# Satellites and autonomous robots: The future for Arctic observations

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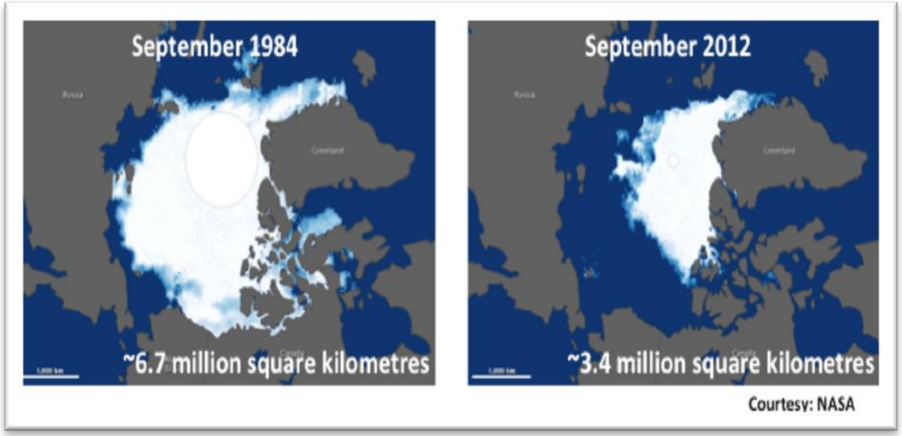
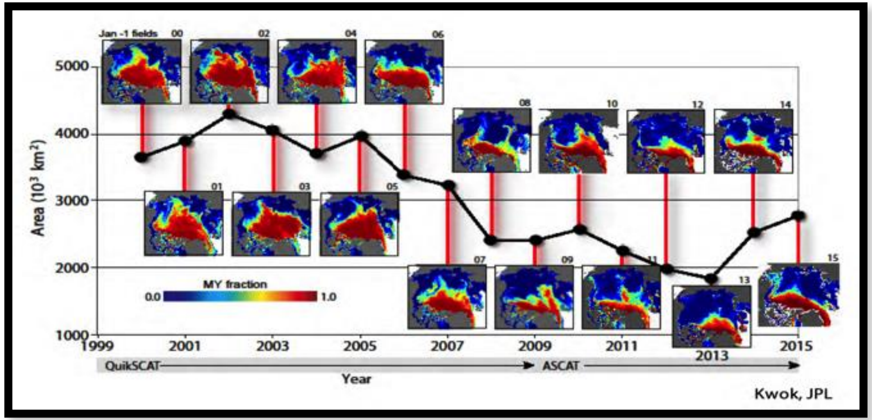
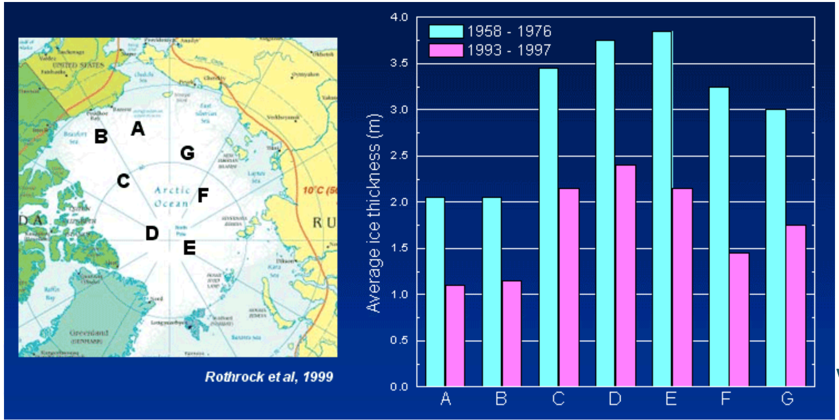
# The top of the world is changing




- Loss of around 50% in area of summer sea ice since late 1970s
  - 7 million km$^2$ in the 1970s
  - 4.2 million km$^2$ in 2007
  - 3.4 million km$^2$ in 2012
  - 4.1 million km$^2$ in 2016 (second lowest)

# Multifaceted impacts….

- **Local/Indigenous communities**
  - Loss of traditional way of life
  - Economies changing

- **Coastal changes**
  - Coastal erosion due to enhanced wave energy

- **Environmental pressures**
  - Loss of habitat/species
  - Increase in ocean acidification
  - Change in ocean properties



# Multifaceted impacts….

- **Climate**
  - Global links to Arctic Change
- **Security**
  - Homeland, energy, food, SAR etc
- **Industry**
  - Shipping, oil/gas, minerals, fisheries, tourism…
- **Economics**
  - UK Stern Review on the Economics of Climate Change (2006). £3.68 trillion
  - What is the cost of Arctic change?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27 February 2012 Last updated at 20:05

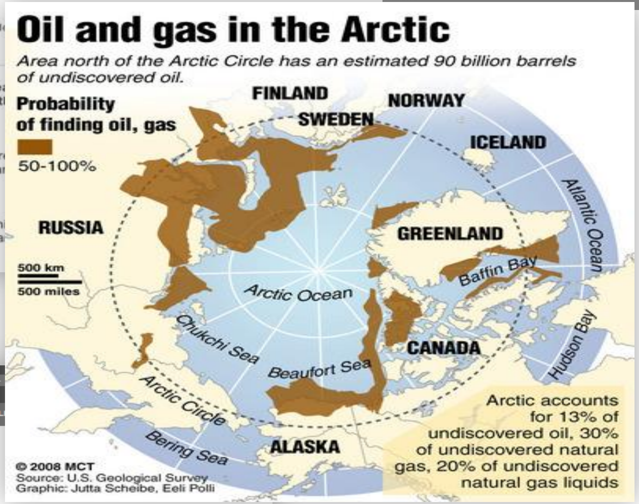
**Melting Arctic link to cold, snowy UK winters**

By Richard Black
Environment correspond

The progressive shrinking of Arctic se is bringing colder, snowier winters to t UK and other areas of Europe, North America and China, a study shows.

As global temperatures have risen, the ar Arctic Ocean covered by ice in summer ar autumn has been falling.

Writing in Proceedings of the National Academy of Sciences (PNAS), a US/Ch based team show this affects the jet strea and brings cold, snowy weather.





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* Reservoir of methane under East Siberian Sea
* Release could accelerate ice melting, global warming
* Risks include extreme weather, poorer health, lower crop output

By Nina Chestney

LONDON, July 24 (Reuters) - A release of methane in the Arctic could speed the melting of sea ice and climate change with a cost to the global economy of up to $60 trillion over coming decades, according to a paper published in the journal Nature.

# Situation awareness: Better Arctic knowledge

**Year on year more activity in the Arctic.**

***To excel in the Arctic… you must understand and predict the environment.***

*The three essential ingredients for Arctic observations are:*

1. *Satellites,*
2. *Autonomous robotic platforms and*
3. *Good communication*

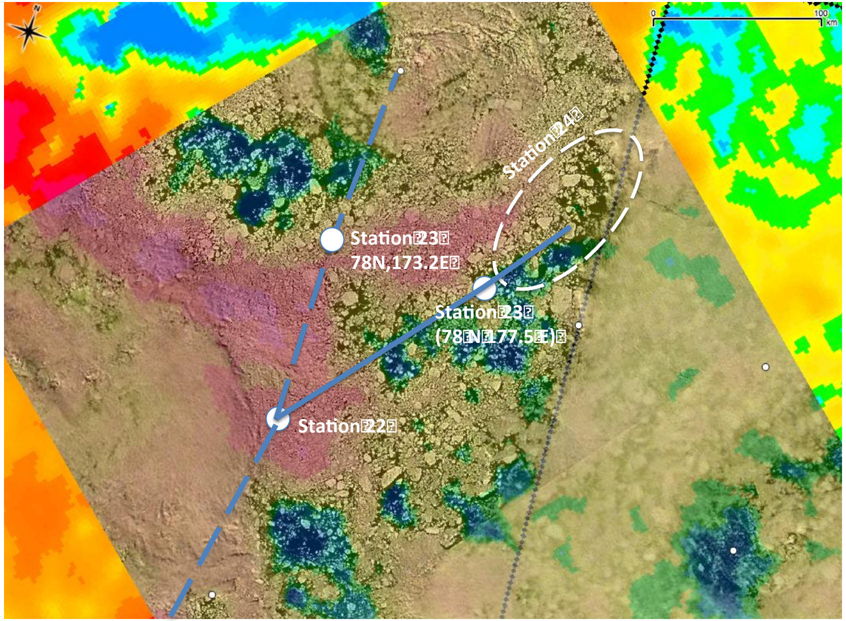
*The fusion of these elements lead to advanced situation awareness.*

# Observations split into two areas..

1. **Operational:** Measurements that have an operational need for up-to-date informational i.e. weather, ice conditions and so on.

2. **Long-term monitoring**: data whose transmission is not time critical.

# Operational Example: Ship routing in ice




**Underlying colour image**: Satellite derived ice concentration (red 100% sea ice, blue open-water: **Overlaid Grey image**: high resolution satellite SAR image showing individual ice floes. (courtesy DMI)

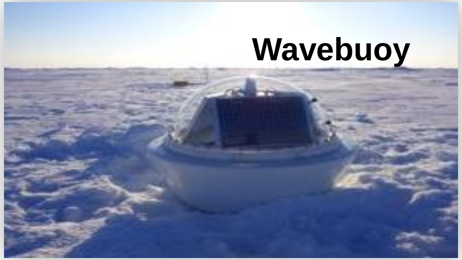
**More efficient ship navigation**

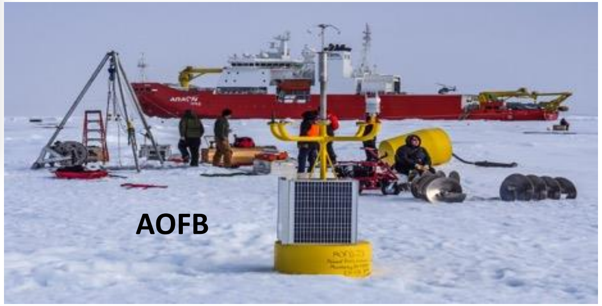
- South Korea Research ship *Araon:* Arctic Ocean 2016.
- Very tight timeline for science.
- Real time planning via satellite images a must.
- Make changes on the fly based on best available information.
- Good communication with the outside world essential.

# Research Example: Long term presence needed





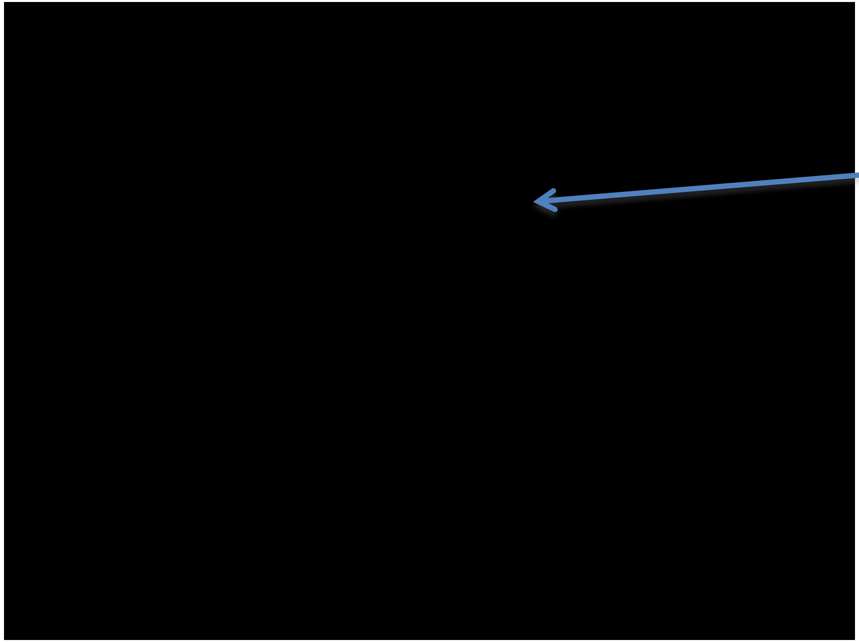





**<u>ONR MIZ programme</u>: Many different assets that all need to communicate to the outside world. Two-way communication is becoming more important.**

****Satellite tracking of all assets****

# MIZ Autonomous Sampling (1 Mar – 20 Oct 2014, 8 months)

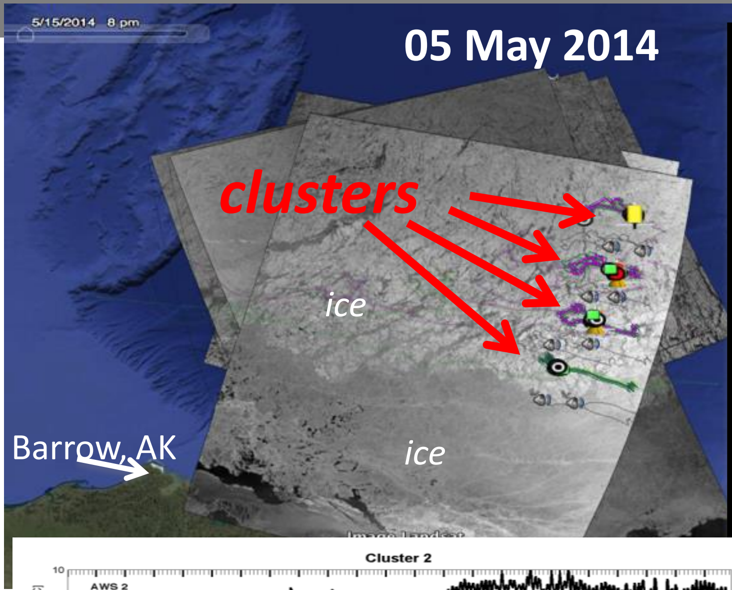


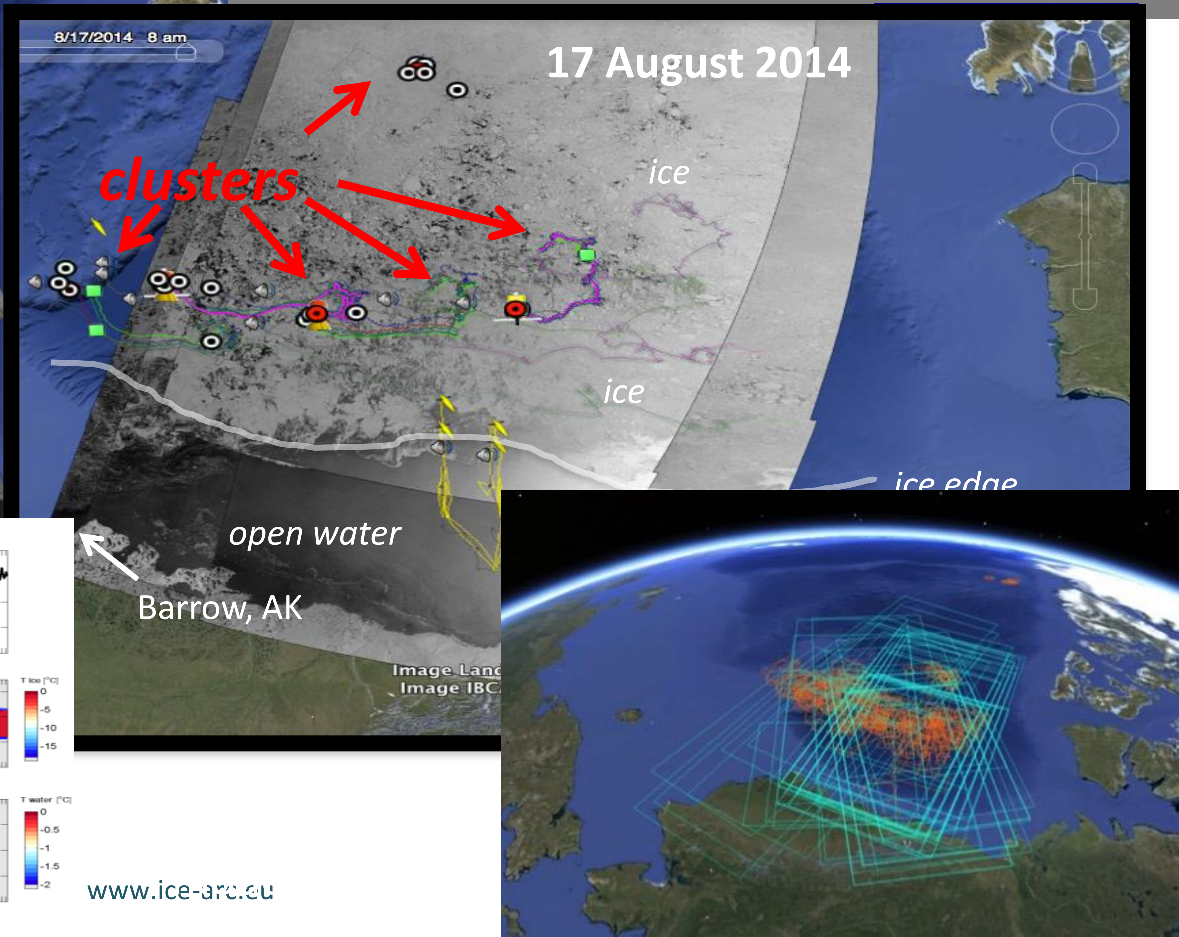
**IBRV Araon deploys '5$^{th}$' cluster**

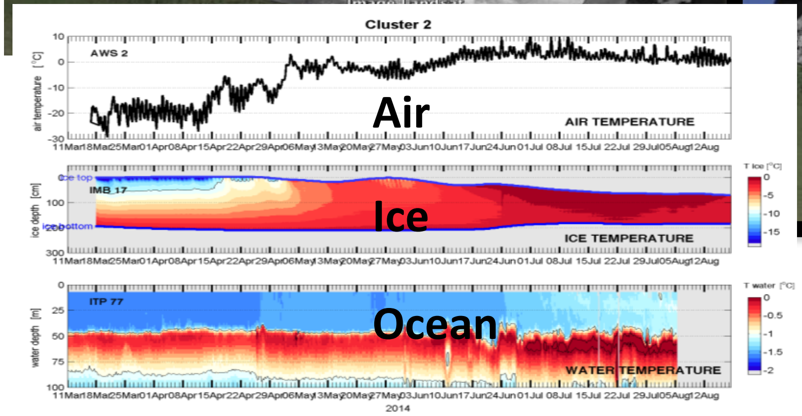

## Technical

1. Develop and demonstrate new robotic networks for collecting observations in, under and around sea ice.
2. Improve interpretation of satellite imagery.
3. Improve numerical models to enhance seasonal forecast capability

# Real Time Situational Awareness

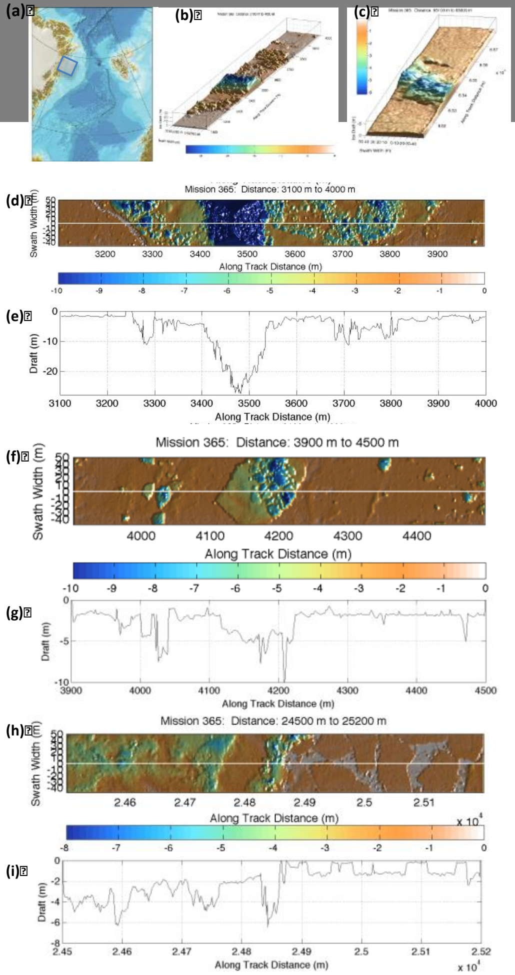


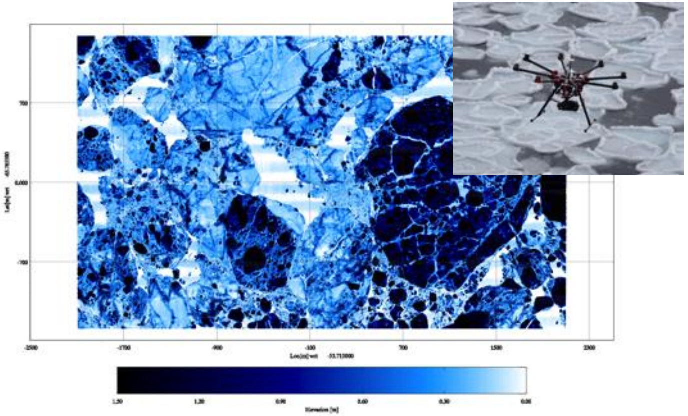



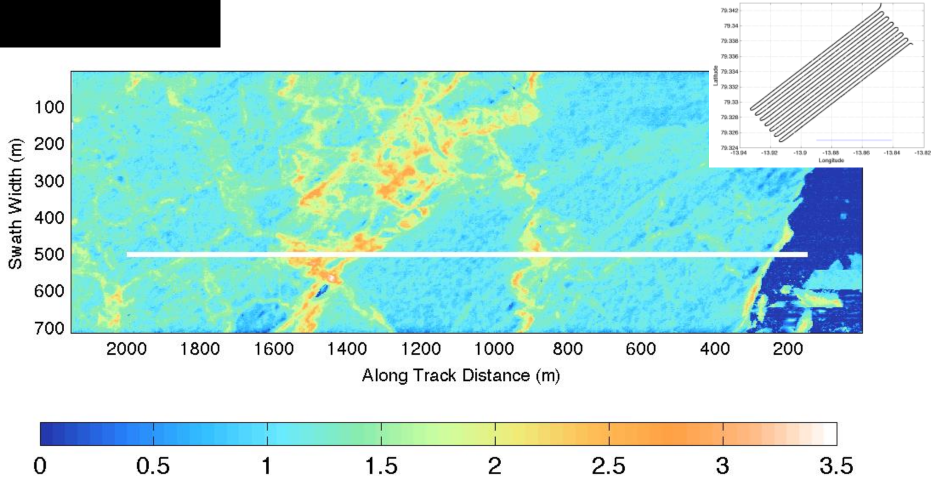




www.ice-arc.eu

# AUV and Drones



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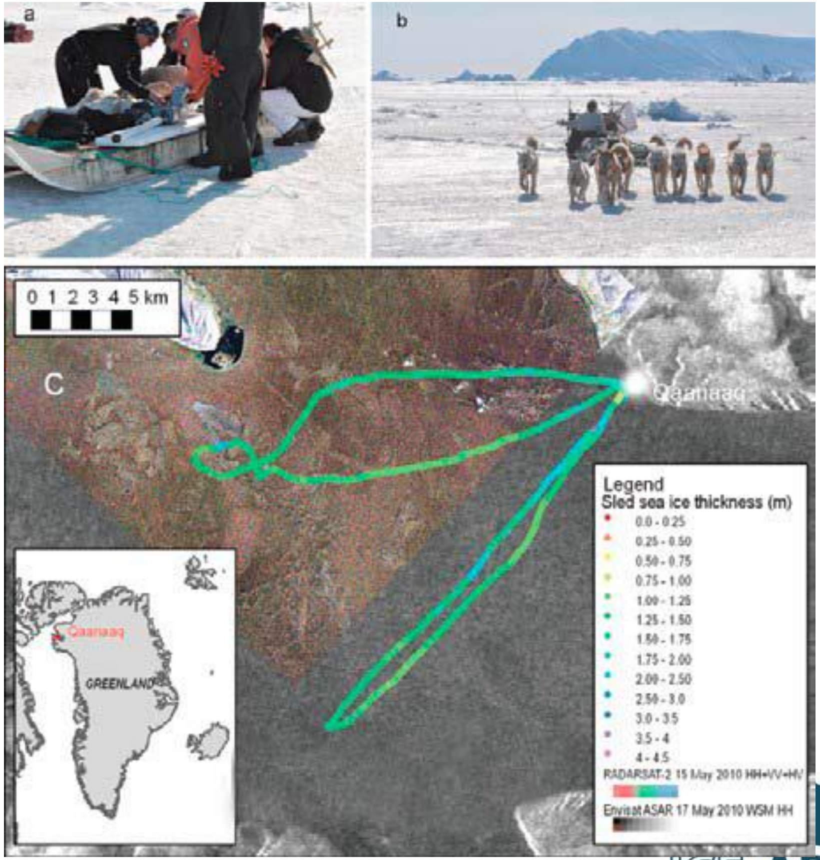
# Local Community : untapped resource

Role for community-based observing initiatives involving equal partnership between scientists and northern residents.

**Win-Win situation**

- Local knowledge
- Break down barriers
- Employment opportunities for youth
- Gather and share information needed by the community and scientists.



# Conclusions

- **More Activity**: Every year there is more human activity in the Arctic. Accurate observations are needed now more than ever.
- **More reliant** on satellite and autonomous platforms (stationary and movable)
- **Opportunities are plentiful**: Technology has never been so cheap and accessible. We are still some way from taking full advantage to what this technology can truly offer.
- **Arctic communications** are mainly, but not exclusively, reliant on one carrier; Iridium. Let's hope it does not fail.
- **Be smart:** Know what is available, know its limitations, and seek work around to address those limitation.
- **Data accessibility benefits all**: Real time access to knowledge/data is key.
- **Develop links to other industries** that operate in harsh environments i.e. space industry, polar shipping etc.
- **Local people**: Take advantage of the people who live in the region. Underutilized resource.

# A final comment…

***Without Satellites and Autonomous platforms working together it is NOT possible to provide the information scientists, industry, military, civil society and policy makers need to understand and operate in the Arctic.***

① **Reduction of uncertainty:** finding a way for teams to apply for funding jointly outside of the relatively narrow opportunities that are presently available.

- A regular call the community can rely on i.e. at the same time of year for example.

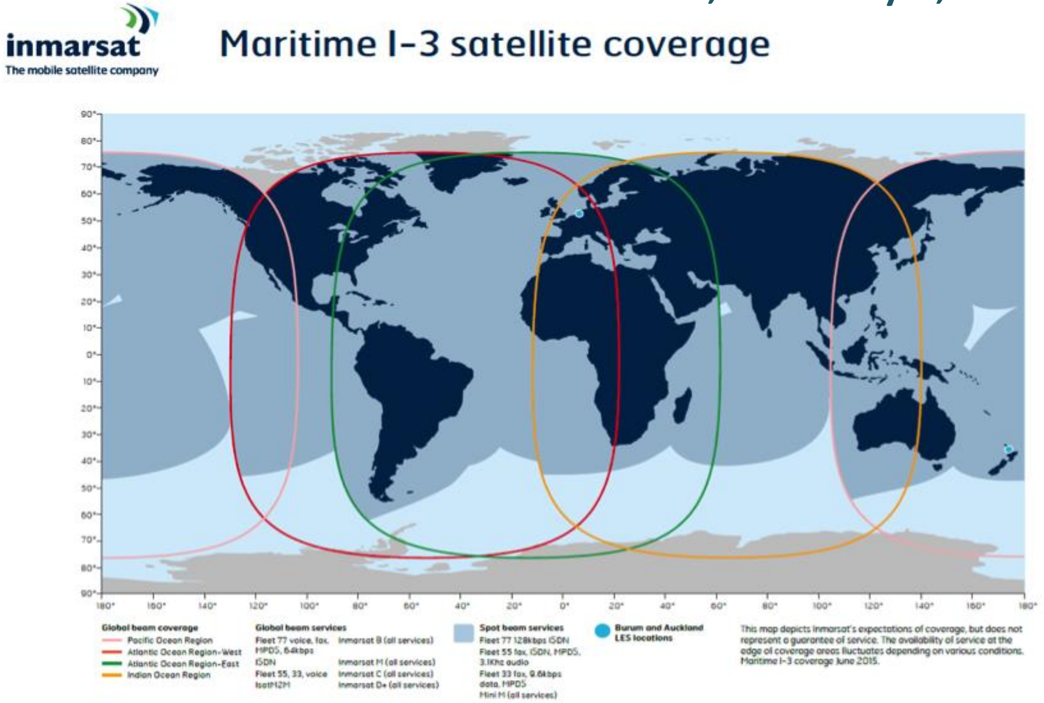
② **Sustainability:** Better coordination of long-term measurements in the Arctic.

- Repopulation of instrumentation whose data is made available to all in near real time

# Communication: The Challenge

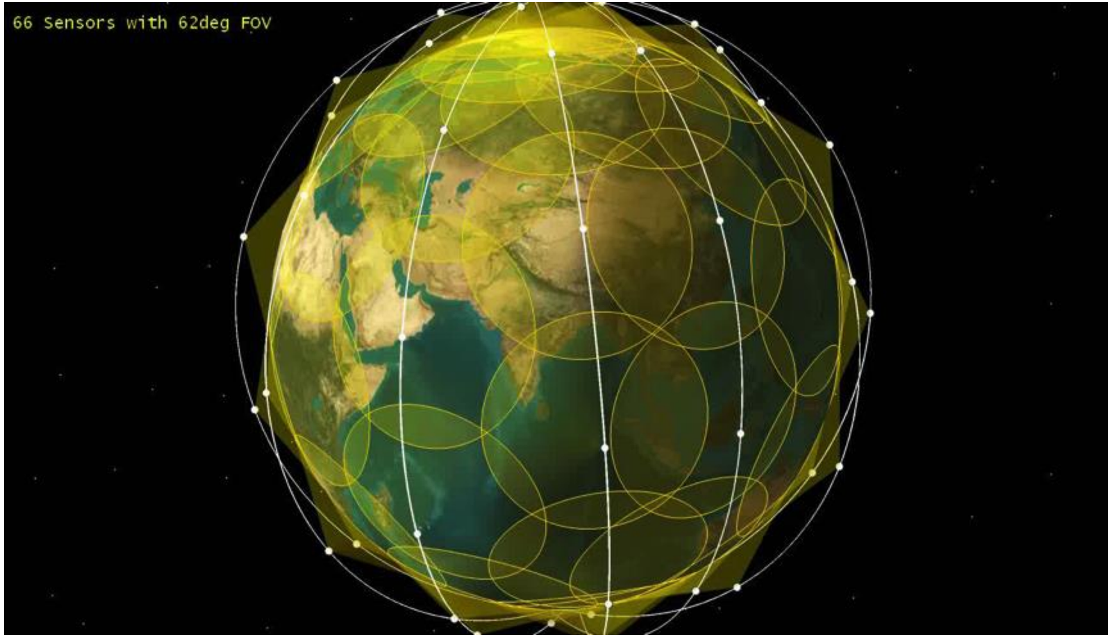
## Geostationary – no coverage > 80˚ ; Limited above 75˚ N

Inmarsat, Thuraya, Intelsat etc




# Reliant of one satellite system: Iridium

## Iridium – polar coverage, ~66 satellites




- Voice, Data and text messaging service.
- Two-way communication.
- Very much the ‘go to’ network for polar research
- Replacement constellation (NEXT) keeps being delayed.

**Other possibilities:**

- ARGOS (French/US)
- GoNets (Russian)

# Benefits

**Well acknowledged that satellites, drones, and autonomous platforms**

-**albeit in the air on ice, or below the water -**

**is the FUTURE for observations of the Polar Regions.**

- What are the benefits?

***'To excel in an environment… you must understand and predict that environment.'***

*Satellite and Autonomous robotic platforms provide this mechanism*

The ability to continuously support industry, military, sciences, communities and policy makers with accurate insights into real time and long-term environmental conditions

Caveat: Need communication protocols and data fusion techniques to ensure that access to the latest information/data immediately no embargo. Third party organisations can then provide added value.

# Opportunities/Challenges…

- Development of new sensors and systems that address Arctic observing needs for different sectors i.e. industry, military, civil-society, academia etc
- Upgrades to existing platforms and sensors to permit deployment in the Arctic
- Explorations of autonomous behaviors appropriate for the Arctic environment
- Novel sensing strategies employing complementary observation types or platforms
- Robust low-power systems that can collect critical environmental data over long periods of time
- Under-ice navigation and data communication capabilities
- The management of data and data sharing is a common challenge
- Fusion of data can still be a problem: improved standards and interoperability.