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Center for Ocean and Ice

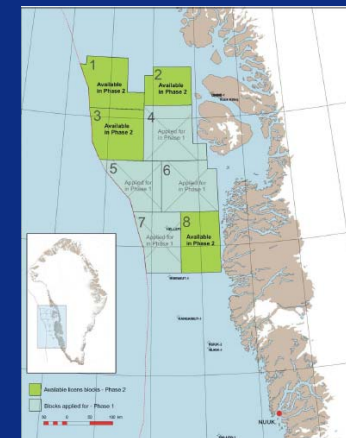
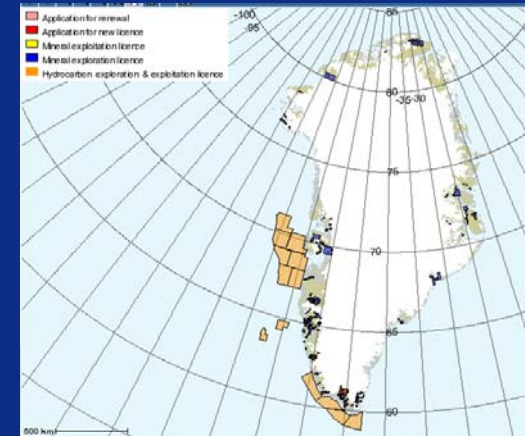
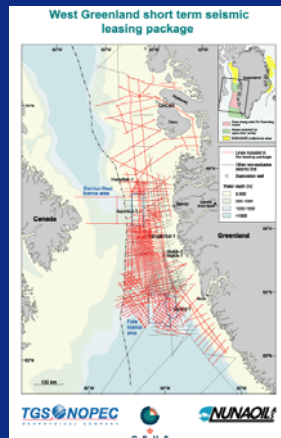
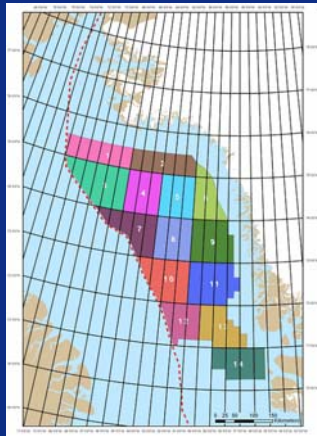


# Challenges to ice monitoring around Greenland

**Leif Toudal Pedersen**  
**Center for Ocean and Ice**  
**Danish Meteorological Institute**



## Expanding oil and gas exploration



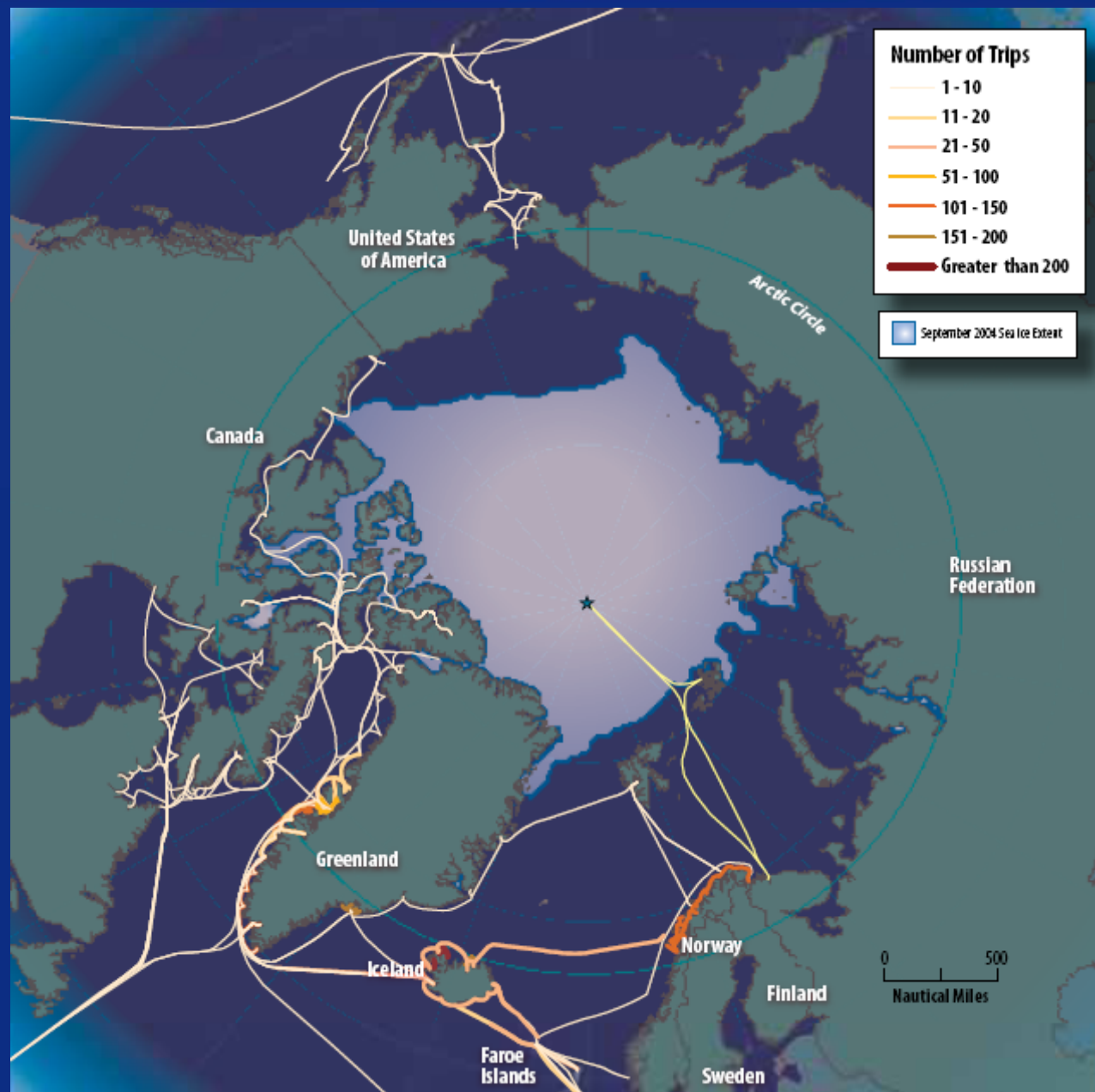


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# Passenger traffic

(from AMSA Arctic Marine Shipping Assessment)







## Increased Tourism



**Crown Princess in Nuuk 2009**  
3000 passengers, 1500 crew



**In August the 'Deutschland'**  
sailed close between several  
large icebergs at the mouth of  
the Ilulissat ice fjord.



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# Changing scenarios

## Fisheries



### Key figures

Royal Greenland A/S had an annual turnover in 2007/2008 of 5.2 billion and more than 2,100 employees around the world.

Turnover DKK million

2007/08	2006/07	2005/06	2004/05	2003/04
5,136	5,093	5,298	4,530	3,921

### OCEAN PRAWNS A/s

SHIPS DATA:

OCEAN PRAWNS

OCEAN TIGER

ATLANTIC ENTERPRISE

(click pictures to enlarge)

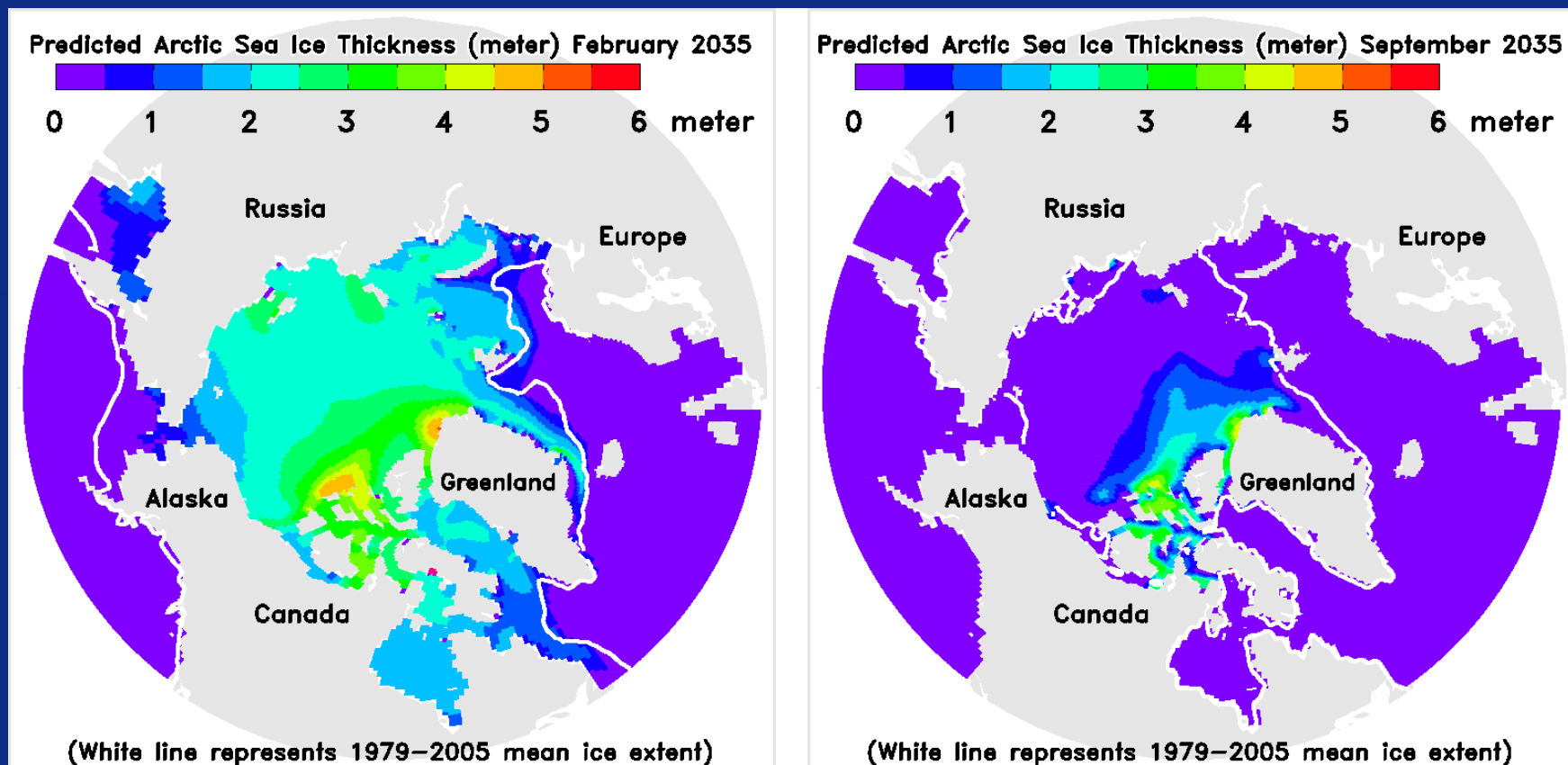
Description:





## Climate model predictions

2035 ??



Based on work by: Polar Science Center, Applied Physics Laboratory,  
University of Washington





## Already observed: September Arctic minimum ice extent

- Avg ice extent 1979-2000: **6.70** M sq km
- 2007 ice extent minimum: **4.13** M sq km
- 2008 ice extent minimum: **4.52** M sq km
- 2009 ice extent minimum: **5.10** M sq km

*NSIDC, 2009*



## Already observed: Changes in Arctic September ice thickness

- **1958-76 avg ice thickness:** **3.02 m**
  - From submarine data
- **1993-96 avg ice thickness:** **1.62 m**
  - From submarine data
- **2003-07 avg ice thickness:** **1.43 m**
  - From satellite data





## **Changing technology**

- **Many ships today have broadband access, more will have in the future**
  - Enables reception of much more information on-board
- **More satellites provide better ice monitoring capability at lower cost**
  - Data policies are developing



# What can we do

- **Increase in ice charting**
  - areas/frequency
- **Supplementary satellite image service**
  - being implemented
- **International collaboration on**
  - standardization (IICWG, EU, EIS)
  - Data policy (ESA, NASA, JAXA, ...)



## **User request: improved forecasting**

- **As operations increase in new regions, we need to strengthen our monitoring and forecasting capabilities**
  - We need more data and understanding, this calls for research and monitoring programmes
    - Better models (ocean, ice and icebergs)
    - More weather stations
    - Ocean monitoring capability
      - IPY (e.g. DAMOCLES)
      - SAON (Sustaining Arctic Observation Networks)
  - Icebergs

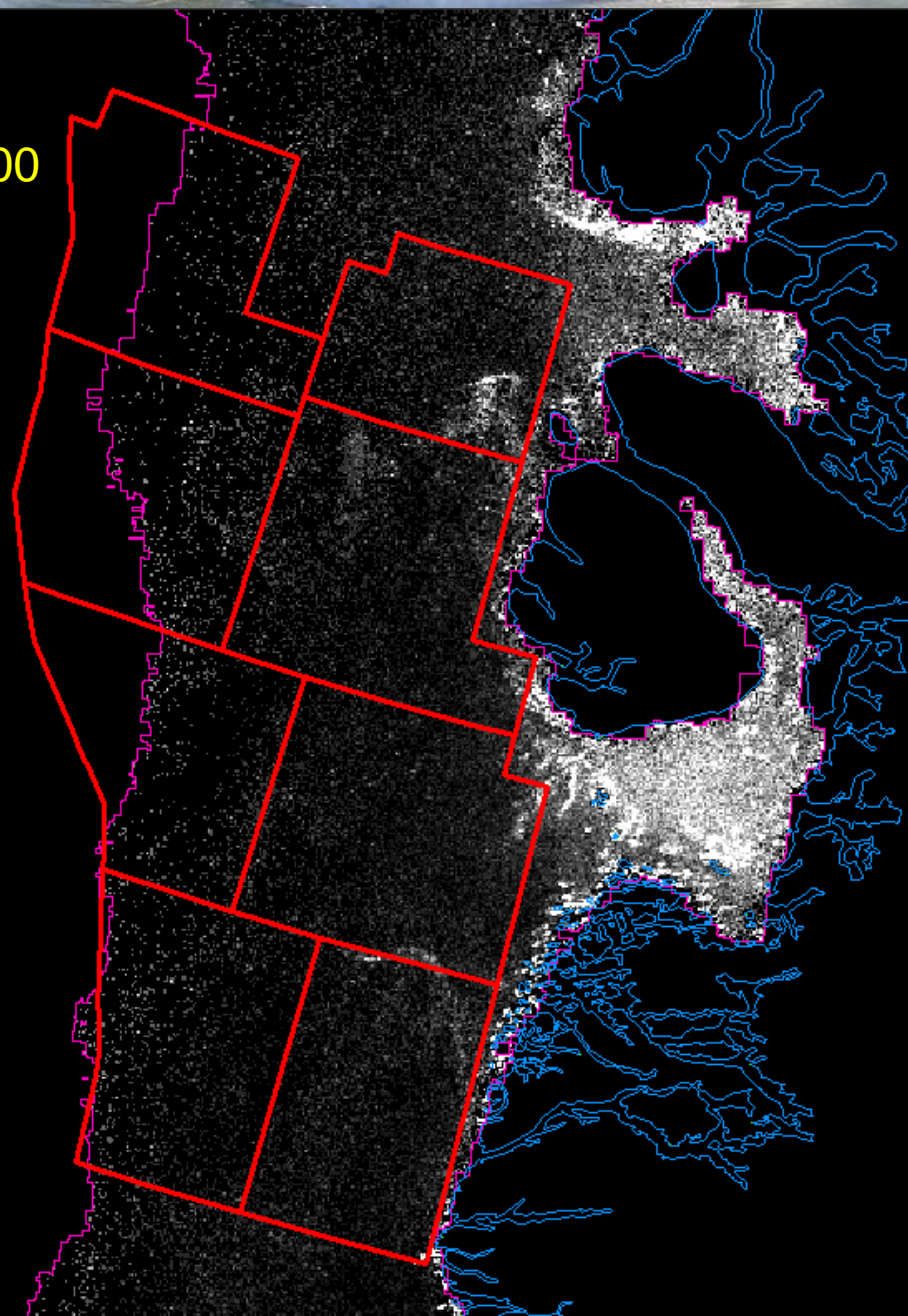


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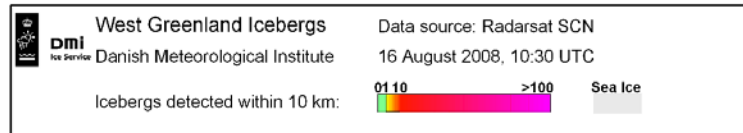
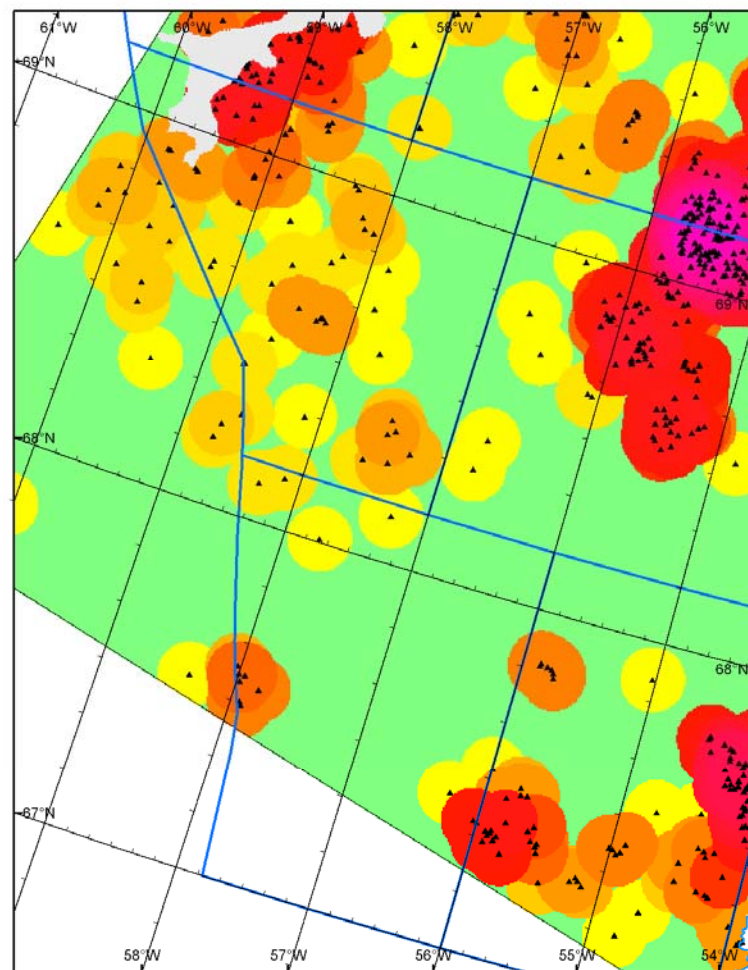
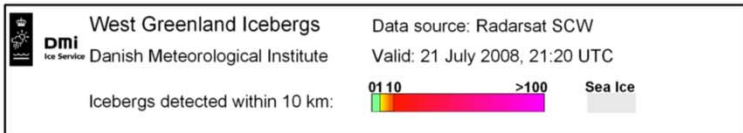
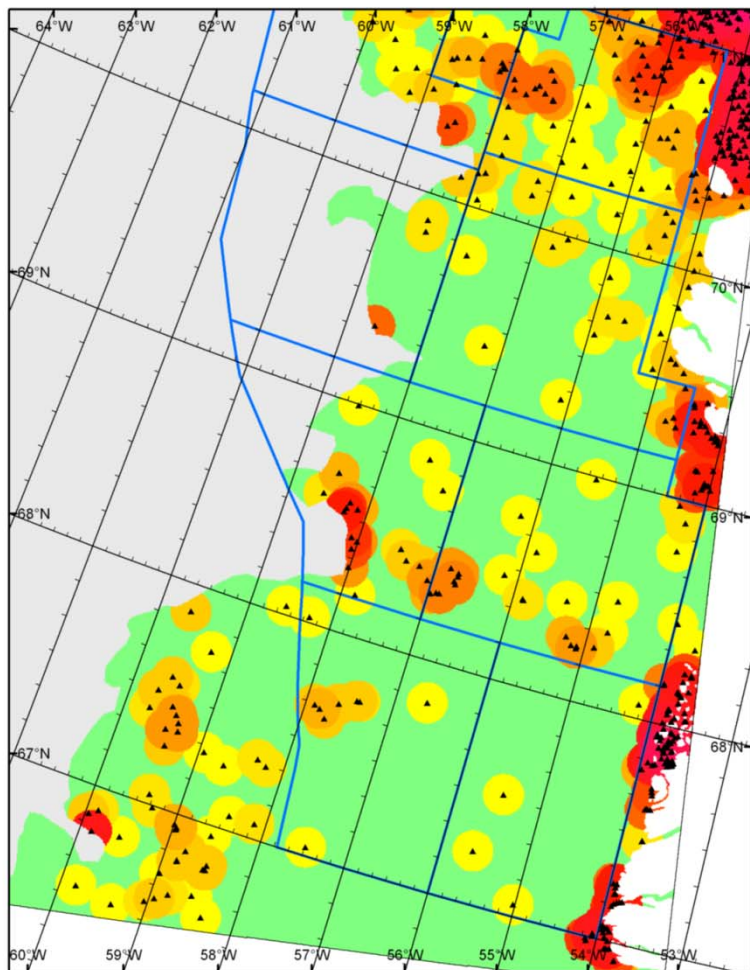
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# Iceberg statistics

Iceberg statistics  
From more than 3000  
Radar images









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## Satellite Images

Satellite Images from the coasts of Greenland

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[Forecasts and observations](#)

[Research and development](#)

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### Modis Satellite Images

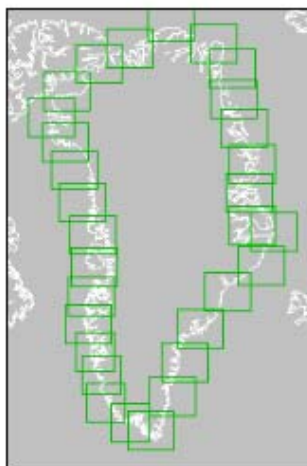
Modis satellite images from areas along the coasts of Greenland. The images are updated several times a day.

The Modis images are delivered by the the University of Dundee, Scotland (the green images) and by NASA's Goddard Space Flight Center. The NOAA images are infrared images from DMI's own receiving stations. The ASAR images are radarimages from ESA's ENVISAT satellite.

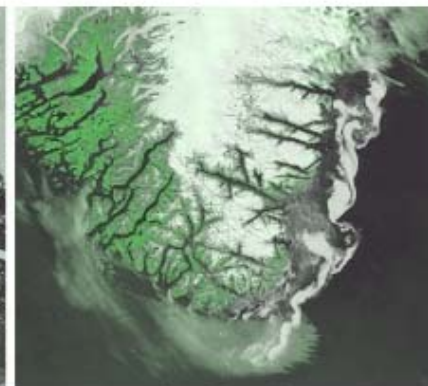


Polar View

Click on the outlined fields on the map below to select the region of your choice.



Station Nord



Kap Farvel



Disko



Ittoqqortoormiit

**Distribution  
of satellite  
images as a  
supplement  
to icecharts**





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# On-board information systems

www.seaice.dk

envisat.n.GMMmos

load

324.0 nm/100pix

500.0 nm/154pix



Ørsted•DTU

focus

zoom +

zoom -

hide

H= m(H)

H= m(I)

I= m(H)

I= m(I)

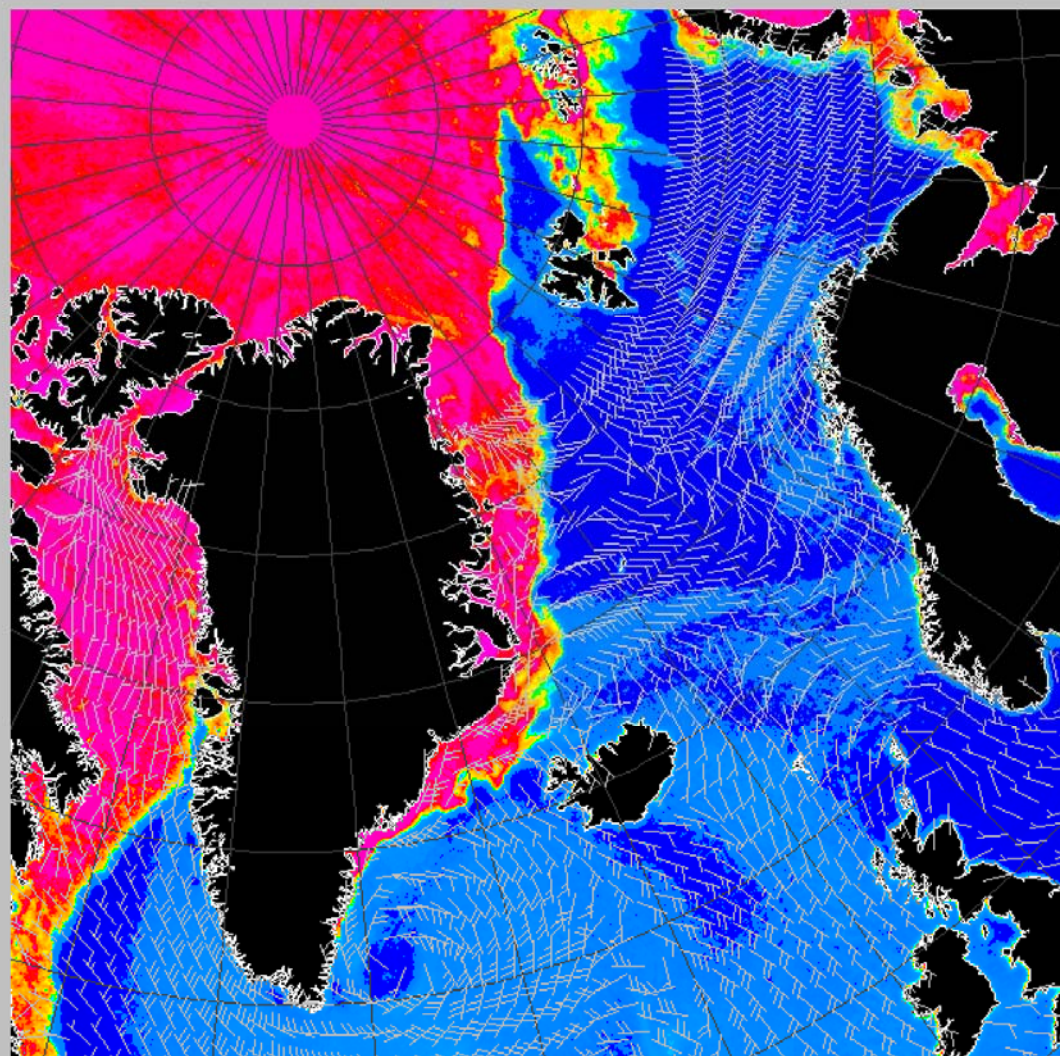
unfilter

adjust FP

stat

dist

logbox ON



12h windforecast

toggle

colorize



— N-Hemisphere coast  
— lat5/lon10  
— 12h windforecast

2006-02-02  
69.0897N 21.2822W  
2644.5000 1588.5000  
PixVal: mtfef00  
ParVal: 0.47

v1.46b

2006 02 02

-y

-m

-d

+d

+m

+y

load





# Conclusions

- Arctic/Greenland sea ice will decrease during the 21st century
- Arctic/Greenland sea ice will continue to form every winter
- Larger interannual variability
- Longer ice free season in potential areas for oil/mineral exploration – increased shipping
- Increased tourism

## Leading to:

- Increased need for ice information and SAR since ice will continue to be a hazard to navigation
  - Increase frequency of ice charts
  - Supplementary satellite image supply
  - Improved forecasting (need for more data)
  - Iceberg monitoring and forecasting
- Need for international collaboration and standardization