WHAT IS AT STAKE IN THE ARCTIC REGION?

J.P. CONTZEN

ESA Workshop

Paris, December 8, 2010

Increased Human Presence

- Economic considerations drive towards an increased human presence in the Arctic region. The impact of climate change will enhance the opportunities for such a presence. Is it possible to achieve a sustainable development of the region? It requires good governance
- Human activities should be conducted with the essential preoccupation of safety for the persons and of preservation of the natural environment.

Safety First

- For ensuring adequate safety levels, beyond developing a satisfactory regulatory environment, technology can definitely help, notably through the recourse to space systems combining earth observation, navigation & positioning and telecommunications capabilities. Keywords in this respect are : monitor, report, guide, remedy

Hazards and Areas of Concern

Main hazards where space techniques can contribute to prevention and mitigation:

- Sea ice conditions
- Icebergs' movements
- Polar Lows
- Permafrost melting
- Chemical pollution/oil spills
- Ocean productivity variations

Three areas are primarily concerned: merchant shipping and tourism, oil and gas exploration and extraction, fisheries

The issues' Matrix

	SEA ICE	ICEBERGS	POLAR LOWS	PERMA-FROST	CHEMICAL POLLUTION OIL SPILLS	OCEAN PRODUCTIVITY
SHIPPING & TOURISM	YES	YES	YES	(YES)	YES	NO
OIL & GAS EXPLORATION / EXTRACTION	(YES)	YES	(YES)	YES	YES	NO
FISHERIES	(YES)	(YES)	YES	NO	(YES)	YES

SEA ICE CONDITIONS

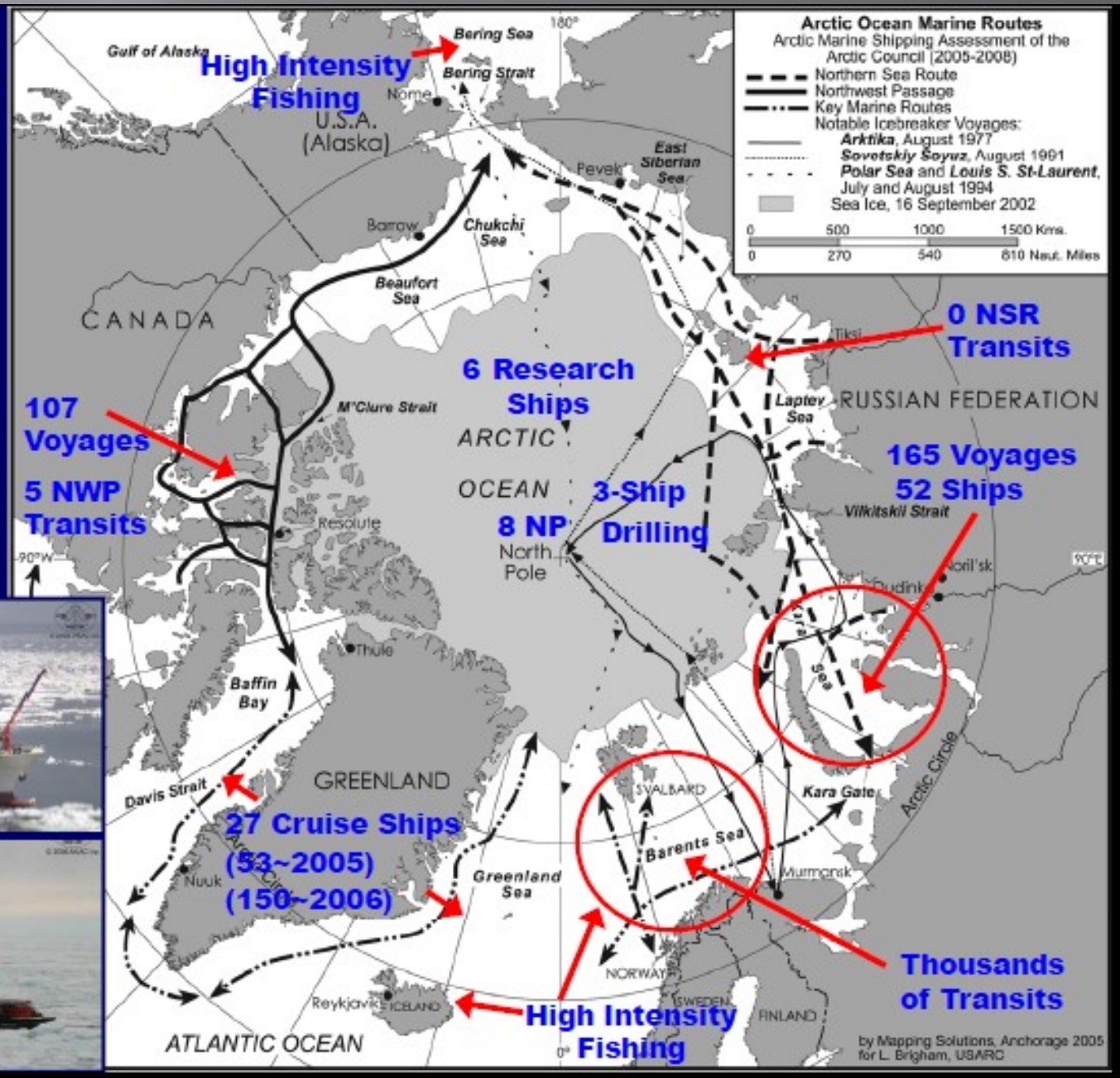
- Shipping has always been fairly intense in the Arctic Sea but with the reduction, induced by global warming, of the sea ice area, it should increase drastically with the extended use of the Northern Sea Route and the Northwest passage. This will lead to a requirement for enhanced support to shipping through improved communications and aid to the navigation. Beyond positioning, satellite earth observation allows to identify pathways through ice fields

The Maritime Arctic of Today

Snapshot of Summer 2004 Traffic

Modes of Arctic Marine Transport

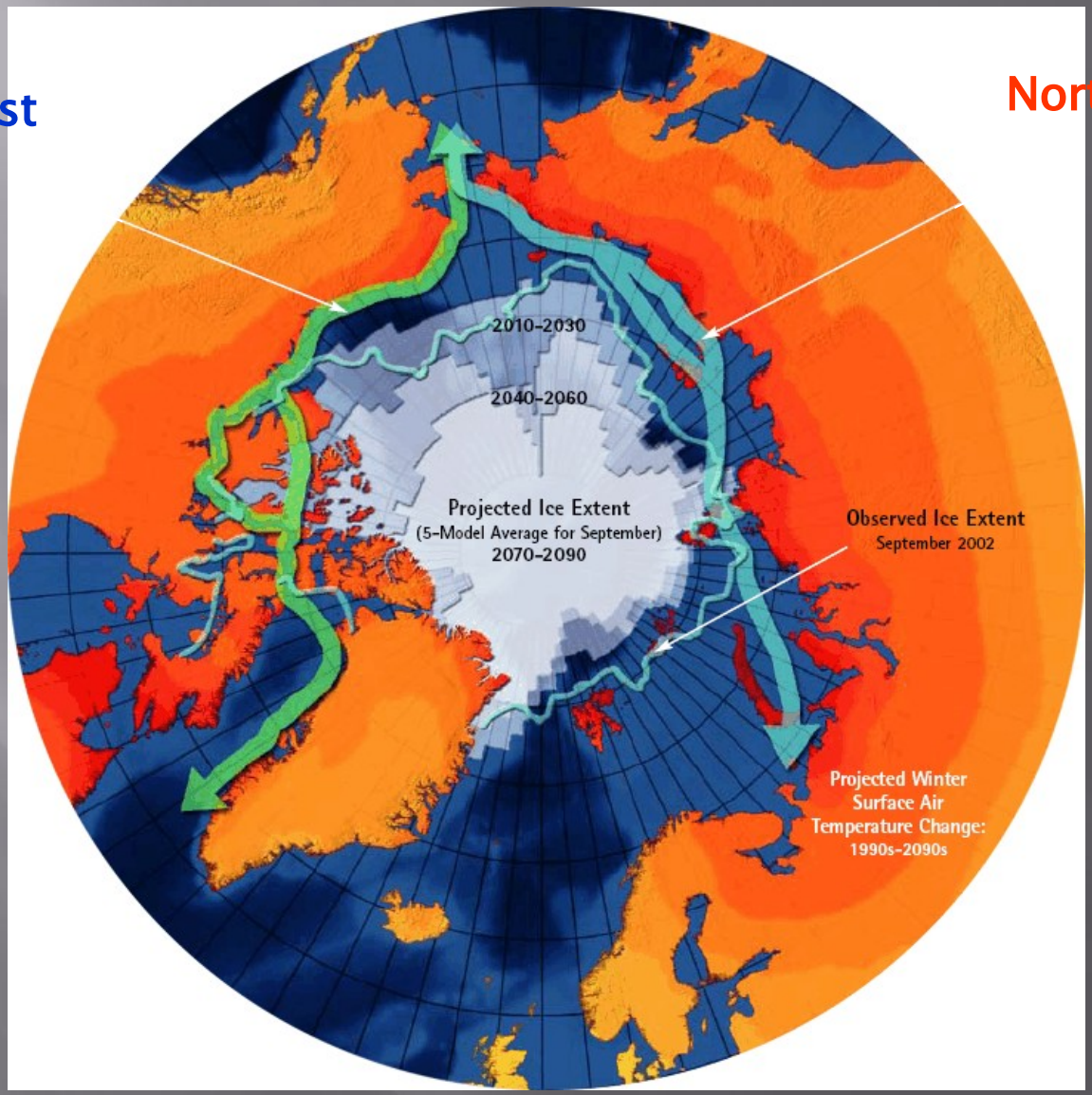
- **Destinational / Regional**
- **Trans-Arctic**
- **Trans-Arctic with Transshipment**
- **Intra-Arctic**

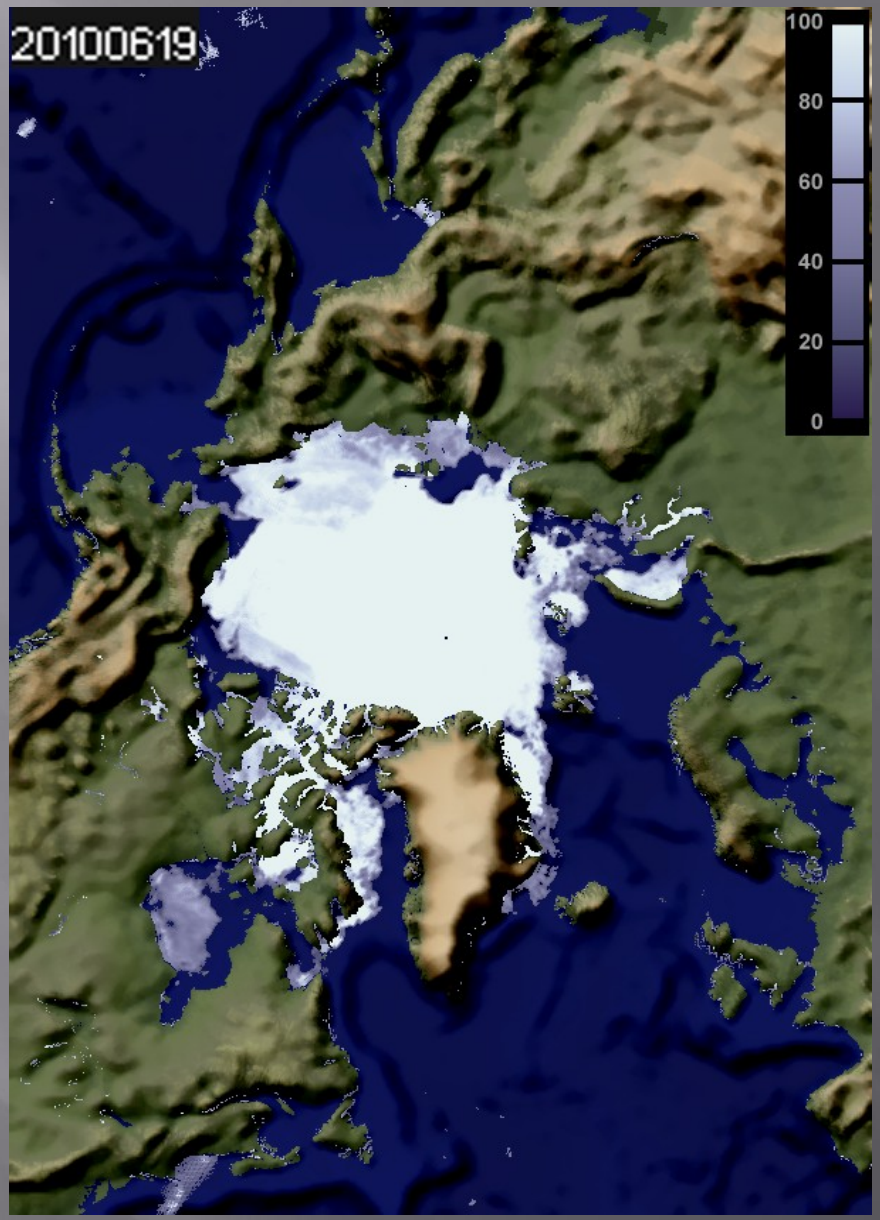


Assessment of expected change of ice cover extent in the Arctic (AMSA project)

Northwest Passage

Northern Sea Route

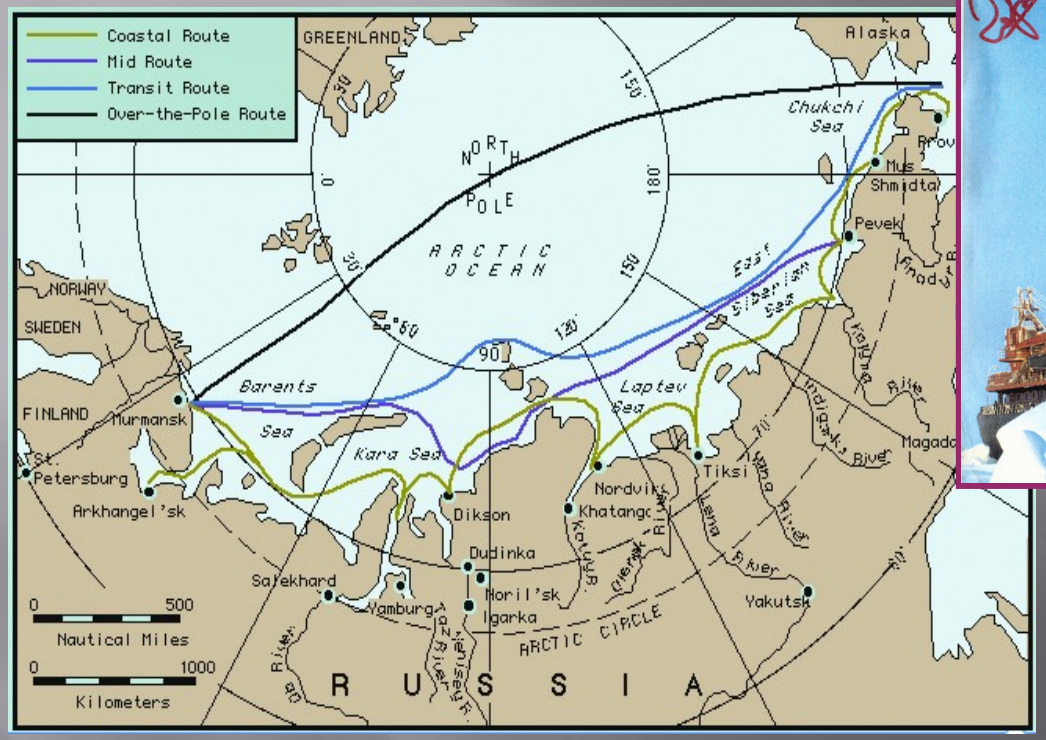




Sea ice area map of AMSR data,
Copyright: NERSC
June 19, 2010


ARCTIC EXPRESS
НОРИЛЬСКИЙ НИКЕЛЬ

Sea ice monitoring along the Northern Sea Route using satellite SAR



Radars/SAR

ERS-1 and ERS-2

RADARSAT

ENVISAT

Field Campaignes

L''Astrolabe (1991)

N/I " Sovetsky Soyuz" (late 1993)

N/I "Vaygach" (February-March 1994)

N/I "Taymyr" (September-October 1994)

C/S " Kandalaksha" (August 1995)

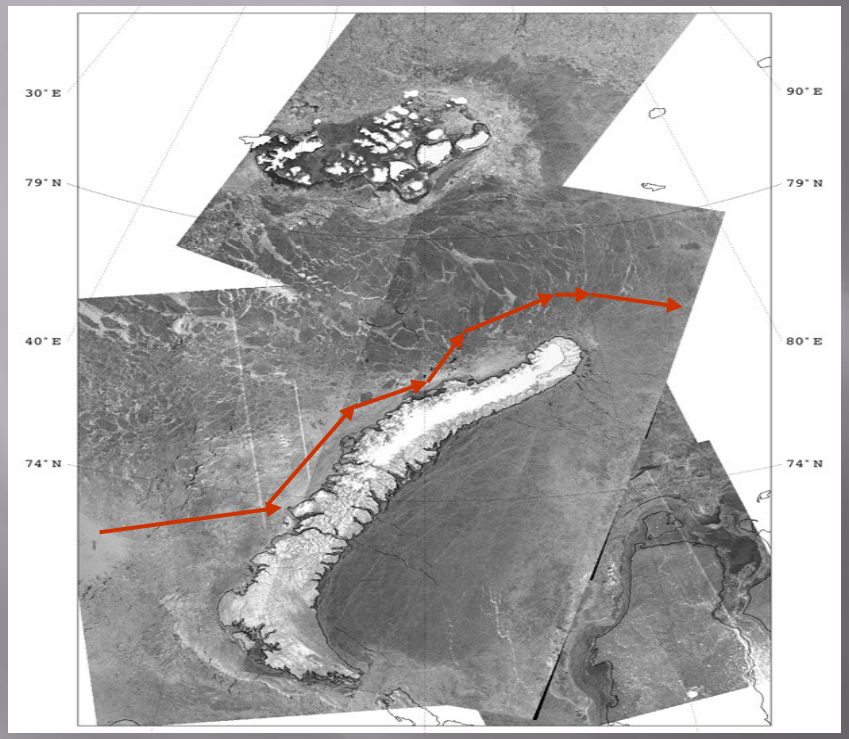
ICEWATCH Project (January-February 1996)

Ice Routes Project (September 1997 and April 1998)

ARCDEV Project (April 1998)

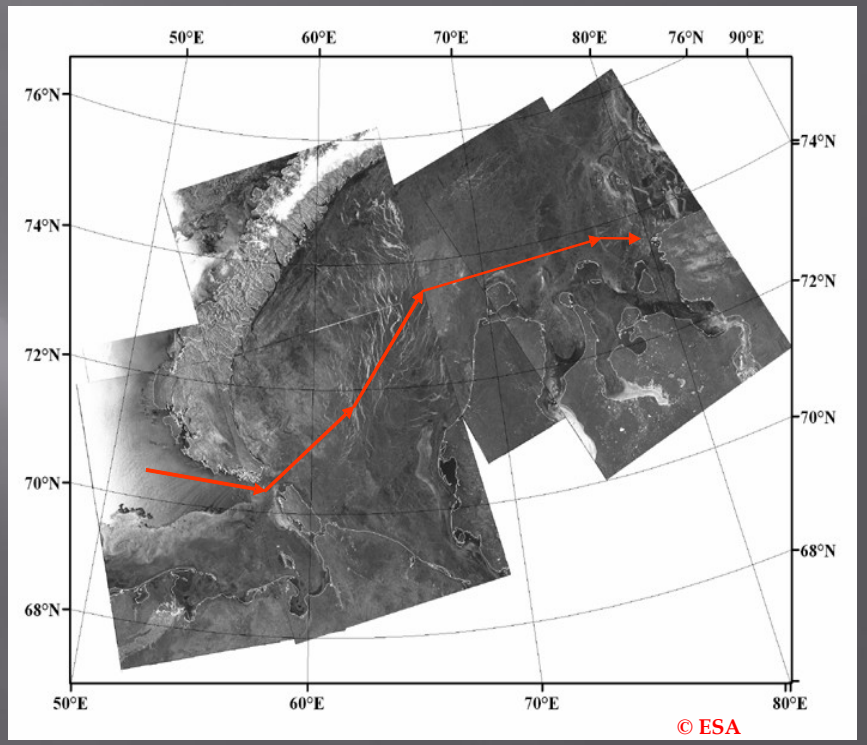
ICEMON Project (June 2003)

Supporting ice navigation



© Canadian Space Agency

Mosaic of RADARSAT ScanSAR images for 23-25 April 1998 with overlaid route of I/B *Sovetsky Soyuz*



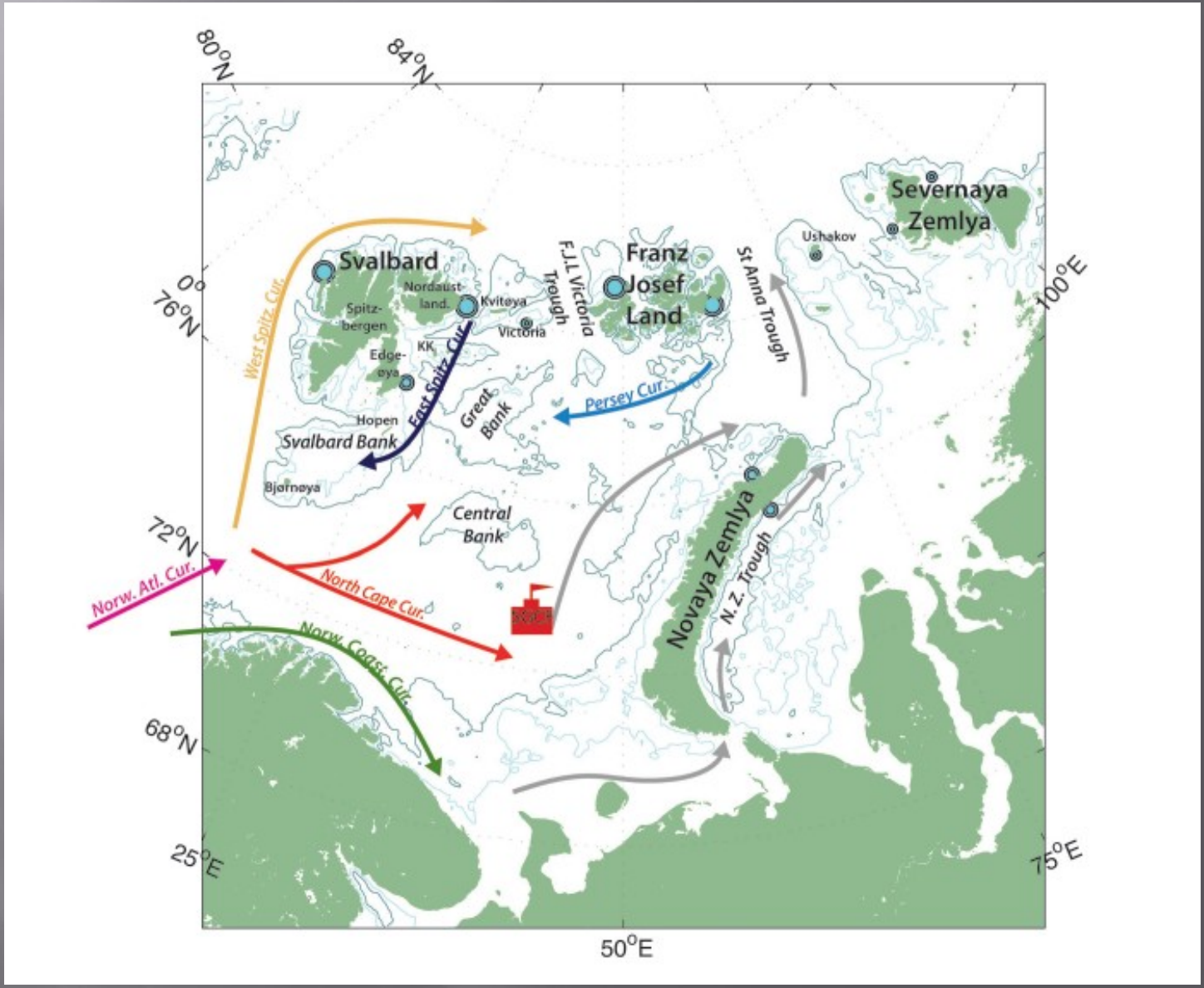
© ESA

Mosaic of ENVISAT ASAR images for 27-28 February 2005. Planning fleet operations between the Barents Sea and Dikson

ICEBERGS' MOVEMENTS

- Icebergs have always constituted a threat in Northern waters (Titanic!) but with global warming leading to the accelerated melting and breakdown of glaciers, their number and geographical spread will increase, enhancing the danger for ships and oil/gas platforms
- A substantial modification of the Arctic Ocean circulation pattern is predicted by climate models in case of CO^2 doubling. Could it affect substantially the icebergs' movement (and the location of fishing grounds)? It is too early to say

Ph.D Thesis of Intissar Keghouche, Un. Bergen



Iceberg detection and mapping in Barents Sea using ENVISAT ASAR images

ENVISAT ASAR WS
15.09.2006

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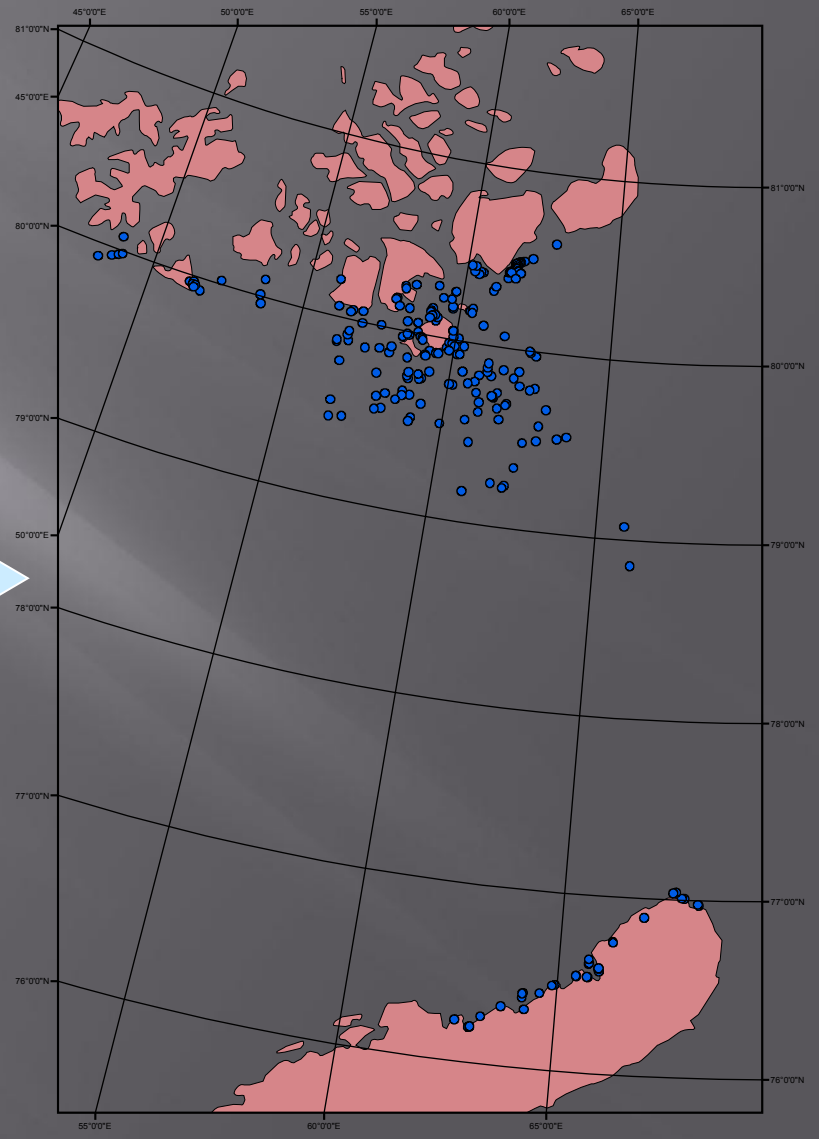
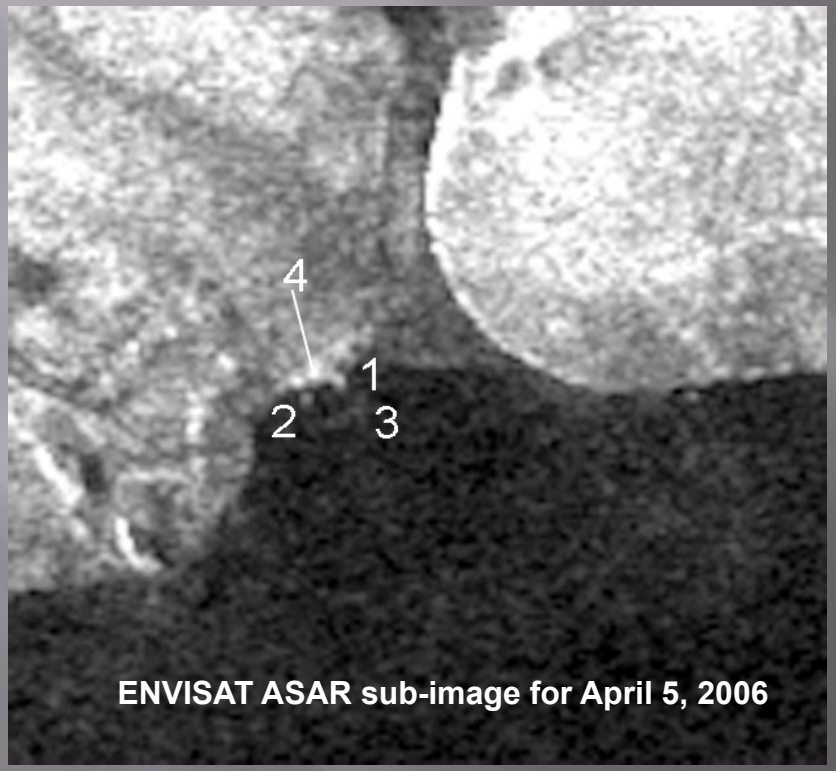
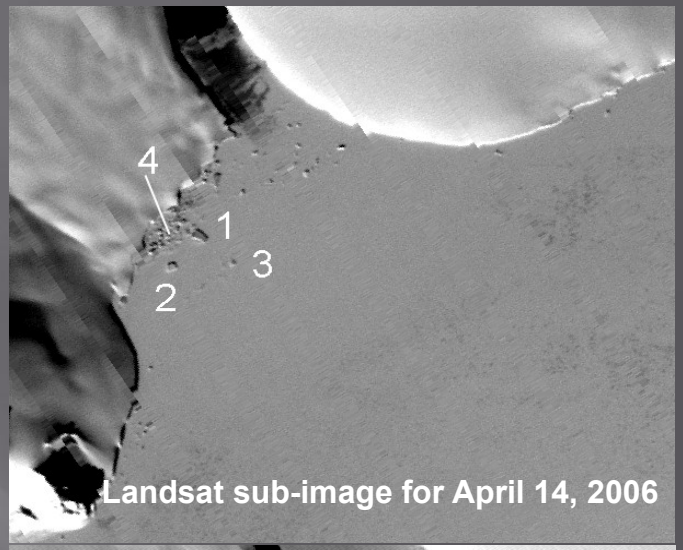
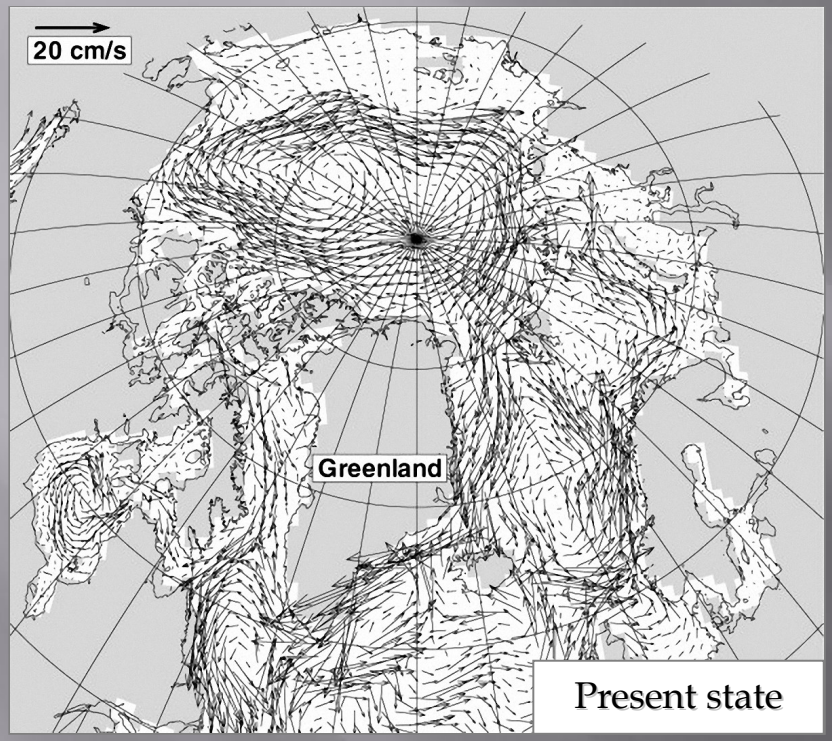


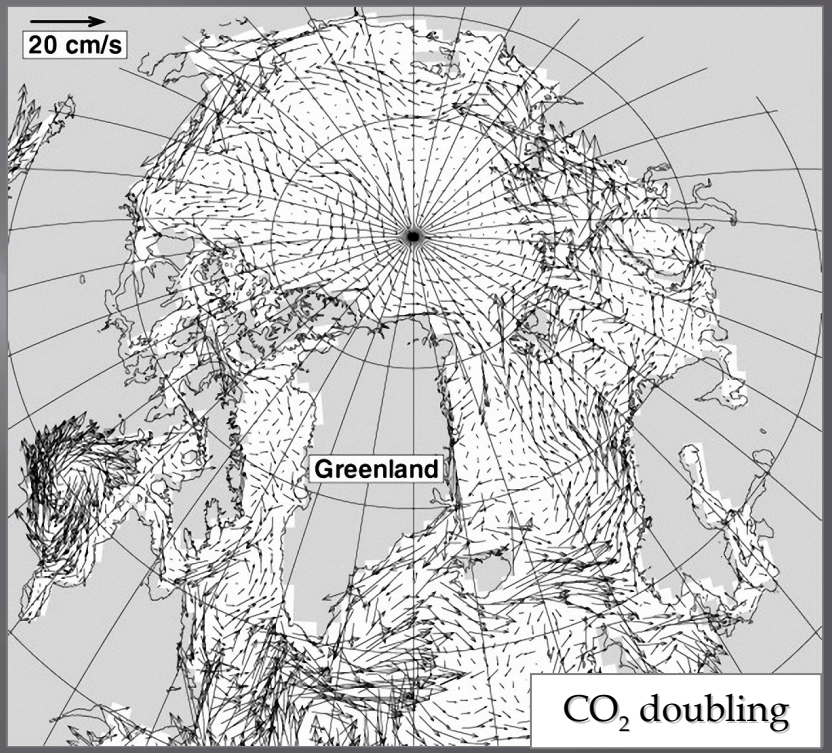
Iceberg detection in SAR and visible images





THE ARCTIC OCEAN CIRCULATION: SUBSTANTIAL WEAKENING PROJECTED





Simulated Arctic Ocean surface circulation under present climate conditions and the CO2 doubling global warming scenario

Johannessen et al. Radioactivity and pollution in the Nordic Seas and Arctic Region. Observations, modelling, and simulations. Springer–Praxis, 2010

POLAR LOWS

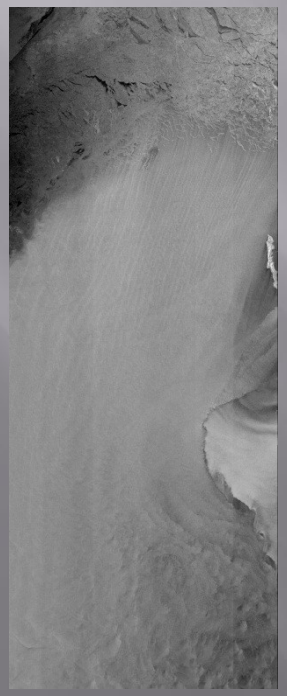
Winter polar lows are continuously formed over the Arctic seas. They are associated with heavy precipitation and severe winds causing serious disturbance in the fishery and transport operations at sea. Polar lows are characterized by a wind speed exceeding gale force (up to 17m/s); their size is usually less than 1000 km but some may span as little as 100 km.

Polar Lows are often not seen on the weather charts issued by local weather bureaus due to their small scales, short life time (typically between 12 and 36 hours) and development in remote and data sparse regions. That is why the satellite data constitute an invaluable and irreplaceable source of information for the polar low detection, tracking and study

Polar low detection and tracking using satellite passive microwave observations

Polar low, detected in Norwegian Sea by screening Envisat ASAR archive images, arose 30 and destructed 31 January 2008

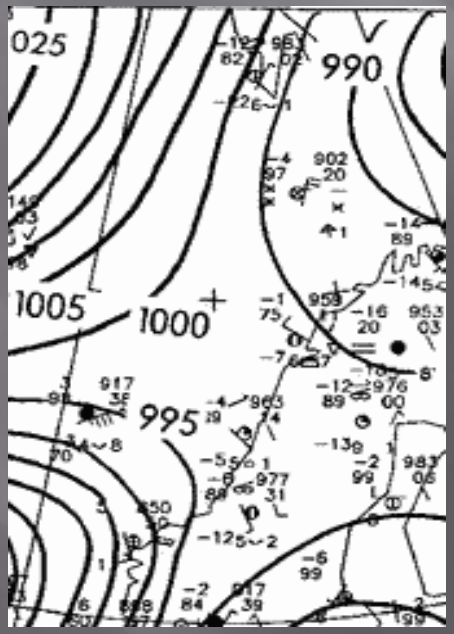
Envisat ASAR
30 January 2008
20:26



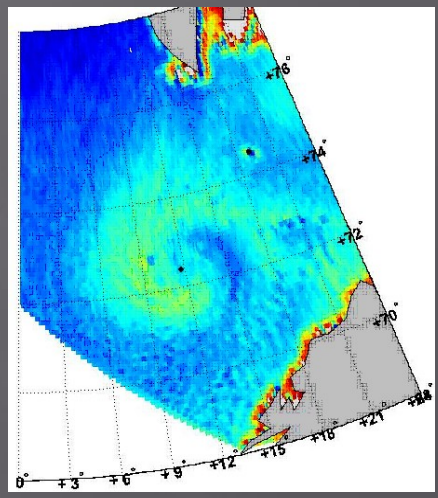
Envisat ASAR
31 January 2008
19:44

This Polar Low is not found on weather chart issued by local weather bureaus. This is typical for Polar Low cases due to their small scales and short life time (typically between 12 and 36 hrs)

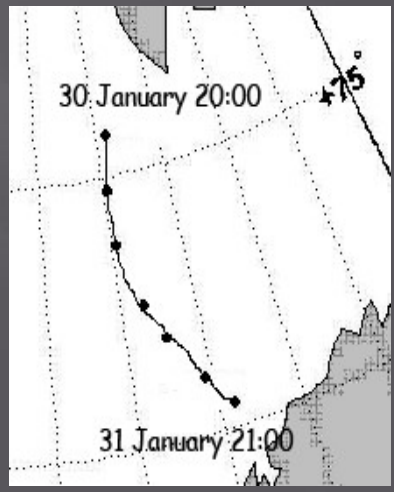
Danish surface analysis map
31 January 2008 06:00



AMSR-E Polar Low detection

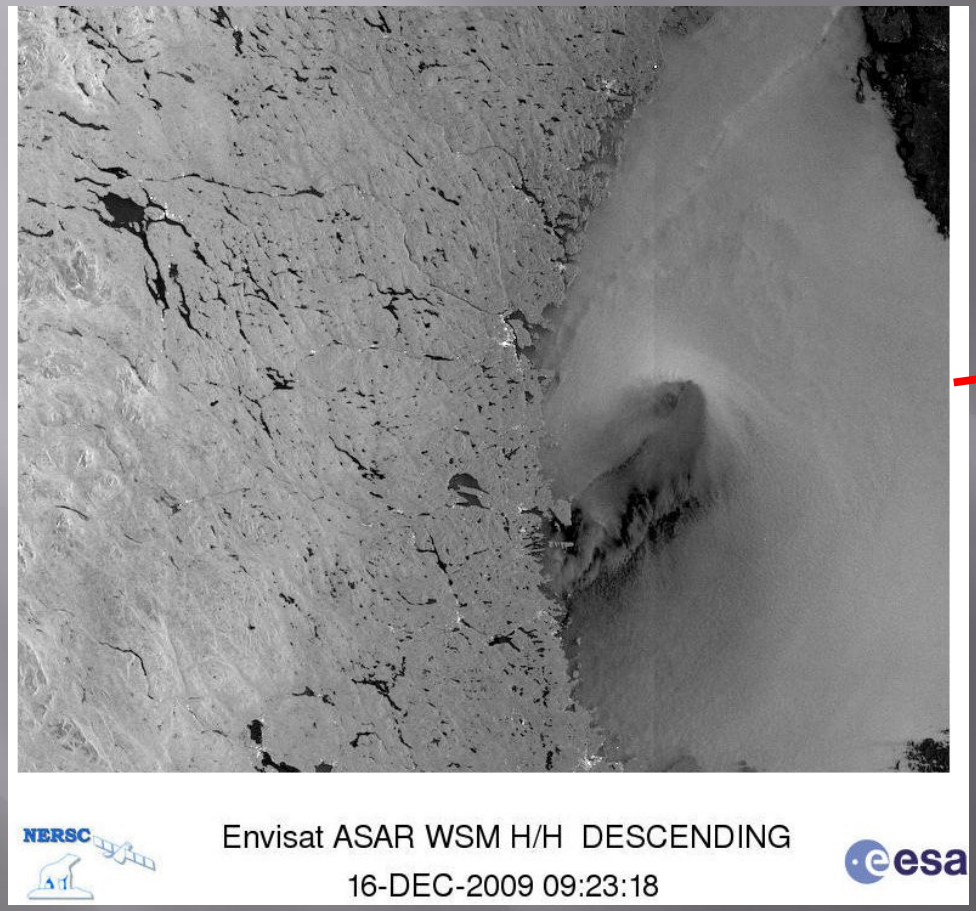


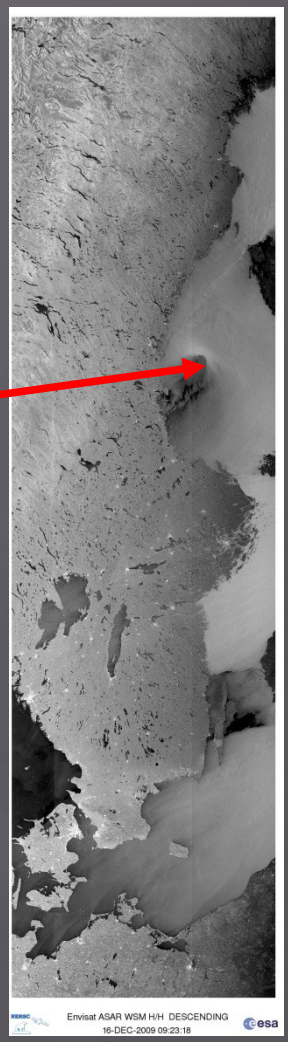
Total water vapor content field retrieved from AMSR-E 31 January 2008 09:35



Polar low trajectory derived from AMSR-E data

Envisat ASAR image of a Polar Low in the Baltic Sea

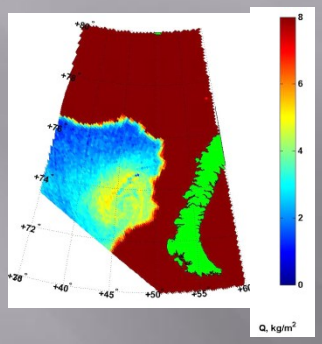




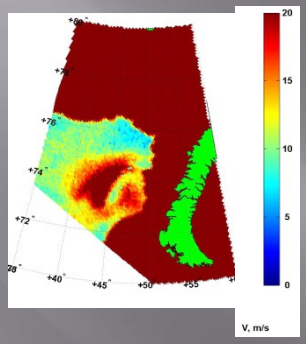
Polar low in Barents Sea, 5 March 2010

Multi-sensor approach for polar low study and monitoring

Aqua AMSR-E

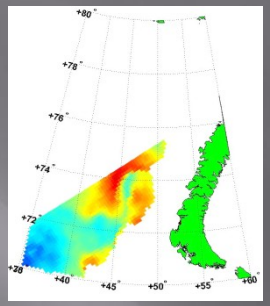


Total water vapor content



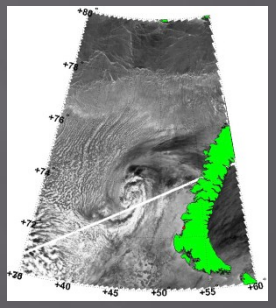
Wind speed

Metop ASCAT

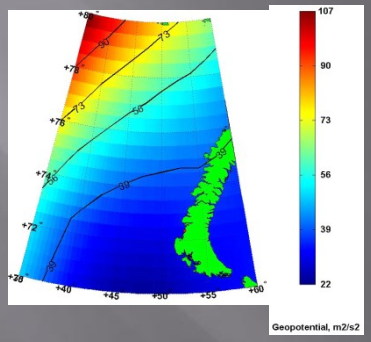


Wind speed

Terra MODIS

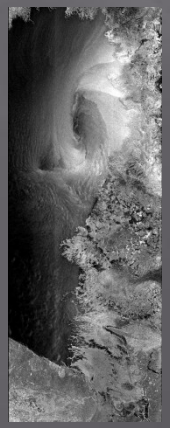


NCEP/NCAR

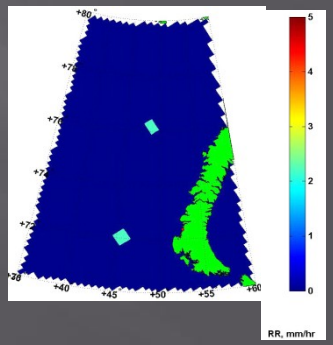


Geopotential

Envisat ASAR



NOAA -16 AMSU-B

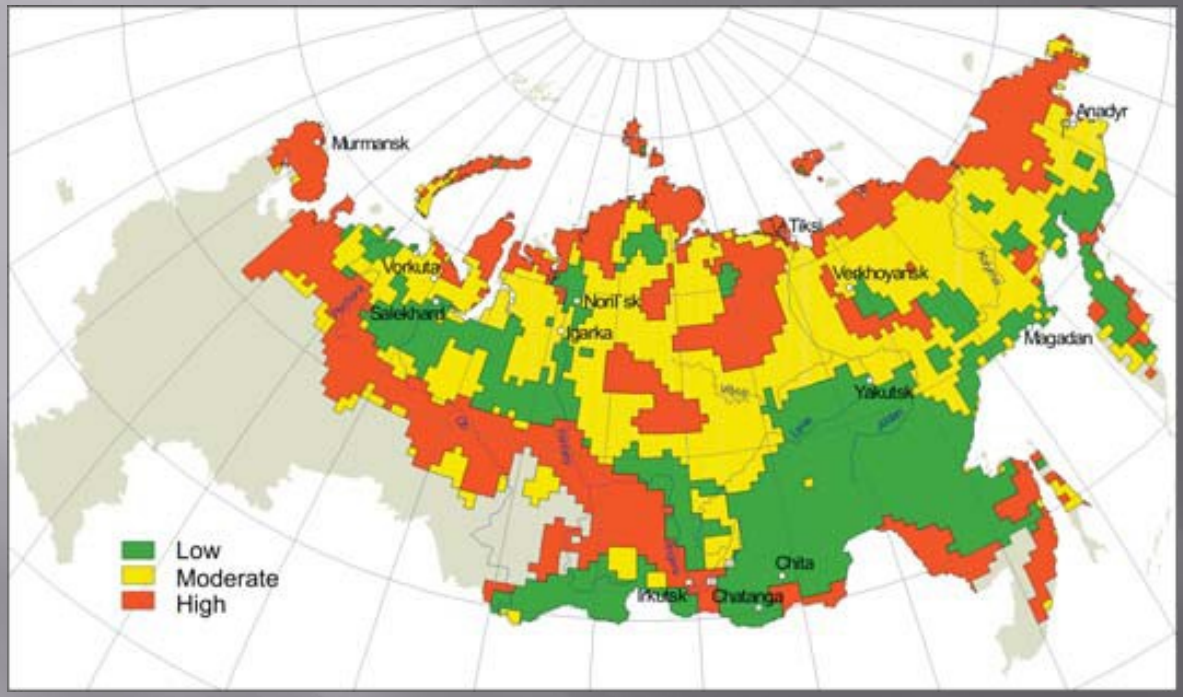


Rain rate

Synergistic use of data – polar low is detected at MODIS, AMSR-E, Metop ASCAT and Envisat ASAR

PERMAFROST

Impact of permafrost thawing on infrastructure



Predictive permafrost hazard map for Russia. The map was constructed using the GFDL climatic scenario for 2050. Permafrost area is split into zones with low, moderate, and high potential hazard to the structures built on permafrost (Anisimov, et. al., 2006)

About 21% of the reported accidents are caused by mechanical damage to the pipelines as a result of increased strength, deformation, and weakening of the foundations anchored in permafrost, and are thus very likely to be related to climatic change, warming, and thawing of the frozen ground (Nikolaev, 1999)

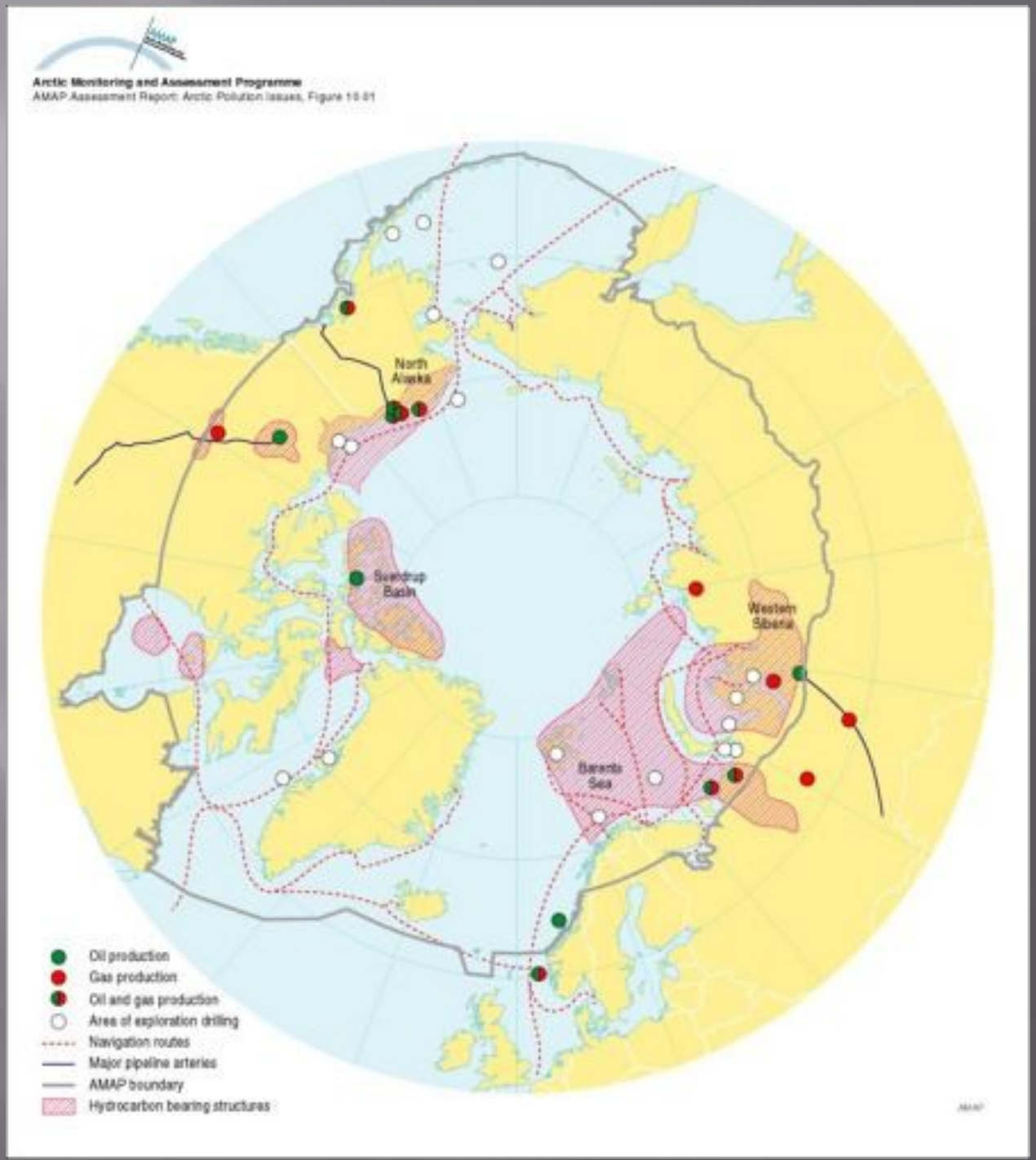
Problems for infrastructures

Cherski, Russia, 2002

Yakutsk, Russia, 2006

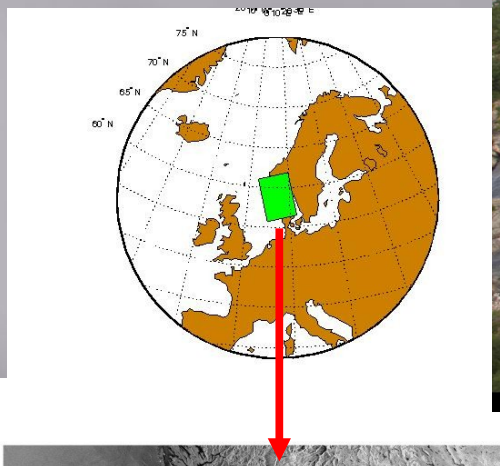
CHEMICAL POLLUTION/OIL SPILLS

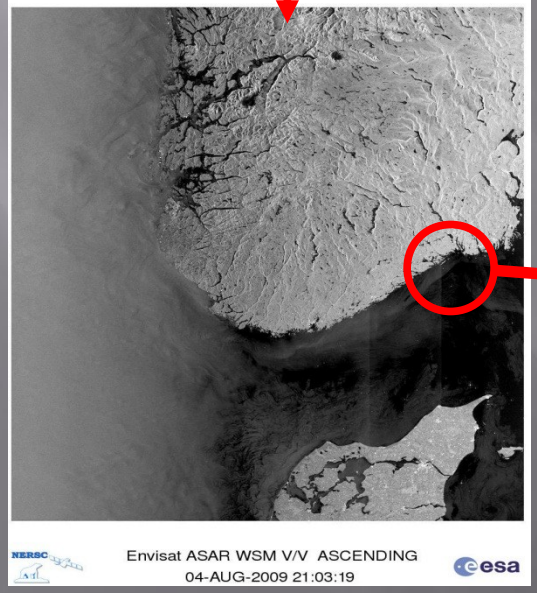
- Oil spills from enhanced oil and gas exploitation constitute a serious concern, increased shipping movements create a greater risk of chemical pollution and industrial activities in the terrestrial part of the region may lead to an increased pollution of the Arctic Sea
- Satellites could be of particular assistance in these remote areas for detection and mitigation
- Oil spills' remediation is more complex in presence of ice than when performed in open sea


Arctic Monitoring and Assessment Programme
AMAP Assessment Report: Arctic Pollution Issues, Figure 19.01
North Alaska
Sverdrup Basin
Western Siberia
Barents Sea
Oil production
Gas production
Oil and gas production
Area of exploration drilling
Navigation routes
Major pipeline arteries
AMAP boundary
Hydrocarbon bearing structures

Oil spill recovery - MV “Full City” (Skagerrak)

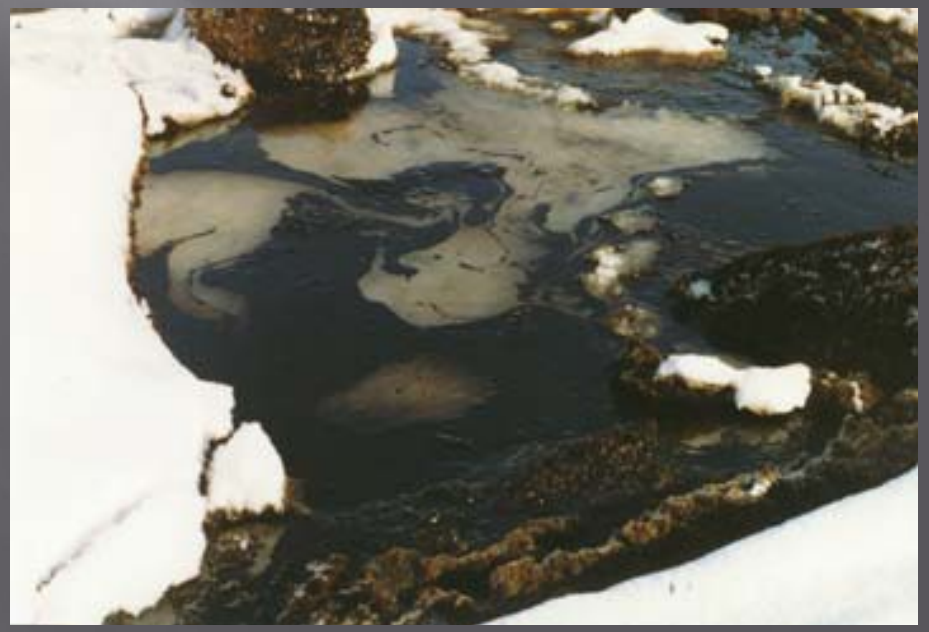
4 Aug 2009
21:03





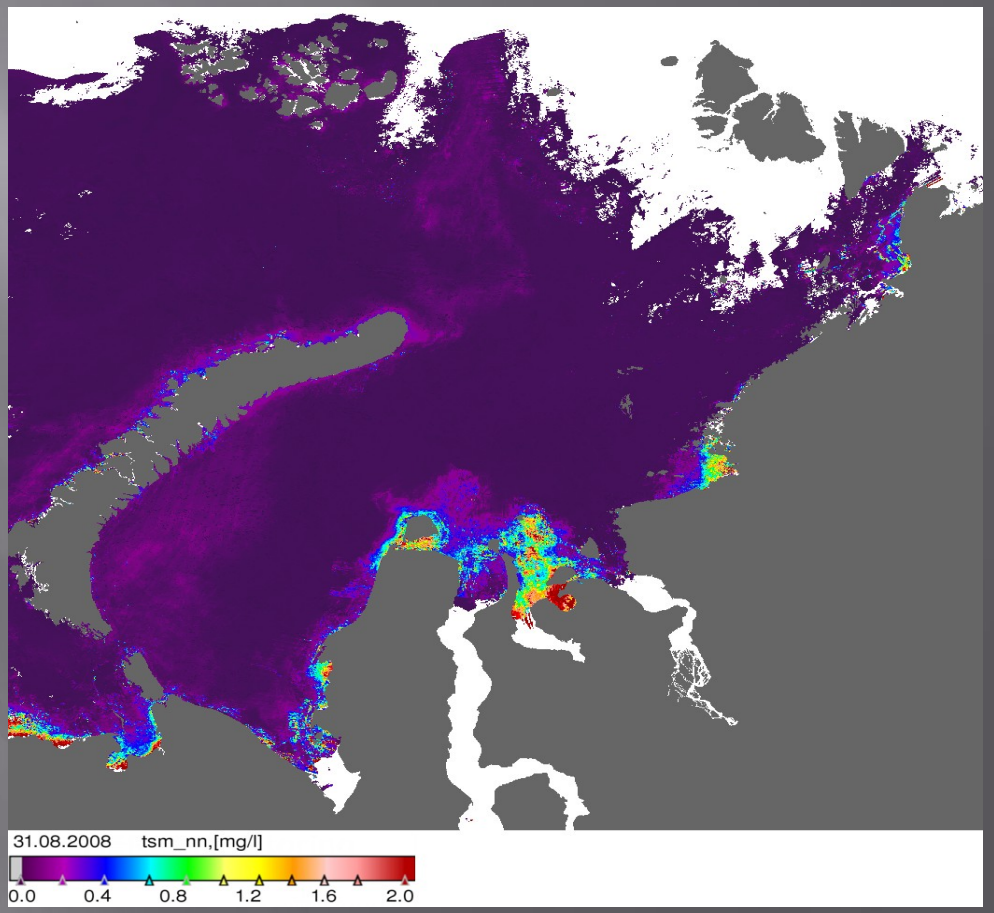
LARGE FIELD TRIAL (20 M^3) OF OIL IN ICE IN THE BARENTS SEA MARGINAL ICE ZONE

Courtesy: Whitney Blanchard



Study of transport of terrogeneous matter to the Kara Sea using satellite data

Reveal of dynamics of this process by multi-year time series of satellite data

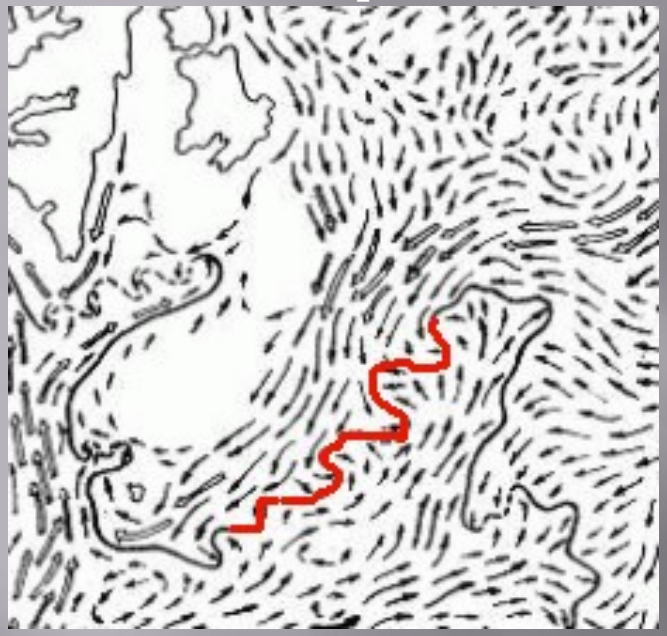


Monthly mean distribution of total suspended matter in the Kara Sea in August 2008 from MODIS-Aqua

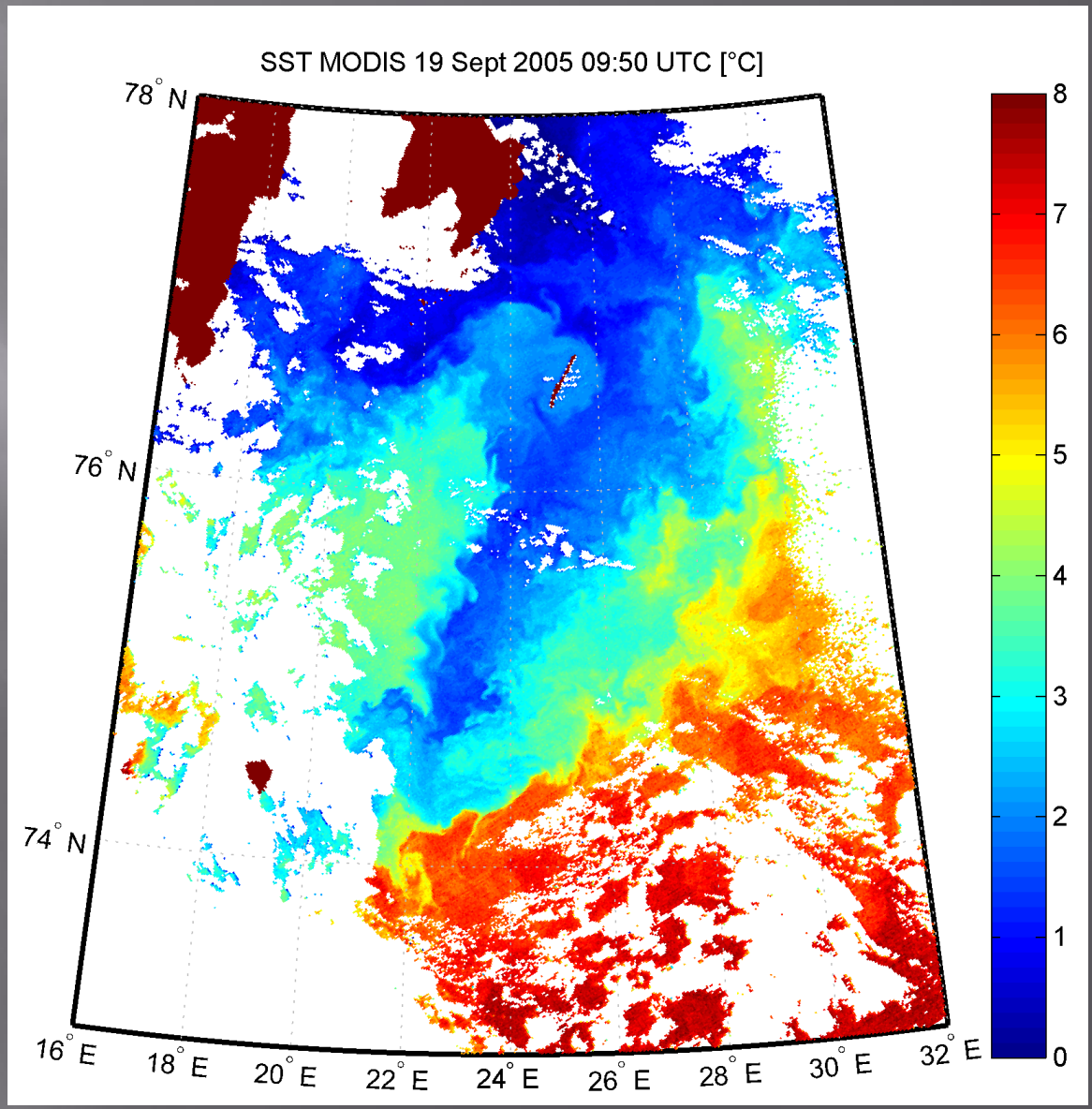
OCEAN PRODUCTIVITY

- Global warming has already led to an increase of the water temperature in Northern seas, forcing some cold water fish species to migrate to higher latitudes, creating new fertile fishing grounds north of the Arctic Circle
- Satellites can assist in identifying fertile fishing grounds but also areas where bloom harmful microalgae *lepidodinium chlorophorum* and coccolithophores *Emiliania huxley,* as well as in surveillance and assistance to fishing vessels
-

The Barents Sea general circulation map

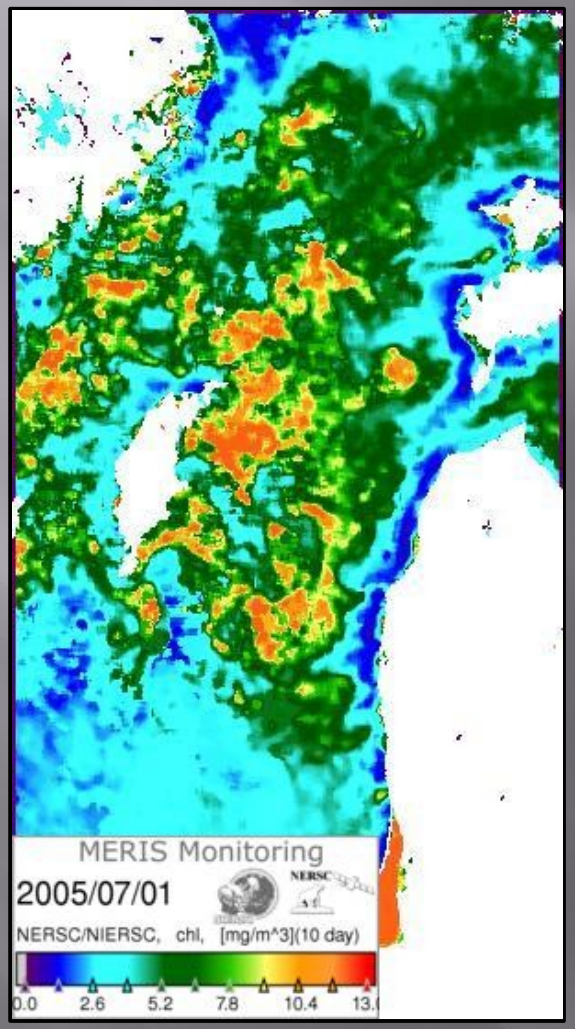


Borders of Cod-fish distribution

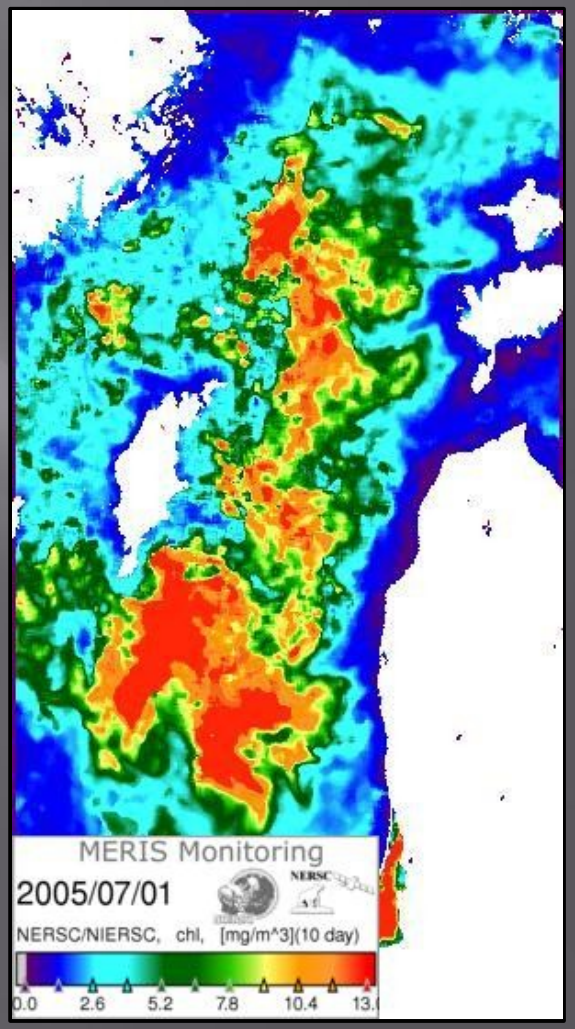


Chlorophyll concentration retrieval from MERIS data using different hydro-optical models

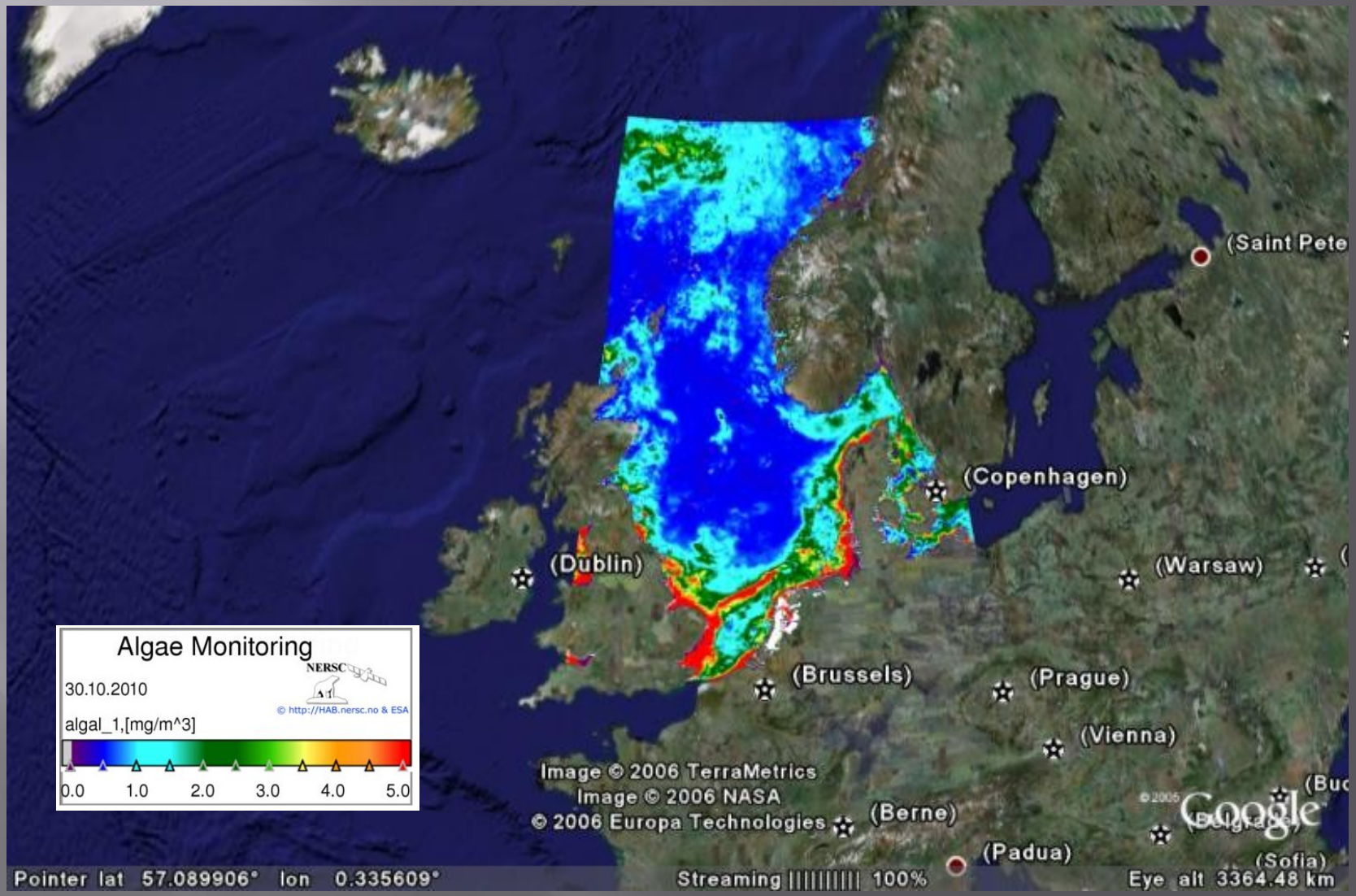
Mesotrophic water body model



Specialized model

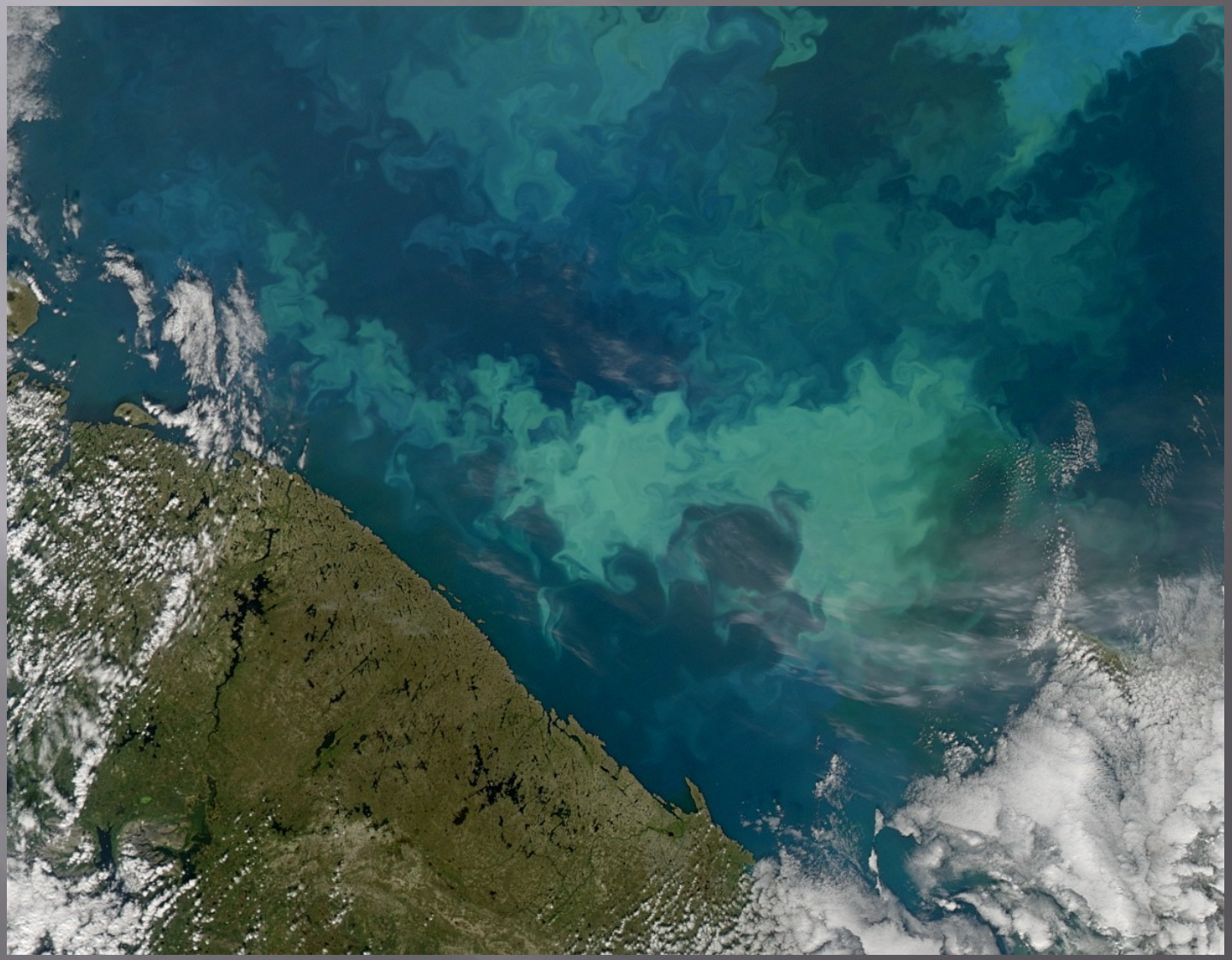


Quasi Real-Time Algal Bloom Monitoring of the North Sea and Skagerrak Region



South-western Barents Sea

RGB MODIS 31 Aug 2010 09:10 UTC – Intensive coccolitophore bloom



In Conclusion

All the cases described in this presentation have been aimed at demonstrating the usefulness of space systems for dealing with Arctic issues.

Earth Observation systems are clearly the most advanced and the most numerous for dealing with these cases but efforts are currently undertaken for reinforcing the capabilities of telecommunications and navigation/positioning/AIS systems. The integrated use of the three space applications should promote the sustainable development of the Arctic Region.

Acknowledgments

The scientific contents of this presentation result from the work of researchers and doctoral students of the Nansen International Environmental and Remote Sensing Center (NIERSC) in Saint Petersburg and of colleagues of the Nansen Environmental and Remote Sensing Center (NERSC) in Bergen. Their assistance is gratefully acknowledged

Thank for your attention!