

Springtime Observations of Black Carbon in Arctic Snow across Northern Russia During IPY 2007-2008

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INTRODUCTION: Radiative transfer modeling and previously collected observations indicate that parts-per-billion amounts of black carbon (BC) can reduce snow albedo significantly, potentially affecting Arctic climate.

• Small, light-absorbing BC particles are produced by incomplete combustion of fossil fuels or biomass burning and may be carried thousands of kilometers in the atmosphere before being scavenged by raindrops or snow crystals.

• Dark particles in the snow reduce the reflectance and increase the absorption of sunlight. 40 parts per billion of soot can reduce the albedo of the snowpack by 1-3% depending on snow grain size. This is not enough to be visible to the eye, but it is important for climate (Warren and Wiscombe, 1980; Clarke and Noone, 1985).

• Variations in snow albedo are climatically important whenever large areas of snow are exposed to significant solar energy. The variations are most important over unshaded terrain, such as the Arctic tundra and polar sea ice in the spring and fall, and less important in winter and in boreal forest.

• Here we describe a new survey of the BC content of Arctic snow over the Russian sector of the Arctic, which was not accessible for the 1983-84 survey.

• See <http://www.atmos.washington.edu/sootinsnow> for more information.

THE JOINT US-RUSSIAN EXPEDITIONS OF 2007 AND 2008. Organization and sponsorship of the expeditions was provided by the Arctic and Antarctic Research Institute, St. Petersburg.

LOGISTICS were provided by Viktor Boyarsky and the staff of the Arctic and Antarctic Museum, St. Petersburg.

These expeditions were carried out under the auspices of IPY (MII), which provided this unique opportunity for international collaboration between Russian and US scientists.



PREVIOUS RESULTS:

A. In 1983-84, Clarke and Noone (1985) measured light absorption from filtered snow on land and sea in the Western Arctic in 1983-4. Their resulting effective BC content of snow, modeled by Warren & Wiscombe (1985), suggested reductions in wavelength integrated albedo of 0-4% due to BC.

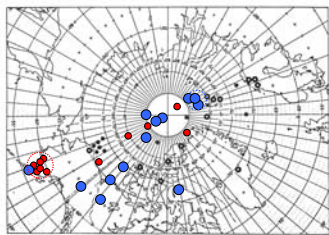
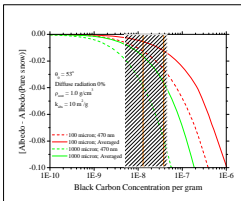


Fig. 1. Map of Arctic sampling locations for the University of Washington expedition in 1983 and 2007-2008.

B. Radiative transfer calculations of the reduction of snow albedo (Warren & Wiscombe, 1985) versus BC concentration for snow grain radii of 100 and 1000 μm . Solid lines are spectrally-averaged and dashed lines are for 470nm (snow albedo most sensitive to soot content). The orange vertical lines are the limits of the Russian samples given below (excluding Vorkuta). The shaded box is the range of values of Clarke and Noone (1985).



LOGISTICS AND ORGANIZATION:

Special thanks to Drs. Vladimir Makarov (L), Sergei Zinov (C, 2nd from left), Dmitri Koslov (R)



Dr. Artur Chilingarov, Hero of the Soviet Union, Promoter of IPY

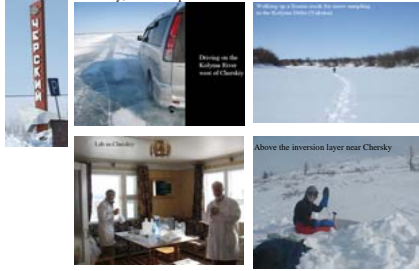
SAMPLE ACQUISITION

- Snow was sampled from sites across the Russian Arctic as indicated in the photos and on the maps below.
- Samples of snow were collected from early April through early May in 2007 and 2008 when the entire winter snowpack was accessible and still well below freezing.
- In many cases, vertical profiles were taken through the annual snow layer.
- The samples were melted and filtered and a visual estimate of the filter loading was made to provide a first-order determination of the concentration.
- These estimates were later compared with results from a spectrophotometer to obtain a more precise result. On average, the initial determination agreed quite well with the spectrophotometer results.
- The material on selected filters has been chemically analyzed for source attribution analysis (Hegg et al., 2008).

Yakutsk, Sakha Republic:

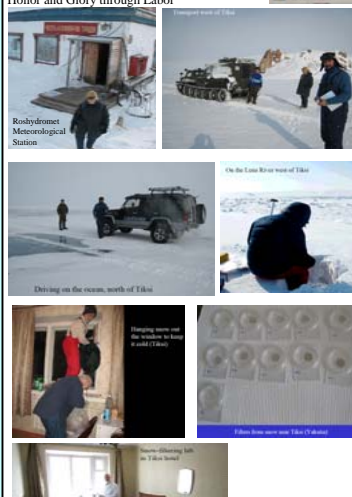


Chersky, Sakha Republic:



Tiksi, maritime gateway of the Sakha Republic

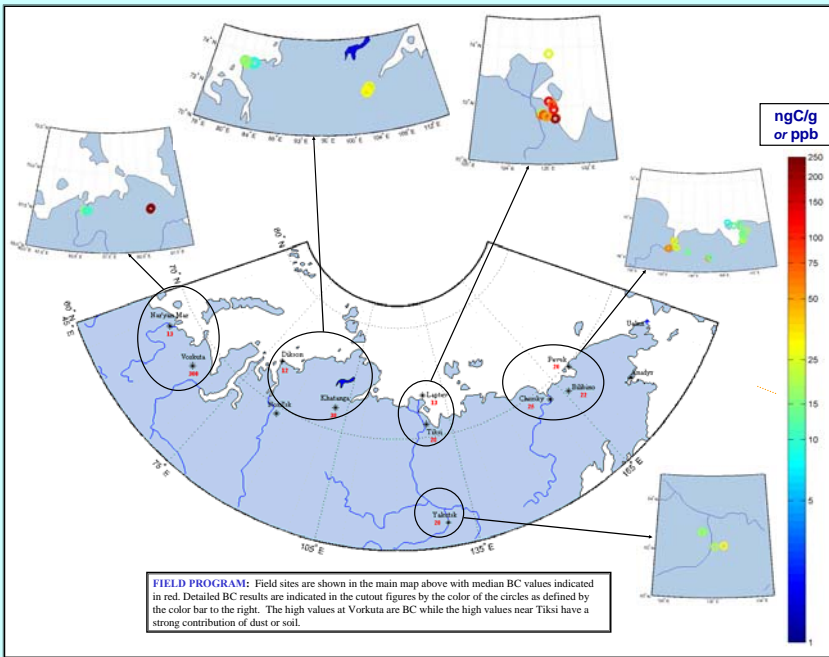
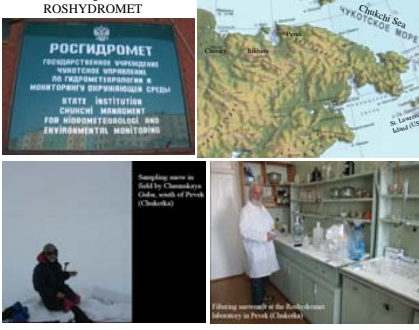
Honor and Glory through Labor



Traverse to Pevek, Chukotka, via Bilbilino:



Pevek – we were guests of ROSHYDROMET



FIELD PROGRAM: Field sites are shown in the main map above with median BC values indicated in red. Detailed BC results are indicated in the cutout figures by the color of the circles as defined by the color bar to the right. The high values at Vorkuta are BC while the high values near Tiksi have a strong contribution of dust or soil.



ORS DAT 1 - Results for 2007 and 2008

Site	Date	BC (ppb)	Notes
Yakutsk	2007-04-15	15	
Chersky	2007-04-20	25	
Tiksi	2007-05-05	10	
Pevek	2008-04-10	30	
Bilbilino	2008-04-15	20	
Vorkuta	2008-04-20	250	High BC
Tiksi	2008-05-05	150	High BC

CONCLUSIONS:

- Equivalent median background BC levels in Russia ranged from 13 to 38 ppb.
- Comparison with results from other regions – Highest BC amounts were found in Russia, Greenland has the lowest values (~2 ppb)
- According to Hegg et al. (2008), the origin of most of the soot at the selected Russian locations is biomass burning.
- Our results are in general agreement with model predictions by Flanner et al. (2007) in the Eastern Arctic.
- Additional data and a detailed description of the entire project are available on our project web site: <http://www.atmos.washington.edu/sootinsnow>.

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