Seismological monitoring in the Arctic: An introduction to INTAROS

Zeinab Jeddi (1), Mathilde B. Sørensen (1), Peter Voss (2), Trine Dahl-Jensen (2) and Tine B. Larsen (2)
(1) University of Bergen (UiB), Earth Science Department, Bergen, Norway (zeinab.jeddi@uib.no)
(2) Geological Survey of Denmark and Greenland (GEUS), Copenhagen, Denmark

Introduction

The Arctic is experiencing the rapid changes in the climate system. Accordingly, several natural disasters, e.g. landslides or earthquakes among others, are likely to increase together with the expected changes in the climatic conditions in the Arctic.
To study the temporal variations of the Arctic seismicity and assess the seismic hazard in the area, a unified earthquake catalogue is required. Many datasets are currently available through national and international monitoring networks, however there has been little effort to integrate these data and make it available to the scientific community. Eu-funded INTAROS project (Integrated Arctic Observation System) is expected to assess the strengths and weaknesses of the existing observing systems, and contribute with innovative solutions to fill some of the critical gaps in the in situ observing network.

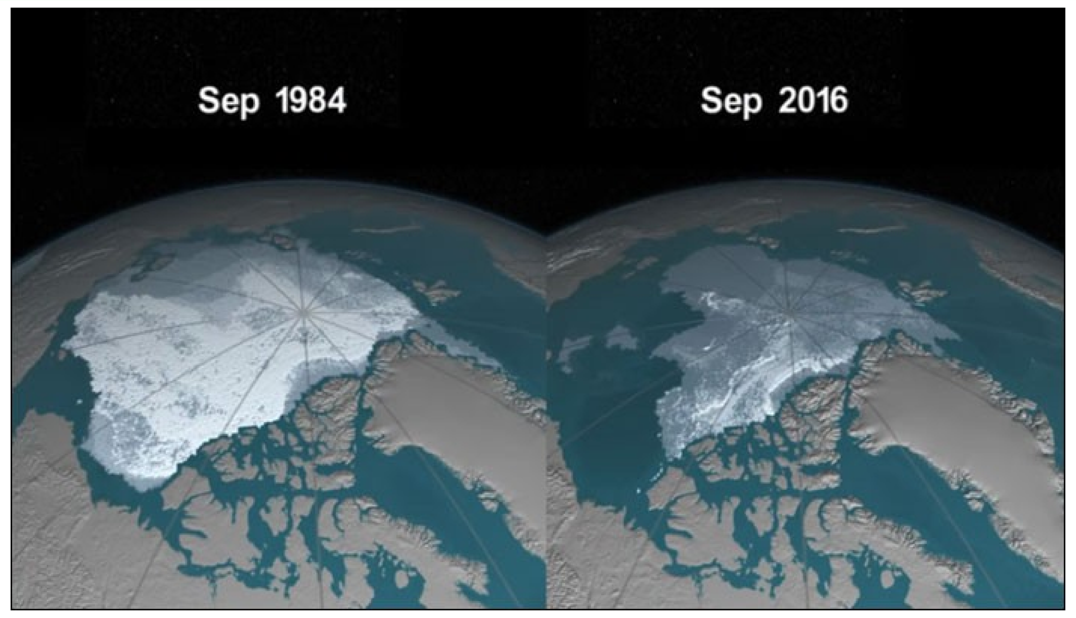

Figure 1: Arctic sea ice changes over the years. [1]

Seismological

The seismological component of the INTAROS is focused on creating a baseline earthquake database, and in this regard a catalog of seismological monitoring capabilities was developed for the Arctic region between 1960 and 2016, together with relocation.

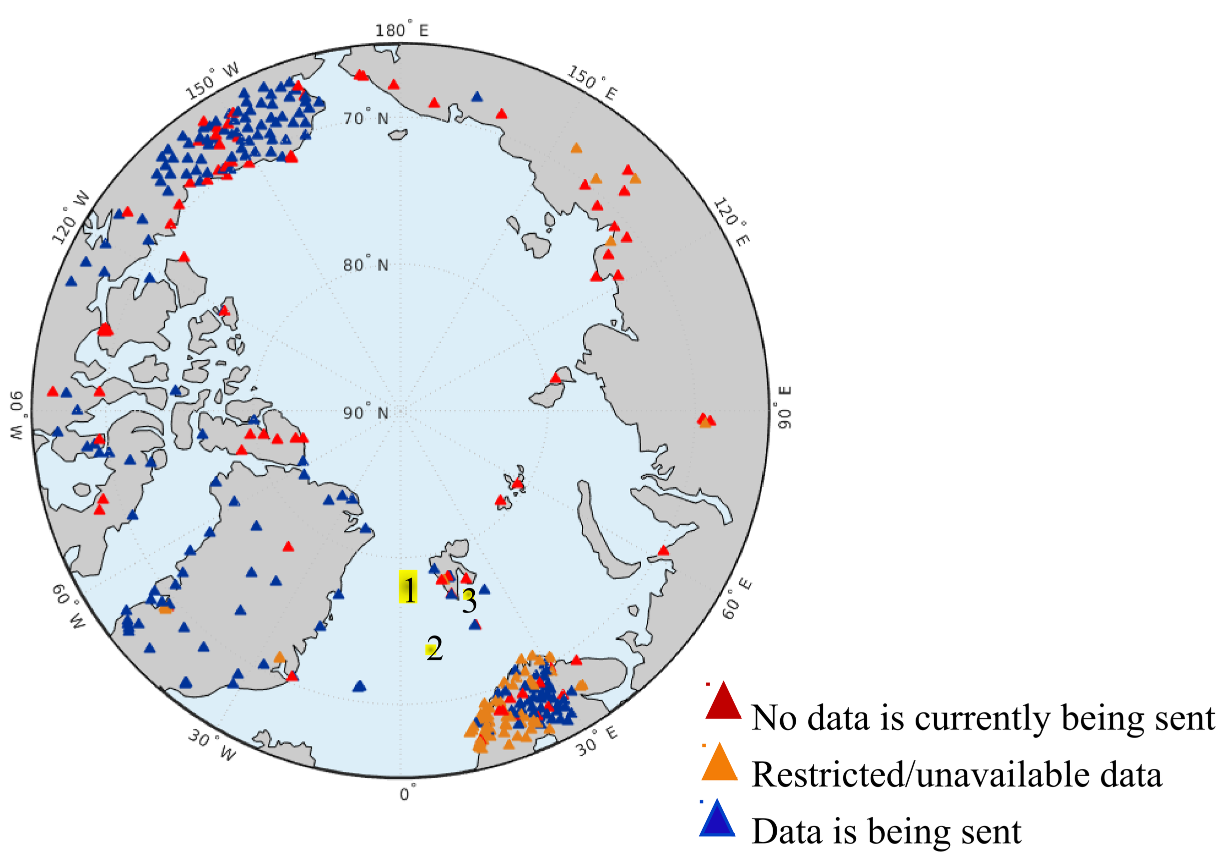

Figure 2: Map of seismic stations in the Arctic. 488 stations, associated with 19 different networks, have been operating in the area between 1950 and 2018. Numbers 1 to 3 refers to in-situ measurements (see section 'In-situ measurements').

Event Catalog

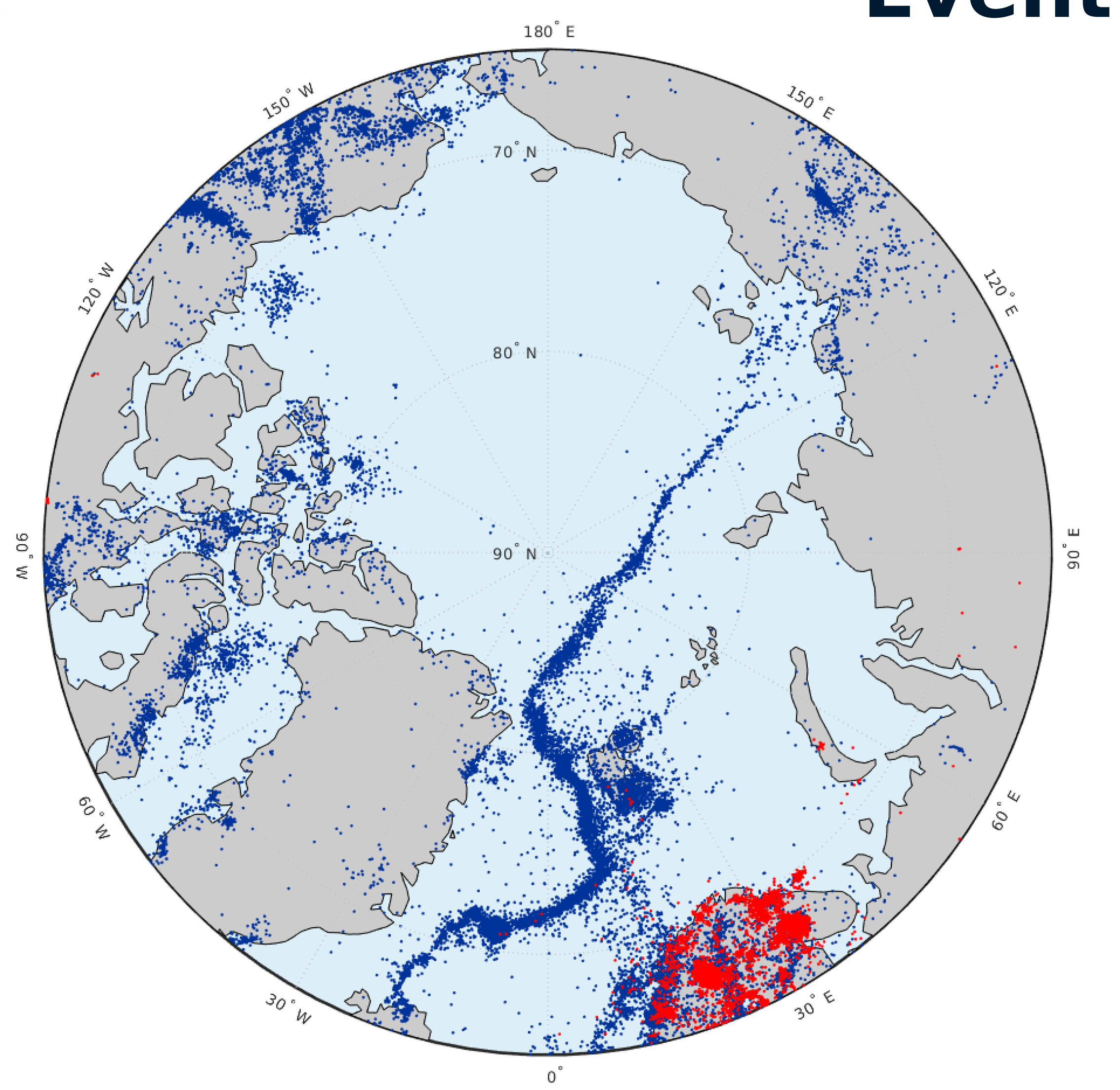

Figure 3: Geographical distribution of events in the Arctic. A baseline earthquake database catalog of seismological monitoring capabilities was developed for the north of Arctic Circle (65°N-90°N) between 1960 and 2016. Blue: Earthquakes, Red: Explosions. In total ~121000 events were reported which Explosions are the most frequent event types in the catalog (~80000 in total).

INTAROS event catalog link:
https://catalog-intaros.nersc.no/dataset/seismic_catalog1.

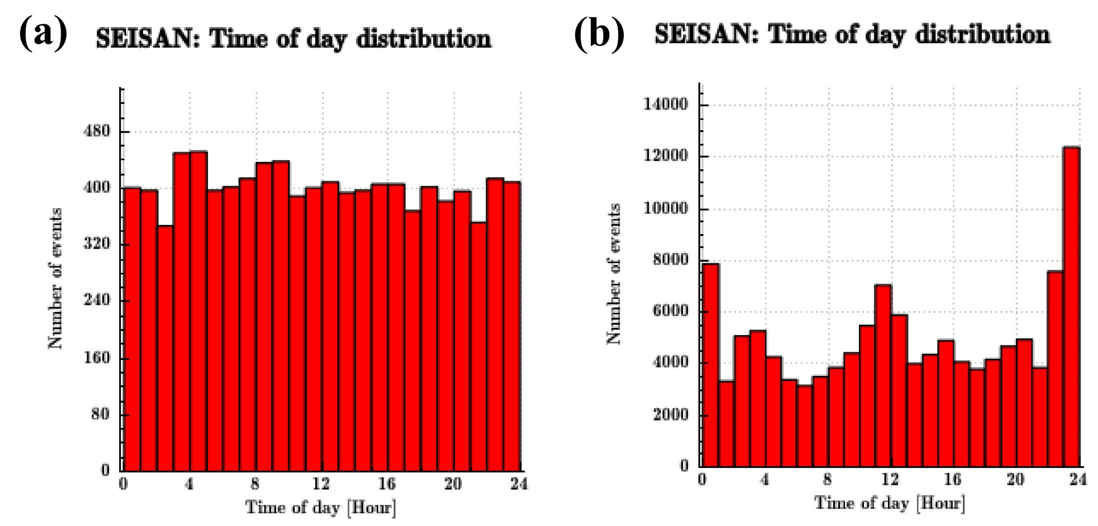

Figure 4: Time of day distribution of the events. **a)** Only earthquakes, **b)** only Explosions.

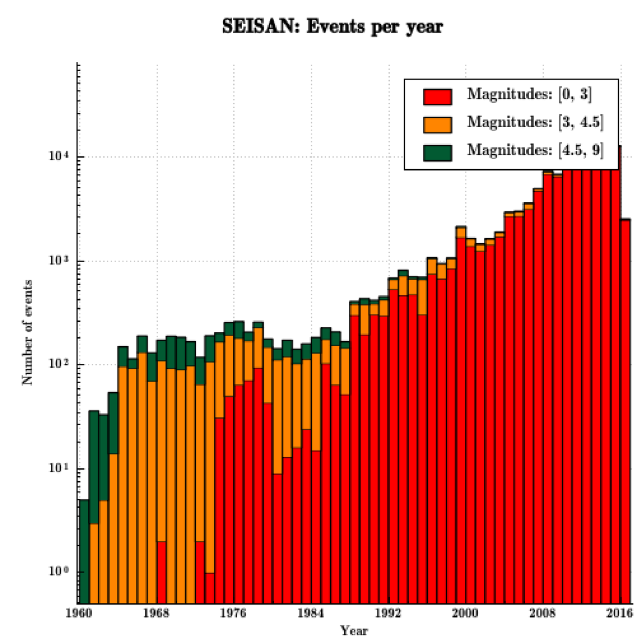

Figure 5: Annual distribution of events for 3 magnitude ranges: M<3, 3<M<4.5 and M>4.5.
Different magnitude scales are used in the catalog and by considering all types, at least one magnitude value is assigned to most of the events (ranging between ML=0.1 to Mb=6.9).

The number of detected events has increased over time, especially since the mid-1980's. The most significant change is seen for smaller events (M<3), owing to improved monitoring at the high latitudes.

Catalog Relocation

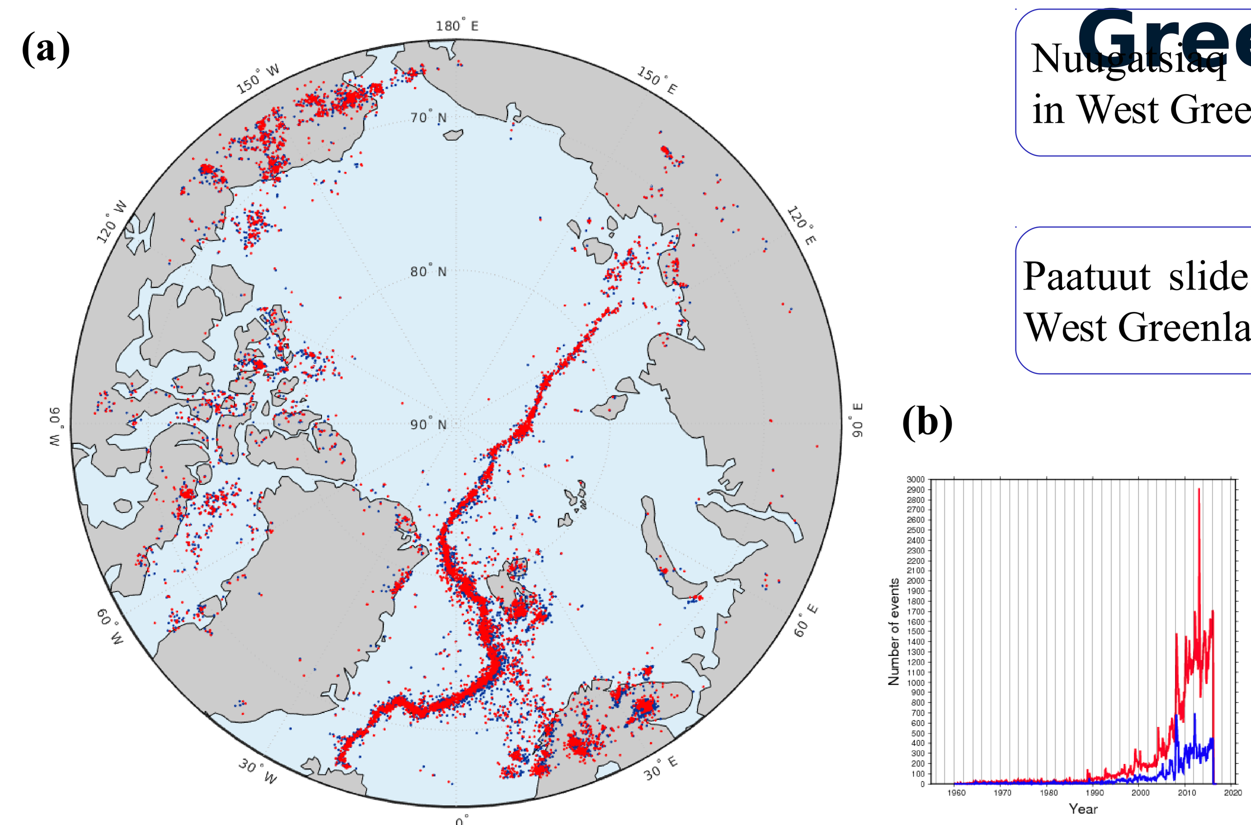

Figure 6: a) ISC locations [2] (blue) compared to relocations using iLOC [3] (red). **b)** Total number of events/month in our catalog (red) in comparison to the number of events with iLOC solutions (blue).

Non-tectonic events in Greenland

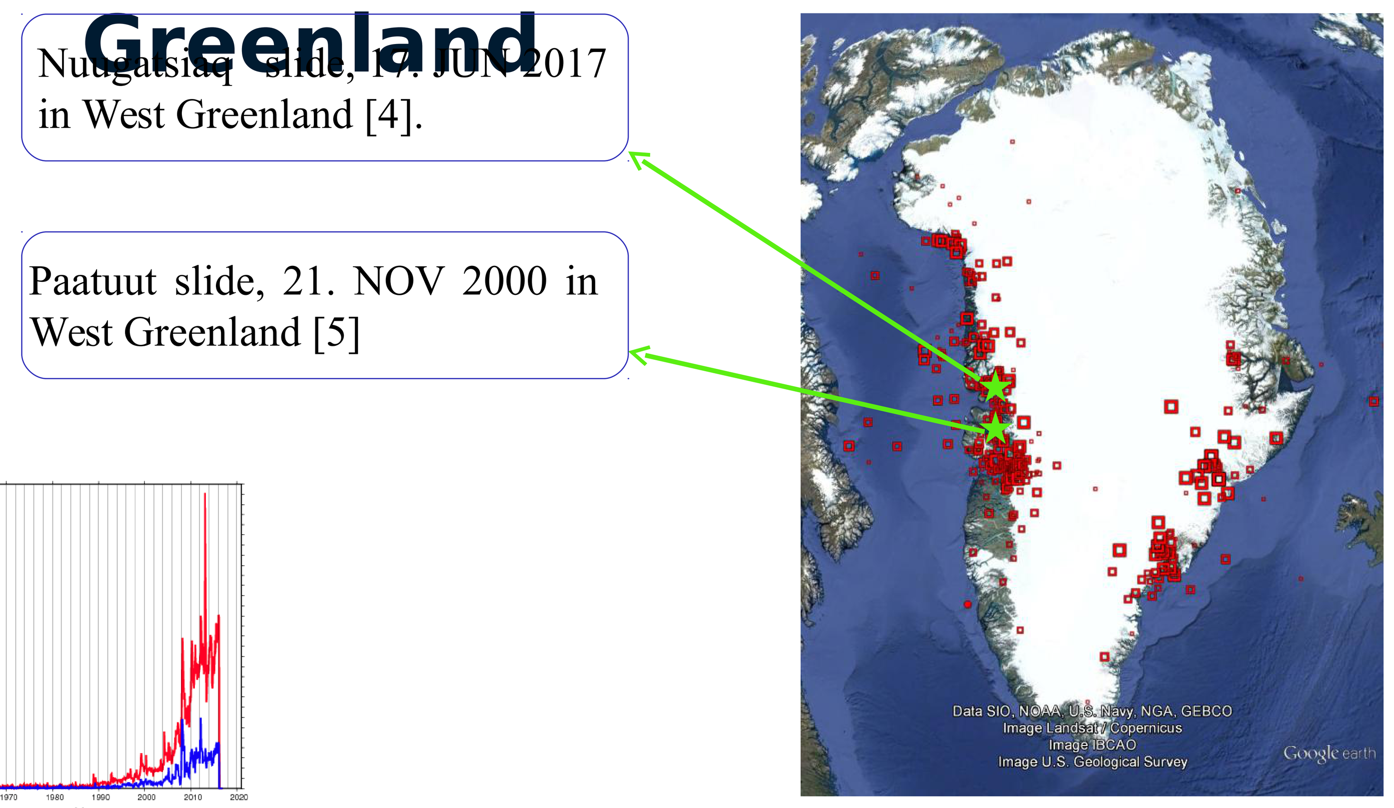

Figure 7: The locations of the glacial earthquakes of Greenland in the database, which are mostly in accordance with the locations of outlet glaciers (red). Stars indicate two significant known landslides in the catalog.

In-situ measurements

To improve the existing catalog and fill part of the large observational gap in the offshore regions of the Arctic (mainly due to the harsh weather conditions), Ocean Bottom Seismometers (OBS) were deployed in different regions of Northern Mid-Atlantic Ridge. The improvement of the monitoring coverage will provide a new dataset which will enable us to lower the earthquake detection threshold in the study area.

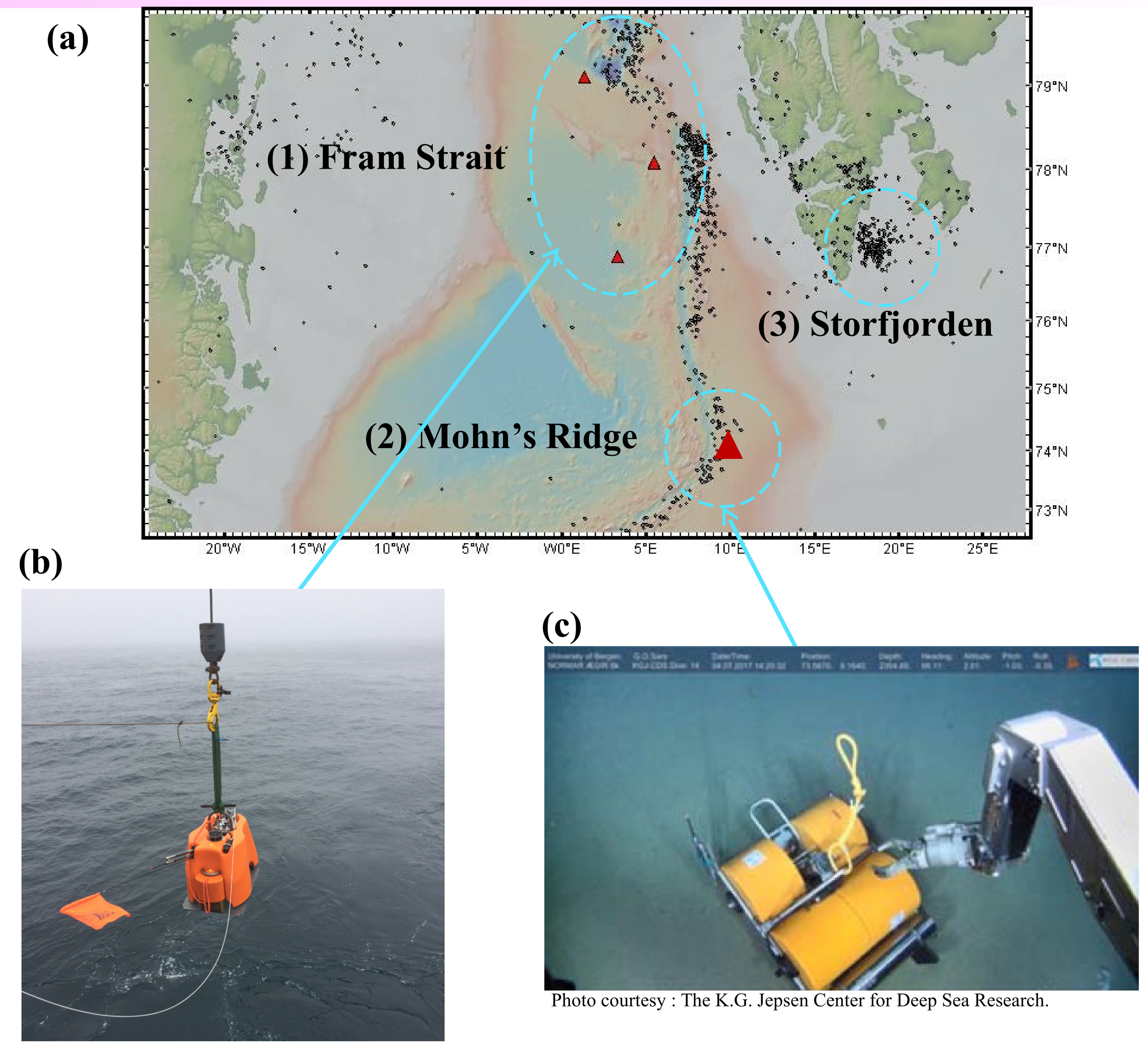

Figure 8: a) Bathymetry map of the area (background color). Black dots indicate the earthquake locations during 2014. (1) **Ongoing monitoring:** Three OBS are deployed in FramStrait along Mid-Atlantic Ridge between Aug.2018 and Aug.2019. **(2) Accomplished deployments:** Mohn's Ridge deployment (6 OBS) was done between Jul.2017 and Feb.2018 by K.G. Jebsen Centre for Deep Sea Research. The OBS network is around the Loki Castle hydrothermal field, located on the ultra-slow spreading ridge. (3) **Future plan:** Three OBS will be deployed in Storfjorden between Aug.2019 and Aug.2020 in collaboration with EPOS-N (European Plate Observing System-Norway) project. **b)** Deployment of OBS (NAMMU type) from INTAROS 2018 field cruise. **c)** OBS systems (LOBSTER type) placed on the sea floor using ROV.

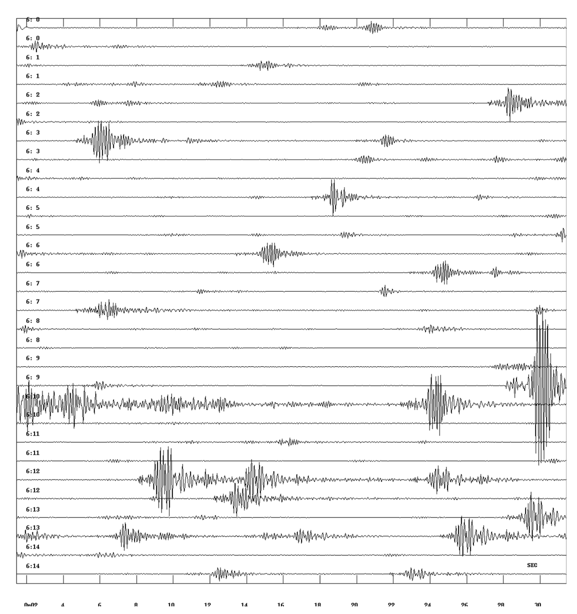

Figure 9. Fifteen minutes of continuous record is shown on one of the Mohn's Ridge OBS systems. Many unknown local events observed clearly in the OBS data which are not recorded in any of regional land stations. Detailed investigation of these activities is ongoing.

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