

National Report Norway

- **HREF-models**
- **The Marine Geoid**
 - **The MAREANO project**
 - **Access to a marine gravity meter and free ship time**
 - **Example from Sognefjorden**
 - **Airborne gravity campaigns?**
- **Continuous MSS surface, BLAST**



Determination of the geoid

- One of the primary objectives of NMA
- Gravimetric geoid
- Traditionally focused on land applications (GNSS)
- Increased focus on the marine geoid (ocean circulation and transport, determination of sea ice thickness in the Arctic)

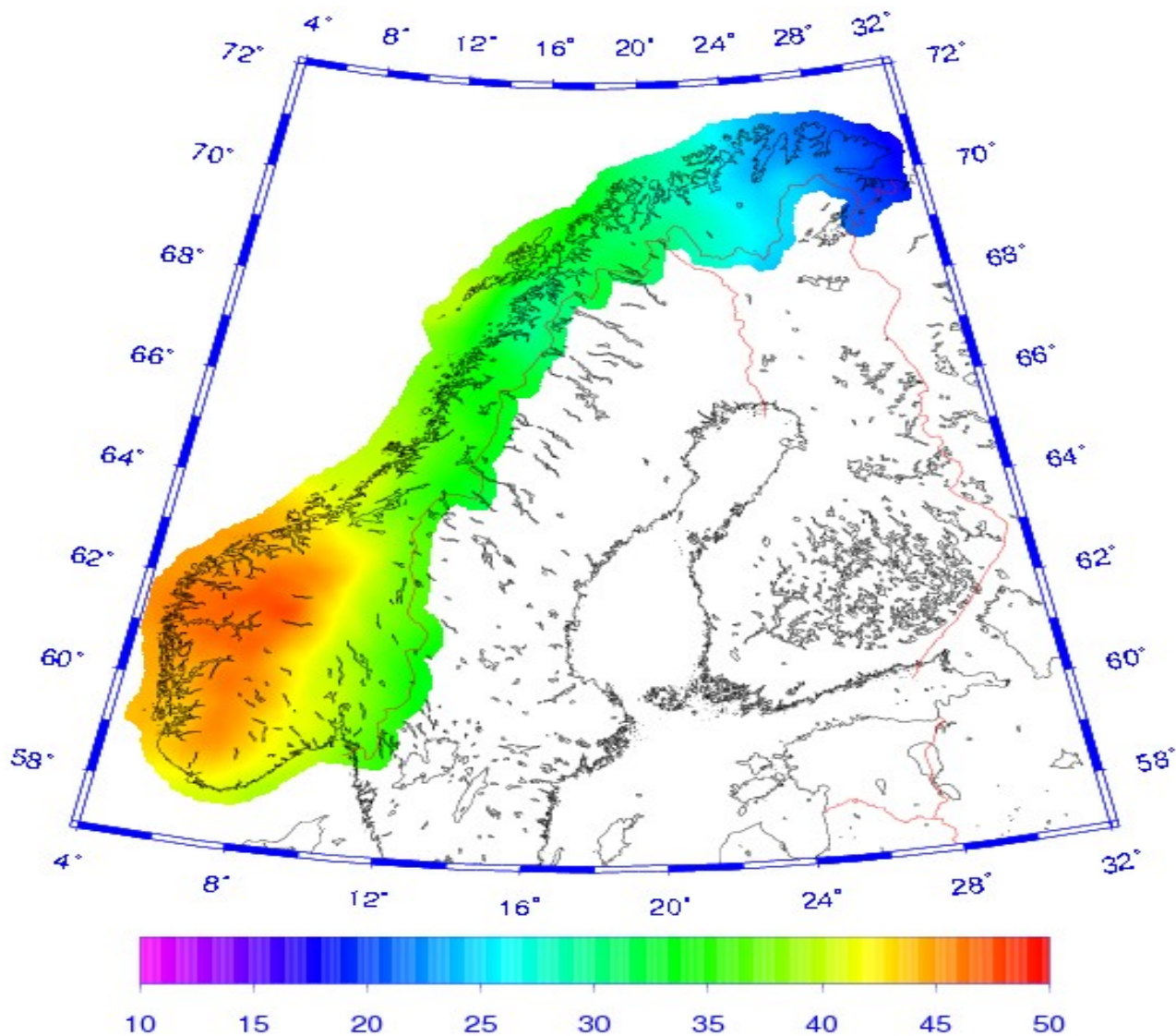


HREF-models (land)

- HREF, Height reference surface models
- Geoid models adjusted to GPS/lev data
- Iterative method, stepwise improvement as more GPS/lev data is made available
- Allows height determination with a standard dev < 2 cm for large parts of Norway
- <http://www.geodesi.no/href>



HREF2008a (m)

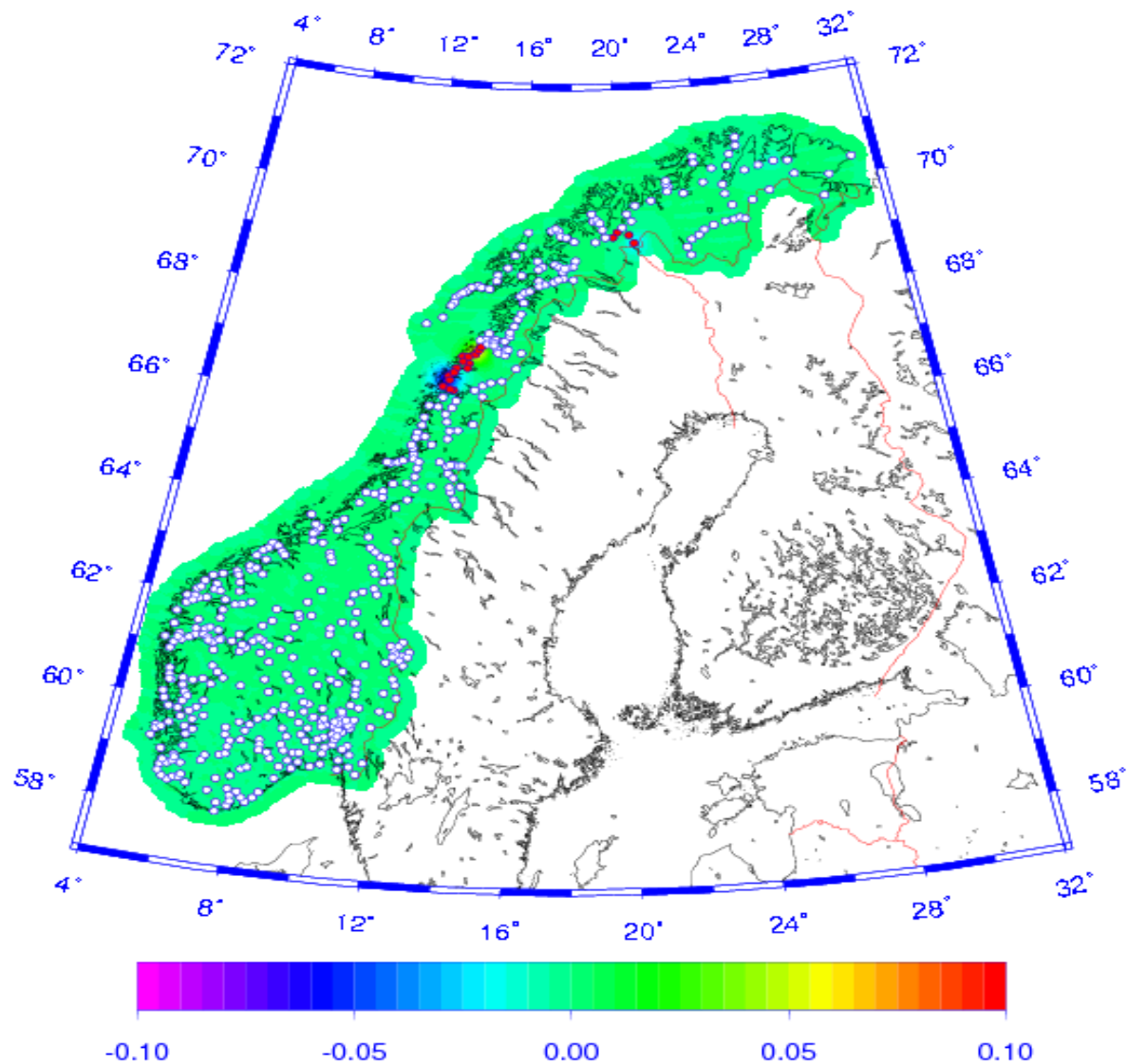


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HREF2008a-HREF2007b (m)

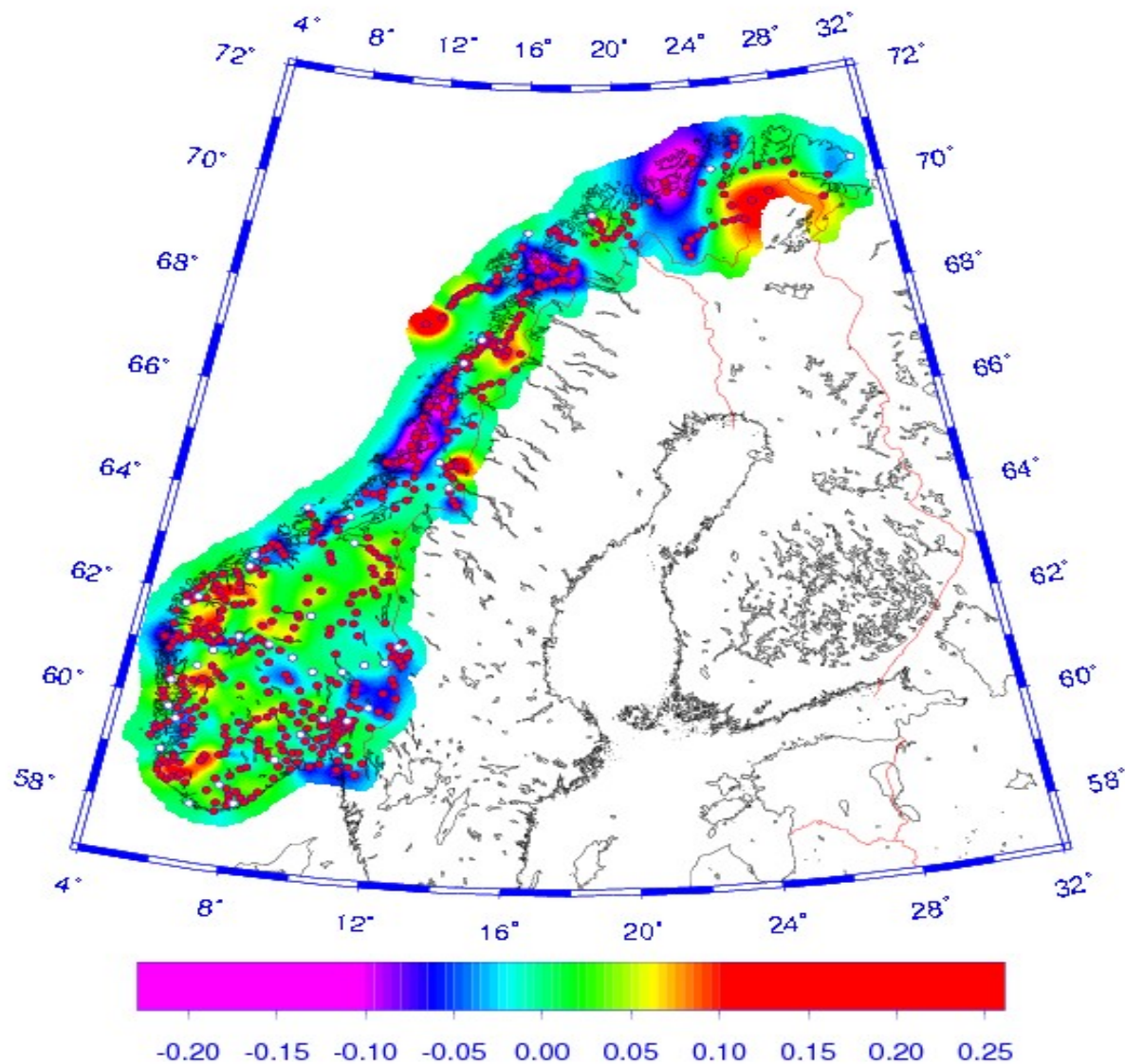


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HREF2008a-HREF1996 (m)



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HREF-models

HREF + GPS => Normal-heights

VREF + GPS => Orthometric heights

All models are derived from the NKG96 quasigeoid

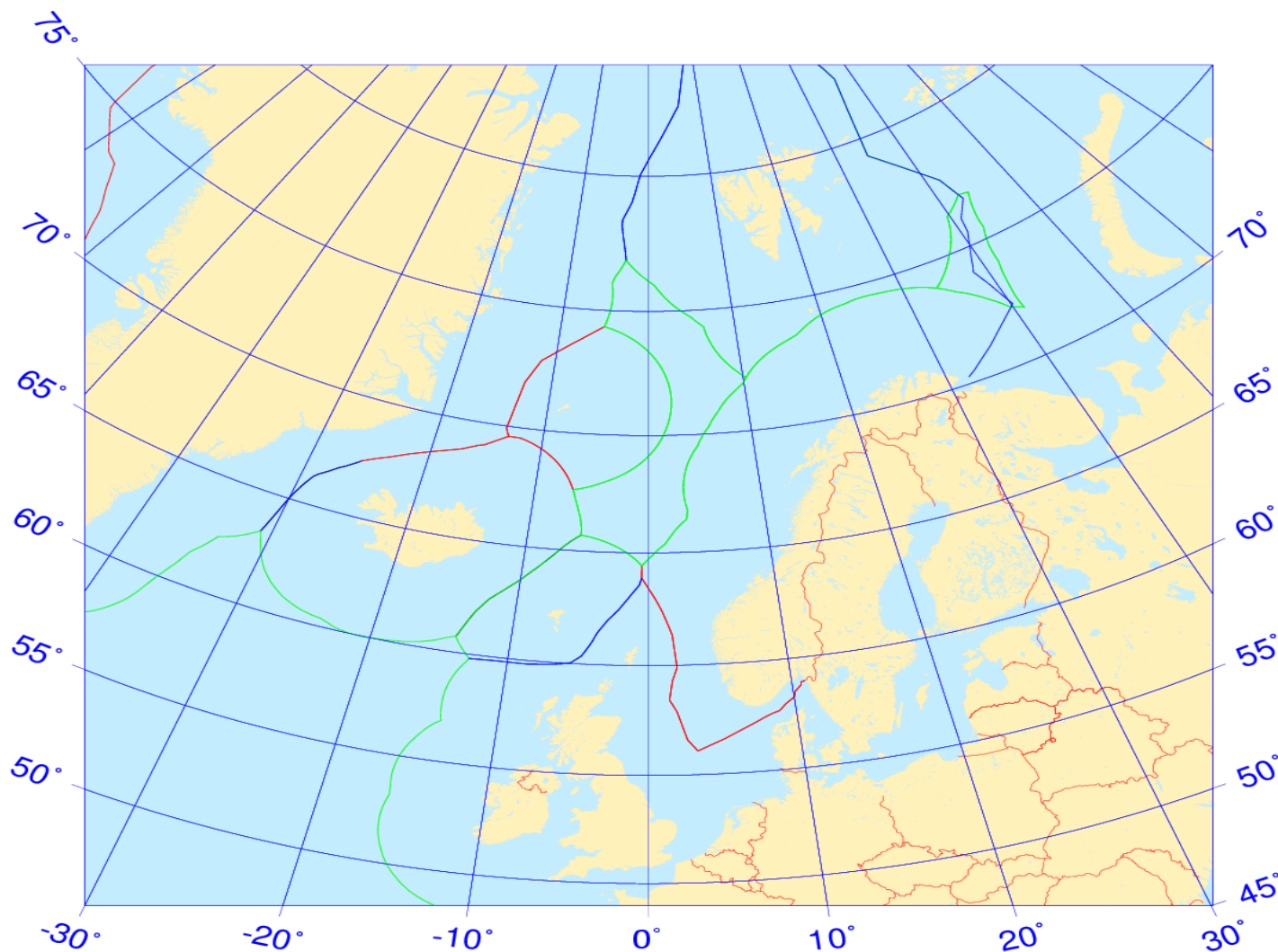
NKG96	---->	NKG96n
↓		↓
HREF1996		VREF1996
1998		1998
1999a,b		1999a,b
2000a,b,c		2000a,b,c
2001a,b,c		2001a,b,c
2002a,b,c,d,e		2002a,b,c,d,e
2003a,b,c,d,e,f		2003a,b,c,d,e,f
2004a,b,c,d,e		2004a,b,c,d,e
2005a,b,c		2005a,b,c
2006a,b,c		2006a,b,c
2007a,b		2007a,b
2008a		2008a

The Marine Geoid

- Limited gravity coverage
- No adjustment data (GPS/lev)
- Acces to marine gravity meter and ship time will fill the holes in the gravity coverage, but this will take time!!!
- An airborne gravity campaign is needed if a detailed regional geoid is to be determined within short time
- Refinement of the GOCE geoid
- Operational usage of satellite altimetry



Marine Boundaries



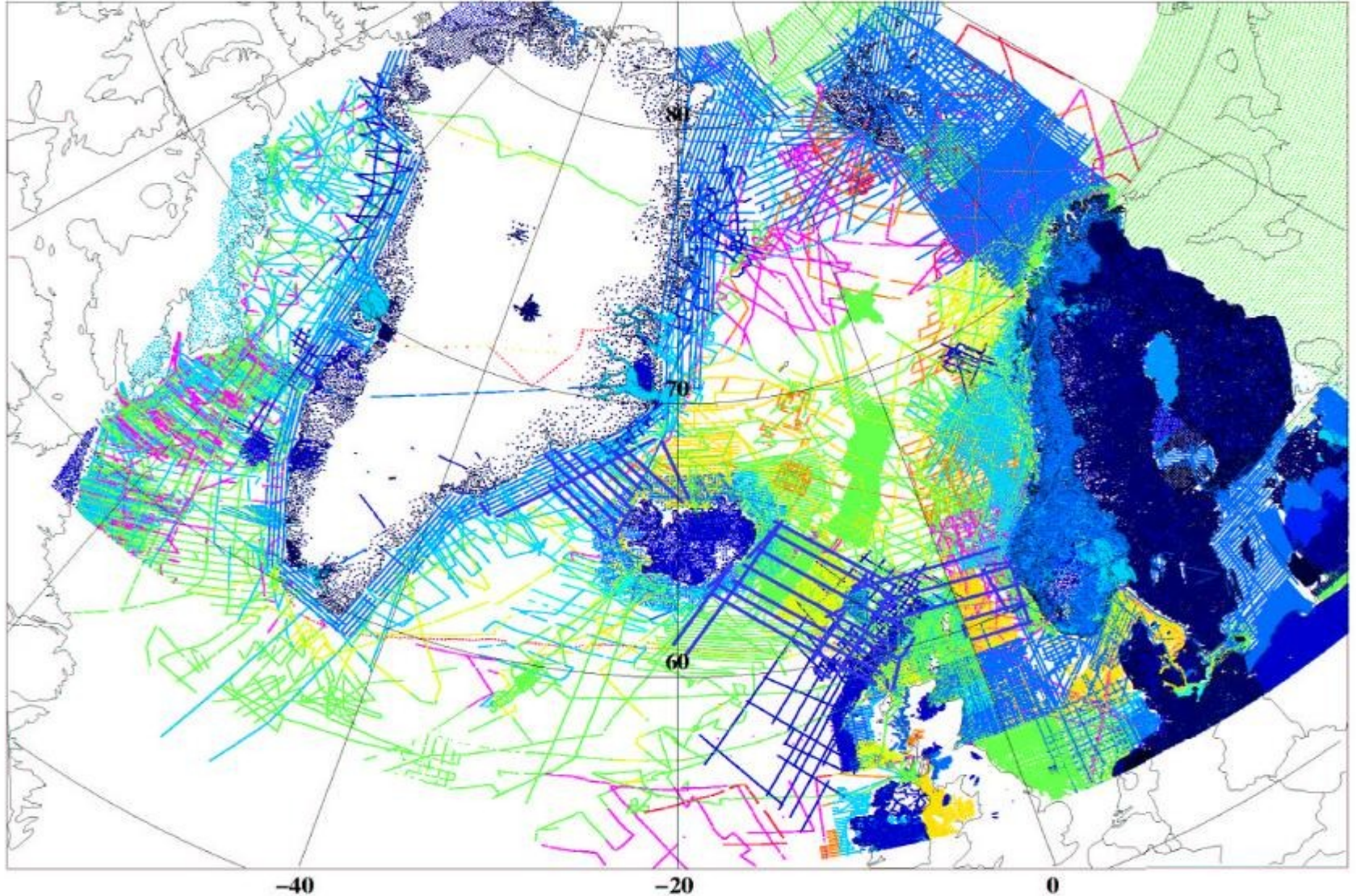
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GMT Nov 26 18:55:22 2001

Vinkeltro kjegle-proeksjon, Statens kartverk, Geodesidivisjonen

500 km

Gravity Coverage



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The MAREANO Project

- **Seafloor mapping, first phase: 2006–2010**
- **Institute of Marine Research, IMR**
- **Geological Survey of Norway, NGU**
- **Norwegian Mapping and Cadastre Authority, NMCA**



About MAREANO

MAREANO maps depth and topography, sediment composition, biodiversity, habitats and biotopes as well as pollution in the seabed in Norwegian coastal and offshore regions. The Programme aims to provide answers to questions such as:

- How is the seascape of the Norwegian continental shelf?
- What does the seabed consist of?
- How is the biodiversity distributed on the seabed?
- How are habitats and biotopes distributed on the seabed?
- What is the relationship between the physical environment, biodiversity and biological resources?
- How are contaminants stored in sediments?

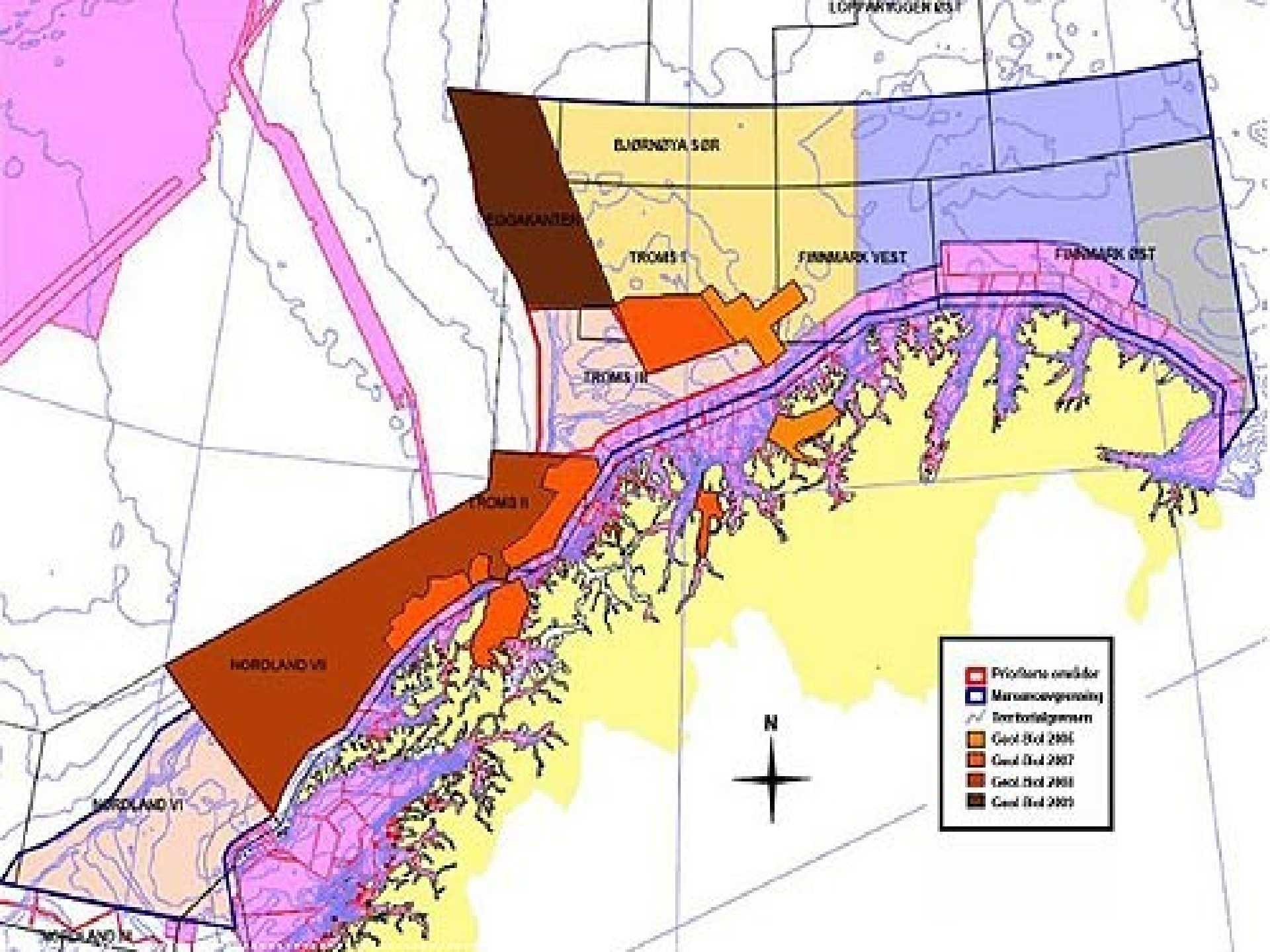
MAREANO is coordinated by the Institute of Marine Research, in collaboration with the Geological Survey of Norway and the Norwegian Hydrographic Service.

The Programme is financed by the Ministry of Fisheries and Coastal Affairs, the Ministry of Environment and the Ministry of Trade and Industry via contributions from the National Budget.

- Financial contribution in 2006: MNOK 23.6
- Financial contribution in 2007: MNOK 32.6
- Financial contribution in 2008: MNOK 32.6

First phase: 2006–2010

MAREANO will fill knowledge gaps related to seabed conditions and biodiversity defined in The Integrated Management Plan for the Marine Environment of the Barents Sea and the Sea Areas off the Lofoten Islands presented by the Government in 2006. The Plan is due to be revised in 2010, and MAREANO will contribute to a better knowledge base for managing human activities such as fishing and oil and gas exploitation. Priority mapping areas for this phase are located along the shelf break and on the continental shelf in the western part of the mapping area. In the Management Plan, these areas are regarded as being especially ecologically important and vulnerable.



The gravity part of MAREANO

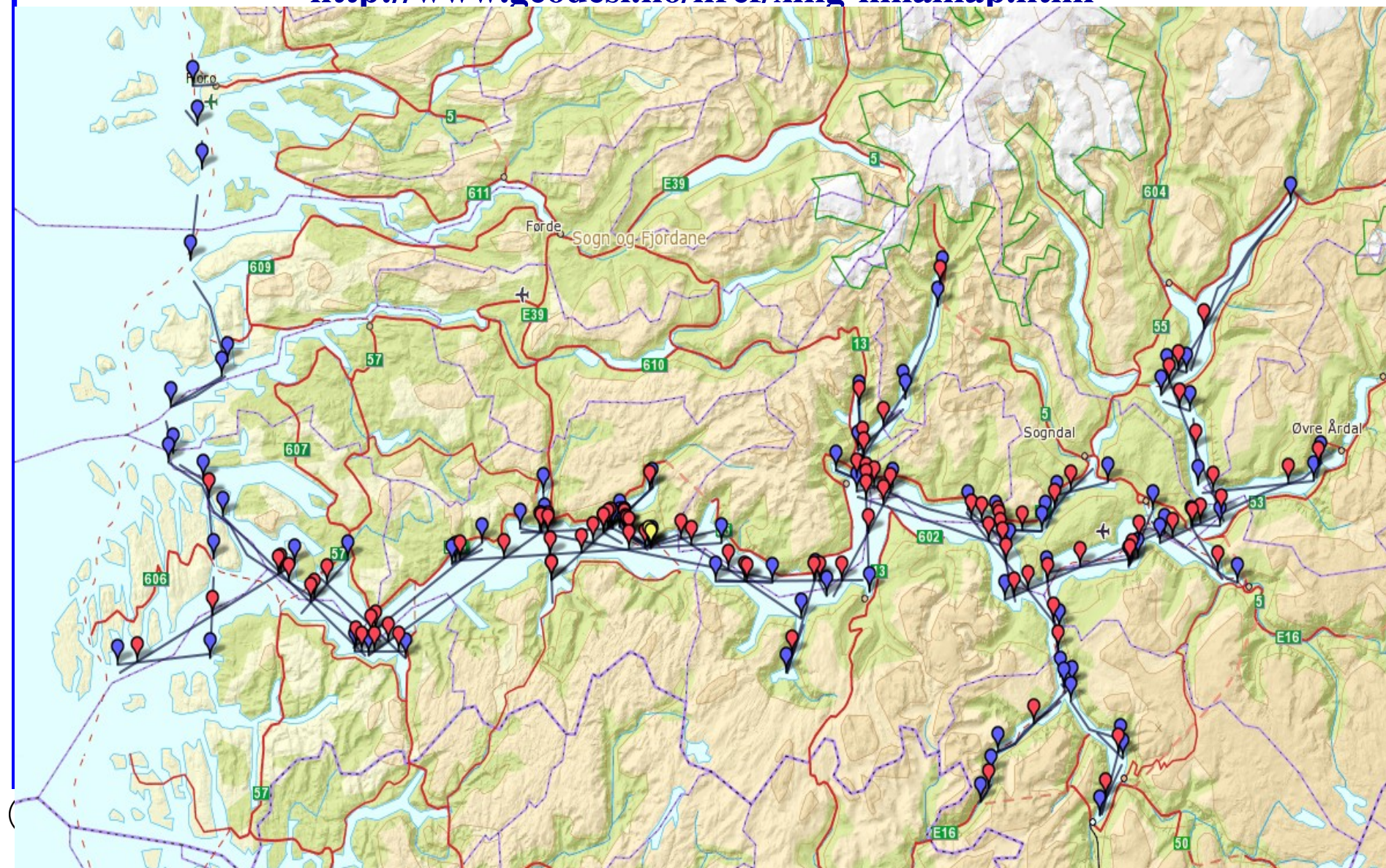
- **NMA**
- **NGA, provides a marine gravity meter, Bell, BGM-3**
- **NGU**
- **IMR**
- **University of Bergen**





Marine Gravity Survey Sognefjorden

<http://www.geodesi.no/href/xing-nmamap.html>



X-over statistics

- **Number of line crossings** : 100
- **Mean of the crossing differences** : -0.03 MGALS
- **Minimum crossing difference** : -3.65 MGALS
- **Maximum crossing difference** : 2.28 MGALS
- **Standard deviation of the differences** : 0.39 MGALS
- **After removing 2 outliers**
- **Standard deviation of the differences** : 0.24 MGALS



Airborne gravity

- **Most cost efficient way to measure gravity**
- **Nordic cooperation since 1996 (AGMASCO). NSI (DNSC), NMA, UoB**
- **Used in GOCINA and OCTAS**
- **DK/NOR campaigns in 1998,1999,2001 and 2003**
- **Dronning Maud Land, Antarctica,2011**



Possible future activity

- Access to a suitable aircraft
- Twin Otter used on Svalbard and Greenland, not sufficient endurance
- NRL, dedicated P-3
- Bjørn Engen approached Luftforsvaret in 2006. Time to re-establish this contact but now in cooperation with FMGT and NRS.







Continuous MSS model (BLAST)

- **SKSK, need for a continuous MSS and LAT model**
- **Altimetry, MSS**
- **Deploy temporary tide gauges**
- **Use the geoid to interpolate between the altimetric MSS and tide gauge data on land**



DTM Norway

- **Access granted for the WG**
- **In the process of updating the model**
- **Old version:**
 - 100mx100m, geographical grid (H. Denker)
 - 50mx50m, geographical grid
 - 25mx25m, given in separate UTM zones
- **New version**
 - 20mx20m, given in separate UTM zones
 - Will be completed by the end of 2010



The Future of NKG and the WGs

- At the NKG Presidium meeting in Finland last year it was questioned whether to keep the current structure and Working Groups or make some changes, big or small. There was for instance a suggestion to have just a few WGs, **the geoid was not one of them**, and to organise some of the activities in projects, of which Ocean Circulation was one. Another suggestion was for the WG's to report to the Presidium on their planned activities for the next year.
- Possible changes to NKG and the WGs will directly influence our work. A short summary of our discussions/view will be sent to the Presidium after the WG meeting.



My personal opinion

- The geoid has never been more relevant and important than today. During the last decade, since the release of the NKG96 model in Vilnius, we have witnessed a revolution with respect to height determination with GNSS. Today heights can be determined with an accuracy of 1-2 cm or better, for large parts of the Nordic and Baltic countries. Further improvements are however needed and we must also start thinking on how to address the time dependency of the geoid.
- The marine geoid will be one of Geodesy's most important contributions to the monitoring of climate change. The combination of a high precision detailed geoid with satellite altimetry will form a new and important dataset for oceanographers when determining and monitoring the ocean circulation. The ESA satellite GOCE will be a very important contributor, but only for wavelengths larger than 100km. For shorter wavelengths, data from GOCE must be combined with traditional gravimetry, like what we have been doing for quite some time now.
- Unlike on land we do not have readily available adjustment data. What we need is the true geoid and we need it at the cm level. We are unfortunately not quite there at the moment. The varying gravity coverage is one challenge. Can our methods be further enhanced/refined, are we using the optimal method etc., is another very important topic for our WG. When combining the geoid with satellite altimetry, are we using the optimal method. Can we enhance the "Direct method (MSSH-Geoid)" by using methods like ICM developed by UEDIN in the GOCINA project, use of collocation (part of Dagny Lysaker's PhD thesis in the OCTAS project)?



My personal opinion, cont.

- I would like to see an even stronger focus on the marine geoid in the future. Should we start developing add on products, like ocean circulation models, based on our geoid model? Someone within NKG ought to do so.
- Some of our activity like gravity campaigns can clearly be organised as projects. The same is the case for a new NKG geoid as long as we will only be using existing methods and do not rely on new developments. I do however feel that it is quite difficult to do so when theoretical improvements are needed. This kind of work is typically done by PhD students, Post doc's etc. and you never know in advance whether there will be a break through or not and when this might happen.
- The need for theoretical work should not be underestimated and it is, in my opinion, a very natural and necessary part of the work done in our WG, and if we should do anything about this then I would suggest to strengthen and not weakening this part. This kind of work can simply not be arranged as a project.
- I am in favour of keeping our WG, but this is my personal opinion. Whether there should be changes to what we do is an open question. Some of our activities might very well be defined as projects.

