Atmospheric toxic processes and fates in the Arctic: Preliminary results from ArcticNet 2005

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1. Introduction and objectives

Atmospheric toxic compounds such as mercury and herbicides release from anthropogenic activities can contribute to the Arctic environment contamination. Mercury depletion events in spring time can load more than 300 tonnes of mercury in the whole Arctic. This mercury loading can be retained in the Arctic or be re-emitted back into the atmosphere. Mercury chemistry might be very active into the Arctic through ozone or/and halogens-mercury chemistry. This chemistry may change the mercury speciation and change its ability to fallout. Herbicides applied in southern Canada may migrate through distillation effect to the northern location. The human contribution to the greenhouse gas content in the atmosphere is significant but natural productions are not negligible. Knowledge of the regulatory mechanisms implicated in natural greenhouse gas exchange is needed to elaborate models and scenarios associated with the global warming.

In this communication, we synthesise preliminary results obtained during the 2005 scientific cruise onboard the NGCC Amundsen from August 5th to October 26th. The aims of this investigation were:

- To measure Total Gaseous Mercury during the cruise;
- To measure mercury speciation during cruise (atmospheric mercury chemistry);
- To measure the mercury gradient (deposition/evasion);
- To measure mercury and herbicides in sediments and water;
- To measure CO_2, CH_4, CO, O_3, H_2 in air;
- To calibrate the two-layer model for mercury and herbicides;
- To apportion potential source of mercury and herbicides in the whole Arctic.

2. Methods

2.1 General set-up onboard the NGCC Amundsen. A removable tower was deployed above the sea, in the front of the ship (Figure 1A). Meteorological (wind speed, wind direction, solar radiations, air temperature, air humidity) and chemical (total gaseous mercury, O_3, H_2, CO, CH_4 and CO_2) parameters were measured over the entire investigation period. Air and water samples were also collected for herbicides.

2.2 Total gaseous mercury. The Total Gaseous Mercury (TGM) analysis was achieved with an automatic analyser (Tekran® 2537A). Briefly, the analytical train of this instrument is based on amalgamation of mercury onto a pure gold surface followed by a thermodesorption and analysis by Cold Vapour Atomic Fluorescence Spectrophotometer (CVAFS) (λ=253.7 nm) providing analysis of TGM in air at sub-ng/m^3 levels.

2.3. Mercury speciation. Automated mercury speciation analyzer systems were used concurrently during the field measurement study (Figure 1B). The analyzer systems included a Tekran® Model 2537A which was used together with a Model 1130 Speciation Unit and a Model 1135 Particulate Mercury Unit to simultaneously monitor gaseous elemental mercury (GEM), reactive gaseous mercury (RGM), and particulate mercury (TPM: 0.1 - 2.5 µm) in ambient air (Tekran, 2001).

2.4. H_2, CO, CH_4, CO_2 and O_3 A chromatographic RGA5 system (Trace Analytical, Maryland) measured H_2, CO, CH_4 and CO_2 continuously and results were obtained at 10 min intervals. Two detectors were mounted in parallel: the reductive gas detector (RGD) for H_2 and CO and the flame ionization detector (FID) for CO_2 and CH_4. A photometric O_3 analyser was used (Model 49C, Thermo Environmental Instruments Inc., Massachusetts).

2.5. Herbicides. Air samples were collected over 1 week integration periods using PS-1 type samplers (Figure 1C) at a flow rate of approx 300 m^3 d^{-1} (~2100 m^3 sample volume), using glass fiber filter for the particle phase and PUF/XAD sandwich for capturing gas-phase chemicals. 200 L water samples were collected and passed through fiber glass filter and XAD-2 resin for extraction. Extractions and analyses will be done in our laboratory at Montreal. Results are not shown here.

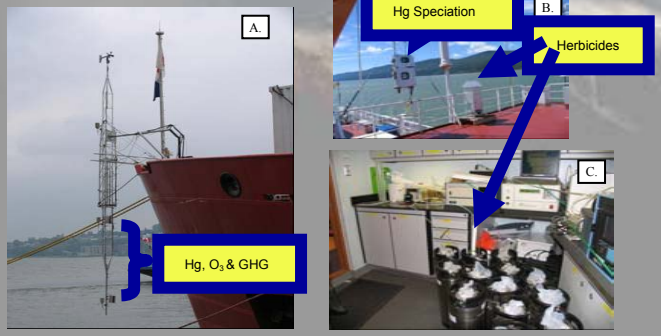

Figure 1. Pictures of the set-up installed onboard the NGCC Amundsen. (A) The removable tower allowed the measurements of TGM, O_3, H_2, CO, CH_4 and CO_2 concentrations gradients. (B) Mercury speciation and air sampler for herbicides are shown with the laboratory (C).

3. Results

3.1 TGM concentrations

TGM concentrations were measured onboard the NGCC Amundsen during the cruise of 2005. As TGM concentrations are followed in continuous at Kuujjuarapik (Centre d'Études Nordiques, Université Laval) and Mingan, it will be possible to compare the datasets in order to study TGM atmospherics transport.

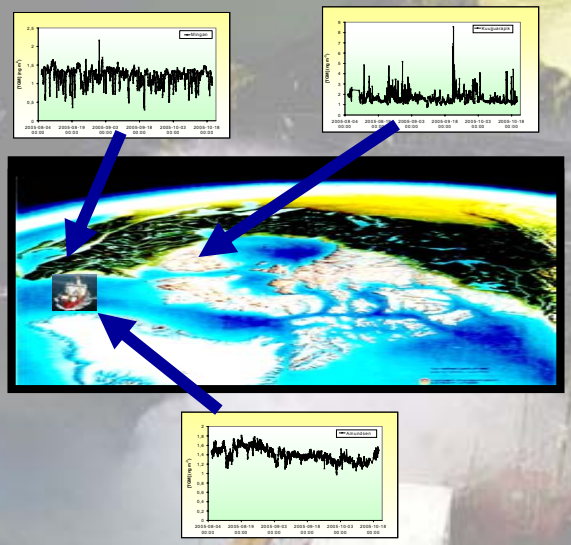

Figure 2. Time series for TGM air concentrations measured onboard the NGCC Amundsen and at Kuujjuarapik and Mingan.

3.2 TGM gradient

TGM concentrations were measured in gradient mode (i.e., lower and upper levels above the water surface) onboard the NGCC Amundsen during the cruise of 2005. Polynomial functions were calculated and plots as indicated in Figure 3. Preliminary results suggested atmospheric mercury deposition on Sept., 7-8 2005 on the Amundsen Gulf.

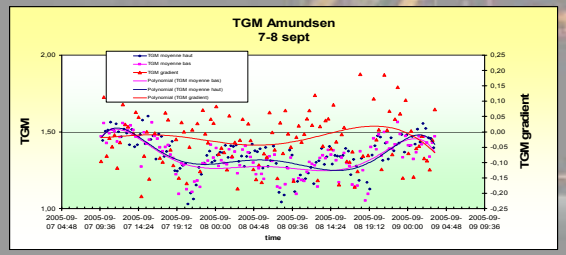

Figure 3. Times series TGM gradient measured along the cruise.

3.3. Mercury speciation

Mercury speciation was studied over the entire cruise period. The results showed that GEM dominated RGM and TPM species (Figure 4).

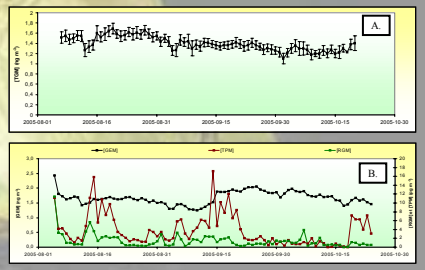

Figure 4. Times series for (A) TGM and (B) mercury speciation measured along the cruise. Each dot represents the daily median concentration.

3.4. H_2, CO, CH_4, CO_2 and O_3 measurements

The east coast of the Hudson bay was very reactive in regard of these trace gases (Figure 5).

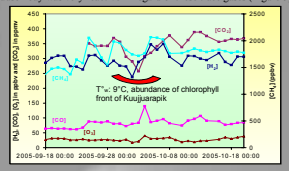

Figure 5. Time series for H_2, CO, CH_4, CO_2 and O_3 air concentrations. Each dot represents the daily median concentration.

3.5. Sampling sites for water and sediments collected along the cruise (Figure 6)

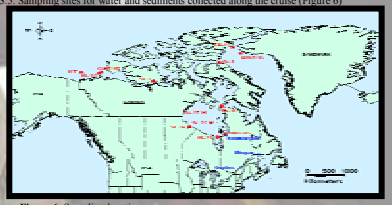

Figure 6: Sampling locations

Average Hg concentrations in sediments and water were respectively, 40±1 ppb and 0.45 ± 0.08 ng/L.
Station 11 (Amundsen Bay) showed the largest Hg concentration sediments whereas station 24 (Neilson river) the largest Hg concentration in water.

Table 1: Mercury concentrations in sediments and water at various sampling sites

Station	sediment		water	
	Hg conc (DW) Average (ng/mg)	Hg conc (DW) SD (ng/mg)	Hg conc Average (ng/L)	Hg conc SD (ng/L)
BA 11	0,047	0,001	0,48	0,19
station 3	0,049	0,002	0,48	0,03
station 7	0,032	0,002	0,39	0,07
station 11	0,087	0,005	0,41	0,12
station 16-17	0,023	0,001	0,25	0,01
AN 03-05	0,015	0,001	0,46	0,02
station 21	0,023	0,001	na	na
station 22	na	na	0,53	0,11
station 24	na	na	0,62	0,11
station 27	0,043	0,001	na	na

4. Perspectives

As TGM, O_3, H_2, CO, CH_4 and CO_2 fluxes will be derived with the turbulent transfer coefficient measured by the University of Manitoba.

Acknowledgments

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