Operation of the

Norwegian National Seismic Network

2011

Supported by

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1 Introduction

This annual report describes the operation of the Norwegian National Seismic Network (NNSN) for the year 2011. The University of Bergen (UiB) has the main responsibility to run the NNSN. This report covers operational aspects for all seismic stations operated by the Department of Earth Science at the UiB and includes the financial report.

The network is supported by the oil industry through the Norwegian Oil Industry Association (“Oljeindustriens Landsforening” (OLF)) and UiB.

The seismicity of Norway and surrounding areas is presented in Appendix 1. The seismic arrays operated by NORSAR are covered in Appendix 2 of this report. NORSAR is subcontracted to deliver data of interest to NNSN and also take part in joint data processing.

2 Operation

In Norway, the University of Bergen (UiB) operates 32 of the seismic stations that form the Norwegian National Seismic Network (NNSN). NORSAR operates three seismic arrays, which also include broadband instruments and one single seismometer station (Figure 1). NORSAR provides data from four broadband stations to the NNSN.

There is an ongoing process by UiB to change short period (SP) with broadband (BB) seismometers and to increase the number of stations where data can be transmitted to Bergen in real time. As of today the number of SP, BB stations and stations with real time transmission are listed in Table 1.

Table 1. Overview of UiB seismic stations

	Short Period	Broadband	Real time
Number of stations	14	18 (15 with natural period greater than 100 sec)	29

The operational stability for each station is shown in Table 2. The downtime is computed from the amount of data that are missing from the continuous recordings at UiB. The statistics will also show when a single component is not working. This is done as the goal is to obtain as complete continuous data from all stations as possible. This means that also communication or computing problems at the centre will contribute to the overall downtime. In the case of communication problems, a station may not participate in the earthquake detection process, but the data can be used when it has been transferred. Thus, the statistics given allow us to evaluate the data availability when rerunning the earthquake detection not in real-time.

The data completeness for the majority of the stations is above 95%, except for the following stations:

- HYA: problems with digitizer
- KTK: problems with digitizer
- KONO: problem with phone line; however more data available from IRIS
- KONS: communication problems
- NSS: problem with digitizer and cable
- TBLU: station powered down in summer holidays

Table 2. Data completeness in % for 2011 for all stations of the NNSN operated by UiB.

Station	Data completeness %
Askøy (ASK)	98
Bergen (BER)	99
Bjørnøya (BJO)	99
Blåsjø (BLS)	100
Dombås (DOMB)	97
Florø (FOO)	98
Flostrand (FLOS)	Closed Mar 2012
Hammerfest (HAMF)	99
Homborsund (HOMB)	100
Hopen (HOPEN)	96
Høyanger (HYA)	89
Jan Mayen (JMI)	99
Jan Mayen (JNE)	99
Jan Mayen (JNW)	99
Karmøy (KMY)	100
Kautokeino (KTK)	86

Station	Data completeness %
Kings Bay (KBS)	98
Kongsberg (KONO)	93
Konsvik (KONS)	90
Lofoten (LOF)	99
Mo i Rana (MOR8)	34 (almost complete since September)
Molde (MOL)	96
Namsos (NSS)	57
Odda (OOD1)	100
Oslo (OSL)	100
Snartemo (SNART)	99
Stavanger (STAV)	99
Steigen (STEI)	95
Stokkvågen (STOK)	99
Sulen (SUE)	98
Blussuvoll (TBLU)	93
Tromsø (TRO)	100

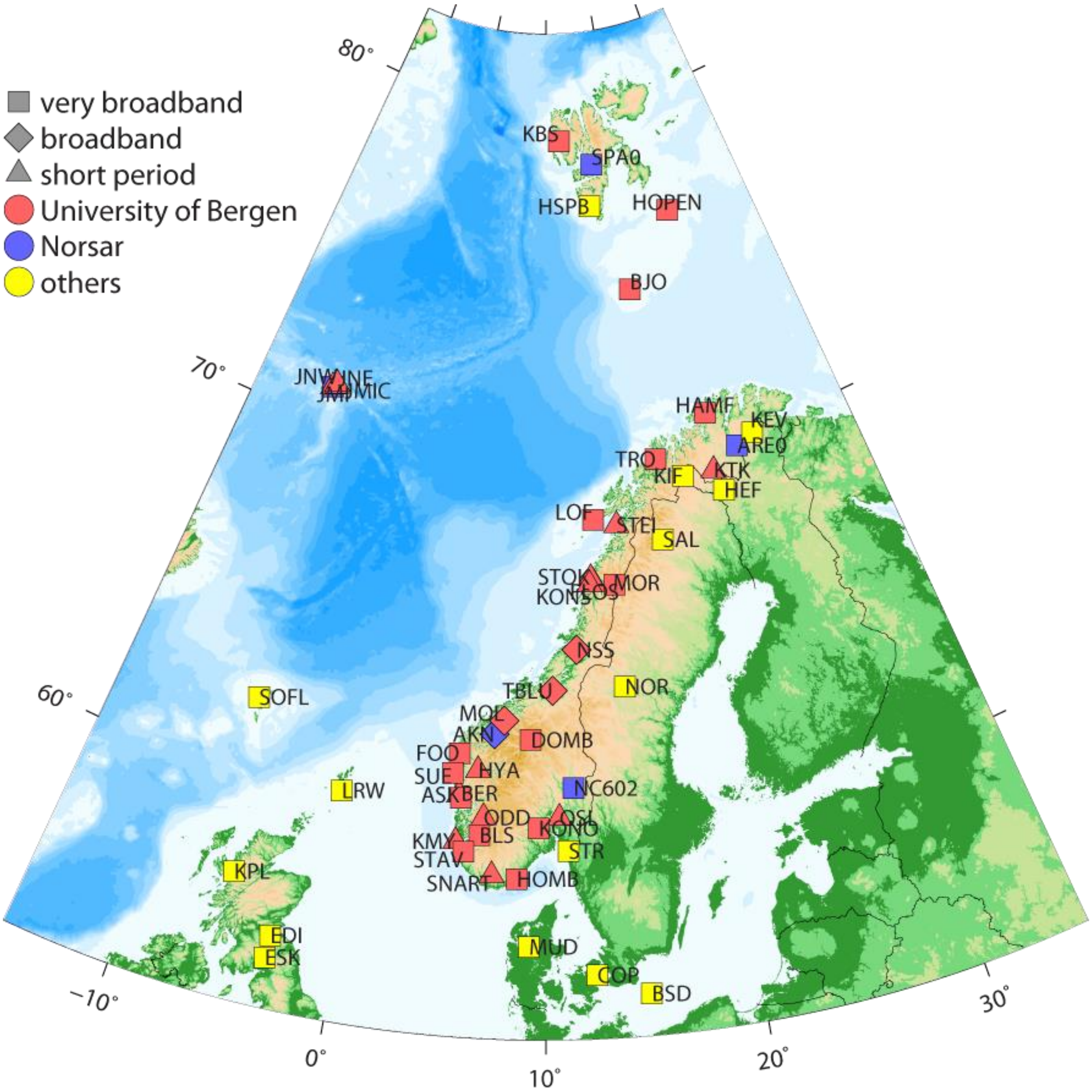

Figure 1. Stations contributing to the Norwegian National Seismic Network (NNSN). UiB operates 32 stations (red) and NORSAR operates the stations marked in blue including the 3 arrays, and station AKN. Data from stations in yellow are received continuously in Bergen, but are operated by neighbouring countries.

3 Field stations and technical service

The technical changes for each seismic station are listed below. It is noted if these changes are carried out by the respective local contact and not by the technical staff of UiB. When a station stops working, tests are made to locate the problem. Sometimes the reason cannot be found and the cause of the problem will be marked as unknown.

Major changes during 2011 were:

MOR8 was upgraded to broadband with real-time satellite communication. A new digitizer and Trillium 120 sec broadband seismometer were installed at BJO. The same digitizer type is now also used at HOPEN. STAV was upgraded to Trillium seismometer and Guralp digitiser early in the year. LOF was upgraded to Trillium seismometer and Guralp digitizer.

Ask (ASK)	17.02.11: Visit. A new Guralp Digitizer (model CMG-D2M4-EAM) was installed. Unit is modified, gain has been changed from 3.2µV to 0.8µV. GPS antenna is now G-13788. Modem restarted
	19.04-26.04.11: Station down, reason unknown. Restart by local operator.
Bergen (BER)	18.01.11. New Guralp digitizer (CMG-D2M4-EAM) installed.
Bjørnøya (BJO1)	9.10.11: Visit: The station was upgraded to a Nanometrics Trillium 120PA sensor, industrial PC, new Guralp CGM-EAM Digitizer and Guralp GPS.
Blåsjø (BLS)	No visit or technical changes.
Blussvoll (TBLU)	7.7.11-3.8.11: Station down during school holidays, eventually restarted by local operator.
Dombås (DOMB)	01.02.11: A new digitizer(CMG-D2M4-EAM) was installed by the local operator.
	19.08.11: Station down 31/07/11 16:32 to 19/08/11 06:30 due to thunder storm. A new modem was installed, but station still not ok. Using ICE communication temporarily. This was a temporary solution, and the station was reconnected to ADSL later in the year.
Florø (FOO)	28.02.11: The existing Guralp sensor was replaced with a Trillium 120 sensor.
Flostrand (FLOS)	05.01.11: GMS router for communication was replaced by local operator.
	15:02.11: The station was down from 13.02.2011 to 15.02.2011 due

	to power loss.
	28.02.11: Station down, possibly problem with cable. The station will not be fixed before the station configuration in the area has been evaluated.
Hammerfest (HAMF)	05.03.11: Local contact checked the GPS 31.03.11: The defective GPS antenna is replaced by local operator. Timing is now OK again.
Homborsund (HOMB)	No visit or technical changes.
Hopen (HOPEN)	The sensor is drifting and is every second week recentred by the local operator. This explains part of the lack of data where the instrument drifts to the limit. Visit: 13.10 2011. Installation of Guralp Digitizer CGM-EAM, Guralp GPS, Industrial PC. The seismometer was turned 90 deg. The Streckeisen STS-2 was not replaced.
Høyanger (HYA)	22.07.11: Station stopped at 14:20 due to thunderstorm. Station down until 23.08. 05.08.11: New PC installed by local operator and communication is working. However, no data recorded due to problem with digitizer. 23.08.11: Visit: The existing SARA digitizer was replaced with a Guralp CMG-DM24-EAM.
Jan Mayen (JMI)	No visit or technical changes. The bandwidth of the satellite link has been increased, and real-time communication is becoming possible.
Karmøy (KMY)	12.12.11: Digitizer replaced with the same type as before (Sara SR-04) by local operator.
Kautokeino (KTK)	11.07.11: 0650 UTC used SMS for remote restart. 08.07.11: Station down. 25.08.11: New PC installed by local operator. 12.09.11: Earthdata digitizer replaced by the local operator due to noise on E component. 21.09.11: Visit. New CMG-DM24-EAM digitizer installed.
Kings Bay (KBS)	No visit or technical changes.
Kongsberg (KONO)	Communication down between 26. September – 14. October 2011 due to a cable problem outside the mine.

Konsvik (KONS)	Occasional communication problems. No visit or technical changes.
Lofoten (LOF)	09-11.05.11: Station upgraded with a Trillium 120PA sensor, a Guralp CMG-DM24-EAM digitizer and an industrial PC.
Mo i Rana (MOR8)	05.01.11: Station restarted by local operator. Down since 30.11.10. The local operator is not available for periods of time during the winter. 11.05.11: Station down. Cable was destroyed. 20.06.11: Visit. A new sensor and digitizer were installed. The cable was repaired, but the sensor still does not work. 19.07.11: Visit. It was not possible to make the sensor work at the site, so it was temporarily moved. Station is now transferring data in real time using satellite communication. A new site will be constructed. 26.10.11: Visit. A new site has been created closer to the farm. A new 100 meter signal cable for the new site was installed, and the sensor was moved to the new site. 10.12.11: Noise including spikes recorded. 21.12.11: Effort put into pin pointing the source for the noise. In the end the earthing for the satellite head was found to be the reason. Connected to station earth. Removed and given separate ground.
Molde (MOL)	No visit or technical changes.
Namsos (NSS)	07.07.11-26.10.11: Station down due to thunderstorm and lightning. Expected damage to PC and Digitizer. 25.08.11: New PC installed by the local operator. Station still down due to serial line converter or digitizer problem.
Odda (ODD1)	No visit or technical changes.
Oslo (OSL)	No visit or technical changes.
Snartemo (SNART)	05.08-10.08.11: No contact with the station, due to local problems at the phone company.
Stavanger (STAV)	08.02.11: Visit. Installed a new BB sensor, Trillium 120PA, new Guralp digitizer (CMG-DM24) and GPS antenna, a new industrial PC.
Steigen	18-29.05.11: Station down due to power loss.

(STEI)

Stokkvågen (STOK)	25.07.11: Thunderstorm and lightning caused communication failure. New modem was installed by the local operator.
Sulen (SUE)	06-08.12.12: Station down due to power loss.
Tromsø (TRO)	No visit or technical changes.

4 NNSN plans

The overall purpose of the NNSN is to provide data both for scientific studies, but equally important for the routine observation of earthquakes. This in principle means that broadband seismometers are desired at all sites. Of course in areas where additional stations are deployed for local monitoring, short-period seismometers are sufficient. The number of broadband seismometers in the network will be increased to replace existing short period instruments. A general goal for the future development has to be to achieve better standardization in particular with the seismometers and digitizers. The total number of stations for now should remain stable, but it is important to improve the overall network performance.

We now report achievements for 2011, and then give the plans for 2012.

4.1 Achievements in 2011

- Mo i Rana: The Mo i Rana station will be upgraded when the satellite link is sufficiently tested.
  Progress: Done. New station completed in October 2011. Trillium 120, CMG-DM24-EAM and satellite communication.
- Lofoten: the station will be upgraded by installing a new digitizer and computer; a broadband seismometer will be installed either at Lofoten or Steigen.
  Progress: Done. The station LOF was upgraded with a Trillium sensor in May 2011.
- Further upgrade: We have received funding from the department for six broadband sensors. Two of these will be used for portable deployment. The other four will be installed on current NNSN stations. The NNSN budget for new investments in 2011 will be used for digitizers.
  Progress: All available broadband sensors are installed. Five stations are being available for temporary deployment.
- New stations: planning for possible stations in the Hardangervidda area and near Bergen will start.
  Progress: The area around Geilo/Ustaoset is of interest due to easy access by train. The local ‘kommune’ has been contacted and the area is explored to find a good site. Noise tests are planned.

- Stokkvågen network: The network was intended to be temporary at the time of installation. With five years of recordings we will look into changing the configuration of these stations. A possible solution is to keep one of them, but to move one of them to half-way between this area and Steigen. Equipment at Stokkvågen, Steigen and the new station will have to be improved. During 2011, a noise site survey will be made. Progress: No progress has been made. Station FLOS is down, and will be closed at end of 2011.
- Continue with the integration of data from Ekofisk and Statfjord.
  Progress: Sample data from Ekofisk were received, and are evaluated. Real-time data transfer still needs to start. A seismometer was deployed at Statfjord was operating from 23.12.10 in the shaft of STC. However, due to unstable power supply no recordings were made.
- Establish automated routines for event based waveform data extraction from NORSAR for the associated triggers to the NNSN database.
  Progress: Beam data are now available from NORSAR and copied to UiB automatically. The beam data has been looked at in specific cases, but are not yet included in the daily processing routines at UiB.
- Procedures: earthquake response and interaction with NORSAR to be developed.
  Progress: Analyst from NORSAR has visited Bergen twice (February and June). A short document with a task list was prepared.
- NNSN website: continue development
  Progress: The menu system and content of the page is under revision. A first version of the new menu system is available. However, progress is a bit slow.

4.2 Plans for 2012

- New station: The station in the Hardangervidda will be installed. During 2011 search for a site at Hardangervidda started. Contact was made with the local ‘kommune’ and seven possible locations were identified. Noise testing are planned during May and installation of the new station during summer 2012.
- Upgrade: Stations OSL, KMY, STEI and STOK will be upgraded to a Guralp digitizer.
- Upgrade: Stations OSL and STEI will be considered for installation of a broadband seismometer.
- Ekofisk: Complete the data integration.
- Strengthen the collaboration with NORSAR on data processing through technical visits.
- Jan Mayen: Improve signal quality of the JMI station and install a broadband seismometer.
- NNSN website: continue development.

Seismicity of Norway and surrounding areas for

2011

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1 Introduction

This annual report on the seismicity of Norway and adjacent areas encompasses the time period January 1st - December 31st, 2011. The earthquake locations have been compiled from all available seismic stations operating on the Norwegian territory including the Arctic islands of Spitsbergen, Bjørnøya, Hopen and Jan Mayen.

In Norway, the University of Bergen (UiB) operates the Norwegian National Seismic Network (NNSN) consisting of 32 seismic stations where 15 have broadband sensors. NORSAR operates three seismic arrays and two seismic station (Figure 2). Data from temporarily installed local networks are also included whenever data are made available. In addition to the NNSN stations, waveform data from other selected stations in Norway (operated by NORSAR), Finland, Denmark, Poland and Great Britain are transferred in real time and included in the NNSN database. In total data from 15 stations located in or operated by neighbouring countries are recorded continuously in Bergen and can be used for locating earthquakes.

Phase data from arrays in Russia (Apatity), Finland (Finess), Sweden (Hagfors) and stations operated by the British Geological Survey (BGS) are also included when available. All phase data are collected by UiB, and a monthly bulletin is prepared and distributed. All local and regional earthquakes recorded on NNSN stations are presented on the web pages and the largest are also e-mailed to the European-Mediterranean Seismological Centre (EMSC) to be published on the EMSC web pages. A brief overview of the events published in the monthly bulletins is given in this annual report. Macroseismic data for the largest felt earthquakes in Norway are collected, and macroseismic maps are presented.

Local, regional and teleseismic events that are detected by the UiB network are included. The merging of data between NORSAR and UiB is based on the following principles:

- **i)** All local and regional events recorded by NORSAR that are also detected by the NNSN network are included.
- **ii)** All local and regional events with local magnitude larger than 2.0 detected by NORSAR and not recorded by the NNSN are included.
- **iii)** All teleseismic events recorded by NORSAR and also detected by the NNSN are included.
- **iv)** All teleseismic events with NORSAR magnitude $M_b \geq 5.0$ are included even not detected by the NNSN.

Data from the British Geological Survey (BGS) are included in the database in Bergen following similar criteria as mentioned above, however only events located in the prime area of interest, shown in Figure 2, are included.

Starting from 2008, the NNSN stations were upgraded to provide continuous data in real time. This has resulted in more effective monitoring of earthquake activity in the region.

2 Data availability to the public

All the data stored in the NNSN database are also available to the public via Internet, e-mail or on manual request. The main web-portal for earthquake information is www.skjelv.no. It is possible to search interactively for specific data, display the data locally (waveforms and hypocenters) and then download the data. Data are processed as soon as possible and updated lists of events recorded by Norwegian stations are available soon after recording. These pages are automatically updated with regular intervals.

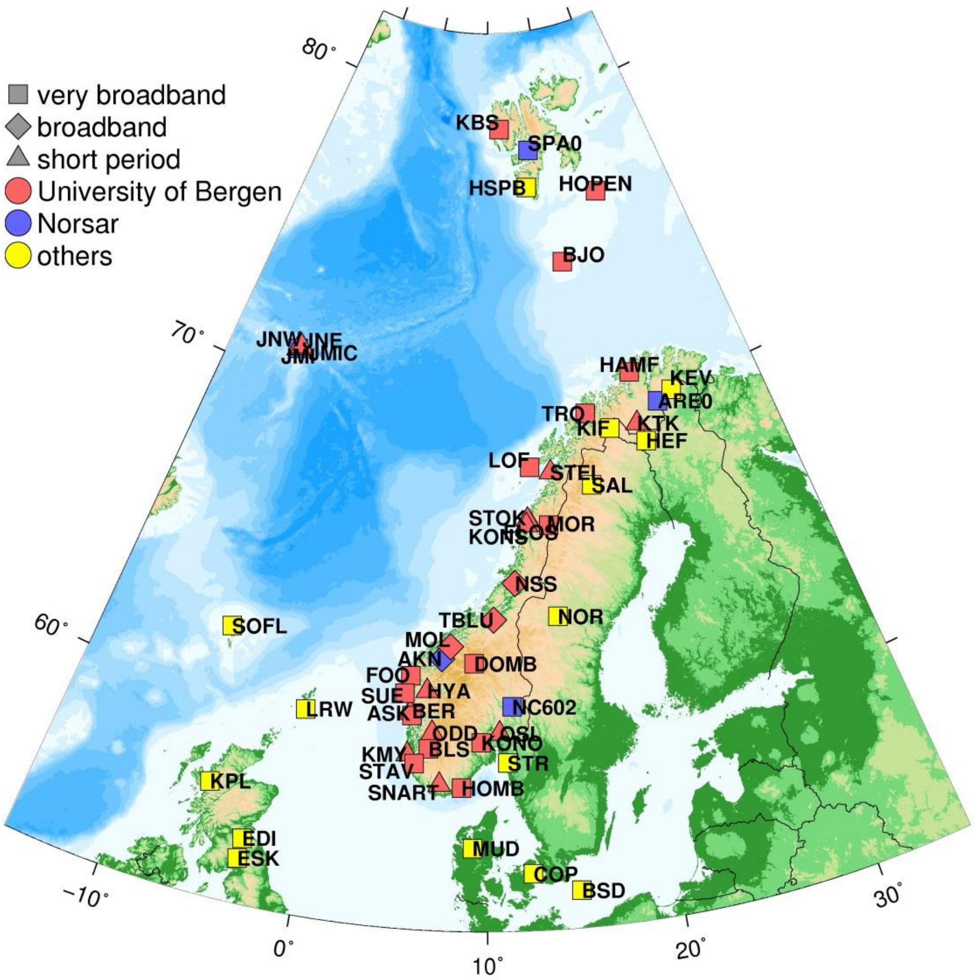

Figure 2. Stations included in Norwegian National Seismic Network (NNSN). UiB operates the 32 stations (red) and NORSAR operates the stations marked in blue including the 3 arrays. Data from stations marked in yellow are received continuously in Bergen, but are operated by institutions in neighbouring countries.

3 Velocity models and magnitude relations

The velocity model used for locating all local and regional events, except for the local Jan Mayen events, is shown in Table 3 (Havskov and Bungum, 1987). Event locations are performed using the HYPOCENTER program (Lienert and Havskov, 1995) and all processing is performed using the SEISAN data analysis software (Havskov and Ottemöller, 1999).

Table 3. Velocity model used for locating all local and regional events, except for the local Jan Mayen events (Havskov and Bungum, 1987).

P-wave velocity (km/sec)	Depth to layer interface (km)
6.2	0.0
6.6	12.0
7.1	23.0
8.05	31.0
8.25	50.0
8.5	80.0

Magnitudes are calculated from coda duration, amplitudes or displacement source spectra. The coda magnitude relation was revised in 2006 (Havskov & Sørensen 2006). The coda wave magnitude scale (M_C) is estimated through the relation

$$M_C = -4.28 + 3.16 \cdot \log10(T) + 0.0003 \cdot D$$

where T is the coda length in seconds and D is the epicentral distance in km. The new scale made M_C more consistent with M_L since M_C in general is reduced. For this report all data are updated using the new magnitude scale. When instrument corrected ground amplitudes A (nm) are available, local magnitude M_L is calculated using the equation given by Alsaker et al. (1991):

$$M_L = 1.0 \cdot \log(A) + 0.91 \cdot \log(D) + 0.00087 \cdot D - 1.67$$

where D is the hypocentral distance in km.

The moment magnitude M_w is calculated from the seismic moment M_0 using the relation (Kanamori, 1977)

$$M_w = 0.67 \cdot \log(M_0) – 6.06$$

The unit of M_0 is Nm. The seismic moment is calculated from standard spectral analysis assuming the Brune model (Brune, 1970) and using the following parameters:

Density: 3.0 g/cm^2
$Q = 440 \cdot f^{0.7}$
P-velocity = 6.2 km/s
S velocity = 3.6 km/s

For more computational details, see Havskov and Ottemöller, (2003).

For the Jan Mayen area, a local velocity model (see Table 4) and coda magnitude scale is used (Andersen, 1987).

Table 4. Velocity model used for locating local Jan Mayen events.

P-wave velocity (km/sec)	Depth to layer interface (km)
6.33	18
8.25	50

The coda magnitude scale for Jan Mayen which is used in this report is given by Havskov & Sørensen (2006). This scale was implemented in 2006 but all events used in this report are updated during April/May 2006.

$$M_C = 3.27 \cdot \log(T) 2.74 + 0.001 \cdot D$$

where T is the coda duration and D is the epicentral distance in km.

The regional and teleseismic events recorded by the network are located using the global velocity model IASPEI91 (Kennett and Engdahl, 1991).

Body wave magnitude is calculated using the equation by Veith and Clawson (1972):

$$Mb = \log(A/T) + Q(D,h)$$

Here h is the hypocentre depth (km), A is the amplitude (microns), T is period in seconds and Q(D,h) is a correction for distance and depth.

Surface wave magnitude Ms is calculated using the equation (Karnik et al., 1962):

$$Ms = \log(A/T) + 1.66 \cdot \log(D) + 3.3$$

where A is the amplitude (microns), T is period in seconds and D is the hypocentral distance in degrees.

Starting from January 2001, the European Macroseismic Scale, EMS98, (Grünthal, 1998) has been used. All macroseismic intensities mentioned in the text will refer to the EMS98 instead of the previously used Modified Mercalli Intensity scale. The two scales are very similar at the lower end of the scale for intensities less than VII.

4 Events recorded by the NNSN

Based on the criteria mentioned in section 1, a total of 3534 local and regional events, were detected by the NNSN during 2011. Of these local and regional events, 73% were large enough to be recorded by several stations and hence could be located reliably. The numbers of local/regional and teleseismic events, recorded per month in 2011 are shown in
Figure 3.
The average number of located local and regional events recorded per month is 215. The number of recorded local/regional events is about the same as in 2010.

A total of 1372 teleseismic events were recorded in 2011. The monthly average of teleselectseismic earthquakes in the NNSN database, is 114. This means that the number has almost doubled since 2010, which is due to the Tōhoku, Japan, earthquake on 11 March. In addition to the locations determined at UiB, also preliminary locations published by the USGS (United States Geological Survey) based on the worldwide network are included for earthquakes also registered by NNSN stations.

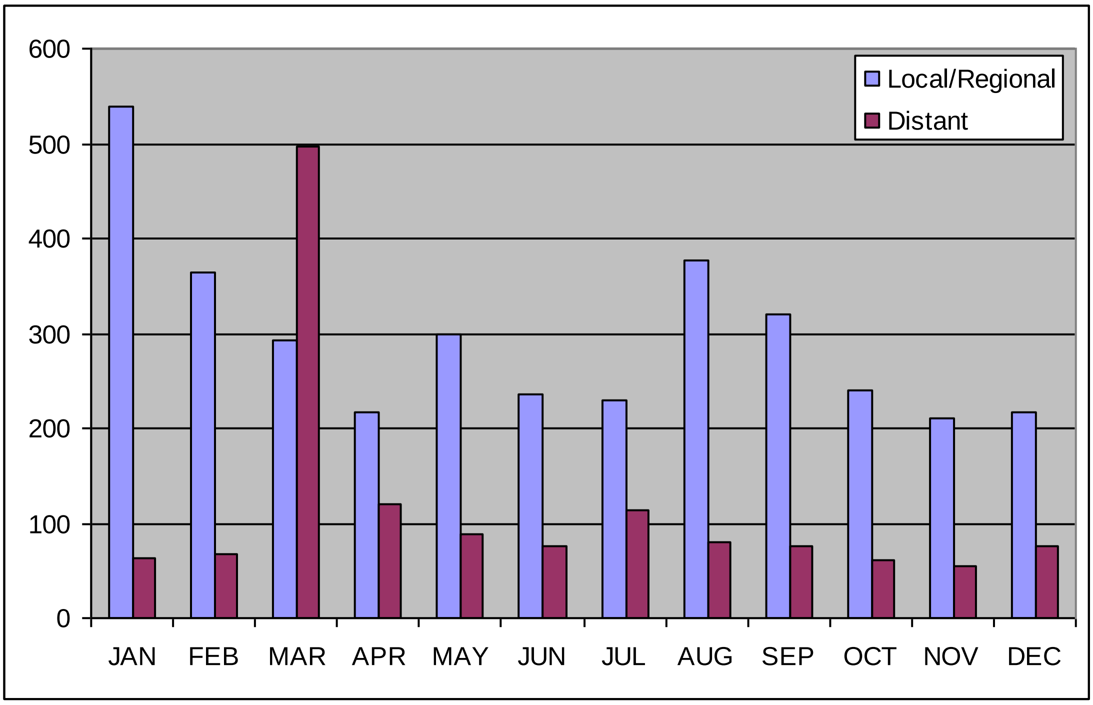

Figure 3. Monthly distribution of local/regional and distant events, recorded during 2011.

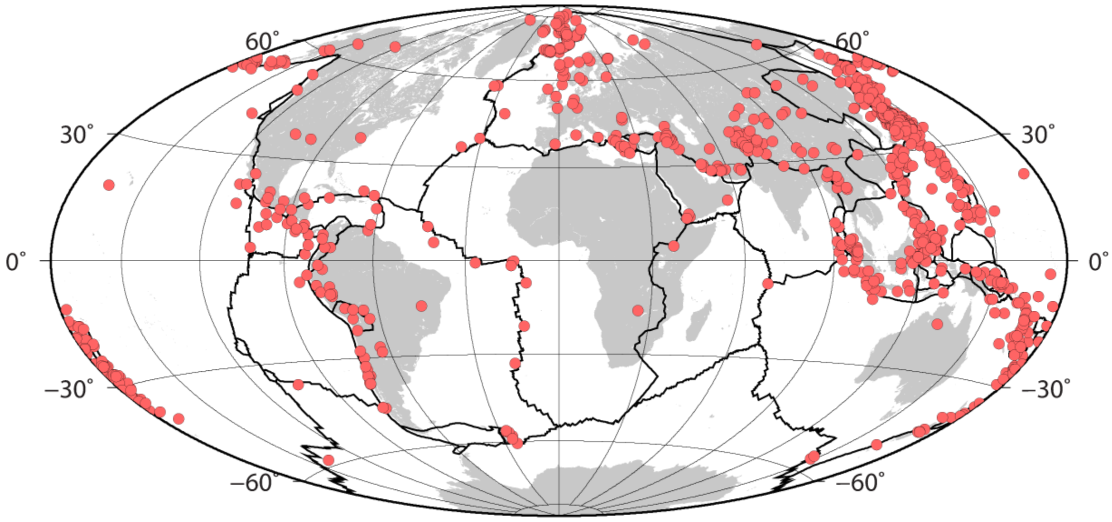

Figure 4. Epicentre distribution of earthquakes with M≥3.0, located by the Norwegian Seismic Network from January to December 2011. Teleseismic events recorded only by NORSAR have M≥5.0.

UiB, as an observatory in the global network of seismological observatories, reports secondary phases from the teleseismic recordings. All events (teleseismic, regional and local) recorded from January to December 2011 with M ≥ 3 are plotted on Figure 3.

Monthly station recording statistics from January to December 2011 are given in Table 5. This table shows, for each station, the number of local events that were recorded only at one station, local events recorded on more than one station and recorded teleseismic events. The statistics are based on the analysed data and are taken from the database.

It must be observed that Table 3 shows both earthquakes and explosions, and that the large number of detections at KTK mainly is due to explosions at the Kirruna/Malmberget mines in Sweden. The MOR station also records the Kirruna/Malmberget explosions, but in addition the station records a large number of local earthquakes. These earthquakes are also recorded on the stations STOK, KONS and FLOS and, therefore, the number of recorded earthquakes in this region is higher.

The following was observed from Table 3:

- The Japan earthquake at 11 March and its aftershocks are clearly seen as a large increase in the number of recorded distant earthquakes at several stations.
- At FOO and STAV an increase in detected teleseismic events can be seen after the installation of Trillium sensors during February. In STAV an improved site, planned for 2012, is expected to increase the number of detected events even more.
- The seismic activity in the Jan Mayen area is higher in January and also in August. In January this increase is due to aftershocks of the M=6 earthquake the same month. The JMI station is detecting a lower number of events than

the other seismic stations located at Jan Mayen due to noisy signals. The JMI station is planned to be upgraded during 2012.

- TBLU and OSL are recording mostly teleseismic earthquakes, which is as expected due to their location in noisy environment. Stronger local earthquakes will however be detected.
- The arctic stations are recording a much larger number of earthquakes than the mainland stations. The seismic activity around Spitsbergen will be presented in a separate section later in this report.
- Four stations are located at Jan Mayen. Data from the BB station JMIC are, together with other BB stations, collected for all teleseismic earthquakes recorded at any of the NNSN stations. Therefore, the number of recorded teteseismic earthquakes is higher than for the other stations at Jan Mayen.
- The four stations KONS, FLOS, STOK and MOR8 are located relative close to each other and are recording a high number of small local earthquakes. The station FLOS has been down since 28 February. The station will not be fixed before the station configuration in the area has been evaluated.
- The following stations have been down for longer periods: FLOS, MOR8 and NSS.

Table 5a. Monthly statistics of events recorded at each station for January-June 2011. Abbreviations are: LM = Number of local events recorded at more than one station, LS = Number of local events recorded at only one station and D = Number of teleseismic events. The station FLOS has been down since 28th February. The station will not be fixed before the station configuration in the area has been evaluated. MOR8 was down from 11 May to September due to broken cable and building of a new site.

	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE		
STATION	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**
ASK	28	0	8	25	0	16	29	0	72	19	0	29	33	0	24	35	0	14
BER	7	0	10	7	0	11	6	0	65	6	0	35	2	0	25	3	0	20
BJO1	23	0	8	7	0	6	15	0	29	6	0	21	19	0	15	19	0	14
BLS5	30	0	20	26	0	18	36	0	74	16	0	36	28	0	34	26	0	18
DOMB	8	0	23	8	0	13	2	0	2	0	0	1	0	0	1	1	0	1
FLOS	23	0	1	26	0	11	-	-	-	-	-	-	-	-	-	-	-	-
FOO	11	0	7	12	0	6	13	0	28	10	0	23	14	0	25	21	0	19
HAMF	8	0	22	2	0	21	6	0	86	11	0	38	17	0	35	12	0	27
HOMB	18	0	17	20	0	9	27	0	56	12	0	37	20	0	28	19	0	21
HOPEN	83	0	27	47	0	22	60	0	103	37	0	38	62	0	19	37	0	18
HYA	23	0	9	19	0	12	32	0	78	20	0	37	32	0	28	35	0	18
JMI	167	0	0	57	0	0	30	0	0	14	0	0	11	0	0	17	0	0
JMIC	168	2	3	95	12	2	51	1	12	36	0	10	53	0	10	46	0	11
JNE	258	0	0	88	0	0	49	0	0	23	0	0	52	0	0	47	0	0
JNW	264	14	0	103	23	0	51	1	0	36	0	0	56	0	0	47	1	0
KBS	99	0	27	61	0	28	67	0	107	36	0	40	105	0	30	66	0	23
KMY	24	0	8	23	0	5	34	0	30	18	0	36	27	0	21	23	0	14
KONO	17	0	20	21	0	18	20	0	90	14	0	44	19	0	31	13	0	22
KONS	52	0	12	28	0	16	16	0	41	13	0	28	2	0	5	12	0	11
KTK1	35	0	29	17	0	38	27	0	146	27	0	55	25	0	37	16	0	22
LOF	16	0	14	5	0	12	3	0	44	7	0	25	11	0	19	16	0	19
MOL	5	0	12	9	0	10	7	0	58	6	0	25	4	0	23	9	0	16
MOR8	35	2	16	21	1	21	27	2	156	19	3	47	4	0	14	-	-	-
NSS	9	0	27	4	0	25	4	0	99	0	0	41	0	0	30	4	0	24
ODD1	34	0	18	29	0	16	38	0	86	16	0	37	17	0	28	9	0	14
OSL	3	0	10	0	0	11	0	0	61	1	0	26	1	0	24	0	0	18
SNART	21	0	13	23	0	15	33	0	80	15	0	34	21	0	30	20	0	13
STAV	2	0	4	5	0	3	13	0	33	11	0	28	15	0	23	10	0	16
STEI	7	0	20	5	0	25	3	0	93	2	0	38	2	0	19	4	0	21
STOK	49	0	8	28	0	10	17	0	32	12	0	26	3	0	18	7	0	5
SUE	33	0	11	20	0	6	25	0	45	17	0	26	30	0	26	32	0	17
TBLU	2	0	7	1	0	13	1	0	56	0	0	29	0	0	20	0	0	15
TRO	22	0	26	11	0	27	18	0	133	15	0	52	16	0	41	18	0	31
NORSAR	31	0	57	21	0	66	36	0	492	16	0	119	20	0	88	17	0	74
ARCES	80	0	0	48	0	0	79	0	0	53	0	1	63	0	0	48	0	0
SPITS	115	1	31	72	1	33	86	0	106	57	0	43	120	0	26	71	0	30

Table 5b. Monthly statistics of events recorded at each station for July-December 2011. Abbreviations are: LM = Number of local events recorded at more than one station, LS = Number of local events recorded at only one station and D = Number of teleseismic events. The station FLOS has been down since 28 February, The station will not be fixed before the station configuration in the area has been evaluated. MOR8 was down from 11th May to September due to broken cable and building of a new site.

	JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
STATION	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**
ASK	27	0	40	47	0	34	35	0	24	31	0	10	27	0	9	12	0	7
BER	10	0	49	15	0	43	9	0	33	9	0	16	8	0	12	6	0	7
BJO1	14	0	29	19	0	24	8	0	19	6	0	4	2	0	9	2	0	5
BLS5	36	0	49	53	0	44	43	0	39	29	0	17	35	0	13	22	0	8
DOMB	6	0	40	5	0	23	3	0	40	2	0	20	4	0	16	3	0	7
FLOS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FOO	16	0	40	28	0	43	16	0	33	18	0	10	9	0	8	7	0	5
HAMF	14	0	45	36	0	45	21	0	38	8	0	24	5	0	14	2	0	9
HOMB	25	0	44	27	0	40	27	0	31	16	0	15	19	0	11	15	0	8
HOPEN	43	0	35	62	0	26	29	0	27	10	0	7	19	0	7	27	0	5
HYA	17	0	18	12	0	5	26	0	27	28	0	17	28	0	11	13	0	7
JMI	18	0	0	74	0	0	34	0	0	33	0	0	6	0	0	10	0	0
JMIC	54	1	26	114	2	28	51	0	20	61	0	6	25	0	2	16	0	2
JNE	55	0	0	94	0	0	51	0	0	55	0	0	21	0	0	16	0	0
JNW	57	0	0	111	1	0	54	0	0	36	4	0	26	0	0	17	0	0
KBS	56	0	45	98	0	43	71	4	41	40	0	17	46	0	10	66	0	9
KMY	32	0	31	44	0	26	41	0	16	25	0	10	29	0	7	19	0	5
KONO	13	0	52	29	2	49	18	0	35	5	0	11	17	0	12	20	0	8
KONS	13	0	15	41	0	29	10	0	36	14	0	17	8	0	12	4	0	7
KTK1	25	3	10	16	0	5	114	0	42	76	2	29	62	0	16	51	1	11
LOF	22	0	46	51	0	43	25	0	40	18	0	15	9	0	10	7	0	6
MOL	7	0	39	13	0	34	5	0	28	6	0	18	3	0	12	4	0	7
MOR8	-	-	-	-	-	-	9	0	38	8	0	23	6	0	16	4	0	10
NSS	1	0	4	-	-	-	-	-	-	1	0	4	2	0	6	0	0	0
ODD1	27	0	47	50	0	41	31	0	28	21	0	18	31	0	9	22	0	8
OSL	3	0	46	2	0	34	2	0	26	0	0	18	0	0	12	0	0	7
SNART	20	0	30	33	0	36	35	0	27	22	0	13	22	0	10	17	0	8
STAV	19	0	48	19	0	41	16	0	28	17	0	15	14	0	8	6	0	6
STEI	13	0	40	35	0	37	16	0	36	10	0	19	5	0	14	4	0	10
STOK	14	0	18	42	0	41	10	0	34	10	0	21	5	0	11	4	0	9
SUE	19	0	44	41	0	41	23	0	25	26	0	9	19	0	7	9	0	5
TBLU	0	0	3	4	0	30	0	0	26	1	0	19	0	0	8	0	0	8
TRO	29	1	58	60	0	49	35	0	41	18	0	27	12	0	13	5	0	10
NORSAR	25	0	105	24	0	75	16	0	71	27	0	60	24	0	52	24	0	65
ARCES	43	0	0	50	0	0	38	0	0	55	0	0	39	0	0	52	0	0
SPITS	6	0	46	113	0	44	76	2	43	47	0	17	62	2	11	82	7	8

5 The seismicity of Norway and adjacent areas

A total of 2553 of the recorded events are located inside the NNSN prime area, 54°N-82°N and 15°W-35°E. During analysis and using the explosion filter (Ottemöller, 1995), 35% of these events were identified as probable explosions. Figure 5 shows all local/regional events in the prime area, analyzed and located during 2011.

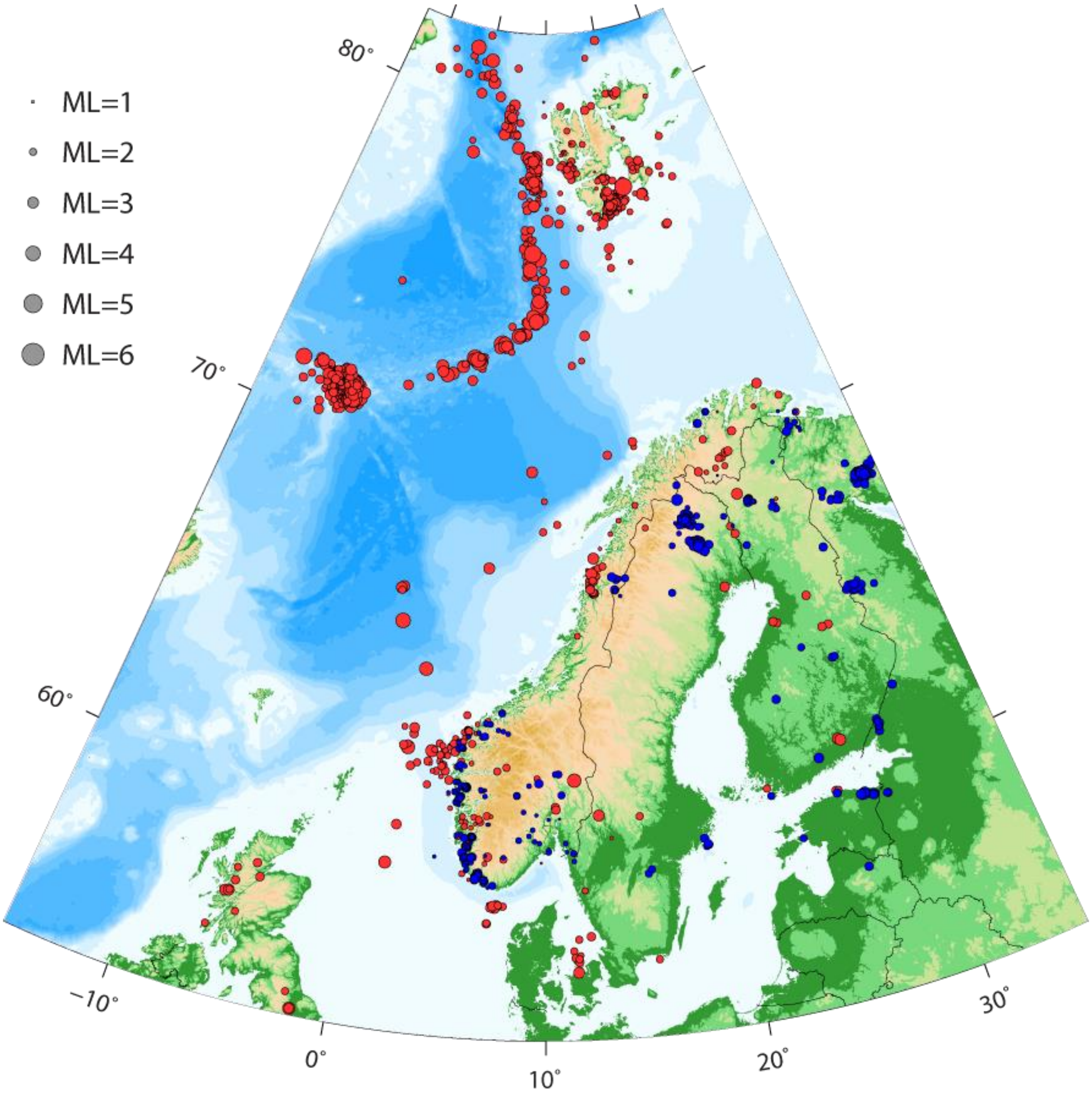

Figure 5. Epicentre distribution of events analyzed and located in 2011. Earthquakes are plotted in red and probable and known explosions in blue. For station locations, see Figure 2.

Figure 6 and Table 4 show the 201 local and regional events, located in the prime area, with one of the calculated magnitudes greater than or equal to 3.0. Among these, 108 are located in the vicinity of Jan Mayen.

It should be emphasized that the magnitude calculation for the earthquakes located on the oceanic ridge in the Norwegian Sea uses the same formula as for mainland Norway. As the scale is not appropriate for this region, the magnitudes for these earthquakes are underestimated. Most of the recorded earthquakes in this area have magnitudes above 3.0 if they are recorded on Norwegian mainland stations.

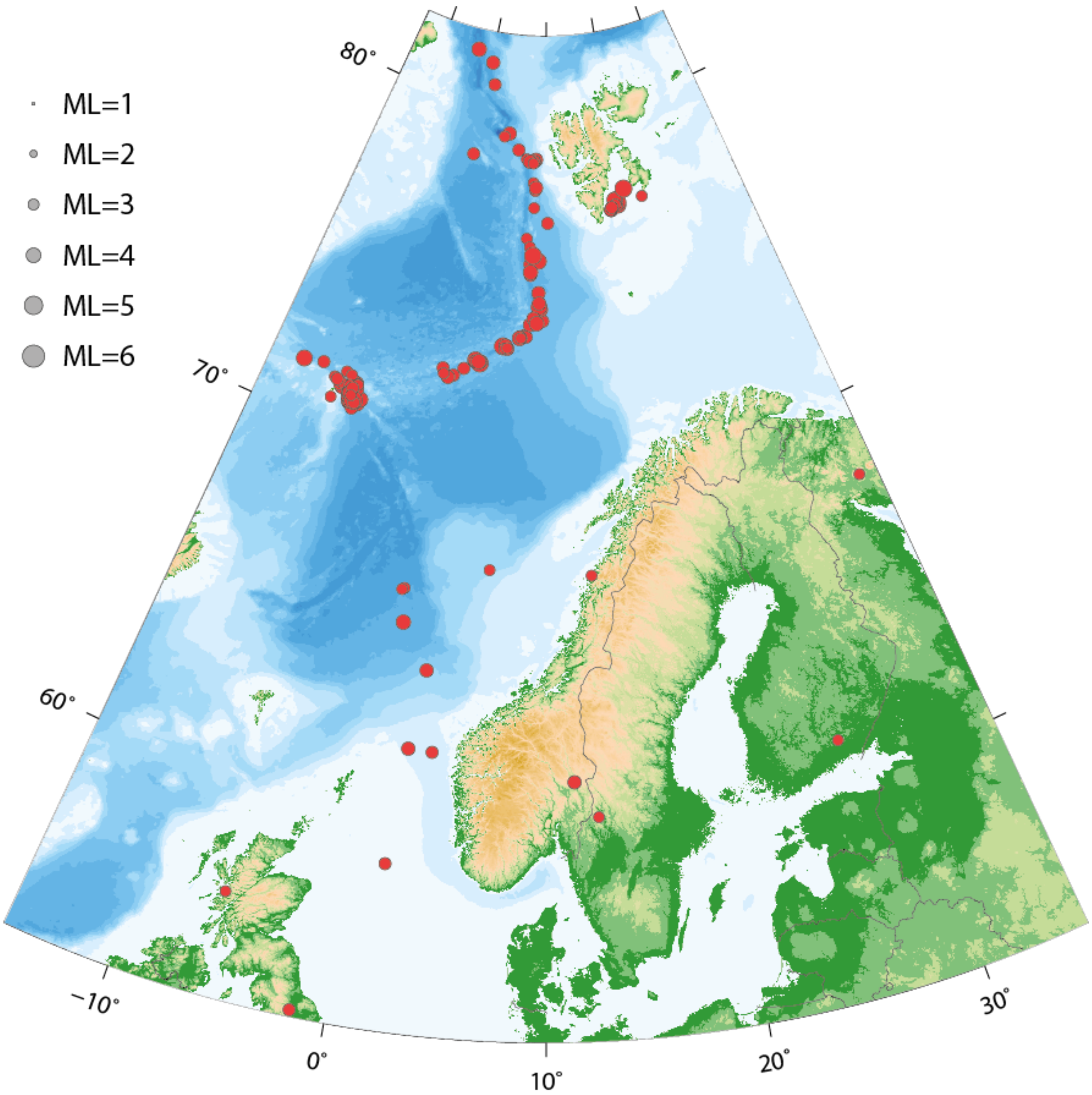

Figure 6. Epicentre distribution of located events with one of the calculated magnitudes above or equal to 3.0. All earthquakes are listed in Table 4 For station location, see Figure 2.

Table 6.

Local and regional events in prime area with any magnitude above or equal to 3.0 for the time period January through December 2011. Only magnitudes reported by the University of Bergen are included. In cases where all BER magnitudes are below 3 but the event still is included in the list, NORSAR has reported a magnitude of 3.0 or larger. Abbreviations are: **HR** = hour (UTC), **MM** = minutes, **Sec** = seconds, **L** = distance identification (L=local, R=regional, D=teleseismic), **Latitud** = latitude, **Longitud** = longitude, **Depth** = focal depth (km), **F** = fixed depth, **AGA** = agency (BER=Bergen), **NST** = number of stations, **RMS** = root mean square of the travel-time residuals,

Mc = coda magnitude, **Ml** = local magnitude and **Mw** = moment magnitude.

Year	Date	HRMM	Sec	L	Latitud	Longitud	Depth	FF	AGA	NST	RMS	Ml	Mb	Mw
2011	1 3	2103	10.0	L	54.168	-1.653	6.9	FF	BGS	40	0.5	3.3		
2011	1 3	2359	42.0	L	71.131	-7.830	10.0	F	BER	4	0.2	3.2		
2011	1 6	0323	58.3	L	70.749	-6.501	10.0	F	BER	31	0.6	4.6		
2011	1 6	0635	39.9	L	76.636	10.148	14.3		BER	7	0.9	2.6		
2011	110	0112	4.7	L	78.443	-0.434	10.0	F	BER	14	1.4	2.5		
2011	111	1040	13.9	L	76.187	7.688	10.0	F	BER	6	0.7	2.2		
2011	114	1101	12.9	L	73.884	9.349	10.0	F	BER	8	0.6	1.8		
2011	118	1700	46.7	L	76.918	18.362	18.6		BER	8	0.5	3.0		
2011	120	1230	27.3	L	75.457	8.139	10.0	F	BER	7	0.5	2.4		
2011	122	0826	21.3	L	76.882	18.251	19.7		BER	16	0.8	3.7		
2011	122	1125	10.7	L	76.989	19.159	15.0		BER	18	0.9	4.3		
2011	123	0602	49.7	L	56.817	-5.833	12.6		BER	35	0.3	3.1		
2011	129	0655	26.1	L	70.789	-6.904	10.0	F	BER	40	1.2	6.0		
2011	129	0701	46.0	L	71.066	-7.221	3.0		BER	4	0.2	3.0		
2011	129	0706	1.6	L	70.977	-7.009	10.0	F	BER	4	0.2	3.4		
2011	129	0708	39.0	L	70.843	-6.572	10.0	F	BER	7	0.5	3.3		
2011	129	0752	57.8	L	70.841	-6.707	5.6		BER	8	0.4	3.4		
2011	129	0756	26.9	L	70.778	-6.765	4.5		BER	8	0.4	3.2		
2011	129	0858	54.9	L	71.141	-6.903	12.0		BER	3	0.1	3.2		
2011	129	0903	15.2	L	71.046	-6.849	3.0		BER	3	0.2	3.0		
2011	129	0909	12.1	L	71.116	-7.131	3.0		BER	3	0.2	3.3		
2011	129	0909	54.1	L	71.168	-6.806	10.7		BER	3	0.1	3.1		
2011	129	0926	41.3	L	71.012	-7.146	3.0		BER	3	0.1	3.1		
2011	129	0931	40.0	L	70.868	-7.002	5.2		BER	8	0.3	3.3		
2011	129	0934	55.0	L	70.875	-7.004	10.0	F	BER	14	0.4	3.2		
2011	129	0936	56.5	L	70.838	-7.015	10.0	F	BER	7	0.4	3.1		
2011	129	1001	10.8	L	70.928	-6.824	3.0		BER	3	0.1	3.5		
2011	129	1009	5.3	L	70.886	-7.116	7.5		BER	10	0.3	3.9		
2011	129	1025	20.3	L	70.781	-6.756	15.0		BER	21	1.0	3.7		
2011	129	1033	10.7	L	71.043	-7.245	3.0		BER	3	0.1	3.1		
2011	129	1056	8.9	L	71.023	-6.831	10.0	F	BER	3	0.1	3.3		
2011	129	1057	42.5	L	70.991	-6.953	10.0	F	BER	3	0.1	3.5		
2011	129	1100	2.6	L	70.863	-6.918	13.0		BER	28	0.6	4.2		
2011	129	1107	34.1	L	70.978	-6.939	10.0	F	BER	4	0.2	3.6		
2011	129	1113	59.0	L	71.511	-8.053	2.9		BER	3	0.4	3.2		
2011	129	1112	21.5	L	71.037	-6.825	10.0	F	BER	4	0.2	3.2		
2011	129	1125	27.9	L	70.946	-7.144	3.0		BER	4	0.1	3.0		
2011	129	1127	40.4	L	71.025	-6.778	1.8		BER	3	0.3	3.2		
2011	129	1131	47.3	L	70.999	-6.926	10.0	F	BER	4	0.2	3.2		
2011	129	1135	49.8	L	70.932	-6.738	3.0		BER	3	0.1	3.2		
2011	129	1146	0.2	L	70.971	-6.842	3.0		BER	4	0.2	3.0		
2011	129	1150	6.8	L	70.761	-6.781	6.0		BER	9	0.3	3.4		
2011	129	1154	40.5	L	71.032	-6.706	3.0		BER	4	0.1	3.1		
2011	129	1158	25.7	L	71.199	-6.821	10.0	F	BER	4	0.2	3.2		
2011	129	1204	22.5	L	71.051	-6.892	10.0	F	BER	4	0.2	3.1		
2011	129	1306	31.5	L	70.793	-6.852	15.0		BER	15	0.6	3.7		
2011	129	1424	5.5	L	71.084	-6.934	12.7		BER	4	0.1	3.2		
2011	129	1434	26.3	L	70.943	-7.105	3.0		BER	4	0.2	3.0		
2011	129	1802	37.6	L	71.151	-6.834	10.0	F	BER	4	0.2	3.4		
2011	129	1819	60.0	L	70.981	-6.982	10.0	F	BER	4	0.2	3.1		
2011	129	1833	45.9	L	70.797	-7.126	15.0		BER	6	0.3	3.5		
2011	129	1955	54.2	L	71.250	-6.928	10.0	F	BER	4	0.2	3.0		
2011	129	2125	11.9	L	70.981	-6.830	3.0		BER	4	0.1	3.0		
2011	130	0154	10.4	L	70.883	-7.316	10.0	F	BER	6	0.3	3.2		
2011	130	0442	29.0	L	70.912	-7.062	3.0		BER	3	0.1	3.3		
2011	130	0451	50.8	L	70.849	-6.696	3.4		BER	11	0.3	3.3		
2011	130	0606	4.6	L	70.998	-7.031	3.0		BER	3	0.1	3.0		
2011	130	0610	3.0	L	71.020	-6.859	3.0		BER	4	0.2	3.2		
2011	130	1010	5.0	L	70.839	-6.689	6.7		BER	15	0.5	3.6		
2011	130	1627	59.6	L	70.835	-6.671	5.1		BER	20	0.5	4.0		
2011	130	1627	59.6	L	71.269	-6.966	10.0	F	BER	4	0.3	4.0		
2011	130	1636	1.5	L	70.892	-6.866	15.0		BER	12	0.6	3.5		
2011	130	2205	43.5	L	70.811	-6.779	10.0	F	BER	9	0.4	3.3		
2011	130	2246	11.8	L	71.340	-7.198	10.0	F	BER	4	0.2	3.1		
2011	130	2254	36.6	L	70.902	-6.758	10.0	F	BER	12	0.5	3.5		
2011	131	0439	30.6	L	70.907	-6.928	3.0		BER	3	0.1	3.4		

2011	131	1334	26.4	L	70.973	-6.720	3.0		BER	4	0.1	3.2
2011	131	1549	55.9	L	71.175	-7.298	10.0	F	BER	3	0.2	3.5
2011	131	1741	40.9	L	71.080	-6.957	10.0	F	BER	4	0.2	3.1
2011	131	2137	28.2	L	71.055	-6.960	10.0	F	BER	4	0.3	3.1
2011	131	2152	8.8	L	70.981	-6.943	10.0	F	BER	4	0.1	3.3
2011	2 2	0709	38.2	L	70.927	-7.101	0.6		BER	4	0.2	3.1
2011	2 3	0755	58.5	L	61.604	3.435	15.0		BER	31	0.8	3.0
2011	2 4	0804	43.3	L	76.846	18.208	18.8		BER	6	0.5	2.3
2011	2 5	0001	22.4	L	70.834	-7.156	6.1		BER	28	0.8	3.9
2011	2 5	0121	5.8	L	71.057	-6.984	3.0		BER	4	0.3	3.1
2011	2 5	0236	9.0	L	71.060	-6.927	11.5		BER	4	0.2	3.1
2011	2 5	1644	56.6	L	70.856	-6.956	10.0	F	BER	24	0.7	3.2
2011	2 5	1743	24.3	L	71.037	-6.919	11.5		BER	4	0.2	3.1
2011	213	1929	2.6	L	58.444	1.672	7.5		BER	40	0.7	2.9
2011	220	1806	39.5	L	70.805	-6.691	2.4		BER	10	0.3	3.4
2011	221	2003	41.2	L	70.983	-7.052	2.2		BER	3	0.2	2.2
2011	226	0430	17.5	L	61.627	2.036	10.0	F	BER	33	1.1	3.0
2011	3 4	1116	46.3	L	73.071	5.762	22.7		BER	23	0.8	2.9
2011	3 6	0525	46.3	L	70.866	-6.234	10.0	F	BER	9	0.6	3.9
2011	3 6	2050	30.5	L	73.018	6.194	10.0	F	BER	15	0.5	2.6
2011	3 7	1352	58.1	L	70.877	-7.157	10.9		BER	21	1.0	4.2
2011	3 7	2304	0.3	L	73.095	6.023	10.0	F	BER	15	0.7	2.8
2011	3 9	0411	4.7	L	73.009	5.930	0.8		BER	9	0.2	3.0
2011	312	0311	39.0	L	63.823	2.513	23.2		BER	21	0.4	2.6
2011	314	0248	22.3	L	72.111	1.385	10.0	F	BER	8	0.4	3.4
2011	315	1056	38.3	L	71.252	-6.817	10.0	F	BER	4	0.4	3.1
2011	315	1145	45.9	L	73.039	6.181	0.0		BER	9	0.4	3.0
2011	317	0231	59.0	L	71.269	-8.955	10.0	F	BER	4	0.2	3.0
2011	319	0234	2.1	L	73.447	7.867	15.0		BER	8	0.3	3.2
2011	320	0314	31.5	L	73.397	7.415	12.0		BER	8	0.3	3.0
2011	321	0605	6.0	L	77.121	22.398	14.5		BER	8	0.5	3.0
2011	322	0547	49.6	L	71.040	-7.433	10.0	F	BER	8	0.4	3.4
2011	324	1700	20.7	L	70.742	-6.742	10.0	F	BER	7	0.2	3.5
2011	325	0200	39.4	L	70.986	-6.884	10.0	F	BER	4	0.3	3.2
2011	325	0522	15.5	L	71.455	-7.562	10.0	F	BER	4	0.5	3.0
2011	325	1554	32.4	L	74.635	9.166	2.8		BER	6	0.4	2.3
2011	327	1134	20.0	L	59.979	12.869	3.5		BER	12	0.5	1.8
2011	329	0236	2.8	L	77.774	8.290	10.0	F	BER	5	0.4	2.4
2011	4 3	2221	55.3	L	76.987	18.586	21.8		BER	10	0.6	3.2
2011	4 5	0407	55.8	L	75.938	8.099	10.0	F	BER	8	0.4	2.1
2011	4 7	1720	56.4	L	78.447	8.537	10.0	F	BER	9	0.5	3.1
2011	410	0555	9.6	L	76.939	18.288	18.8		BER	7	0.5	2.7
2011	414	1552	8.3	L	75.536	9.111	3.0		BER	22	0.9	2.8
2011	420	0607	29.9	L	70.980	-7.407	10.0	F	BER	6	0.5	3.2
2011	421	0012	6.0	L	73.843	9.655	0.0		BER	13	0.6	2.3
2011	5 1	0330	4.2	L	71.183	-6.857	10.0	F	BER	8	0.4	3.3
2011	5 1	0956	27.7	L	80.494	0.998	15.0		BER	10	0.7	2.7
2011	5 2	1003	56.2	L	70.566	-6.753	10.0	F	BER	8	0.5	3.4
2011	5 5	0157	59.6	L	77.092	18.934	19.1		BER	12	0.8	3.2
2011	5 5	1109	4.8	L	77.074	19.170	15.0		BER	15	1.0	4.3
2011	5 5	1114	5.2	L	77.075	18.852	18.3		BER	6	0.3	3.1
2011	5 5	2323	14.7	L	79.151	4.424	10.0	F	BER	5	0.6	3.2
2011	513	1634	52.5	L	70.952	-7.054	0.0		BER	4	0.3	2.8
2011	513	1653	30.7	L	70.976	-7.034	0.0		BER	4	0.3	3.2
2011	514	0312	36.5	L	70.997	-7.089	0.0		BER	4	0.3	3.0
2011	516	2012	43.5	L	73.375	7.976	15.0		BER	11	0.3	3.3
2011	521	0242	45.6	L	76.969	19.053	15.0		BER	8	0.7	2.7
2011	521	1946	29.9	L	71.048	-8.094	10.0	F	BER	9	0.7	3.6
2011	525	1608	40.0	L	74.165	9.345	10.0	F	BER	12	0.6	2.8
2011	525	1655	37.9	L	74.229	9.231	13.8		BER	19	0.8	3.1
2011	531	0645	41.0	L	79.059	3.668	15.0		BER	6	0.6	2.6
2011	6 4	0423	49.1	L	73.327	7.352	10.0	F	BER	25	0.5	2.6
2011	6 7	0615	4.9	L	71.453	-12.038	10.0	F	BER	12	0.6	3.3
2011	6 8	1303	43.4	L	81.415	-3.056	0.0		BER	9	0.7	2.4
2011	6 9	1340	55.4	L	70.720	-7.136	10.0	F	BER	9	0.6	3.8
2011	610	0357	32.0	L	77.554	8.577	15.0		BER	6	0.4	2.4
2011	611	1643	53.3	L	78.397	8.316	10.0	F	BER	6	0.4	3.0
2011	614	2350	56.5	L	73.330	7.476	8.3		BER	17	0.5	2.0

2011	616	0007	22.3	L	77.069	18.881	15.0	F	BER	14	0.8	3.0	
2011	620	2331	3.9	L	73.721	8.344	22.9		BER	18	0.5	3.8	
2011	622	0426	1.3	L	70.763	-6.859	10.0	F	BER	13	0.4	4.0	
2011	623	0828	59.6	L	77.118	18.618	19.5		BER	7	0.4	3.0	
2011	624	1827	54.5	L	77.151	18.833	15.0		BER	9	0.5	2.9	
2011	624	2256	23.6	L	75.138	8.263	10.0	F	BER	11	0.5	2.1	
2011	628	1003	4.3	L	65.041	0.592	15.0	F	BER	27	0.8	2.9	
2011	7 1	0939	12.9	L	73.909	8.708	10.0	F	BER	16	0.8	2.2	
2011	7 3	1643	4.3	L	70.769	-6.893	1.1		BER	8	0.5	3.5	
2011	713	0237	23.2	L	78.406	8.109	10.0	F	BER	8	0.6	2.8	
2011	714	2242	15.6	L	66.769	5.985	15.0	F	BER	19	0.5	2.1	
2011	717	0901	14.9	L	70.692	-8.724	0.0		BER	4	0.3	2.4	
2011	721	0059	16.9	L	60.954	11.574	17.4		BER	70	0.7	3.3	3.5
2011	727	1425	30.6	L	72.342	2.270	10.0	F	BER	17	0.7	2.6	
2011	729	0736	40.2	L	77.206	18.976	17.2		BER	6	0.4	2.8	
2011	729	0847	46.8	L	77.176	18.957	21.1		BER	12	0.9	3.0	
2011	8 3	1532	42.9	L	77.163	18.792	15.0		BER	15	0.5	3.0	
2011	8 4	0322	25.1	L	71.099	-8.362	19.6		BER	4	0.1	3.0	
2011	8 4	0604	54.8	L	71.038	-7.377	10.0	F	BER	4	0.1	3.2	
2011	8 4	0647	22.8	L	70.952	-7.317	10.0	F	BER	12	0.4	3.1	
2011	8 4	1941	13.9	L	70.918	-7.347	10.0	F	BER	8	0.4	3.4	
2011	8 4	2017	44.9	L	70.865	-7.363	10.0	F	BER	10	0.5	3.7	
2011	8 5	2353	55.2	L	78.409	8.339	10.0	F	BER	7	0.3	3.0	
2011	8 7	0448	56.7	L	78.450	7.220	0.0		BER	10	0.4	3.1	
2011	8 7	2248	29.8	L	72.035	0.936	12.1		BER	8	0.3	2.2	
2011	813	0014	56.0	L	71.206	-8.526	10.0	F	BER	4	0.1	3.0	
2011	816	1029	55.4	L	65.984	0.272	10.0	F	BER	14	0.6	2.2	
2011	817	2024	41.7	L	71.169	-8.198	10.0	F	BER	4	0.1	3.2	
2011	820	0323	49.5	L	71.162	-7.433	10.0	F	BER	7	0.4	3.3	
2011	821	0442	37.9	L	70.954	-7.097	0.0		BER	4	0.1	3.1	
2011	822	0024	41.6	L	70.942	-7.403	13.0	F	BER	10	0.3	3.8	
2011	822	0533	51.5	L	74.330	9.235	10.0	F	BER	11	0.5	2.3	
2011	824	0808	14.5	L	72.526	3.678	10.0	F	BER	46	0.9	3.4	
2011	824	0811	31.4	L	72.585	3.755	14.2		BER	19	0.5	2.7	
2011	824	0910	13.3	L	72.615	3.251	10.0	F	BER	25	1.1	2.9	
2011	824	1047	29.9	L	72.592	3.230	10.0	F	BER	22	0.7	2.8	
2011	824	1252	53.6	L	72.584	3.555	31.0		BER	21	0.5	2.8	
2011	9 2	0954	43.3	L	78.397	7.651	1.4		BER	14	0.9	2.9	
2011	910	0621	3.1	L	71.554	-10.333	18.0		BER	8	0.1	3.3	
2011	927	1732	12.4	L	77.014	18.866	19.4		BER	8	0.3	2.8	
2011	10 2	0504	26.3	L	70.981	-7.376	3.9		BER	7	0.3	3.5	
2011	10 2	1319	11.3	L	70.969	-7.432	10.0	F	BER	7	0.4	3.4	
2011	10 2	2054	44.9	L	77.423	20.247	13.8		BER	22	1.1	3.9	
2011	10 5	0413	36.4	L	75.696	8.458	15.0		BER	15	0.8	2.7	
2011	1012	0637	55.0	L	65.942	0.145	10.0	F	BER	19	0.5	2.4	
2011	1017	2336	8.8	L	70.806	-6.661	2.2		BER	10	0.4	3.5	
2011	1019	2235	7.9	L	75.214	8.231	20.8		BER	17	1.0	2.8	
2011	1020	1912	48.1	L	72.275	0.374	31.0		BER	17	1.7	3.4	
2011	1024	1438	7.0	L	71.107	-6.626	10.1		BER	4	0.4	3.1	
2011	1025	0232	17.2	L	70.786	-6.802	10.0	F	BER	34	0.9	4.3	
2011	1025	0306	37.6	L	71.237	-6.791	10.0	F	BER	4	0.2	3.2	
2011	1025	2305	47.0	L	70.726	-6.697	6.2		BER	8	0.3	3.4	
2011	1030	1129	20.7	L	73.757	9.026	10.0	F	BER	17	0.8	2.4	
2011	1031	1443	21.6	L	71.226	-8.701	3.0		BER	4	0.1	3.3	
2011	11 1	0328	17.5	L	72.121	0.493	0.0		BER	12	3.5	3.2	
2011	11 3	0039	20.4	L	76.877	18.173	17.8		BER	9	0.5	2.9	
2011	11 4	0703	7.5	L	76.945	18.336	17.5		BER	8	0.5	2.9	
2011	1113	1848	36.5	L	66.625	13.196	7.0		BER	17	0.5	2.7	
2011	1114	0816	9.1	L	78.701	5.967	10.0	F	BER	6	0.4	2.8	
2011	1118	2324	51.2	L	67.660	33.709	0.0		BER	7	0.6	3.0	
2011	1119	2104	25.9	L	81.113	0.001	0.0		BER	7	0.5	2.8	
2011	1122	2252	50.7	L	71.114	-7.156	0.1		BER	9	0.4	3.3	
2011	1122	2255	52.8	L	70.894	-7.144	0.0		BER	4	0.2	3.1	
2011	12 1	0604	15.2	L	60.956	26.597	0.0		BER	6	0.4	3.0	
2011	12 7	1131	41.9	L	78.336	8.176	0.0		BER	6	0.3	3.0	
2011	1218	0919	43.1	L	77.059	8.467	15.0		BER	9	1.1	2.4	
2011	1224	2239	7.8	L	77.635	8.623	13.0		BER	8	1.1	3.0	

The largest local or regional earthquake in 2011, recorded on Norwegian stations and within the prime area, occurred on January 29th at 06:55(UTC) southeast of Jan Mayen. The earthquake had a magnitude of M_L=6.0 (BER) and was strongly felt at the island 70 km away. The largest earthquakes in the vicinity of the Norwegian mainland are:

- The earthquake located close to Elverum, Hedmark, occurring on 21 July at 02:59 local time (00:59 UTC) with a magnitude of M_L=3.5. This earthquake was reported felt.
- Two earthquakes located offshore Florø, Sogn og Fjordane, occurred on 3 February and 26 February, respectively. The earthquakes were registered both on Norwegian and British seismic stations and both have a magnitude M=3.0. One of the earthquakes is located close (about 50 km) to the Statfjord area.
- An earthquake occurred in the North Sea on 13 February at 19:29 (UTC) with magnitude M_L=2.9. This event was located within 5 km of the Sleipner field.

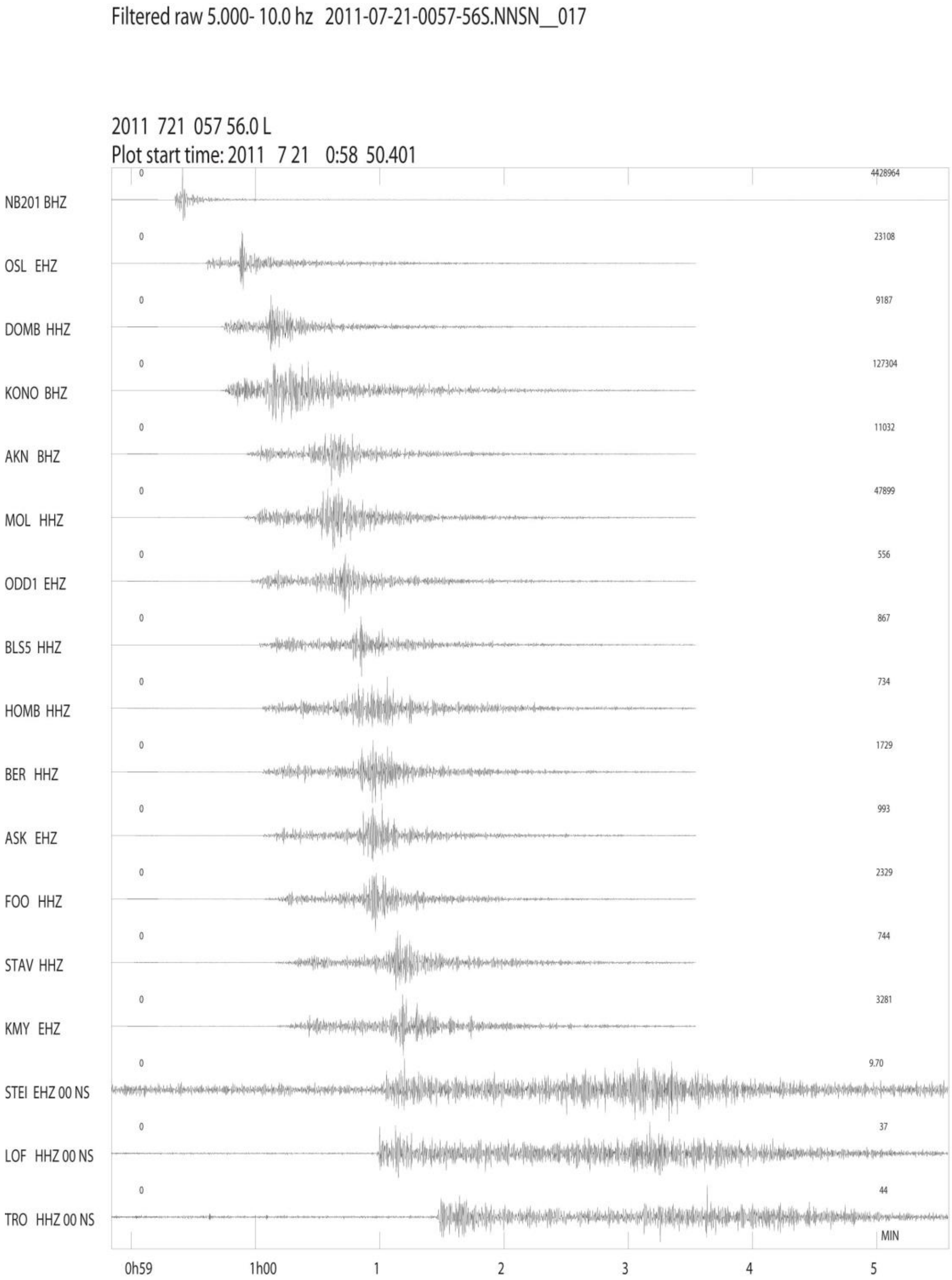

Figure 7. Seismograms for the earthquake occurring on 21st July at 00:59 (UTC) and located close to Elverum, Hedmark. The seismograms are filtered between 5-10 Hz. The horizontal time scale is minutes, first marking at 00:59(UTC).

5.1 Seismicity in Nordland

Figure 8 shows the seismicity in Nordland since 2000. The area includes the locations of earthquake swarm activity such as Meløy, Steigen and Stokkvågen. The latter two areas are clearly visible on the map.

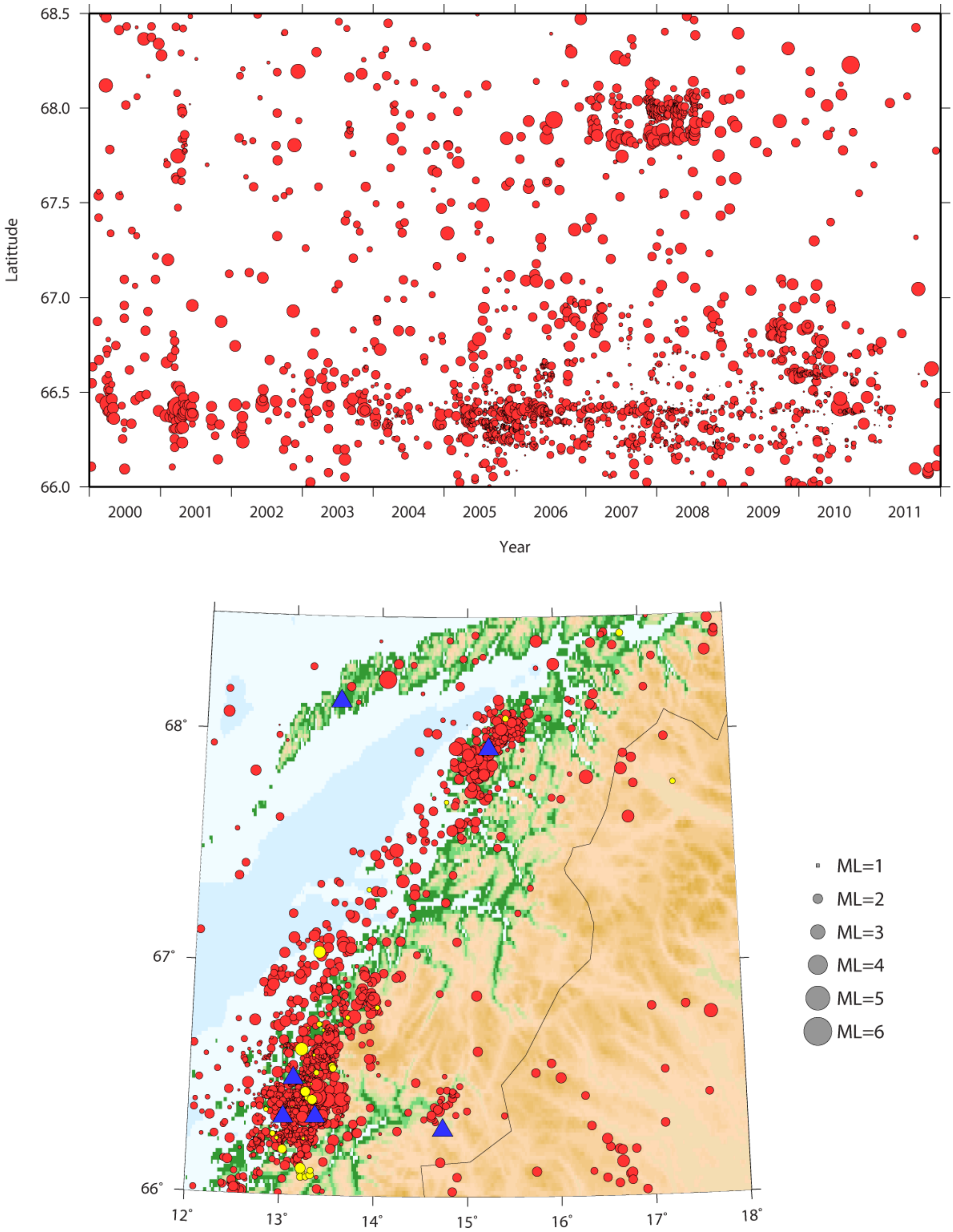

Figure 8. Seismicty in the Nordland area. Bottom: Red circles show seismicity for 2000-2010, and yellow circles show seismicity for 2011. Explosions are excluded. The blue triangles give the station locations. Top: Seismicity in the same area is plotted as latitude versus time of occurrence.

Steigen was active between 2007 and 2008, but has been relatively quiet since then. The activity in the Stokkvågen area has been nearly continuous, but specific clusters in time and space have occurred. The temporal distribution shows the cluster in 2005, which is when the three station network was installed. The number of events in 2011 was lower than in previous years, probably reflecting that the station FLOS went down in February. It is not planned to continue this station.

5.2 Seismicity in the arctic area

With the mainland stations on the Lofoten, in Tromsø and Hammerfest, the network on Jan Mayen, and stations on Bjørnøya, Hopen and Svalbard, the network detection capability in the arctic area is relatively good. We define the artcic area as the region 65-85°N and 20°W-50°E. Most of the activity falls into three areas: Jan Mayen, the Mid-Atlantic ridge and Storfjorden southeast of Svalbard, as can be seen in Figure 9.

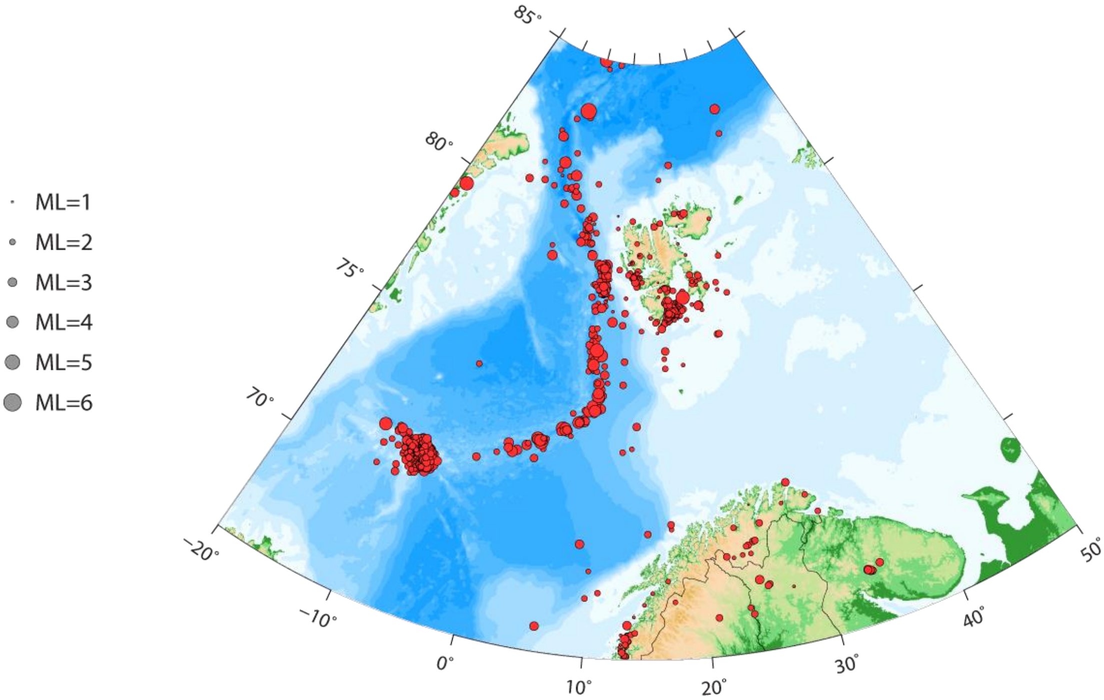

Figure 9. Seismicity in the Norwegian arctic area during 2011. A total of 1510 located earthquakes.

5.3 Jan Mayen

Jan Mayen is located in an active tectonic area with two major structures, the Mid Atlantic ridge and the Jan Mayen fracture zone, interacting in the vicinity of the island. Due to both tectonic and magmatic activity in the area, the number of recorded earthquakes is higher than in other areas covered by Norwegian seismic stations. During 2011 a total of 739 earthquakes were located as seen in
Figure 10 and of these, 110 had a magnitude equal or above 3.0. The largest earthquake in the Jan Mayen region in 2011 occurred on 29 January at 06:55 (UTC). This earthquake was located at 70.79N and 6.90W with a magnitude of 6.0. The earthquake was strongly felt by the population on the island only 70 km from the hypocenter. The mechanism was similar to the M=6.0 event in 2004 (Sørensen et al., 2007). However, the 2011 event was located about

40 km to the southeast of the 2004 event. Both earthquakes are attributed to the Jan Mayen fracture zone and fall onto the Koksneset fault.

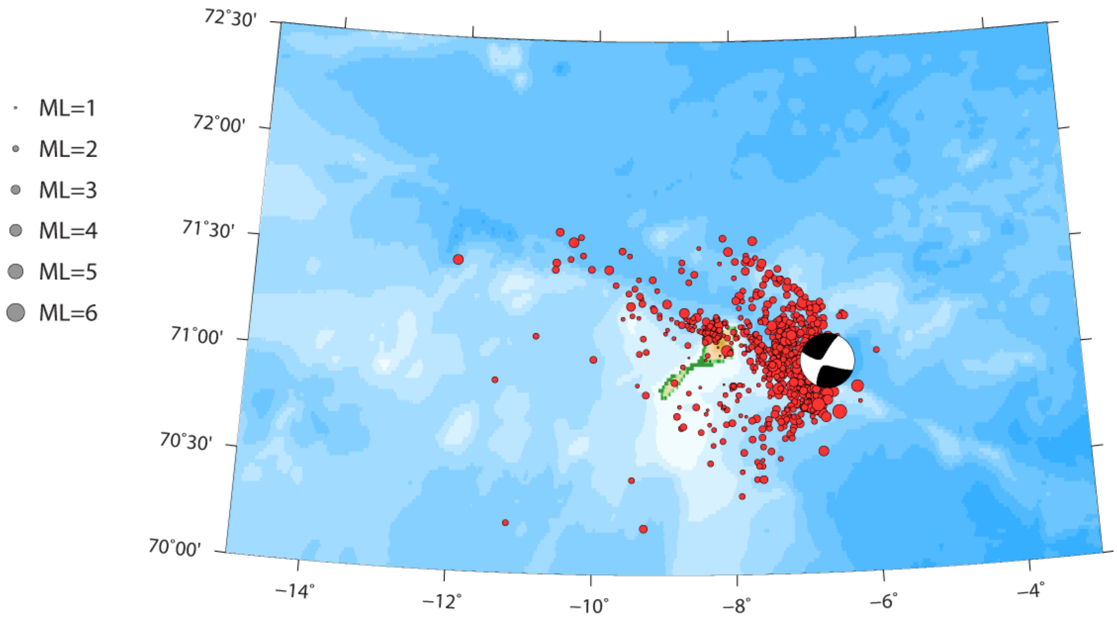

Figure 10. Earthquakes located in the vicinity of Jan Mayen during 2011. The moment tensor solution from the Harvard CMT catalog for the 2011 earthquake is plotted on top of the seismicity.

The number of recorded earthquakes in the Jan Mayen area has varied over the last years (Figure 11). The number of relative strong earthquakes (M≥3) shows smaller time variation than for the smaller earthquakes. The increases in 2004 and 2005 were due to the M=6.0 earthquake in 2004 and its aftershocks (Sørensen et al., 2007). The same is true for 2011, where the M=6.0 earthquake on 29 January was followed by a sequence of aftershocks.

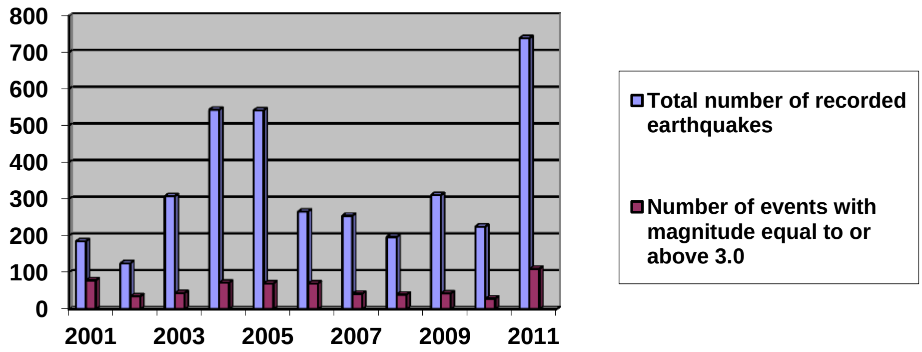

Figure 11. Yearly distribution of earthquakes located in the Jan Mayen area since 2001.

5.4 Storfjorden

The Storfjorden area southeast of Svalbard has been seismically active since the M_w=6.0 earthquake on 21 February 2008. A preliminary study was presented by Piril et al. (2008).

One of the main objectives from this study was to resolve the source mechanism, which was found to be oblique-normal. This result was found from the inversion of both regional and teleseismic data. The earthquake had a high number of aftershocks.

A total of more than 20 earthquakes with magnitude larger than 4 have occurred in the area since 2008. An interesting question is whether the earthquakes now are aftershocks to the event in 2008. From the monthly number of all detected earthquakes, shown in Figure 11, it seems that the activity had decreased until the start of 2009 and then remained relatively low until late 2009. In 2010 the number had increased again and remained mostly stable in 2011. This is mostly explained by an increase in the number of smaller earthquakes as seen by the almost constant levels of earthquakes with M>2.5 since 2008. The better detection is due to usage of the data from the Hornsund (HSPB) station.

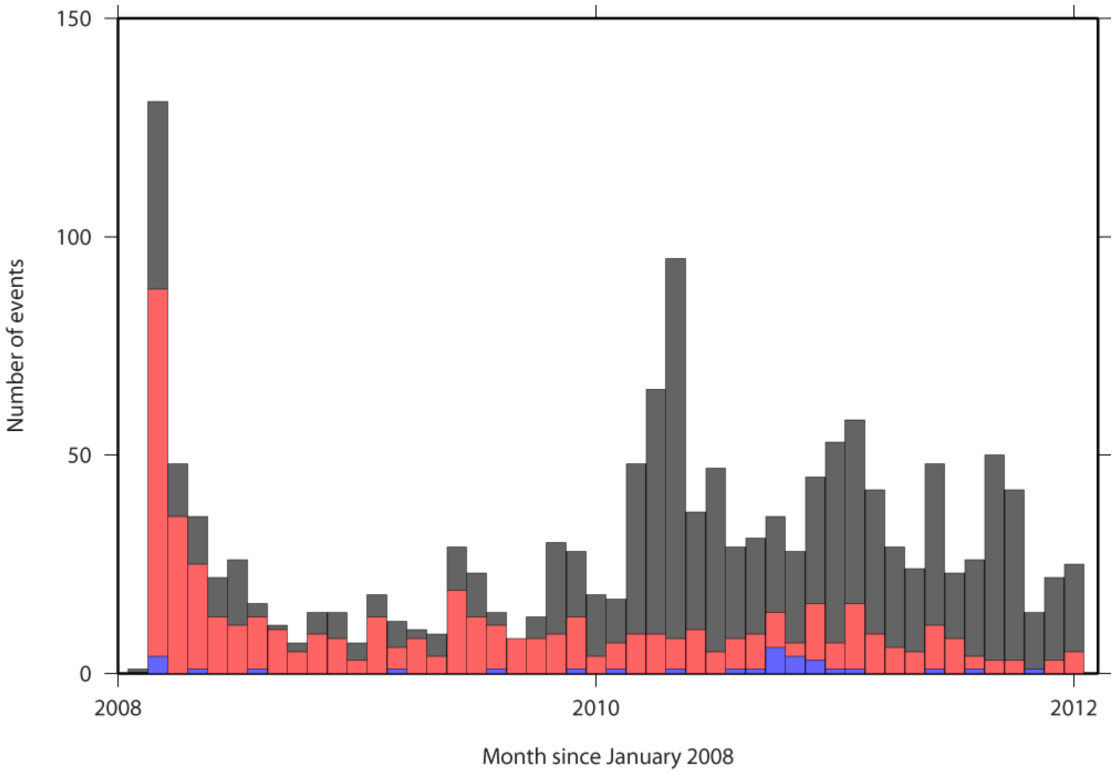

Figure 12. Monthly number of earthquakes in the Storfjorden area since January 2008. The colours show: grey – all events, red – M>2.5, blue M>4.0.

Figure 13 shows both a map with the seismicity since 2000 and the distribution of events over time. The onset of the activity in the Storfjorden area in February 2008 is obvious from the time plot. The seismicity in 2011 is mostly concentrated in the southwestern half of the area that has been active since 2008.

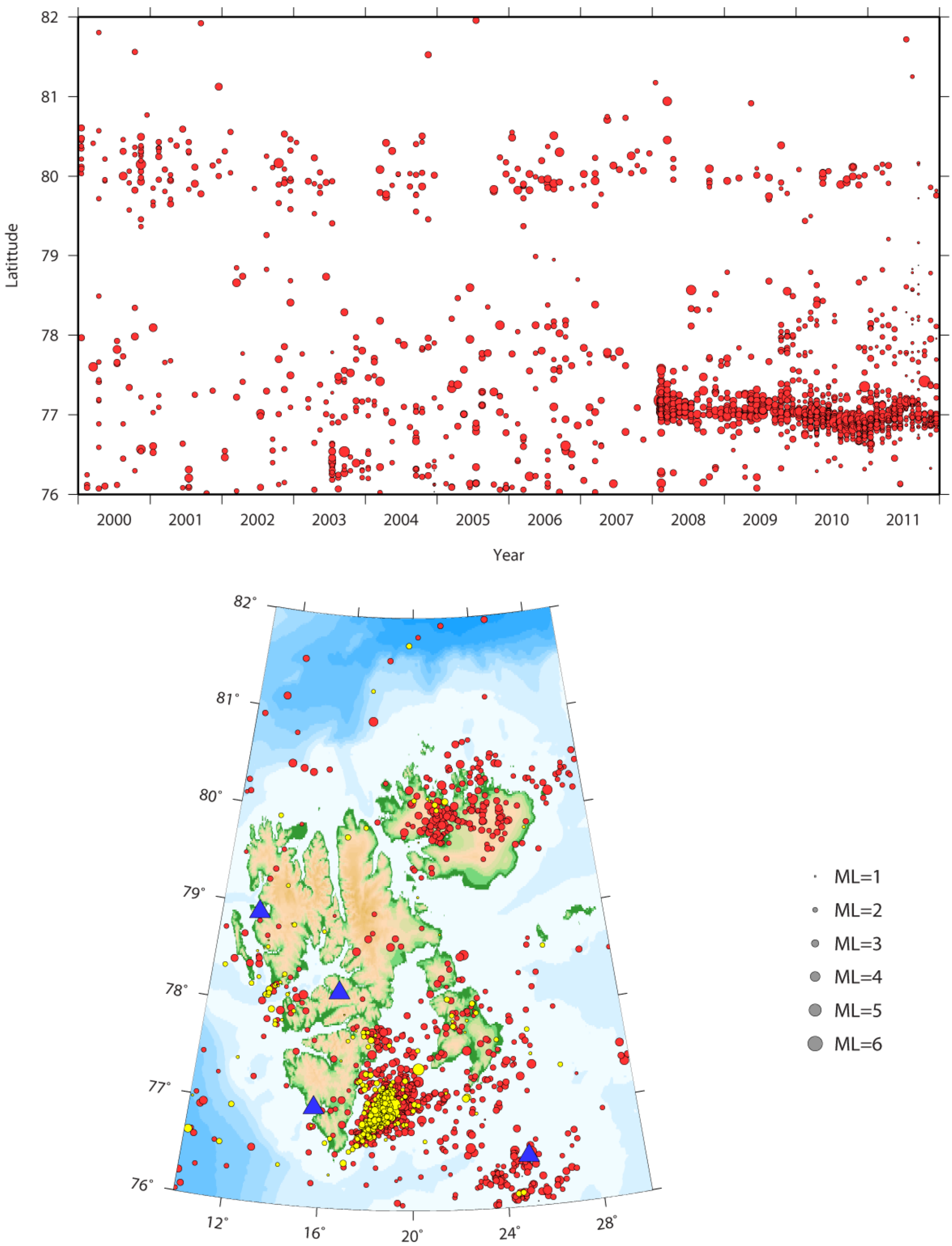

Figure 13. Seismicty in the Svalbard area. Bottom: Red circles show seismicity for 2000-2010, and yellow circles show seismicity for 2011. The blue triangles give the station locations. Top: Seismicity in the same area is plotted as latitude as function of time.

5.5 Hedmark

An earthquake occurred about 15 km northwest of Elverum on 21 July 2011 at 00:59:16.9 (UTC) with a magnitude ML=3.3. The earthquake was felt with a maximum intensity of MMI=V. The event occurred within the NORSAR array and could, therefore, be well located. The location based on all elements of the NORSAR and the NNSN stations was 60.954°N and 11.574°E, with a depth of 17.4 km. A detailed study by Schwitzer (2011) placed the event at 60.9642°N and 11.5849°E with a depth of 22.8 km. Schweitzer (2011) determined the mechanism to be reverse with the nodal planes striking NNE-SSW and N-S.

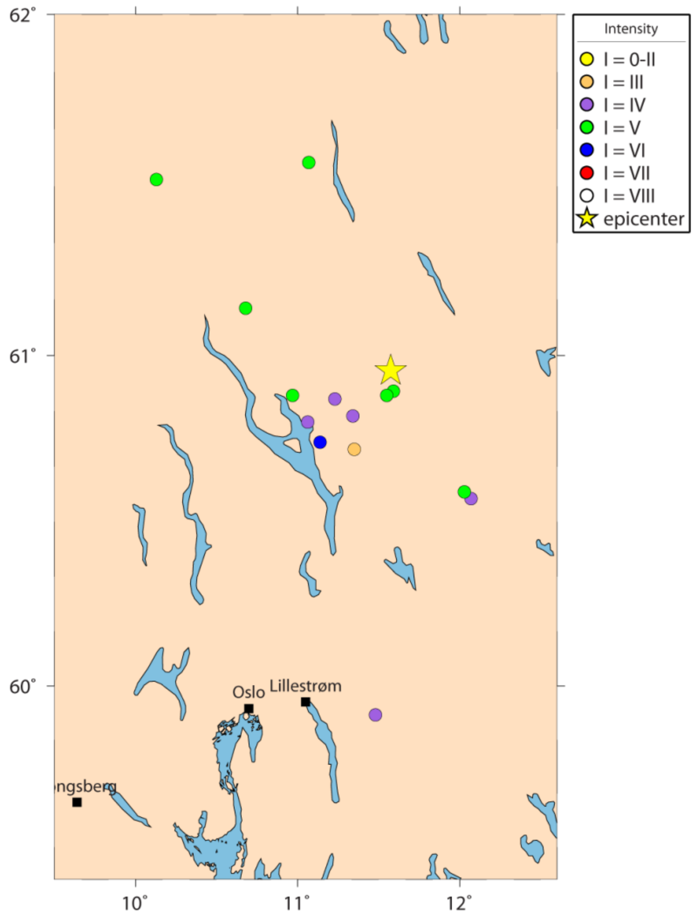

Figure 14. Macroseismic map of the 21 July 2011 Elverum earthquake.

5.6 Oslo

The car bomb explosion in Oslo within the executive government quarter that started the terror attack of 22 July 2011 was recorded on the seismometer installed at the Geologibygningen, UiO, station OSL, about 3 km from the explosion. Using the OSL station only, the location of the explosion was determined at 59.910°N and 10.752°E (Figure 15) with an origin time of 13:25:21.9 (UTC). The magnitude measured on the OSL station was ML=1.3. The seismograms recorded at OSL station (Figure 16) show P and S arrivals, but also the acoustic wave that is marked with 'I'. The travel time of this acoustic wave is consistent with a distance of 3 km and a sound speed of 340 m/s.

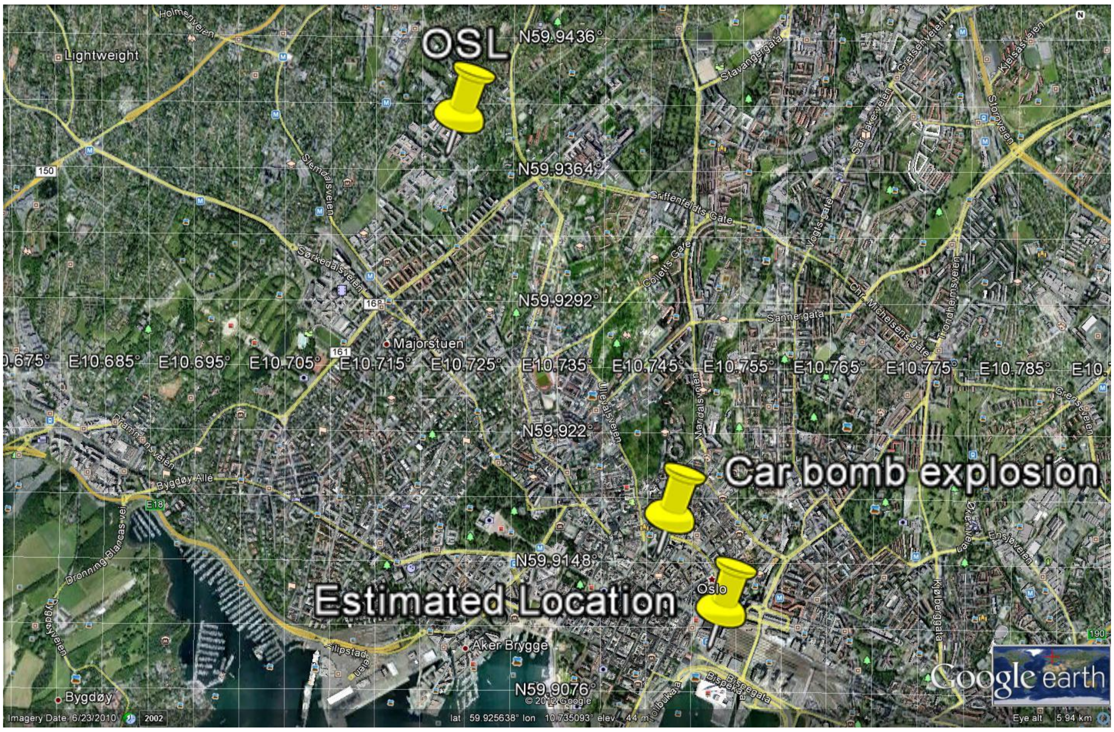

Figure 15. Comparison of estimated location of the car bomb explosion to the actual location. The location of the station OSL is marked, about 3 km to the northwest of the explosion.

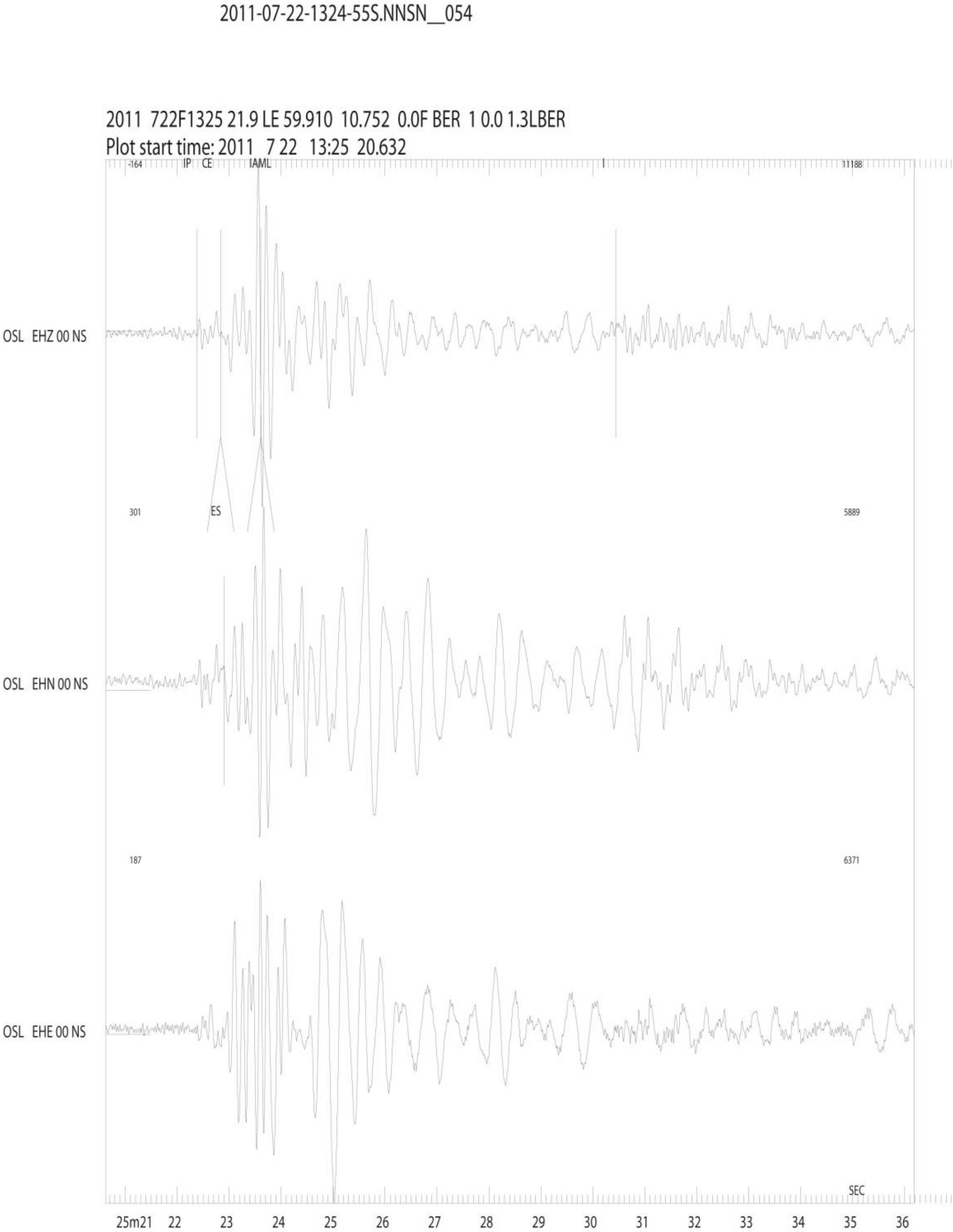

Figure 16. Seismograms recorded at station OSL from the car bomb explosion on 22 July 2011. The phase marked with 'I' gives the onset of the acoustic wave.

6 Felt earthquakes

From 2006 it is possible to report felt earthquakes over the internet. When an earthquake is reported felt by an sufficient number of people, questionnaires are available for the public on the site www.skjelv.no. In total, 15 earthquakes were reported felt and located within the target area during 2011 (see Table 7 and

Figure 17). Not all earthquakes were felt in Norway. For the Jan Mayen island the number of felt earthquakes is expected to be larger then reported.

Table 7.
Earthquakes reported felt in the BER database in 2011. Abbreviations are: $\mathbf{M_c}$ = coda magnitude, $\mathbf{M_L}$ = local magnitude and $\mathbf{M_w}$ = moment magnitude, **W**: questionnaires received on web (Y/N). W is blank for earthquakes not felt in Norway.

Nr	Date	Time (UTC)	Max. Intensity (MMI)	Magnitude (BER)	Instrumental epicentre location	W
1	12.01.11	06:01	V	M_c=2.3, M_L=1.8, M_W=2.3	60.24N / 10.52E	Y
2	12.01.11	18:09	III	M_c=2.3, M_L=1.5, M_W=1.9	60.17N / 10.55E	Y
3	16.01.11	22:43	III	M_c=1.8, M_L=1.7,	59.89N / 05.48E	N
4	19.01.11	13:32	III	M_c=1.7, M_L=1.3	60.01N / 09.50E	N
5	29.01.11	06:55	IV	M_L=6.0	70.79N / 06.90W	N
6	27.03.11	11:34	II	M_C=3.1, M_L=1.8	59.97N / 12.87E	N
7	21.05.11	19:46	II	M_c=1.9, M_L=3.6	71.05N / 08.09W	N
8	21.07.11	00:59	V	M_L=3.3, M_W=3.5	60.95N / 11.27E	Y
9	03.08.11	20:33		M_L=2.2, M_C=2.9	68.21N / 24.57E	
10	21.08.11	08:37	III	M_L=2.7	56.85N / 05.66W	
11	21.08.11	18:24	III	M_L=1.8	56.86N / 05.66W	
12	13.11.11	02:39	IV	M_c=2.4, M_L=2.0, M_W=2.0	60.44 N / 05.29E	Y
13	13.11.11	18:48	II	M_L=2,7, M_C=2.8	66.63 N / 13.19E	N
14	14.11.11	00:33		M_L=2.2	57.50N / 05.54W	
15	31.12.11	00:16	II	M_L=2.1	61.63N / 04.76E	N

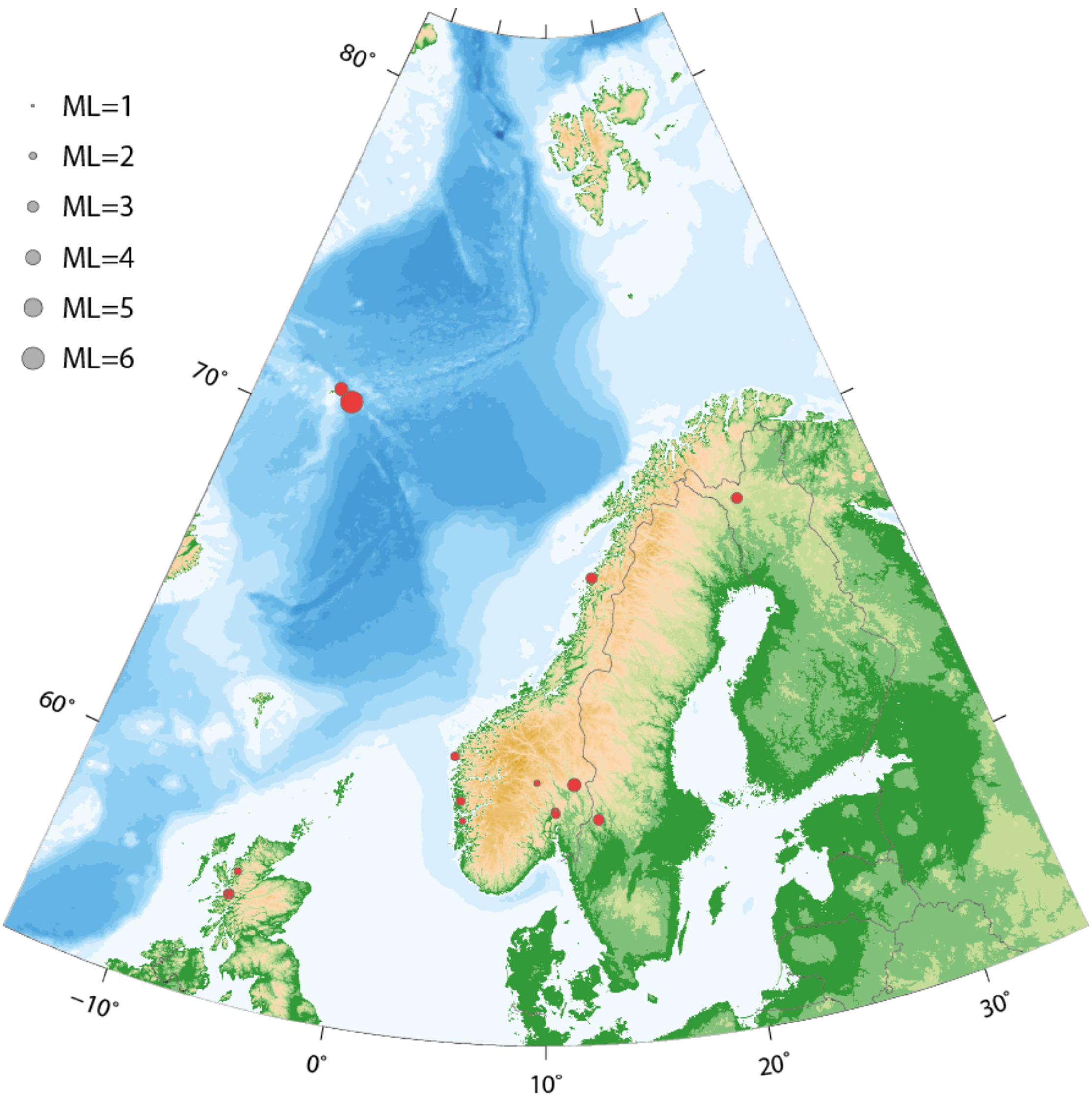

Figure 17. Location of the 15 earthquakes reported felt during 2011.

7 Use of NNSN data during 2011

Data collected on Norwegian seismic stations are made available through the Internet and is provided on request to interested parties. Therefore it is difficult to get a comprehensive overview on the use and all publication based on Norwegian data.

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1 Introduction

This annual report describes the operation of the Norwegian National Seismic Network (NNSN) for the first part of 2011. The network is financially supported by the oil industry through the Norwegian Oil Industry Association ("Oljeindustriens Landsforening", OLF) and the University of Bergen (UiB). UiB has the main responsibility to run the NNSN. This report covers operational aspects for all seismic stations operated by the Department of Earth Science at the UiB and includes the financial report.

2 Operation

In Norway, UiB operates 32 of the seismic stations that form the Norwegian National Seismic Network (NNSN). NORSAR operates 3 seismic arrays, which also include broadband instruments, and two single seismometer stations (JMIC and AKN) (Figure 19). In total, NORSAR provides data from five broadband stations to the NNSN. The station HSPB is operated jointly between NORSAR and the Geophysical Institute, Polish Academy of Sciences, Warsaw, Poland. The seismicity detected by the network is processed at UiB, but also NORSAR integrates their results in the joint database at UiB. A seismicity map for the reporting period is shown in Figure 20.

UiB is in the process of upgrading the NNSN by changing short period (SP) to broadband (BB) seismometers and to increase the number of stations where data can be transmitted to Bergen in real time. A further effort is made to install additional high quality digitizers. The current status of this upgrade is shown in Figure 18. As of today the numbers of SP, BB stations and stations with real time transmission are listed in Table 1.

Table 8. Overview of UiB seismic stations

	Short Period	Broadband	Real time
Number of stations	14	18 (15 with natural period greater than 100 sec)	29

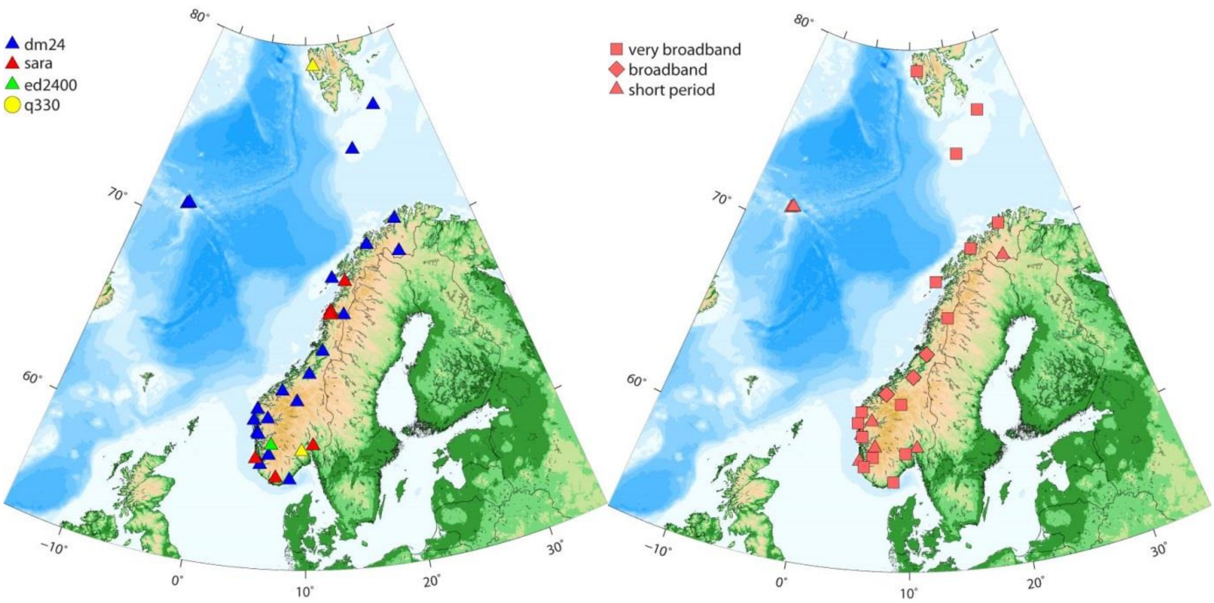


Figure 18. Status of the NNSN stations operated by UiB as of 31 October 2011. Left: Overview of digitizers, still to be upgraded are types Sara and EarthData (ED). Right: Overview of seismometers, where 15 are very broadband.

The operational stability for each station is shown in Table 2. The downtime is computed from the amount of data that are missing from the continuous recordings at UiB. The statistics will, therefore, also show when a single component is not working. This is done as the goal is to obtain as complete continuous data from all stations as possible. Also, communication or computing problems at the centre will contribute to the overall downtime. In the case of communication problems, a station may not participate in the earthquake detection process, but the data can be used when it has been transferred. Thus, the statistics given allow us to evaluate the data availability when rerunning the earthquake detection not in real-time.

The downtime for the majority of stations is below 5%. Larger down time were observed for the following stations: FLOS, HYA, KTK, KONS, MOR, NSS, and TBLU (see technical service overview for details).

Table 9. Data completeness in % for January to September 2011 for all stations of the NNSN operated by UiB.

Station	Data completeness in %
Askøy (ASK)	97
Bergen (BER)	99
Bjørnøya (BJO)	100
Blåsjø (BLS)	100
Dombås (DOMB)	98
Florø (FOO)	99
Flostrand (FLOS)	**20**
Hammerfest (HAMF)	99
Homborsund (HOMB)	100
Hopen (HOPEN)	96
Høyanger (HYA)	**86**
Jan Mayen (JMI)	99
Jan Mayen (JNE)	99
Jan Mayen (JNW)	99
Karmøy (KMY)	100
Kautokeino (KTK)	**82**

Station	Data completeness in %
Kings Bay (KBS)	99
Kongsberg (KONO)	97
Konsvik (KONS)	**88**
Lofoten (LOF)	99
Mo i Rana (MOR8)	**Ca. 50**
Molde (MOL)	98
Namsos (NSS)	**69**
Odda (OOD1)	100
Oslo (OSL)	100
Snartemo (SNART)	95
Stavanger (STAV)	99
Steigen (STEI)	95
Stokkvågen (STOK)	99
Sulen (SUE)	99
Blussvoll (TBLU)	**90**
Tromsø (TRO)	100

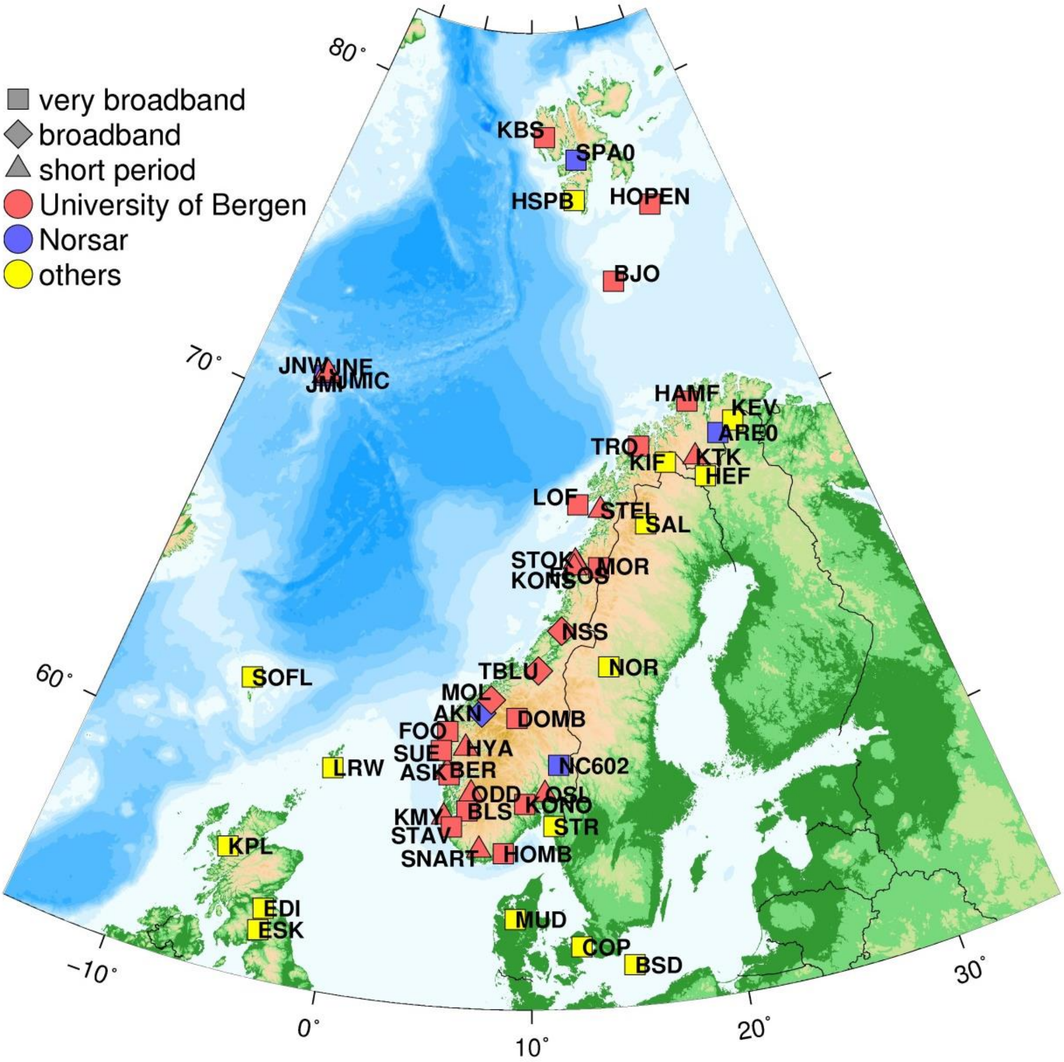


Figure 19. Stations delivering data to the NNSN database.

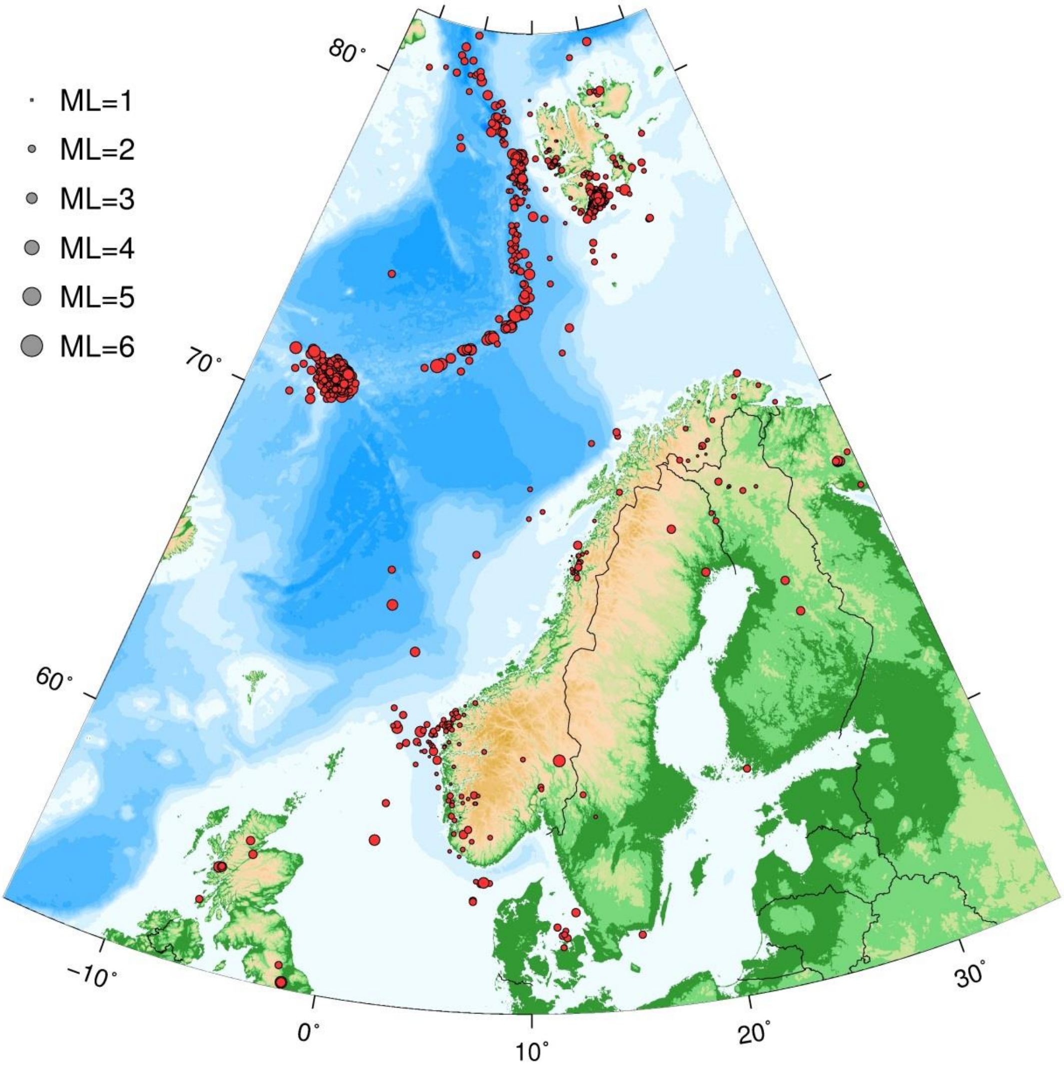


Figure 20. Seismity map showing assumed earthquakes for the period January to September, 2011.

3 Field stations and technical service

The technical changes for each seismic station are listed below. It is noted if these changes are carried out by the respective local contact and not by the technical staff of UiB. When a station stops working, tests are made to locate the problem. Sometimes the reason cannot be found and the cause of the problem will be marked as unknown.

Major changes during this reporting period of 2011 were:

Ask (ASK)	17.02.11: Visit. A new Guralp Digitizer (model CMG-D2M4-EAM) was installed. Unit is modified, gain has been changed from 3.2µV to 0.8µV. GPS antenna is now G-13788. Modem restarted 19.04-26.04.11: Station down, reason unknown. Restart by local operator.
Bergen (BER)	18.01.11. New digitizer (CMG-D2M4-EAM) installed.
Bjørnøya (BJO1)	No visit or technical changes.
Blåsjø (BLS)	No visit or technical changes.
Blussvoll (TBLU)	7.7.11-3.8.11: Station down during school holidays, eventually restarted by local operator.
Dombås (DOMB)	01.02.11: A new digitizer(CMG-D2M4-EAM) was installed by the local operator. 19.08.11: Stations down 31/07/11 16:32 to 19/08/11 06:30 due to thunder storm. A new modem was installed, but station still not ok. Using ICE communication temporarily.
Florø (FOO)	28.02.11: The existing Guralp sensor was replaced with a Trillium 120 sensor.
Flostrand (FLOS)	05.01.11. GMS router for communication was replaced by local operator. 15:02.11: The station was down from 13.02.2011 to 15.02.2011 due to power loss. 28.02.11: Station down, possibly problem with cable. The station will not be fixed before the station configuration in the area has been evaluated.
Hammerfest (HAMF)	05.03.11: Local contact checked the GPS 31.03.11: The defective GPS antenna is replaced by local operator. Timing is now OK again.
Homborsund (HOMB)	No visit or technical changes.
Hopen	No visit or technical changes. The sensor is drifting and is every second week recentred by the local operator. This explains part of the lack of

(HOPEN)	data where the instrument drifts to the limit.
Høyanger (HYA)	22.07.11: Station stopped at 14:20 due to thunderstorm. Station down until 23.08. 05.08.11: New PC installed by local operator and communication is working. However, no data recorded due to problem with digitizer. 23.08.11: Visit: The existing SARA digitizer was replaced with a Guralp CMG-DM24-EAM.
Jan Mayen (JMI)	No visit or technical changes. The bandwidth of the satellite link has been increased, and real-time communication is becoming possible.
Karmøy (KMY)	No visit or technical changes.
Kautokeino (KTK)	11.07.2011. 0650 UTC used SMS for remote restart. 08.07.11: Station down. 25.08.11: New PC installed by local operator. 12.09.11: Earthdata digitizer replaced by the local operator due to noise on E component. 21.09.11: Visit. New CMG-DM24-EAM digitizer installed.
Kings Bay (KBS)	No visit or technical changes.
Kongsberg (KONO)	Communication down from 26.09.11.
Konsvik (KONS)	Occasional communication problems. No visit or technical changes.
Lofoten (LOF)	09-11.05.11: Station upgraded with a Trillium (120PA) sensor and a Guralp (CMG-DM24-EAM) digitizer.
Mo i Rana (MOR8)	05.01.11: Station restarted by local operator. Down since 30.11.10. The local operator is not available for periods of time during the winter. 11.05.11: Station down. Cable was destroyed. 20.06.11: Visit. A new sensor and digitizer was installed. The cable was repaired, but the sensor still don’t work. 19.07.11: Visit. It was not possible to make the sensor work at the site, so it was temporarily moved. Station is now transferring data in real time using satellite communication. A new site will be constructed.
Molde (MOL)	No visit or technical changes.

Namsos (NSS)	07.07.11-26.10.11: Station down due to thunderstorm and lightning. Expected damage to PC and Digitizer. 25.08.11: New PC installed by the local operator. Station still down due to serial line converter or digitizer problem.
Odda (ODD1)	No visit or technical changes.
Oslo (OSL)	No visit or technical changes.
Snartemo (SNART)	05.08-10.08.11: No contact with the station, due to local problems at the phone company.
Stavanger (STAV)	08.02.11: Visit. Installed a new BB sensor, Trillium 120PA, new Guralp digitizer (CMG-DM24) and GPS antenna, a new industrial PC.
Steigen (STEI)	18-29.05.11: Station down due to power loss.
Stokkvågen (STOK)	25.07.11: Thunderstorm and lightning caused communication failure. New modem was installed by the local operator.
Sulen (SUE)	No visit or technical changes.
Tromsø (TRO)	No visit or technical changes.

4 NNSN plans

The overall purpose of the NNSN is to provide data both for scientific studies, but equally important for the routine observation of earthquakes. This in principle means that broadband seismometers are desired at all sites. Of course in areas where additional stations are deployed for local monitoring, short-period seismometers are sufficient. The number of broadband seismometers in the network will be increased to replace existing short period instruments.
A general goal for the future development has to be to achieve better standardization in particular with the seismometers and digitizers. The total number of stations for now should remain stable, but it is important to improve the overall network performance.

We now report achievements for 2011, and then give the plans for 2011/12.

4.1 Achievements in 2011

- Mo i Rana: The Mo i Rana station will be upgraded when the satellite link is sufficiently tested.
  Progress: Done. New station completed in October 2011. Trillium 120, CMG-DM24-EAM and satellite communication.

- Lofoten: the station will be upgraded by installing a new digitizer and computer; a broadband seismometer will be installed either at Lofoten or Steigen.
  Progress: Done. The station LOF was upgraded with a Trillium sensor in May 2011.
- Further upgrade: We have received funding from the department for six broadband sensors. Two of these will be used for portable deployment. The other four will be installed on current NNSN stations. The NNSN budget for new investments in 2011 will be used for digitizers.
  Progress: All available broadband sensors are installed. Five stations are being available for temporary deployment.
- New stations: planning for possible stations in the Hardangervidda area and near Bergen will start.
  Progress: The area around Geilo/Ustaoset is of interest due to easy access by train. The local 'kommune' has been contacted and the area is explored to find a good site. Noise tests are planned.
- Stokkvågen network: The network was intended to be temporary at the time of installation. With five years of recordings we will look into changing the configuration of these stations. A possible solution is to keep one of them, but to move one of them to half-way between this area and Steigen. Equipment at Stokkvågen, Steigen and the new station will have to be improved. During 2011, a noise site survey will be made.
  Progress: No progress has been made. Station FLOS is down, and will be closed at end of 2011.
- Continue with the integration of data from Ekofisk and Statfjord.
  Progress: Sample data from Ekofisk were received, and are evaluated. Real-time data transfer still needs to start. A seismometer was deployed at Statfjord was operating from 23.12.10 in the shaft of STC. However, due to unstable power supply no recordings were made.
- Establish automated routines for event based waveform data extraction from NORSAR for the associated triggers to the NNSN database.
  Progress: Beam data are now available from NORSAR and copied to UiB automatically. The beam data has been looked at in specific cases, but are not yet included in the daily processing routines at UiB.
- Procedures: earthquake response and interaction with NORSAR to be developed.
  Progress: Analyst from NORSAR has visited Bergen twice (February and June). A short document with a task list was prepared.
- NNSN website: continue development
  Progress: The menu system and content of the page is under revision. A first version of the new menu system is available. However, progress is a bit slow.

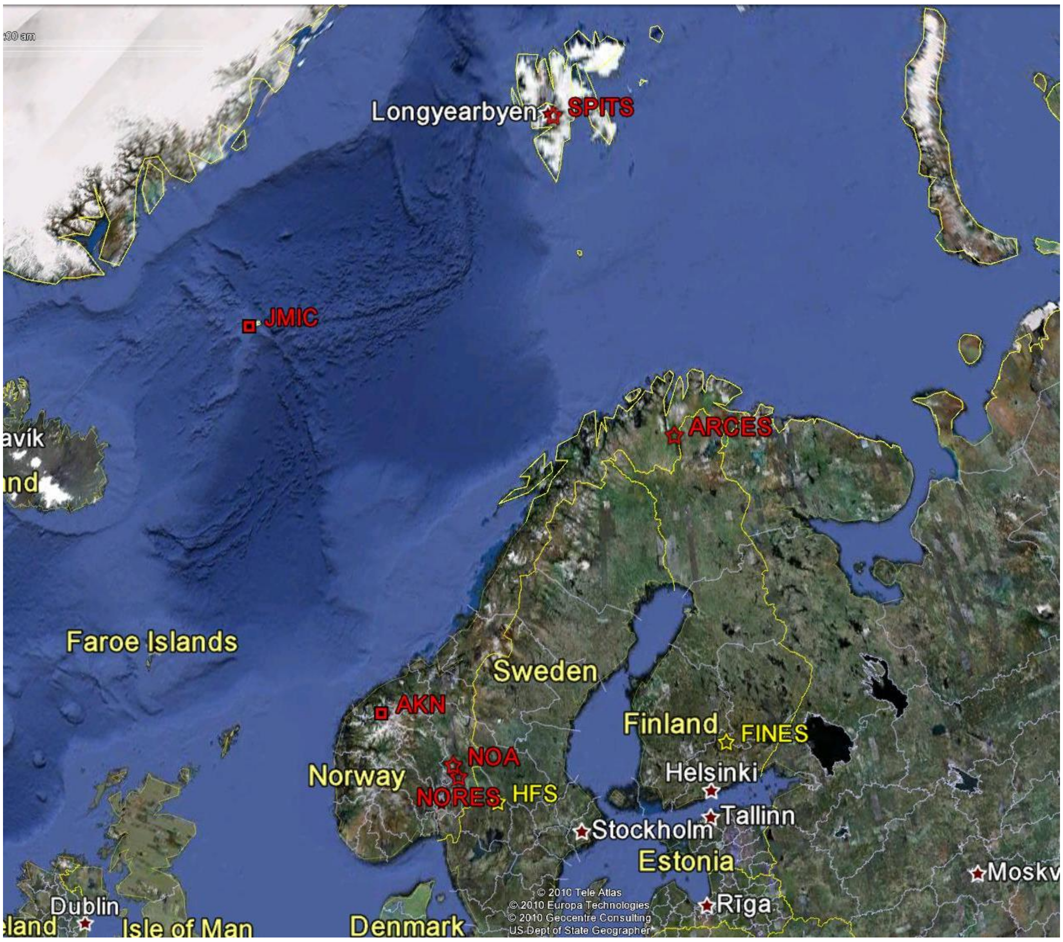
4.2 Plans for 2012

- New station: The station in the Hardangervidda will be installed, a site will be decided on in 2011.
- Upgrade: Stations OSL, KMY, STEI and STOK will be upgraded to a Guralp digitizer.
- Upgrade: Stations OSL and STEI will be considered for installation of a broadband seismometer.
- Ekofisk: Complete the data integration.

- Strengthen the collaboration with NORSAR on data processing through technical visits.
- Jan Mayen: Improve signal quality of the JMI station and install a broadband seismometer.
- NNSN website: continue development.

The NORSAR Stations and Arrays - 2011

NORSAR currently operates three seismic arrays (ARCES in Finnmark (25 sites), SPITS on Spitsbergen (9 sites) and NOA in southern Norway (42 sites)) and two broadband stations (JMIC on Jan Mayen and AKN in the county of Møre og Romsdal). The fourth seismic array NORES (25 sites) was hit by lightning in 2002 and was partly refurbished end of 2010. Additionally NORSAR collects data from the FINES array in southern Finland and the HFS array in southern Sweden. The data streams are available in real-time at NORSAR and are subjected to immediate automatic processing and analyses. All waveform and parametric data are openly available and can be accessed through web-interfaces or direct means.



NORSAR seismic stations JMIC and AKN and arrays NOA, ARCES, SPITS and NORES (partly refurbished).

The NORSAR webpage www.norsardata.no provides access to general station information, to automatic and reviewed seismic bulletins, to real-time plots of short and long-period data and to an AutoDRM request form for waveform data retrieval.

1 New developments at NORSAR

The seismic array NORES close to Løten, Hedmark has been partly refurbished in December 2010 and is being used as an experimental array since then. We installed at the innermost 9 sites (out of 25 sites) of the NORES array 3-component short-period instruments. Data from the NORES array are crucial for the detection and localization of small seismic events in Southern Norway.

New 3-component broad-band sensors with a hybrid instrument response (360 sec – 50 Hz) have been installed at each of the former broad-band sites of the NOA array (sites NAO01, NB201, NBO00, NC204, NC303, NC405, NC602). For about a 3-months period the new instruments have been running in parallel to the original instruments. End of October 2011 we switched off the original instruments and data forwarding from the new hybrid instruments to NNSN commenced. In spring 2012 we will complete the upgrade of the original one-component short-period sites of NOA with vertical-hybrid broad-band instruments (120 sec - 50 Hz). In the final configuration the NOA array will have 7 three-component and 35 one-component sites.

2 Systems Recording Performance

All data recorded at NORSAR are continuous. The following table provides a monthly overview on the data availability of the 12 data streams provided by NORSAR to NNSN.

	ARE0	JMIC	NAO01	NB201	NBO00	NC204
Jan	100.00	99.66	100.00	100.00	100.00	99.82
Feb	99.99	99.78	100.00	99.99	99.99	99.80
Mar	100.00	100.00	100.00	100.00	99.99	99.85
Apr	100.00	100.00	100.00	100.00	99.99	99.83
May	100.00	97.84	100.00	99.99	100.00	99.79
Jun	100.00	98.72	99.97	96.32	99.99	99.77
Jul	100.00	96.82	99.98	80.11	99.96	99.77
Aug	100.00	99.69	99.97	99.81	99.99	99.66
Sep	99.21	99.97	99.98	99.98	99.99	99.91
Oct	100.00	100.00	99.94	99.99	99.98	99.88
Nov	96.46	100.00	99.94	99.97	99.97	99.71
Dec	100.00	99.61	99.99	99.95	99.99	99.98

	NC303	NC405	NC602	SPA0	AKN	HFC2
Jan	100.00	100.00	100.00	100.00	100.00	100.00
Feb	100.00	99.99	100.00	100.00	99.77	100.00
Mar	100.00	100.00	98.30	100.00	100.00	100.00
Apr	100.00	100.00	100.00	99.94	100.00	100.00
May	100.00	100.00	99.96	100.00	100.00	96.53
Jun	100.00	99.99	99.98	100.00	100.00	98.72
Jul	100.00	99.97	99.99	97.10	100.00	100.00
Aug	95.52	99.97	91.17	99.01	100.00	74.73
Sep	98.89	99.99	99.99	99.99	100.00	99.92
Oct	100.00	100.00	100.00	99.96	99.84	100.00
Nov	98.76	99.98	99.99	100.00	99.99	100.00
Dec	99.98	99.96	100.00	100.00	96.59	100.00

Table 1. Systems recording performance (in % of data completeness) for the 12 data streams provided from NORSAR to NNSN.

3 Detections

The NORSAR analysis results are based on automatic phase detection and automatic phase associations which produce the automatic bulletin. Based on the automatic bulletin a manual analysis of the data is done, resulting in the reviewed bulletin. The automatic bulletin for northern Europe is created using the Generalized Beam Forming (GBF) method. This bulletin (www.norsardata.no/NDC/bulletins/gbf/) is subsequently screened for local and regional events of interest in Fennoscadia and in Norway, which in turn are reviewed by an analyst. Regional reviewed bulletins from NORSAR are available from 1989 and from 1998 onwards they are directly accessible from via internet (www.norsardata.no/NDC/bulletins/regional/). Table 2 gives a summary of the phase detections and events declared by GBF and the analyst.

	Jan.	Feb.	March	April	May	June
Phase detections	160379	122100	153146	127385	145738	122652
Associated phases	6726	5008	6867	5315	5797	5012
Un-associated phases	153653	117092	146279	122070	139941	117640
Screened GBF events for Fennoscandia/Norway	1153	883	1234	966	1077	991
No. of events defined by the analyst	94	53	88	57	65	53
	July	Aug.	Sep.	October	Nov.	Dec.
Phase detections	137926	147173	181920	161251	159100	178099
Associated phases	5795	5862	8443	8252	6409	6835
Un-associated phases	132131	141311	173477	152999	152691	171264
Screened GBF events for Fennoscandia/Norway	1157	1205	1892	1910	1436	1423
No. of events defined by the analyst	53	59	41	60	48	59

Table 2. Phase detections and event summary.

4 Combined NORSAR-UiB data analyses

Array processing is fundamentally different to single-station processing and there is no straightforward way to merge and commonly process array and single-station waveform data. However, on a higher level parameters like phase arrival readings from array beams and single stations can be combined and be used for event localization. At NORSAR the parameters of analyst-reviewed events are converted into parameter files in Nordic format and forwarded via ftp to UiB on a daily basis. The magnitude threshold has been lowered to about M 1.5 for regional events of potential interest for the NNSN. After transferring the parameter files, the NORSAR analyst logs into the the UiB data base using SEISAN and integrates the events. Integration means to merge NORSAR and UiB events, which may require to repick seismic phases, to include new phase readings, to edit double phase readings and to relocate the seismic event with the new parameters.

5 NORSAR-UiB data streams

All historic and realtime NORSAR data can be downloaded using the well-known automated Data Request Manager (AutoDRM). In addition NORSAR has established a seedlink server (athene.norsar.no) that provides realtime data streams from all NORSAR broadband instruments. UiB is currently receiving 12 three-components streams from stations ARE0 (ARCES array), JMIC, NAO01, NB201 NBO00 NC204, NC303, NC405, NC602 (NORSAR array), SPA0 (SPITS array) , HFC2 (Hagfors array) and AKN which can be integrated into their single-station processing schemes.

6 The use of Norwegian data

Data collected on Norwegian seismic stations are made available through the Internet and is provided on request to interested parties. Therefore it is difficult to get a comprehensive overview on the use and all publication based on Norwegian data. The following reference list shows publications and presentations of NORSAR scientists for the reporting period, based on data of NNSN and NORSAR stations.

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