**Introduction**

Ice nucleating particles (INPs) are a small subset of aerosols that can trigger heterogeneous freezing in the atmosphere. They can influence climate and the hydrological cycle by acting as nuclei for ice clouds and mixed-phase clouds. In order to improve climate predictions, characterization of INP properties is needed, such as the freezing efficiency. Here we investigated the efficiency of aerosol particles at nucleating ice as a function of size at Alert, Canada during a 3-week campaign in March, 2016.

**Questions**

- What is the size distribution of INPs and total aerosol particles?
- How does the freezing efficiency change as a function of size?
- Can the size distribution of INPs be explained by the size distribution of total aerosol particles with different freezing efficiencies of each size mode?

**Methods**

Aerosol particles with sizes from 0.1 to 10µm were collected on hydrophobic glass slides using Micro-Orifice Uniform Deposit Impactor (MOUDI). INP concentrations were measured with the droplet freezing technique (DFT). The aerosol particle concentrations were determined with scanning mobility particle sizer (SMPS) and optical particle counter (OPC).

**Results I**

- Size distribution of INPs and total aerosol particles.
  - Fraction of INPs ≥1µm is 0.77 at -15°C, 0.73 at -20°C, 0.68 at -25°C.
  - Particles ≥1µm represent 0.2% of the total numbers and 9.5% of the total surface areas of aerosol particles.

**Figure 3.** The number (N) and surface area (S) of aerosol particles with different sizes. The aerosol particle size distributions vary significantly in different temperature conditions. The surface area distribution of aerosol particles can be described using a lognormal distribution function.

**Figure 4.** Freezing efficiency as a function of size at -15°C, -20°C and -25°C, respectively.

**Results II**

The surface area distribution of aerosol particles can be described as the sum of n lognormal distributions (3) (three modes in this case), where \(N_i\) is the number concentration, \(D_m\) is the median diameter and \(\sigma_i\) is the standard deviation of each mode. By using the \(n_i\) (\(n_i\) ≥ INPs/surface area) values shown in Figure 4 for each size mode, the INP number distribution can be well explained.

\[
dS/d\log D_p = \sum_{i=1}^{n} \frac{n_i D_m^2 N_i}{(2\pi \sigma_i)^{2.5}} \exp \left( \frac{-(\log D_p - \log D_m)^2}{2\log^2 \sigma_i} \right)
\]

**Table 1.** Number distribution of INPs at -15°C, -20°C and -25°C, respectively.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Mode 1</th>
<th>Mode 2</th>
<th>Mode 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>-15°C</td>
<td>68</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td>-20°C</td>
<td>1.4</td>
<td>0.6</td>
<td>1.2</td>
</tr>
<tr>
<td>-25°C</td>
<td>1.7</td>
<td>1.25</td>
<td>1.6</td>
</tr>
</tbody>
</table>

**Figure 5.** Prediction of aerosol surface area distribution and INP number distributions using the parameters in the table above.

**Conclusions**

- Supermicron particles only make up a small fraction of total aerosol particles, but contribute to a large fraction of INP concentrations.
- The freezing efficiency of aerosol particles depends strongly on size with large particles being more efficient.
- The INP distribution can be well explained by combining the size distribution of aerosol particles with different \(n_i\) values for each size mode.

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1 Ramanathan, V., Crutzen, P.J., Kiehl, J.T., Rosenfeld, D., Aerosol, Climate and the Hydrological Cycle, Science, 294, 2119-2124 (2001)

This work is funded by Natural Sciences and Engineering Research Council of Canada (NSERC) through the NETCARE program. The authors would like to thank the researchers from Environment Canada and technicians at the Alert scientific station who have contributed to this work.

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**References and Acknowledgement**