Monitoring Arctic Aerosols

Dave Hofmann with contributions from Russ Schnell, Bob Stone and John Ogren
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Boulder, Colorado, USA

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Source regions of aerosol transported into the Arctic

dust
smoke
volcanoes

Courtesy of Bob Stone, NOAA/ESRL
ARCTIC HAZE HAS BEEN STUDIED FOR AT LEAST THE PAST 25 YEARS

AGASP- Arctic Gas & Aerosol Sampling Program 1983-1989

Six Distinct Arctic Haze Layers Upwind of Barrow, Alaska. Nearest Possible Sources are 10,000 km distant.

Courtesy of Russ Schnell, NOAA/ESRL
Black Carbon Profile Upwind of Barrow, Alaska
March 11, 1983

Altitude (km)

Black Carbon (ng m\(^{-3}\))

Barrow ground level
April 1982

Courtesy of Russ Schnell, NOAA/ESRL
Black Carbon is usually accompanied by carbon dioxide and methane.

Courtesy of Russ Schnell, NOAA/ESRL
NOAA-federated Long-term Aerosol Network

Legend
- NOAA
- affiliate
- future sites

http://www.esrl.noaa.gov/gmd/aero/

Courtesy of John Ogren, NOAA/ESRL
LONG-TERM ARCTIC AEROSOL MEASUREMENTS

Implementation status

<table>
<thead>
<tr>
<th></th>
<th>Barrow</th>
<th>Tiksi</th>
<th>Summit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiative properties</td>
<td>100%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Chemical composition</td>
<td>50%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Size distribution</td>
<td>100% (2007)</td>
<td>100% (Finland)</td>
<td>0%</td>
</tr>
<tr>
<td>Cloud condensation nuclei</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Light absorbing particles in snow</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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</tbody>
</table>
Aerosol Light Absorption at Barrow

- Proportional to black carbon
- Measured by NOAA since 1988
- Seasonal - peak in winter from “Arctic haze”

Courtesy of John Ogren, NOAA/ESRL
Monthly averaged concentrations for March of a) light scattering and b) light absorption at 550 nm for sub-10 micron aerosol at Barrow, and c) black carbon (ng m⁻³) for Alert. Trend lines are not shown for significance < 90%. Data made available for Barrow by NOAA ESRL and for Alert by the Canadian National Atmospheric Chemistry (NAtChem) Database and Analysis System. From Quinn et al., *Tellus 59B*, 99-114, 2007.
Monthly averaged concentrations in $\mu g$ S m$^{-3}$ of sulfate for March and April. Trend lines are not shown if the significance for the trend is $< 90\%$. Data made available for Alert by the Canadian National Atmospheric Chemistry (NAtChem) Database and Analysis System, for Barrow by NOAA PMEL (http://saga.pmel.noaa.gov/data/), and for the other stations by EMEP (http://www.emep.int/). From Quinn et al., *Tellus 59B*, 99-114, 2007.
Monthly averaged AOD anomalies at Barrow, Alaska for March and April. The anomalies are relative to a base of non-volcanic years. Data from 1982 and 1983 and from 1992 and 1993 were removed due to stratospheric aerosol from the major El Chichón and Pinatubo volcanic eruptions, respectively. Vertical lines represent the 1σ standard deviation of the monthly mean. Data made available by NOAA ESRL. From Quinn et al., *Tellus 59B*, 99-114, 2007.
Actual time 20040629.120000 (3-hour time steps)

FLEXPART Tracer Simulation (A. Stohl 2006)

Courtesy of Bob Stone, NOAA/ESRL
Desert Dust

SeaWiFs

Courtesy of Russ Schnell, NOAA/ESRL
Asian Dust (brownish yellow plumes) being blown from the Gobi Desert over the Sea of Japan in early April 2002. Dust/haze was observed at Barrow, Alaska about 7 days later following each event. Images courtesy of NASA SeaWiFs and ORBIMAGE.

Courtesy of Russ Schnell, NOAA/ESRL
REDOUBT (60.5° N) ERUPTION IN ALASKA MARCH 23, 2009
CONCLUSIONS

• The scattering component of Arctic Haze began to decline about 1980 although the decline appears to have stopped about 1998 and may have increased since that time.

• Arctic black carbon has also declined since measurements began about 1988.

• Black carbon from forest fire smoke is a long-range transport threat in the Arctic.

• Desert dust likewise will continue to affect Arctic air quality.

• Volcanic eruptions are sporadic sources of Arctic pollution, critical for aviation.

• Long-term monitoring at an increased number of Arctic sites is necessary in order to determine trends in specific components in the future.
Bob Stone, who is responsible for a large part of ESRL’s Arctic aerosol work, is currently on the PAM-ARCNIP mission, on the twin turbo-prop Polar 5 (AWI-Polar Institute) from Bremerhaven, Germany to the USA by way of the North Pole, and will be at the Russian Station North Pole 36 April 3-5.
# ID    Name                  Dates
1. BRE  Bremerhaven      dep. 30 Mar
2. TRO  Tromso          30-31
3. LGY   Longyearbyen (base) 31-7
4. N36    N. Pole 36 (ice is.) 3-5
5. SND    Station Nord      8-9
6. ALT    Alert          9-13
7. EUR    Eureka         13-15
8. RES    Resolute       15-17
9. SHB    Sachs Harbor    17-18
10. FAI    Fairbanks      18-19
11. BRW  Barrow         19-25
12. INU    Inuvik        25-26
13. OSH  Oshawa, CAS       arr. 27 Apr
Drifting station North Pole - 36

WMO index - UFT

North Pole-36: 2009.03.04 12:00 UTC 87.8N 133.1W T_e: -35.8°C P_e: 1018.3hPa 3.0m/s SEE(120°)

Operative meteorology

Archive of 6-hours synoptic meteorology (NP-35): [.txt] [archived messages] [.zip]

Contact information: V.Smolyanitsky (vms@aari.ru)

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# WMO/GAW Recommended Aerosol Parameters

## Continuous Measurements

<table>
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<tr>
<th>Core Variables</th>
<th>Comprehensive Variables</th>
<th>Intermittent Measurements</th>
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<tbody>
<tr>
<td>AOD - multiwavelength</td>
<td>( \sigma_{sp} ) - multiwavelength</td>
<td>Size distribution</td>
</tr>
<tr>
<td>( \sigma_{sp} ) - multiwavelength</td>
<td>( \sigma_{bsp} ) - hemispheric backscatter coefficient</td>
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<tr>
<td>( \sigma_{ap} ) - multiwavelength</td>
<td>( \text{CNC} ) – number concentration</td>
<td>Chemical composition – size fractionated</td>
</tr>
<tr>
<td>Chemistry – 2 size ranges</td>
<td>( \text{CCN} ) – cloud condensation nuclei</td>
<td>( f (\text{RH}) ) – scattering dependence on humidity</td>
</tr>
<tr>
<td>Mass – 2 size ranges</td>
<td></td>
<td>( \text{CCN spectra} ) – several supersaturations</td>
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<tr>
<td></td>
<td></td>
<td><strong>Vertical distribution</strong> – lidar, aircraft profiles</td>
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