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Comparison of Measurements of Aerosol Elemental Carbon at Wrangel Island, USSR, and Barrow, Alaska

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Abstract

During the winter and spring seasons of 1989 and 1990, we collected samples of the background aerosol at Wrangel Island in the eastern Soviet Arctic. The samples were analyzed by optical transmission to determine the concentration of aerosol "black" carbon (BC), with results ranging from 5 to 167 nanograms per standard cubic meter. These results are compared with the continuous measurements at the NOAA/CMDL monitoring station at Barrow, Alaska for cases when meteorological trajectories connected the two locations with transit times of from one to two days. The preliminary results suggest that concentrations of aerosol BC are reduced at Wrangel relative to Barrow.

Keywords:
Atmosphere; aerosol; black carbon; "Arctic Haze"; optical transmission; meteorological trajectory.

Introduction

Aerosol black carbon (BC) is chemically inert and has a small particle size. This allows for its transport over great distances to remote regions of the earth. It has been documented for many years in the springtime "Arctic Haze" (Rahn 1981, 1985; Schnell 1984; Barrie 1986). BC is a strong absorber of visible light, and its presence in the Arctic, either in the ambient atmosphere or deposited on the snow or ice surface, may lead to changes in the solar radiation balance. BC is removed from the atmosphere by both wet and dry deposition; however, the removal rates are unknown. Theoretical calculations suggest lifetimes of one week to one month (Ogren and Charlson 1983). These rates must be quantified if further progress is to be made in assessing the impact of BC on the climates of the Arctic and the globe.

Experimental Procedures and Results

With the intention of measuring BC over a wide geographic area to determine its distribution, transport pathways and removal rates, a collaborative research project was initiated under the US-USSR Bilateral Agreement on the Environment. The project includes the sampling and analysis of "Arctic Haze" aerosols for their carbon content in a comparative study conducted simultaneously at Wrangel Island and Barrow, Alaska. The locations of the monitoring sites are shown in Fig. 1.

These two sites are at almost equal latitudes, are separated by only flat ocean surface (no topography, nor any anthropogenic sources in between), and meteorological trajectories frequently connect the two with transit times on the order of one to two days. The US participants provided an aerosol sampler which was installed at Wrangel Island. Samples were collected there during the winter-spring seasons of 1989-90 and 1990-91.

All samples were collected on pre-fired quartz fiber filters. Multiple optical scattering within the filter fibers eliminates any effect on optical transmission due to scattering from the particles (Rosen and Novakov 1983). Thus, a measurement of the optical transmission may be directly interpreted in terms of a surface loading of optically absorbing BC (Gundel *et al.* 1984). The aerosol samples were analyzed both in Moscow and in Berkeley.

Figure 2 shows a correlation plot of the optical attenuation measurements. From the above results, it is clear that the methods for sampling and analysis of BC aerosols give results that are agreed upon by laboratories in both the USA and the USSR, and that these methods may be used at remote field stations.

The Barrow measurements have a time resolution of one hour, while the Wrangel data are from 3 to 60 hours. Many of the BC samples from Wrangel Island were contaminated by local aerosol from local combustion sources but 51 samples are believed to be representative of the background Arctic air. The results showed concentrations of aerosol BC ranging from 5 to 167 nanograms per cubic meter, values that are quite comparable with measurements made at high-latitude stations in the Western Arctic at this time of year. The object of the collaboration is to compare these data with corresponding measurements at Barrow in the hopes that information may be gained on the atmospheric lifetime of BC aerosol in the Arctic region. An example of such comparisons is shown in Fig. 3.

An ensemble of backward trajectories at the 1000 hPa level centered at Wrangel Island were calculated for each background measurement. The 1000 hPa level was chosen because we are interested in the transport of surface level air. The temperature inversion typical of late spring gives the possibility that BC aerosol will remain in the boundary layer during transport to Wrangel Island.

The Wrangel values of BC concentration for the cases are less than the corresponding Barrow data by a factor of two or greater. The large differences in BC concentrations during 1 – 2 days of transport from Barrow to Wrangel are inconsistent with previous estimates of a one week to one month atmospheric lifetime for BC. The data suggest

the following possibilities: (a) lifetimes are shorter than expected; (b) the few cases available for analysis are insufficient to draw any conclusions regarding atmospheric lifetimes of BC; (c) there is a dilution mechanism caused by meteorological factors. In order to evaluate these or other possible explanations it is necessary to obtain more measurements at these and additional Arctic sites.

Conclusions

During the winter and spring seasons of 1989 and 1990, aerosol samples were collected on Wrangel Island in the eastern Soviet Arctic. The samples were analyzed in Moscow and in Berkeley for aerosol BC. Comparison of the filters' analyses showed excellent agreement between the methods used in the two laboratories. The results showed that many of the samples were contaminated by emissions from local combustion sources at the research station. However, 51 samples were representative of the background Arctic aerosol at that time and location. The results from those filters showed concentrations of aerosol BC ranging from 5 to 167 ng/m^3, values that are comparable with those measured at high latitude locations in the Western Arctic.

We compared BC measurements made at climate monitoring stations in the Soviet and Alaskan Arctic. The measurements are evaluated in terms of the meteorological link between the two stations. A few cases were found where the air mass had passed over Barrow 1 – 2 days before, and showed a reduction of aerosol BC concentration in transit. The reduction may be due to deposition on the ice surface as well as dilution. It is hoped that this promising start to the collaborative project will lead to coordinated measurements through the US-USSR Bilateral Agreement on the Environment or through other cooperative programs in the future.

Acknowledgments

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Figure Captions

Fig. 1 Location of the Soviet and American aerosol monitoring stations.

Fig. 2 Correlation plot of optical transmission analyses performed in Moscow and in Berkeley.

Fig. 3 Excerpt from time series of aerosol BC concentrations at Wrangel Island and Barrow.

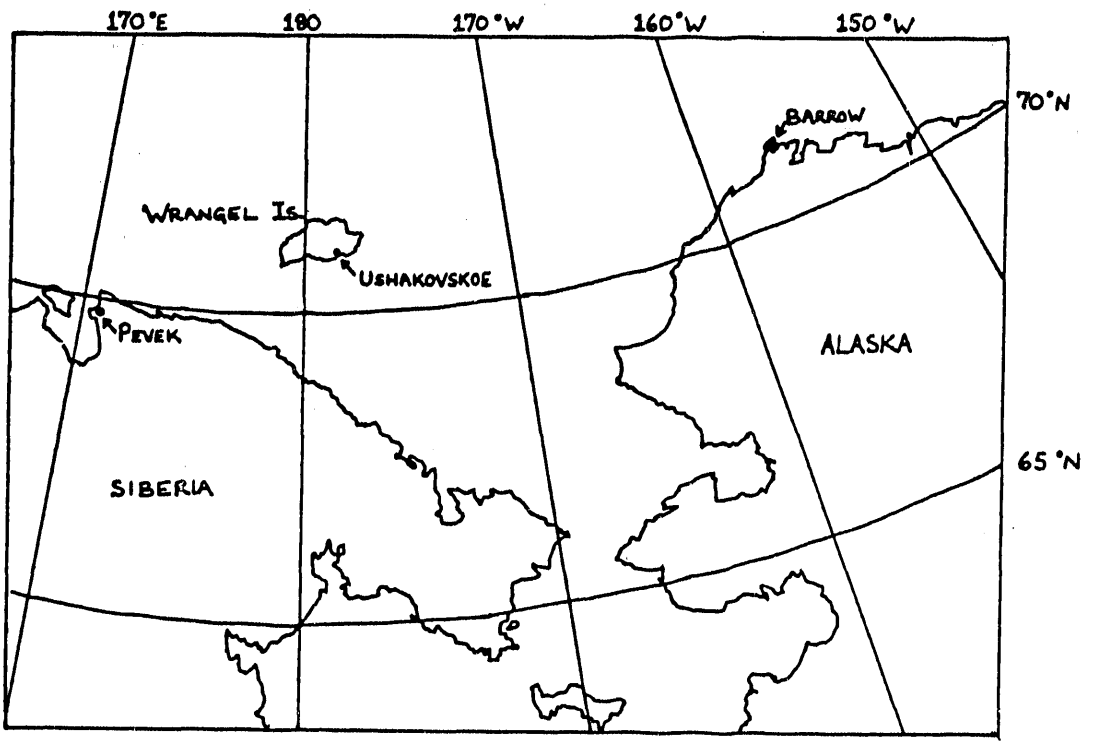
170°E
180
170°W
160°W
150°W
70°N
65°N
BARROW
WRANGEL Is.
USHAKOVSKOE
PEVEK
ALASKA
SIBERIA

Figure 1

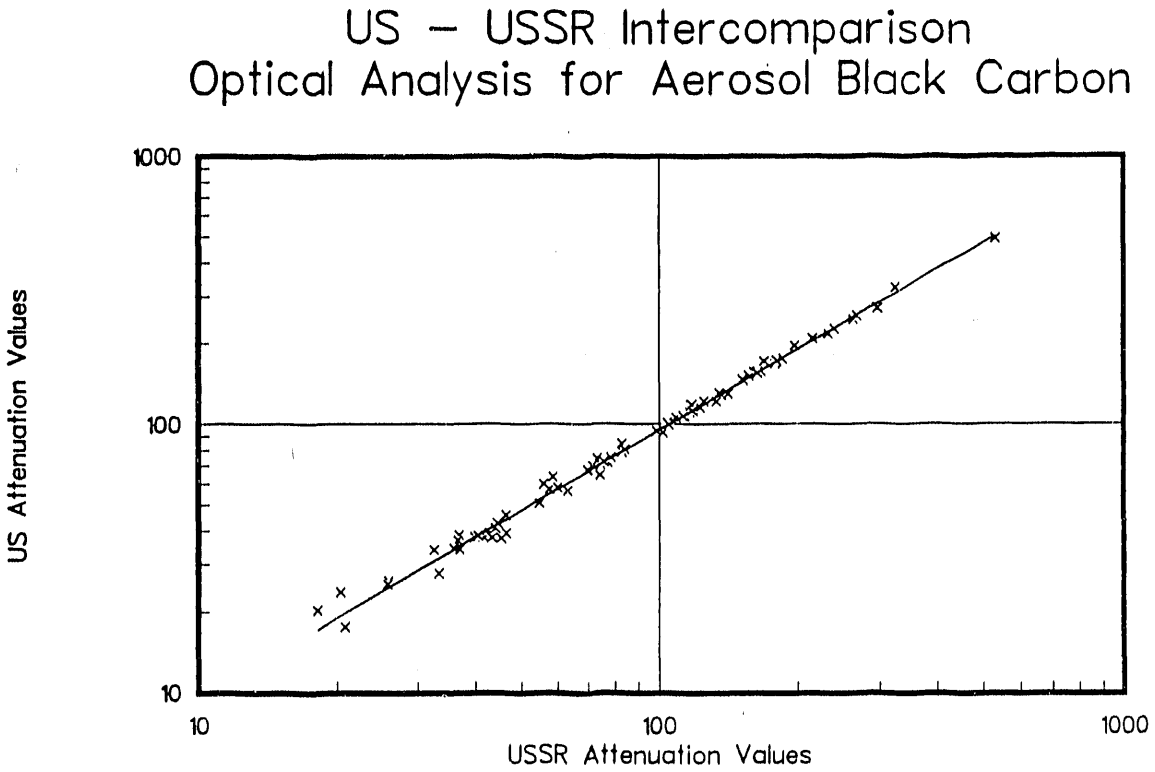
US – USSR Intercomparison
Optical Analysis for Aerosol Black Carbon
US Attenuation Values
1000
100
10
10
100
1000
USSR Attenuation Values

Figure 2

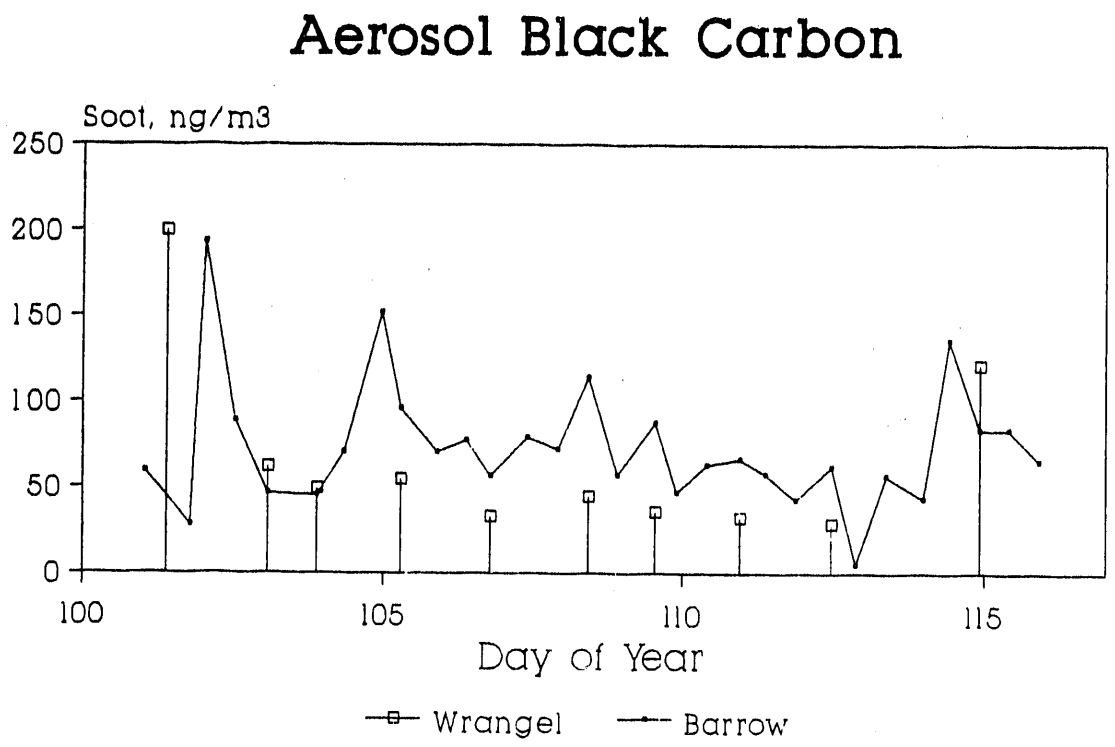
Aerosol Black Carbon
Soot, ng/m3
250
200
150
100
50
0
100
105
110
115
Day of Year
Wrangel
Barrow

Figure 3

END

DATE
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5/20/92