Operation of the

Norwegian National Seismic Network

2008

Supported by

University of Bergen

and

Norwegian Oil Industry Association

Prepared by

Department of Earth Science
University of Bergen
Allegaten 41, N-5007 Bergen

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1. Introduction

This annual report describes the operation of the Norwegian National Seismic Network (NNSN) for the year 2008. It covers operational aspects as well as a financial report for all seismic stations operated by the Department of Earth Science at the University of Bergen (UiB), which has the responsibility of the NNSN.

The network is supported by the oil industry through the Norwegian Oil Industry Association ("Oljeindustriens Landsforening" (OLF)) and the University of Bergen (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.

2. Operation

The operational stability for each station is shown in Table 1. The average downtime for all stations during this reporting period is 1.3 % compared to 2.1 % in 2008. This is acceptable since the goal of average downtime is below 2%.

Table 1. Downtime in % for 2008 for all stations of the NNSN.

Station	Downtime in %
Askøy (ASK)	0
Bergen (BER)	0
Bjørnøya (BJO)	1
Blåsjø (BLS)	0
Dombås (DOMB)	0
Espegrend (EGD)	0
Florø (FOO)	10
Flostrand (FLOS)	0
Homborsund (HOMB)	0
Hopen (HOPEN)	2
Høyanger (HYA)	0
Jan Mayen BB (JMI)	0
Jan Mayen SP (JMI)	0
Jan Mayen (JNE)	0
Jan Mayen (JNW)	0
Karmøy (KMY)	6
Kautokeino (KTK)	0

Station	Downtime in %
Kings Bay (KBS)	1
Kongsberg (KONO)	0,5
Konsvik (KONS)	0
Lofoten (LOF)	1,5
Mo i Rana (MOR8)	0
Molde (MOL)	1
Namsos (NSS)	0
Odda (OOD1)	4
Oslo (OSL)	2,5
Rundemanen (RUND)	7,5
Snartemo (SNART)	3
Stavanger (STAV)	0
Steigen (STEI)	0
Stokkvågen (STOK)	0
Sulen (SUE)	4
Blussvoll (TBLU)	0
Tromsø (TRO)	0
Average	1,3

3. Field stations and technical service

The technical changes for each seismic station are listed below. It is noted if these changes are not related to a visit from the technical staff at the University of Bergen. 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.

Bjørnøya (BJO1)

No visit or technical changes.

Blussvoll (TBLU)

13.11.08 Visit. A new station located in Trondheim,
was installed with the following equipment:
1 PC optiplex 170L ST: GB1732J with Seislog for Linux.
1 Skjerm 19" LCD
1 Guralp SN:T6278 4GB CMG-6TD-001
15.12.08. New Sensor/digitizer T6281 512 Mb CMG-T6D-0003 replaced by local operator.

Blåsjø (BLS)

07.05.08. Visit. New digitizer (ED2400), GPS, Dell PC, Seislog for Linux, was installed. By a mistake damping resistance was not installed.
21.05.08. Damping resistance, 5.6 Kohm, was installed by the local operator.

Dombås (DOMB)

06.11.08. ADSL was installed and connected to a new PC (industr.),
1 SARA SADC 20 Digitizer and GPS.
When starting, no input signal. After some testing it turned out that the signal cable was broken. Tried to fix the cable without succeeding. A new signal cable has to be installed next visit.
18.11.08. A new signal cable (black) was installed. This time a 3 comp SARA Digitizer, s/n MAT322, 2 Hz geofones was installed in the aluminium box. Inside the building, a new Guralp Digitizer CMG-DM24-S3, ser. no. A1219 was installed. PC is Seislog for Linux

Florø (FOO)

01.01 – 06.02.08. A malfunctioning digitizer caused low S/N level. Attempts were made to fix the problem remotely. Station down for 37 days.
07.02.08. Visit. A new ED2400 digitizer, a new Dell PC with Seislog for Windows was installed. A PC replaced the Lap Top. The 3 SS-1 Rangers sensors were replaced with a new BB sensor, Trillium 120P.
The aluminium box was wet inside, cleaned it up.

Flostrand (FLOS)

No visit or technical changes.

Homborsund (HOMB)

21.11.08. Visit. A new station, located 15 km southwest of Grimstad,
was installed with the following equipment:
1 Industrial PC with Seislog for Linux
1 Nanometrics Trillium 120P S/N 0427
1 Guralp CMG-DM24-2000 S/N A1225
1 Power supplies Mascot 6823, 500mA.

Hopen (HOPEN)

6 – 14.01.08. Station down for 8 days due to a malfunction PC.
14.01.08. A new PC was installed by the local operator.
30.09.09. New Linux PC and connection to internet by Satellite Communication, installed by the local operator.

Høyanger (HYA)

No visit or technical changes.

Jan Mayen (JMI)

No visit or technical changes.

Karmøy (KMY)

10.09.08. PC restarted at 11:55 by the local operator. No data lost.

Kautokeino (KTK)

No visit or technical changes.

Kings Bay (KBS)

No visit or technical changes.

Kongsberg (KONO)

No visit or technical changes.

Konsvik (KONS)

No visit or technical changes.

Lofoten (LOF)

18. – 21.01.08. Restarted PC by use of the Telecommander. Station down for 3 days. Reason unknown.
22. – 25.03.08. Station down for 3 days. Reason unknown.
23.07.08. New Dell PC, Seislog for Linux, was installed by the local operator. Data transferred by ADSL line.

Mo i Rana (MOR8)

No visit or technical changes.

Molde (MOL)

07. 11.08. A new PC, Seislog for Linux was installed to replace the old PC Seislog for Windows.

Namsos (NSS)

No visit or technical changes.

Odda (ODD1)

07.05.08. Visit. A new Dell PC with Seislog for Linux was installed.
22.05.08. When the PC was set up, the sample rate had a mismatch to the digitizer. Changed the sample rate from 50 Hz to 100 Hz. Data lost 7-22/5-08. Station down for 15 days.

Oslo (OSL)

1 – 11.01.08. Station down for 10 days. Reason unknown.

Rundemanen (RUND)

15.01.08. Station down since 01.01.08 due to error on digital line.
During February and March digital line unstable.
18.06.08. Visit. The line converted from digital to analog. Installed 1 PTS-3 box (Sprengnether). Gain 84 dB, filter 5-10Hz. 5V full scale.

Snartemo (SNART)

23.07.08. Noise 50 Hz.
Replaced the Digitizer SADC 20, but still 50 Hz noise without finding the source.
09.10.08. Noise on Z and EW component.
Corrosion on the vertical seismometer. Dismantled and cleaned the seismometer, cleaned also the NS and EW seismometer. Noise ok.

Stavanger (STAV)

11.-12.06.08. Visit. Installed new Dell PC with Seislog for Linux, new digitizer (Nanometrics RD3). The data are now transferred on a ADSL line.
17. – 30.06.08. A new digitizer (RD3) was replaced by the local operator. Station down for 14 days due to a malfunctioned digitizer.

Steigen (STEI)

No visit or technical changes.

Stokkvågen (STOK)

No visit or technical changes.

Sulen (SUE)

30/1 – 14.02.08. Station down for 15 days. Reason unknown.

Tromsø (TRO)

No visit or technical changes.

WNN network: Bergen (BER), Espegrend (EGD), Ask (ASK), Rundemanen(RUND)

18.06.08. Rundemanen (RUND) replaced Bergen (BER) in the WNN network.
23.09.08. Visit. Windows-PC was replaced with Linux-PC. The reason is that Seislog for Linux has problems with the ED2400 digitizer.

4. NNSN-plans 2009

Plans and progress for 2008:

- Plan: Convert the whole network to a real time network, include 10 stations from Finland, Denmark and the UK, 4 stations from NORSAR and install 2 new stations to form an approximately 45 station real time network. The location of all seismic stations can be seen in Figure 1.
    - Progress: 42 stations are now in real time, the remaining will be included once the communication is available. Two new stations are installed, HOMB and TBLU.
- Plan: Store all continuous data from all stations in the NNSN data base.
    - Progress: Completed for 42 stations, remaining will be included when communication is ok.
- Plan: Include NORSAR array detections in real time system.
    - Progress: No new software has been made by NORSAR yet to enable this function since all emphasis was put in getting real time digital data.
- Plan: Move all real time processing and data storage to new Linux system.
    - Progress: Completed
- Plan: Upgrade network with 10 new digitizers.
    - Progress: 4 Digitizers have been installed.
- Odda (ODD) is upgraded with ADSL connection and the data are now transferred in real time.
- Høyanger (HYA) is upgraded with new equipment i.e. PC (industrial quality) running Linux Seislog and digitizer.
- Blåsjø (BLS) is upgraded with new equipment.
- Dombås (DOMB) is upgraded with ADSL.
- Namsos (NSS) is upgraded with new equipment.

Currently the upgraded ISDN stations (BLS, HYA, KTK, NSS, and SUE) work in semi real time, meaning data is transmitted within 15 minutes. For this reason they do not participate in the triggersystem, but all data is stored.

The last station in NNSN without internetcommunication, Hopen, finally got a satellite link in the fall. This was done in cooperation with the University of Tromsø and the Meteorological Institute. Communication costs will be quite high compare to the other stations (56 kNOK/year).

The main problem in the transition to the new network has been the difficulty in obtaining ADSL lines to the stations. New lines must be ordered centrally at the UIB and this combined with the new company providing communication (Ventelo) has delayed the installation of communication. After a few months of frustration, we were allowed to use other companies and are now also using Telenor and NexeGenTel. Finally there are sites where ADSL is not available and we are currently testing two types of mobile phone connections.

The other problem making slowing down the progress has been the late delivery of the new digitizers. Unfortunately this is a type of equipment which cannot be easily obtained elsewhere. As replacement, lower quality digitizers have been used in some of the stations.

The moving of the data collection and processing system to a new platform is now complete although minor problems still remain. This task and setting up of the real time communication, has used most of the technical resources in 2008. Figure 2 shows a flow diagram of the NNSN real time data acquisition.

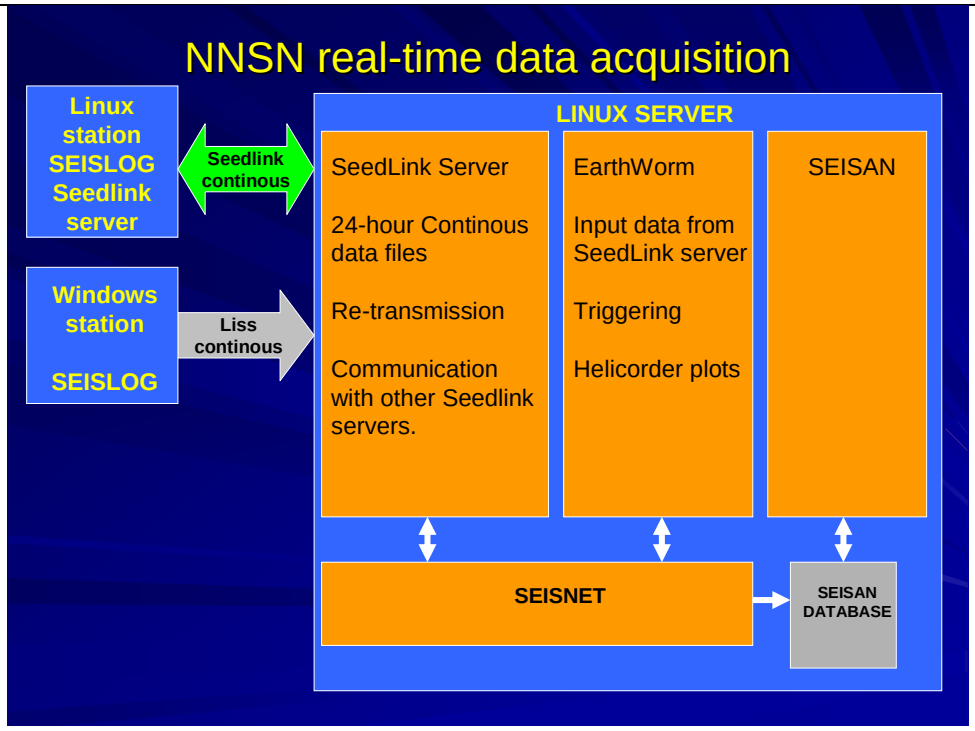

Figure 2. Diagram showing the NNSN real time data flow.

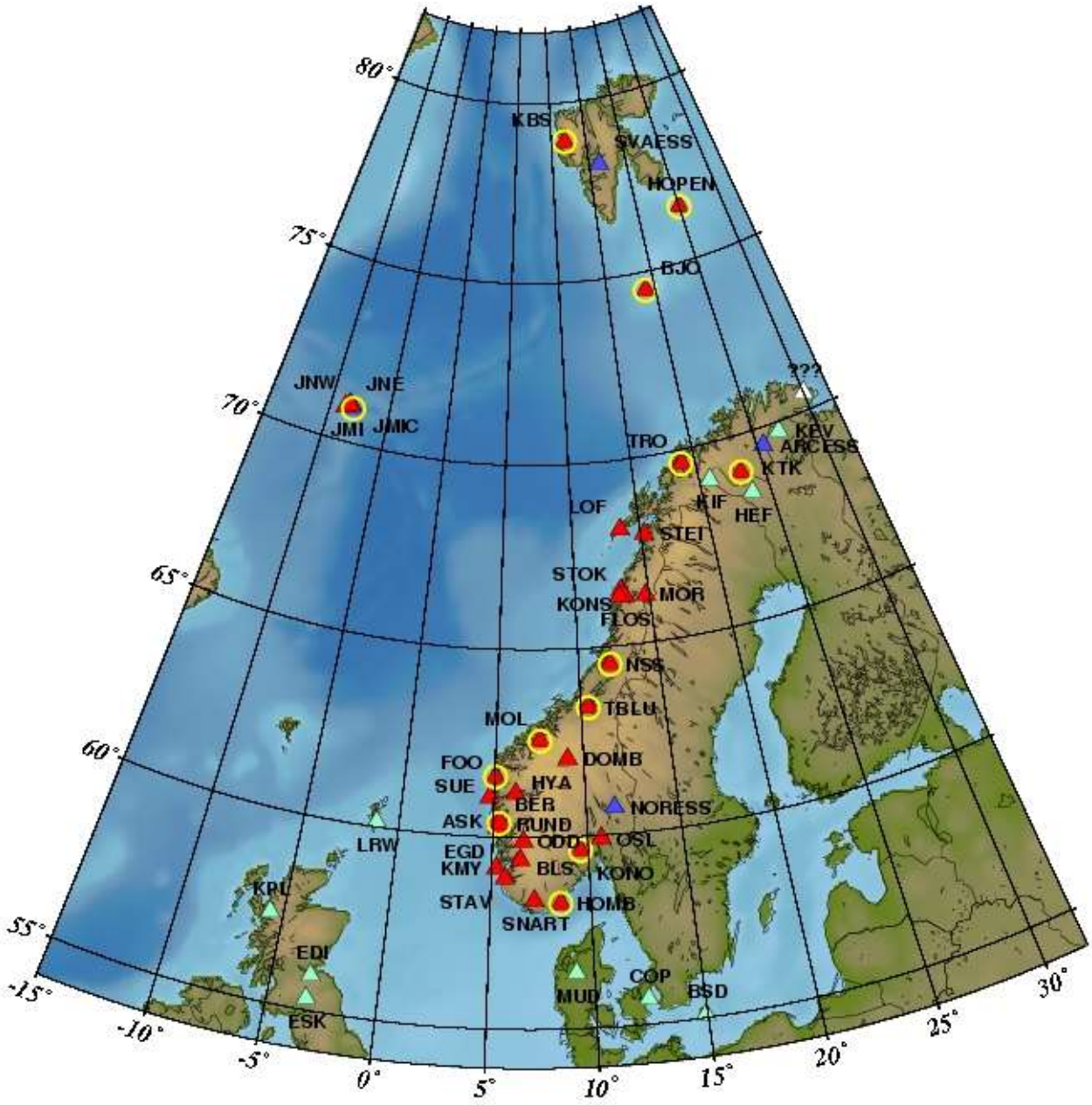

Figure 1. Stations contributing to the NNSN database. Norwegian stations with yellow circles are BB stations. NNSN stations: red triangles, NORSAR stations: blue triangles, British, Danish and Finnish stations transmitting signals in real time: green triangles and station marked with white triangle is to be installed in 2009.

Plans for 2009

♦ UiB

- Sulen (SUE) will be upgraded with ADSL, line is ready but modem has not yet been installed. New equipment, including PC and digitizer, will be installed.
- Install a new Broad band station in Finmark.
- Karmøy KMY will get new equipment, mobile phone solution will be tested
- Mo i Rana (MOR) will get new equipment, mobile phone solution will be tested.
- Test mobile phone solution for the following stations: Høyanger (HYA), Blåsjø (BLS), Kautokeino (KTK), Karmøy (KMY), Mo i Rana (MOR)
- Minor upgrade on several stations.

There are two more ADSL station (SUE ans NSS) to be installed. GSM mobile phone solutions, today used on 2 stations near Stokvågen (FLOS and KONS), are a bit too slow to provide reliable data since there is no 3G coverage at these sites. This is also the case for the remaining 5 sites and ICE (communication based on old NMT network) solutions will be tested. However it is now doubtful that ICE can be used due to economical problems at ICE.

♦ NORSAR

- Develop the prototype of an event detection system to be integrated with NNSN.
- Improve joint processing.

♦ NORSAR-NNSN joint analysis work

The NORSAR analyst is, on a daily basis, merging the NORSAR local recordings into the NNSN database and relocates the event.

♦ Other

- Develop joint web pages
- Offshore stations. There is an ongoing effort to connect one sensor from Ekofisk and plans to install a new sensor at Statfjord

APPENDIX 1

The NORSAR Regional Arrays

The NORSAR Station and Arrays

NORSAR currently operates three seismic arrays (ARCES in Finnmark (25 sites), SPITS on Spitsbergen (9 sites) and NOA in southern Norway (42 sites)) and the broadband station JMIC on Jan Mayen. The fourth seismic array NORES (25 sites) was hit by lightning in 2002 and is under reconstruction. Additionally NORSAR collects data from the FINES array in southern Finland and the HFS array in southern Sweden. The data streams are available in realtime 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.

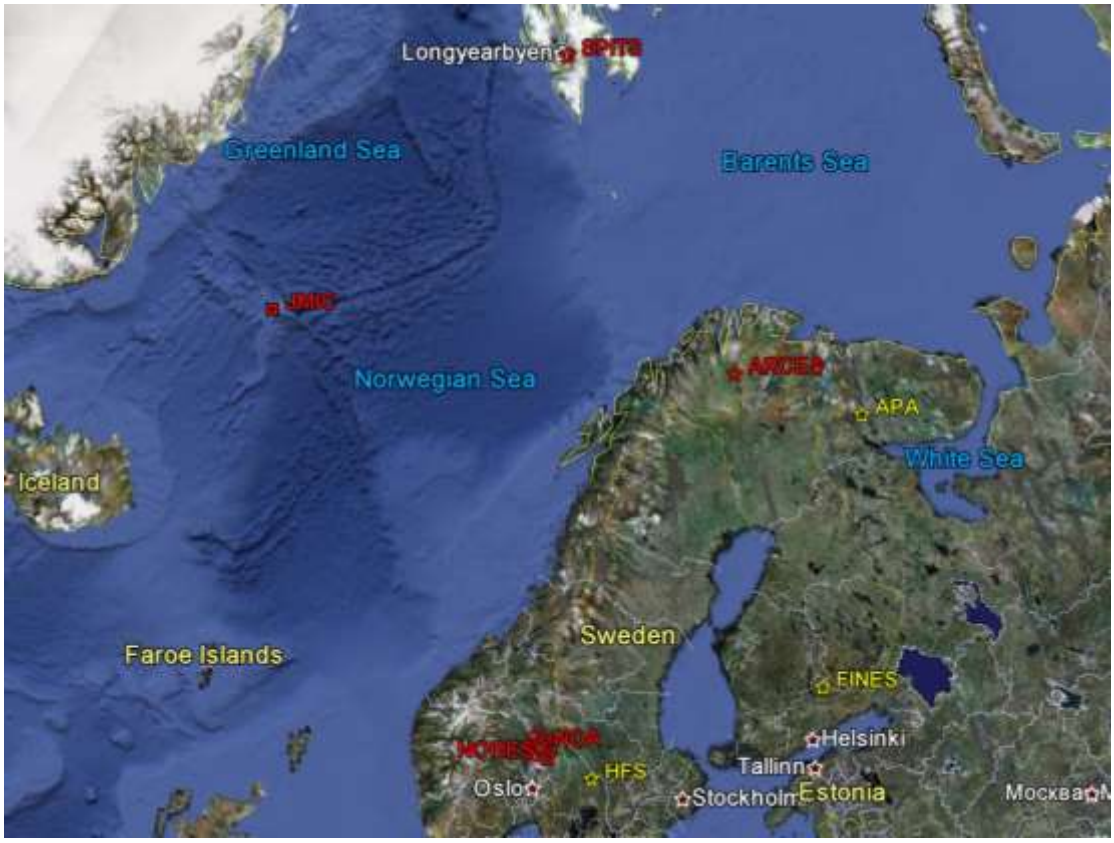

Fig. 1. NORSAR seismic station JMIC and arrays NOA, ARCES, SPITS (and NORES under reconstruction).

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 Systems Recording Performance

The arrays have continuous data recording. In 2008 the data completeness for the SPITS array was 89.41%, for the ARCES array 98.55%, and for the NORSAR array 97.81%. The performance in terms of monthly completeness statistics is shown in Table 1.

	ARCES	SPITS	NORSAR

January	99.639%	99.639%	98.408%
February	99.913%	99.913%	97.130%
March	99.449%	99.449%	95.235%
April	98.588%	98.588%	95.236%
May	93.276%	93.276%	95.234%
June	95.062%	95.062%	95.766%
July	99.831%	71.400%	95.418%
August	97.222%	60.063%	87.081%
September	99.782%	59.671%	96.234%
October	100%	99.994%	97.238%
November	99.968%	100%	97.939%
December	99.859%	95.908%	99.004%

Table 1. Systems recording performance (in % of data completeness) for three arrays operated by NORSAR in 2008.

2 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	154415	145482	161045	141179	156807	141294
Associated phases	4564	9622	7540	6329	6086	5103
Un-associated phases	149851	135860	153505	134850	150721	136191
Screened GBF events for Fennoscandia/Norway	941	1719	1456	1158	1155	1000
No. of events defined by the analyst	51	182	81	94	94	75
	July	Aug.	Sep.	October	Nov.	Dec.
Phase detections	171338	181645	138281	195823	159442	173256
Associated phases	6042	7087	5645	8332	5597	5864
Un-associated phases	165296	174558	132636	187491	153845	167392
Screened GBF events for	1198	1589	1178	1713	1205	1345

Fennoscandia/Norway						
No. of events defined by the analyst	78	76	87	96	83	52

Table 2. Phase detections and event summary.

3 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.

4 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 10 three-components streams from stations AREO, JMIC, NAO01, NB201 NBO00 NC204, NC303, NC405, NC602, SPA0, which can be integrated into their single-station processing schemes.