Bathymetric data acquisition in Arctic waters within the Danish Continental Shelf Project

Morten Sølvsten, Uni Bull, Richard Pedersen & Christian Marcussen

Arctic-Antarctic Seafloor Mapping Meeting 2011

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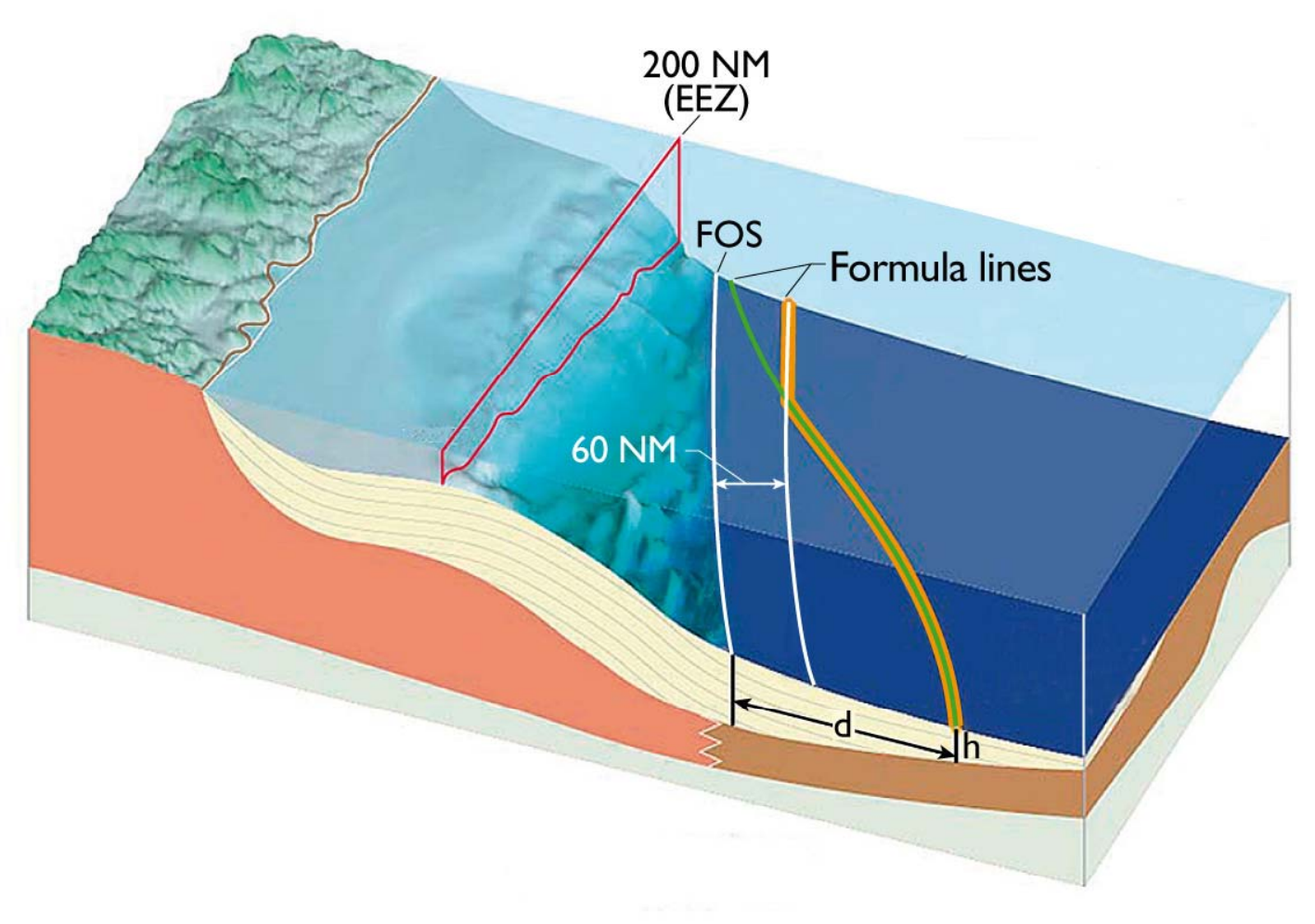


Foot of Slope (FOS): maximum change of gradient at the base of the continental slope

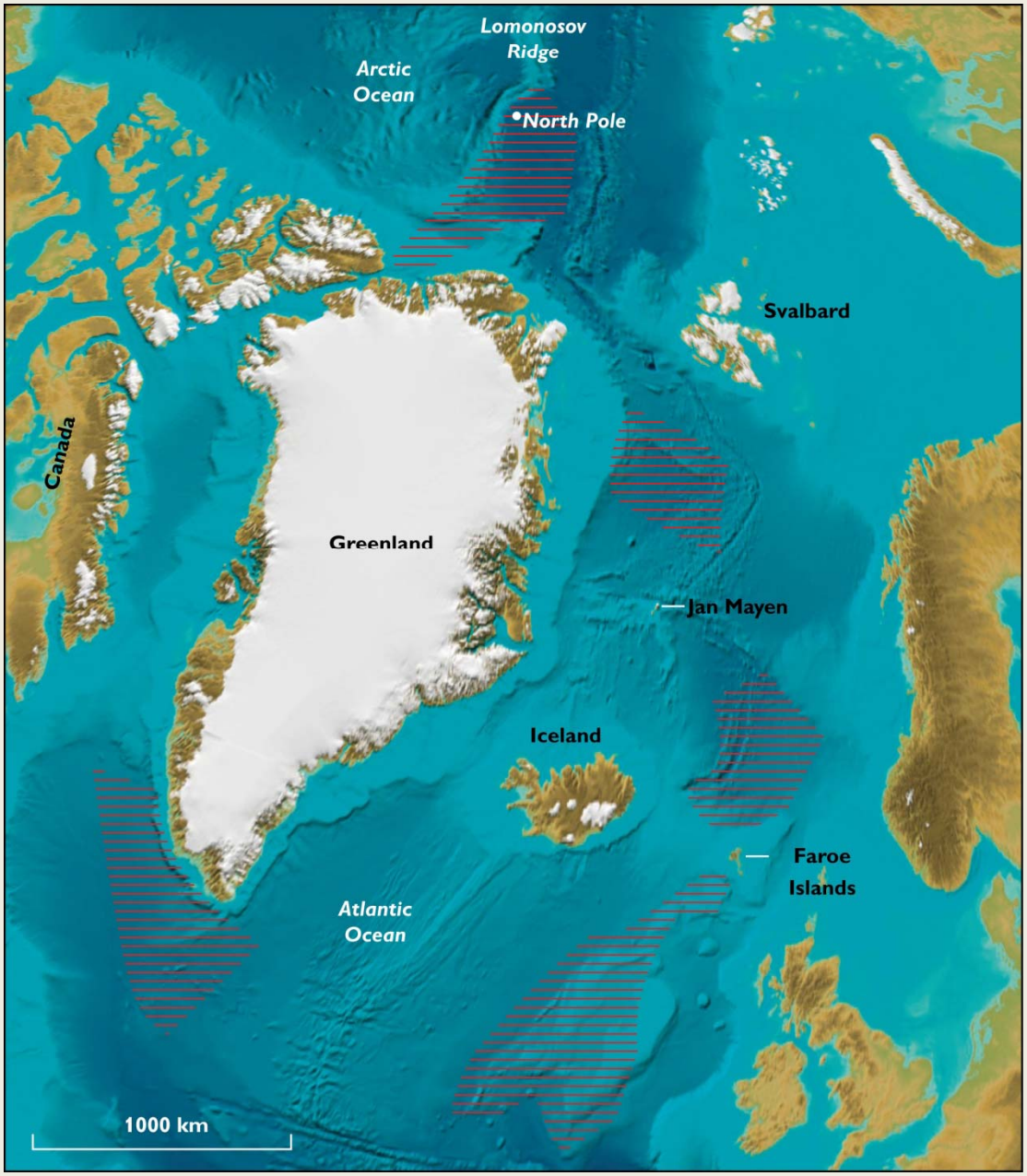
1 nautical mile = 1.15075 mile = 1852 meters

Formula lines

Either FOS + 60 nautical miles or 1% sediment formula

Constraint lines

Either 350 nautical miles or 2500 meter isobath + 100 nautical miles



Kingdom of Denmark - Areas of interest

2 areas around the Faroe Islands

3 areas around Greenland

Partial submission for the area N of the Faroe Islands submitted in April 2009 and for the area S of the Faroe Islands in December 2010

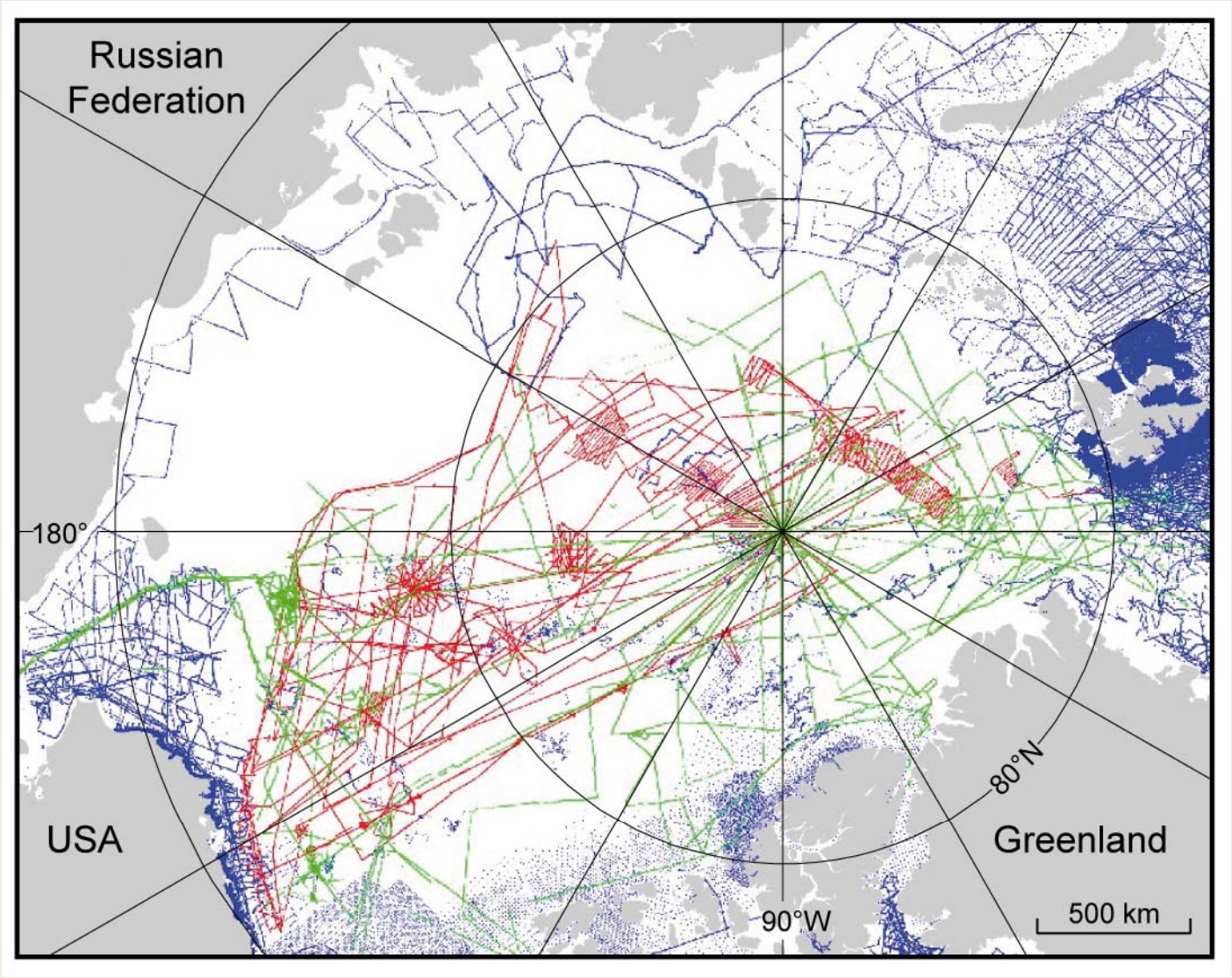
Ongoing work in the areas around Greenland with a deadline at the end of 2014.

The challenge

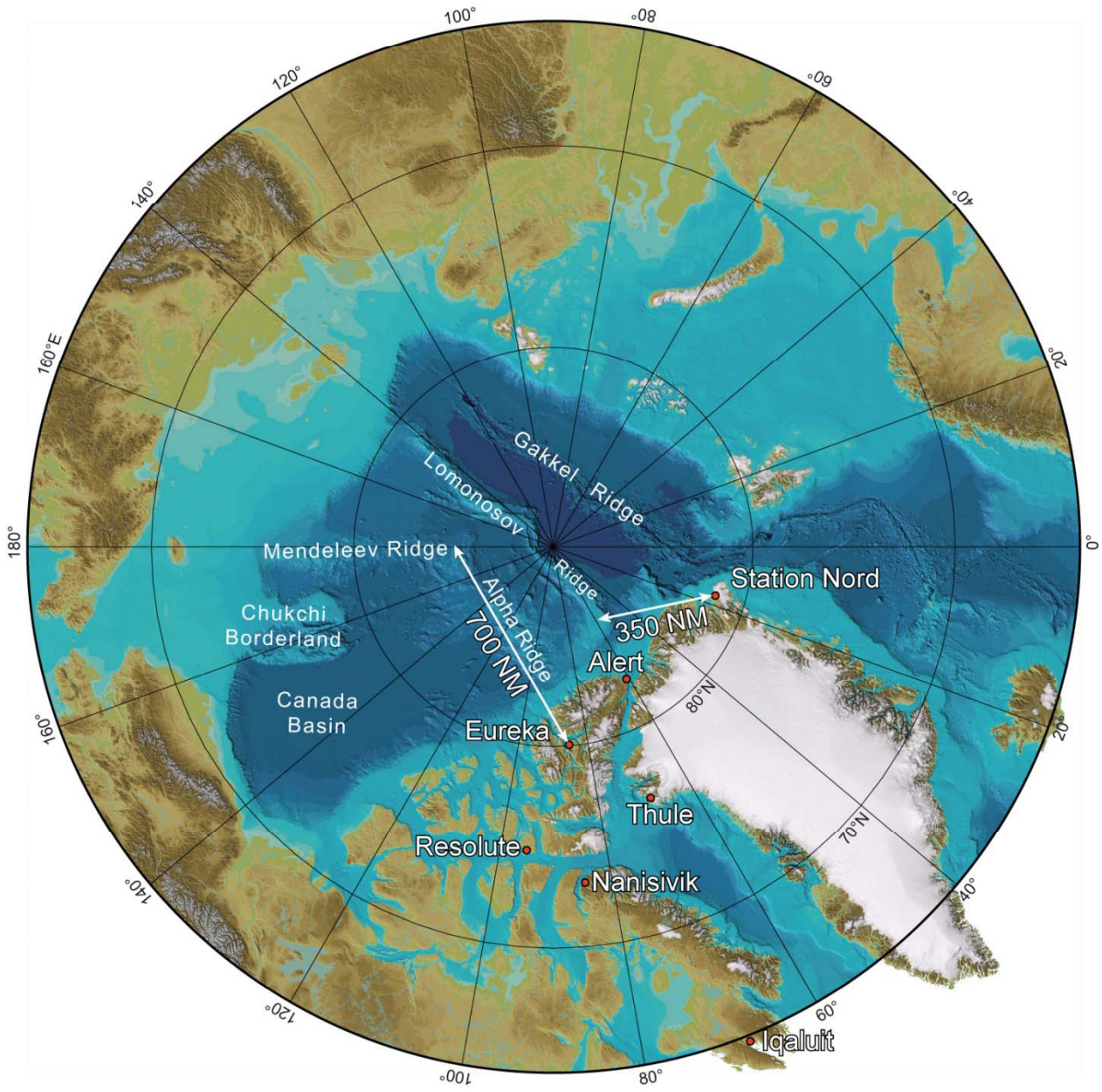
When the project started in 2002 we where facing the following issues:

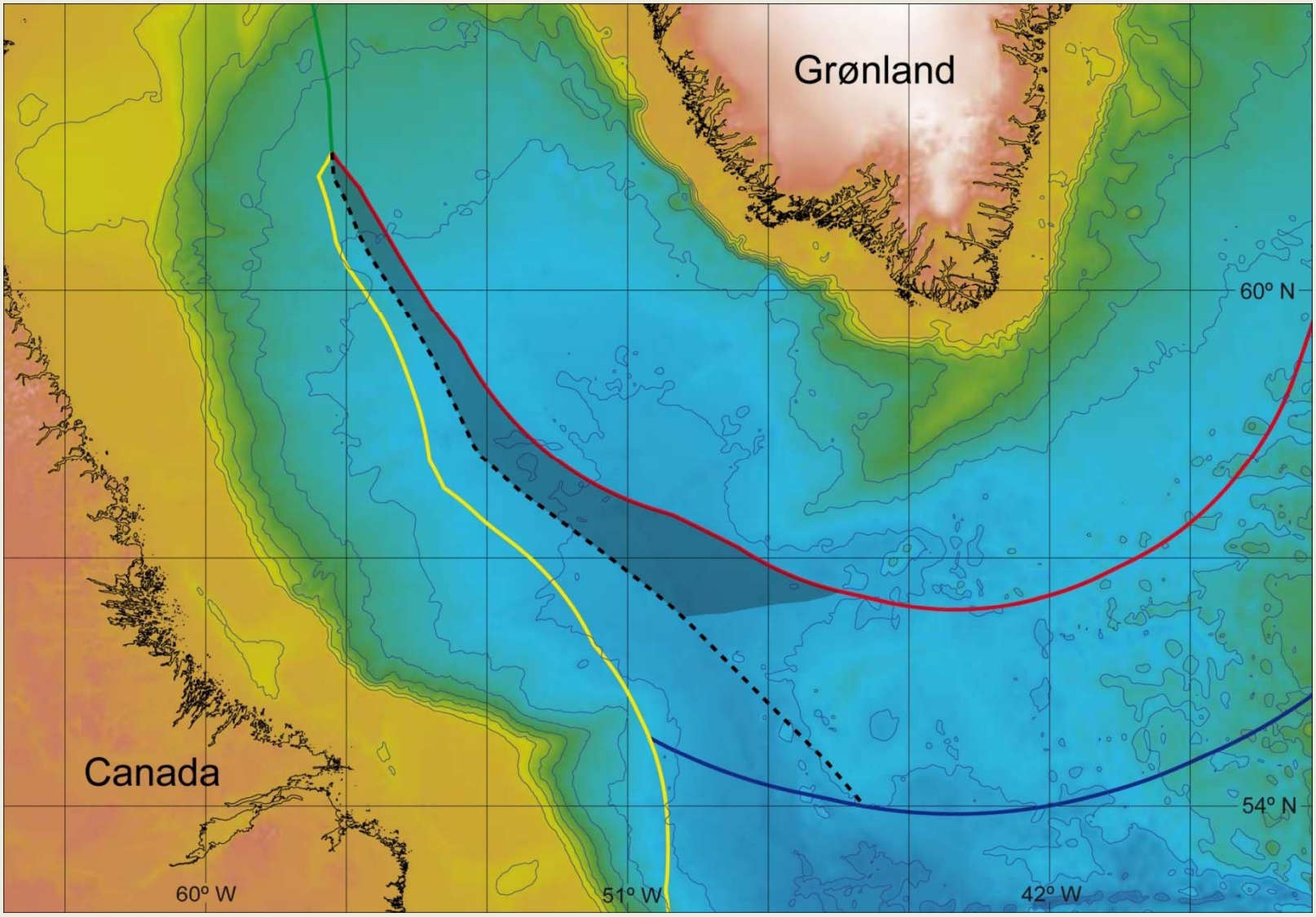
- 2 of 3 areas around Greenland where covered by sea ice
- Existing bathymetric data coverage was sparse especially in the Arctic Ocean.
- No Danish logistical knowledge and facilities
- Areas of interest very remote
- 2001 submission of the Russian and the recommendation by CLCS in 2002

Conclusion: Cooperation with other countries etc. necessary!



Existing bathymetric data coverage in the Arctic Ocean (Jakobsson et al. 2000).


Lomonosov Ridge
Gakkel Ridge
Mendeleev Ridge
Alpha Ridge
Chukchi Borderland
Canada Basin
700 NM
350 NM
Station Nord
Alert
Eureka
Thule
Resolute
Nanisivik
Iqaluit
80°N
70°N

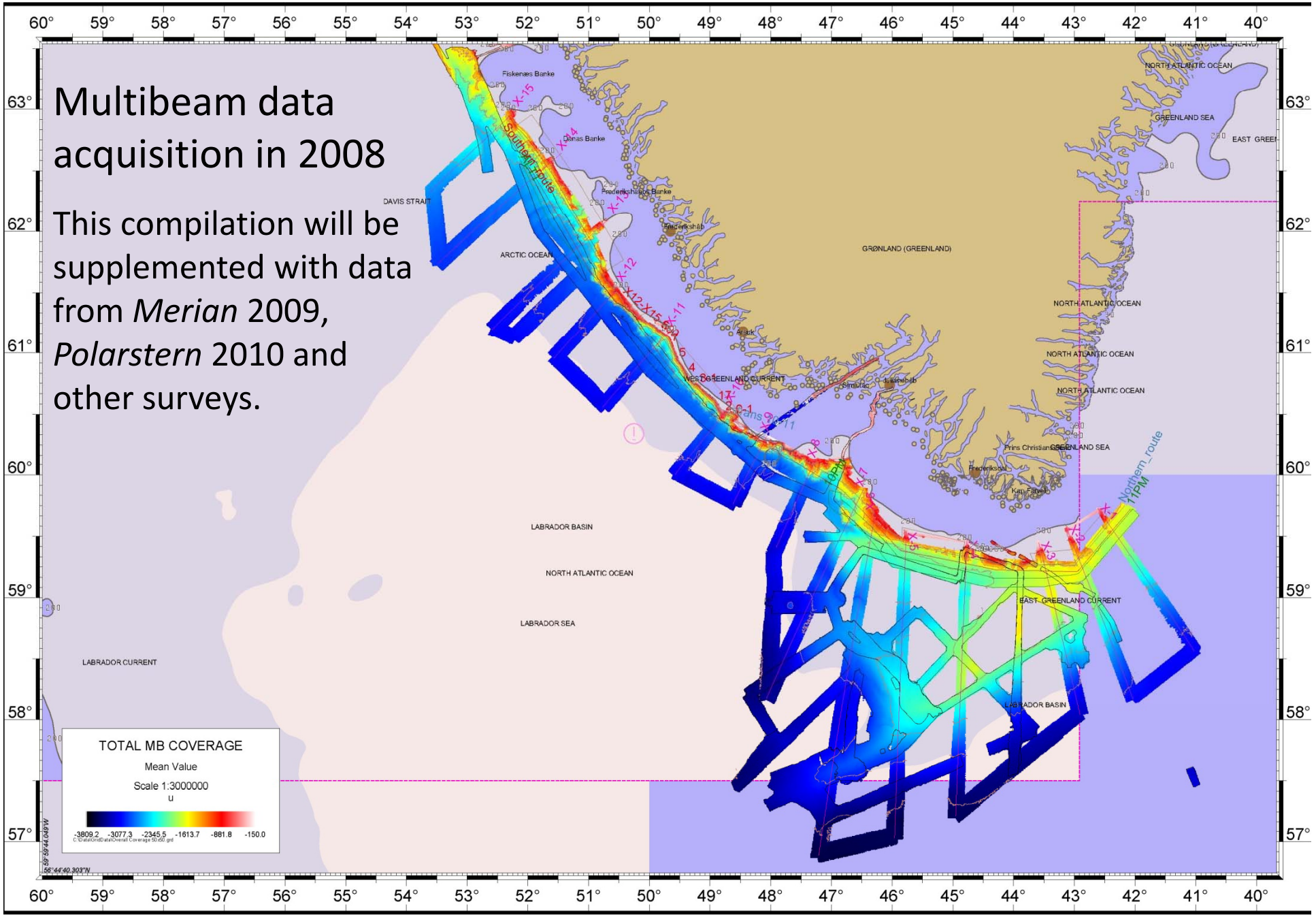


eCS = extended continental shelf

Possible eCS area south of Greenland

Multibeam data acquisition in 2008

This compilation will be supplemented with data from *Merian* 2009, *Polarstern* 2010 and other surveys.



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Methods of bathymetric data collection in the Arctic Ocean

Multibeam data collection — Ice breaker (– Submarine – AUV)

Single beam data collection

- Survey lines — Ice breaker (– Submarine – AUV)
- Spot soundings — Helicopter

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Spot soundings - Helicopter

Platform : Helicopter in spring time

What is needed? - Simple setup

- Position - GPS receiver
- Depth – 12/15/24 kHz transducer with echosounder
- Data collection – Laptop
- Sound speed correction – XCTD and XBT – Running mean
- Ice thickness correction – A qualified guess
- Tidal correction – negligible

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Single beam survey lines

Platform : Ice breaker – Submarine – AUV

What is needed? - Simple setup

- Position - GPS receiver and INS system for submerged vehicles.
- Depth – 12/15/24 kHz transducer with echosounder
- Data collection – PC
- Sound speed correction – CTD or SVL or tables – Running mean
- Tidal correction – negligible

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Multibeam soundings

Platform : Ice breaker – Submarine – AUV

What is needed? - Complex setup

- Position - GPS receiver and INS system for submerged vehicles. Position update a problem.
- Depth – 12/24 kHz transducer with multibeam
- Motion sensor
- Data collection – PC
- Sound speed correction – CTD or SVL – Raytracing
- Tidal correction – negligible

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Icebreaker

- Good position at all times
- Possibility to collect seismic and other scientific data at the same time.

- Data are noisy and sparse from time to time – from breaking ice.
- Costs are very high especially if you need a lead icebreaker.

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Submarine / AUV

- Clear of noise from breaking ice.
- Better control of sound speed – may collect data from below the top layer.

- Submarine may *not* be surfaced frequently for military reasons.
- Nuclear submarines are not readily available.
- An AUV has to be brought in by icebreaker – for two reasons; Sea ice will drift and range from shore/ice camp will be to distant.

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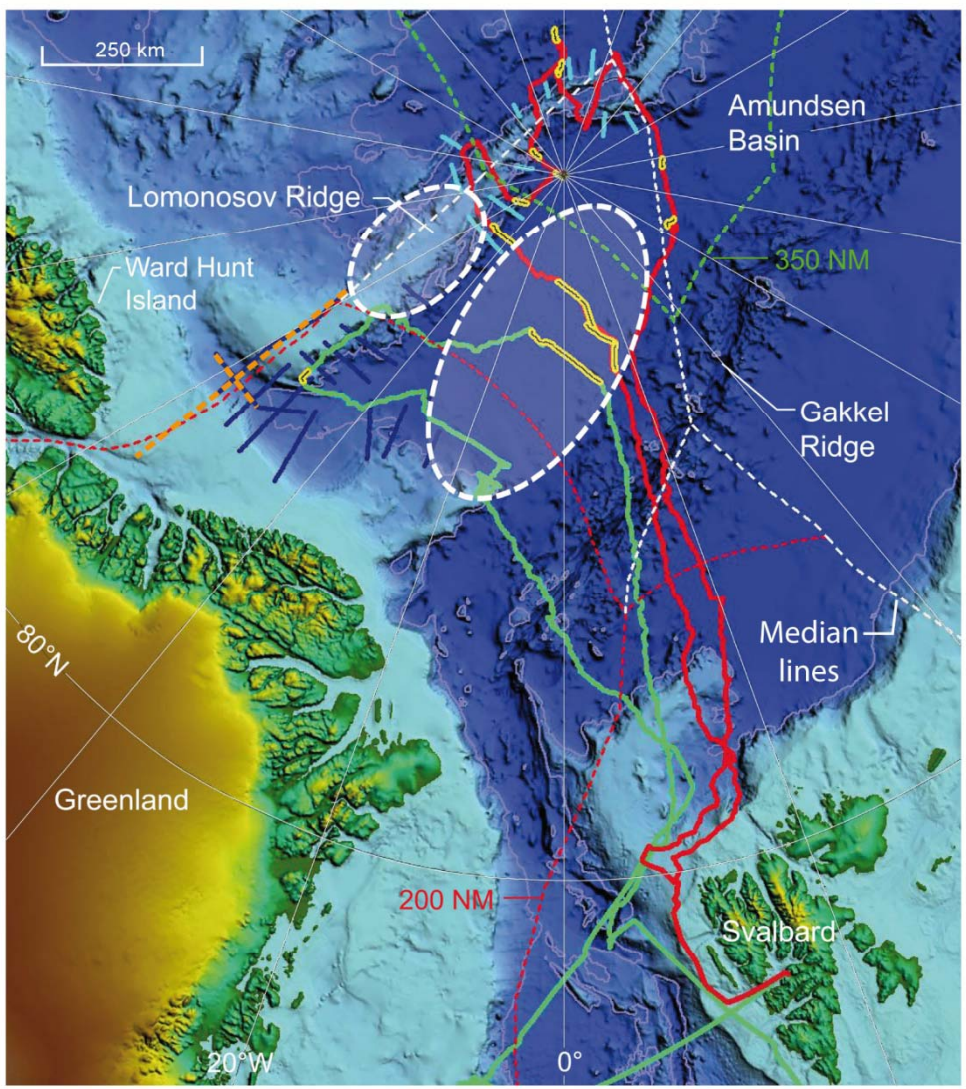
Helicopter

- Fast transit between spot soundings
- Limited number of people needed

- Logistical very complex operations to set up ice camp and fuel depots.
- For safety reasons more than one aircraft needed.
- Very weather depend operations.
- Limited range



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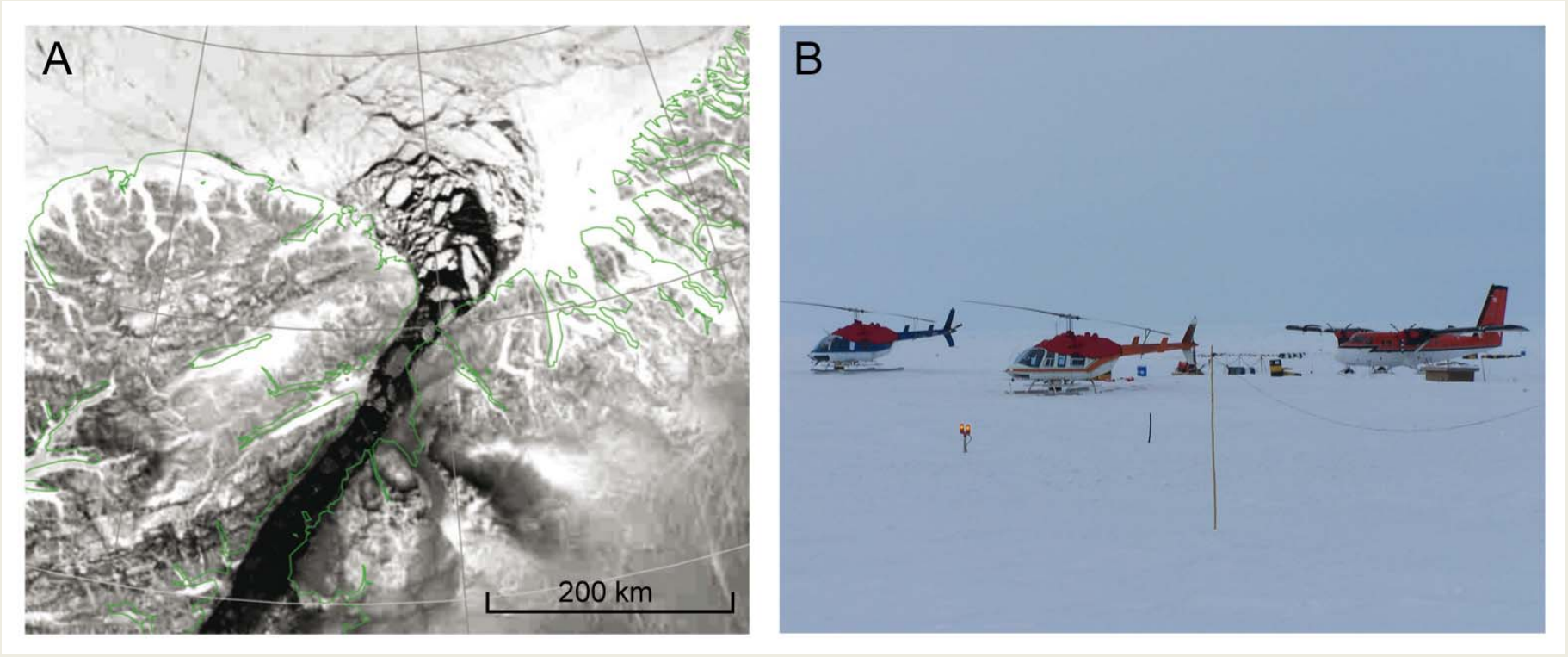
Field work north of Greenland from 2006 to 2009

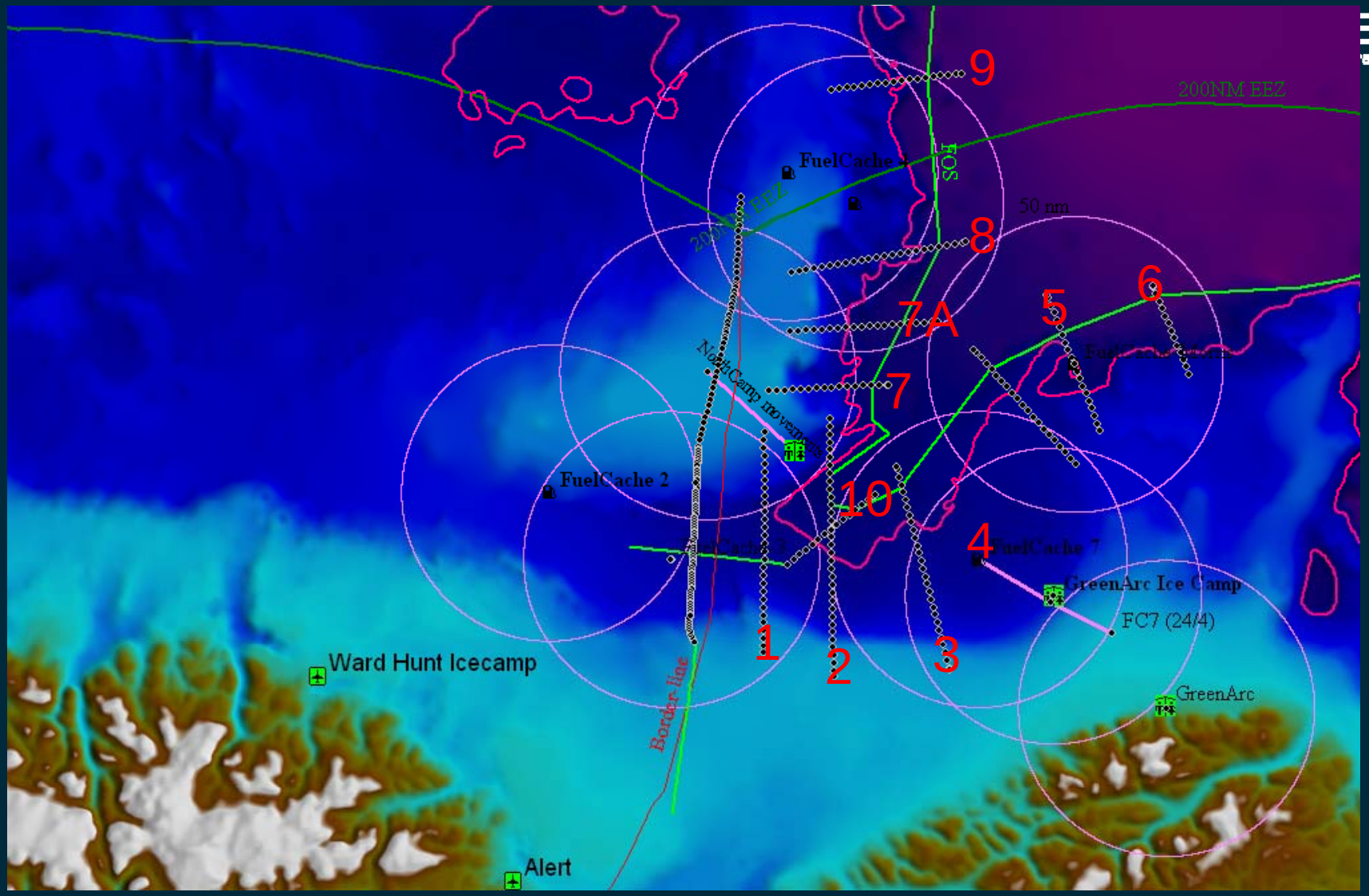
Focus on the acquisition of bathymetric and seismic data.

The white ellipses show the LOMROG III work areas planned for 2011 or 2012.

White stippled lines – unofficial median lines.



Weather and ice conditions - Spring of 2007



LOMBAG in 2009 – Cooperation with Canada

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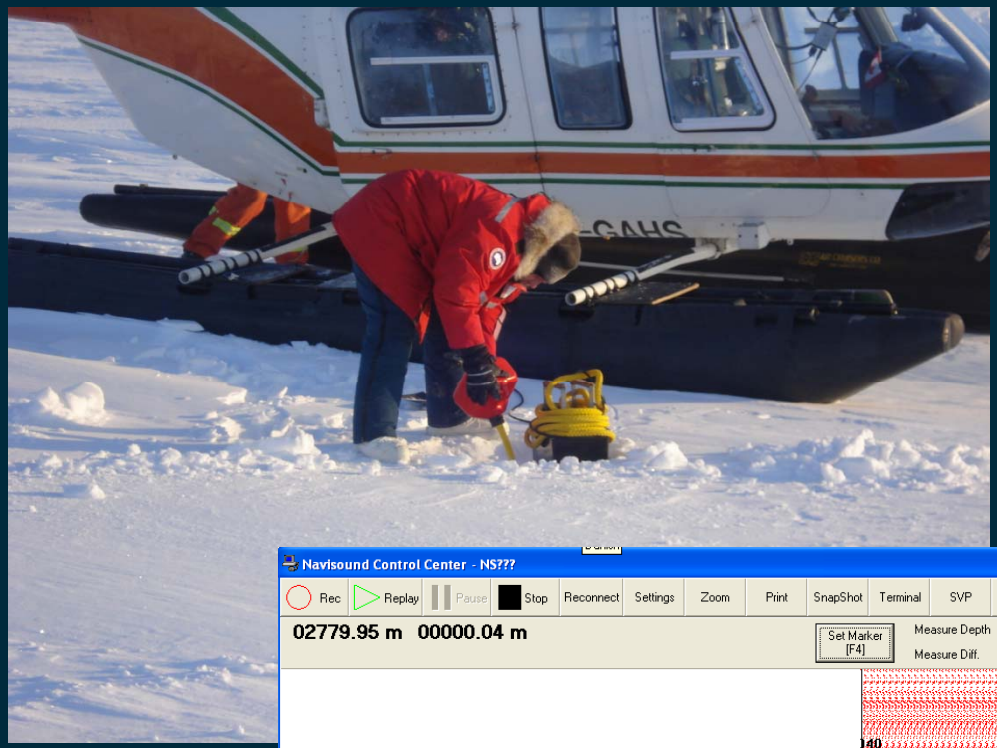
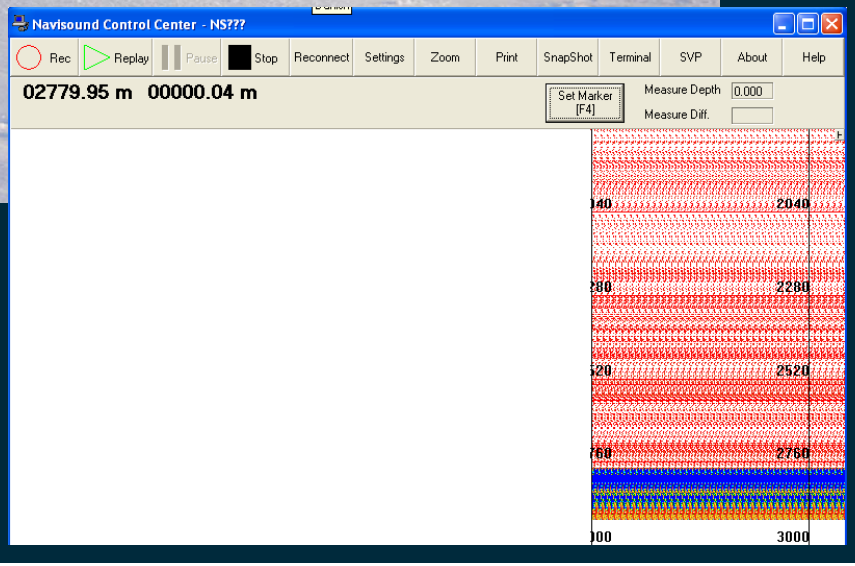
Echosounding on ice





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Measurements on a frosen lead

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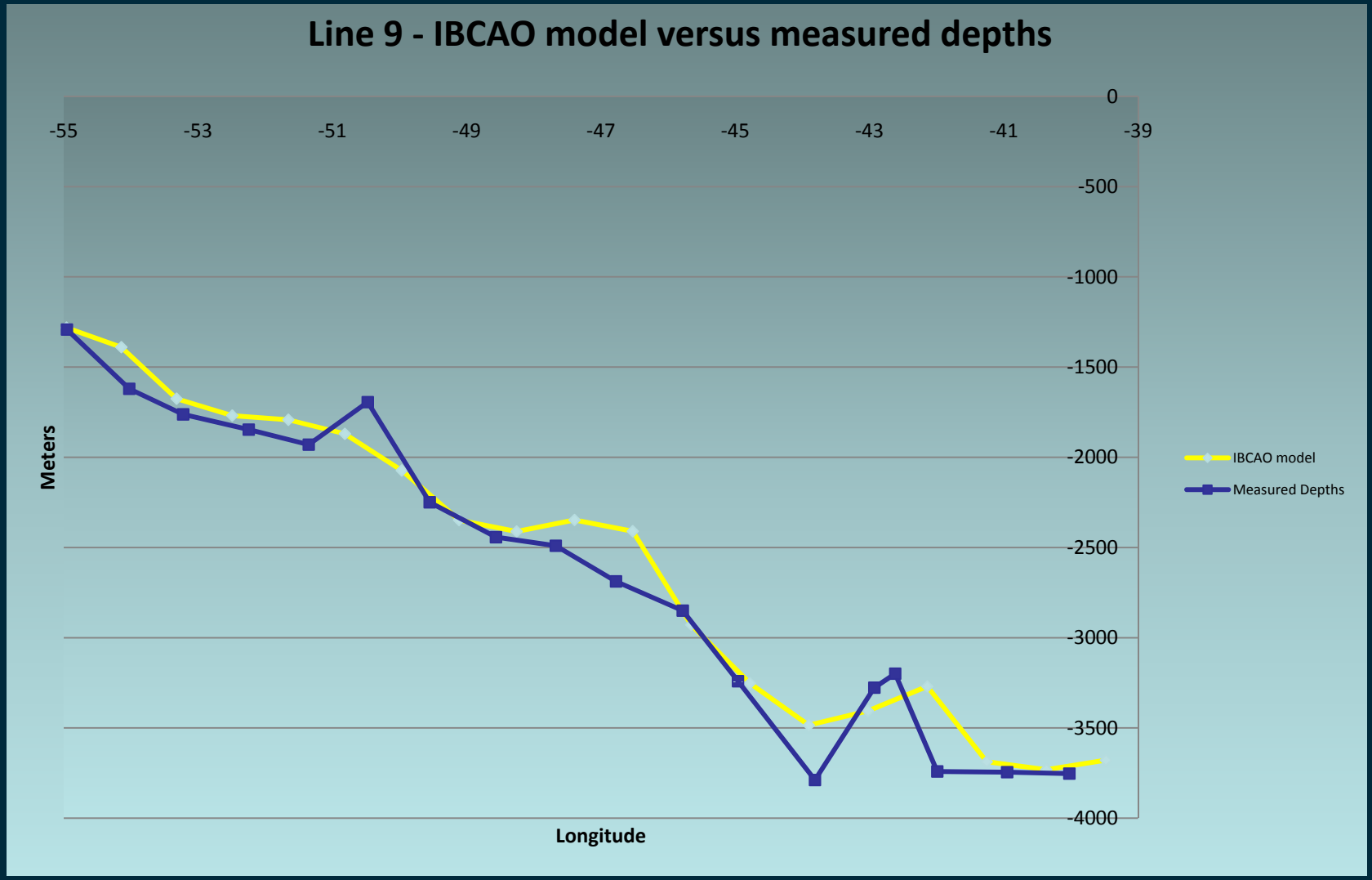

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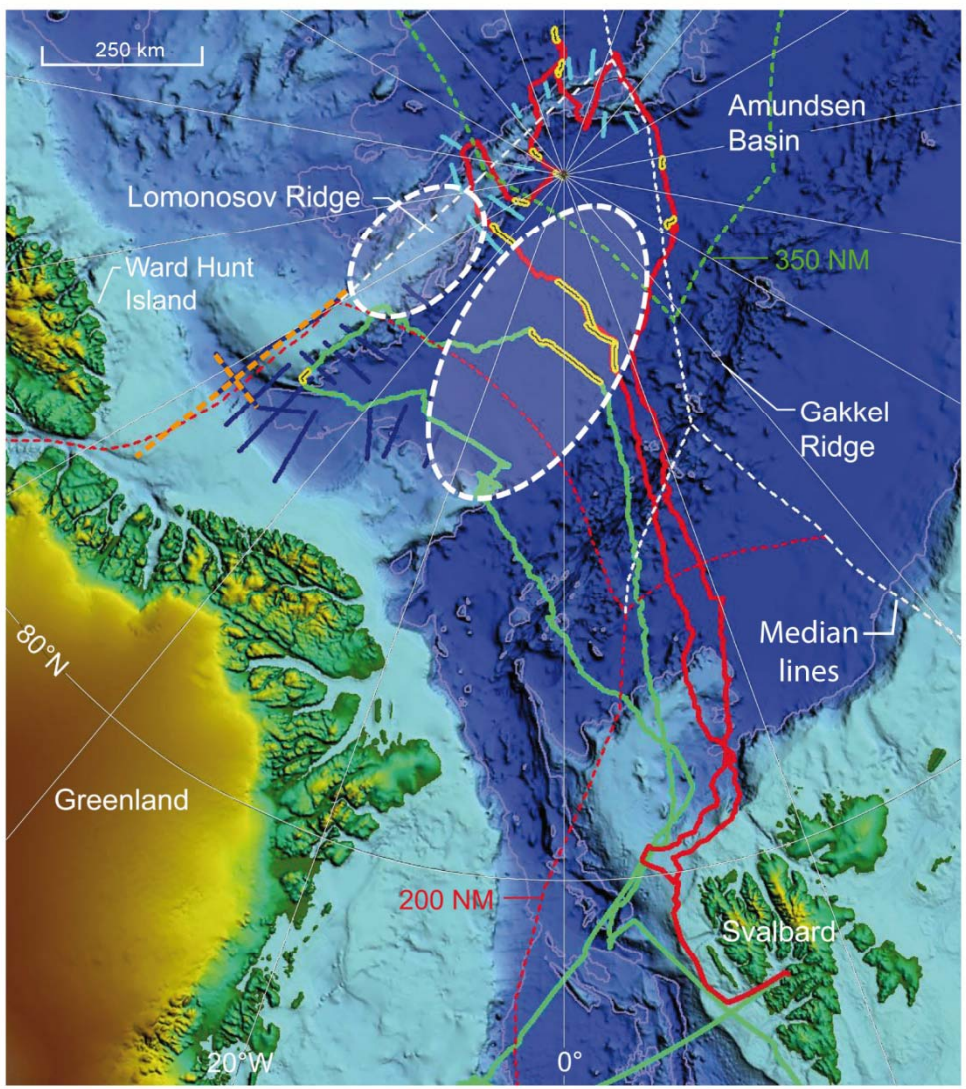
North Camp breaking up



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A


B


C


D

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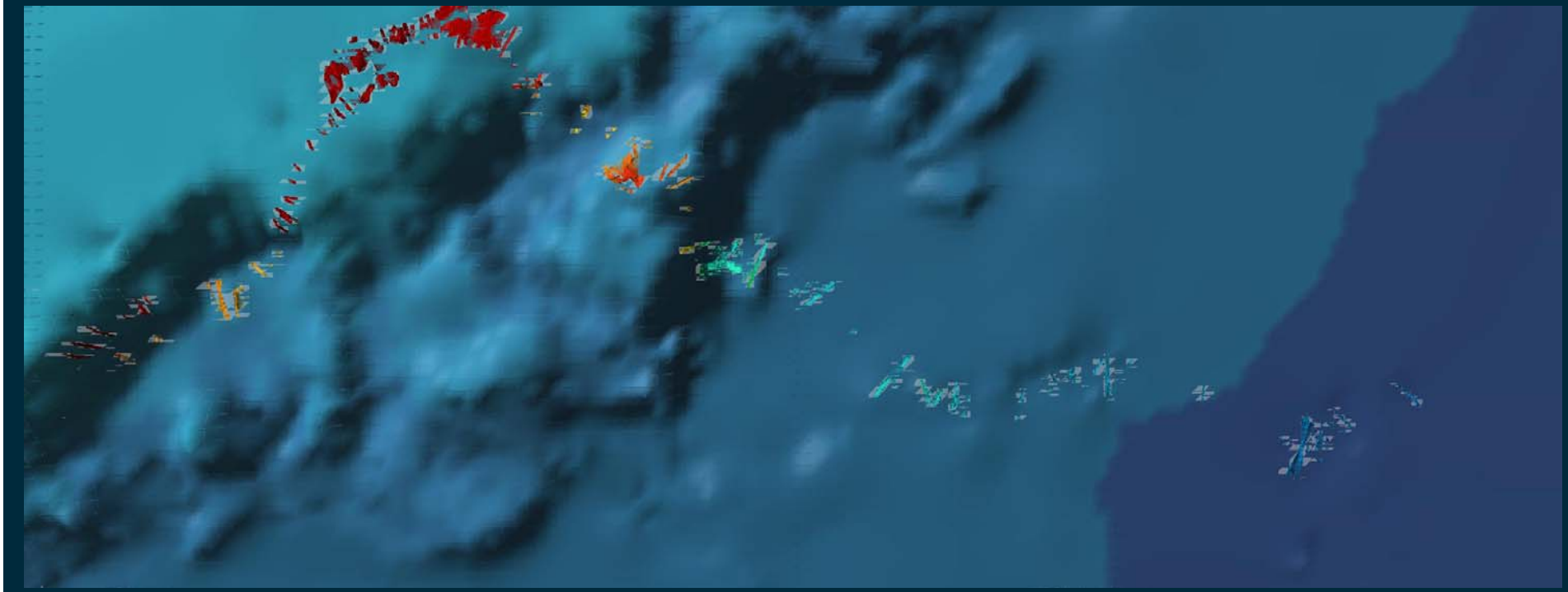
Lack of coverage



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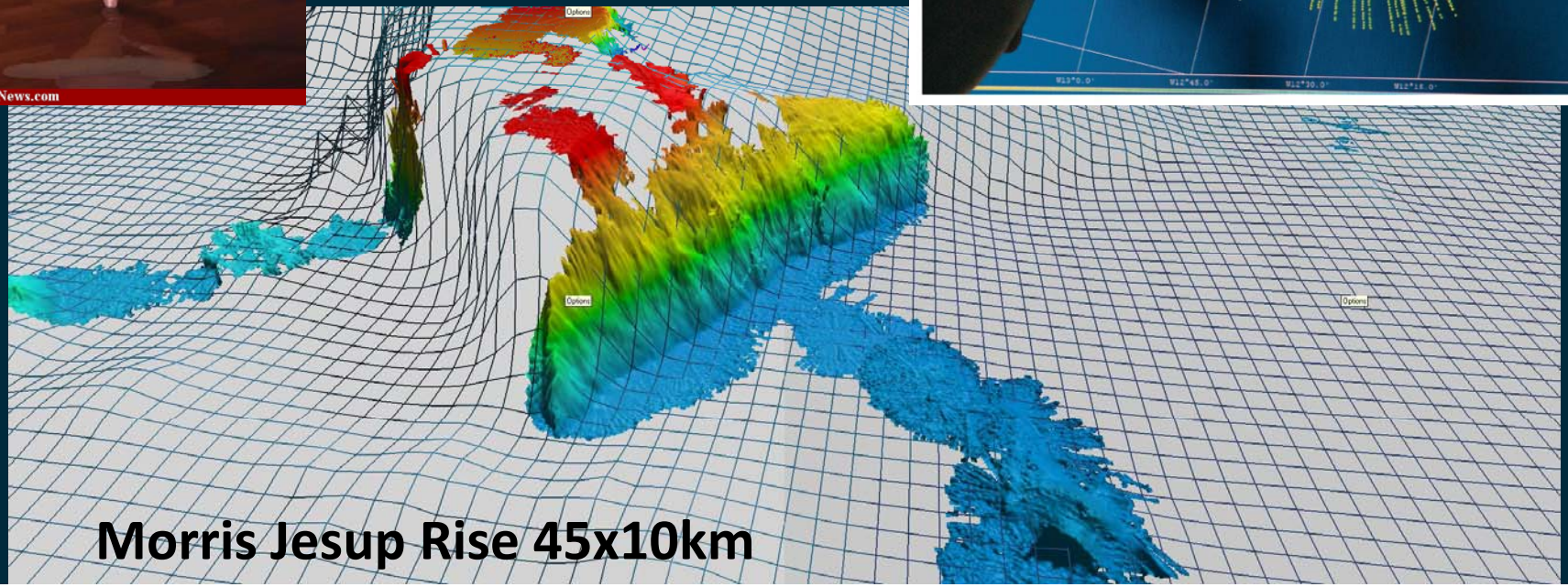
The Ballerina or Pirouette surveying method



Morris Jesup Rise 45x10km

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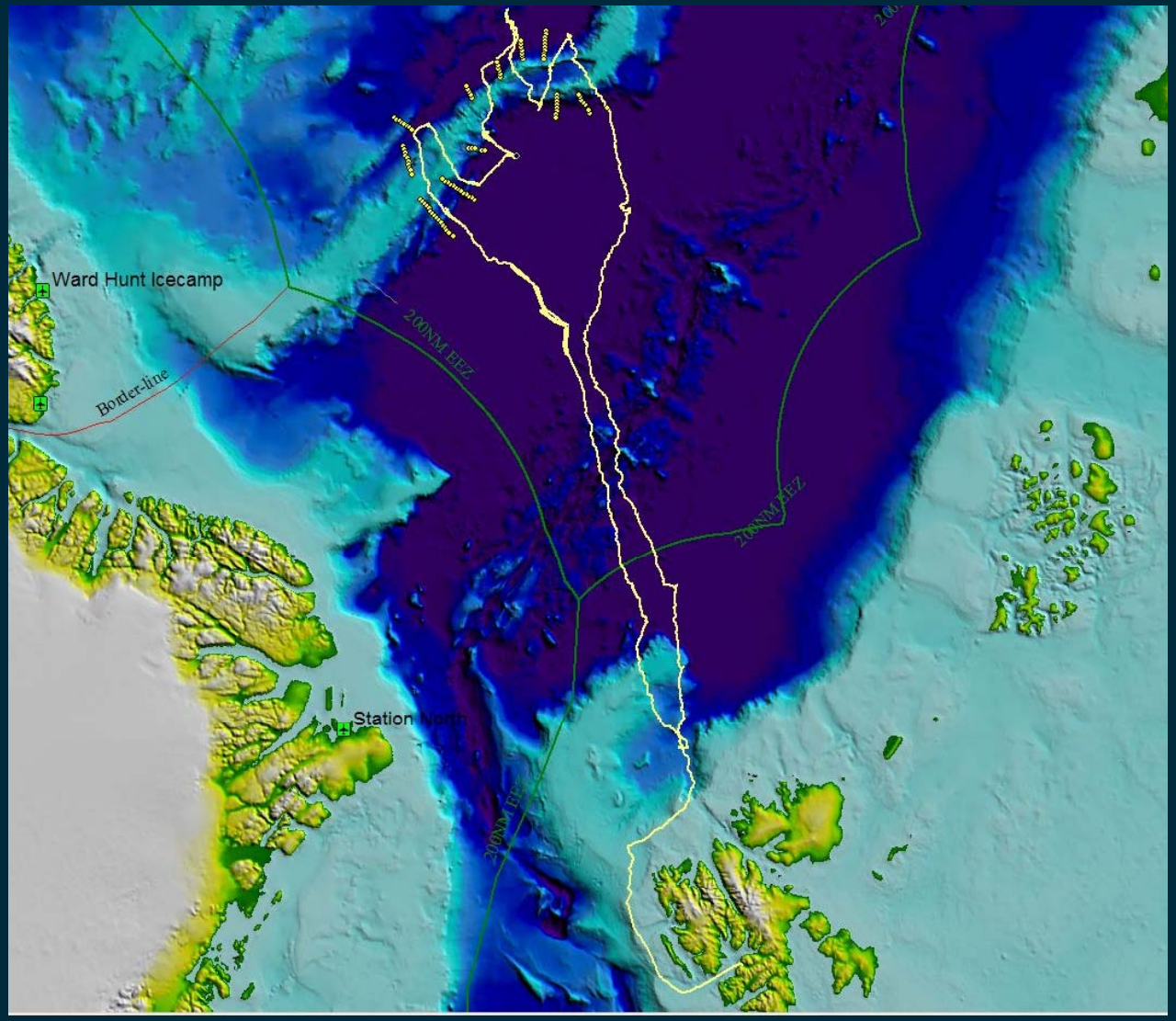
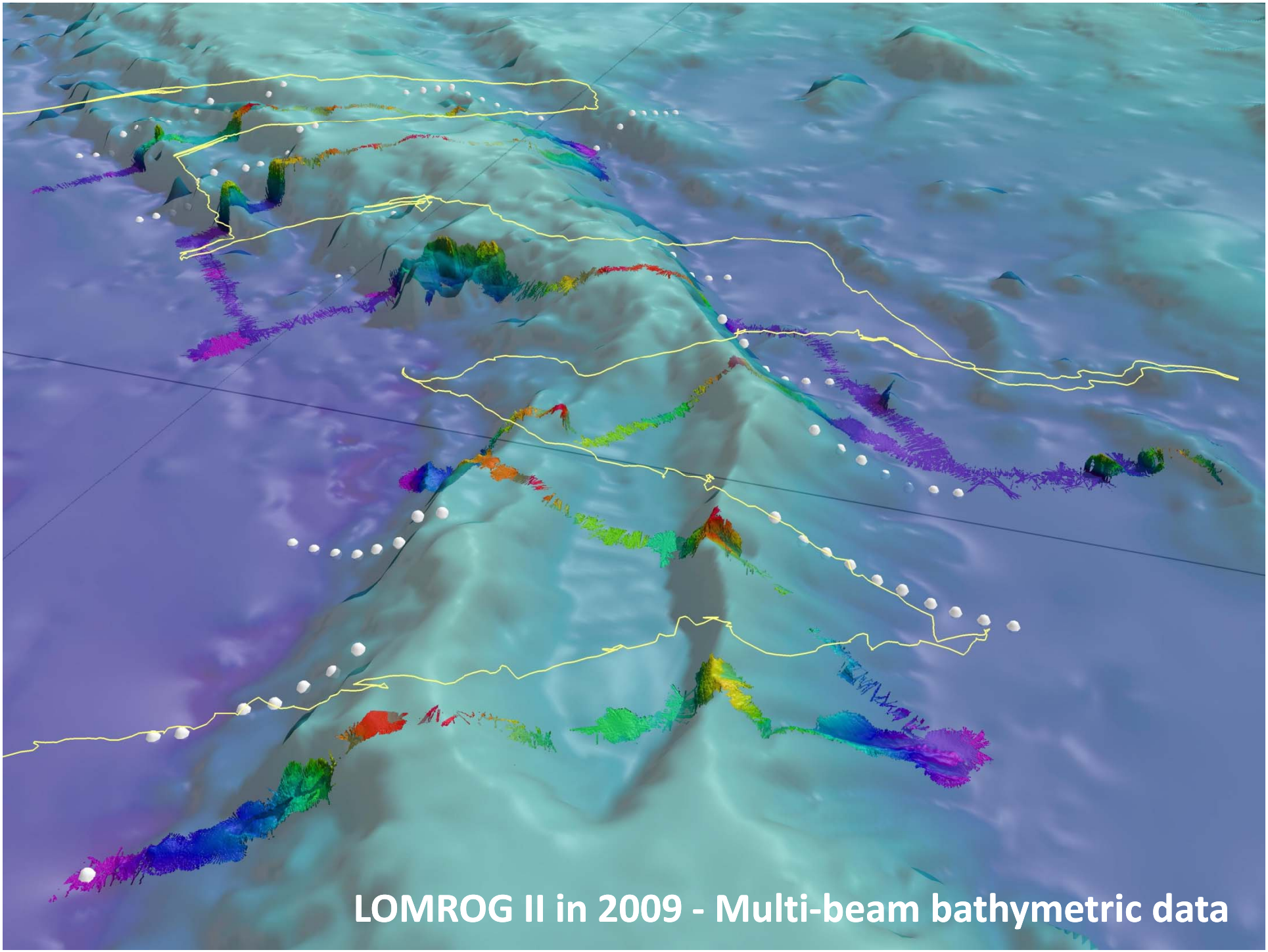
LOMROG II - 2009




LOMROG II in 2009 - Multi-beam bathymetric data

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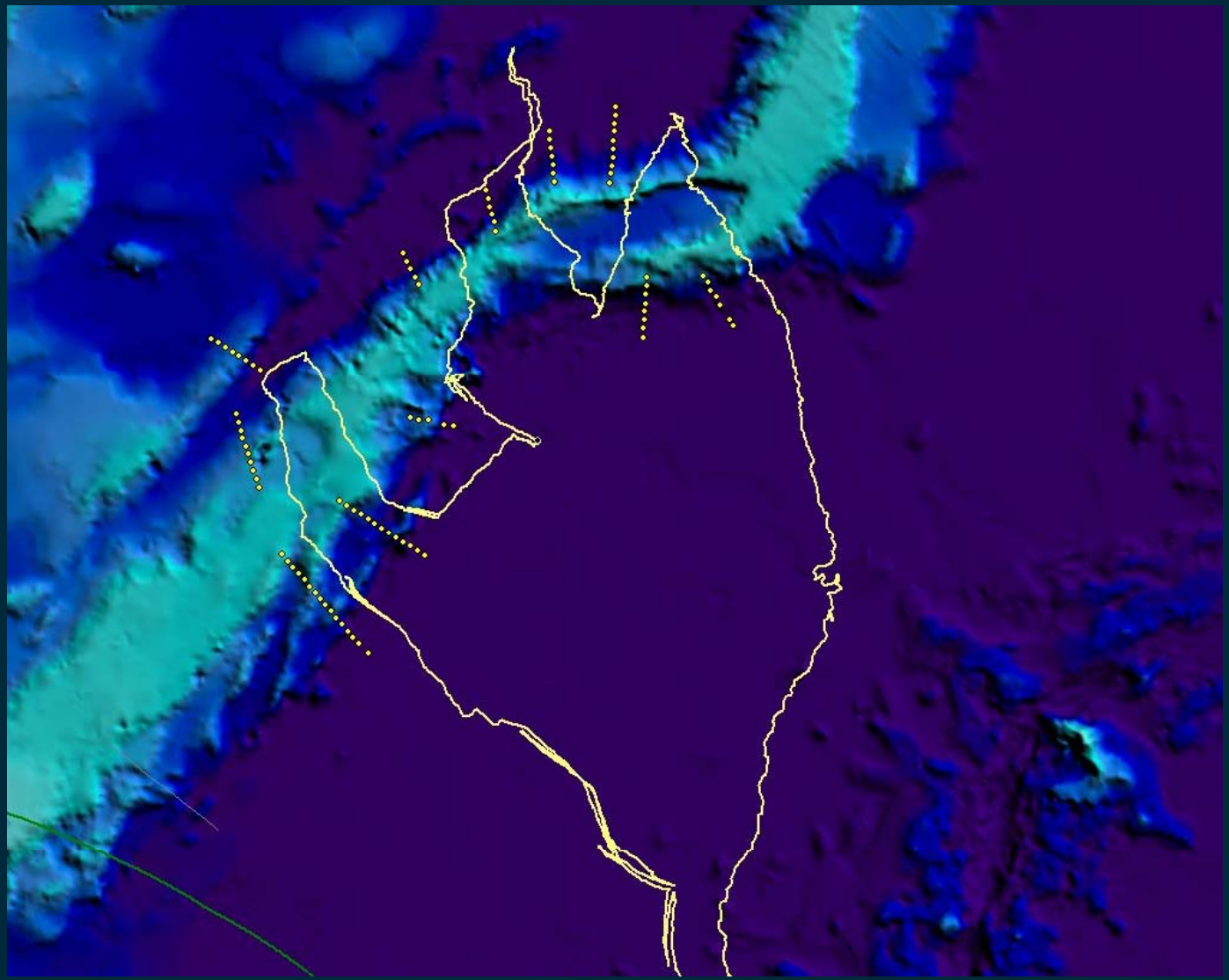
LOMROG II - 2009



Singlebeam echosoundings

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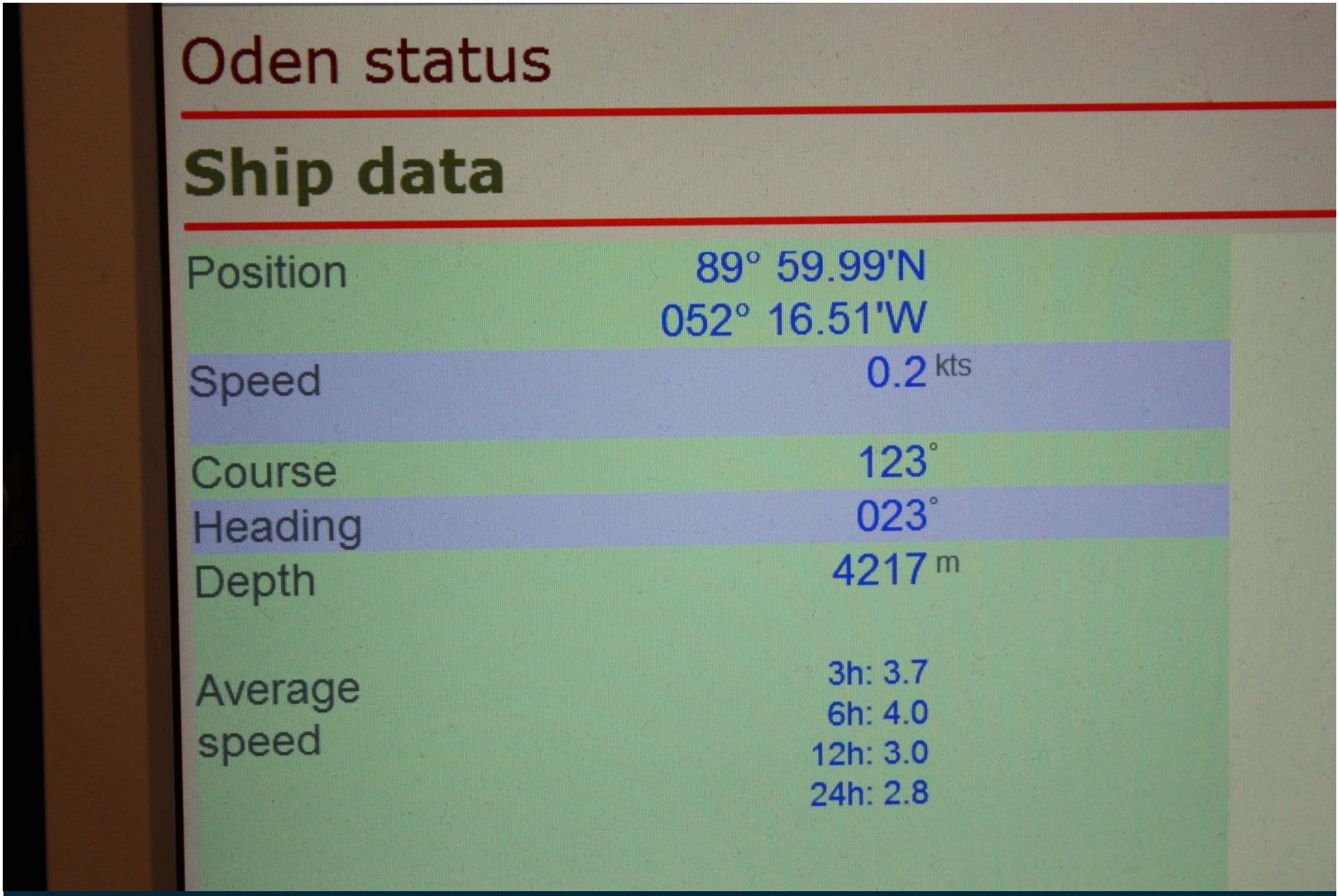
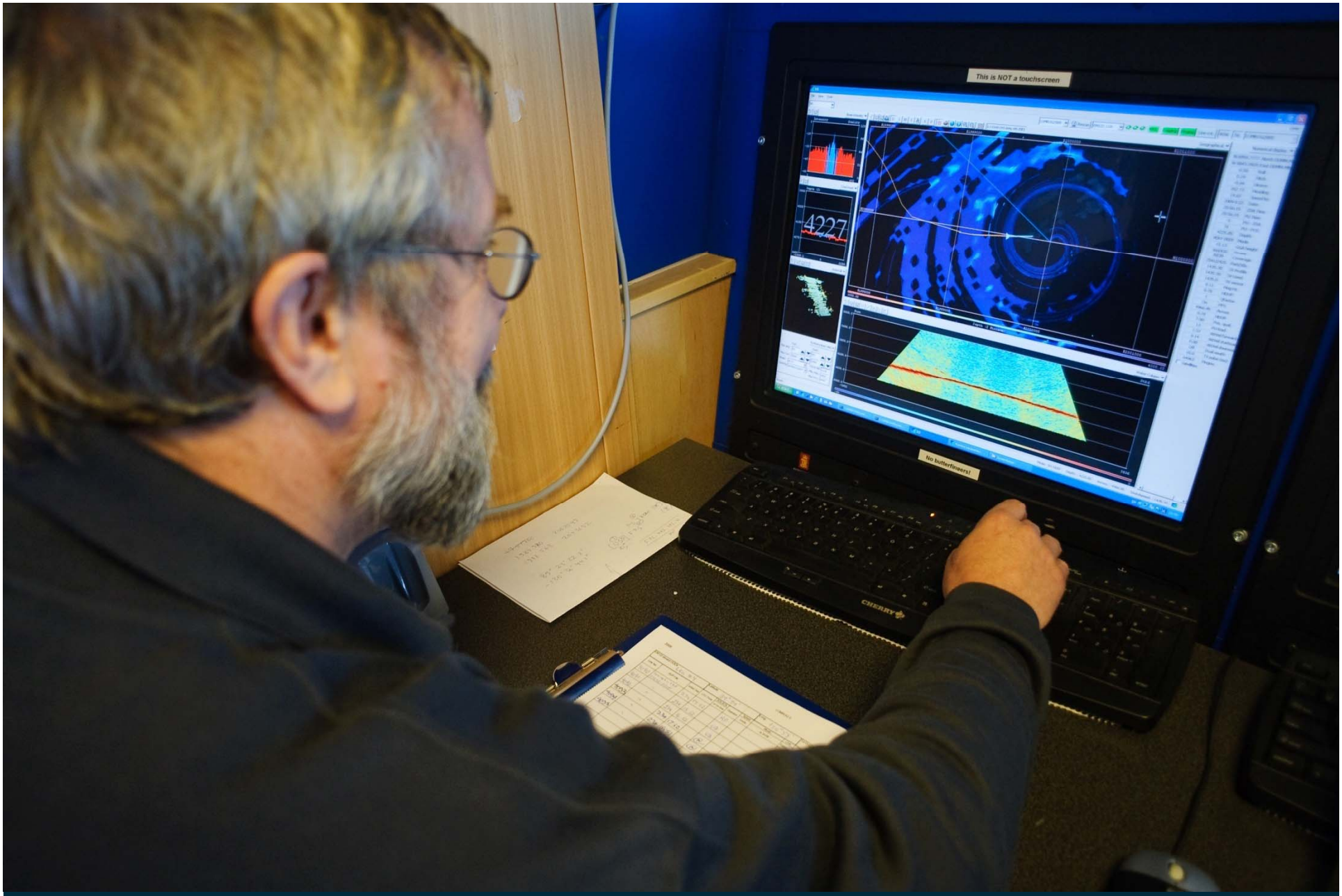
CTD from sea ice


Oden status
Ship data
Position
89° 59.99'N
052° 16.51'W
Speed
0.2 kts
Course
123°
Heading
023°
Depth
4217 m
Average speed
3h: 3.7
6h: 4.0
12h: 3.0
24h: 2.8



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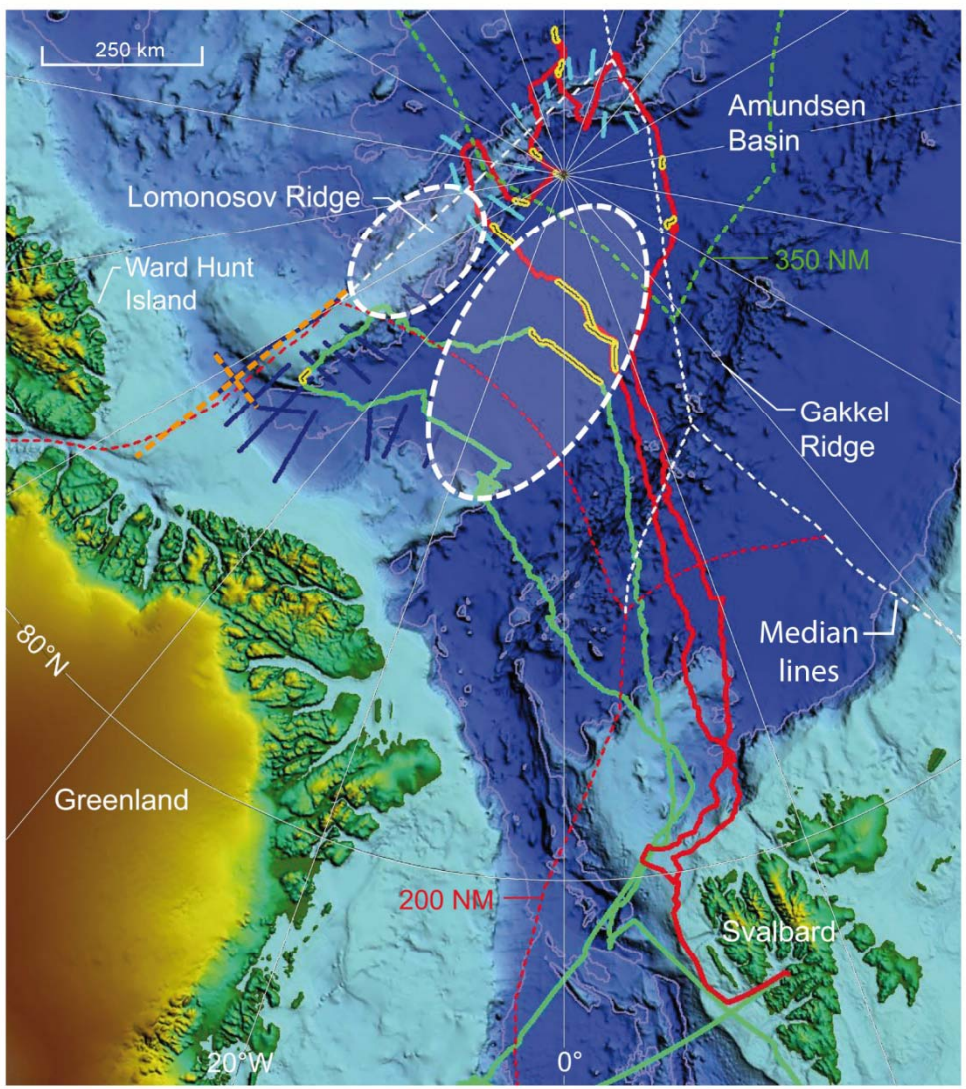

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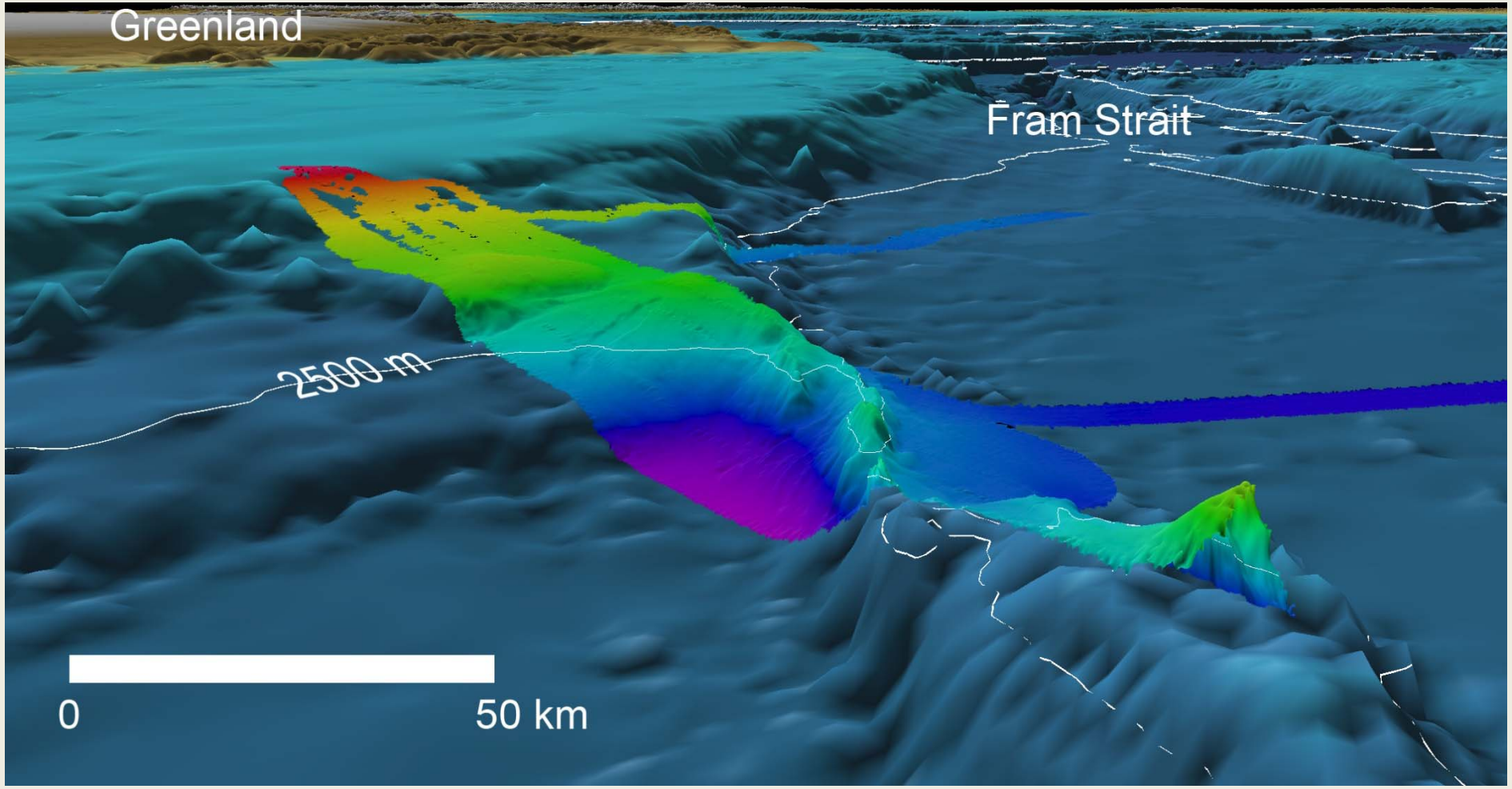

Multibeam bathymetry collected from the East Greenland Ridge during the LOMROG 2007 cruise. The multibeam bathymetry is here shown overlaid on the new IBCAO version 2.0, which has made use of these data in this area (courtesy Martin Jakobsson). New survey in August/ September 2011.

Conclusions

- Good cooperation with other countries and institutions especially Canada and Sweden.
- We still need to acquire more data both in the Arctic Ocean and off NE Greenland but have a valid concept for doing so.
- All bathymetric data acquired can be used to update IBCAO.