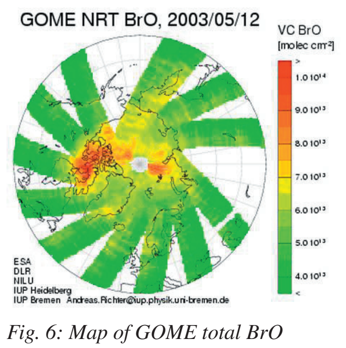

Fig. 6: Map of GOME total BrO column on 12 May.

Conclusions

- Four minor AMDEs were investigated
- Two local events / short-range transport in early spring (31 march, 9 April)
- Two long-range transport events in late spring, advected from further north (16 May, 25 May)

❖ *As expected AMDEs follow the apparition of bromine clouds at the polar sunrise, starting at lower latitudes and moving poleward with the sun rising there.*

❖ *By improving the method used to investigate AMDEs, the full path followed by depletions could be established (forward trajectories) and the areas affected by increased deposition flux could be located.*

References

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