Rapid Changes in the Canadian North
Urgent Needs for Research, Monitoring and Adaptation

Warwick F. Vincent, CEN & Dépt de biologie, Université Laval, Québec
Optical Society (OSA) and International Photonics Advocacy Coalition (IPAC)
meetings with Federal Government representatives, 19 October 2017
Two features that make the North vulnerable to change:

- Ice-based environments
- Polar amplification
IPCC Report 2013: Projections for 2100

POLAR AMPLIFICATION

(a) Change in average surface temperature (1986–2005 to 2081–2100)

RCP 2.6

RCP 8.5

(°C)
Polar amplification – 1960 to 2011

https://nsidc.org/cryosphere/arctic-meteorology/climate_change.html
CENTRE FOR NORTHERN STUDIES (CEN)
- Interuniversitaire
- Multidisciplinaire
- Réseau de stations

CENTRE D’ÉTUDES NORDIQUES
CEN Centre for Northern Studies
Markham Ice Shelf  2007  2008
Ward Hunt Ice Shelf, Canadian High Arctic (collapsed in 2011/12)
Thaw lakes
Hudson Bay
Canada: 50% of our land area has permafrost
Permafrost = permanently frozen ground

“Permafrost is defined as ground that remains at or below 0°C for at least two consecutive years.”

- Lots of it
- Foundation
- Ancient Carbon
- Lakes & Wetlands
- Downstream Effects
- It’s changing (rapidly)

Rapid permafrost change
Permafrost is part of the natural infrastructure, a defining feature of northern ecosystems… Also affected by snow and liquid water
Permafrost provides the foundation for northern built infrastructure

Major influence on municipal and residential infrastructure

Major influence on transportation infrastructure

Salluit, Nunavik

Yellowknife, NWT
Permafrost is a global carbon reservoir

Organic carbon content of permafrost estimated as:

$800 \times 10^{15} \text{ g (Pg)} \text{ C}$

Atmospheric CO$_2$ content:

$850 \times 10^{15} \text{ g (Pg)} \text{ C}$

(Hugelius et al. 2015)

Fosheim Peninsula, Ellesmere Island, NU
G. Henry et al.
Mobilisation and release from lakes of ancient soil organic carbon:

- carbon dioxide
- methane
- impacts on water quality
Biological coupling:
Migration between the lakes and sea

Arctic Char
Importance of permafrost:

- It is in transition: with rapid thawing associated with climate change


Link for more information: http://www.nrcresearchpress.com/doi/pdfplus/10.1139/as-2016-0027
Herschel Island, Yukon Territory
Sinking into the sea

The coastline of the Northwest Territories is eroding faster than scientists can measure it.

Link for full news article including video:
Permafrost thaw in Salluit shifts land, lives

"I feel the whole town should move"

SPECIAL TO NUNATSIAQ NEWS

MONIQUE POLAK
Postmedia News
CEN Network: Umiujaq, Nunavik

Soil temperature profile, Nunavik; Michel Allard

1995  2007
Thawing permafrost a growing problem for Iqaluit airport

Manager wants more information on ground below runway as renovations are slated to start soon
Towards a rain-dominated Arctic

R. Bintanja¹,²* and O. Andry¹

Climate models project a strong increase in Arctic precipitation over the coming century¹, which has been attributed primarily to enhanced surface evaporation associated with sea-ice retreat². Since the Arctic is still quite cold, especially in winter, (strong in winter, moderate in summer)³, the seasonally varying fraction of rain/snow will inevitably change as well. Whereas increased precipitation leads to more snowfall, higher atmospheric temperatures tend to reduce snowfall⁴. Because of these opposing
Ottawa threatens to sue railway owner over broken rail line to Churchill, Manitoba

The government says Denver-based Omnitrax has 30 days to fix the Hudson Bay Railway to Churchill or face an $18.8-million lawsuit.
Current and future sea ice trends
Stroeve and Notz (2015)

Arctic Monitoring and Assessment Program (AMAP)
Industrial development in the changing Arctic

Raglan Mine, Nunavik

• Permafrost stability for infrastructure
• Chemical stability of mine tailings
• Waste storage, treatment and discharge
• Shipping – port facilities and monitoring

http://www.nunatsiaqonline.ca/pub/photos/raglan.jpg
Increased marine transport across the Arctic Ocean
Giant cruise ship makes historic voyage in melting Arctic


The cruise ship’s route in 2016 and 2017
THE ARCTIC MARINE ECOSYSTEM

Microbiome

Sentinel North

HUMAN
POLAR BEAR
SEABIRDS
ICE ALGAE

SEAL
SYMPAGIC FAUNA
PHYTOPLANKTON

NARWHAL
ARCTIC COO

THEMISTO LIBELLULA
MICROBIAL FOOD WEB (BACTERIA, FLAGELLATES)

KILLER WHALE
WALRUS
BOWHEAD WHALE

BENTHOS

DETURITUS (DEAD ORGANISMS)

GELATINOUS CARNIVOROUS ZOOPLANKTON

ZOOPLANKTON (COPEPODS)
Vulnerability of the Arctic Ocean ecosystem: climate change & acidification

Polar Regions: The Arctic

Why study the Arctic Ocean?

The Arctic Ocean, covering an area of over 14,056,000 km², may be one of the world’s oceans most vulnerable to climate change. With a fairly constant water temperature of 0°C, the Arctic has the ability to absorb carbon dioxide more readily than warmer waters. Ocean acidification may be occurring faster at the poles than other climate regions for several reasons:

- Cold water more readily absorbs CO₂, lowering the pH,
- Added melt-water and increased riverine input is forcing additional uptake of CO₂,
- Reduced sea-ice coverage results in more seawater exposure to and uptake of atmospheric CO₂, and
- Expanded ocean-surface area may in turn alter the production and decomposition of organic carbon, a complex process that plays an important role in ocean chemistry.

Our data from 2010 and 2011 cruises show large areas of the Canada Basin which are already undersaturated with respect to aragonite—a shell forming mineral important to growth and survival of important food web organisms, like pteropods.

https://coastal.er.usgs.gov/ocean-acidification/research/polar.html
### Age distribution of Inuit and all Canadians

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Total Canadian Population</th>
<th>Total Inuit population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>#</strong></td>
<td><strong>%</strong></td>
</tr>
<tr>
<td>0 - 4</td>
<td>1,690,400</td>
<td>5</td>
</tr>
<tr>
<td>5 - 9</td>
<td>1,808,280</td>
<td>6</td>
</tr>
<tr>
<td>10 - 14</td>
<td>2,078,135</td>
<td>7</td>
</tr>
<tr>
<td>Subtotal 0 - 14</td>
<td>5,576,805</td>
<td>18</td>
</tr>
</tbody>
</table>

**35% of the Inuit population is younger than 15 years old**

Inuit Statistical Profile
www.itk.ca/inuit-statistical-profile
Rapid Changes in the Canadian North
Urgent Needs for Research, Monitoring and Adaptation

- The North is changing rapidly
- These changes are already affecting ecosystems, landscapes, communities, industry
- More rapid changes are expected ahead
- Urgent need for smart technologies for: research & monitoring, management & adaptation

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