Assessing mining impacts from dust and black carbon on Arctic snow in Svalbard, Norway

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Background

Black carbon (BC) is a product of incomplete combustion of fossil fuels and biomass burning. BC in the cryosphere is mainly studied for its impacts on snow and ice albedo. The dark particles increase absorption of solar radiation, heating the adjacent ice. Thus, BC impacts water resources, such as the timing of the seasonal snow-melt pulse, as well as glacier-fed water sources. Remote sensing of BC is not currently possible, however the high concentrations near mining sites. Remote sensing of BC is not currently possible, however the high concentrations near mining sites in Svalbard may provide potential testing grounds.

Site Description

Svalbard is the largest island of the Spitsbergen archipelago from 74° to 81° N Lat. It is barren, treeless, and sparsely populated. The coal mining industry first settled Svalbard during the early 20th century, although only a few mines remain operational. Thus, it is possible to sample both contaminated and non-contaminated sites. Mine 7, an active mine, provides coal for the main settlement of Svalbard, Longyearbyen.

Field Sampling

At the 5 sites, spectral hemispherical directional reflectance (HDRF) of snow surface was measured every 10 ft, then averaged.

Snow samples from top 10 cm of snow surface were collected for Particulate Refractory Black Carbon (rBC). Frozen samples were transported to coolers to UNIS and shipped with dry ice to boulder, CO. No thaw was observed.

Research Aims

To determine mining impacts on snow and ice albedo reduction.

To compare BC levels at the non-contaminated site in Northern Svalbard to the contaminated site near Mine 7.

To determine the relative contribution of BC to albedo reduction.

To explore the mining site as a potential testing site for remote sensing of BC due to high concentrations.

Analytical Methods

Spectral HDRF measurements were made using an Analytical Spectral Devices Field Spectrometer Pro. RBC was measured with a Single Particle Soot Photometer (SP2).

Results

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>rBC (mg/l)</th>
<th>Snow Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Fjorden</td>
<td>1.1</td>
<td>Recently Fallen</td>
</tr>
<tr>
<td>Upwind of Mine</td>
<td>4.7</td>
<td>Recently Fallen</td>
</tr>
<tr>
<td>Mine 7</td>
<td>34.5</td>
<td>Old, Coarse Grain</td>
</tr>
<tr>
<td>Downwind of Mine – Dirty</td>
<td>294.0</td>
<td>Old, Coarse Grain</td>
</tr>
<tr>
<td>Downwind of Mine – Clean</td>
<td>87.0</td>
<td>Old, Coarse Grain</td>
</tr>
</tbody>
</table>

Table 1: Refractory Black Carbon (rBC) Concentrations, and snow grain type.

Figure 1: Spectral HDRF reductions correspond with increasing BC concentrations.

Figure 2: Refractory Black Carbon (rBC) Size Distribution, larger particles closer to the mine.

Figure 3: Continuum Removal Spectral HDRF from 758 – 768 nm. The area of reduced spectral HDRF corresponds directly with increasing BC levels.

Figure 4: Minimum value of Continuum Removed Spectral Albedo from 758-768nm. Significant correlation with measured BC concentrations.

Conclusions

This study demonstrates that mining in the Arctic reduces the spectral HDRF of snow, and is linked to BC concentrations. Snow grain size also is an important factor which can reinforce the radiative forcing and can vary in relation to BC concentration and as a result of freeze-thaw processes in the snow-pack.

Results are further significant due to growing pressure on Arctic communities for mining exploration. Diminishing sea-ice resulting in increased shipping traffic may also contribute more BC to the Arctic. The 758-768 nm band may support this mining area of Svalbard as a testing site for remote sensing of BC due to high contamination levels.

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