Studies on ice cores and snow chemistry in the Arctic

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-Opportunities for Norway-Japan Collaboration
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Why ice cores?

• To improve the projection of future Arctic climate and environment changes (including retreat of sea ice, ice caps and Greenland ice sheet) associated with global warming, climate and ice sheet modeling needs to be improved.

However,

• Due to large natural variability of the Arctic climate system and lack of long-term observations, it is difficult to separate anthropogenic and natural climate changes.
Why ice cores?

• The Arctic climate is sensitive to location of the radiative forcing (Shindell and Faluvegi, 2009).

• Aerosols which affect radiative forcing (BC, sulfate, dust etc.) show large regional and temporal variability, which is not well understood.

Therefore,

• Long-term proxy records of the past Arctic climatic and environmental changes are necessary.
ICAPP (Ice-Core Circum Arctic Paleoclimate Program)

An International umbrella led by Canada
Initiated in mid-1990’s

Circum-Arctic ice core study sites

1. Site-J
2. Summit (GRIP)
3. North GRIP
4. Penny Ice Cap
5. Agassiz Ice Cap
6. Devon Ice Cap
7. Vestfonna
8. Austfonna
9. Snøfjellafonna
10. Høghetta Ice Dome
11. Åsgordfonna
12. Mt. Logan
13. Mt. Wrangell
14. Aurora Peak
15. Mt. Ushkovsky
16. Mt. Ichinsky
<table>
<thead>
<tr>
<th>Date</th>
<th>Drilling Sites</th>
<th>Latitude, Longitude</th>
<th>Altitude (m a.s.l.)</th>
<th>Drilling depth (m)</th>
<th>10 m ice temperature(°C)</th>
<th>Ice density (kg/m³)</th>
<th>Ice density (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May-Jun. 1987</td>
<td>Høghetta Ice Dome</td>
<td>79°17'N, 16°50'E</td>
<td>1200</td>
<td>85.61 (bedrock)</td>
<td>-11.0</td>
<td>(ice)</td>
<td>(ice)</td>
</tr>
<tr>
<td>Jul.-Aug. 1992</td>
<td>Snøfjellafonna</td>
<td>79°08'N, 13°18'E</td>
<td>1190</td>
<td>83.92</td>
<td>-2.8</td>
<td>565</td>
<td>775</td>
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<td></td>
<td></td>
<td>79°08'N, 13°19'E</td>
<td>1160</td>
<td>24.41</td>
<td></td>
<td></td>
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<tr>
<td>Jun.-Jul. 1993</td>
<td>Ásgårdfonna</td>
<td>79°27'N, 16°43'E</td>
<td>1140</td>
<td>185.3, 49</td>
<td>-6.8</td>
<td>808</td>
<td>881</td>
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<tr>
<td>Sep. 1994</td>
<td>Brøggerbreen</td>
<td>78°52'N, 11°55'E,</td>
<td>550</td>
<td>10</td>
<td>(0)</td>
<td>812</td>
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<tr>
<td>May-Jun. 1995</td>
<td>Vestfonna</td>
<td>79°58'N, 21°01'E</td>
<td>600</td>
<td>210</td>
<td>-3.7</td>
<td>639</td>
<td>839</td>
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<td>Mar.-Apr. 1998</td>
<td>Austfonna</td>
<td>79°48'N, 24°00'E</td>
<td>750</td>
<td>118.62</td>
<td>-1.0</td>
<td>601</td>
<td>876</td>
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<tr>
<td>Apr.-May 1999</td>
<td>Austfonna</td>
<td>79°50'N, 24°00'E</td>
<td>750</td>
<td>289.075</td>
<td>-2.8</td>
<td>649</td>
<td>840</td>
</tr>
</tbody>
</table>
Ice core drill sites in Svalbard (Collaboration with Norway)

- Vestfonna (1995) (580m)
- Austfonna (1999) (750m)
- Snøfjellafonna (1992) (1190m)
- Lomonosovfonna (1250m)
- Longyearbyen

Svalbard
Reconstruction of past temperature

Longyearbyen mean annual air temperature

δ¹⁸O: Proxy for Temperature

Lomonosvfonna 1997 core δ¹⁸O

Austfonna 1999 core δ¹⁸O

Isaksson et al., 2003
Red: Sites showing early 20th century warming
1. Dye 3 (2590m)
2. Summit (3240m)
3. Agassiz Ice Cap (1750m)
4. Penny Ice Cap (1900m)
5. **Austfonna (750m)**
6. Site J (>2000m)
7. **Vestfonna (580m)**
8. **Academii Nauk Ice Cap (810m)**
9. **Vetrenity Ice Cap (505m)**
10. Lomonosovfonna (1250m)

Unpublished
Temperature variations in Greenland

Vinther et al. (2006)
Sea-ice extent in western Barents Sea & Austfonna 1999 core $\delta^{18}$O

Isaksson et al., 2003
Reconstruction of air pollutants

Matoba et al., 2002

Vestfonna, Svalbard
Reconstruction of air pollutants

Goto-Azuma and Koerner, 2001
1. Dye 3
2. Summit
3. Agassiz Ice Cap
4. Penny Ice Cap
5. Snøfjellafonna
6. B21

Goto-Azuma and Koerner, 2001
Future studies

- Analyses of existing ice cores.
  - High resolution analyses.
  - New chemical species (BC, halogens, trace metals, organic materials etc.)
- Drilling of new ice cores.
  - Collaboration project on ice core drilling on Austfonna to the bedrock.
  → Needs to be funded!
- Previous cores need to be updated!
  → Needs to be funded!
Future studies

○ Snow chemistry studies across the Arctic (including Svalbard).

→ Inventory of aerosols contained in snow needed for modeling aerosol transport and albedo effects.

- Ongoing seasonal snow sampling in Alaska, Siberia and Mongol under the GRENE project.

- Sampling also on the Arctic ice caps and glaciers including Svalbard?

○ Aerosol, stable isotopes of water vapor and meteorological observations on ice caps.