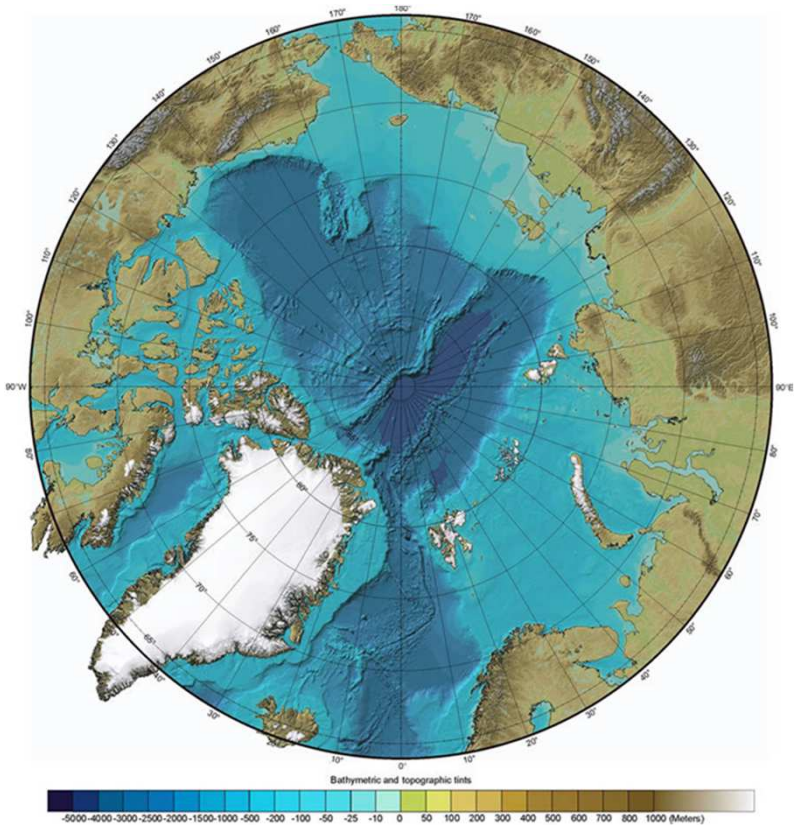
Natural Hazards in the Arctic

Mathilde B. Sørensen
Dept. of Earth Science, University of Bergen, Norway

Natural hazards in the Arctic



(from NOAA)

«Direct events»
•Earthquakes
•Landslides/submarine slides/snow avalanches
•Volcanic eruptions
•Extreme meteorological events
•Floods

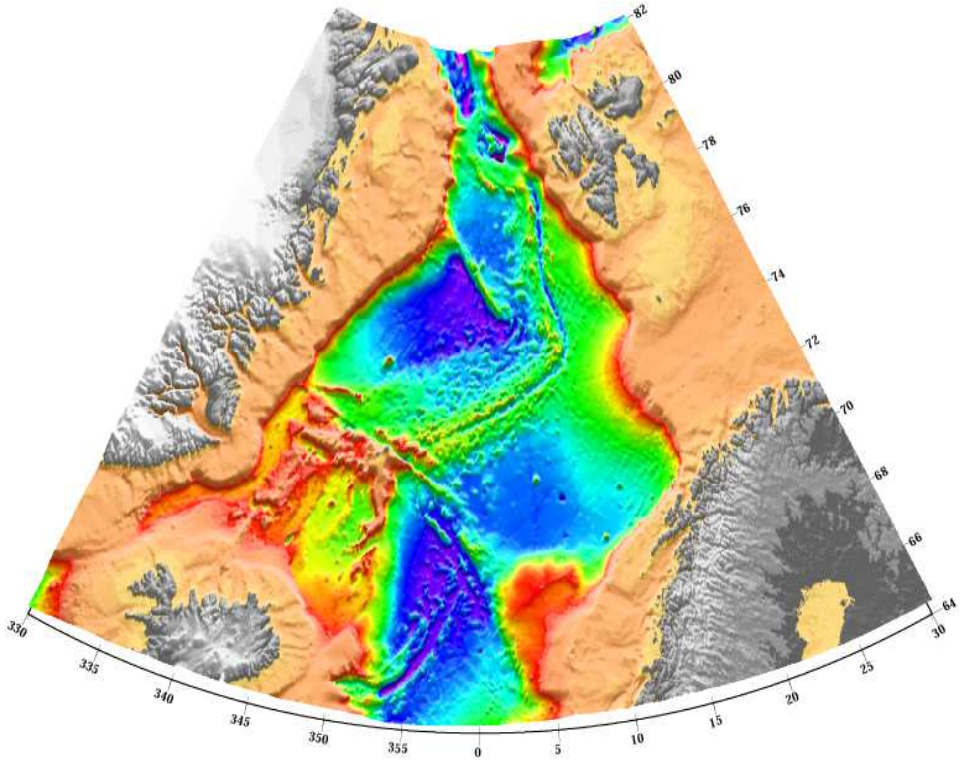
«Triggered events»
•Tsunamis
•Landslides/submarine slides/snow avalanches
•(Volcanic) earthquakes

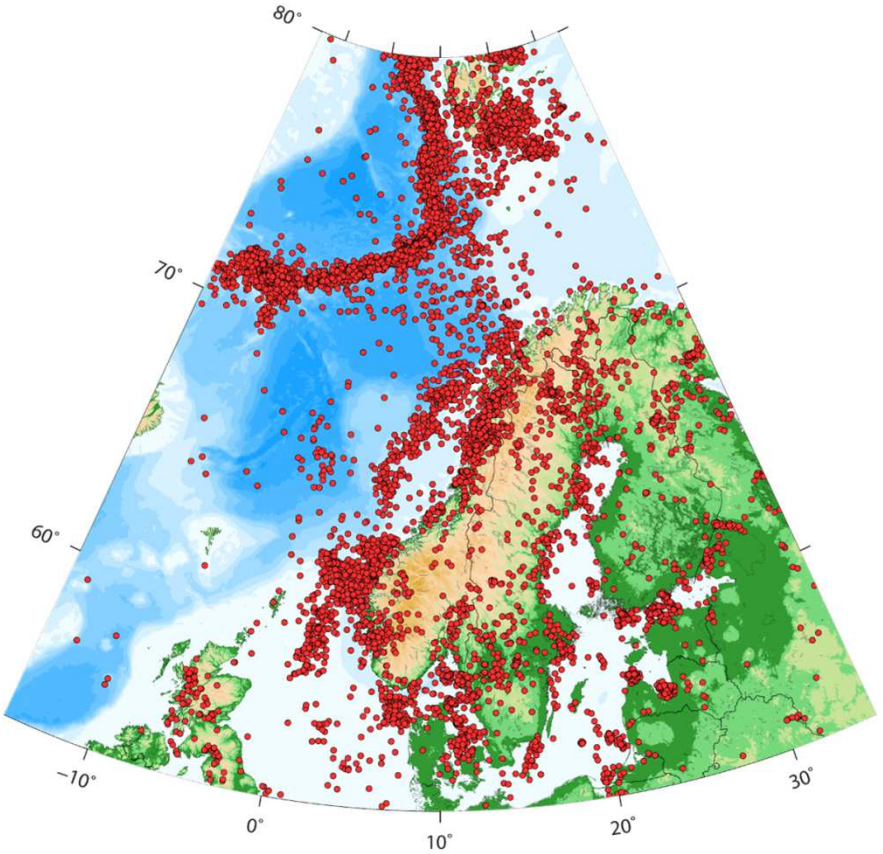
Climate change effects
•Thawing of permafrost
•Melting of land ice
•Changes in sea ice cover
•…

Natural hazards become a problem when they interact with human infrastructure

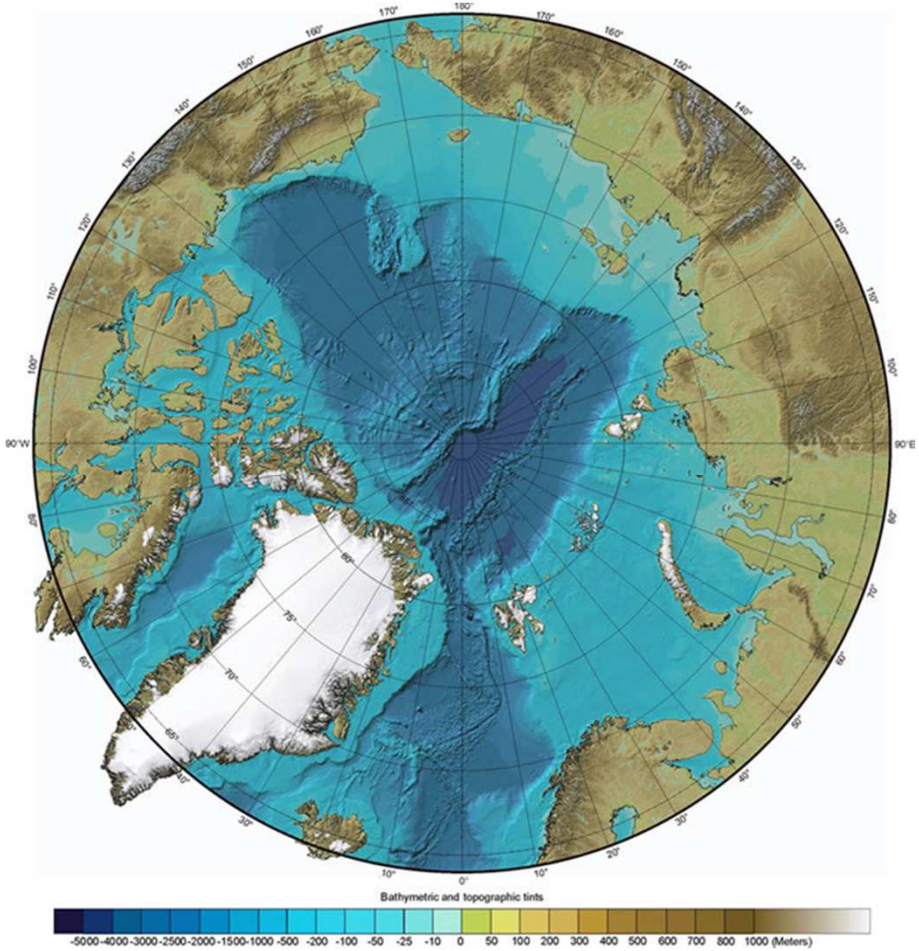
Extreme calving event in Greenland
https://www.youtube.com/watch?v=wcurEjHWs9g
(0:40)

Seismicity in Norway and the adjacent offshore areas in the period 1980-2010 (data from NNSN)



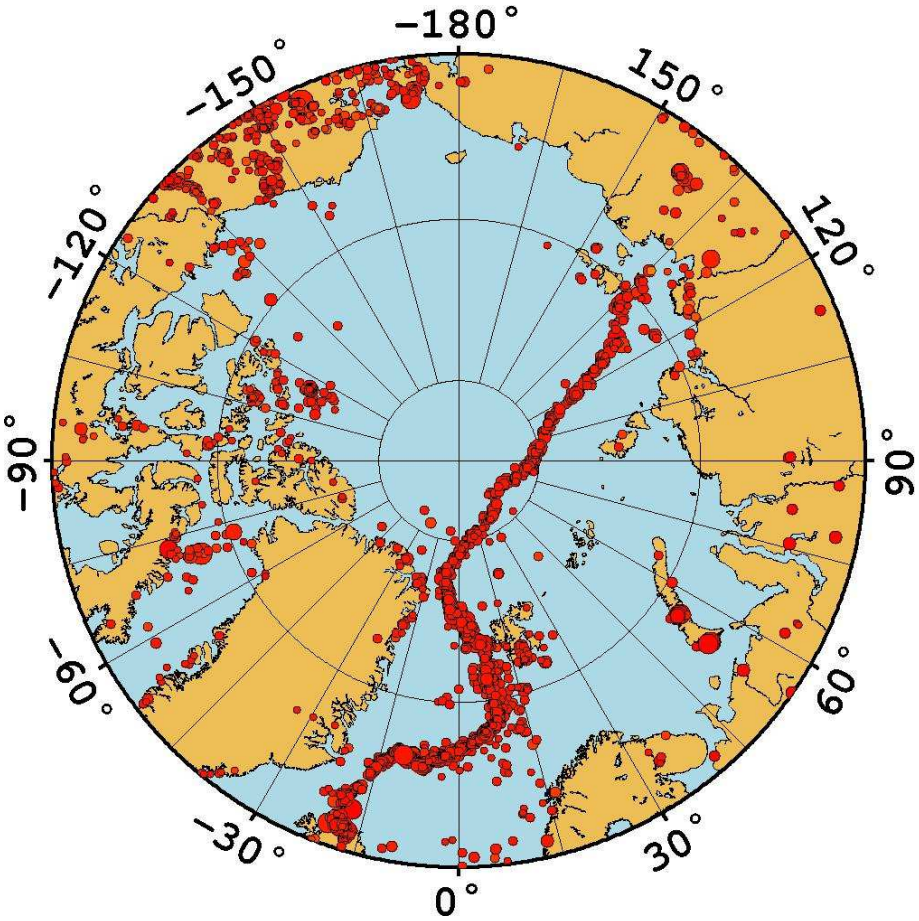


European Plate Boundary in the Arctic



(from NOAA)

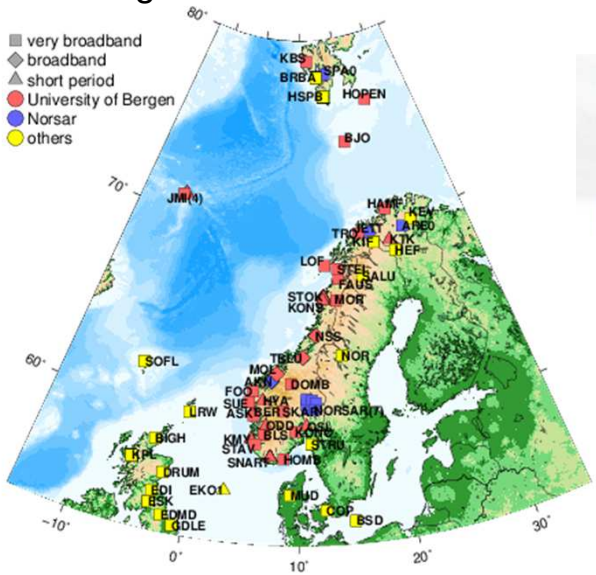
Seismicity in the Arctic



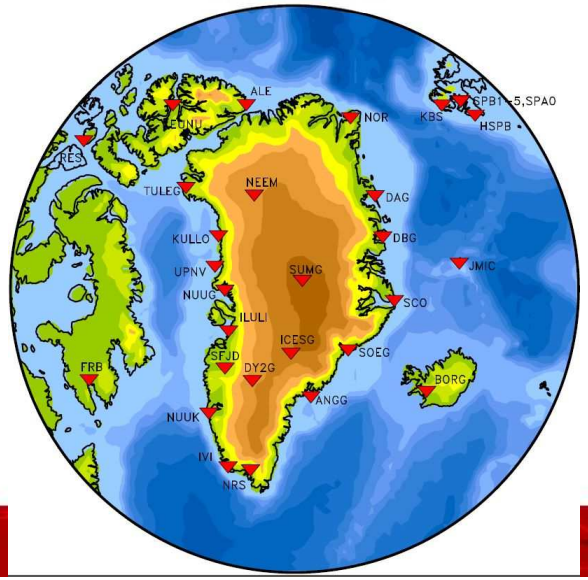
(data from USGS 1900-2013, M>4)

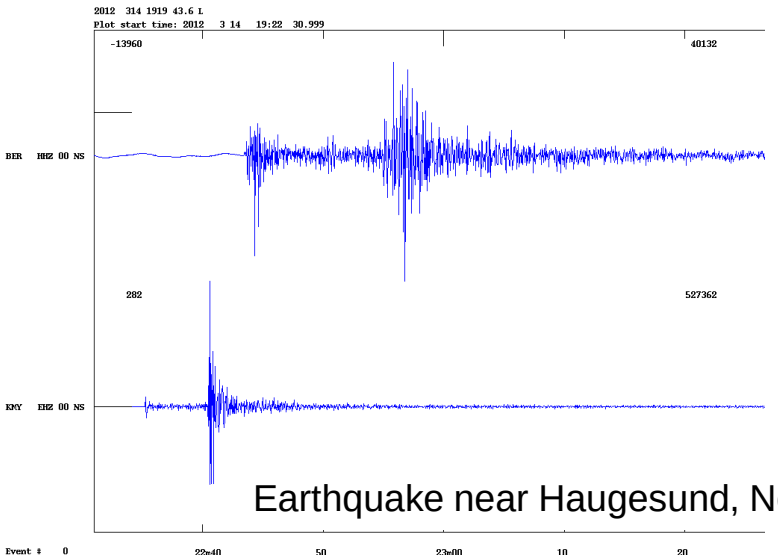
Monitoring: seismic networks

Norwegian National Seismic Network

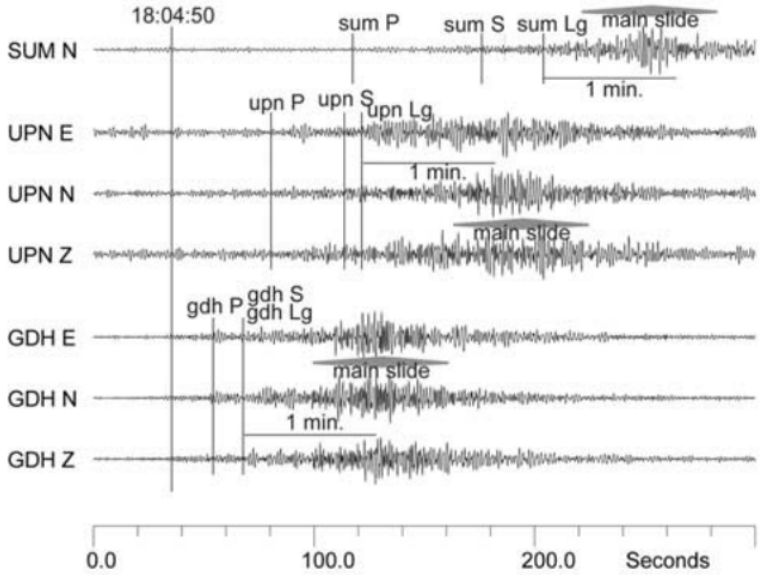


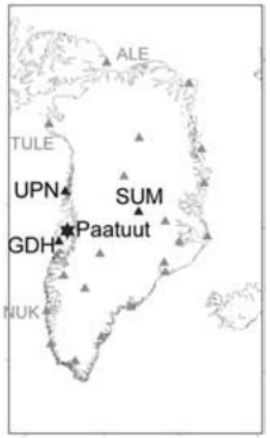
GLISN stations





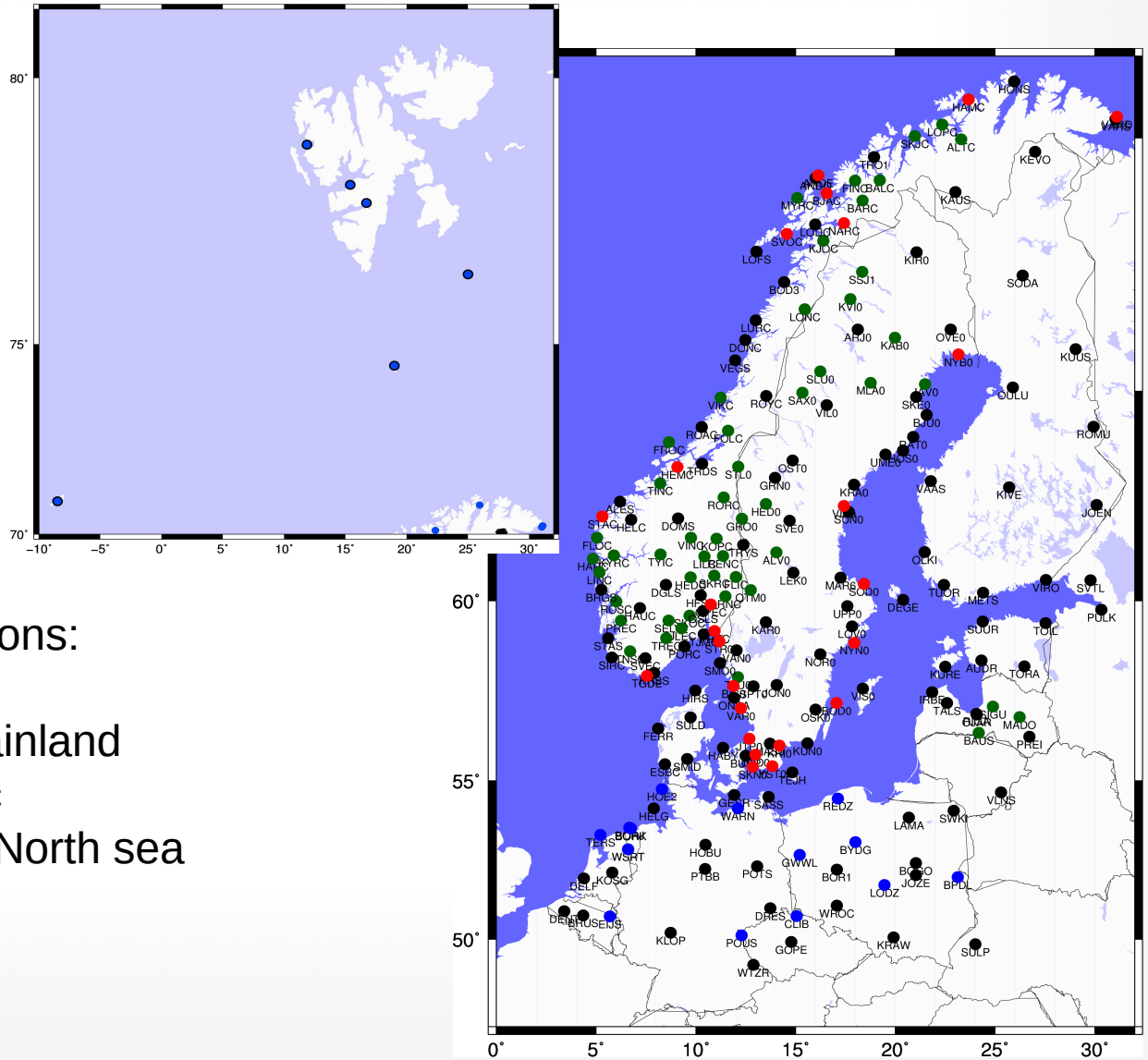
Earthquake near Haugesund, Norway





Landslide in Greenland, 2000

GNSS (GPS) infrastructure in Norway and Northern Europe



Kartverket GPS stations:

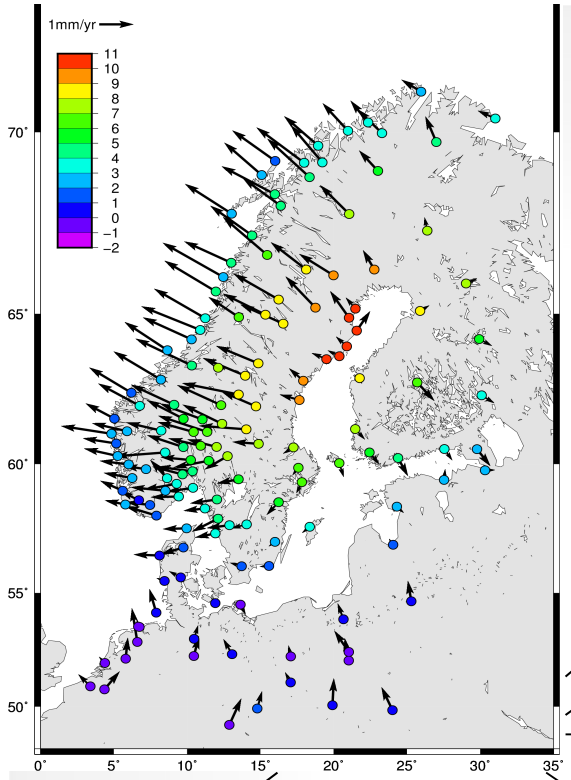
~ 200 stations on the Norwegian mainland

~ 9 stations in Arctic

~ 25 stations in the North sea

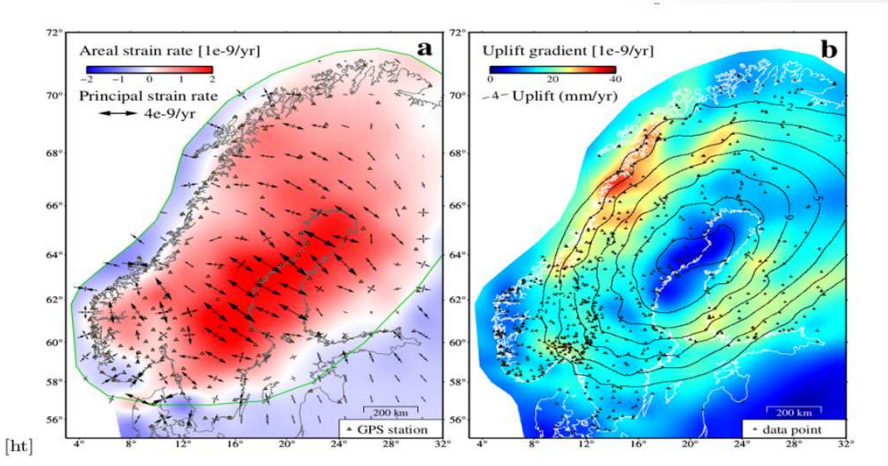
Kartverket H. Kierulf

GPS derived velocity fields have several geophysical applications



Neotectonic

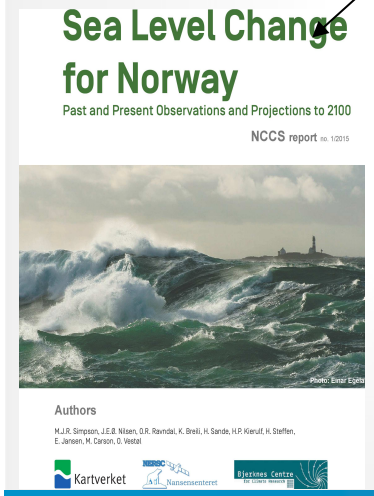
Glacier massbalance



[ht]

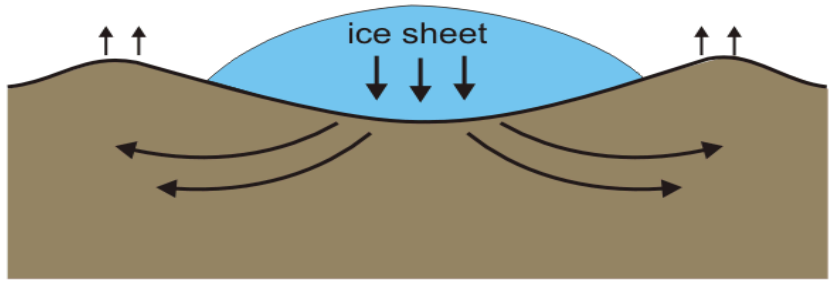
Strain rate (from keiding etal 2015)

Earthquakes



Hydrological loadings

GIA, Ice history and rheology



H. Kierulf, Kartverket

EPOS: European Plate Observing System

Resarch Infrastructures and e-science for data and observations on geo-hazards and geo-resources

European Tectonic Plate covers a considerable geographical area

EPOS: a single, pan-European distributed RI

TCS Seismology

80 Seismic Networks

4939 Seismic Stations

1 PB of Data

TCS Geodesy

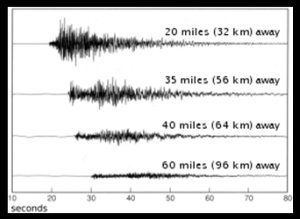
56 GNSS Networks

2272 GPS Stations

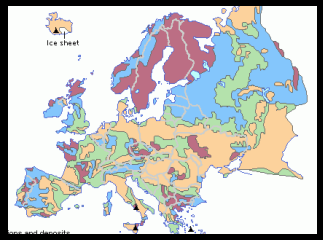
1.2 PB of Data

Diverse Data

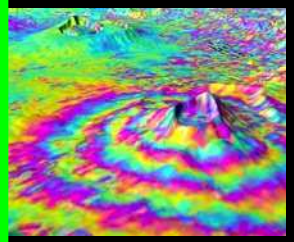
Seismograms



Geological Maps



SAR Interferograms



Hazard Maps

EPOS: a single, pan-European distributed RI

What is EPOS?

EPOS is a **long-term plan for the integration**
of research infrastructures for solid Earth Science in Europe

EPOS integrates the
existing (and future) advanced
European facilities into
a single, distributed,
sustainable infrastructure
taking full advantage of new **e-science opportunities**

25 COUNTRIES
Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Grecee, Hungary, Iceland, Ireland, Italy, Netherland, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom

4 INTERNATIONAL ORGANIZATIONS
Orfeus, Emsc, Euref, Intermagnet

256 NATIONAL RESEARCH INFRASTRUCTURES

4939 SEISMIC STATIONS

2272 GPS RECEIVERS

464 TB SEISMIC DATA

118 LABORATORIES

828 INSTRUMENTS

Several PetaBytes of solid Earth Science data will be available

Several thousands of **users** expected to access the infrastructure

Solid Earth Science

- Different communities involved
- Multidisciplinary contributions
- Community building
- Services to society
- Geo-Hazards
- Geo-Resources
- Environmental hazards (including anthropogenic hazard)

Recent achievements in EPOS

- Following an initial 4-years with a **Preparatory Phase** project **(EPOS-PP)** funded by EU-FP7, **EPOS** has now started it's **Implementation Phase (EPOS-IP)** which is funded by Horizon2020 (total budget: 18.2 Million EUR).

- Parallel with this, **Norwegian National EPOS Consortium (NNEC)** which was established in 2009, has developed the EPOS-Norway Project.

- **EPOS-Norway Project (EPOS-N)** has secured funding from RCN (total budget: 51 Million NOK).

Norwegian National NNEC Consortium

http://www.epos-no.org
http://www.epos-eu.org

EUROPEANPLATEOBSERVINGSYSTEM

University of Bergen,
CMR, NGI, NGU, NORSAR, SK, UiO

Research Infrastructure and E-science for Data and Observatories on Earthquakes, Volcanoes, Surface Dynamics and Tectonics

EPOS-N

EUROPEANPLATEOBSERVINGSYSTEM EPOS-Norway

Main objectives of EPOS-Norway

The main vision of the European Plate Observing System (EPOS) is to address the three basic challenges in Earth Sciences:

- Unravelling the **Earth's deformational processes** which are part of the Earth system evolution in time.
- Understanding the **geohazards** and their implications to society.
- Contributing to the safe and sustainable use of **georesources**.

The goal of EPOS-Norway is to bring all data that maps the physical conditions of the Earth's crust under a unified umbrella that;

- Makes **data available and easier accessible** to the full geoscience community (and the public).
- Provides an **integrated infrastructure** that can be used by geoscientists and provide mechanisms for improved use of all available geodata.
- Initiates and facilitates **closer interaction between scientists from different fields** in terms of joint interpretation of different data for the same geographical areas.

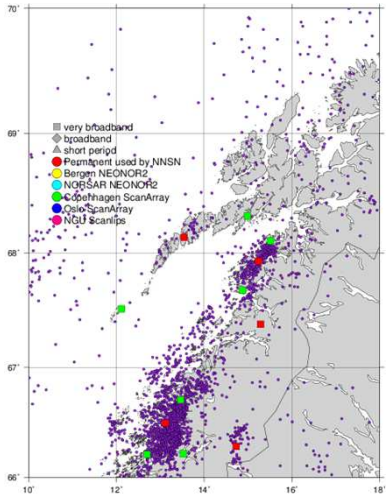
EPOS-Norway aims to implement this goal through:

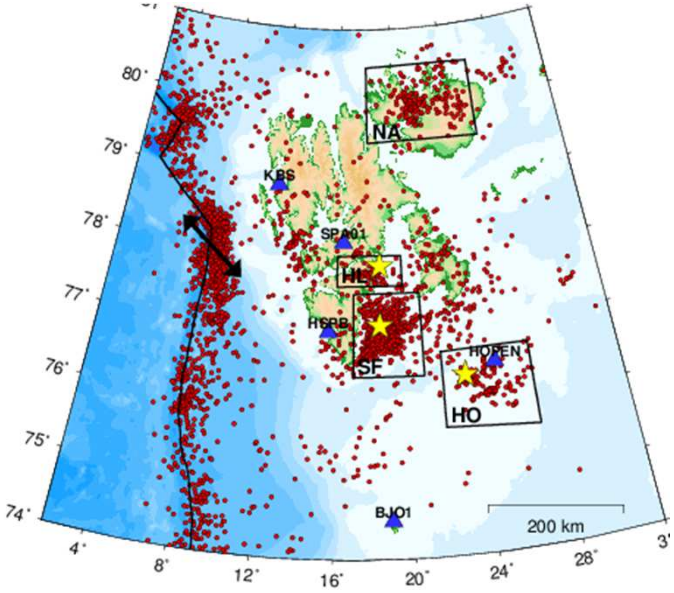
- **Component-1**: **Developing a Norwegian EPOS e-infrastructure** to integrate the data from the seismological and geodetic networks, as well as the data from the geological and geophysical data repositories, which is in line with European EPOS implementation.
- **Component-2: Improving the monitoring capacity in the Arctic**, including northern Norway and the Arctic islands.
- **Component-3: Establishing a Solid Earth Science Forum** for providing a constant feedback mechanism for improved integration of multidisciplinary data, as well as training of young scientists for future utilization of all available solid Earth observational data through a single e-infrastructure.

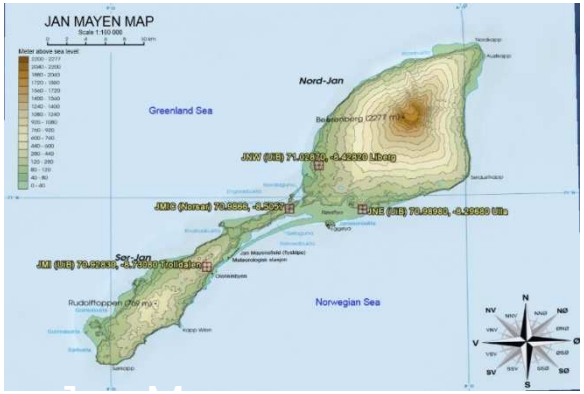
EPOS-Norway (EPOS-N) RCN Project

- **Component 1:** E-infrastructure
  - Integration of Solid Earth Data in Norway
  - Developing technologies for visualization and processing for Europe
- **Component 2:** Improved Observations in the Arctic
  - Nordland (seismic and geodetic stations)
  - Svalbard (seismic and geodetic stations)
  - Jan Mayen (volcano observatory)
  - Bjørnøya (seismic array)
  - OBS – offshore surveys
  - Knipovich Ridge aeromagnetic survey
- **Component 3:** Solid Earth Science Forum
  - Solid Earth Science Forum Workshops
  - Training sessions
  - External Advisory Board

EPOS-N geographic areas

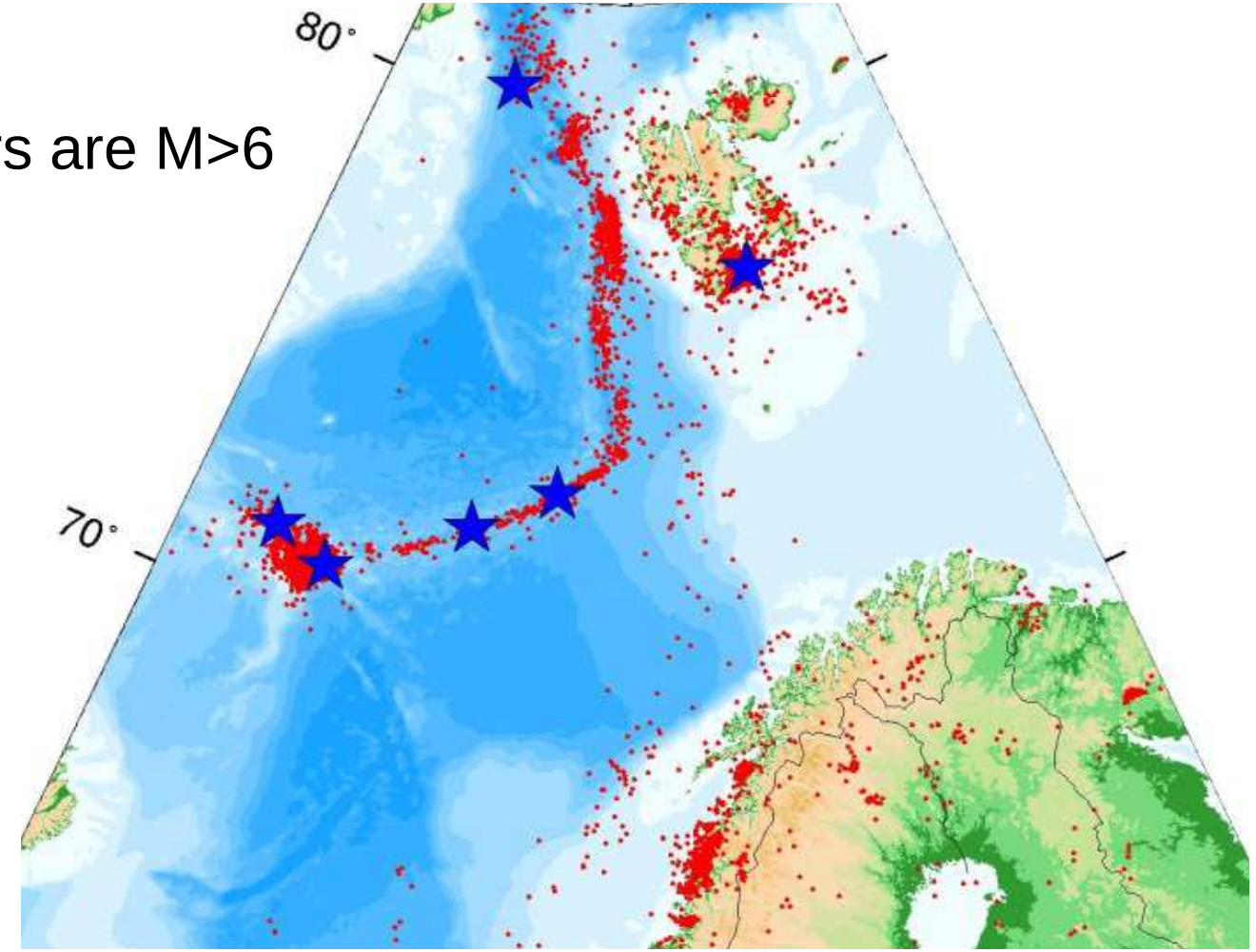




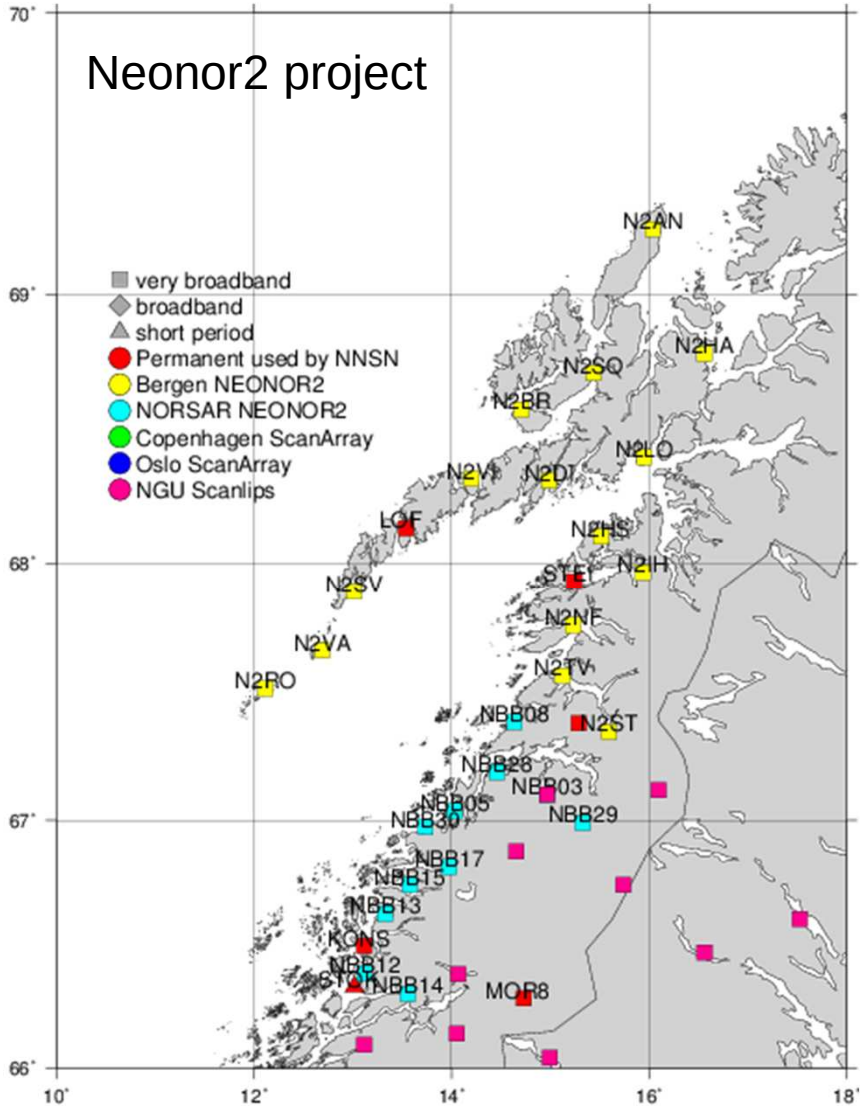


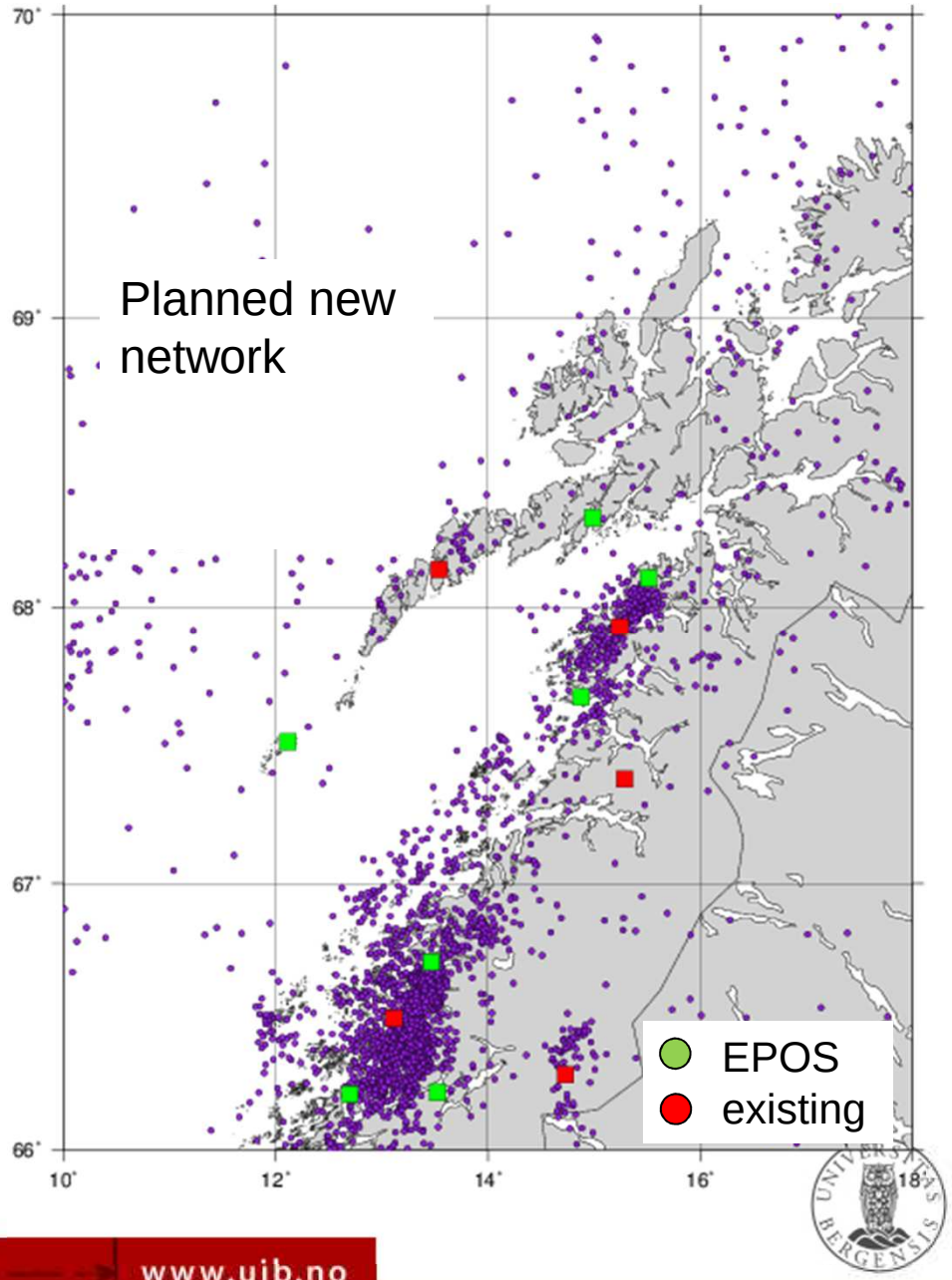
Seismicity 2008-2012

Blue stars are M>6

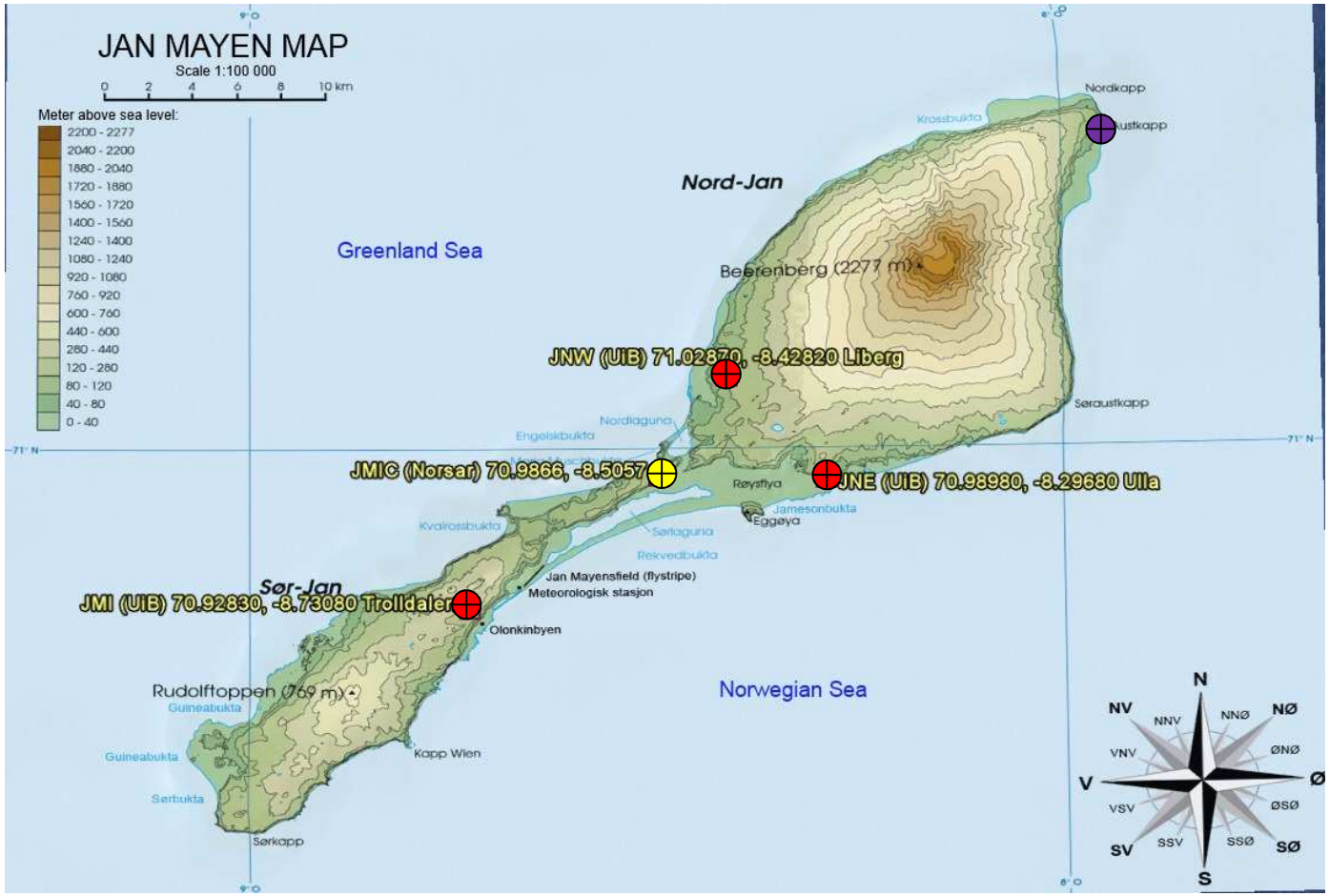


Nordland


Neonor2 project
very broadband
broadband
short period
Permanent used by NNSN
Bergen NEONOR2
NORSAR NEONOR2
Copenhagen ScanArray
Oslo ScanArray
NGU Scanlips
N2AN
N2HA
N2SQ
N2BR
N2LO
N2VI
N2DT
LOF
N2HS
N2IH
STEI
N2SV
N2NF
N2VA
N2TV
N2RO
NBB08
N2ST
NBB26
NBB03
NBB05
NBB29
NBB30
NBB17
NBB15
NBB13
KONS
NBB12
NBB14
MOR8
70°
69°
68°
67°
66°
10°
12°
14°
16°
18°


Planned new network
EPOS
existing
70°
69°
68°
67°
66°
10°
12°
14°
16°
18°

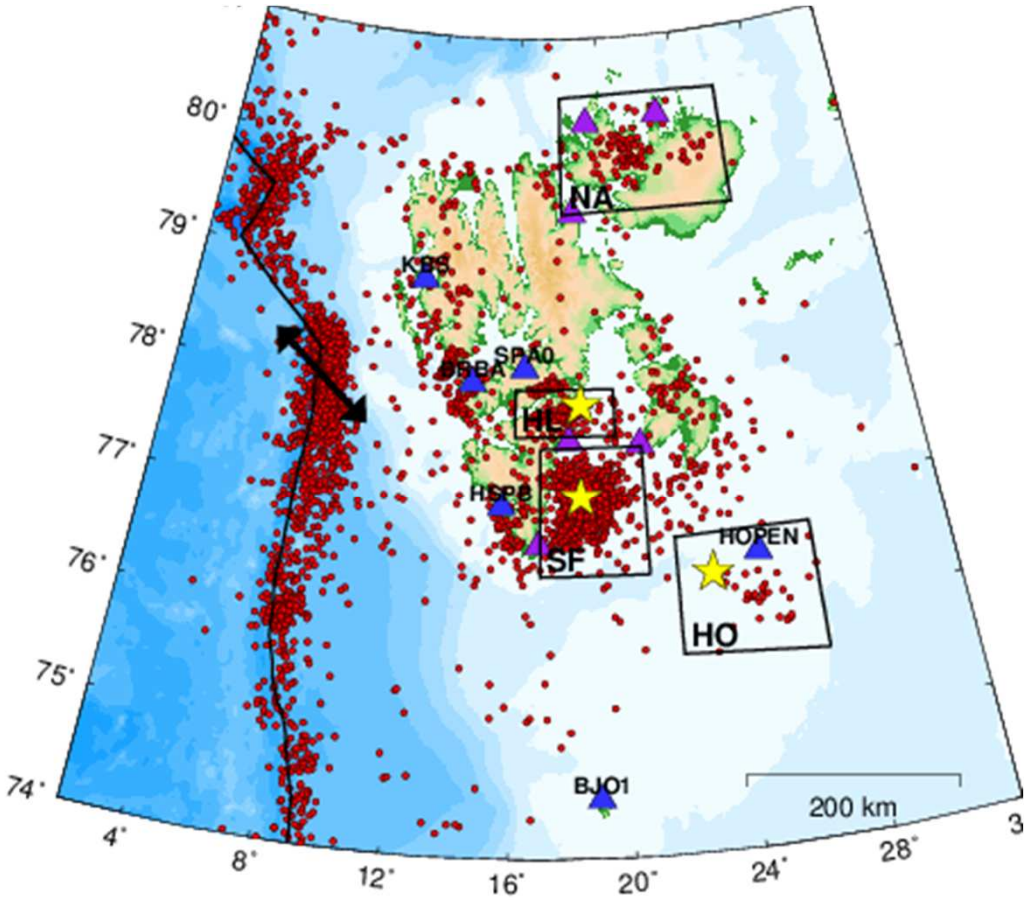
Jan Mayen



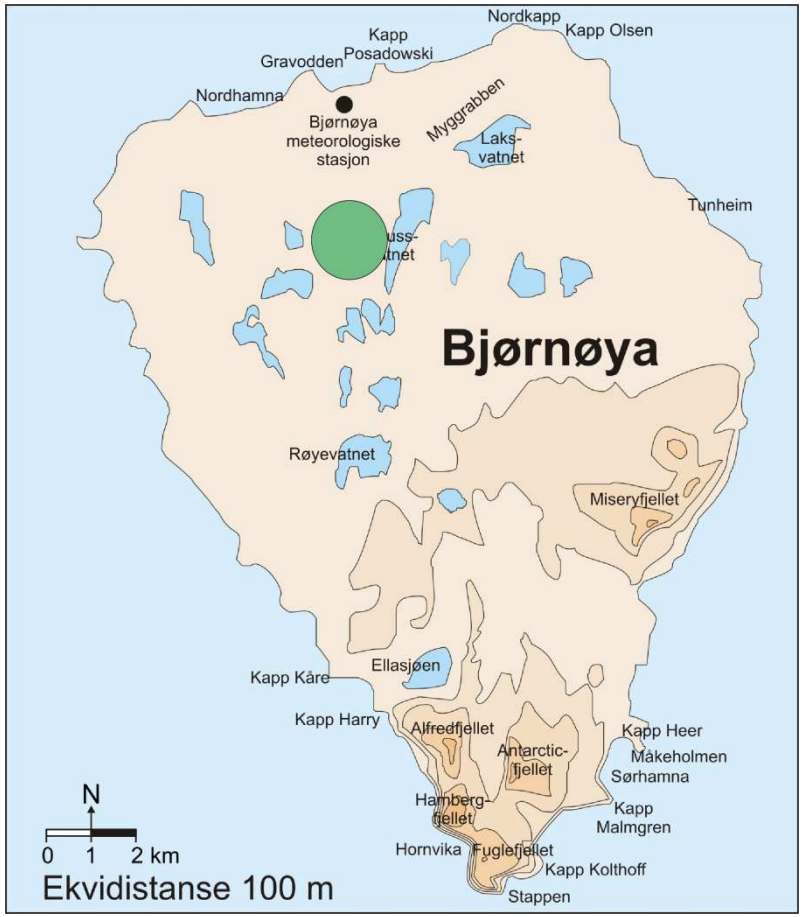
EPOS EUROPEANPLATEOBSERVINGSYSTEM

UNIVERSITAS BERGENSIS

Svalbard


80°
79°
78°
77°
76°
75°
74°
4°
8°
12°
16°
20°
24°
28°
NA
HL
SF
HO
KBS
SPA0
HSPB
HOPEN
BJO1
200 km

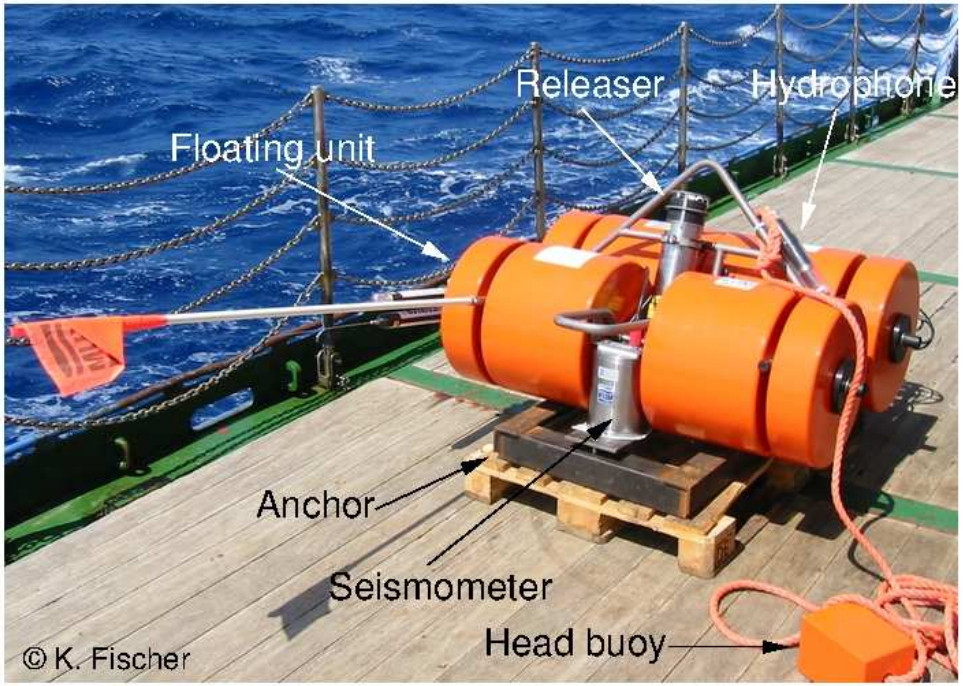
Area for planned deployment of a 9-element seismic array



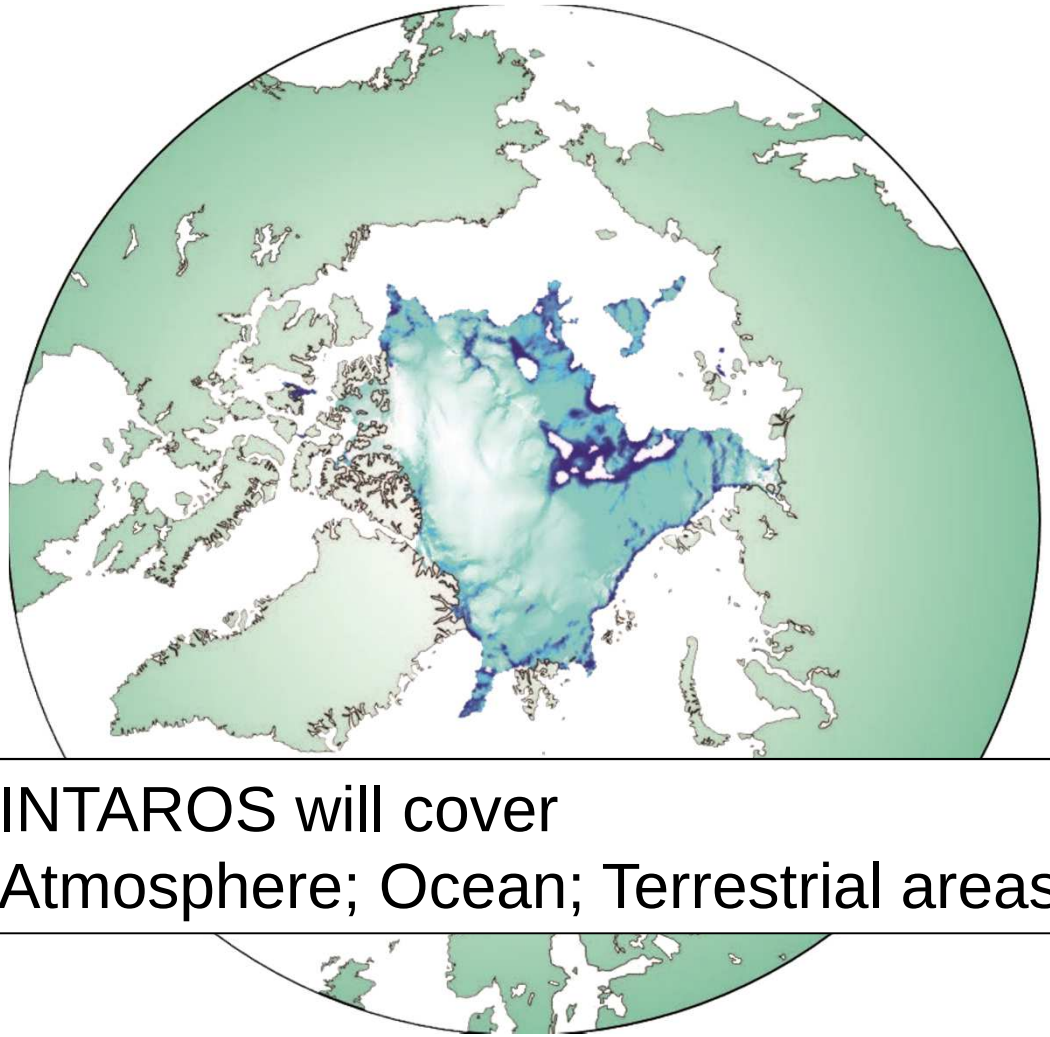
OBS (3 broadband systems)

To be deployed from ship or ROV

First deployment planned through INTAROS project



INTAROS overall objective



INTAROS will cover
Atmosphere; Ocean; Terrestrial areas

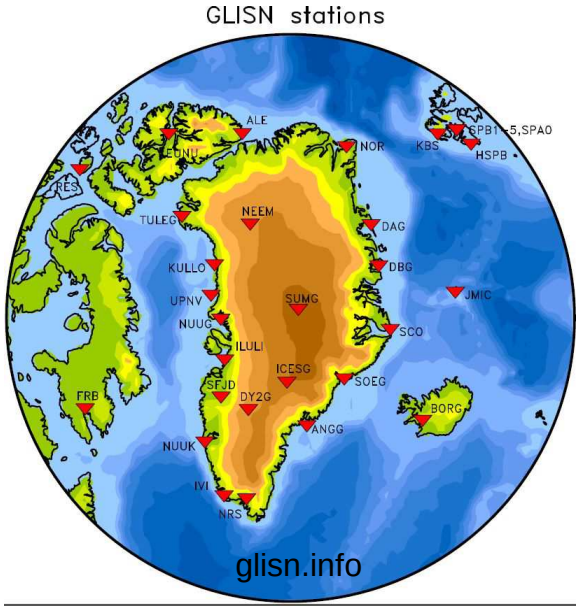
Is to develop an efficient integrated Arctic Observation System by

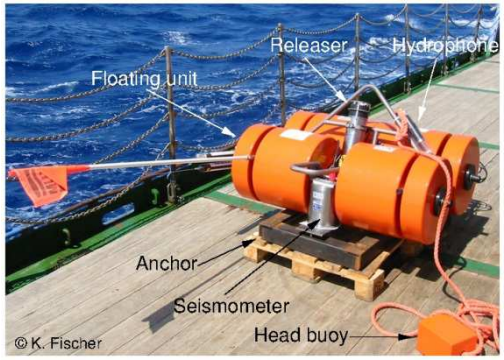
- **extending,**
- **improving and**
- **unifying**

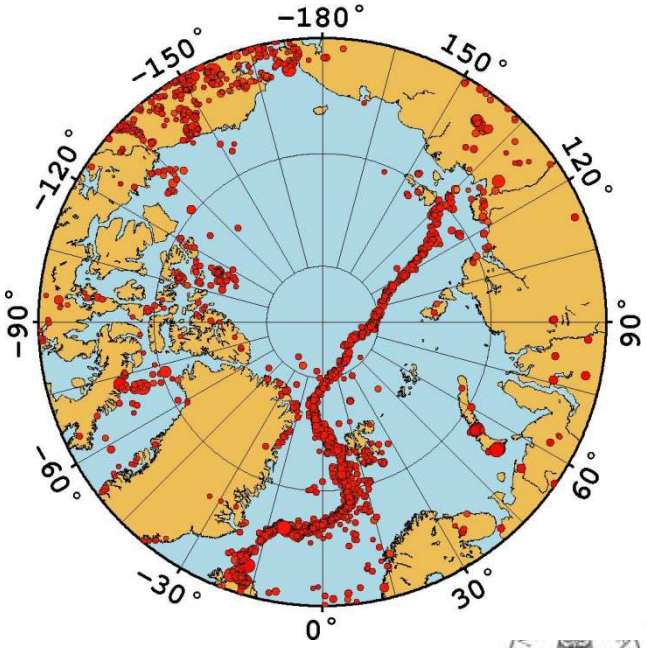
existing and evolving systems in the different regions of the Arctic

INTAROS monitoring of natural hazards

- Merge all available seismometer data from existing stations
- Extend monitoring to offshore areas
- Combine with data from the local populations



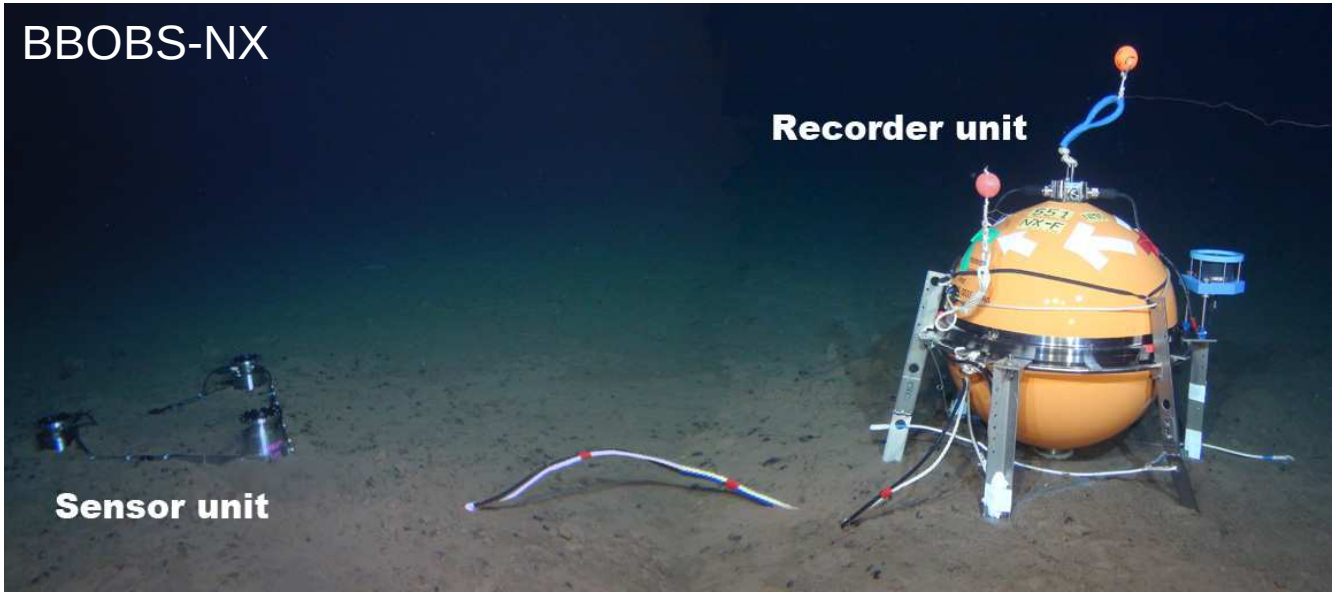




INTAROS expected outcomes

- Improved monitoring of natural hazard events => better understanding of challenges in a changing climate
- Data for improved weather forecasting and climate models
- Laying the foundation for interdisciplinary work
- Involvement of, and awareness building among, local populations

The longer-term vision…



Stay tuned…

- Natural hazards are expected to become more significant in the Arctic in the future
- There are still large monitoring gaps in the Arctic region
- Some of these gaps will be filled in the near future