Meeting Summary, Atmospheric Observations Session RUSALCA Project Meeting, Kotor, Montenegro, October 2005

Summary of Presentations by C.Cahill (ffcfc@uaf.edu) and A.Astakhov (astakhov@poi.dvo.ru)

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Atmospheric Aerosols over the Bering and Chukchi Seas were sampled during Leg 2 of the RUSALCA cruise track. Results were presented at the Kotor Meeting by C. Cahill, University of Alaska Fairbanks. Average size-fractionated aerosol mass and trace elemental composition were determined for every 3.6 hours during the duration of the RUSALCA cruise (August 6th through August 24th, 2005). The samples were collected using a 3-stage DRUM aerosol impactor (a rotating drum cascade impactor) with a 2.5 μm particle cut-point cyclone inlet placed on the top deck of the Russian research vessel, the Professor Khromov. The samples were analyzed by β-gauge and Synchrotron X-Ray Fluorescence (S-XRF) techniques to determine aerosol mass and elemental composition. These techniques provided 3.6-hour average concentrations of mass and 42 elements from sodium through uranium that are comparable with previous measurements made during summer 2003 in the Bering and Chukchi Seas on the Chinese research vessel, the Xue Long, and existing ground-based measurements in Alaska. These techniques have been used to successfully follow the international transport of specific elemental species from their source regions to the Arctic (Cahill, 2003; Wetzel *et al.*, 2003).

Figure 1 shows a time series of selected elements representing different aerosol types: sodium for sea salt, potassium for wildfire smoke, zinc for metal smelting, calcium for soil and sulfur for anthropogenic sources. Several periods of interest occur in the graph. The period prior to August 10th coincides with the ship being in port or near at Nome so anthropogenic and ship exhaust emissions dominate the aerosol. The elevated potassium, a tracer of biomass burning, observed during the period from August 23rd through August 24th shows the impact of the Alaskan wildfires on the aerosol composition and concentration when the ship neared the coast of Alaska during an east-to-west wildfire smoke transport event. The elevated calcium on August 13th corresponds to either soils transported from south-eastern Russia over the Sea of Okhotsk and Kamchatka or, potentially, volcanic ash from Sheveluch volcano in Kamchatka.

According to meteorological back-trajectories (NOAA Air Resources Laboratory HYSPLIT transport and dispersion model [http://www.arl.noaa.gov/ready/hysplit4.html]), several of the periods with elevated concentrations during the middle of the cruise (for example August 14th and 16th) correspond to air coming from Russian industrial regions, such as Norilsk. For most of the rest of the cruise, the air contained low aerosol mass concentrations with sea salt being a dominant species.

The measurements made during this research cruise are comparable to measurements made during summer 2003 in the Bering and Chukchi Seas on the Chinese research vessel, the Xue Long, during CHINARE II. Both cruises show periods of industrial emissions superimposed on clean, marine background aerosols.

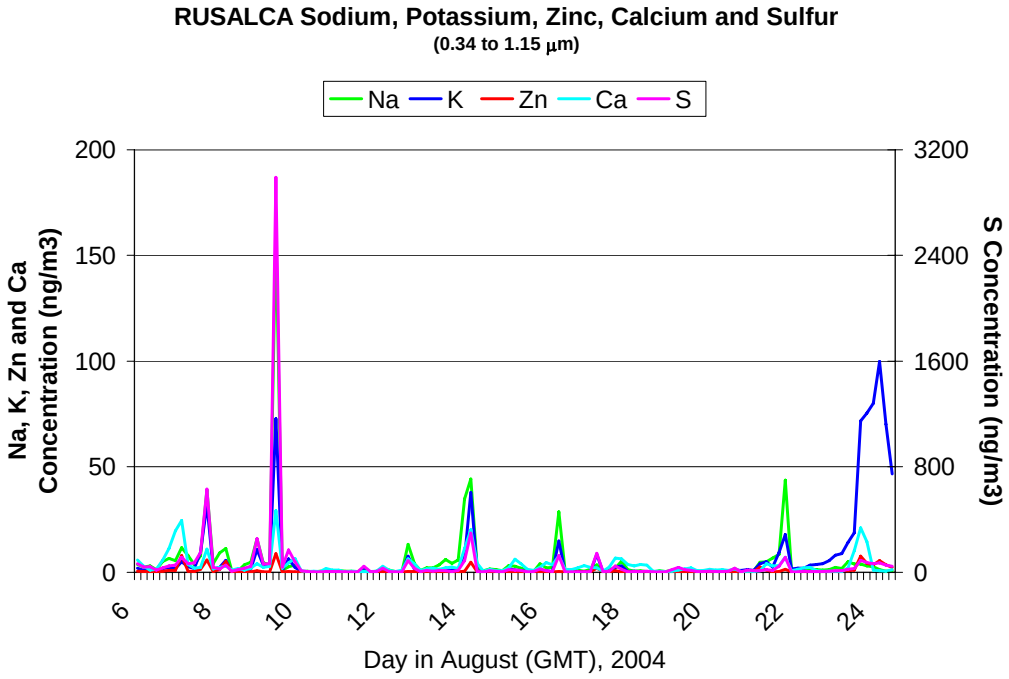

Figure 1. Time series for sodium, potassium, zinc, calcium and sulfur for the entire period of the RUSALCA cruise.

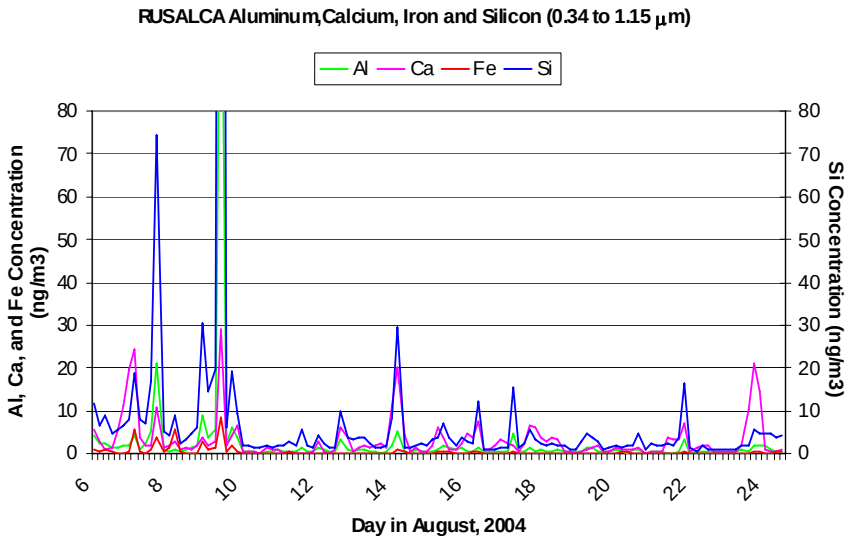

Figure 2. Time series for soil elements (aluminum, calcium, iron, silica) for the entire period of the RUSALCA-2004 Leg 2 cruise. The soil elements observed on August 13th appear to be associated with volcanic activity at Sheveluch on the northern Kamchatka peninsula.
We did not observe any Gobi or Taklamakan dust during this cruise.

The information on aerosols collected during this cruise will assist scientists in understanding the sources, types and sizes of aerosols present over the Bering and Chukchi Seas during the Arctic summer. This information will help quantify the atmospheric deposition of specific trace metals and other elemental species to the seas (where they can be either pollutants or nutrients) and provide a measure of the influence of the aerosols on the radiative balance over the seas. The impact of the aerosols on the radiative balance could influence the effectiveness of atmospheric models for calculating climate changes.

The gaseous atmospheric mercury concentrations were measured during Leg 1 of the RUSALCA-2004 cruise track, particularly at the Piips Volcano. Results were presented at the Kotor meeting by A. Astakhov of the V.Il'ichev Pacific Oceanological Institute.

A Zeeman atomic absorption mercury spectrometer with high frequency modulation of light polarization, RA-915+, for direct on-line measurements of the mercury concentration in air was used for these investigations. The real-time measurements were made with visualization of the process on a computer display. The detection limits for mercury gas in air were governed by shot noise and equal to 2 ng/m^3 for a 1 second average or 0.3 ng/m^3 for a 30 second average.

The concentration of mercury in air was determined 840 times during Leg 1 of the RUSALCA expedition from Vladivostok, Russia, to Nome, Alaska (Fig. 3). Atmospheric monitoring of mercury along this leg track revealed high concentrations, 2.8 ng/m^3, in the Japan Sea near the Asian coastline. By contrast, atmospheric mercury concentrations in the Okhotsk and Bering Seas averaged 1.6-1.7 ng/m^3. The very high levels of gaseous mercury detected during this investigation over the Japan Sea likely reflects anthropogenic mercury sources on mainland Asia and matches the analyses made by *A.P.Dastoor and Y. Larocque [2004]*.

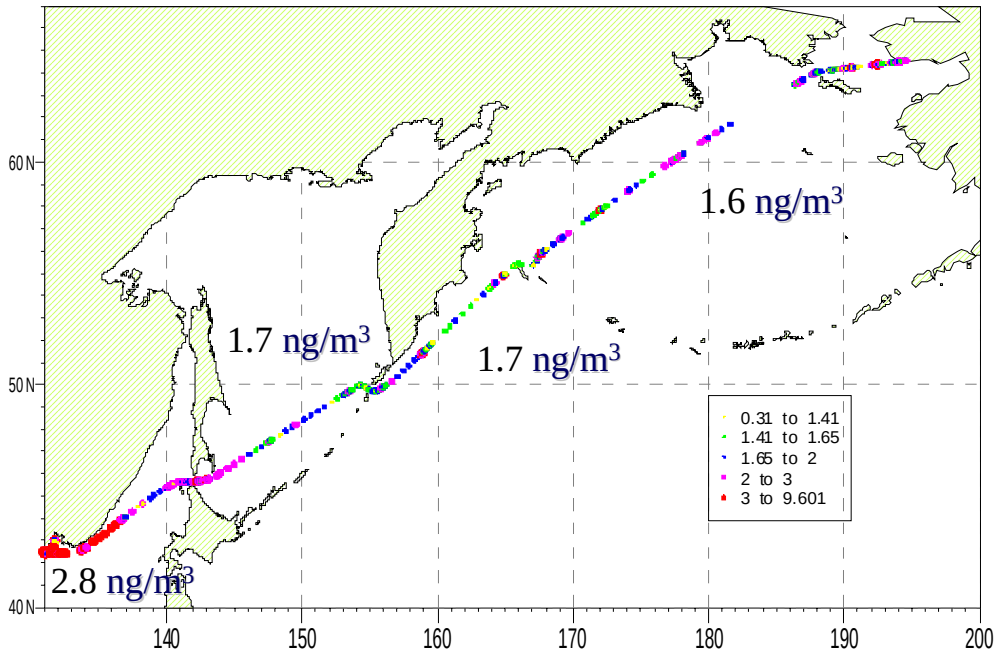

Fig. 3. Gaseous mercury content in air in ng/m3 for RUSALCA-2004 cruise Leg 1 track, July 22 – August 5 2004. The figures show average mercury contents in the air above the Japan, Okhotsk and Bering Seas.

Local atmospheric mercury anomalies in excess of 7 ng/m^3 were detected after the ship crossed through the main geological structures corresponding to boundaries between lithospheric plates: LaPerous Strait (Amur and Okhotsk Plates boundary) and the Kurile Island Arc (Okhotsk and Pacific Plates boundary). An additional mercury anomaly was detected at the boundary of the Pacific Ocean with the Bering Sea over and adjacent to the Piip Submarine Volcano, which lies at a depth of 360 m near the Kommondorskiy Islands. Acoustic data illustrated clearly that a gas plume rises from the crest of the undersea volcano to the sea surface. Atmospheric mercury data were collected as the ship carried out seafloor investigations of the Piips Volcano. The

contoured data presented in Figure 4 illustrate that the atmospheric mercury accumulated in a isobate shaped region with two high mercury concentration focal points (with concentrations in excess of 2 ng/m^3) situated just to the north west of the two submarine peaks (the loci of hydrothermal vents). Wind direction is superimposed on the mercury concentrations in the figure and illustrates that the source of the mercury anomaly is most likely gaseous mercury being degassed by the volcano below and then blown to the northwest by the winds.

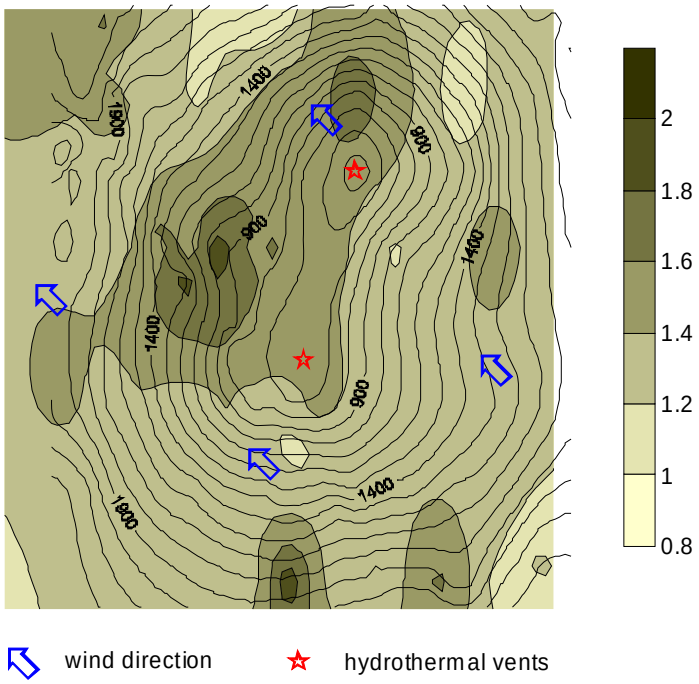

Fig. 4. Gaseous atmospheric mercury concentrations (in ng/m^3) above Piip Submarine Volcano (isobaths in m).

Atmospheric observations collected during the RUSALCA-2004 Cruise revealed low concentrations of anthropogenic pollution in the summertime air above the Bering and Chukchi Seas. So, any atmospheric parameters can be used for monitoring natural events in the seas and over adjacent lands: monsoonal variation, upwelling, permafrost degradation, hydrothermal activity and volcanic eruptions.