# What's really happening with Arctic sea ice?


Canadian Coast Guard

Fisheries and Oceans Canada | Pêches et Océans Canada

Environment Canada | Environnement Canada

Service météorologique du Canada
SMC
MSC
Meteorological Service of Canada


## Douglas Bancroft

Co-Director
North American Ice Service

Director
Canadian Ice Service

# Credits:

- John Falkingham
- Roger De Abreu
- Luc Desjardins
- Kerri Warner
- Amanda Reinwald
- Canadian Coast Guard
- FedNav
- Many others

# Outline

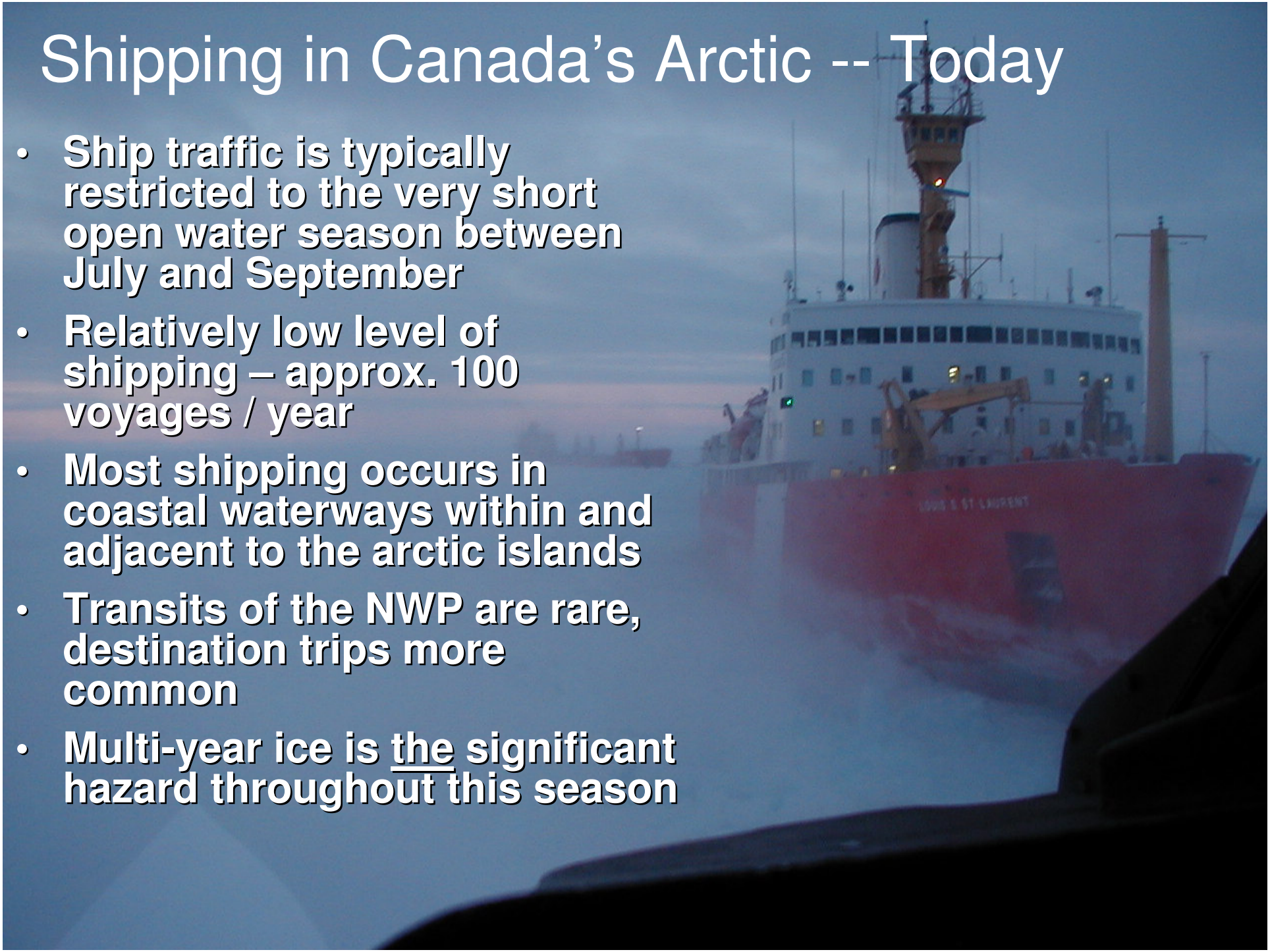
- Sea ice and ice services
- 100 years of change in Arctic sea ice
- The future of Arctic sea ice
- The summer of 2008
  - what just happened?
- Impacts on Canadian Arctic shipping
- Conclusions

# Sea ice - a very Canadian issue

- Canada claims the world's:
  - longest coastline
  - greatest area of ice
- Annual variation in extent of ice is » ½ the area of Canada (4M km$^2$)
- Seasonal effects on:
  - weather and climate
  - marine ecosystems
  - safety and efficiency of marine transportation

# Shipping in Canada's Arctic -- Today

- **Ship traffic is typically restricted to the very short open water season between July and September**
- **Relatively low level of shipping – approx. 100 voyages / year**
- **Most shipping occurs in coastal waterways within and adjacent to the arctic islands**
- **Transits of the NWP are rare, destination trips more common**
- **Multi-year ice is the significant hazard throughout this season**



# A Harsh Marine Environment
## … under normal conditions

# The Canadian Ice Service

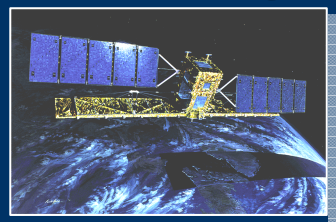
Provides ice information in support of:

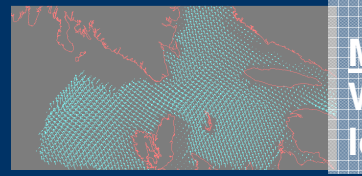
- Coast Guard Ship routing
- Coast Guard Icebreaking
- Climate monitoring
- Weather forecasting

By doing….

- Reconnaissance
- Analysis and Forecasts
- Product Distribution and Archive
- Specialised Informatics & Applied Science

# Integration of Information





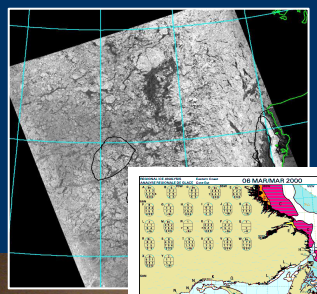
**Satellite**
***Optical***
NOAA AVHRR
Others

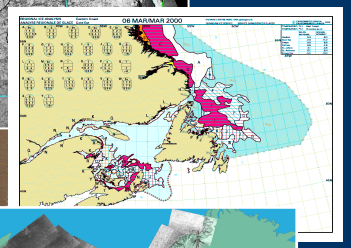
***Microwave***
RADARSAT
ENVISAT
QUIKSCAT
DMSP SSM/I

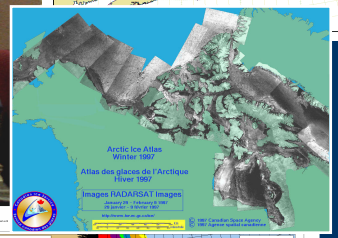
**Airborne**
Visual Obs
SLAR/SAR

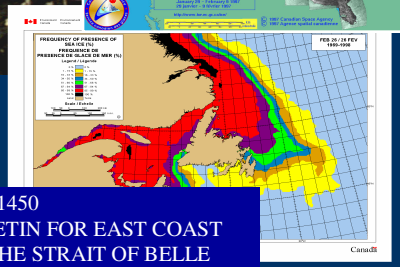
**Surface**
Buoys
Ship Reports
Shore Obs

**Models**
Weather
Ice









FICN11 CWIS 181450
ICEBERG BULLETIN FOR EAST COAST WATERS AND THE STRAIT OF BELLE ISLE
AND ITS APPROACHES ISSUED BY ENVIRONMENT CANADA FROM CANADIAN ICE
SERVICE IN OTTAWA AT 1500 UTC WEDNESDAY 18 OCTOBER 2000.

**Image Products**
Analysed images

**Chart Products**
Daily tactical ice analyses
Weekly strategic ice analyses

**Climatological Products**
Ice Atlases
Normals / Extremes

**Text Products**
Ice hazard warnings
30-day forecasts
Seasonal Outlooks

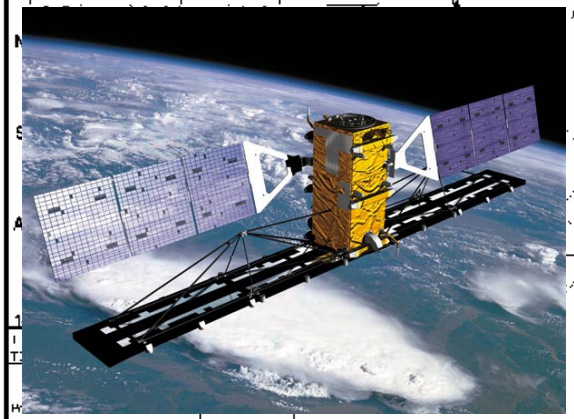
REGIONAL ICE ANALYSIS
ANALYSE REGIONALE DE GLACE

Western Arctic
Arctique de l'Ouest

# 05 SEP/SEP 2005

CANADIAN ICE SERVICE
SERVICE CANADIEN DES GLACES





| | | |
|---|---|---|
| Inuvik | 5.6 | 7.1 |
| Kugluktuk | 6.4 | 5.5 |
| Cambridge Bay | 4.2 | 2.9 |

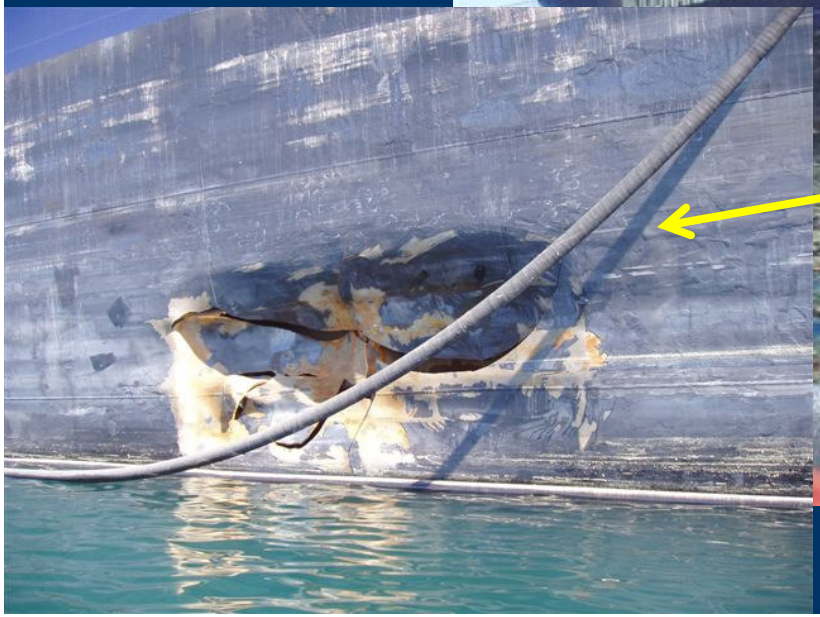
# Products & Services

- Direct support to Canadian Coast Guard
  - **Daily ice charts and bulletins** ***(2800 charts/yr)***
  - **Image products** ***(7000 images/yr)***
  - **Tactical aircraft support** ***(700 hrs/yr)***
  - **Aircraft, Ship & Ice Offices staff** ***(2500 person-days)***
- Other Clients
  - **Daily Ice Warnings, Edge Analysis, Regional Charts**
  - **Iceberg Analysis and Prediction**
  - **30 Day Forecasts, Seasonal Outlooks and Summaries**
  - **Ice Climatology**

  *TOTAL: >1/2 M products/yr, with ~2 M deliveries/yr*
  - *Web Site: 1.8 M* Visits/yr, 0.8 M Unique Visitors/yr

# We Support Safe & Efficient Shipping

***Sea ice is a significant marine hazard***

**Photos courtesy of Stephen Neatt CCG**

# We Support Safe & Efficient Shipping

***Icebergs are a significant marine hazard***

***Reduta Ordona in drydock after striking an iceberg (July, 1996)***

# We Support Safe & Efficient Shipping

***Icebergs are a significant marine hazard***

# East Coast Icebergs

- By 15 March 2008, 249 icebergs had drifted south of 48N.
- By 28 March this had increased to 739.
- Just one month into the 2008 season there have already had more icebergs threaten mariners (and oil rigs) near the Grand Banks than from 2004-2007 combined.
- August 2008 – a new 23 sq km iceberg detached from Greenland and may pose an extreme 2009 hazard

# We Support Safe and Efficient Shipping

Delays are a major Deterrent to Transit Shipping

Ice information reduces transit times & increases safety


**M/V Umiak-I off Voisey Bay May 27, 2007**
**Courtesy Tim Keane, Fednav Shipping Ltd.**

# We Enable Offshore Industry

*Ice information is used in the design, construction & operation of offshore platforms*

# We Support Northern Communities

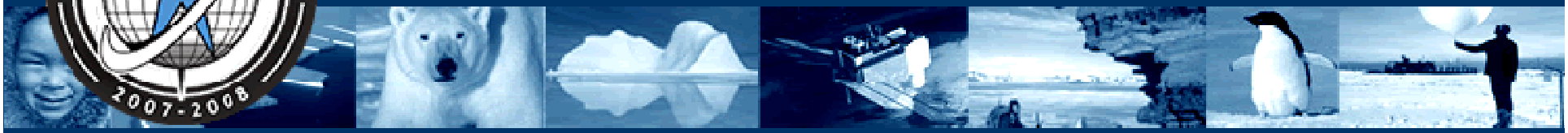
*Sea ice information is used on a daily basis by those who live by and travel on sea ice*

# We Support Weather Forecasting

*Ice information is used in numerical weather models to forecast weather*

# We Support Science

## International Polar Year 2007-2009




*The CIS is providing logistical and science support to the International Polar Year*

# Strong Links to Federal Policy Initiatives and partners

- Canada's Northern Strategy
- UNCLOS ratification
- Sustainable Development
  - Infrastructure design
  - Input to regulations
- Climate ChangeAdaptation
- International Polar Year
- Practicing Sovereignty
- Supporting Security Ops

# Are the risks real?

a small cruise ship, ice
and a hole about the size of a fist


BBC map

Photo – Washington Post

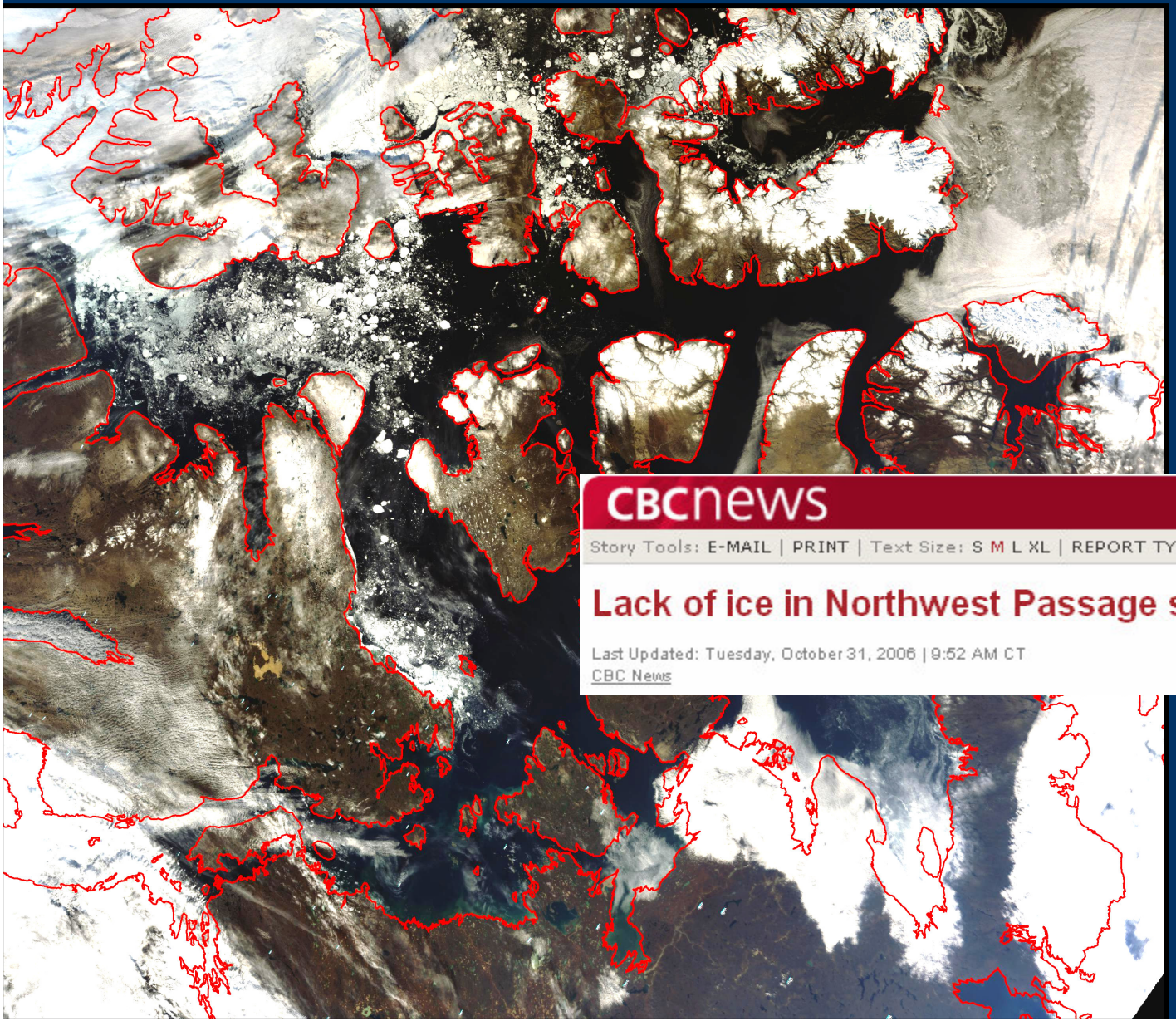
# Getting caught in ice is not good

# Unusual sea-ice events 2005

- The 66 square-km Ayles ice shelf
- Broke away in August 2005
- Freed by high temperatures
- and winds.
- 3,000 years old
- 15 km long by 5 km wide
- 35 meters thick
- Detected by Laurie Weir NAIS in near real time


Copland, Mueller and Weir (2007)

# Unusual sea-ice events 2006



**MODIS**
**September 24, 2006**

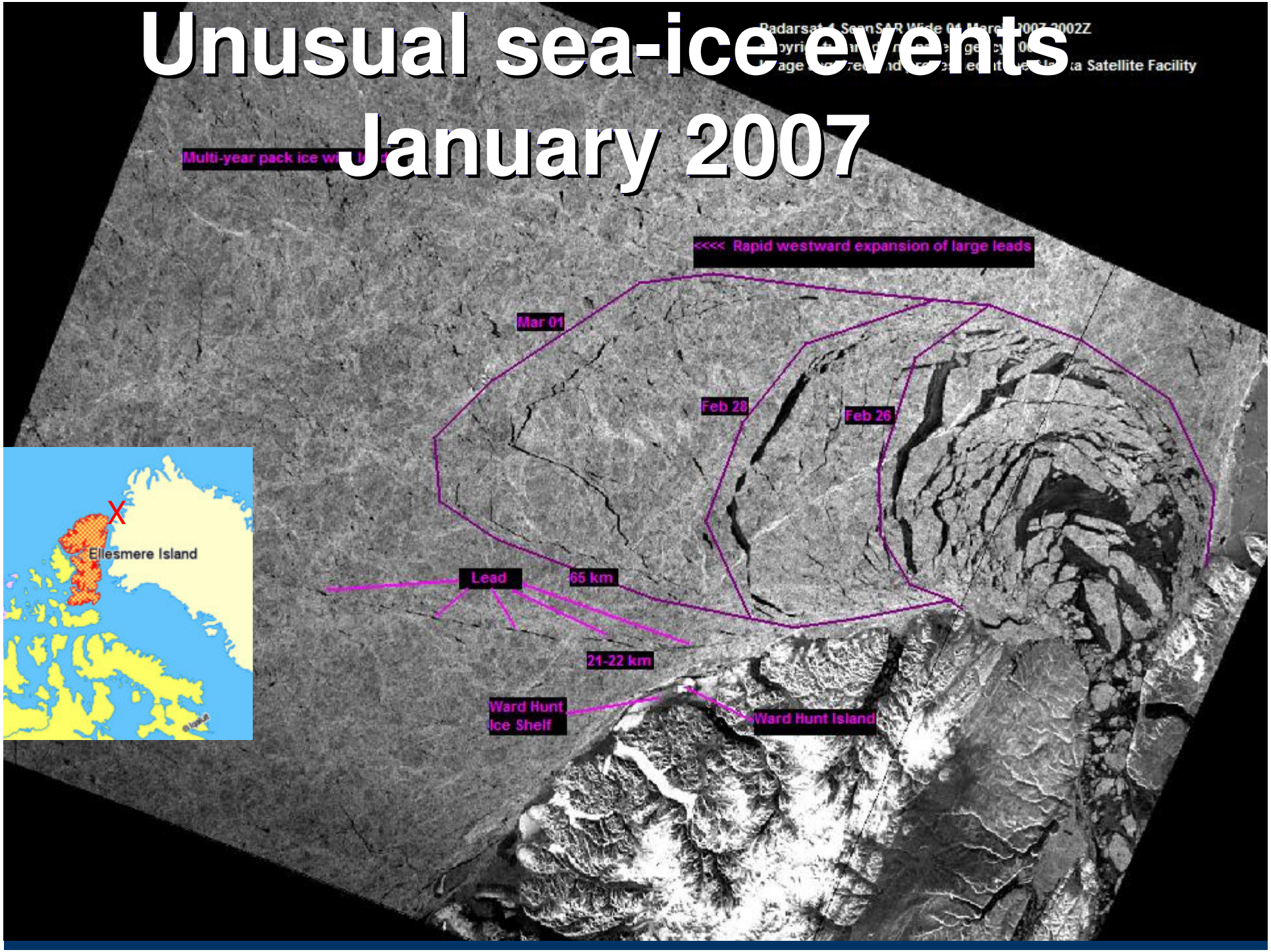
CBCnews CANADA | NORTH

Story Tools: E-MAIL | PRINT | Text Size: S M L XL | REPORT TYPO | SEND YOUR FEEDBACK

## Lack of ice in Northwest Passage stuns researchers

Last Updated: Tuesday, October 31, 2006 | 9:52 AM CT
CBC News

# Unusual sea-ice events January 2007



# Large fracturing of Lincoln Sea

- Occurs when Nares Strait does not consolidate Unusually wide-spread fracturing resulted around northern Ellesmere Island
- Warnings issued to polar teams heading to the North Pole from Ward Hunt
- Event happened again in the spring of 2008

# Unusual sea-ice events 2007

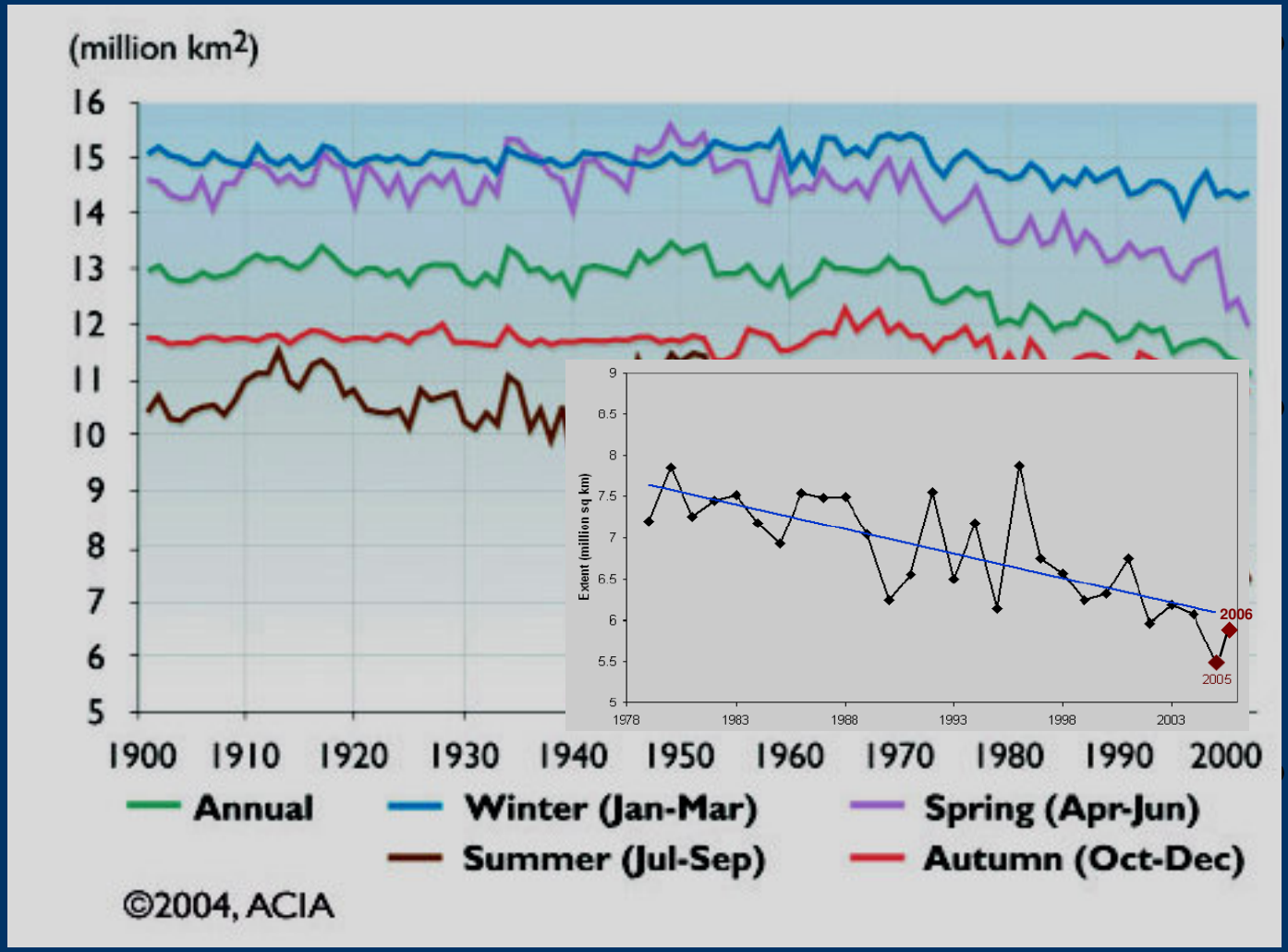
## “Crushing ice imprisons sealing ships Coast Guard pushing hard to aid 100 trapped vessels, including one of their own”

**Supplies low for ice-bound N.L. sealers**
**Thursday, April 19, 2007**

# Arctic Ocean Summer 2007 Record Minimum Ice Extent

- 40 year normal minimum ice extent
  6.7 million sq km
- Previous record minimum summer 2005
  5.3 million sq km
- 17 September 2007 extent
  **4.1 million** sq km
- This was not expected by any of the long range climate models for several decades
- The scientific community was “stunned”

# Arctic Sea Ice Extent 1900-2006

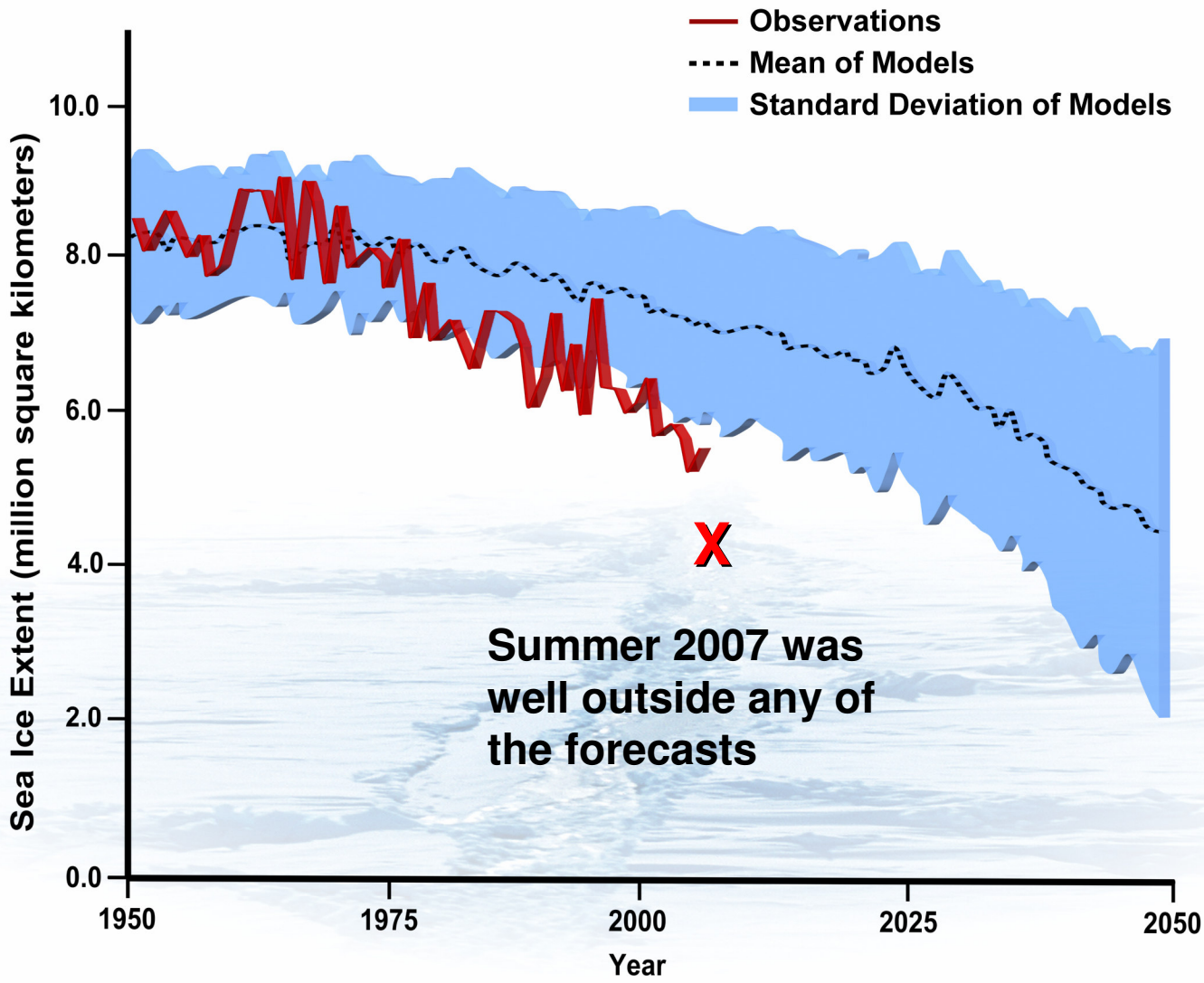



Significant decreases since 1950

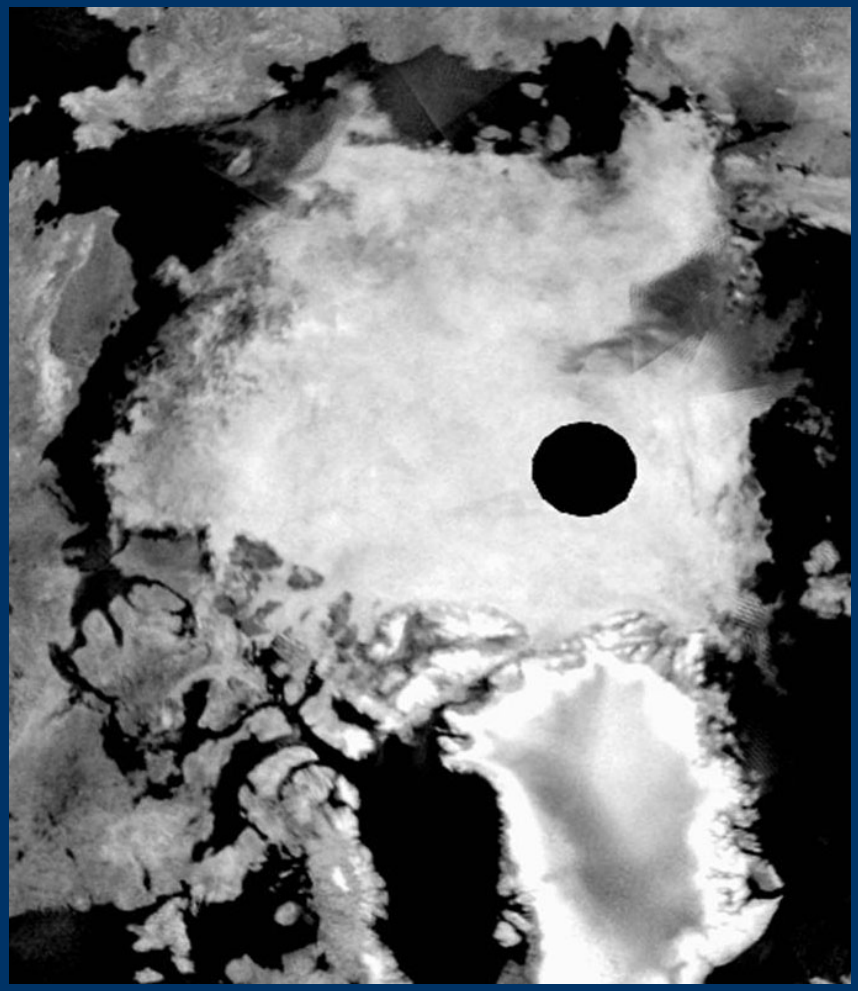
Decrease largest in summer

Accelerating in recent years

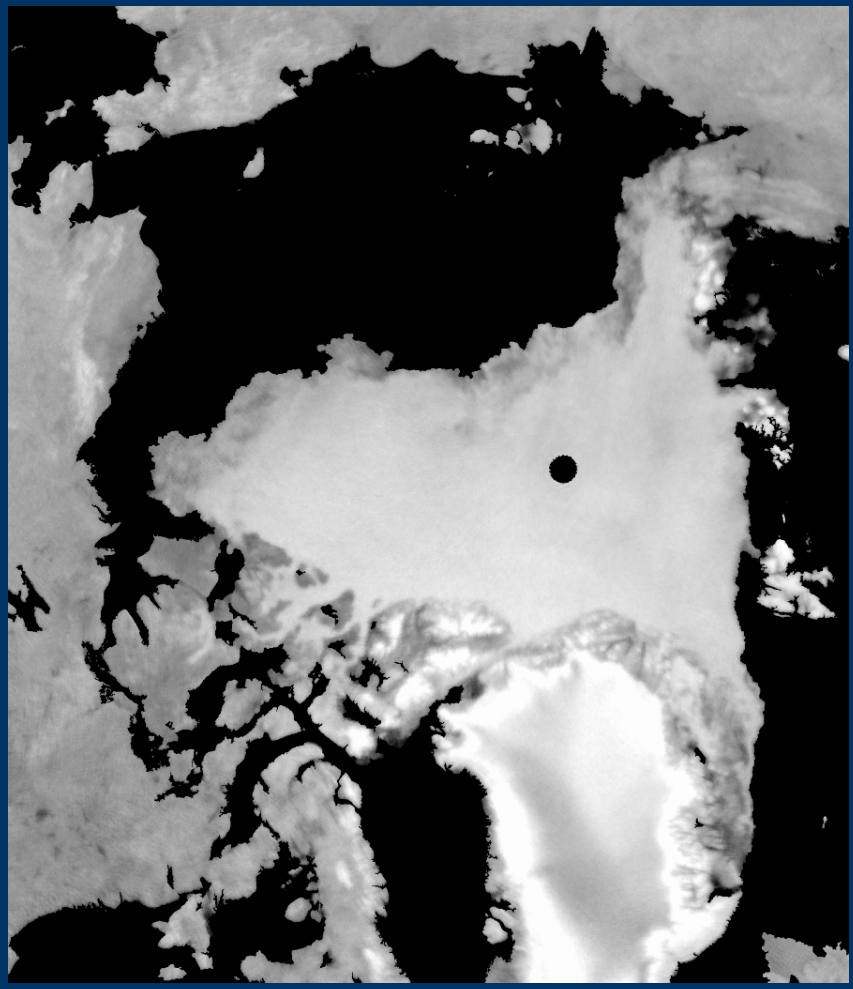
# Arctic September Sea Ice Extent: Observations and Model Runs



# Summer sea ice minimum
# The view from space

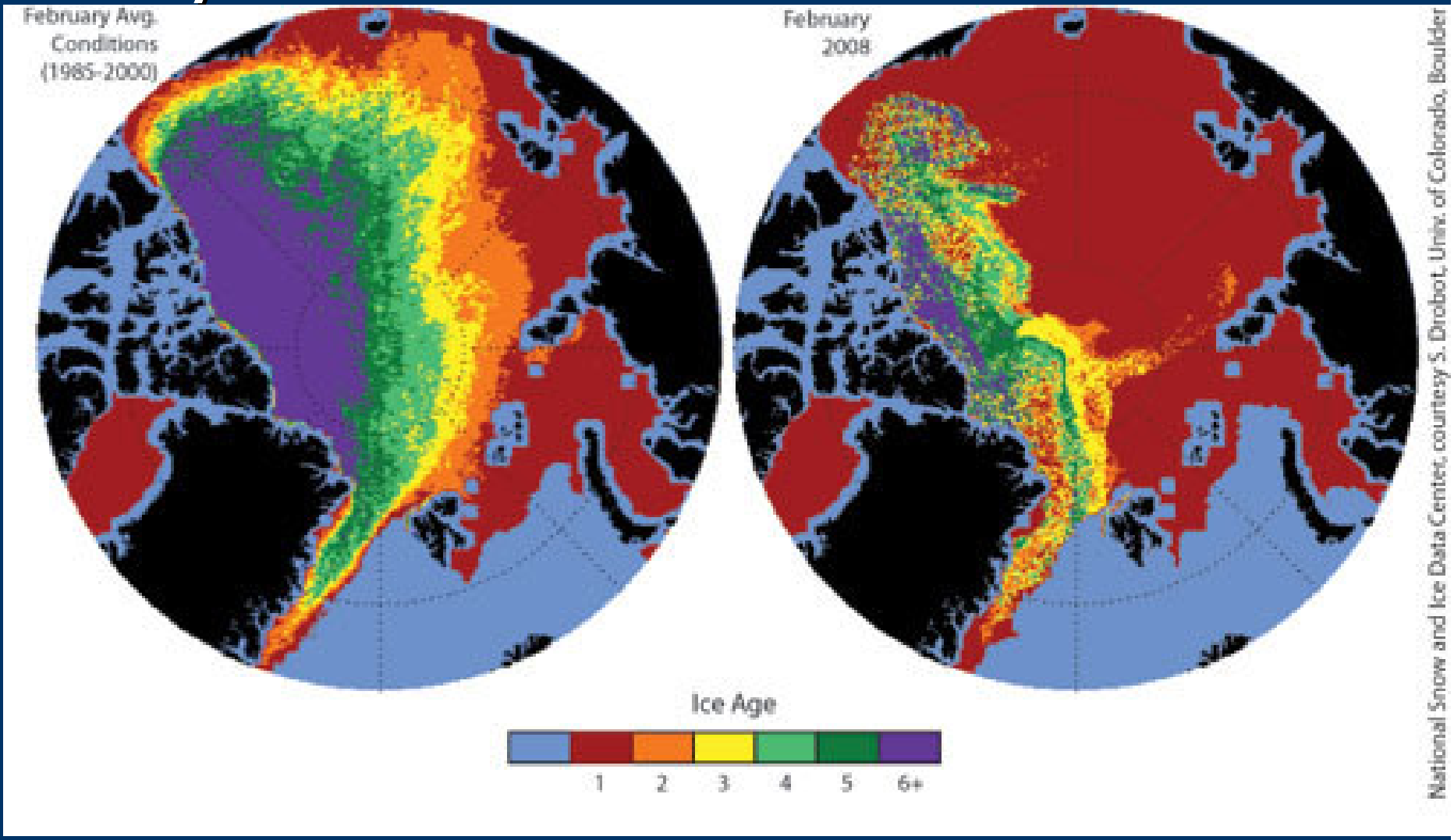


September 2001



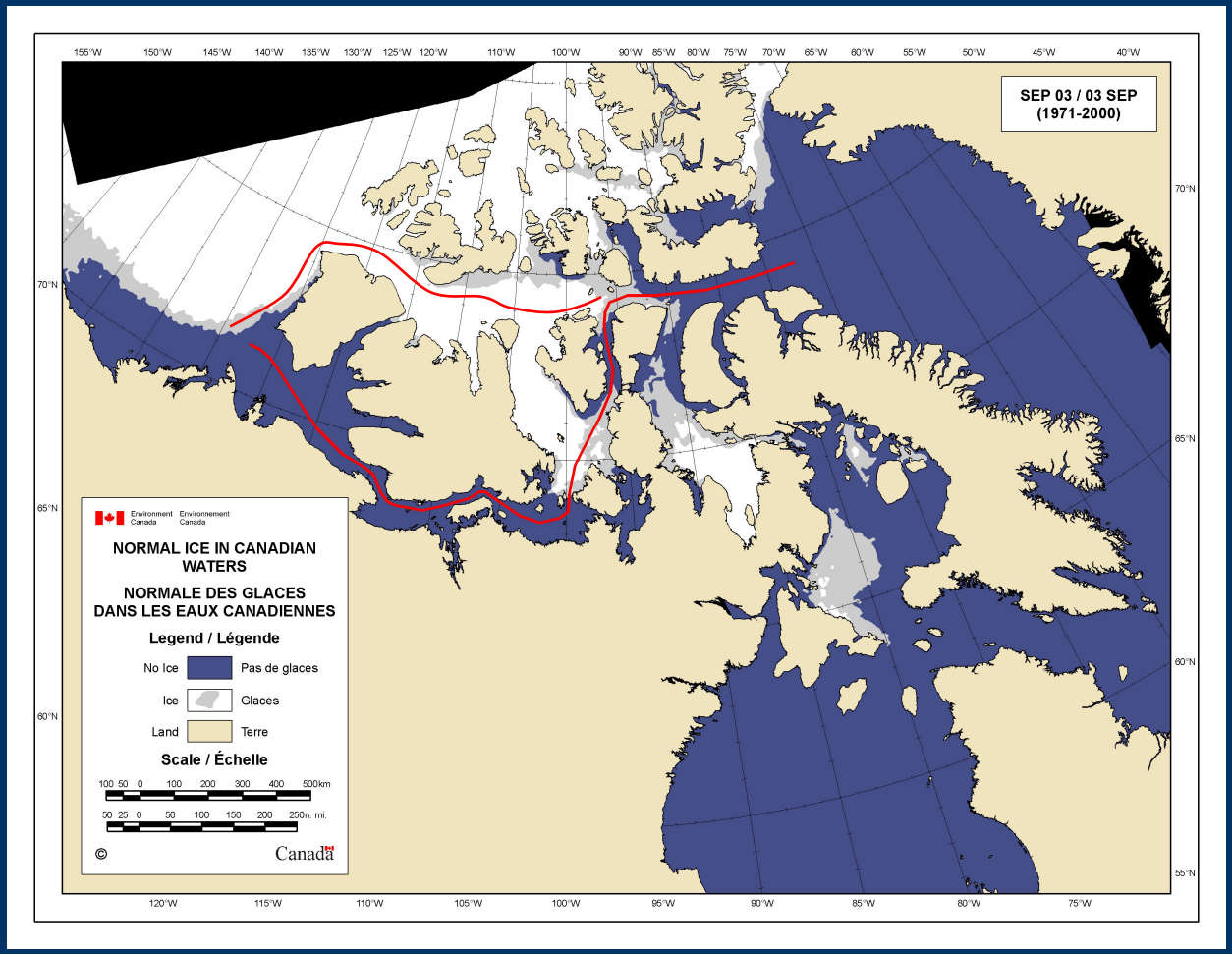
September 2007

# Remaining Multiyear is younger and likely thinner



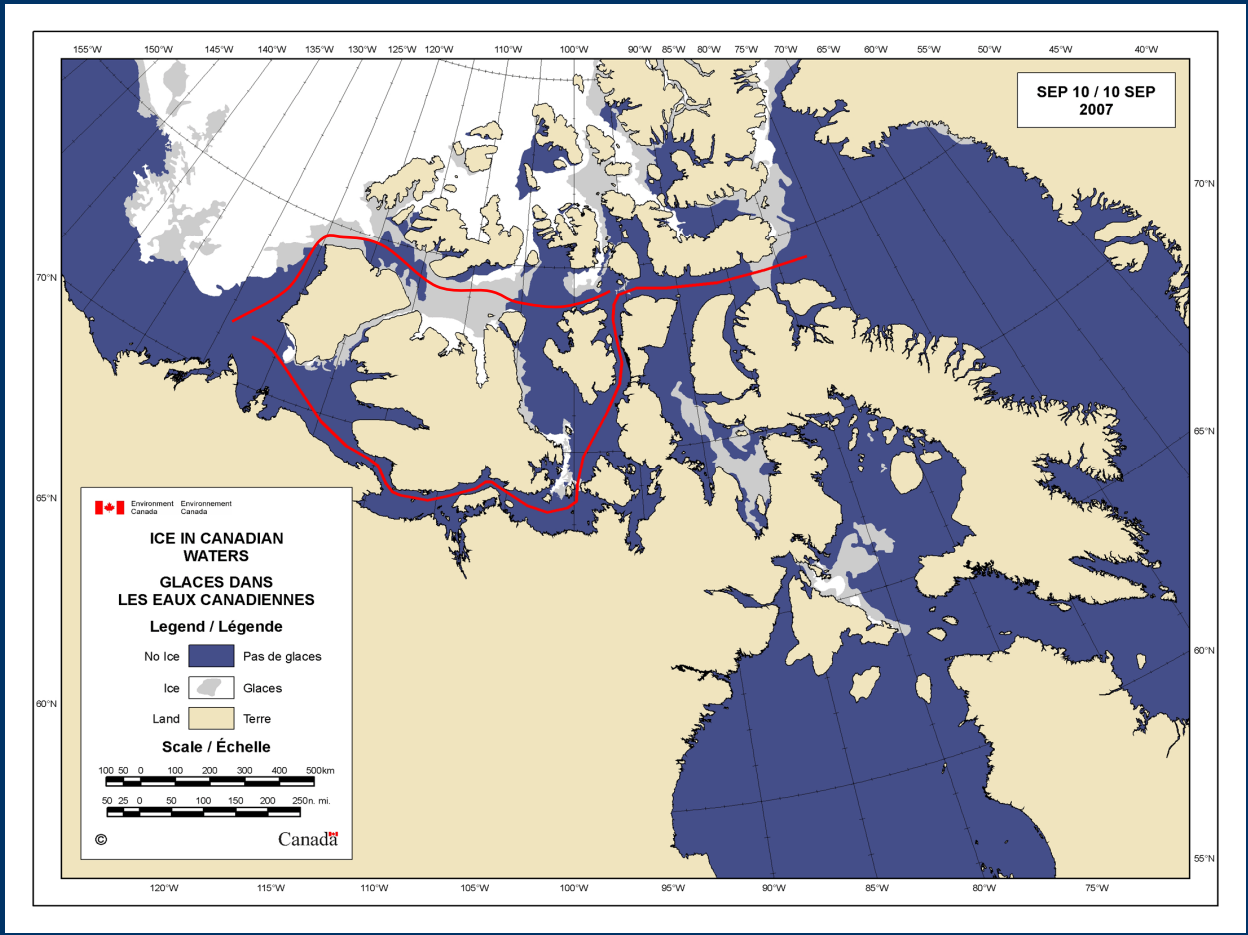
# Normal Ice Conditions – Sept 3

- 30 year average



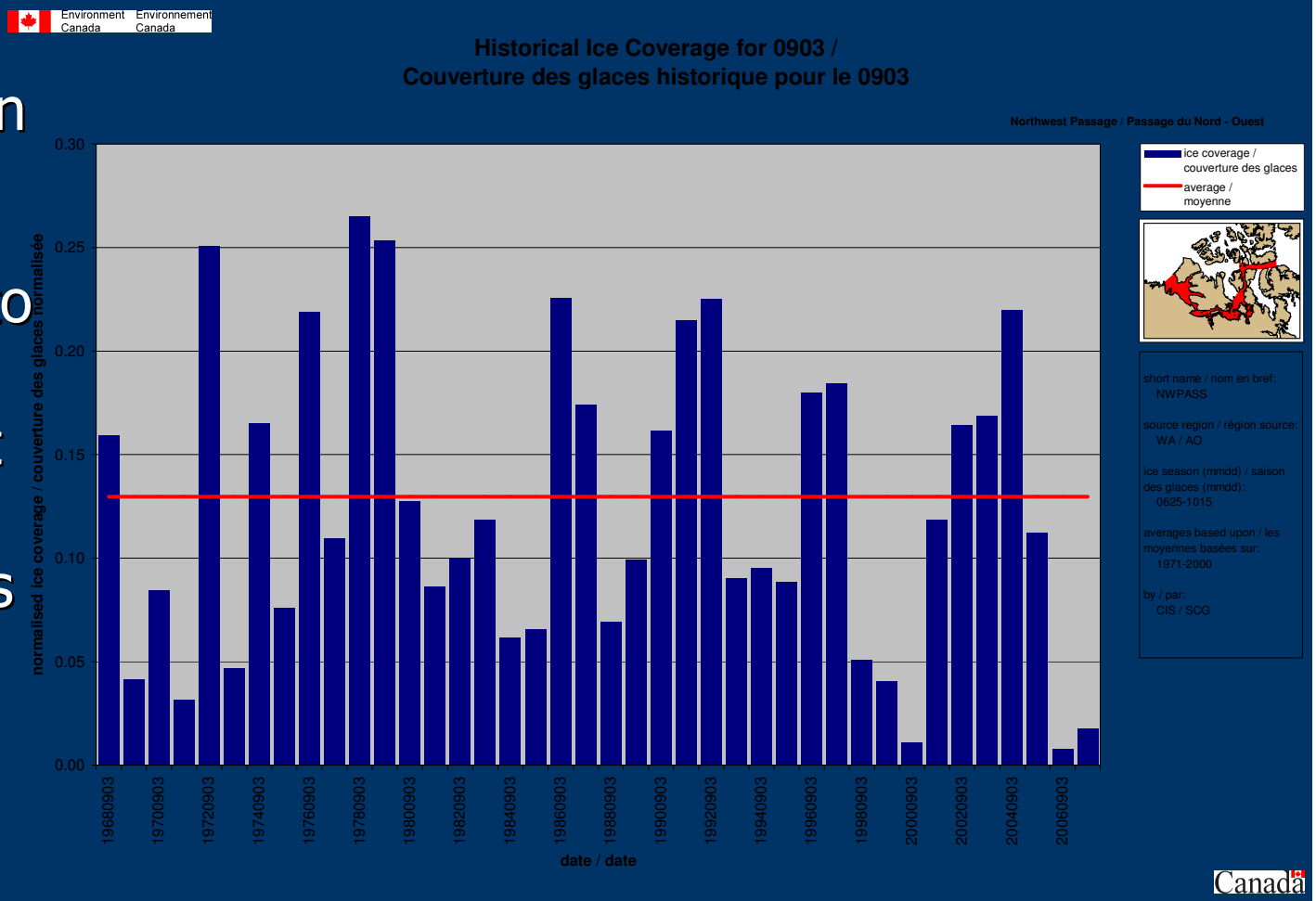
# 2007 Northwest Passage (NWP) Nearly Clear of Ice

- Along the southern, most frequently used branch of the NWP there was only about 20 km of ice to traverse (normally 400 km) of ice
- For the 1st time in recorded history, the northern deep draft channel of the NWP was easily navigable throughout its length



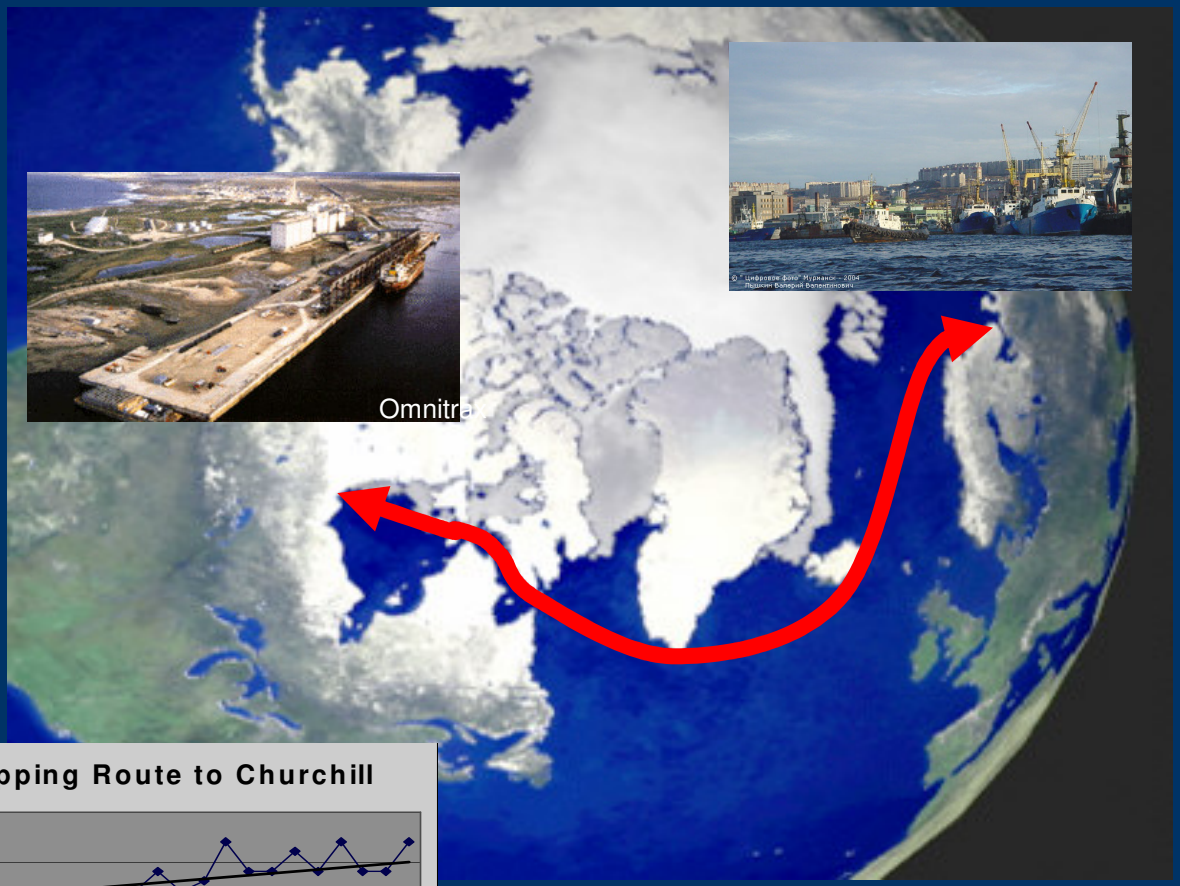
# Northwest Passage – record low two years running

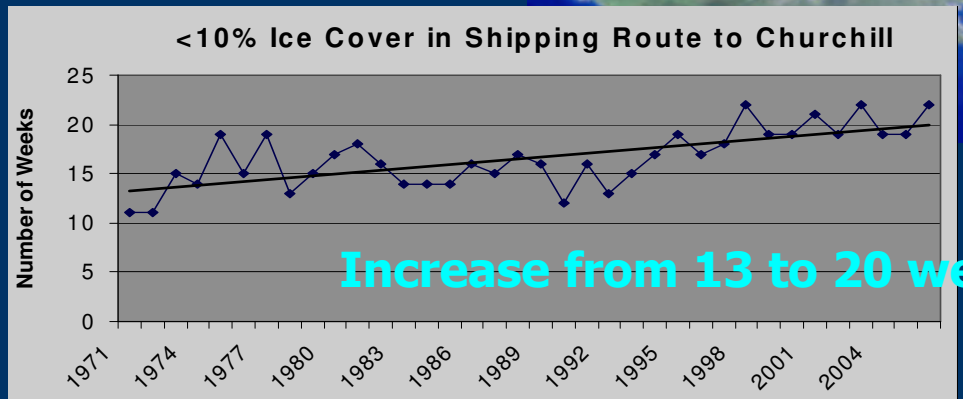
- Extent of ice on Sept 3 since 1968 shows extreme year to year variability
- 2006 had least ice
- 2007 almost as low



# The Arctic Bridge Murmansk to Churchill

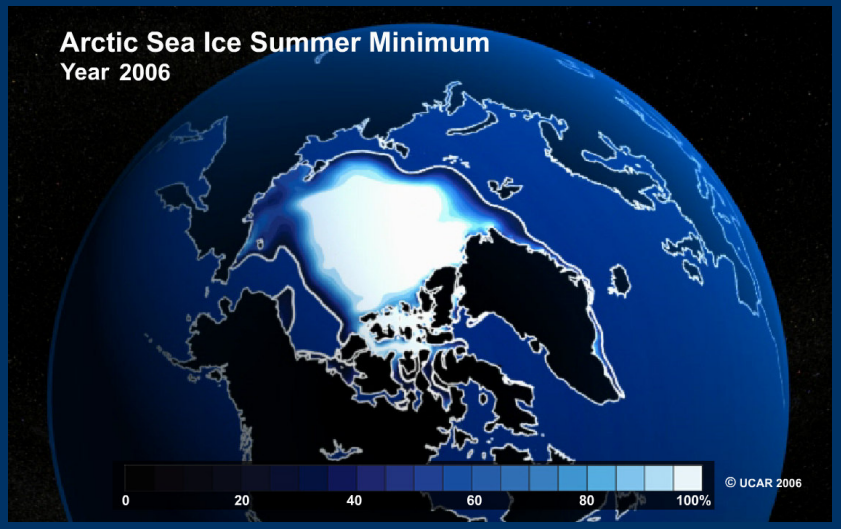
- Open water shipping route to Churchill now almost half a year
- Hudson Bay to soon look like Gulf of St Lawrence?

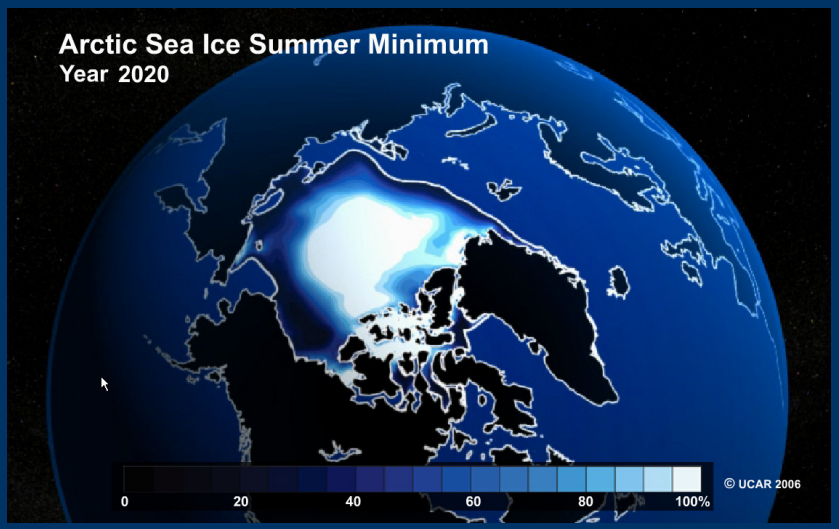


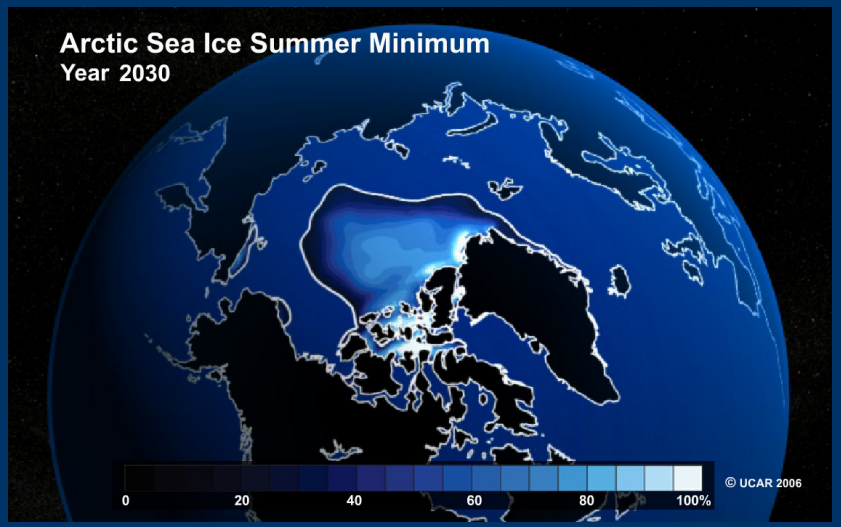


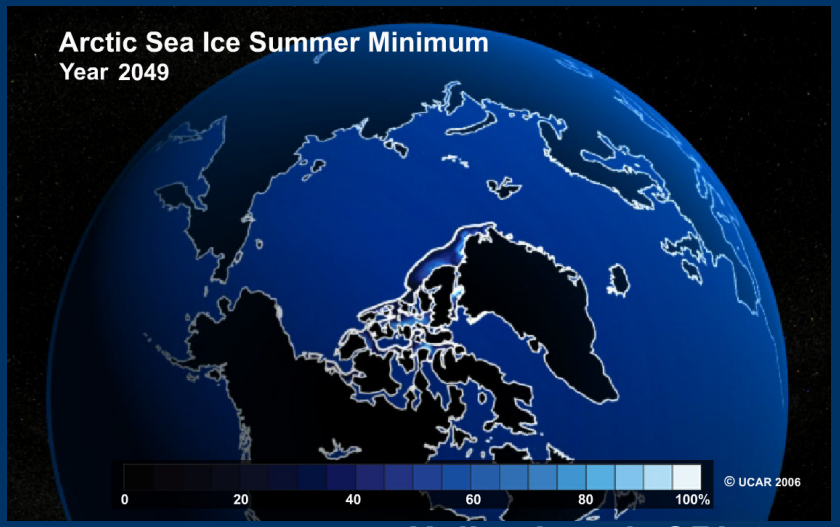

**Increase from 13 to 20 weeks in 35 years**

# One of the more realistic inter-decadal forecasts



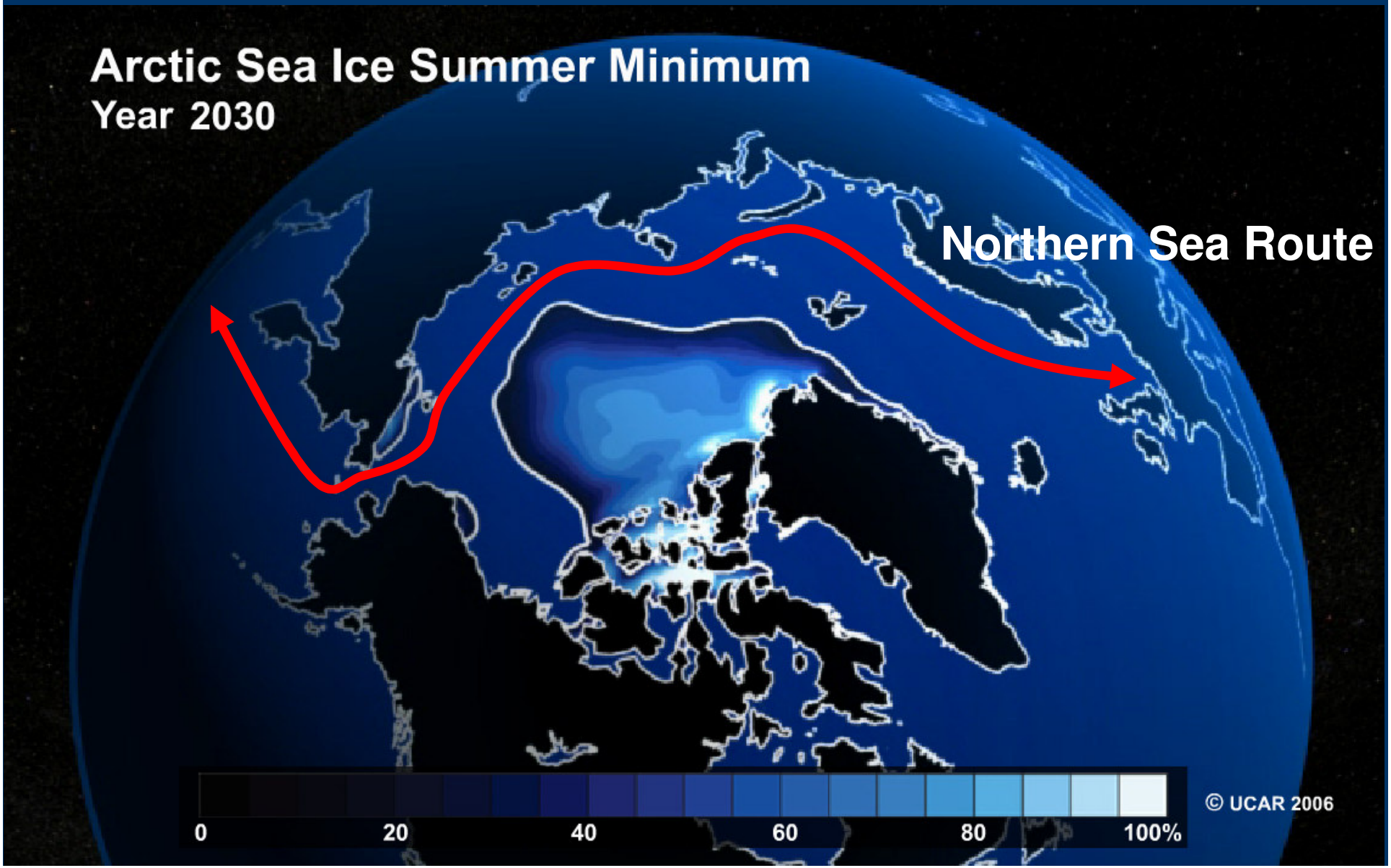




Holland *et.al.*, GRL 2006

**Last remaining multi-year ice will occur in and pushed up against the Canadian Arctic Archipelago**

# NWP will have to compete with alternative transit routes that are expected to open first



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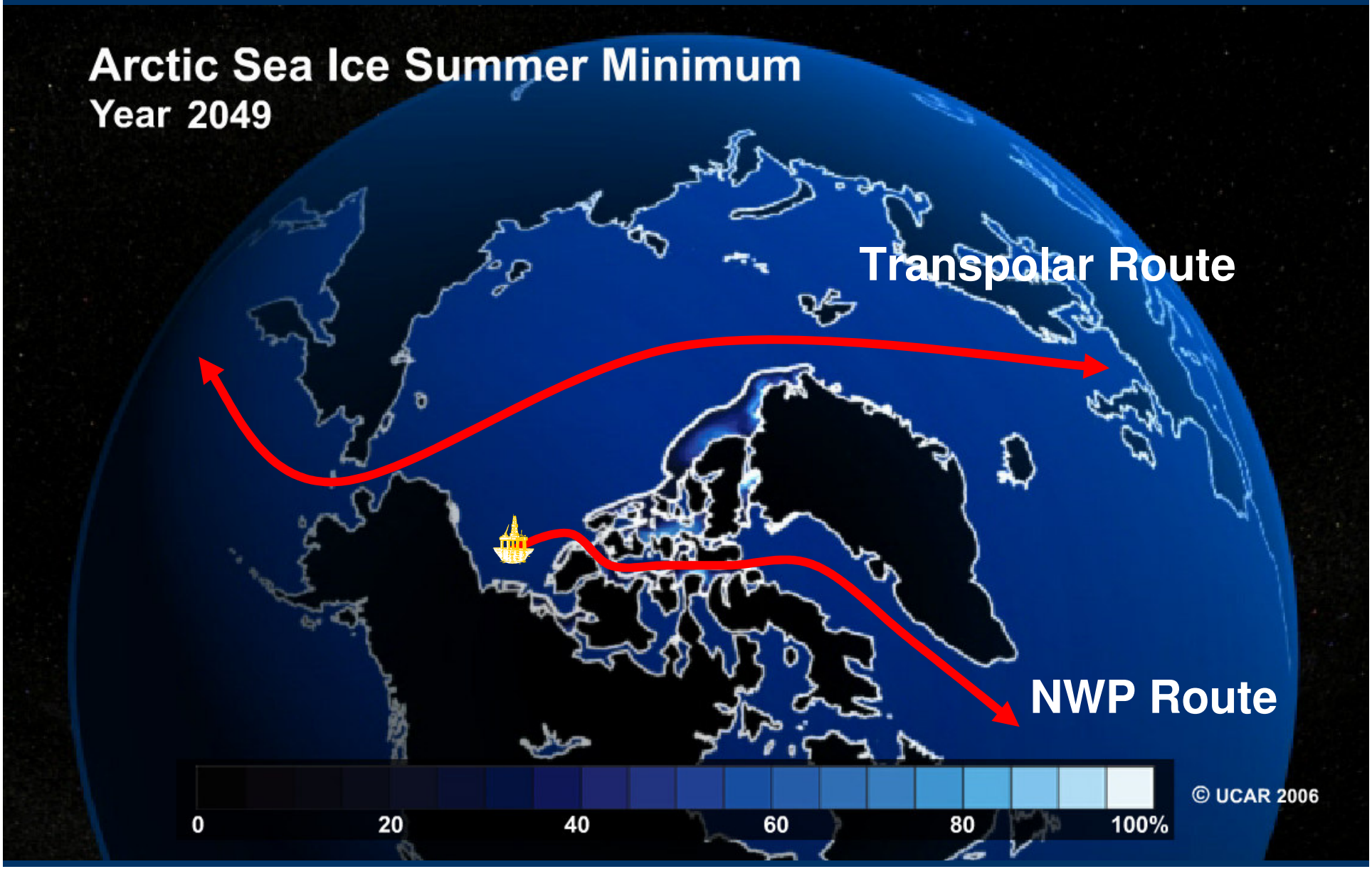
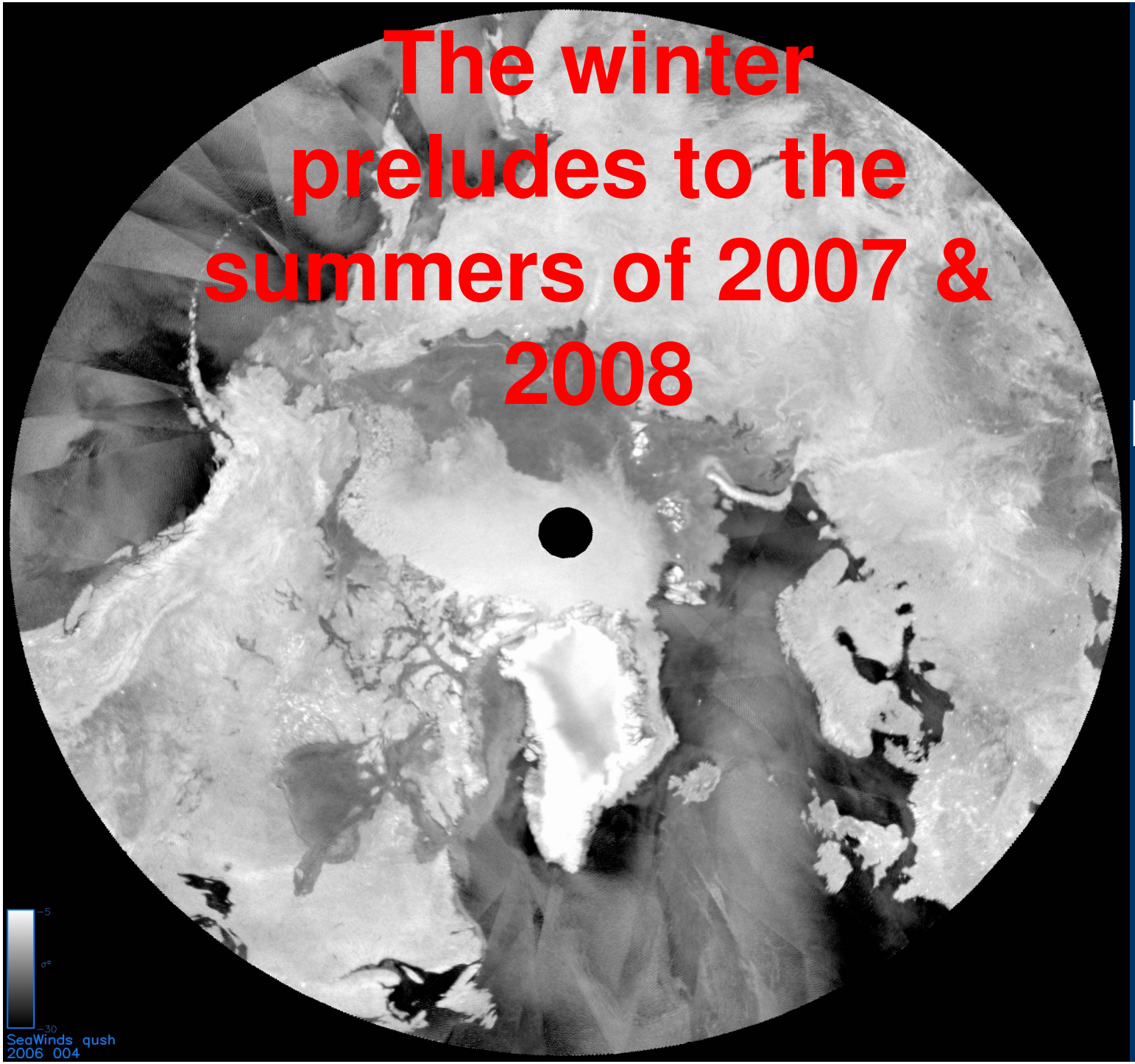
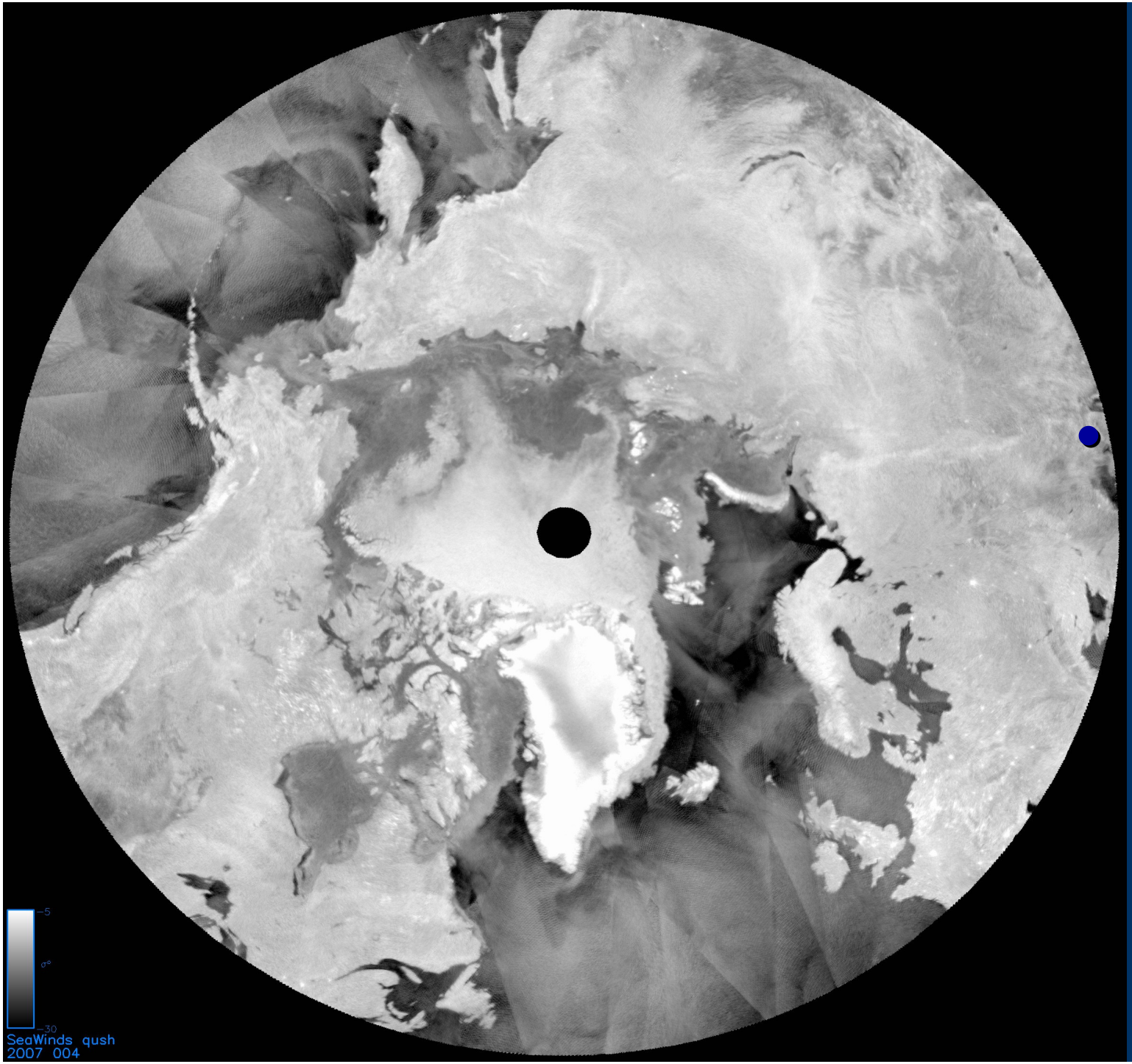


# The winter preludes to the summers of 2007 & 2008

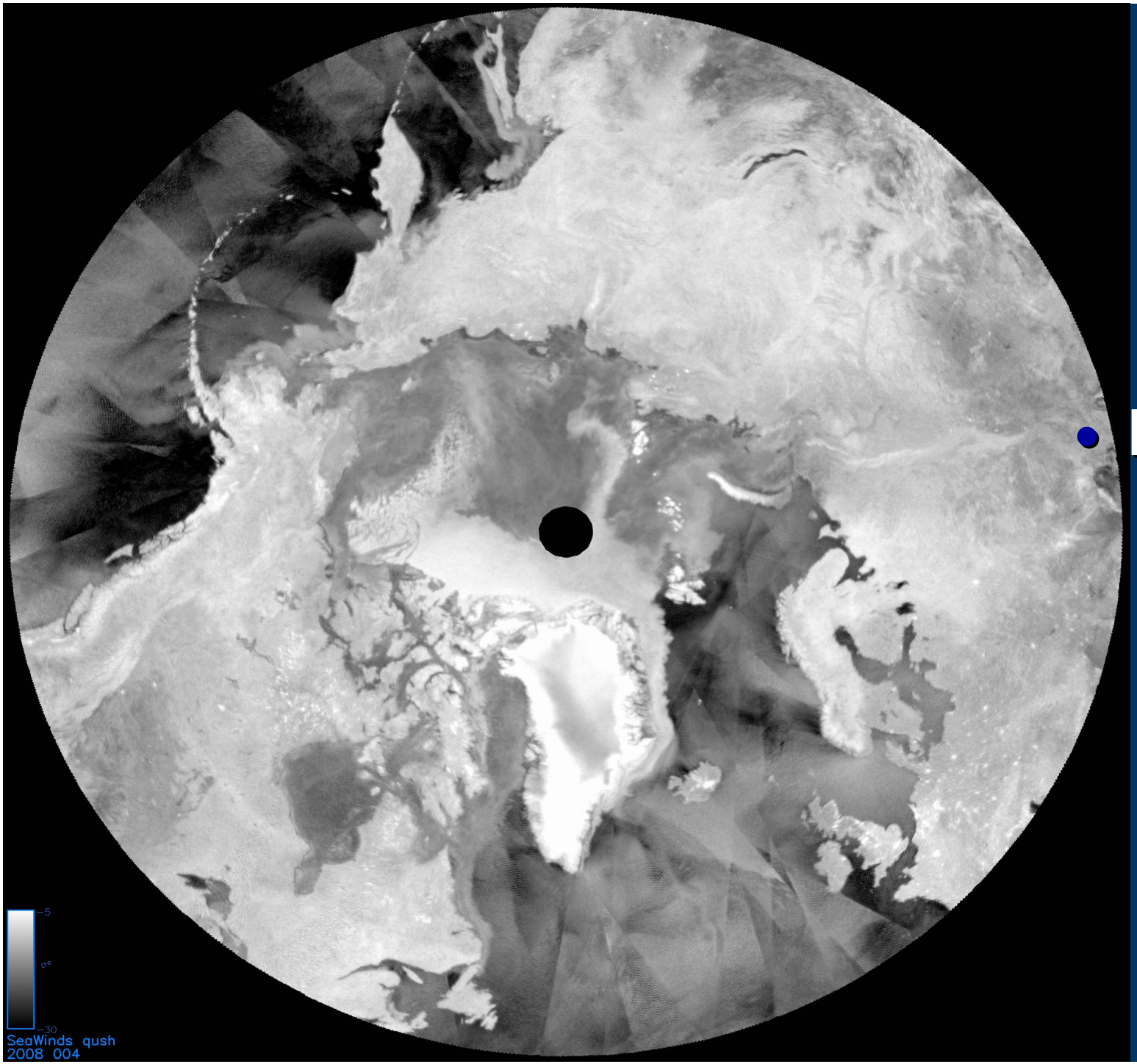



- Jan 06

Multi year




- Jan 07
- Multi year




- Jan 08
- Multi year

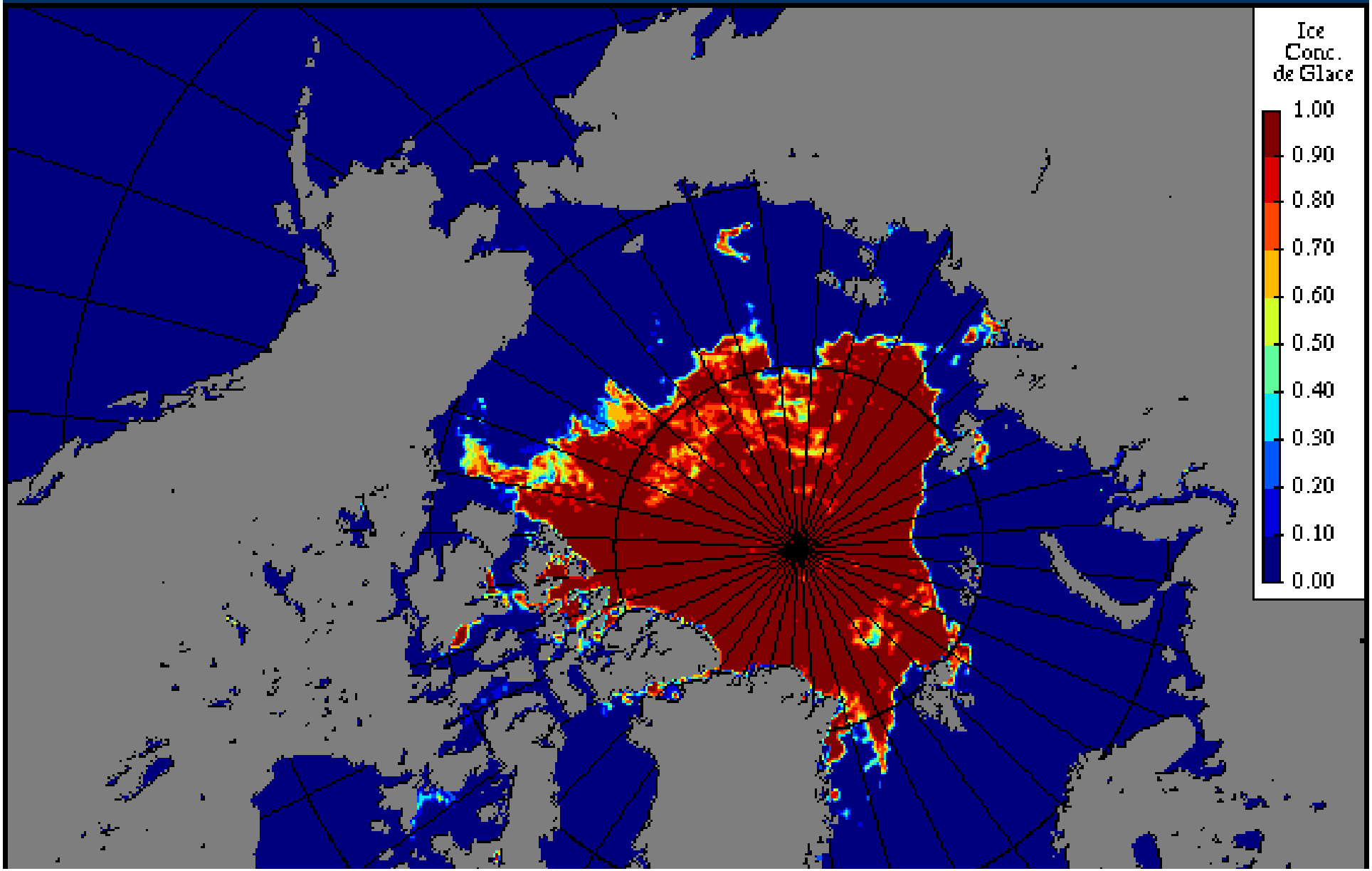
# Forecast: summer/fall 2008

- Many diverse opinions for 2008
- The Beaufort and Chukchi Sea summer 2007 high pressure caused the open water in the Siberian, Chukchi and Beaufort seas
  - This was not forecast to happen in 2008
- 2008 started with less ice than 2007
- 2008 forecast to be cooler than 2007
- A great demand for a long range ice outlook
  - These had never been produced by EC CIS before

# CIS 2008 forecasts

- Briefed to senior officials starting March 2008
- 65% probability of another record overall Arctic sea ice minimum extent – 3.6 M sq km
- Risk of large drifting packs of multi year ice in western Beaufort to Chukchi Sea
- NWP open for third year in a row. Northern Sea Route over Russia also to open
- 65% probability of areas of open water at or near the North Pole

# Verification … not bad!

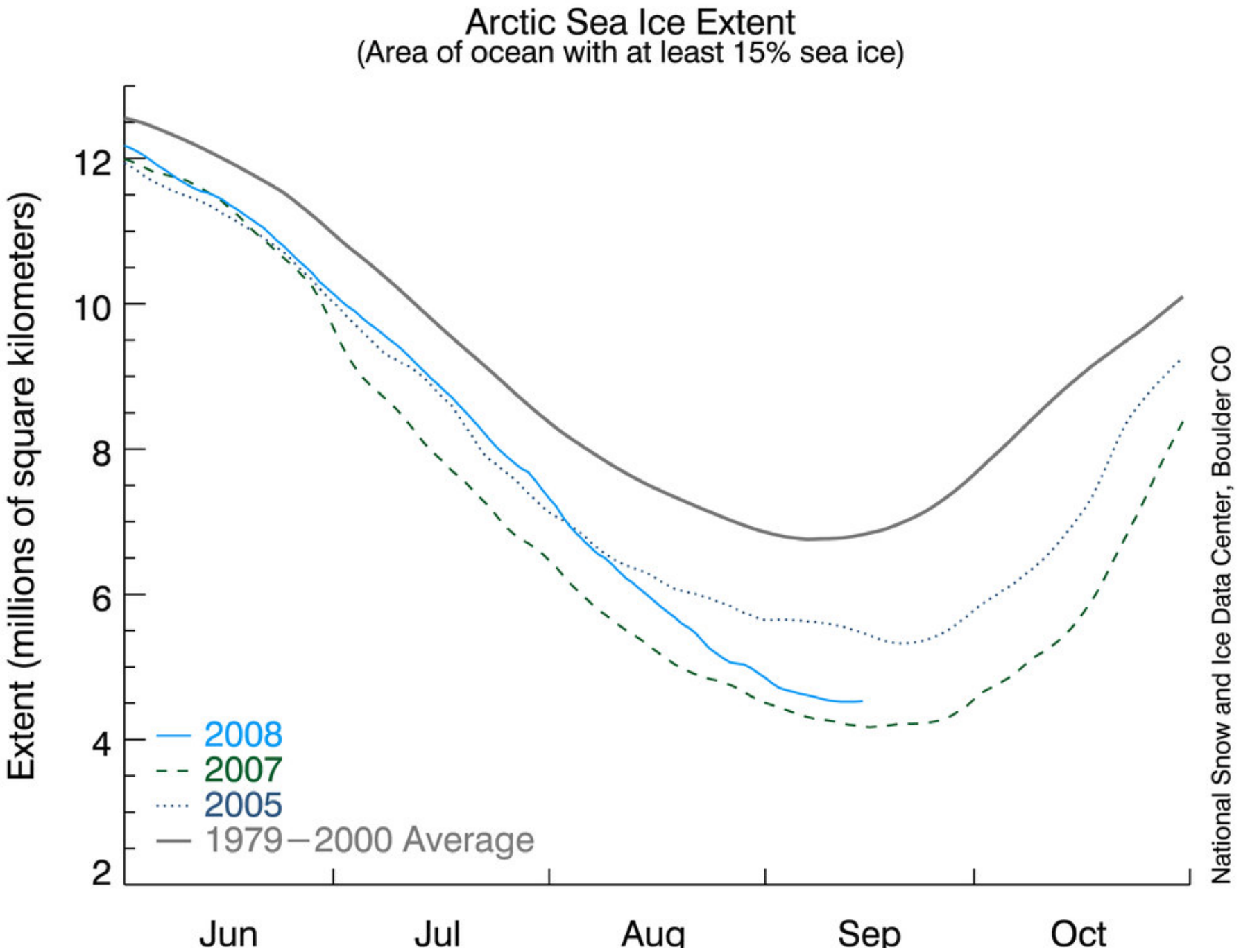


# Summer 2008 actual events

- Did not set a new record minimum extent
  - Albeit close
- Did set a record for record minimum ice volume
- There were large packs of multi year ice drifting from the western Beaufort to Chukchi Sea
- NWP was open for third year in a row.  Northern Sea Route over Russia was also to open
- NWP deep water route was navigable for second year in a row
- Some areas of open water near the North Pole

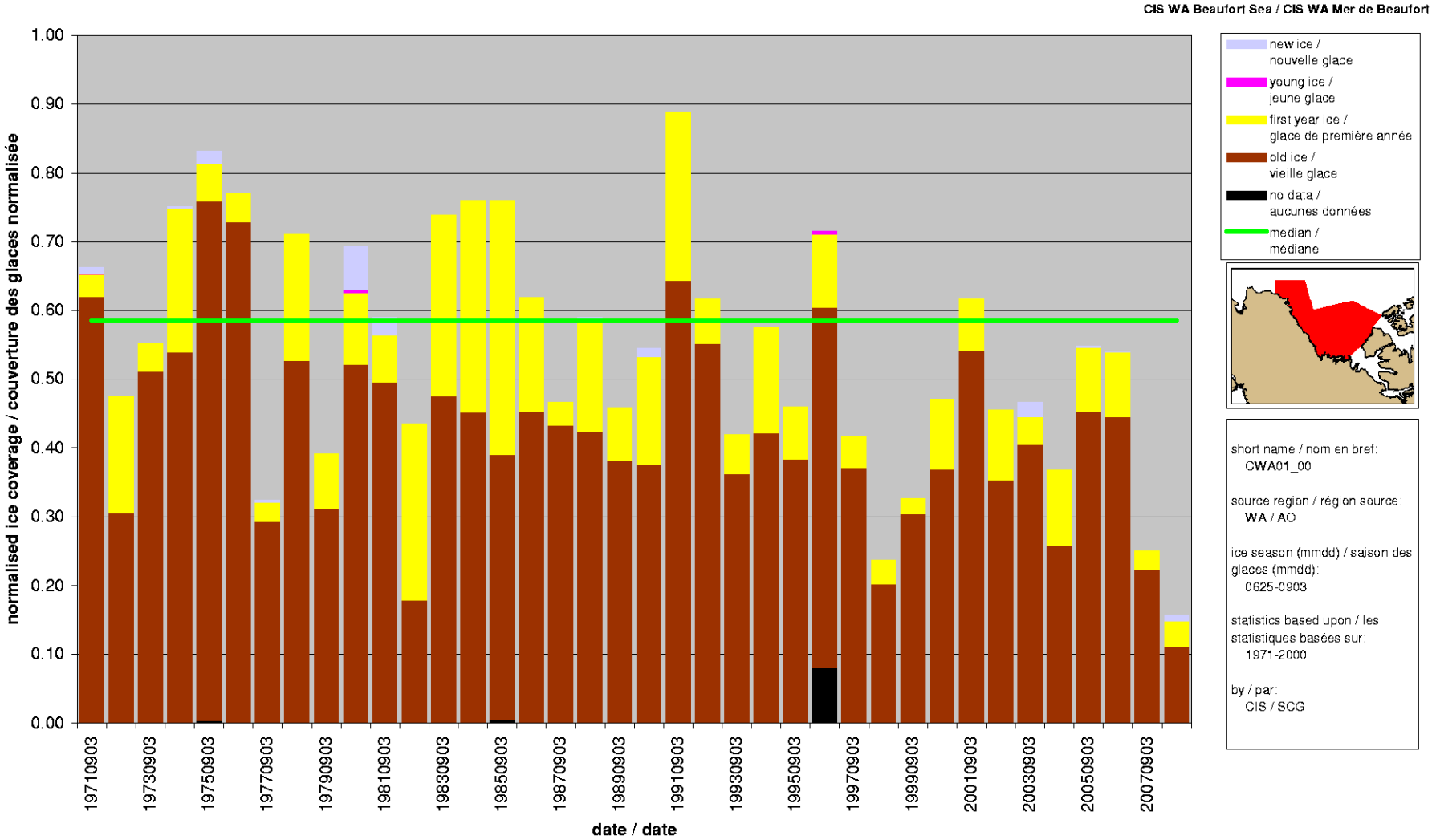
# Summer 2008 Minimum

- Arctic sea ice minimum 4.5 million sq km
  - second lowest in modern records
- 2008 minimum extent was only 9.4% more than the record-setting 2007 minimum
  - Despite overall cooler summer temperatures
  - Reinforces the strong negative trend in summertime ice extent
- The 2008 minimum extent is 15.0% less than the next-lowest minimum extent set in 2005
  - 33.1% less than the average from 1979 to 2000


Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)
Extent (millions of square kilometers)
12
10
8
6
4
2
2008
2007
2005
1979–2000 Average
Jun
Jul
Aug
Sep
Oct
National Snow and Ice Data Center, Boulder CO

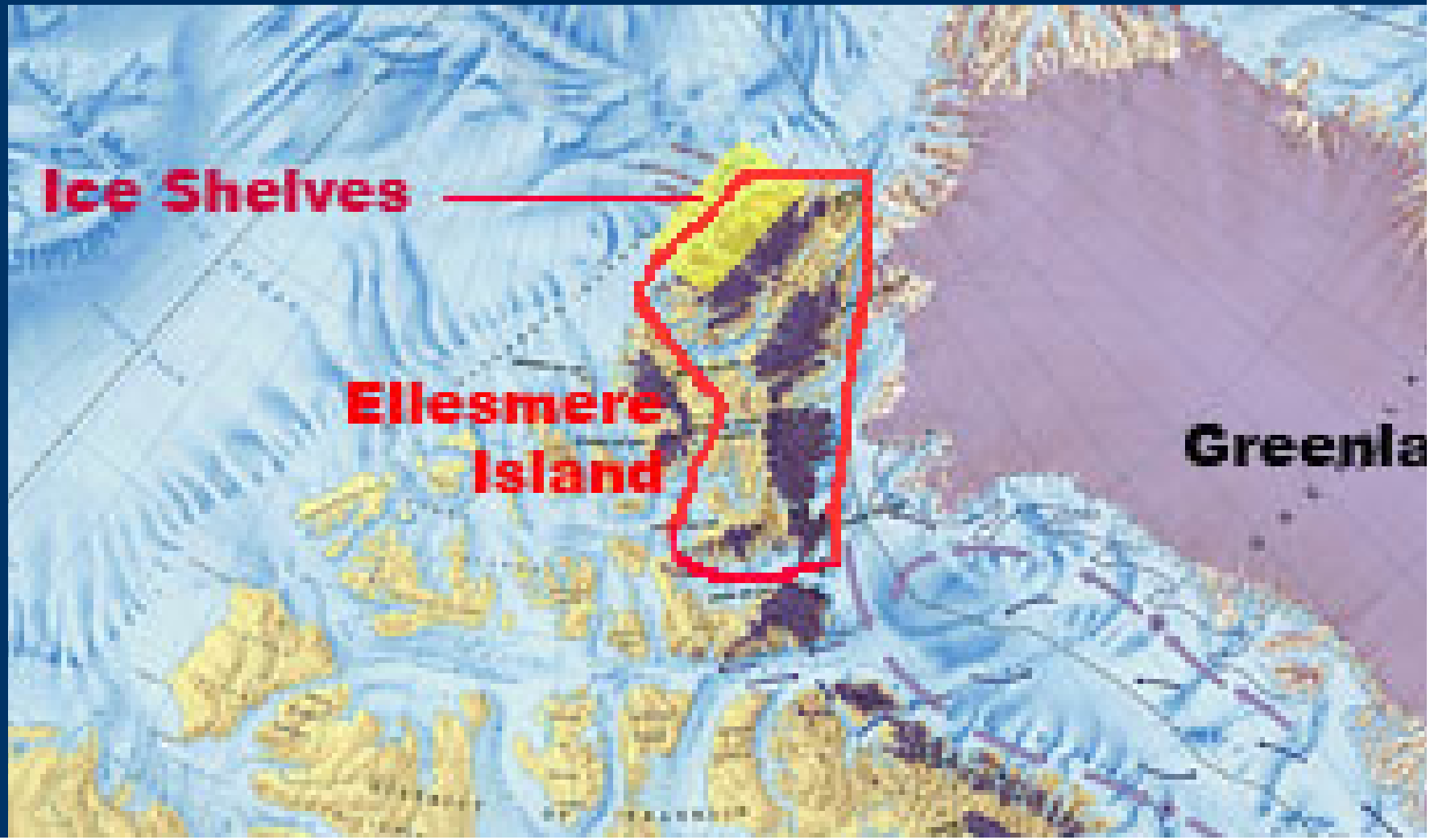
Environment Canada Environnement Canada

# Historical Ice Coverage by Type for 0903 / Couverture des glaces historique par type pour le 0903




Canada

# Loss of Northern Ice Shelves

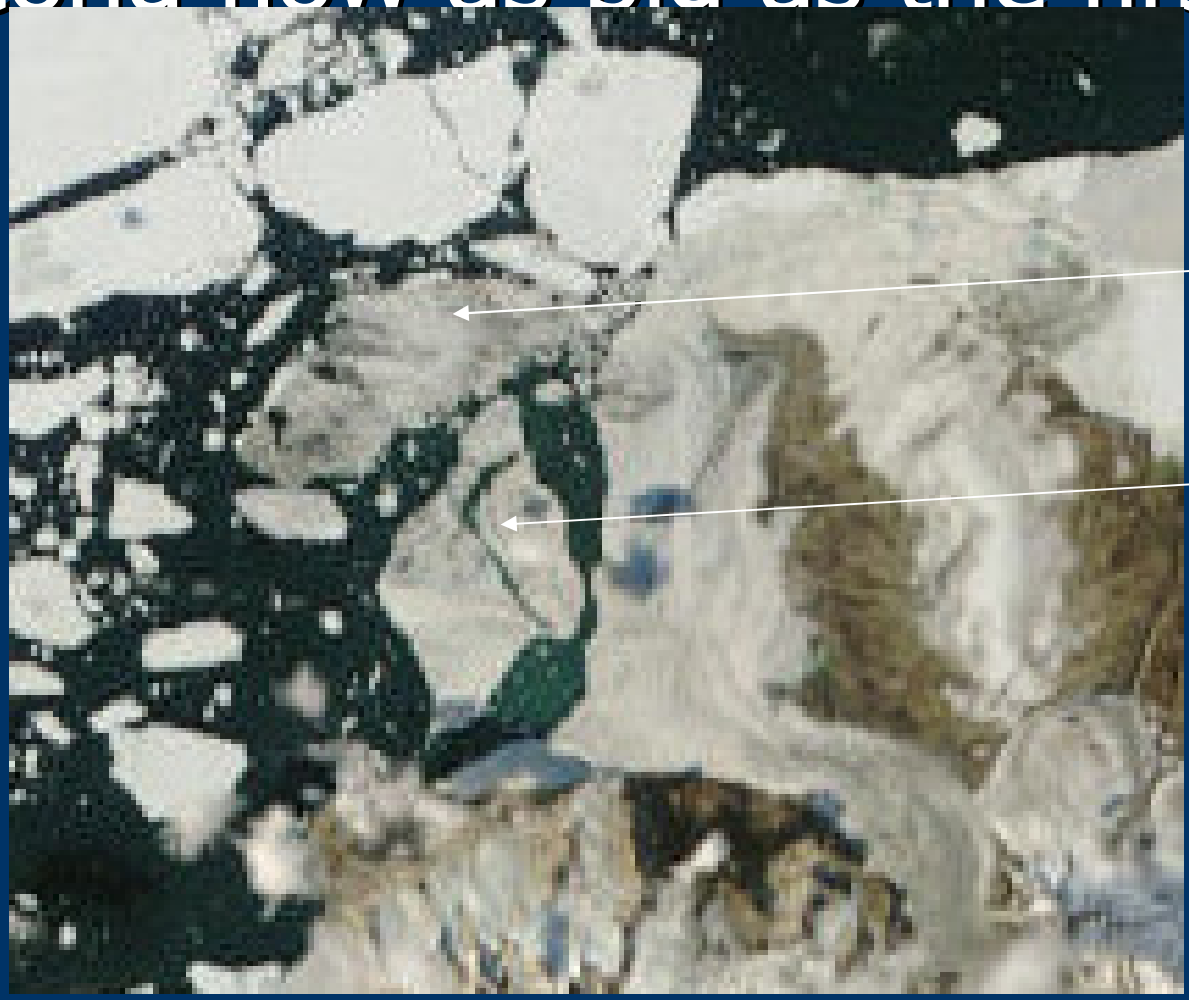


# Loss of three ice shelves

- The Ward Hunt Ice Shelf 22 – 24 July:
  - First calving (4.2 $km^2$ piece) July 22
  - 24 July - second ice island, about 14 $km^2$
- Then Serson
  - 31 July & 1 August, two each over 60 $km^2$
- And then Markham
  - between 4-12 August

# Serson 1 - break up - animation

# Serson 2– by 1 August 2008
# A second flow as big as the first

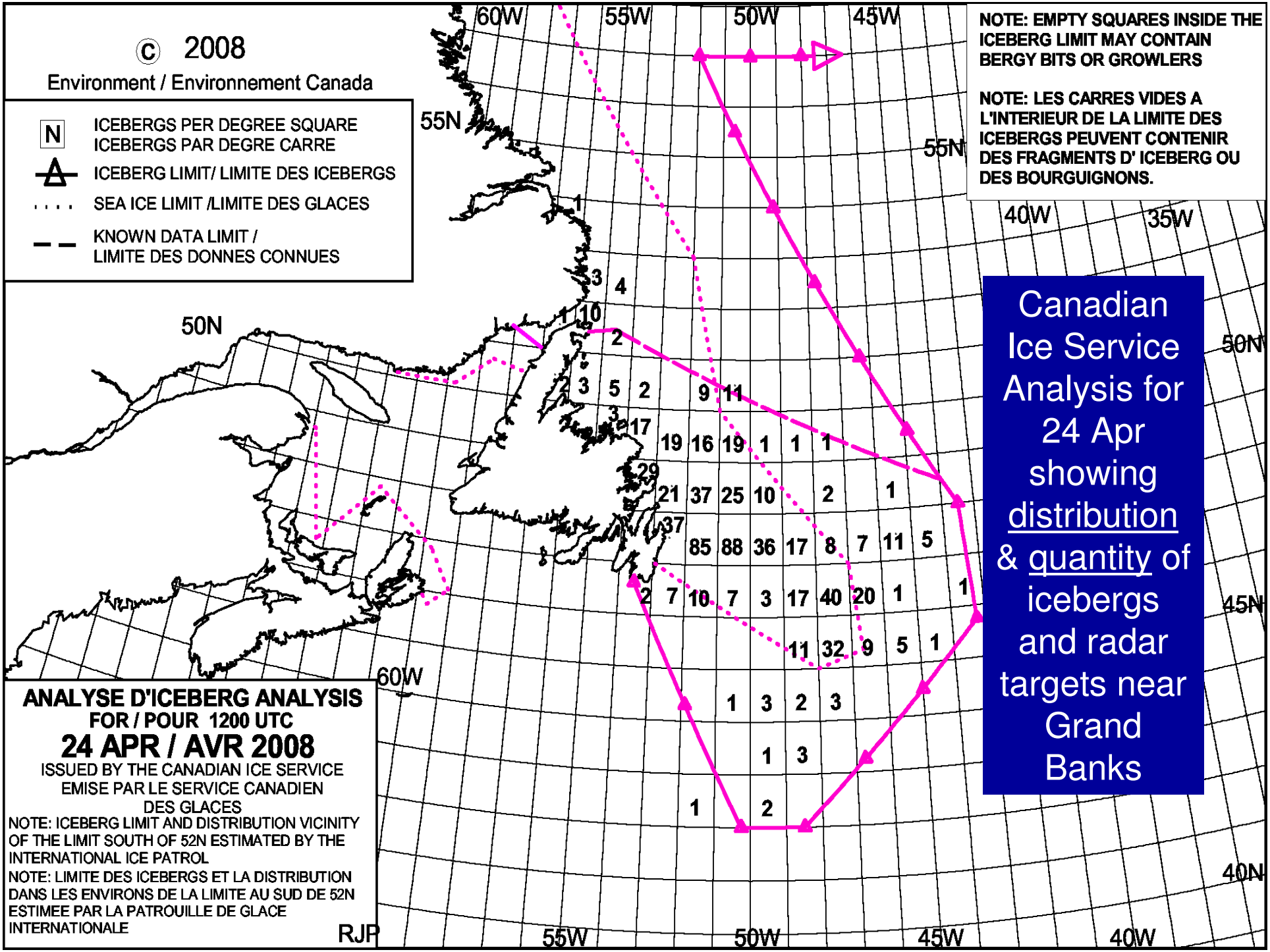


# What does it all mean?

- All these events are consistent with the other changes in the area
- Ice shelf break up leads to the creation of ice islands, which are significant potential hazards to marine shipping and offshore oil and gas development.
- Also, large icebergs pose similar risks

# 2008 East Coast Icebergs

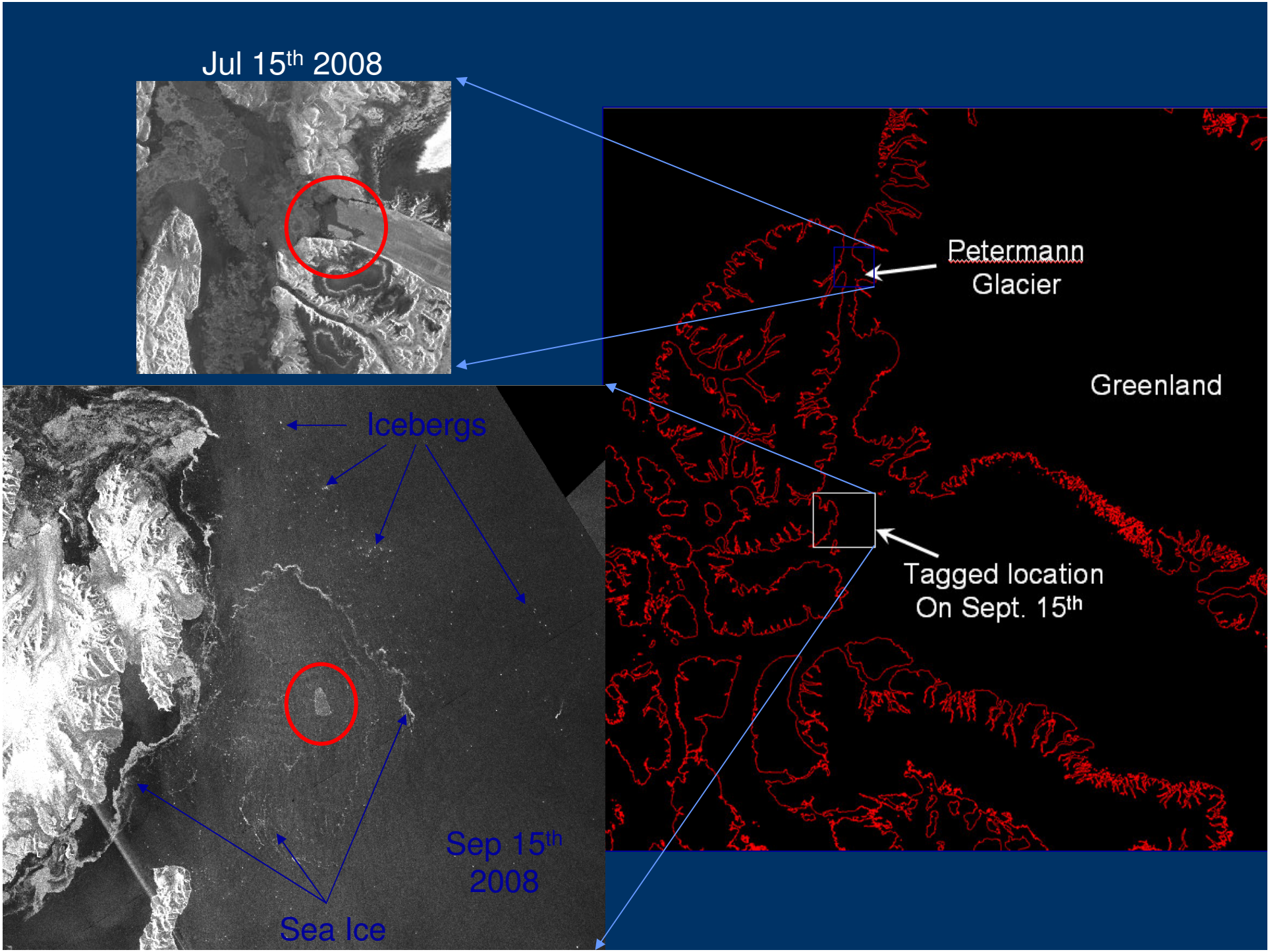
- By 15 March 2008, 249 icebergs had drifted south of 48N.
- By 28 March this had increased to 739.
- There were more icebergs that threatened mariners and oil rigs near the Grand Banks than from 2004-2007 combined.
- August 2008 – a new 23 sq km iceberg detached from Greenland and may pose an extreme hazard


© 2008
Environment / Environnement Canada
N ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
ICEBERG LIMIT/ LIMITE DES ICEBERGS
SEA ICE LIMIT /LIMITE DES GLACES
KNOWN DATA LIMIT /
LIMITE DES DONNES CONNUES
NOTE: EMPTY SQUARES INSIDE THE ICEBERG LIMIT MAY CONTAIN BERGY BITS OR GROWLERS
NOTE: LES CARRES VIDES A L'INTERIEUR DE LA LIMITE DES ICEBERGS PEUVENT CONTENIR DES FRAGMENTS D' ICEBERG OU DES BOURGUIGNONS.
60W
55W
50W
45W
40W
35W
55N
50N
45N
40N
ANALYSE D'ICEBERG ANALYSIS
FOR / POUR 1200 UTC
24 APR / AVR 2008
ISSUED BY THE CANADIAN ICE SERVICE
EMISE PAR LE SERVICE CANADIEN
DES GLACES
NOTE: ICEBERG LIMIT AND DISTRIBUTION VICINITY OF THE LIMIT SOUTH OF 52N ESTIMATED BY THE INTERNATIONAL ICE PATROL
NOTE: LIMITE DES ICEBERGS ET LA DISTRIBUTION DANS LES ENVIRONS DE LA LIMITE AU SUD DE 52N ESTIMEE PAR LA PATROUILLE DE GLACE INTERNATIONALE
RJP
Canadian Ice Service Analysis for 24 Apr showing distribution & quantity of icebergs and radar targets near Grand Banks

# The very large new iceberg

- Calved off Petermann glacier 15 July 2008
- Initially 10.5 km X 3.6 km
- Now 7.3 km X 3.6 km
  - about 21 $Km^2$ and a billion tons
- Tagged with beacons by CCGS Amundsen
  - collaboration DFO/EC/academic science

# Location 16 September 2008


Jul 15th 2008
Petermann
Glacier
Greenland
Tagged location
On Sept. 15th
Icebergs
Sep 15th
2008
Sea Ice

# Arctic Shipping Trends

- **Cruise ships**
  - Summer navigation pushing start of season earlier and earlier
  - Large numbers of passengers in ships not designed for Arctic use
  - Likely the least prepared / equipped vessels for the Arctic
- **Sealift**
  - Summer navigation trying to extend season at both ends
  - Increased shipping to serve growing population and economy
  - Vessels adequate for the task with well experienced crews
- **Bulk cargo in and out of Churchill**
  - Year-round traffic requiring ice navigation for 6 months of year
- **Ore Carriers / Tankers from Arctic to Atlantic**
  - Regular year-round voyages by purpose-built ships designed for the Arctic (iron, copper, oil, gas and more)
- **Voyages of Opportunity**
  - One-off voyages taking advantage of a short route and easy ice conditions
  - Rogue vessels?

# Impact on ice & marine services

- Arctic shipping season is lengthening
  - Increased demand for marine weather and ice information
    - Starting earlier in the summer – lasting longer in fall
    - Wider geographic span - Non traditional areas
    - Levels of CIS support requested by CCG exceed partnership agreement
    - Longer lead time forecasts requested, e.g. seasonal forecasts
  - southern winter shipping season is not shortening yet
    - Southern & northern services beginning to overlap
- Increasing demand due to traffic increase
- Increasing demand from policy
  - Northern initiatives, e.g. Arctic METAREAs
  - DFAIT negotiations
- We need an ice forecast capacity

# Broader Impacts on Canadians

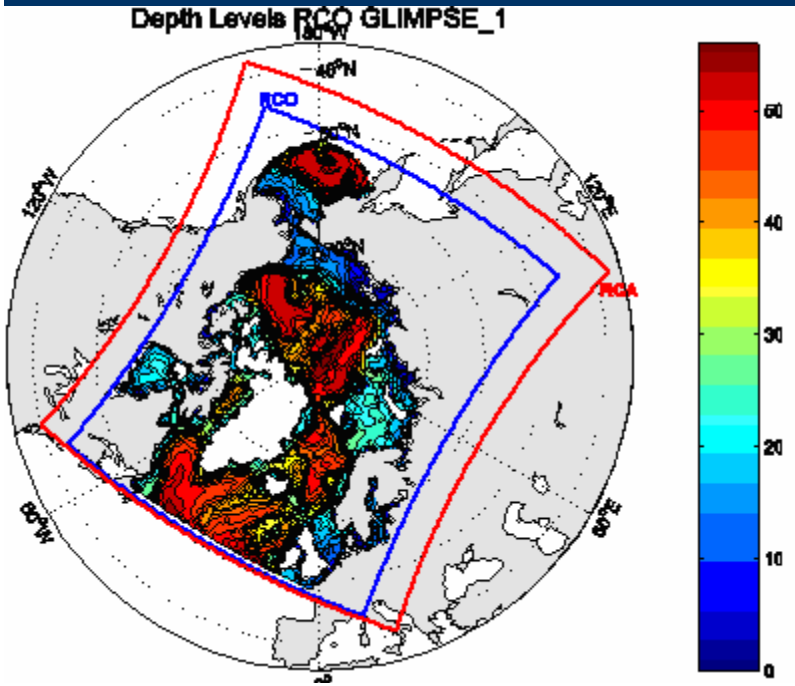
- Industry, Regulators and Enforcers
  - updates needed to northern marine transportation regulations
  - changing icebreaking requirements
  - increased risk of accidents, SAR ops, and environmental response
- People Living in the North
  - front-line of changing conditions (from sea ice to permafrost)
  - traditional knowledge is failing to inform
  - activities on water and ice will continue to have higher risks

# Canadian Ice Service response

- Supported CCG and OGD partners
  - exceeded agreed level of services
- Supported Federal Policy Initiatives
  - GoC Northern Strategy
  - UNCLOS ratification
  - DFAIT AWPPA
  - Climate Change
- Practiced Sovereignty
- Supported Security Operations
- Provided logistical and science support to IPY
- Enabled northern industry
  - Both operations and planning

# Now What?

- Reduce the uncertainty!
- Develop operational data assimilating coupled ice-ocean-atmosphere models to provide a proper basis for forecasts




**Three temporal scales needed**

Tactical – 0 to 7 days
support operations
Operational – inter-seasonal
support planning
Strategic – 30 year ensembles
support infrastructure
design

# Conclusions

- There has been a significant decrease in the extent of sea ice in the Northern Hemisphere and in the Canadian Arctic since 1971 and particularly since 1990.
- This trend is expected to continue; but...
- High variability should continue; as well as continued multi-year ice fragments in NWP
- Reduced sea ice coupled with rising resource prices is increasing shipping in the Canadian Arctic - destination shipping will increase.

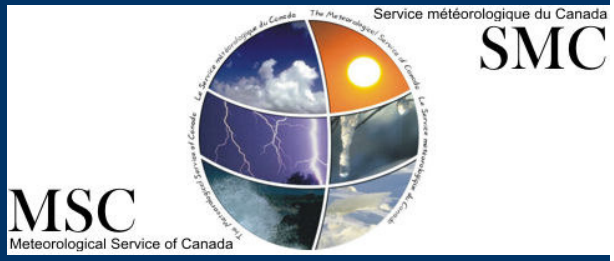
# Final Words

- The Northern Sea Route and Trans-Polar routes will attract routine Atlantic-Pacific transit shipping before the Canadian North West Passage
- Extreme inter-annual variability in ice conditions, winter ice cover and lack of infrastructure will continue to make the NWP less attractive to transit shipping (except destination transits of ore carriers and Beaufort Sea oil & gas tankers)
- There is and will be a continued increasing demand for MSC ice and weather services in the north.
- Need for science partnerships and investments for prediction capacity


Canadian Ice Service
Service canadien des glaces


SALUTI PRIMUM AUXILIO SEMPER

# Questions?


Service météorologique du Canada
SMC
MSC
Meteorological Service of Canada


North American Ice Service
National Ice Center
International Ice Patrol
Canadian Ice Service
Service canadien des glaces