Monitoring polar regions

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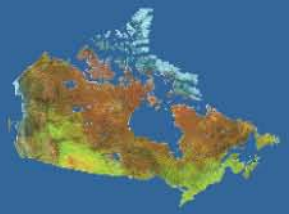
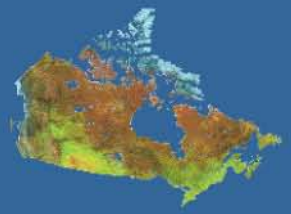
What's been going on



- Polar regions were expected to respond first to climate change
  - i.e. feedback in the Arctic from albedo changes
- Changes are happening on such a large scale that ordinary citizens need very little experience to interpret EO and the sea ice change it reflects.
- What next?
  - Long term climate models predict the disappearance of all multi-year sea ice in the Arctic before the end of the 21st century
  - Other scientists have predicated such catastrophic loss as early as 2015.
  - Still others point to the recent small recovery in ice extent as pointing to inter-annual variability as a key element.

Polar changes



- The Arctic is changing faster than anywhere else on earth. That change needs to be tracked in order to mitigate and adapt, both in the Arctic and globally.
- A global increase of 2º globally would mean a warming of more than 5º in most areas of the Canadian Arctic.
- Arctic is a key controller of global change, primarily through changes in ice cover, ocean circulation
- Sea ice loss has major implications for traditional lifestyles and indigenous food security
- Melting polar glaciers and ice sheets could contribute significantly to global sea level rise.

The Arctic sea ice story…

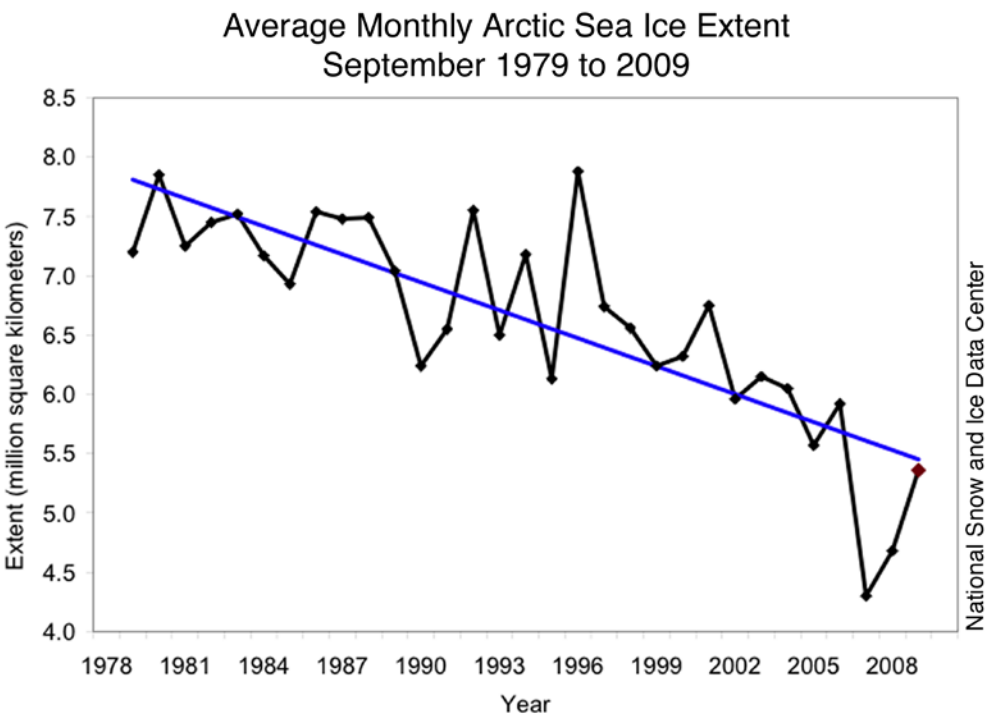
Long-term EO show changing Arctic sea ice conditions

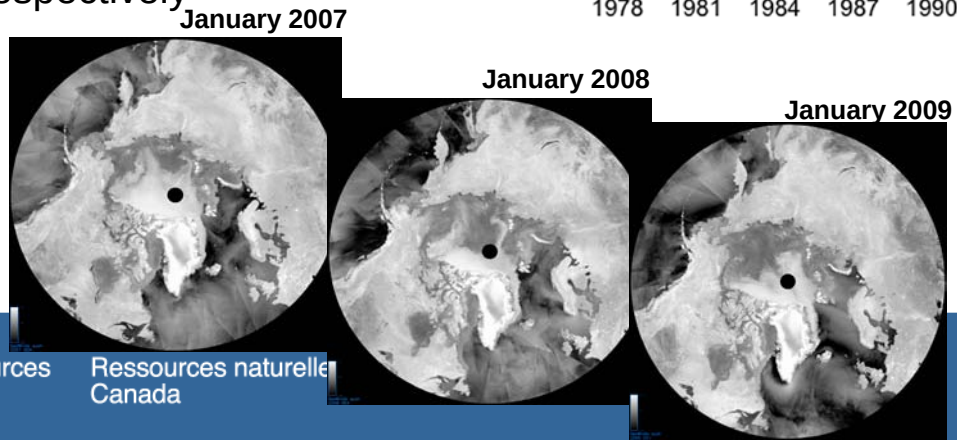
Sea ice extent is declining

Sea ice reflects sunlight, keeping the Arctic region cool and moderating global climate

Arctic sea ice extent is decreasing at a rate of 11.2 percent per decade during September

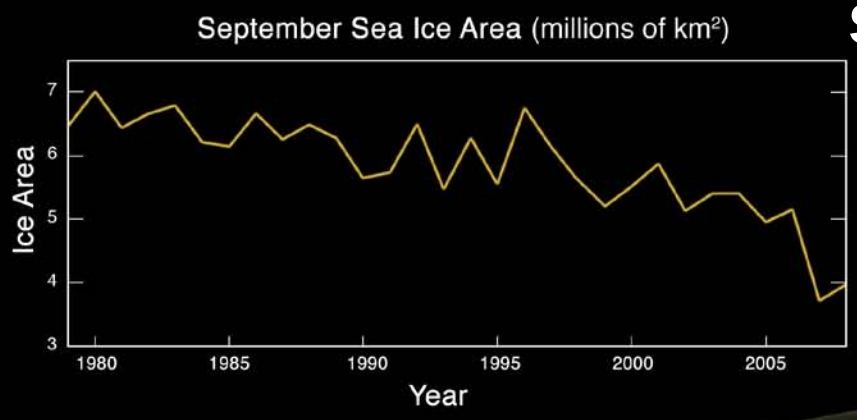
The summers of 2007, 2008 and 2009 had the lowest minimum ice extents since 1971: **4.2, 4.7 and 5.1 million sq km,** respectively





Winter conditions are a prelude to the summer melt season

Significant reduction in summer minimum sea ice extent in 2007 compared to the 30 year average



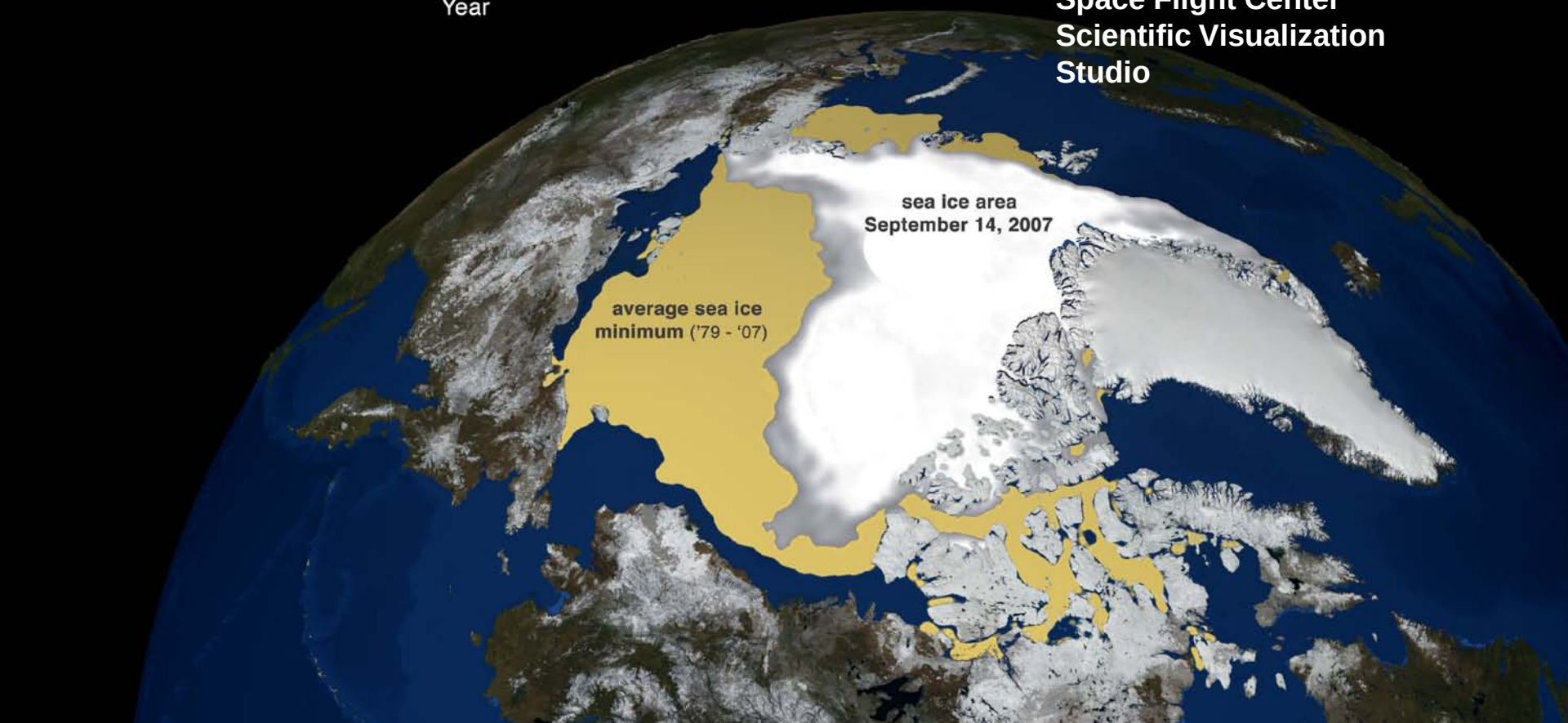
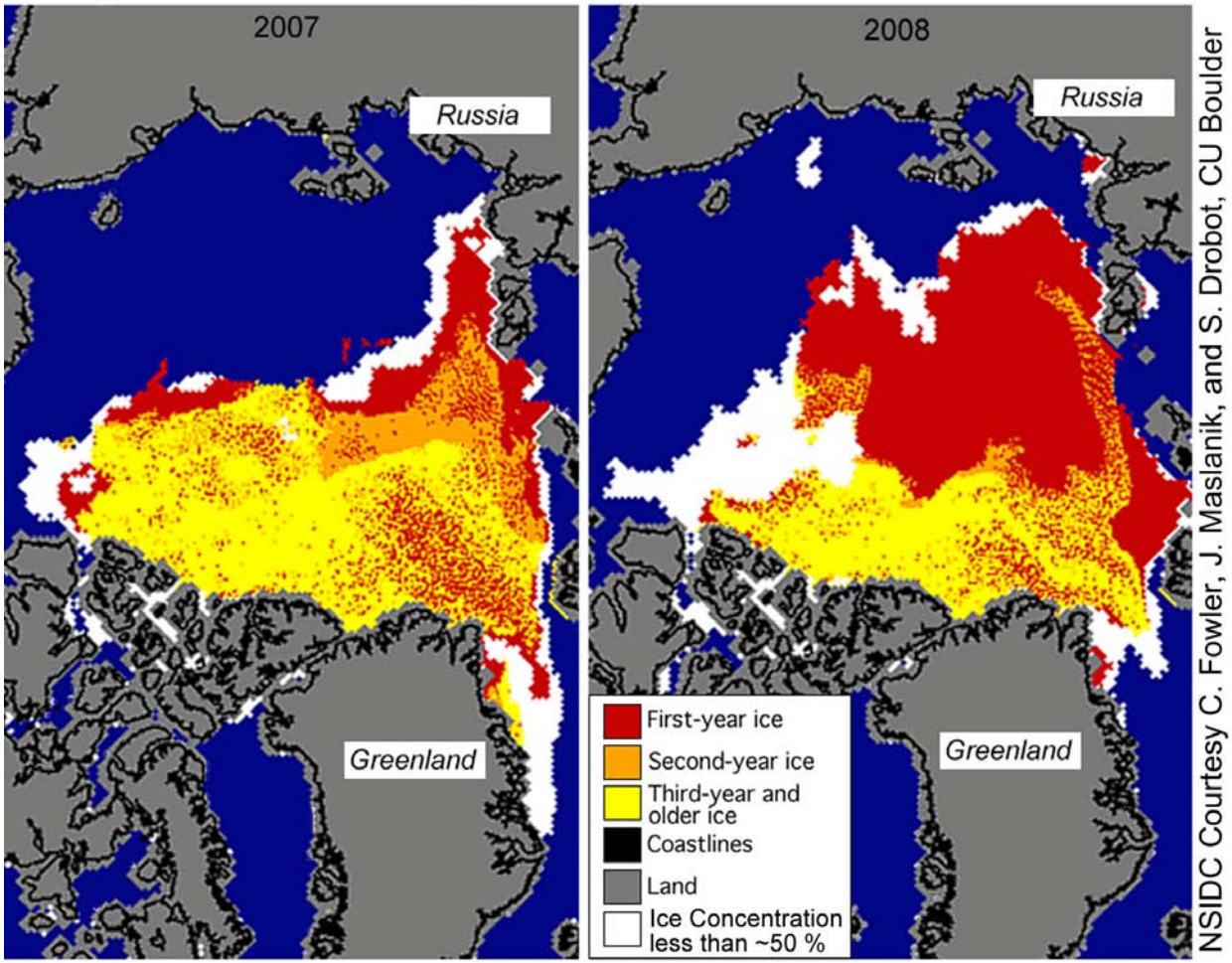


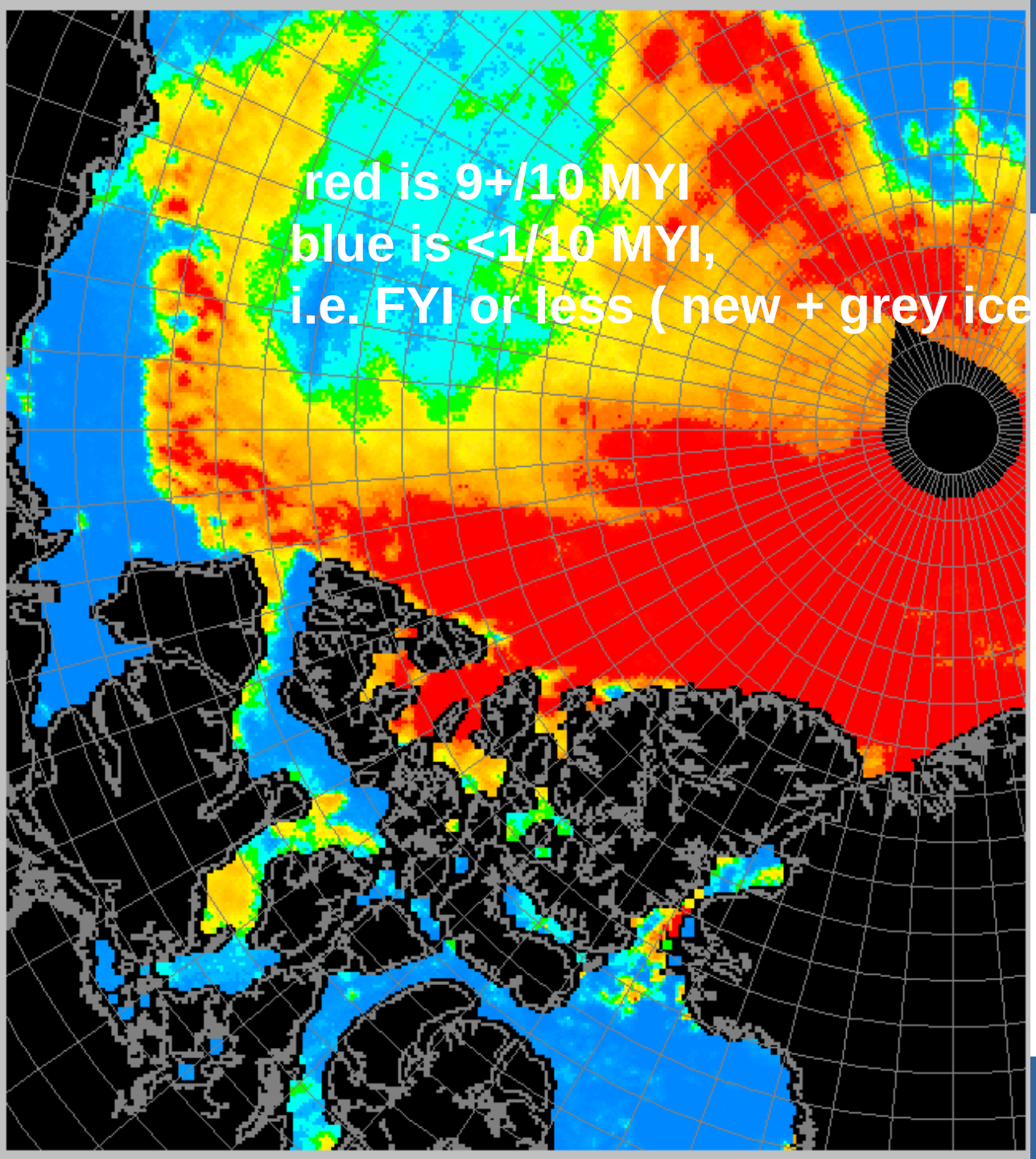
Image: NASA/Goddard Space Flight Center Scientific Visualization Studio

Not only is ice extent decreasing but so is ice age and volume

Arctic sea ice age, September 2007 and 2008

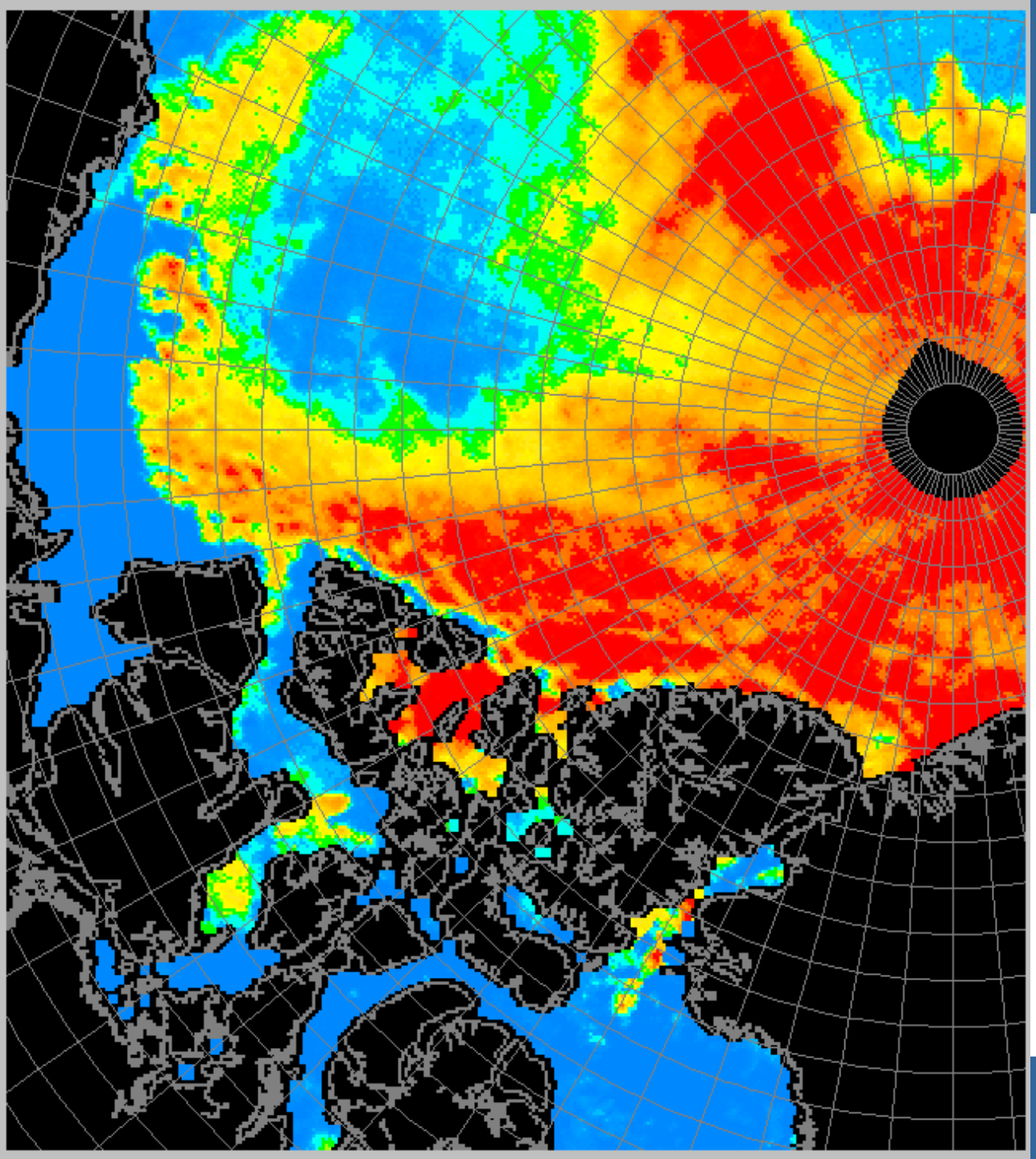


NSIDC Courtesy C. Fowler, J. Maslanik, and S. Drobot, CU Boulder



AMSR-derived map
Multi Year Ice
01 February, 2010

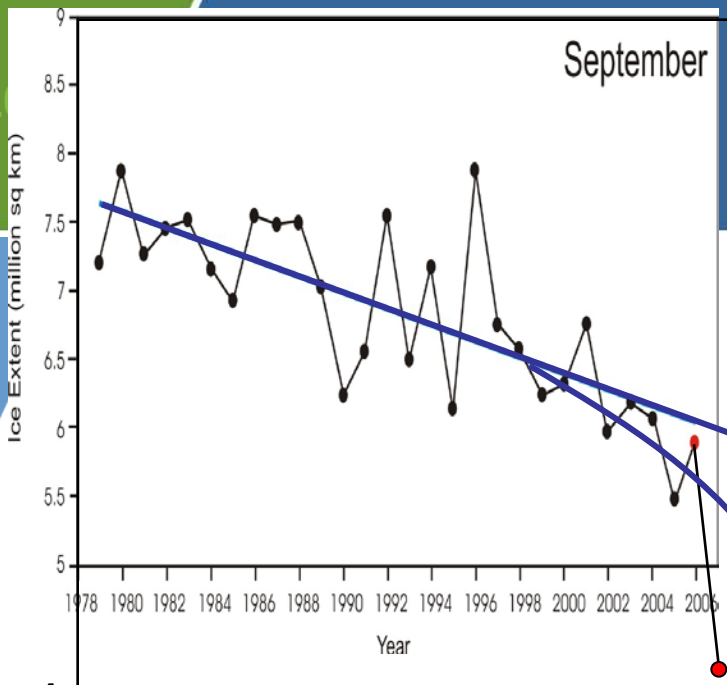
Canada



AMSR-derived map
Multi Year Ice
10 February, 2010

Canada

Future scenarios
Many crystal balls



Actual observations of sea ice extent are less than even the most aggressive predictions…

IPCC 2004

2080

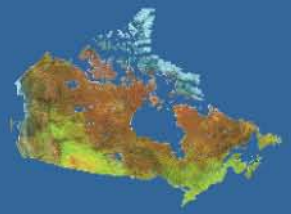
Maslowski et al 2005

Holland et al. 2007

4
3
2
1
0

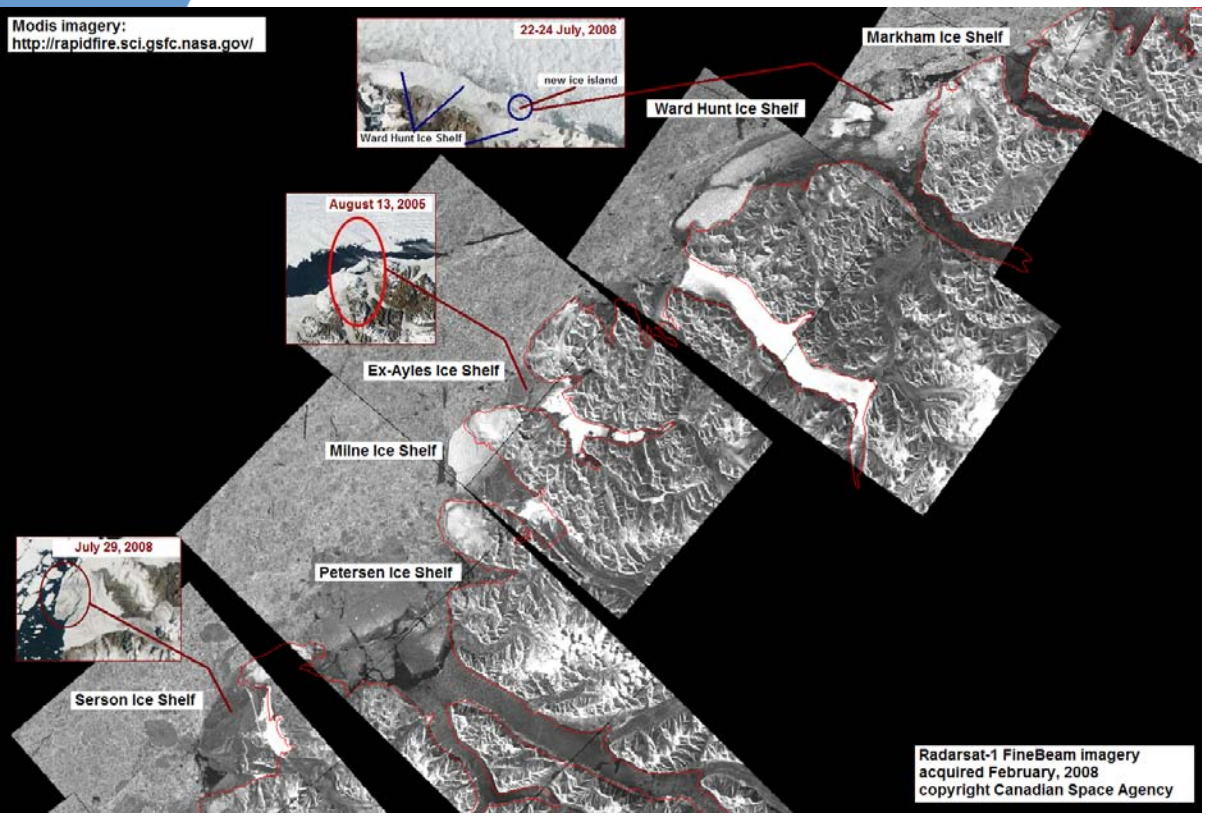
1980 1990 2000 2010 2020 2030 2040 2050

Other polar stories



- Glaciers, ice shelves, massive icebergs
- Ocean temperature, salinity and currents
- Ecosystems impacts
  - e.g. North American western Arctic is predicted to be one of five global hotspots for species turnover.
  - Alien Invasive Species
- Permafrost changes
- Antarctica – ice tables
- Surface snow cover
- Atmospheric temperature anomalies

Canada lost 3 ice shelves from the northern coast of Ellesmere Island in 2008

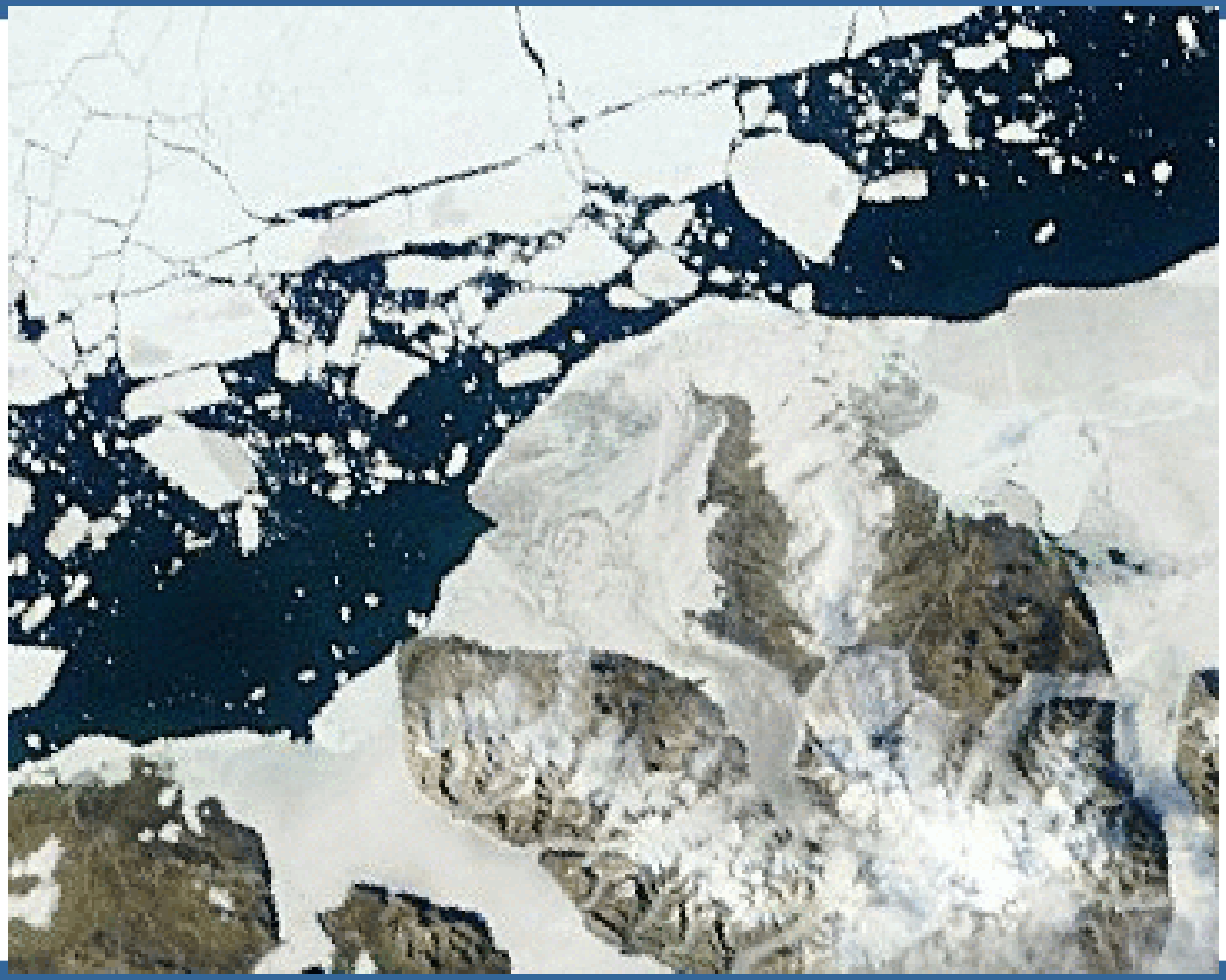


The Ward Hunt Ice Shelf fragmented July 22-24

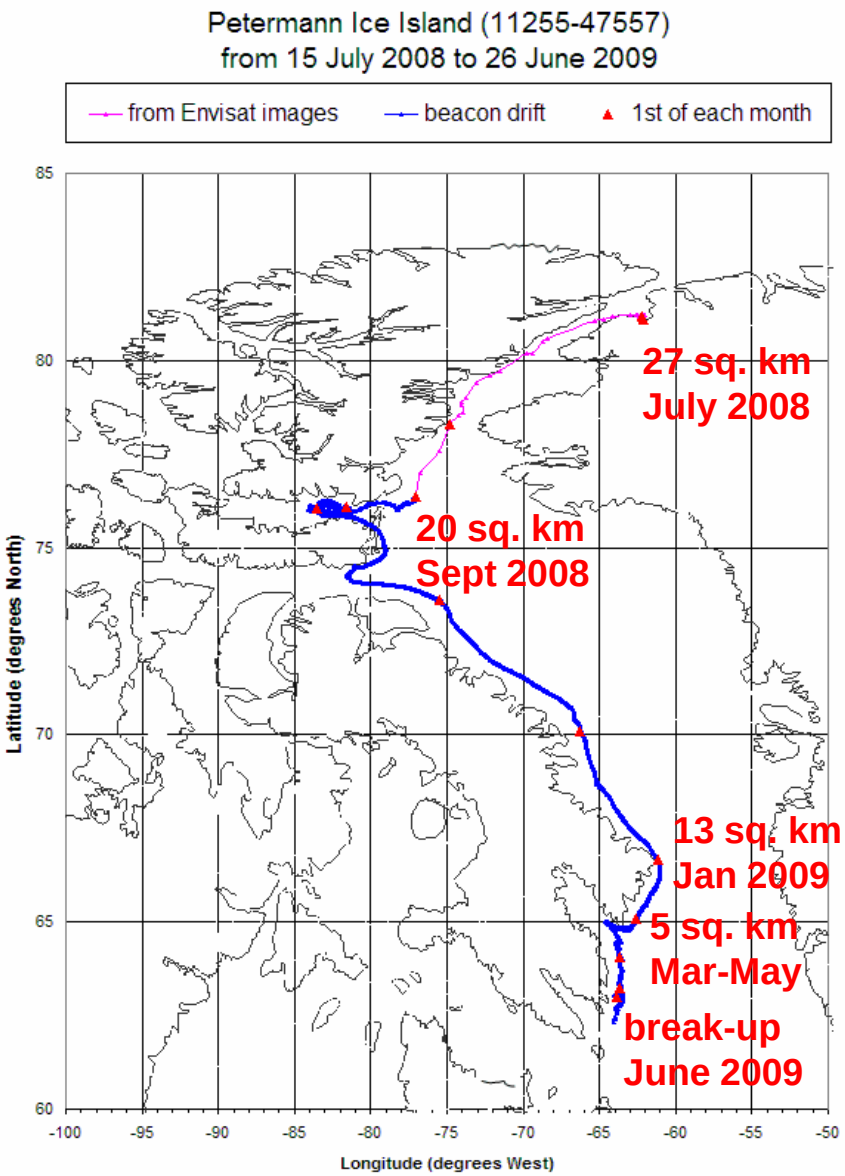
Then the Serson Ice Shelf broke off July 31 - Aug 1

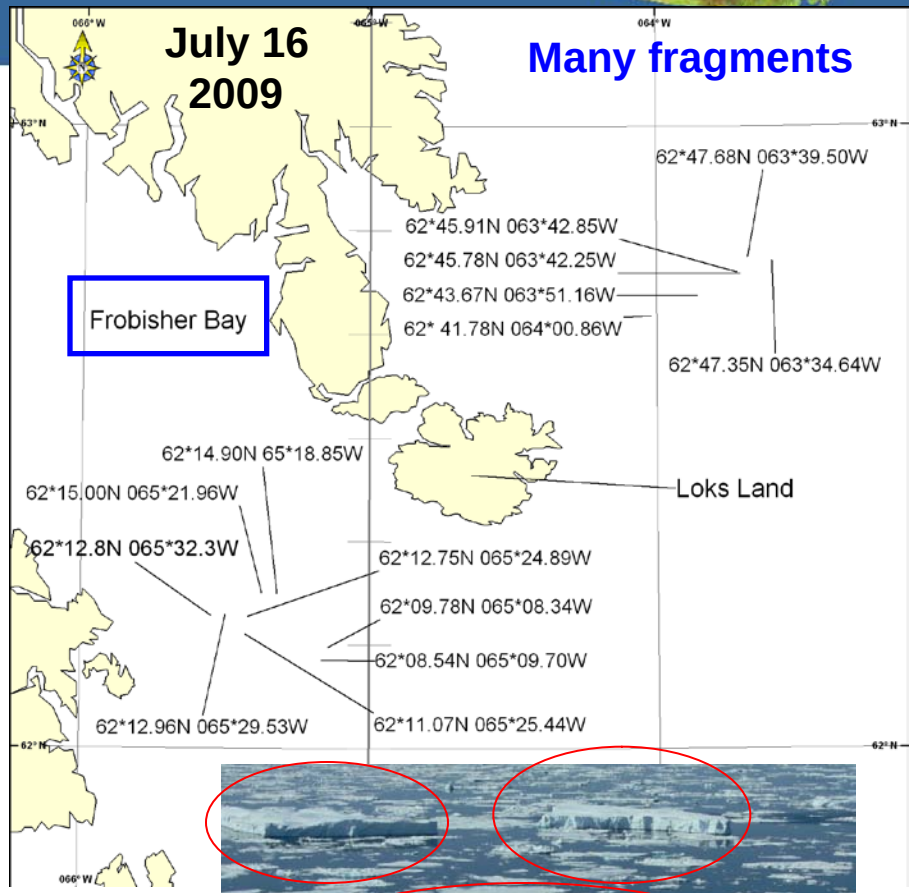
Finally the Markham Ice Shelf disintegrated between Aug 4-12

Serson 1 - break up - animation

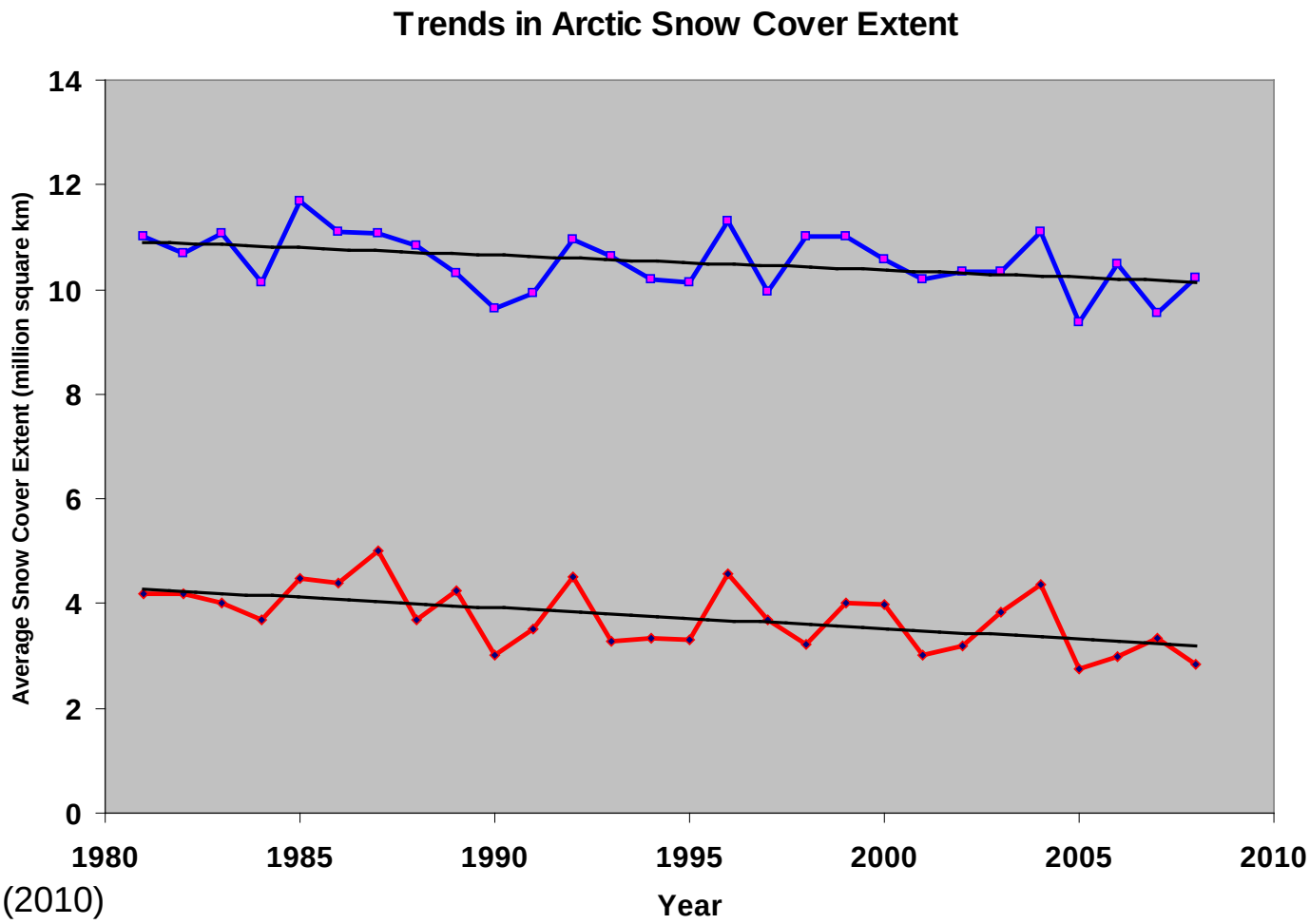


Greenland Petermann Ice Island





Northern hemisphere snow
Preliminary IPY project results



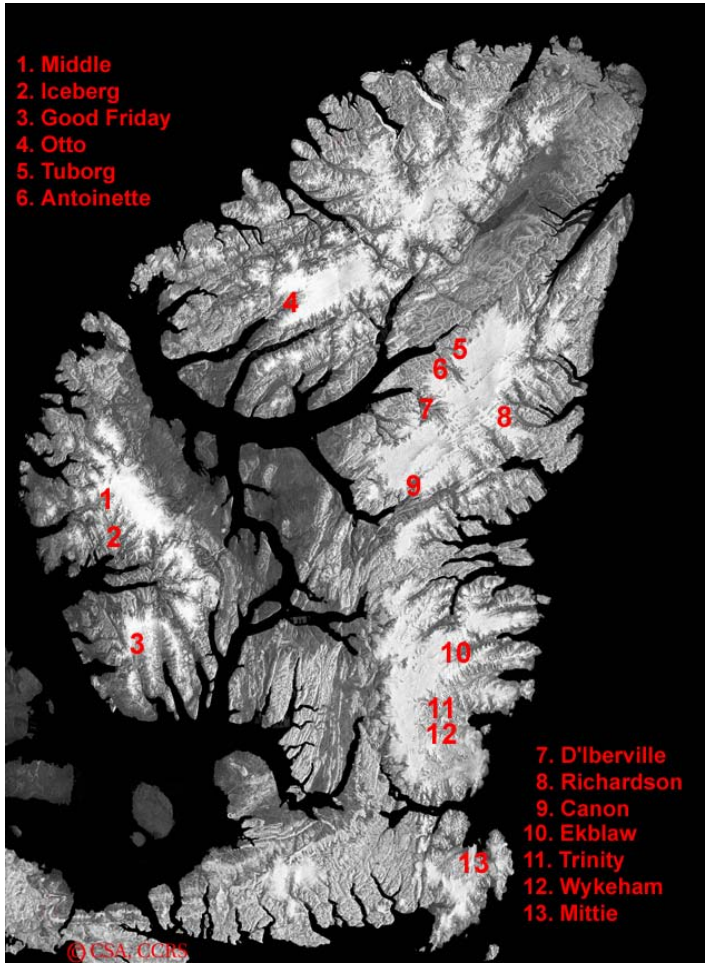
Zhao, H., and R. Fernandes (2010)
AVHRR polar pathfinder snow cover

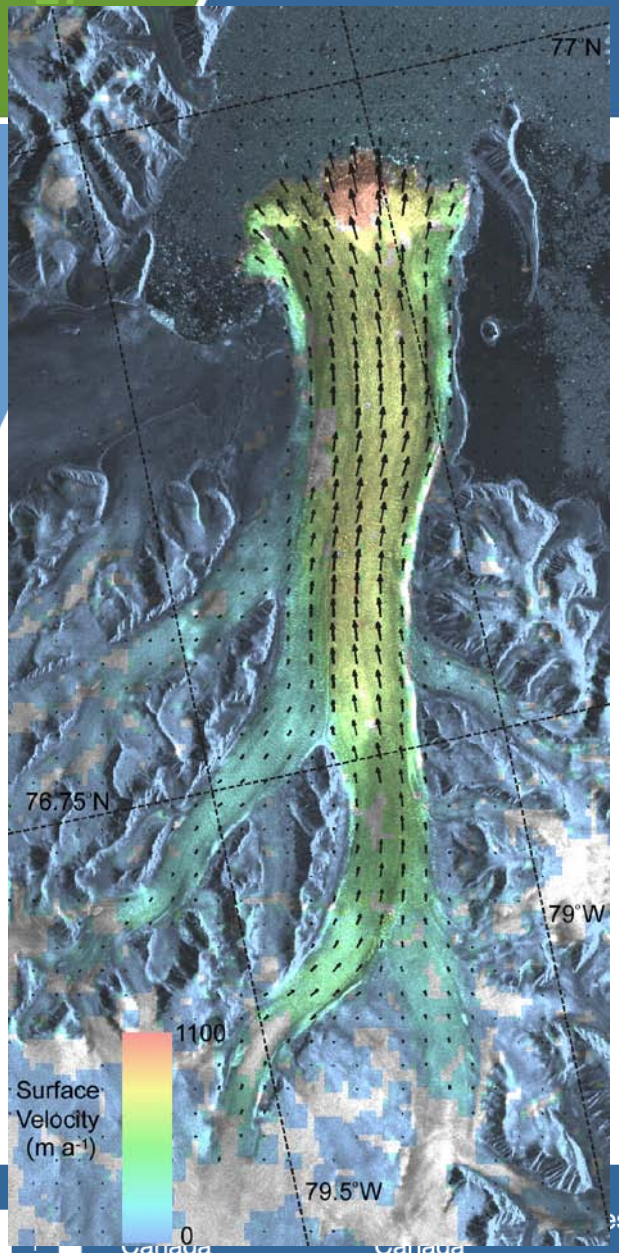
Monitoring Arctic Glacier Dynamics using Interferometric SAR

Naomi short, Laurence Gray & Dave Burgess

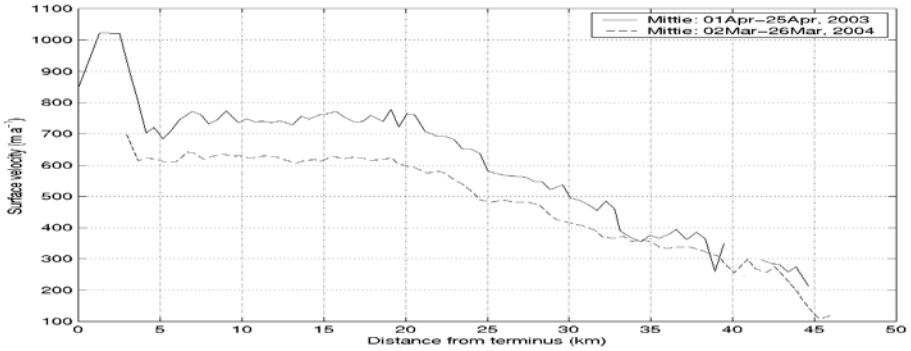
- The speckle tracking technique is a variant of InSAR and has been successfully applied in the Canadian Arctic.

- Ten years of large scale measurements of glacier dynamics. 14 glaciers monitored, many repeatedly.



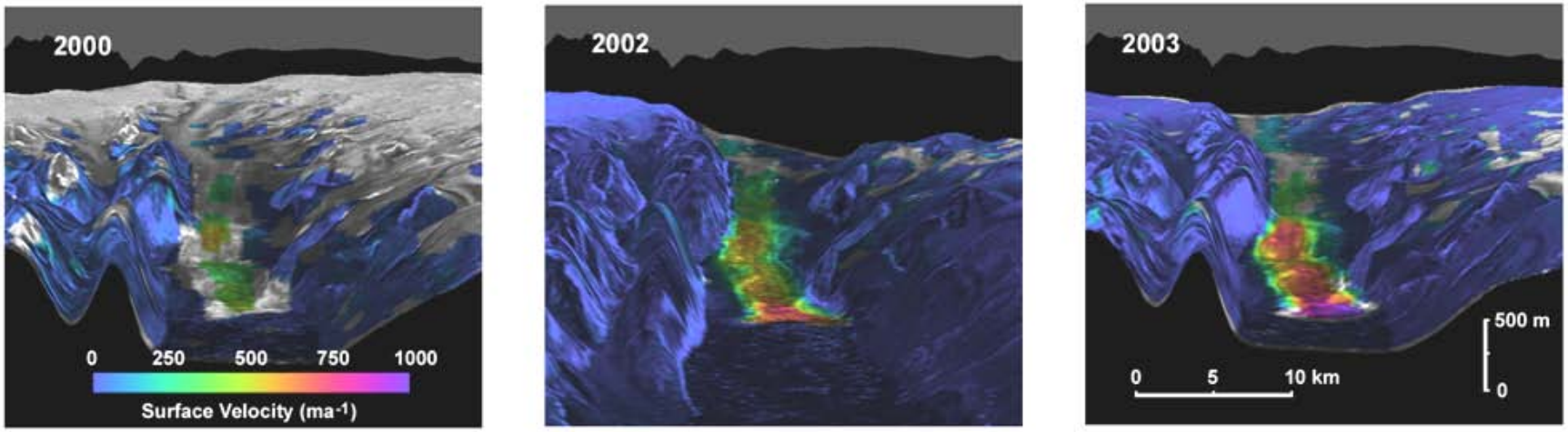


Speckle tracking provides speed and flow direction measurements, and, with repeat monitoring, trends in time.



Mittie Glacier

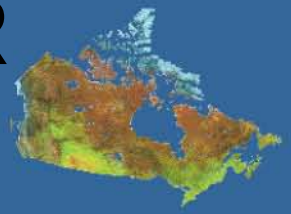
Otto Glacier example



- Glaciers are faster and more variable than previously thought
- Comparisons with balance velocities indicate that many glaciers are losing mass
- Many glaciers demonstrate surge behaviour
- There is a need to separate out cyclical surging from climate response

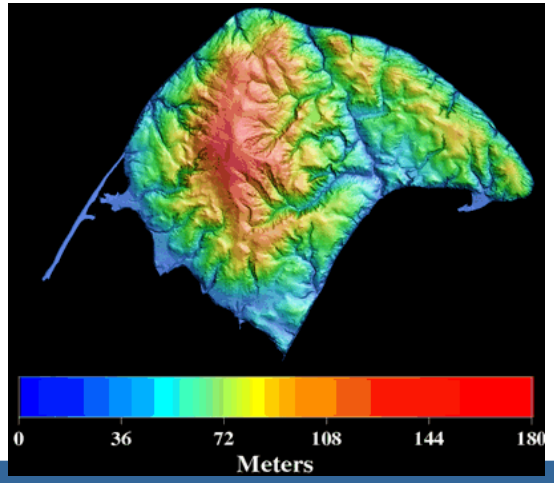
Permafrost change – INSAR

Brian Brisco



Seasonal subsidence

- L-band InSAR
- Herschel Island
- Late summer subsidence
- <7cm of subsidence on exposed hilltops
- Positive air temperatures until early October

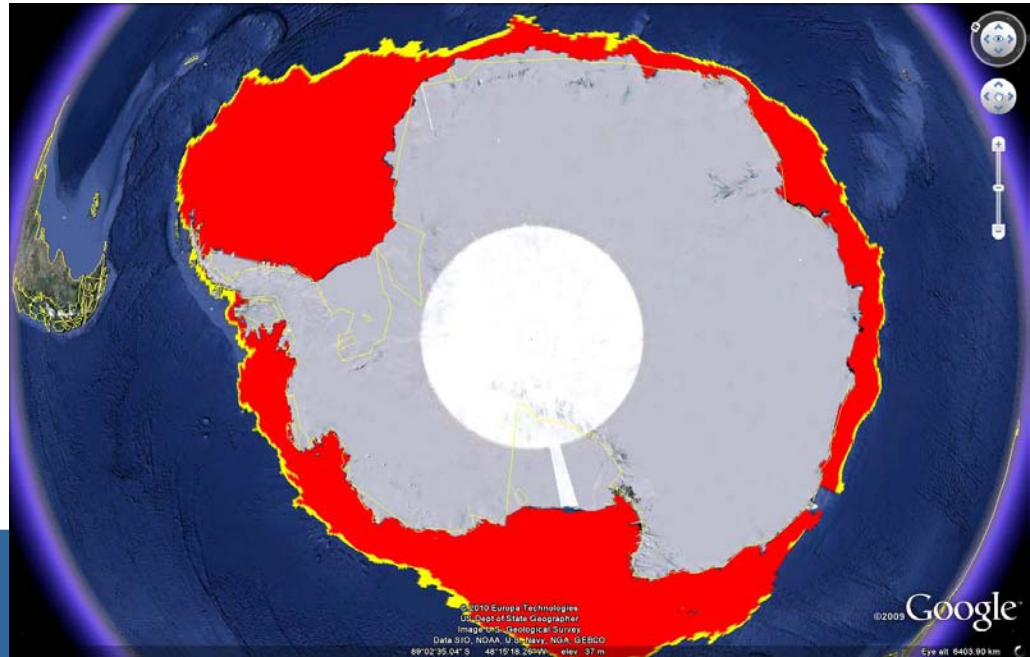


ALOS –PALSAR
Aug19 - Oct04, 2007

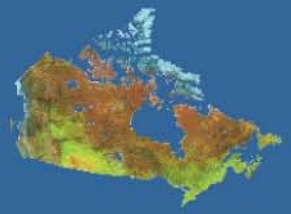
© CCRS 2009

And that other polar region….

- US NIC and NSIDC ongoing operations
  - Suite of products freely available
- RADARSAT- Antarctic Mapping Missions (AMM)
  - good example of coordination of spacecraft ops and polar scientists

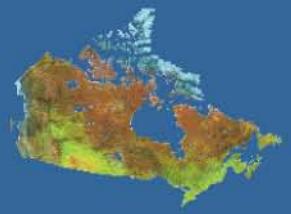


The EO challenges



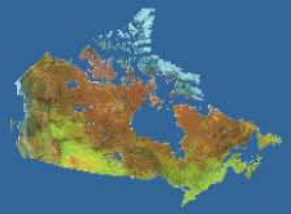
- Polar regions are large
- Polar surface dynamics occur on a wide range of timescales
  - sea ice, very dynamic
  - glaciers change much more slowly
- Scientists measure different things at different and have different requirements
  - E.g. glaciologists have higher need for precision -- measuring smaller changes.
- All climate scientists, regardless of application, look for dataset to monitor change over decades.
- Depending on sensor, orbital inclination for polar orbiting satellites can lead to doughnut hole in coverage
  - Can be overcome with careful Space Operations

EO experience to date



- EO has been absolutely essential data sets for climate monitoring since the 1970s (i.e. the passive microwave record)
  - some of the best (longest) records for sea ice are from operational meteorological satellites, eg, SSM/I
- Scientists rely on space agencies to provide measurement over the timescales and large scale necessary to identify and monitor climate change.
- Most EO Satellites in near polar orbits provided generous coverage due to precession of orbits at high latitudes
- Passive and active microwave satellites (radar) allow for surface measurements through cloud cover, and in day or the long polar nights
- Scientists rely on space operations to provide continuity of measurements, fidelity (i.e. calibration) of measurements, communication of spacecraft and sensor status and forecasts of sensor health and/or mission risk.
- In case of SAR satellites, space operations also has the overhead of continual sensor programming and conflict management between operational users and researchers

EO success stories



- Glacier and sea ice thickness measurements this decade via ICESAT (Ron Kwok JPL)
- Contribution of the SMMR and SSM/I data record on measuring changing sea ice extent
- NOAA and BYU QuikSCAT products and their value in mapping sea ice extent
  - designed for measuring surface winds over ocean, but invaluable to both operational and climate sea ice mapping of both poles.
- NSIDC archive and provision of passive microwave data.
  - "long term preservation of data".
  - Create and archive higher level products for climate
  - Level 2 and 3 products – data archiving and QA is important

Where to now?

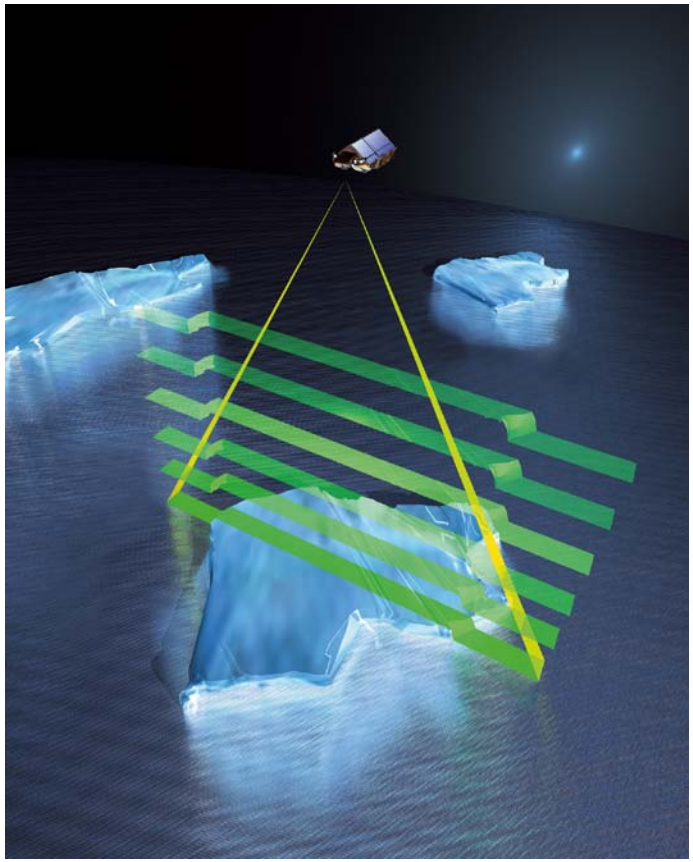
- Mission continuity
  - Weather satellites, e.g. SSMI follow-on
  - AMSR 2
  - C band SAR
- Cryosat 2
- Altimeters at higher latitudes
- Proposed PCW mission
  - continual 15 min. snapshots of the Arctic
  - potential role for Molynia orbits and creative Space Operations.

Acknowledgements

ArcticNet
Canadian Ice Service
CSA
ESA
JPL
NASA
National Ice Center
NRCan CRRS
NSIDC

…..and many more

- Cryosat 2



Questions?