Dynamics of Mercury in the Barrow Springtime Polar Environment

S.B. Brooks[1], S.E. Lindberg[2], H. Skov[3], A. Saiz-Lopez[4], and J. Plane[4]

[1]NOAA Atmospheric Turbulence and Diffusion Division, 456 S. Illinois Ave., Oak Ridge, TN 37831; 865-576-1233, steve.brooks@noaa.gov
[2]National Environmental Research Institute of Denmark, DK 4000 Roskilde
[3]Oak Ridge National Laboratory, Oak Ridge, TN 37831
[4]University of East Anglia, Norwich, UK NR47TJ

Schroeder et al. [*Nature, 394*, 331-332, 1998] first reported springtime episodic gaseous elemental mercury (GEM or Hg^o) depletions based on ground measurements of air at Alert, Canada. Since then these events have proven to be widespread in the polar regions. At Barrow, Alaska, we have linked these depletions with the near-surface air formation of reactive mercury (Hg(II)) and the accumulation of total mercury in the snowpack. For the first time, we have combined Hg flux rate measurements, atmospheric chemistry measurements, and air mass trajectories to give a comprehensive view of the dynamics of springtime Arctic mercury. Most probably, the local destruction of ozone and the conversion of GEM, from long range transport, to a reactive form is carried out by monatomic bromine formed by the photolysis of bromine. The formed mercury bromide radical may react further with e.g., molecular oxygen and in a series of reaction steps under cold temperatures ($< \sim -9^oC$) leading to reactive gaseous mercury (RGM).

$$Br_2 + hv \Rightarrow 2Br;\ \ Br + O_3 \Rightarrow BrO + O_2\,;\ BrO + BrO \Rightarrow 2Br + O_2;\ Br + Hg^o \Rightarrow HgBr$$

The source of Br_2 is likely the sea-ice environment. The multi-axis differential optical absorption spectroscopy (DOAS) technique was used to measure the slant column densities of BrO. RGM and BrO concentrations peak simultaneously in the afternoon. The extremely short lifetime of BrO and the high photodisociation potential of Br_2, even under weak sunlight conditions, are emphasized by the steep post-sunrise and pre-sunset slopes of the BrO concentration. For the 3-day period shown, flux (RGM and Fine Particulate Mercury; FPM) into the snowpack was 895 ng m^{-2}, GEM emission from the snowpack was 443 ng m^{-2}, netting a snowpack gain of 452 ng m^{-2}. The dynamic deposition and re-emission rates underscore the delicate balance of the Arctic mercury phenomena where sunlight both induces conversion and deposition, and photoreduction mercury flux from the mercury-rich snow surface. More preliminary results of the ongoing 2004 International Barrow Arctic Mercury Study (ends May 5) will also be presented.

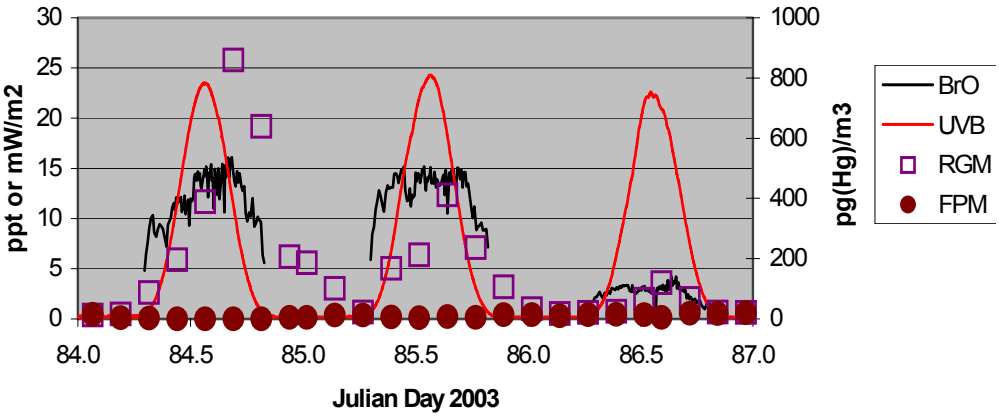

Figure 1. BrO, incident solar UVB, reactive gaseous mercury (RGM), and fine particulate mercury (FPM) near-surface air measurements at Barrow March 25-27, 2003 (local time).