The 45th Nordic Seismology Seminar
8th-10th of October 2014 in Visby on Gotland

Wednesday October 8

11.30-12.00	**Registration** at Wisby Strand, Strandvägen 4
12.00-13.30	**Lunch**
13.30-16.00	**Seminar** Wisby Strand
13.30	**Welcome**
13.40-14.00	Northern Finland Seismological Network: a tool to analyse long-period seismological signals *Elena Kozlovskaya*
14.00-14.20	Ostrobothnia Local Seismic Network (OBF) Detection and location capability of phase 1 *Jari Kortström*
14.20-14.40	Towards a homogenized earthquake catalogoue for the Fennoscandian shield *Marja Uski*
14.40-15.20	**Coffee**
15.20-15.40	On seismic hazard assessment for the Eastern Baltic region *Bela Assinovskaya*
15.40-16.00	The 2014 magnitude 4.1 Sveg earthquake *Björn Lund*
16.00-17.30	**Poster session** Wisby Strand

A quantitative method to map the source distribution of microseisms using noise Covariograms; *Hamzeh Sadeghisorkhani*

A strategy for earthquake catalog relocations using the maximum likelihood method; *Ka Lok Li*

Current software development at SNSN; *Peter Schmidt*

Seismic monitoring of glacier calving and surging on Spitsbergen, Svalbard; *Andreas Köhler*

New Fennoscandian shield empirical ground motion characterization models; *Tommi Vuorinen*

Analysis of waveforms of local earthquakes in the West Bohemia/ Vogtland area and Reykjanes Peninsula; *Alena Bouskova*

Earthquakes in Greenland and single station detection;
Peter H. Voss

2.5D waveform and real noise simulation of receiver functions in 3D models
Christian Schiffer

	It is about 1 km between Wisby Strand and Scandic Visby
18.00	Check-in at Scandic Visby, Färjeleden 3
18:30	**Dinner** at Scandic Visby

Thursday October 9

09.00-15.00	**Seminar** Scandic Visby
09:00-09:20	Back-Projection Analysis of Moderate to Large Earthquakes Using Data from the Swedish National Seismic Network (SNSN) *Hossein Shomali*
09:20-09:40	A Proterozoic boundary in southern Norway revealed by joint-inversion of P-receiver functions and surface waves *Valérie Maupin*
09:40-10:00	Multiscale, finite-frequency P & S tomography of the upper mantle in the southwestern Fennoscandian Shield *Valérie Maupin*
10:00-10:20	Automated event detection algorithm based on signal-to-noise ratio migration *Frederic Wagner*
10:20-11:00	**Coffee**
11.00-11.20	Probabilistic Seismic Hazard (PSHA): Challenges and Alternatives *Conrad Lindholm*
11.20-11.40	Time-Delay Correction Surfaces for Improved Seismic Array Performance *Steven J Gibbons*
11:40-12:00	Stress Tensors and Diverse Focal Mechanism Solutions of Microseismic Events during Active Deformation in Krysuvik Geothermal Area, SW Iceland, in 2009 *Sigridur Kristjansdottir*
12.00-13.20	**Lunch**
13:20-13:40	Stress Pattern of the Shanxi Rift System, North China, Inferred from the Inversion of New Focal Mechanisms *Bin Li*
13:40-14:00	Active faults and potential ground shaking in Cuba *Mathilde B. Sørensen*

15.00-19.00	**Cultural program** around Visby by bus (outdoor activities and walking)
19.00	**Dinner** in Visby (the bus will drop us directly at the restaurant)

Friday October 10

09:00-09:20	Presentation of the LKAB project: Analysis of mining induced seismicity at Kiirunavaara Mine *Christina Dahnér*
09:20-09:40	Seismic analysis of mine collapse signals in NE Estonia *Heidi Soosalu*
09:40-10:00	NEONOR2 project - Neotectonics in Nordland *Ilma Janutyte*
10:00-10:20	NordQuake – Closing remarks and Future Cooperation *Peter H. Voss*
10.20-11.00	**Coffee**
11:00-11:20	FIN-EPOS – a Finnish national initiative of EPOS *Annakajsa Korja*
11:20-11:40	EPOS and Seismology in the Nordic countries *Reynir Bödvarsson*
12:00-13.00	**Lunch**
13.00-15.00	EPOS discussion

The 45th Nordic Seismology Seminar 8th-10th of October 2014

Wednesday October 8

13.40-14.00
Elena Kozlovskaya

Northern Finland Seismological Network: a tool to analyse long-period seismological signals

Elena Kozlovskaya (1) and Riitta Hurskainen (1)
(1) University of Oulu, Sodankylä Geophysical Observatory/Oulu unit, Oulu, Finland

Sodankylä Geophysical Observatory of Oulu University (SGO) is located at 67˚22' N, 26˚38' E in the middle of Finnish Lapland. It was established in 1913 and since then has gained a long experience in carrying out multi-disciplinary geophysical observations in Arctic environment. Seismological observations at the University of Oulu and SGO have been carried out since 1965. During 2005-2008 the SGO modernized own sort-period permanent seismic network, enhanced the number of stations and equipped them with the VBB seismic sensors. The stations are located at latitudes from 65^0 N to 68^0 N. They form the Northern Finland Seismological Network (NFSN) that is a part of a national Finnish network of permanent seismic stations and a part of FIN- EPOS research infrastructure since 2014. At present, continuous seismic data of the NFSN are archived in the GFZ Seismological Data Archive of the GeoForschungsZentrum Potsdam (Germany) and in the own backup archive of the SGO. The data of the NFSN are routinely used for monitoring of seismic activity in Northern Europe and world-wide and information about seismic events is published in several on-line bulletins.

Due to the recent mineral exploration and mining boom in northern Finland, a new task for the NFSN will be recording and analysis of mining-induced seismicity and estimating of seismic hazard associated with it. This will enable to launch national hub of the EPOS Induced Seismicity Node, where data of induced seismicity will be collected and combined with the information provided by the mining companies.

During installation of instruments of the NFSN, particular measures were taken in order to improve instruments performance at long periods. In Arctic conditions the performance of broadband seismic instruments is affected by large ambient temperature variations and geomagnetic field disturbances (geomagnetic pulsations). In 2007-2009 the NFSN was a part of the POLENET/LAPNET IPY project. In addition to lithosphere structure studies, the project aimed at registration of long-period glacial seismic events originating from Greenland Ice Sheet. Analysis of data recorded by the NFSN during the IPY demonstrated that the network is capable to record not only long- period glacial events from Greenland in the period range of 30-140 s, but also other slow events originating from the northern part of the Mid-Atlantic Ridge, as well as and long-period seismic signals from events originating from Arctic and Russia. Slow events are rarely reported by seismological agencies, because routine methods of events detection are based on analysis of short-period body waves. This motivated further development and enhancement of the NFSN. In 2013-2014 three new VBB seismic stations will be installed in the Finnish Lapland. Together with the existing NFSN station, they will form a broadband seismic array aiming at detection and location of seismic events in long-period range.

In our presentation we discuss factors affecting performance of VBB seismometers at long periods and problems connected with identification and location of slow events by array techniques.

14.00-14.20
Jari Kortström

Ostrobothnia Local Seismic Network (OBF) Detection and location capability of phase 1

Outti Valtonen, Jari Kortström, Marja Uski and Annakaisa Korja
Institute of Seismology, Department of Geosciences and Geography
University of Helsinki

A Decision-in-Principle for the construction of new nuclear power plant by Fennovoima Oy has been ratified by the Finnish parliament in 2011. The site of the new plant in Hanhikivi, Pyhäjoki, Northern Ostrobothnia, Finland, is characterized by low-active intraplate seismicity, with earthquake magnitudes rarely exceeding 4.0. The guidelines of the IAEA (3.30, 2010) state that when a nuclear power plant site is evaluated a network of sensitive seismographs with a recording capability for micro-earthquakes should be installed to acquire more detailed information on potential seismic sources. The data processing, reporting and network operation are advised to be linked to the national or regional networks. Earthquakes that are recorded within and near such a network should be carefully analyzed and connected to the regional seismotectonic studies.

Such a network was planned and its detection capability was simulated by Tiira et al. (2011). An optimal configuration of ten seismograph stations within 50 km radius from the Hanhikivi nuclear power plant site was proposed for further research. The network will consist of nine new sites and one existing station (OUF). The network is dense enough to fulfil the requirements of azimuthal coverage better than 180 degrees and automatic location capability down to ML 0.0 within a radius of 25 km from the site.

The first four stations (OBF0, OBF4, OBF6 and OBF7) have been built during 2012-2013. The new stations and OUF have been operated automatically as part of the daily seismic detection and location routine of the Institute of Seismology, University of Helsinki from the 1st of June 2013. The detected events have been identified using spectral methods and their automatic locations have been stored in a data bank. Earthquakes have been relocated manually and, when possible, focal mechanism solutions have been determined.
A total of eight earthquakes were detected inside or in the vicinity of OBF network in 2013. The magnitudes of the events ranged from 0.1 to 1.0. Only the largest event was automatically detected by FNSN. Two additional events were detected when the new stations were included in automatic processing, and five more after visual inspection of seismograms from the local stations. Preliminary focal mechanism solutions could be determined for the three largest earthquakes. The mechanisms were of strike-slip type with preferred nodal planes trending roughly NNW-SSE, i.e., parallel to lineaments within the Raahe–Ladoga shear complex. The solutions have large error margins due to the lack of local crustal velocity model and the relatively large azimuth gap.

14.20-14.40
Marja Uski

Towards a homogenized earthquake catalogoue for the Fennoscandian shield

Marja Uski, Björn Lund and Kati Oinonen

Fennovoima Oy is planning to build a new nuclear power plant at Hanhikivi, situated in the municipality of Pyhäjoki, Northern Ostrobothnia, Finland. In 2013 a sequence of studies were initiated for seismic hazard evaluation at the potential nuclear power plant site. The study region includes land and marine areas of Finland, Sweden and NW Russia within a distance of 500 km from the Hanhikivi site.

The Fennoscandian earthquake catalogue FENCAT (1610-2012) is the main source of seismicity data available for the region. The catalogue has been complemented with micro-earthquake observations from the Swedish National Seismic Network operated by Uppsala University.

Here we present the steps taken to prepare a homogenized catalogue of independent earthquakes for the seismic hazard project. The data cleaning process included removal of non-tectonic events such as rock bursts, mine collapses and suspected explosions. The next step, de-clustering analysis, aimed at identification and removal of fore- and aftershocks from the data in order to identify a subset of temporally independent earthquakes. The resulting project catalogue contains 4587 earthquakes, and about 10 per cent of the original events were removed as dependent events.

Finally, the data set was homogenized in magnitude, with all earthquakes assigned a moment magnitude, Mw, based on local magnitude and moment data collected for this study.

15.20-15.40
Bela Assinovskaya

On seismic hazard assessment for the Eastern Baltic region

Assinovskaya B.A., Ovsov M.K., Geophysical survey RAS, Saint-Petersburg, Russia, assinovskaya@plkv.gsras.ru

The eastern part of the Baltic Sea region seemed to be out of contemporary seismic hazard assessments carried out in the EU and Russia. The reasons are the follows: first, its geographical location between Russia and the European Union, second, the most part of the region is a water area, poorly researched in terms of tectonics, geodynamics and strong seismic motion parameters.

In this work, the region is considered as a whole. The seismic hazard assessment carried out in the following sequence: first, the seismic regionalization using a new structural analysis method of geophysical and geodynamic data was conducted, second, the collection and standardization of regional earthquake data were made, third, rates of occurrences were estimated, forth, a regional model of seismic attenuation was obtained. Next, the probabilistic models of seismic hazard based on seismic process rate, attenuation characteristics and geographic locations of earthquakes were compiled using the computer system CRISIS 2007 (Ordaz et al., 2007).

The seismic regionalization was conducted by applying own GIS technology "Structural Analysis ", that is especially effective in areas insufficiently studied tectonically and with low seismic activity when active faults doesn’t come to the surface. This technology is based on a wide range of multivariate methods such as factor, cluster, variance analyses and image processing. As an input information gravity and magnetic, heat flow, topography and bathymetry, GPS geodynamics data were used. As a result, a map of seismotectonic zoning consisting of a series of linear and areal structures was compiled. These structures were ranked according to the maximum possible magnitude of the earthquakes. The most significant zones in terms of potential seismic hazards seemed to be quasi-linear Kaliningrad, Gotland and Estonia structures. 16 structures were identified in the study area in all; some of them doesn’t have their own seismicity and were to be considered inactive. The Mmax evaluation was based on the connection of this parameter with the length of fault or part of the fault or of the size of entire seismogenic zone. The empirical correlations obtained by different authors were used. The parameters, namely b-value, magnitude threshold Mmin, the number of events per year with a magnitude Mmin and their errors were derived from the regional unified earthquake catalogue. The catalogue was composed based on the sources (URL: http// www.seismo.helsinki.fi), (Aronov and Aronova, 2009) and own data. The database contains information on 525 events occurred in 1375 - 2013 with magnitudes from 0.5 up to 5. The sampling was seemed to be representative in the range years 1900 – 2000 from the magnitude Mw of 3 and in the range of years 2000 -2013 from the magnitude 1.2. The recurrence equation was compiled and b-value seemed to be equal to 0.9 at the MRS error of approximation 0.92.

The particular attention was paid to the compilation of PGA (peak ground acceleration) attenuation equation. Unfortunately, there are no regional instrumental records such as response spectra acceleration but there are numerous data on the perceptibility of some moderate earthquakes of the last decades. These data were used to compile an equation connecting magnitude, distance and intensity MSK-64 (Assinovskaya and Nikonov, 1998). The last expression was reformatted in order to calculate the required PGA parameters. The PGA at 10% exceedance probability in the next 10, 50, 100 and 500 years were calculated with the computer software package CRISIS 2007.

The corresponding maps covering both coastal areas of the eastern part of the Baltic Sea from the west of the Kaliningrad region up to the Narva River and the entire water area were compiled (Figure 1). Figure1 shows the most used in building intensity distribution in terms PGA for return period of 50 years at 10% probability of exceeding of these values. It is seen that the area of the most seismic hazard generated Kaliningrad and Gotland areas practically have merged forming a vast zone of intensity also about 100 cm/sec^2 in the south of the region. In the eastern part of the Baltic Sea, the Osmussaar transverse seismogenic zone also generates the same intensity of PGA. Accordingly, expected acceleration values are more 100 cm/sec^2 and about 180 cm/sec^2 for the return period of 1000 years and 5000 years respectively. The results can be used in the construction of important structures offshore like pipelines and onshore like power nuclear stations.

15.40-16.00
Björn Lund

The 2014 magnitude 4.1 Sveg earthquake

B. Lund, H. Shomali, D. Buhcheva, K. Högdahl, A. Tryggvason, R. Bödvarsson, P. Schmidt, Uppsala University
Peer Jørgensen, University of Copenhagen

On September 15, 2014, at 15:08 local time, a magnitude 4.1 earthquake occurred in southern Härjedalen, central Sweden. The event was widely felt throughout central and southern Sweden, reports of swaying buildings came from as far as Stockholm and Eskilstuna, some 350 kilometers away. Initial locations put the event in a sparsely populated area 25 km southeast of Lillhärdal, 42 km south of Sveg.

In this presentation we will re-analyze the event using permanent Swedish and Norwegian stations, and also data collected by a temporary network from the University of Copenhagen. We present a source mechanism and show spectral and ground motion characteristics of the event. We will also show the results of the macroseismic survey. Although this region of Sweden is virtually devoid of recorded seismicity, we present what seismicity we have and set the event into the geologic and tectonic context.

16.00-17.30 **Poster session**

- **A quantitative method to map the source distribution of microseisms using noise Covariograms;** *Hamzeh Sadeghisorkhani*

Hamzeh Sadeghisorkhani1, Ólafur Gu›mundsson1,2, Roland Roberts1 and Ari Tryggvason1 1 Department of Earth Sciences, Uppsala University, Sweden; 2 School of Science and Engineering, Reykjavík University, Iceland

Ambient Noise Cross-Correlation is widely used to measure seismic wave's travel-time used in Tomography. One of the main features of this method is that incoming energy of noise must come from all directions and be perfectly random in order to give reliable measurements. Microseisms are generated at seas by gravity waves, and since oceans are not uniformly distributed, microseisms are directional. This directionality affects on measurements of group and phase velocity. It is useful to estimate the noise-source distribution prior to measurement of group and phase velocity. A method for mapping the noise-source distribution of microseisms based on a distribution of plane waves from all directions is introduced, using the cross-correlations of all station pairs in a sub-network of stations. In this method we invert the envelope of cross-correlations for the angular distribution of microseismic energy. A non-uniform noise-source distribution or an anomaly in a noise field can be seen as a variation of cross-correlation amplitude in correlograms with the angle between inter-station and noise anomaly directions. We demonstrate some synthetic results which show a good angular resolution of this method to map incoming ambient noise energy for a set of SNSN's stations in the north of Sweden.

- **A strategy for earthquake catalog relocations using the maximum likelihood method;** *Ka Lok Li*

Ka Lok Li1, Ólafur Gu›mundsson1, Ari Tryggvason1, Reynir Bödvarsson1, and Bryndís Brandsdóttir2 1Department of Earth Sciences, Uppsala University 2Science Institute, University of Iceland September 15, 2014

A strategy for relocating earthquakes in a catalog is presented. The strategy is based on the argument that the distribution of earthquakes in a catalog is reasonable a priori information for earthquake relocation in that region. This argument can be implemented using the method of maximum likelihood for arrival time data inversion, where the a priori probability distribution of the event locations is defined as the sum of the probability densities of all events in the catalog. This a priori distribution is then multiplied by the standard misfit criterion in earthquake location to form the posterior likelihood function, assuming the two are independent. The probability density of an event in the catalog is described by a Gaussian probability density. The a priori probability distribution is, therefore, defined as the normalized sum of the Gaussian probability densities of all events in the catalog, excluding the event being relocated. For a linear problem, the posterior likelihood function can be approximated by the joint probability density of the a priori distribution and the distribution of unconstrained locations due to misfit alone. After relocating the events according to the maximum of the posterior likelihood function, a modified distribution of events is generated. This distribution should be in general more densely clustered than before. A new a priori distribution, which is the second power of the original a priori distribution, is used and the process is repeated. This new a priori distribution has a stronger attracting effect than the original one, which clusters the events more. For subsequent runs, the k-th power of the original distribution is used, where k is the number of run. The best catalog is picked based on the trade off between the data misfit and the diffuseness of the catalog. The strategy is applied to the aftershock sequence in southwest Iceland after a pair of earthquakes on 29th May 2008. The relocated events reveal the fault systems in that area. Synthetic data sets are used to test the general behaviour of the strategy.

- **Current software development at SNSN**; *Peter Schmidt*

Peter Schmidt, Behzad Oskooi, Reynir Bödvarsson, Björn Lund, Hossein Shomali, Arnaud Pharasyn, Michael Schieschke

Much of the software used in the daily operation at the Swedish National Seismic Network (SNSN) has been developed in-house. Here we report on the status of three inter-related open source projects at the SNSN which are approaching their first release and which may be of interest to the seismological community: (1) a seismic metadata server (SMD); (2) a waveform data server (WDS); and (3) the saatviewer, a visualization tool for research, development and daily analysis.

The SMD is a threaded TCP/IP server for management of seismic station metadata. It is written in python with client application programming interfaces (API's) available in python, C++, and C. SMD loads metadata from SEED dataless files, regularly updating the information in memory if a newer version of a particular dataless file is encountered.

The WDS is a threaded TCP/IP server written mainly in C and intended to ease access to seismic waveform data by hiding the details of data formats and the physical location of the data. The server dynamically loads readers for various data formats at runtime. This allows for adding and removal of data readers without having to modify the core source code of the server. Currently, a client C-API exists but python and Matlab API's are planned. The WDS server includes an internal SMD-client for retrieval of metadata if needed by a specific reader but also implements the possibility for the client to supply such information if the SMD server is not available.

The saatviewer is a platform for visualization and analysis of waveform data, as well as for development of seismic analysis tools. The software is written in C++ using Qt for the graphical user interface (GUI) and includes internal clients for both SMD and WDS. The saatviewer can operate in two modes, browser mode and plugin mode. In browser mode the saatviewer displays the waveform data of stations selected in the GUI, allowing the user to visually browse back and forth through the data. In plugin mode, the saatviewer dynamically loads an application/plugin that will control the retrieval, interactive analysis and visualization of the data. For development of new plugins the saatviewer has a C-API with various functions for access to the GUI, retrieval of data, operations on data and visualization of data. This allows for fast development and testing of new ideas on data analysis.

All three projects are approaching maturity and the goal is to be able to offer the first official releases of them during 2015, allowing the community to evaluate and provide feedback to aid in their continued development.

- **Seismic monitoring of glacier calving and surging on Spitsbergen, Svalbard;** *Andreas Köhler*

Andreas Köhler[1], Christopher Nuth[1], Heidi Sevestre[1,2], Douglas I. Benn[2,3], Adrian Luckman[2,4], Johannes Schweitzer[5], Christian Weidle[6]

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6) Department of Geosciences, Christian-Albrechts-Universität zu Kiel, Germany

Seismic observations can be used to monitor and better understand glacier dynamics such as basal sliding, crevassing, ice faulting, and calving. We use seismic data recorded on permanent broadband stations on Spitsbergen, the main island of the Svalbard Archipelago, as well as data from a local, temporary seismic network in northwestern Spitsbergen to detect, locate and analyze glacier seismicity. We observe a high number of icequakes related to glacier calving with characteristic seasonality and signal frequency spectrum. We calibrate regionally observed calving events by using the local records and direct visual observations of calving at Kongsfjord, northwestern Spitsbergen. We analyze the temporal distribution of calving seismicity within the past decade with special focus on Kronebreen, a fast-flowing tidewater glacier at Kongsfjord that shows a recent accelerating retreat. We also observe a cluster of seismic events emitted by a catastrophic glacier surge in southern Spitsbergen. The Nathorstbreen glacier system went through a surge phase between 2008 and 2013. In early 2009, a high number of seismic events are observed during the initial surge phase of Zawadskibreen, one of the branches of the system. Observable seismicity is absent during the progression of the surge after May 2009. We discuss different source mechanisms for these events, i.e. bed-failure at the glacier tongue and ice faulting. Remote sensing observations show fault-like structures within the ice along the margin of Zawadskibreen, where the ice is ripped apart on the margins. These structures have a much larger extent than normal glacier crevasses and their generation during the initial phase of the surge may be the source of seismic evens. We also observe another, but indirect indicator for glacier surging in Svalbard: there is a dramatic increase in number of seismic calving events during surges of Tunabreen (2003) and Wahlenbergbreen (2011) compared to melt seasons in other years.

- **New Fennoscandian shield empirical ground motion characterization models;** *Tommi Vuorinen*

Tommi Vuorinen, Timo Tiira, Institute of Seismology, POB 68, FI-00014 University of Helsinki,

The Fennoscandian shield is a seismically quiet area with a scarcity of strong earthquakes and, consequently, an area lacking strong motion data. This lack of empirical strong motion data and the subsequent lack of advanced stochastic and theoretical models of seismic response limit the ground motion prediction equation (GMPE) development for the region. In order to create GMPEs targeted for the Fennoscandian shield, we take advantage of the comparatively large ground motion database and use a more direct empirical approach which doesn't rely on pre-existing models and simulations of the Fennoscandian seismicity.

We present here the resulting two GMPEs, which were created by applying the empirical data derived from 1523 earthquakes observed at 84 recording stations to an existing attenuation relationship, GMPE. Within the magnitude-distance range of the dataset, the equations model the peak

ground accelerations (PGA) and pseudo-spectral accelerations (PSA) reasonably well. Residuals of the ground-motion prediction display no clear trend with regards to either magnitude or distance.

We further assess the limits of usability of the resulting GMPEs and discuss the limitations of the empirical methods used in creating the models.

- **Analysis of waveforms of local earthquakes in the West Bohemia/ Vogtland area and Reykjanes Peninsula;** *Alena Bouskova*

A.Bouskova, P. Hrubcova V. Vavrycuk and J. Horalek, Geophysical Institute, Academy of Sciences of the Czech Republic, Bocni II/1401, 14131 Praha 4, Czech Republic

The West Bohemia/Vogtland area, siuated at the intersection of two main fault systems, Eger rift trending ENE and Mariánské Lázně fault zone trending NNW, is known for its swarm seismicity and large-scale diffuse degassing of mantle-derived fluids. Two Quaternary volcanoes, Komorní Hůrka and Železná Hůrka, indicate recent geodynamic activity of this region. The seismicity is monitored by seismic stations of the WEBNET network, which has been operating for more than twenty years. Local earthquakes recorded by this network are concentrated to several focal zones with the prevailing number of events in Novy Kostel focal zone. Seismic records of local events give us the database for further investigation of this geodynamic region.

Apart from standard processing of data (picking of P- and S-wave arrivals, localization and magnitude estimation of events), high quality of data enable us detailed analyses of seismograms. They display pronounced reflected and refracted waves both for P- and S-wave onsets and also split S waves. Additionally seismic signals show deviations from the simple 1-D upper-crust velocity model, the v_P/v_S ratio variability, wave back-azimuth deviations and anisotropic behaviour of the area. Such informations improve our knowledge about investigated tectonic structure of the whole geodynamic area monitored from the seismic rays.

The other seismic swarm area of our interest, volcanicaly as well as tectonicaly active Reykjanes peninsula in SW Iceland, is monitored by REYKJANET network since autumn 2013. We use seismograms of local earthquakes recorded by REYKJANET stations for similar studies as in West Bohemian area, but these studies are only at the beginning.

References

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Hrubcová, P., Vavryčuk, V., Boušková, A., & Horálek, J., (2013): Moho depth determination from waveforms of microearthquakes in the West Bohemia/Vogtland swarm area. J. Geophys. Res,.**118**, 1-17. doi: 10.1029/2012JB009360.

- **Earthquakes in Greenland and single station detection;** *Peter H. Voss*

Peter H. Voss and Hans Peter Rasmussen
Geological Survey of Denmark and Greenland – GEUS

Results from the earthquake monitoring in Greenland during the last decades are presented, and these results show; a large increase of the number of detected earthquakes, an improved detection threshold, new areas of high seismicity, several earthquake clusters and seismicity below the ice cap. The development of the seismic monitoring have gone from having only three seismic stations placed in Greenland in the 1960'ties, to a start where there today are 20 permanent stations placed in Greenland. All 20 stations are equipped with broadband sensors, of which 17 transmit 100sps data in real time, and 3 transmit 1sps data with a delay, using Internet or the Iridium satellite system. The resent major improvement of the seismic monitoring is performed by the Greenland ice sheet monitoring network (GLISN, http://glisn.info). Using single station analyzing technique, the detection threshold has been lowered during the resent decade. The power of the technique is shown at the latest station to become online, station NOR at Station Nord in North-East Greenland. In the period since the station became online by ultimo NOV 2013 to 15th of AUG 2014, 2161 events has been detected at the station, but only 13.4% of these events was recorded on other stations. The outcome of this analysis is presented in connection to the overall image of the seismicity of Greenland.

- **2.5D waveform and real noise simulation of receiver functions in 3D models;** *Christian Schiffer*

Schiffer, C., Jacobsen, B.H., Balling, N.

Thursday October 9

09:00-09:20
Hossein Shomali

Back-Projection Analysis of Moderate to Large Earthquakes Using Data from the Swedish National Seismic Network (SNSN)

Hossein Shomali, Reynir Böðvarsson, Björn Lund, Peter Schmidt and Roland Roberts, Department of Earth Sciences, Uppsala University, Sweden

Detailed knowledge of source rupture process of moderate to large earthquakes can be obtained by back-projecting high-quality teleseismic P-wave trains recorded at teleseismic distances (30°–90°). The well-correlated and uniform wavefronts observed by a dense array of seismometer are propagated back in time and space to the source region in order to map the timing and location of the energy released during the rupture process. This provides rapid and robust image of source characteristics from the high-frequency radiated seismic energy (0.2-1.0 Hz) in the P-wave trains which are extremely useful in relation to the issuing of warnings and assessments immediately after the occurrence the events. We apply the method to 66 three-component broadband (CMG-3TD) seismic stations of the Swedish National Seismic Network (SNSN) operated by Uppsala University since 1998. The SNSN array covers an area about 450 km by 1450 km with the high concentration of stations along the Baltic Coast. Well-correlated and uniform recorded waveforms of moderate to large earthquakes at teleseismic distances provide a high quality dataset with insignificant site effects suitable for back-projection application. It is especially significant that SNSN stations record clear signals even from distance earthquakes at relatively high frequencies. The potential of the method in identifying the rupture propagation and its slip distribution is shown by applying the method to a number of large earthquakes including the March 11, 2011, Mw 9.1 subduction zone thrust, Japan, the April 11, 2012, Mw 8.7 intraplate strike-slip, northern Sumatra and the April 16, 2013, Mw 7.7 subduction zone, Makran/Iran earthquakes. The extent and magnitude of the fault slip and the progression of slip along the causative faults are presented by back-projecting the high-frequency radiated seismic energy in the P-wave trains using data from SNSN.

09:20-09:40
Valérie Maupin

A Proterozoic boundary in southern Norway revealed by joint-inversion of P-receiver functions and surface waves

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We have estimated the seismic S-wave velocity structure of the crust and uppermost mantle in southern Norway and western Sweden by joint inversion of teleseismic P-receiver functions and Rayleigh wave phase velocities. The data come from the temporary broad band seismological experiments MAGNUS and DANSEIS, and nearby permanent stations in Norway and Sweden. The S-wave velocity profiles in western and central southern Norway show a sharp and well defined Moho discontinuity at depths between 29 and 42 km. In contrast, in the northeastern part of the study area, we do not find a sharp Moho, but a gradual crust-mantle transition from 40 to 50 km depth. The gradual crust-mantle transition could be caused by mafic underplates that are only partially eclogitized, whereas the sharp and well-defined Moho discontinuity can be a consequence of extensional collapse of the Sveconorwegian orogen. The boundary between a sharp Moho discontinuity and a gradual crust-mantle transition has a northwest strike, and crosses perpendicularly through the Caledonides, suggesting that the boundary survived the Caledonian orogeny.

09:40-10:00
Valérie Maupin

Multiscale, finite-frequency P & S tomography of the upper mantle in the southwestern Fennoscandian Shield

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We present a P- and S-wave regional tomography of the upper mantle in southwestern Scandinavia using a wavelet-based, multiscale parameterization of the model, and finite-frequency kernels for the inversion. Relative travel time residuals of direct P- and S-waves are measured in two different frequency bands each and are corrected for crustal structure using a detailed model for the study area. Resolution tests are used to find optimal damping values not only for relative variations in Vp and Vs separately, but also for perturbations in their ratio Vp/Vs. The tests show that features down to a size of 100 (150) km can be well resolved in the P (S) tomography. To ease comparison with previous studies we have also performed multiscale tomographies using ray-theory-based kernels. Our finite-frequency, multiscale models of variations of Vp and Vs confirm the existence of low velocities below southern Norway and Denmark and high velocities beneath the shield proper in Sweden, as seen in previous studies, but add more details to this simplified picture. The low velocities below southern Norway and Denmark are shown to be confined to a channel-like structure at about 100 to 200 km depth, and the lateral transition from low to high velocities follows zones of Carboniferous-Permian extension and magmatism very closely. A deeper low velocity anomaly below central southern Norway emerges from the channel at 150 km depth and extends to a depth of 350 km. In the Swedish area, we infer high velocities in Vp and Vs, and negative anomalies in Vp/Vs, indicating a strongly depleted mantle. We propose that the episodic erosion and convective removal of an originally thick mantle lithosphere below southern Norway to its current thickness of about 100 km could have been a trigger for episodic uplift in the Mesozoic and Cenozoic.

10:00-10:20
Frederic Wagner

Automated event detection algorithm based on signal-to-noise ratio migration

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A seismological network of high station density consisting of 25 broadband stations has been recording for a total period of 4 years (2009-2013) in SW Iceland. The area shows natural seismic activity in Hengill and its neighbouring volcanic systems situated within the spreading zone of the Atlantic Mid Ocean Ridge. Additionally, induced seismicity took place during the drilling (late 2011) and pumping (2012-present) stages at the geothermal power plant in Hellisheidi, SW Iceland. The normal processing steps include trace filtering followed by phase detection, determination of first P- and S-phase arrivals, and a subsequent event association. Here we have used the SIL-system (Bödvarsson et al. 1996) software for this (the system used at the Icelandic and Swedish national networks), which is a completely automated process. At this stage the observer comes in and manually adjusts the picks. At best, only a minimal human interaction is required for this, but sometimes a more tedious process of untangling picks wrongly associated to closely spaced events, and/or investigating false alarms is required. An automated procedure producing reliable event locations and phase picks is therefore desired to deal with the large amount of data available.

Common detection/phase picking routines search for phases trace-wise before associating picked phases with potential events. More recent approaches make use of increased computational resources and put the event detection into the foreground, analysing the coalescence (migration) of modified seismic traces using, commonly, a 1-d a-priori velocity model of the area under investigation (e.g. Drew et al. 2013, Langet et al. 2014).

This work follows the same concept of migrating different input functions (modified traces, i.e. detection functions) into an a-priori velocity cube in order to locate accumulation of high amplitudes. The induced sources leading to quick successions of low amplitude events require phase accurate detection functions with narrow signal width that distinguish closely spaced events. On the other hand, narrow signals will not coalesce when the a-priori model is inaccurate. The complex geological structure in the Hengill area poses a challenge for the correct setup of such an automated detection procedure.

A 3-d P- and S-wave velocity model resulting from previous tomographic studies served as a-priori model for the migration-based detection. Nevertheless, a wide signal detection function was preferred. The short-term-average long-term-average ratio (STA/LTA) of frequency filtered traces as detection function has been found to yield most stable results and reliable detections due to its good coalescence and phase accuracy. For a small subset of test data, the detection algorithm has been able to detect all high quality events previously detected by the SIL-detection algorithm combined with the manual revisions. Additionally, a large number of low and medium quality events have been found that remained undetected by the SIL-system, either due to low signal-to-noise ratio or overlapping phases. In a second stage the automatically detected events shall be used to pick P- and S-phases, thus completing the automated detection and phase picking algorithm.

11.00-11.20 *Conrad Lindholm*

Probabilistic Seismic Hazard (PSHA): Challenges and Alternatives

Conrad Lindholm, NORSAR

The use of satellite based data is increasingly important in all sciences, and this includes also solid earth sciences and specifically seismology. In recognition of the limitations of traditional Probabilistic Seismic Hazard Analysis (PSHA) we have explored the use of strain data, derived from GPS measurements and earthquake focal mechanisms, for constraining earthquake recurrence of large earthquakes within and along the western Himalaya arc. Our preliminary results hinge on a number of assumptions in addition to a rather simple interpretation of the newly available strain data, in which all accumulated strains must be released in coseismic slip. The results indicate for some segments along the Himalaya arc a reasonable correlation with historical earthquake activity, while other segments seem characterized by a significant amount of yet unreleased earthquake slip, i.e. a situation that can be interpreted as predicting a great potential for large future earthquakes on these segments.

11.20-11.40 *Steven J Gibbons*

Time-Delay Correction Surfaces for Improved Seismic Array Performance

Steven J Gibbons

Seismic arrays use delay-and-stack beamforming both to improve the signal-to-noise ratios of seismic signals and to provide more accurate and robust direction measurements than are possible using single 3-component stations.

There is often a significant discrepancy between the inter-sensor time-delays predicted by plane-wave models and those measured empirically for observed wavefronts. These discrepancies can result in significant bias in backazimuth and apparent velocity measurements, and cause waveform misalignment that degrades the beamforming operation. Due to its large aperture, the NOA array in Southern Norway has some of the most significant time-delay discrepancies in the International Monitoring System. We demonstrate the problems caused and describe a procedure for the calculation of robust correction surfaces. Application of these corrections results in significantly higher SNR and accuracy in slowness estimates. At smaller aperture seismic arrays, the time-delay discrepancies are likely to be smaller although the corrections that need to be applied are likely to vary significantly as a function of frequency.

11:40-12:00 *Sigridur Kristjansdottir*

Stress Tensors and Diverse Focal Mechanism Solutions of Microseismic Events during Active Deformation in Krysuvik Geothermal Area, SW Iceland, in 2009

Sigridur Kristjansdottir, Kristjan Agustsson, Olafur G. Flovenz, Aurore Franco, Laurent Geoffroy, and Catherine Dorbath Iceland GeoSurvey, Grensasvegur 9, 108 Reykjavik, Iceland

Krysuvik is a geothermal area located on the Reykjanes Peninsula in southwest Iceland. The peninsula is an oblique spreading plate boundary, striking N80°E compared to the spreading direction of N100.4°E (C. DeMets, 2010). Early in 2009 a signal of uplift was detected in the area. The uplift continued until the fall of 2009 when the area started subsiding. Another period of uplift started in April 2010 and lasted until the beginning of 2012 when the area began subsiding again. Intense seismic swarms were recorded on a dense seismic network located in the area during the period of unrest in 2009. Altogether over 10,000 earthquakes were detected. The activity was characterized by short, intense swarms in between longer, quieter periods. A detailed analysis was performed on the focal mechanism solutions of ~1,000 events, including a stress tensor inversion for several swarms in the Krysuvik and nearby Fagradalsfjall areas. Earthquakes of different faulting types characterize individual swarms, with normal, reverse, and strike-slip events taking place in the same swarms. Stress tensor inversion reveals a NW-SE trending minimum horizontal stress, in good agreement with previous studies in the area. No direct indication of magmatic involvement during the deformation sequence is observed.

13:20-13:40
Bin Li

Stress Pattern of the Shanxi Rift System, North China, Inferred from the Inversion of New Focal Mechanisms

Bin Li*, Kuvvet Atakan, Mathilde Bøttger Sørensen, Jens Havskov
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Earthquake focal mechanisms of the Shanxi rift system, North China, are investigated for the time period 1965 - Apr. 2014. A total of 143 focal mechanisms of $M_L \geq 3.0$ earthquakes were compiled. Among them, 105 solutions are newly determined by combining the P-wave first motions and full waveform inversion, and 38 solutions are from available published data. Stress tensor inversion was then performed based on the new database. The results show that most solutions exhibit normal or strike-slip faulting, and the regional stress field is characterized by a stable, dominating *NNW-SSE* extension and an *ENE-WSW* compression. This correlates well with results from GPS data, geological field observations and leveling measurements across the faults. Heterogeneity exists in the regional stress field, as indicated by individual stress tensor inversions conducted for five subzones. While the minimum stress axis (σ_3) appears to be consistent and stable, the orientations, especially the plunges, of the maximum and intermediate stresses (σ_1 and σ_2) vary significantly among the different subzones. Based on our results and combining multidisciplinary observations from geological surveys, GPS and cross-fault monitoring, a kinematic model is proposed, to illustrate the present-day stress field and its correlation with the regional tectonics, as well as the current crustal deformation of the Shanxi rift system. Results obtained in this study, may help to understand the geodynamics, neotectonic activity, active seismicity and potential seismic hazard in this region of North China.

13:40-14:00
Mathilde B. Sørensen

Active faults and potential ground shaking in Cuba

Mathilde B. Sørensen (1), Bladimir Moreno Toiran (2), Lars Ottemöller (1)
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Cuba is located just north of the Caribbean-North American plate boundary, and especially the southern part of the country is affected by occasional large earthquakes. Several previous studies have focused on mapping active faults in Cuba. However, many of these studies have a local or regional focus, and results are often not easily accessible for the international community. We therefore compile and merge available models of active faulting in Cuba to obtain information about active faults at a national scale. It is furthermore attempted to assess the earthquake potential of these faults. The Oriente Fault Zone poses the greatest seismic hazard to Cuba and especially to the city of Santiago de Cuba. To quantify this hazard we simulate the ground shaking to be expected for scenario earthquakes along this structure. Simulations are based on a stochastic methodology and are performed for scenario earthquakes of different magnitudes. Input parameters are constrained by analyzing seismicity

recorded by the Cuban Seismic Network. The impact of the scenario earthquakes is evaluated both at a regional scale and locally in Santiago de Cuba, accounting for local-scale soil amplification.

Friday October 10

09:00-09:20 *Christina Dahnér*

Presentation of the LKAB project: Analysis of mining induced seismicity at Kiirunavaara Mine

C. Dahnér, LKAB, S. Dineva, Luleå Technical University, B Lund, Uppsala University, A. Tryggvason, Uppsala University

The LKAB iron ore mine in Kiruna has experienced severe seismicity in the production areas since 2007, with event magnitudes up to M_L (UPP) =2.9. In response to the seismicity, the mine has implemented a number of changes in order to mitigate the seismic hazard. These changes were based on "world best practices" from a rock mechanical perspective. The three most fundamental changes are: 1) expanding the seismic system in two stages into a mine-wide system with 220 sensors, 2) designing and installing a dynamic re-enforcement system, 3) scheduling of the mining sequences based on interpreted seismic hazard from the seismic data.

For better management of the seismic hazard, a project on mine induced seismicity at Kiirunavaara was initiated. The project integrates information from seismological and rock mechanical analysis. The focus of this presentation is on the concept of the project with emphasis on the seismological part. During the project we will:

- Use time lapse tomography to define how the on-going mining affects the re-distribution of mining induced stresses.
- Analyze the correlation between mining induced stress changes and seismicity.
- Analyze the correlation between rock mass properties and the seismicity.
- Analyze the mechanisms of the seismic sources and stress inversion.

The project work so far has consisted of:

- Measured mining induced stresses and installation of stress monitoring at two different locations
- Preliminary work on a kinematic model
- Extensive rock mechanical core logging
- Initial work on passive tomography
- Initial work on focal mechanisms and moment tensor solutions.

The project has three major final goals:

- Increasing the knowledge of seismic hazard related to mining induced stress changes and small scale geological and rock mass properties.
- Developing a tool for tracking high stress zones and areas with potentially higher seismic hazard forming on a monthly basis
- Increasing the understanding of the nature of the induced seismic sources and their relationship with the mine infrastructure, the mining sequencing and geological features.

09:20-09:40 *Heidi Soosalu*

Seismic analysis of mine collapse signals in NE Estonia

Heidi Soosalu[1,2], Savka Dineva[3], Merike Ring[2], Ingo Valgma[2], Oleg Nikitin[4], Kaupo Rõivasepp[1,2] [1]Geological Survey of Estonia, [2]Tallinn University of Technology, [3]Luleå University of Technology, [4]Eesti Energia Mining

Seismicity in Estonia is monitored by a 3-station national network and the

Finnish network of the Institute of Seismology, University of Helsinki. Although Estonia is a low-seismicity region (in average one earthquake per two years), several tens of seismic events (< 2 in magnitude) per month are detected. Blasts in oil shale open cast mines or limestone quarries are the cause of most of them. Event identification is aided by mining companies who provide information on their blasting schedules.

Two extraordinary seismic events were detected in 2008, on 21 January (magnitude 1.6) and on 2 July (magnitude 1.8). They were located in the area of an underground oil shale mine within the NE Estonian shale deposit. The seismograms differ drastically from typical signals of blasts or local earthquakes with their low frequencies, long duration and monochromatic low-frequency coda. Their time of occurrence, 01:30 and 01:44 local time, respectively, is very atypical compared to routine explosions of the area. As a rule, blasting operations in open mines are allowed only during daylight hours.

The collapses occurred because of roof failure above pillars too small in dimensions within a room-and-pillar section in the mine. The surface expressions, ground depressions of roughly oval shape, have been pinpointed in a woodland area, at approximately 100 m distance from each other. This area is also in vicinity of a defined risk zone due to karst formation.

Knowledge on the exact locations of both the events, and quantitative information on dimensions of the collapses makes these cases attractive for analysis of seismic signals and magnitude estimation. A detailed analysis of the regional seismograms from both Estonian and Finnish seismic stations was made to define the type of the seismic waves and the dynamic parameters of the seismic sources. An attempt was made to perform the moment tensor inversion for the two collapses to find out the type of the seismic sources.

Existence of overlapping information on parameters of these events makes them useful for assessing similar events with less precise data. Also, these cases may even provide analogies for analysis of low-frequency volcanic events, the mobile fluid being air in mine shafts rather than magma in volcanic channels.

This study is supported by the Estonian Research Council grant ETF9018 “Mine collapses in NE Estonia – detection, identification and causes”.

09:40-10:00 **NEONOR2 project - Neotectonics in Nordland**

Ilma Janutyte Ilma Janutyte, NORSAR, Gunnar Randers vei 15, N-2007 Kjeller, Norway

The NEONOR2 project (Neotectonics in Nordland), which started in 2013, is lead by the Geological Survey of Norway (NGU) in cooperation with the Norwegian Mapping Authority (Kartverket), NORSAR, the Norwegian Petroleum Directorate (NPD), and the University of Bergen (UiB). The Norwegian Research Council is financing three postdoc positions while the other contributions come from industry. The project is built on the earlier NEONOR project (Neotectonics in Norway), which was carried out from 1997 to 2000.

The area offshore of Nordland is regarded as a potential province for new large petroleum discoveries. However, the Nordland area proved to be tectonically active, and it was concluded that neotectonic deformation processes may constitute geohazard and influence the behavior of hydrocarbons on the continental shelf of Norway. Thus, a better understanding of the recent deformation processes is needed. The prime objective of the NEONOR2 project is to promote understanding of regional-scale stress and strain dynamics in the Nordland area through a detailed monitoring of seismicity, and to link this to geodetic movements (and in situ stress state), and in turn to tectonics, vertical deformations and isostatic processes through modelling. The seismological part of the project is carried out by NORSAR and UiB. We aim to map in detail the regional seismicity areas of Nordland in order to obtain the best onshore and offshore coverage. This is to test and improve the currently known pattern of enhanced and reduced seismicity, and to map the onshore-offshore extent of the stress regime. To this purpose we deployed 21 temporary seismic stations. The local array configuration of the seismic stations allows to detect the offshore events with higher precision.

10:00-10:20
Peter H. Voss

NordQuake – Closing remarks and Future Cooperation

Peter H. Voss
Geological Survey of Denmark and Greenland – GEUS

The Nordic Earthquake Researcher Network – NordQuake, was established in 2011 with founding from NordForsk, an organisation under the Nordic Council of Ministers that provides funding for Nordic research cooperation as well as advice and input on Nordic research policy (http://www.nordforsk.org/). NordQuake aims to strengthen and increase the quality of the earthquake research and research training in the Nordic and Baltic countries. NordQuake will e.g. organize and hold meetings and training courses for earthquake researchers and students at universities and other research institutions in the Nordic and Baltic countries and training courses for PhD students and young researchers. Researcher Network meetings was planned for 2012, 2013 and 2014 and training courses was planned for 2012 and 2013. The 2012 training course was undertaken in June hosted by University of Bergen, Norway, with 11 participants. The 2013 training course was undertaken in June hosted by GEUS, Denmark, with 23 participants. Outcome of the course is presented. The status and closing remarks of NordQuake project is given. The presentation will end by a discussion with the audience regarding future plans for the Researcher Network and the established platform. http://nordquake.net

11:00-11:20
Annakajsa Korja

FIN-EPOS – a Finnish national initiative of EPOS

Annakaisa Korja

Institute of Seismology, Department of Geosciences and Geography, University of Helsinki

The European Plate Observation System (EPOS http://www.epos-eu.org/) is the integrated solid Earth Sciences research infrastructure (RI) approved by ESFRI. EPOS is coordinating the integrated use of data, models and facilities from spatially separated networks, observatories, temporary deployments and research facilities of Solid Earth science in Europe. It will provide an efficient and comprehensive multidisciplinary research platform and a data portal by integrating the existing national RI.

This Finnish national EPOS initiative is a joint proposal of the Universities of Helsinki and Oulu, the Finnish Geodetic Institute, the Finnish Meteorological Institute, the Geological Survey of Finland and CSC- IT Center for Science. The infrastructure consists of permanent and portable seismic and geodetic networks, magnetic observatories, portable electromagnetic arrays, geophysical and geodynamic modeling laboratories that are scattered around the country. Each RI relies heavily on technological development, international expertise and data exchange. The host-organizations will own both the data and the infrastructure also in the future and thus the operation and maintenance of the RI is funded through host organizations annual budgets. Modernization, upgrading and expanding of the networks and databanks will be funded by infrastructure grants.

Finland has signed the Letter of Intent (LOI) to build EPOS-ERIC and has taken first steps in confirming the participation in EPOS-ERIC, if the terms of joining are reasonable. The next step is to build a FIN-EPOS RI-consortium that could act as a partner in EU-projects associated with EPOS, organize the Finish participation in EPOS and lobby for Finnish research interest in the implementation and building phases of EPOS. FIN-EPOS will co-operate with the other Nordic EPOS consortia.

11:20-11:40 *Reynir Bödvarsson*

EPOS and Seismology in the Nordic countries

Reynir Bödvarsson, Roland Roberts. Uppsala University

EPOS is a pan-European initiative to better coordinate access to and use of Solid Earth Science data in Europe. EPOS's profile is not completely defined, but there is a strong focus on seismology. The EPOS planning phase is financed by the EU, via the ESFRI program. The intention is that running costs will be covered by national funds. There is likely to be significant financing available over the next few years for the implementation phase. The process for allocating this funding will, if it materializes, come very soon and the planning process will be rapid.

EPOS is likely to significantly affect how seismology "works" in Europe and in the Nordic countries. It is important that we, preferably together, have a clear vision of how we would like this to work in our part of the world. Much of the discussion in the EPOS planning phase has revolved around who should do things, as opposed to what should be done. As EPOS has failed to produce clear lists of what it should do, with priorities, it seems sensible that we Nordic seismologists do this. Which functions are necessary and desirable for future seismology in Europe? Which of these functions should be carried out at national or regional level, and which should be centralized to European centres? What roles would be appropriate for the Nordic countries?