Helmholtz Centre Potsdam
GFZ German Research Centre
for Geosciences

Michael Grund, Alexandra Mauerberger, Joachim R.R. Ritter, Frederik Tilmann

Broadband Recordings for LITHOS-CAPP: LITHOspheric Structure of Caledonian, Archaean and Proterozoic Provinces, Sep. 2014 - Oct. 2016, Sweden and Finland

Scientific Technical Report STR17/02 – Data
GIPP Experiment and Data Archive

www.gfz-potsdam.de

HELMHOLTZ
ASSOCIATION

Recommended citation:

Grund, M., Mauerberger, A., Ritter, J. R., Tilmann, F. (2017): Broadband Recordings for LITHOS-CAPP: LITHOspheric Structure of Caledonian, Archaean and Proterozoic Provinces, Sep. 2014 - Oct. 2016, Sweden and Finland, (Scientific Technical Report STR - Data; 17/02) (GIPP Experiment and Data Archive), Potsdam: GFZ German Research Centre for Geosciences.
DOI: http://doi.org/10.2312/GFZ.b103-17029

ScanArray Core data set:

Thybo, H., Balling, N., Maupin, V., Ritter, J., Tilmann, F. (2012): ScanArray Core (1G 2012-2017). The ScanArray consortium. Other/Seismic Network.
DOI: http://doi.org/10.14470/6T569239

Supplementary data sets:

Grund, M., Mauerberger, A., Ritter, J., Tilmann, F. (2017): Broadband Recordings for LITHOS-CAPP: LITHOspheric Structure of Caledonian, Archaean and Proterozoic Provinces, Sep. 2014 - Oct. 2016, Sweden and Finland – Recorder log-file - Datasets. GFZ Data Services.
DOI: http://doi.org/10.5880/GIPP.201417.1

Imprint

Helmholtz Centre Potsdam
GFZ German Research Centre
for Geosciences

Telegrafenberg
D-14473 Potsdam

Published in Potsdam, Germany
Oktober 2017

ISSN 2190-7110

DOI: http://doi.org/10.2312/GFZ.b103-17029
URN: urn:nbn:de:kobv:b103-17029

This work is published in the GFZ series
Scientific Technical Report (STR)
and electronically available at GFZ website
www.gfz-potsdam.de

Grund, M., Mauerberger, A., Ritter, J. R., Tilmann, F.

Broadband Recordings for LITHOS-CAPP: LITHOspheric Structure of Caledonian, Archaean and Proterozoic Provinces, Sep. 2014 - Oct. 2016, Sweden and Finland

Scientific Technical Report STR17/02 – Data
GIPP Experiment and Data Archive

Broadband Recordings for LITHOS-CAPP: LITHOspheric Structure of Caledonian, Archaean and Proterozoic Provinces, Sep. 2014 - Oct. 2016, Sweden and Finland

Michael Grund[1], Alexandra Mauerberger[2], Joachim R.R. Ritter[1*], Frederik Tilmann[2*]

[1] Karlsruhe Institute of Technology KIT, Geophysical Institute GPI. Hertzstraße 16, 76187, Karlsruhe, Germany

[2] Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, Germany

[*] corresponding authors

Abstract

LITHOS-CAPP is the German contribution to the international ScanArray experiment. ScanArray is an array of broadband seismometers with which we aim to study the lithosphere and upper mantle beneath the Scandinavian Mountains and the Baltic Shield. LITHOS-CAPP contributed 20 broadband recording stations from September 2014 to October 2016, 10 in Sweden and 10 in Finland, continuously recordings at 100 samples per second. The stations were deployed by the KIT Geophysical Institute and GFZ section 2.4 (seismology). They form part of the temporary network ScanArrayCore (FDSN network code 1G 2012-2017)

Related data sets

- DOI of ScanArray Core data: http://doi.org/10.14470/6T569239 (this report only refers to a subset of this dataset)
- DOI of log file archive: http://doi.org/10.5880/GIPP.201417.1

Coordinates: 60-67°N / 14-28°E

Keywords: Seismology, temporary broadband seismic experiment, lithospheric structure, Scandinavia

Table of Contents

Abstract 1

Related data sets 1

Table of Contents 2

1. Introduction 3

2. Data Acquisition 5

2.1 Experiment Design and Schedule 5

2.2 Network Geometry and Location 6

2.3 Instrumentation 8

Sensors 8

Loggers 9

2.4 Orientations of Sensors 10

3. Data Processing 11

4. Data Description and Completeness 12

5. Data Quality and Accuracy 14

6. Data Availability and Access 16

7. Acknowledgments 17

8. References 17

Appendix 18

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

1. Introduction

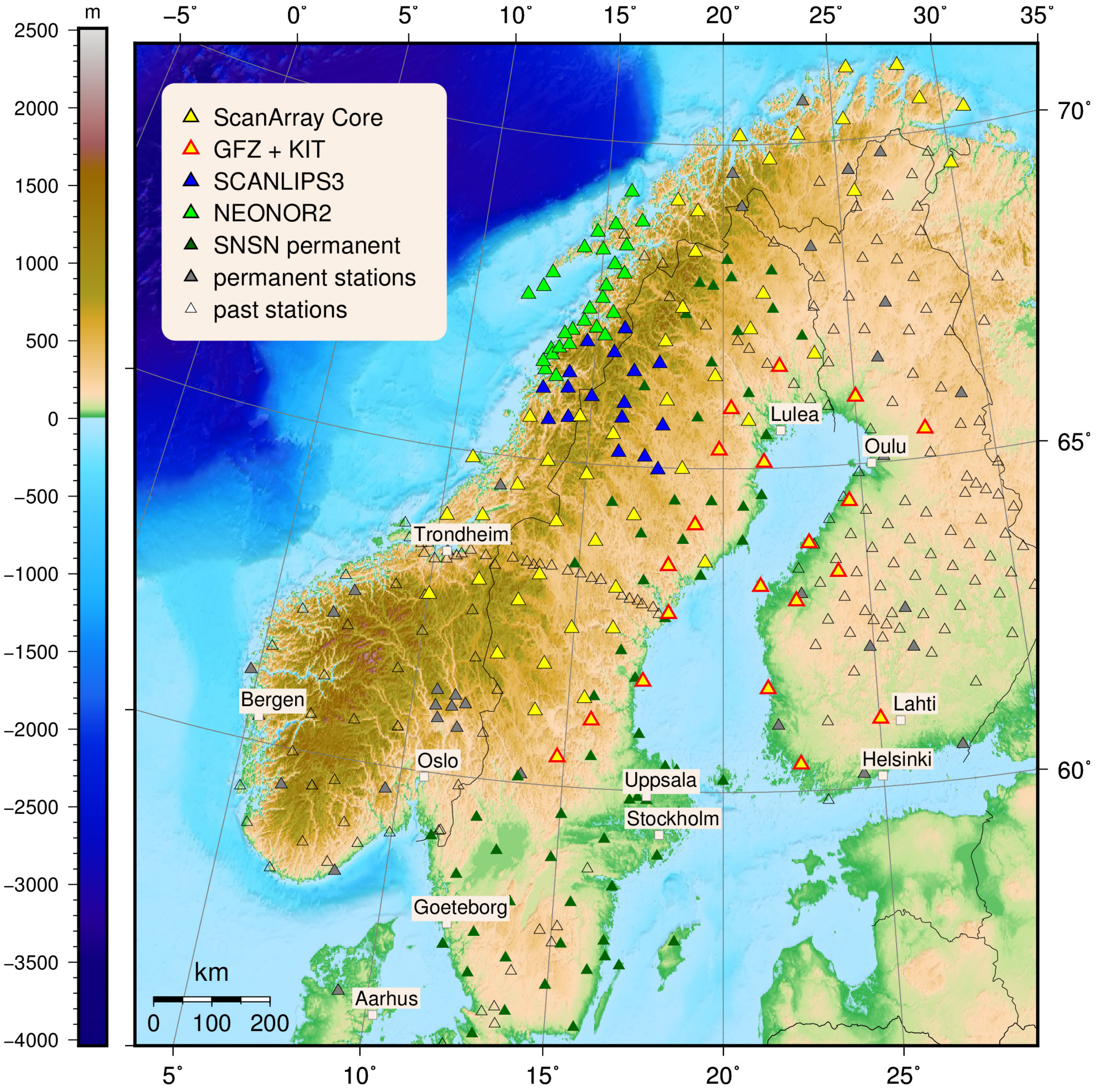
The deep structure and the evolution of the Baltic (or Fennoscandian) Shield and the Caledonian Scandinavian Mountains (Scandes) are the focus of an international team of geoscientists (Figure 1). The main effort is a joint seismological experiment (ScanArray) which covers the whole area for the first time. The western rim of Scandinavia with the Scandes mountain range has elevations of up to 2500 m. Since this region lacks recent compressional tectonic forces, it provides a great opportunity to understand the geodynamical evolution of crustal and upper mantle structures at passive continental margins. In the central part of Scandinavia the Baltic Shield grew during several collisional phases whose present deep structure is only poorly understood.

The LITHOS-CAPP project (LITHOspheric Structure of Caledonian, Archaean and Proterozoic Provinces) is the German contribution to the ScanArray initiative (Helmholtz-Centre Potsdam GFZ German Research Centre for Geosciences and Karlsruhe Institute of Technology, KIT). ScanArray is a consortium including also NORSAR (http://www.norsardata.no/), NGU (http://www.ngu.no/en/node, both Norway) as well as the Universities of Copenhagen, Oslo, Leicester, Uppsala, Bergen, Aarhus and Oulu. In fall 2014, 97 broadband stations have been deployed by the project partners covering central and northern Norway and Sweden and the western margin of Finland. Twenty broadband seismic stations were provided by the Geophysical Instrument Pool Potsdam (GIPP) and Section 2.4. Seismology of GFZ and operated for 2 years.

Our project links to former studies which mainly covered the southern regions of Scandinavia. An unusually shallow crust and lithosphere-asthenosphere boundary have been found beneath the high-topography Scandes mountain range of western Norway, where a clear crustal mountain root seems to be absent. However, the lower topography regions of eastern Norway and Sweden reveal a thicker crust, which contrasts with the principles of Airy isostasy. Lower seismic velocities than expected for a tectonically stable region have been found for southern Norway with a sharp transition to higher seismic P-wave and S-wave velocities beneath Sweden. To obtain a high-resolution (lithospheric) shear wave model, we will combine tomographic and waveform inversions of surface waves and ambient noise subsequently producing 3D velocity models, including both isotropic and anisotropic analyses. The focus is on the variation of crustal and lithospheric structure as well as seismic velocity across the Scandes mountain range and western (Phanerozoic) and eastern (Proterozoic) Scandinavia. The spatial variation of anisotropic structures can give us a hint at the tectonic formation since anisotropy may differ between the tectonic units or could be consistent over larger regions.

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

Figure 1: ScanArray station network. Twenty LITHOS-CAPP stations (yellow triangles with red edges) are part of the subnetwork ScanArray Core that consists also of recording stations from the Universities of Copenhagen, Aarhus and Oslo (in total 69 stations). The NEONOR2 network (28 stations) is operated by the University of Bergen and NORSAR and SCANLIPS3D (20 stations) by the University of Leicester. The Swedish National Seismic Network (SNSN) is a permanent restricted network operated by the University of Uppsala. ScanArray partners have access to the SNSN data from 2012-2016.



STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

2. Data Acquisition

2.1 Experiment Design and Schedule

Within the framework of LITHOS-CAPP, 20 temporary seismic broadband stations were deployed and operated by KIT and GFZ in Finland and Sweden to record teleseismic earthquakes and local seismicity in the period September 2014 to October 2016 (Figure 1). In total, ScanArray includes around 130 temporary stations as well as about 115 permanent stations in Norway, Finland and Sweden. In general, interstation distances within the ScanArray network are approximately 50 to 60 km. Depending on the individual site conditions, sensors were installed on bedrock, concrete floors or concrete plates close to or within residential as well as governmental buildings. Power supply was mostly contributed by the individual site owners. After the installation in September/October 2014, service trips were undertaken to check the technical components as well as change and save the hard drives with the data (in May 2015, September 2015 and May 2016). Finally, stations were removed in September/October 2016, thus two years of continuous recording were accomplished.

Figure 2: Exemplary instrument installations at recording stations SA49, SA64, SA38 and SA54. At station SA49 the sensor (red arrow) was installed underneath the building. At stations SA64, SA38 and SA54 cellars were used. The sensors were protected with insulation material against temperature variations.

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

2.2 Network Geometry and Location

The seismic stations were installed close to or within buildings (Figure 2) to ensure a continuous power supply over the long-lasting winter periods. Depending on the individual site, most sensors were directly installed on concrete floor or bedrock. To establish a consistent nomenclature, station names were generated for the whole ScanArray network. Thus, the LITHOS-CAPP station names listed in Table 1 are part of this superordinated naming system and are not labeled with consecutive numbers from 1 to 20. Please note that station SA21 was removed in May 2015 due to flooding caused by snow melt water. In September 2015, this station was reinstalled at the same property a few hundred meters away as station SA21A. If more than one data logger is listed for a station, this indicates a replacement due to technical problems. Besides all station names, Table 1 lists the locations, elevations, and sensor and data logger types with serial numbers as well as runtime periods of the individual data loggers.

Table 1: Instrumentation information including serial numbers of the used sensors and data loggers for each recording station. Note the replacement of station SA21 as SA21A. Note that the deployment period reflects the time the station was deployed in the field, not the data holdings. There is a discrepancy at some stations because of station outages due to technical failures.

Station	Location	Alt/m	Sensor, ID	Logger, ID	Deployment period
SA19 (Ertsjärv, SWE)	66.5654N, 22.1788E	178	Trillium 120 PA, 003	EDL-PR6 3226	2014/09/18-2016/09/23
SA21 (Tervola, FIN)	66.0406N, 25.0304E	79	CMG-3ESPC, 008	EDL-PR6 3250	2014/09/30-2015/05/12
SA21A (Tervola, FIN, replaced)	66.0405N, 25.0295E	79	CMG-3ESPC, 008	EDL-PR6 3397	2015/09/19-2016/10/06
SA23 (Bredsel, SWE)	65.9262N, 20.3008E	115	CMG-3ESPC, 005	EDL-PR6 3219	2014/09/20-2016/09/22
SA28 (Pudasjaervi, FIN)	65.4469N, 27.5106E	172	Trillium 240, 632	EDL-PR6 3247 EDL-PR6 3028	2014/09/29-2016/05/10 2016-05/10-2016/10/06
SA29 (Lilltraesk, SWE)	65.2879N, 19.8452E	346	Trillium 240, 631	EDL-PR6 3241	2014/09/20-2016/09/24
SA30 (Jaevrebodarna, SWE)	65.0923N, 21.4977E	6	CMG-3ESPC, 007	EDL-PR6 3220	2014/09/21-2016/09/24

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

Station	Location	Alt/m	Sensor, ID	Logger, ID	Deployment period
SA36 (Pyhajoki, FIN)	64.4402N, 24.5172E	51	Trillium 120 PA, 004	EDL-PR6 3246 EDL-PR6 3070	2014/10/01-2015/07/06 2015/07/06-2016/10/05
SA38 (Oertraesk, SWE)	64.1291N, 19.0003E	236	CMG-3ESPC, 004	EDL-PR6 3218	2014/09/15-2016/09/24
SA42 (Palmantie, FIN)	63.8265N, 23.0079E	1	CMG-3ESPC, 013	EDL-PR6 3245 EDL-PR6 3401	2014/10/04-2016/05/10 2016/05/10-2016/10/05
SA46 (Bredbyn, SWE)	63.4896N, 18.0945E	140	Trillium 120 PA, 002	EDL-PR6 3222	2014/09/15-2016/09/25
SA47 (Pulkkinen, FIN)	63.3596N, 23.9733E	106	CMG-3ESPC, 010	EDL-PR6 3240 EDL-PR6 3163	2014/10/04-2015/05/17 2015/05/17-2016/10/04
SA49 (Soedra Vallgrund, FIN)	63.1749N, 21.2788E	6	CMG-3ESPC, 011	EDL-PR6 3254	2014/10/09-2016/10/03
SA52 (Pelmaa, FIN)	62.9381N, 22.4878E	20	Trillium 240, 634	EDL-PR6 3253	2014/10/05-2016/10/04
SA54 (Hemsoen, SWE)	62.7504N, 18.1489E	13	Trillium 240, 630	EDL-PR6 3224	2014/09/14-2016/09/26
SA60 (Arnevikon, SWE)	61.6930N, 17.3793E	15	CMG-3ESPC, 002	EDL-PR6 3216	2014/09/13-2016/09/21
SA61 (Maentykallo, FIN)	61.5934N, 21.4622E	2	Trillium 120 PA, 005	EDL-PR6 3249 EDL-PR6 3403	2014/10/06-2016/05/09 2016/05/09-2016/10/03
SA64 (Lammi, FIN)	61.0537N, 25.0399E	123	Trillium 240, 633	EDL-PR6 3252	2014/10/08-2016/10/02
SA65 (Svabensverk, SWE)	61.0535N, 15.7698E	99	CMG-3ESPC, 001	EDL-PR6 3215	2014/09/11-2016/09/22
SA66 (Bjoerbo, SWE)	60.4468N, 14.7806E	239	Trillium 120 PA, 001	EDL-PR6 3244	2014/09/10-2016/09/21
SA67 (Tuorla, FIN)	60.4158N, 22.4439E	45	CMG-3ESPC, 009	EDL-PR6 3251	2014/10/07-2016/10/02

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

2.3 Instrumentation

All sensors and data loggers were kindly provided by GIPP and GFZ section 2.4. Ancillary equipment (batteries, GPS antennas etc.) was purchased with DFG funding, or on loan from the GIPP and KArlsruhe BroadBand Array (KABBA) at KIT. All stations recorded data with three components (vertical, N-S, E-W) and a sampling rate of 100 Hz. Table 1 lists the individual instrumentation configurations at each recording station.

Sensors

- 5 Nanometrics Trillium 240 seismometers (240 s)
- 5 Nanometrics Trillium 120 PA seismometers (120 s)
- 10 Guralp CMG-3ESPC seismometers (60 s)

For additional information see: http://www.gfz-potsdam.de/en/section/geophysical-deep-sounding/infrastructure/geophysical-instrument-pool-potsdam-gipp/instruments/seismic-pool/

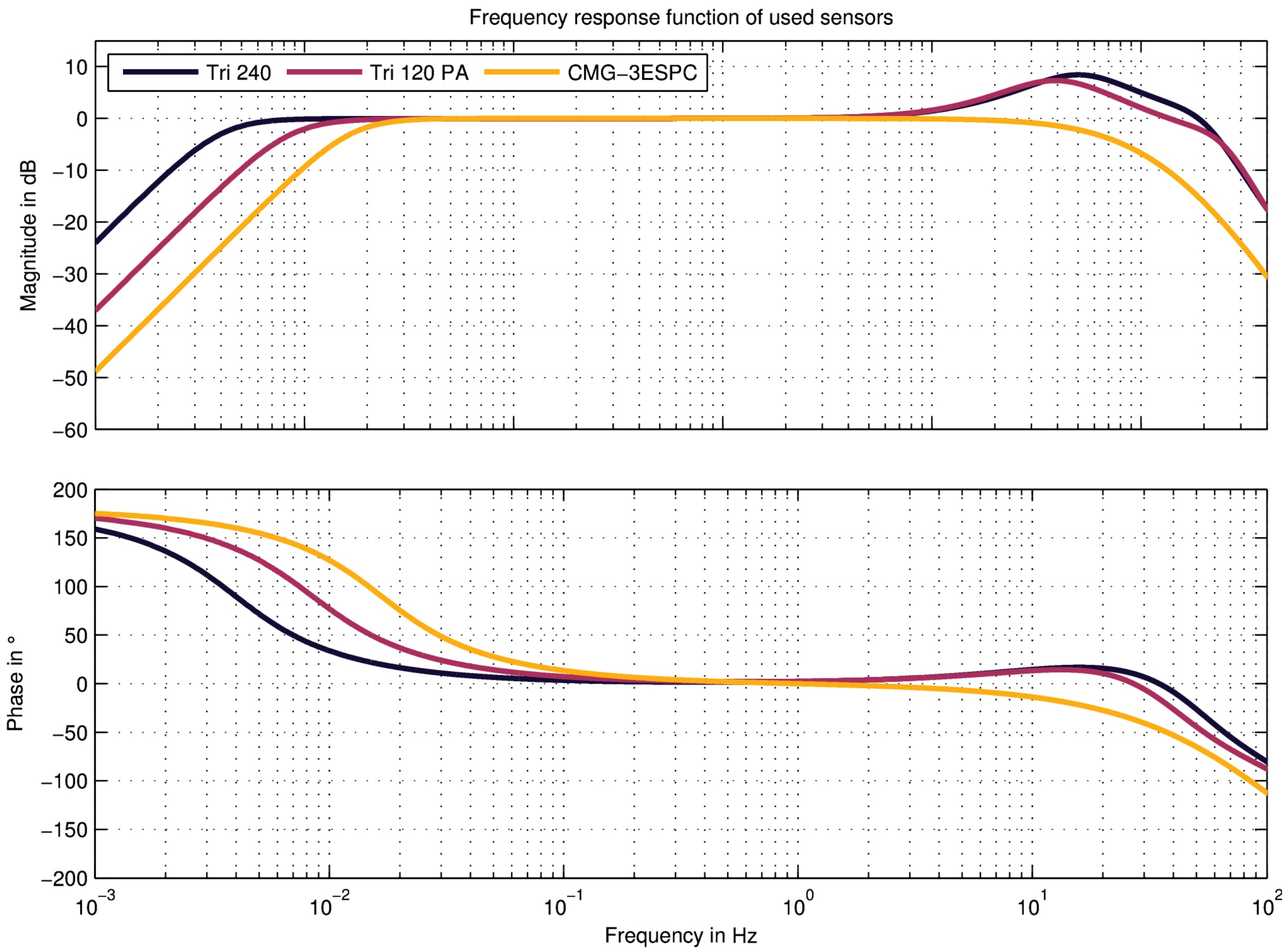


Figure 3: Instrument responses of the three used sensors Nanometrics Trillium 120 PA & 240 and Guralp CMG-3ESPC.

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

Loggers

All seismic stations were equipped with EarthData PR6-24 recorders as data loggers (EDL, see http://www.gfz-potsdam.de/en/section/geophysical-deep-sounding/infrastructure/geophysical-instrument-pool-potsdam-gipp/instruments/seismic-pool/recorder-earthdata-pr6-24/). The data was stored on exchangeable hard disks (36.6 GB) which were replaced during each station service. The EDL recorded continuously at 100 samples per second and pre-amplification was set to 0.4.

Logger settings and sensor characteristics to deconvolve time series to true ground velocity from the raw data are listed in Table 2. Instrument response functions for the used sensors based on the values of Table 2 are displayed in Figure 3.

Table 2: Properties of the used sensors and data loggers.

Sensor	**A/D conversion in counts / V**	**Sensitivity in V / (m / s)**	**Norm factor**	**Poles**	**Zeros**
Trillium 240	400000	1200	451700	-1.7700E-02 + 1.7600E-02i	0
				-1.7700E-02 – 1.7600E-02i	0
				-1.2670E+02 + 0.0000E+00i	-9.1660E+01
				-1.9200E+02 + 2.5900E+02i	-1.6010E+02
				-1.9200E+02 – 2.5900E+02i	-3.2070E+03
				-5.5770E+02 + 1.1400E+03i	
				-5.5770E+02 - 1.1430E+03i	
Trillium 120 PA	400000	1200	1.70369E+09	-3.8590E-02 3.6490E-02i	0
				-3.8590E-02 - 3.6490E-02i	0
				-1.9000E+02 + 0.0000E+00i	-1.0600E+02
				-1.5800E+02 + 1.9300E+02i	-1.5800E+02
				-1.5800E+02 - 1.9300E+02i	
				-6.3900E+02 + 1.4180E+03i	
				-6.3900E+02 - 1.4180E+03i	
CMG-3ESPC	400000	2000	5.715E+08	-7.4000E-02 + 7.4000E-02i	0
				-7.4000E-02 – 7.4000E-02i	0
				-1130.97	
				-1005.31	
				-502.655	

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

2.4 Orientations of Sensors

During installation of the Swedish stations, sensors were orientated to true north using a fiber-optic gyroscope of type iXblue OCTANS (typical uncertainty of 0.1°[1]). For the installations in Finland the GIPP gyroscope was not available and orientations were obtained using an Azimuth Pointing System (APS), kindly supplied by University of Oulu (Finland). Similar to the gyroscope this system is unaffected by local magnetic interference. However, good GPS reception is required and thus measurements in most cases had to be conducted outside the buildings. Afterwards, measured directions to true north (accuracy < 0.2°, depending on GPS integrity[2]) were transferred to the position of the sensors via laser. Before station removal, in October 2016, all sensor orientations were checked with the GIPP gyroscope directly at the sensor to detect possible misorientations. In general, misorientations are smaller than 5° at most sites (Table 3). However, for three stations deviations of > 5° were measured (SA21A, SA52, SA36). Station SA36 was wrongly orientated: towards west instead of north (Δ ~90°). Data for the correct ZNE system can be recovered by rotating the corresponding station components N-S and E-W using the equations by Plesinger et al. (1986). **See also stationXML files for the misorientations when using the waveforms!**

In Figure 4 we present a data example with wrong and corrected component time series of the 2016/08/24 Central Italy earthquake with magnitude M_w 6.2.

Table 3: Determined misorientations of the sensor orientations in Finland. Absolute measured orientations are listed in the second column, orientations relative to true north in the third column.

Station	Measured absolute orientation	Orientation relative to true north
SA21 (Tervola)	3.4°	+3.4°
SA21A (Tervola)	15.4°	+15.4°
SA28 (Pudasjaervi)	356.1°	-3.9°
SA36 (Pyhajoki)	272.0°	-88.0°
SA42 (Palmantie)	358.6°	-1.4°
SA47 (Pulkkinen)	2.9°	+2.9°
SA49 (Södra Vallgrund)	355.8°	-4.2°
SA52 (Pelmaa)	353.6°	-6.4°
SA61 (Maentykallo)	1.9°	+1.9°
SA64 (Lammi)	0.3°	+ 0.3°
SA67 (Tuorla)	359.7°	- 0.3°

[1] https://www.ixblue.com/products/octans (last access, 04/11/2016)
[2] http://www.lasertech.com/Azimuth-Pointing-System.aspx (last access, 04/11/2016)

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

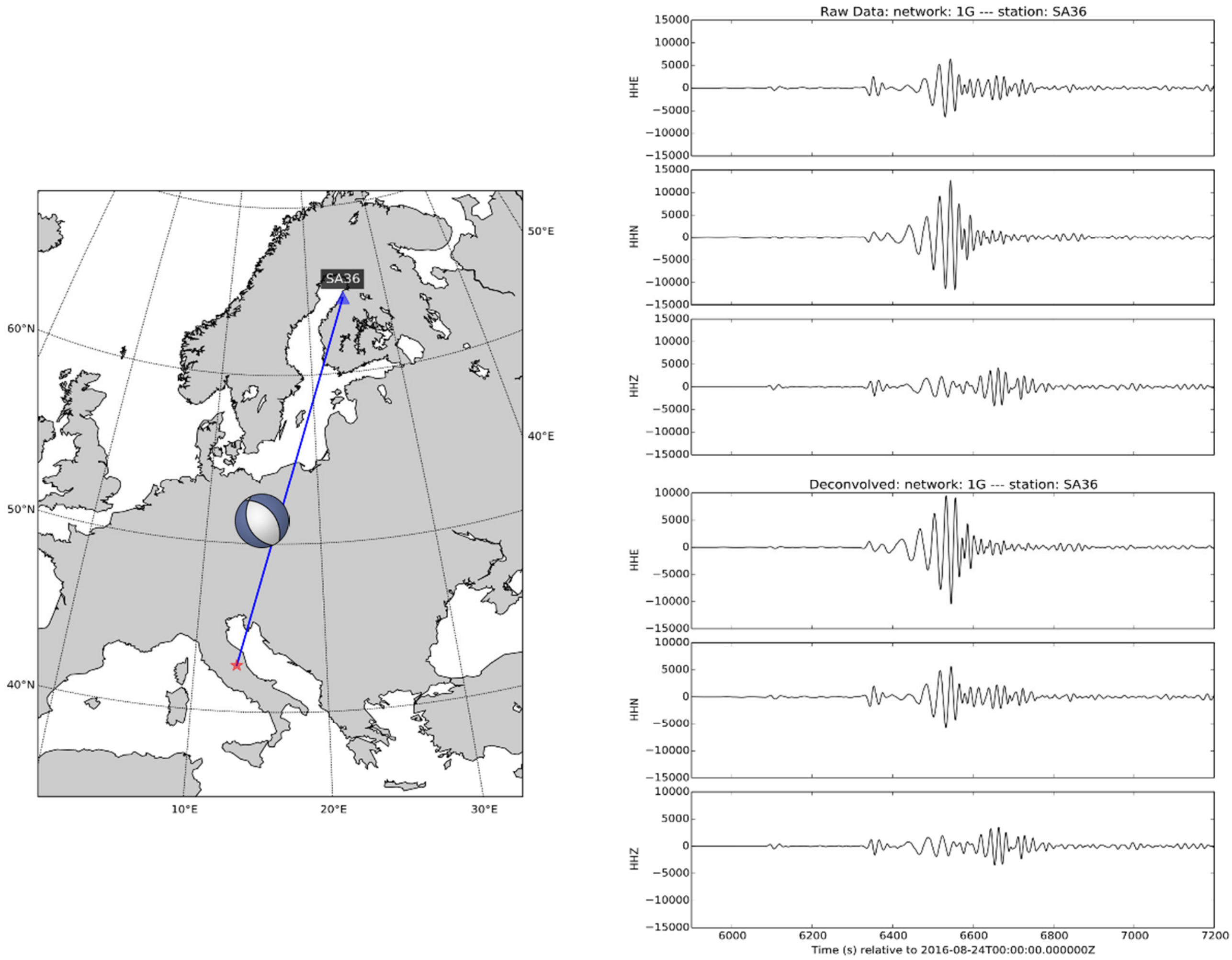


Figure 4: Comparison of the misorientation effect on the raw waveforms and the corresponding rotated, deconvolved traces using ObsPy (Krischer et al., 2015). The example dataset displays the Z, N, E components of the 24th August 2016 Central Italy earthquake (red star) with magnitude M_w 6.2 at station SA36 in Finland. Since the misorientation was nearly 90° and the wave propagates mainly towards north, the N and E components appear to be switched for the corrected data. Both raw and deconvolved waveforms were bandpass filtered between 20 s and 100 s.

3. Data Processing

The data set was preprocessed at GFZ in Potsdam and converted from the raw EDL MSEED files (*.pri[012]) to standard MSEED files using the *mseed2mseed* tool provided by the GIPP. The digital MSEED data with a sampling rate of 100 samples per second was originally stored in day files. After conversion, channels were renamed to HHZ, HHN, HHE. Only for station SA36 the channels were labeled as HHZ, HH1, HH2 indicating the misorientation described above. All measured misorientations of the Finnish stations have been included in the stationXML metadata files.

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

4. Data Description and Completeness

Recording at each station started as described in Table 1. As mentioned above, due to the long winter periods, especially in the northern part of the network, only three service trips were conducted to save the data and check the instruments. During the first service trip in May 2015, besides several technical problems with some data loggers (see Table 1), station SA21 was removed since the site was flooded and the sensor did not work anymore. After maintenance and repair, during the second service trip in September 2015, the sensor was reinstalled in the same area, but some 50 m away from the old site (new station code SA21A).

Technical problems occurred also at station SA36 caused by an incorrect installation in September 2014. Data is corrupted by bit noise and hence useless until 18/09/2015. Therefore, this data were not transferred to the GEOFON archive. After fixing this problem, station SA36 ran for only 5 days before it had been off until the next service trip in May 2016. Hence, data exist mainly from 10/05/2016 onwards.

A detailed description of all problems and component changes is given in the Appendix (Service Trips Summary Table).

For most stations data coverage is 100 % (Figure 5) but at some sites we only have up to 50 % due to unforeseen technical problems during the long periods between the individual service trips.

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

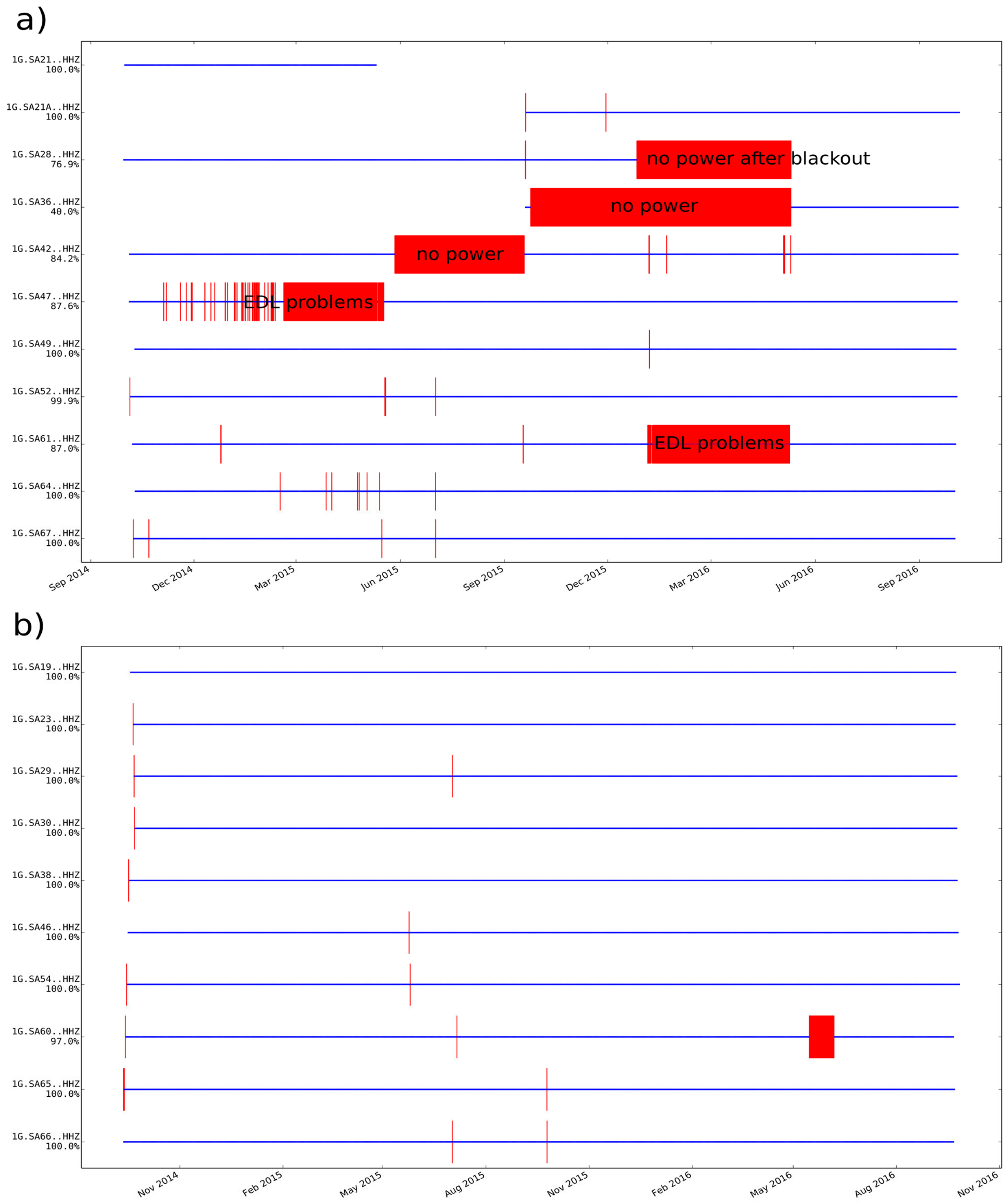


Figure 5: Data availability for the (a) Finnish and (b) Swedish stations. Note that station SA21 was off since June 2015 and had been redeployed in September 2015 as SA21A. Gaps are indicated by vertical red lines. Blue lines indicate available data.

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

5. Data Quality and Accuracy

GPS signals were regularly lost at many stations, but for most of the stations GPS timing was logged at least once per day to synchronize the recordings. However, at stations SA46, SA54 (old military bunker) and SA64 the GPS signals were completely lost for several months. Hence, their recorded times should be considered unreliable during these times. Regarding all other stations GPS timing problems can be neglected to our knowledge. Detailed GPS information is shown in the Appendix. Here, the AVR (Automatic Voltage Regulator) flag labels indicate times where the EDL shut down either automatically (red dot) or manually by technicians (green dot). GPS signal which was lost for more than 60 seconds is indicated by red bars. Bad timing accuracy with a larger misfit of 5 ms is shown as purple bar. We provide the complete log files (*msg and pll files) for all 20 stations if detailed GPS information is necessary. Data is structured in following directory trees: */logs_yyyy/station/day of year/*msg* and */logs_yyyy/station/day of year/*pll.*

Data quality is in general high but depends on the local noise conditions (water pumps, etc.). Since most stations were placed within buildings (cellars etc., see Figure 2) temperature changes for the sensor are small. However, some sensors were installed outside (close to buildings) only protected by insulation material against environmental influences. To give an overview, in Figure 6 (Nanometrics sensors with eigenperiods of 120 s and 240 s) and Figure 7 (Guralp sensors with eigenperiod of 60 s) we display the power spectral density (PSD) of all stations separated in two-week periods of recording in summer and winter.

Since stored data is in counts, we processed the corresponding time series for the PSD calculations. First, data was converted to true ground velocity in m/s, followed by removal of mean, trend and instrument response (deconvolution), tapering and bandpass filtering between 240 s or 120 s and 50 Hz. Depending on the sensor orientation, the recordings were rotated to account for the misorientations given in Table 3. For the PSD calculation we use a single taper method with 24-hour long time windows that are finally stacked to get an overall averaged PSD for the two-week period. For the summer period we used data from 11/07/2016 to 24/07/2016 at all stations, except SA21 and SA28 for which data was taken from 11/04/2015-24/04/2015 (see Figure 5). The winter period covers data from 02/11/2015 to 15/11/2015 at all stations, except station SA21 for which we used data from 02/11/2014 to 15/11/2014. For station SA36 no PSD was calculated for the winter period due to missing data.

In general, the long period recordings (< 20sec) show a low SNR where some stations exceed the New High-Noise Model (NHNM) by Peterson (1993). For several stations located in or close to buildings, the high frequency range above 2 Hz is dominated by several high amplitude peaks mainly caused by human activity or machinery. Furthermore, during winter time the low frequency bands between 0.04 Hz and 1 Hz are highly affected by the oceanic microseism. In the New Low-Noise Model (NLNM), the two peaks between 0.06 Hz and 0.07 Hz and at around 0.2 Hz correspond to the primary and secondary oceanic microseism, respectively. At a few stations we also see potentially increased noise levels (2-7 Hz) due to wind turbines that are located at distances between 5 km and 10 km from our recording sites.

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

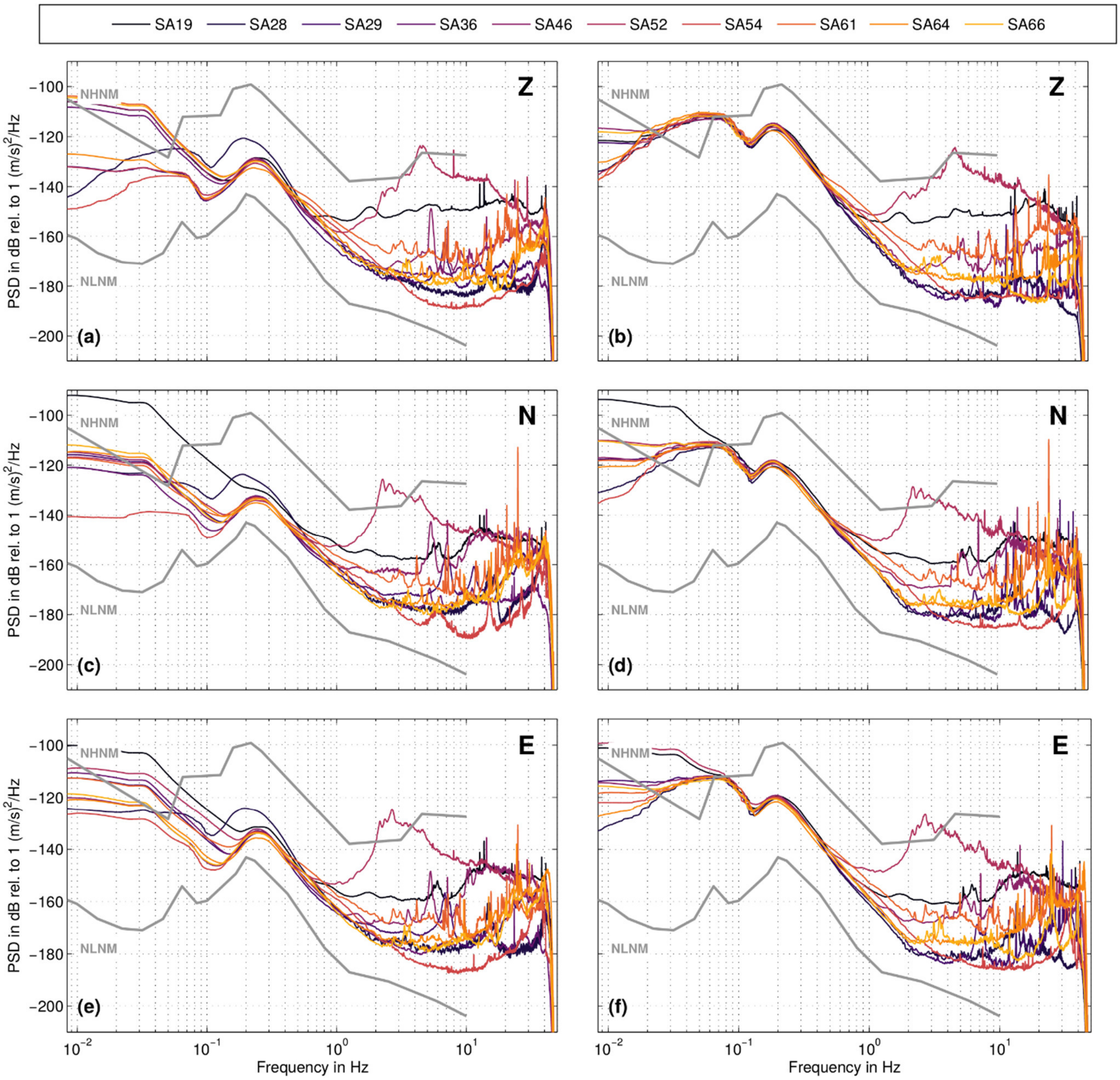


Figure 6: PSD spectra for stations with Nanometrics Trillium sensors calculated for a two-week period in summer (left column), and winter (right column). The NLNM and NHNM after Peterson (1993) are indicated as gray lines.

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

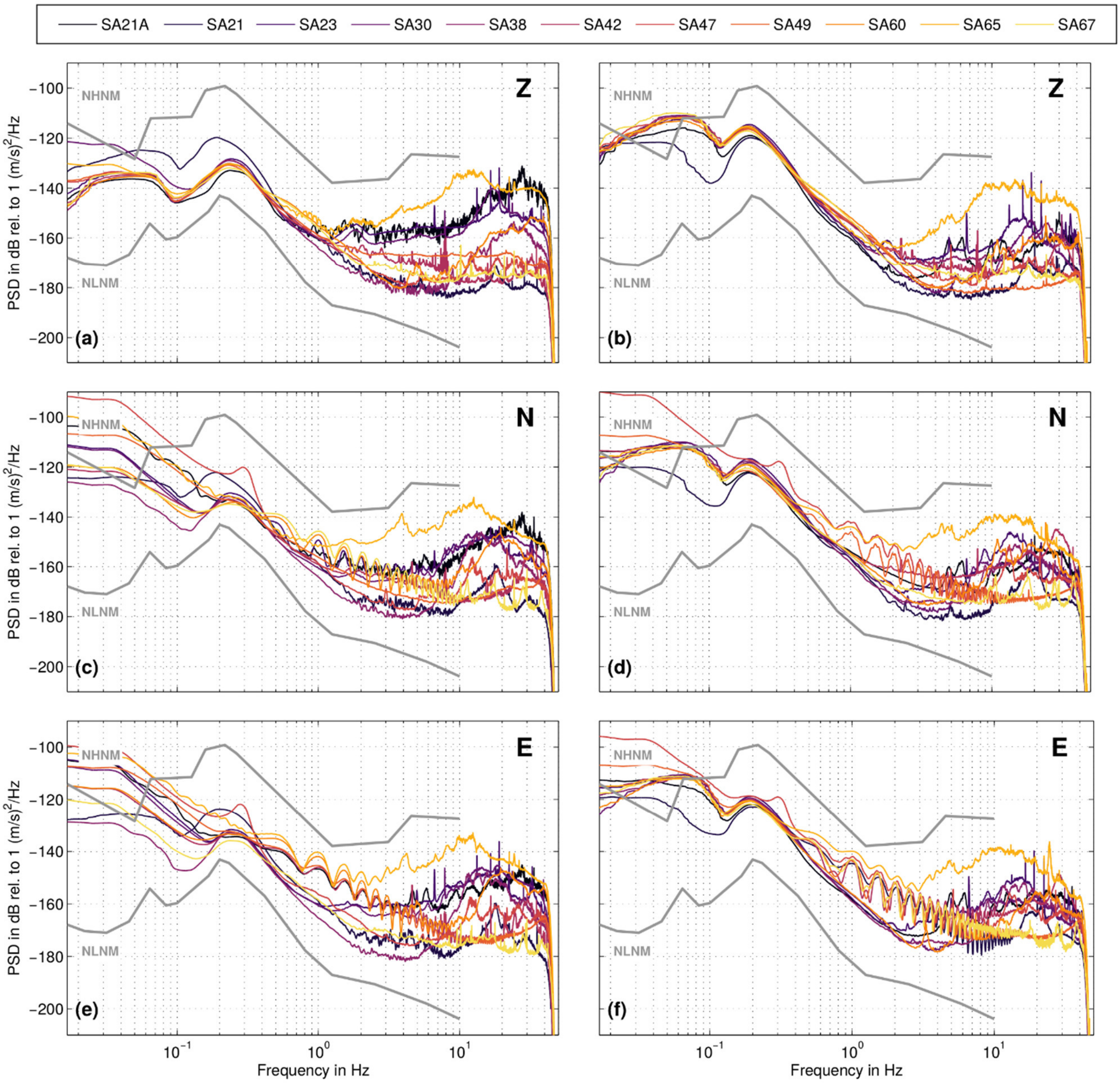


Figure 7: PSD spectra for stations with Guralp sensors calculated for a two-week period in summer (left column), and winter (right column). The NLNM and NHNM after Peterson (1993) are indicated as gray lines.

6. Data Availability and Access

The data is archived in the GFZ Seismological Data Archive (GEOFON) with the network code 1G where it will be made freely available to the scientific community in October 2019. Metadata is stored in StationXML inventory files. Both data can be accessed via http://geofon.gfz-potsdam.de/waveform/.

The log files with the GPS information are archived in the *GIPP Experiment and Data Archive* and can be requested via http://doi.org/10.5880/GIPP.201417.1

When using these data, please cite the ScanArrayCore dataset, and acknowledge the use of GIPP

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

instruments (if using data from other stations within ScanArrayCore, please acknowledge the respective instrument providers). You can additionally cite this Scientific Technical Report STR, especially if referring to particular details explained therein.

Recommended citation for the data described in this publication is:

Thybo, Hans; Balling, Niels; Maupin, Valerie; Ritter, Joachim; Tilmann, Frederik (2012): ScanArray Core (1G 2012-2017). The ScanArray consortium. Other/Seismic Network. DOI: http://doi.org/10.14470/6T569239.

Recommended citation for this report:

Grund, M., Mauerberger, A., Ritter, J. R., Tilmann, F. (2017): Broadband Recordings for LITHOS-CAPP: LITHOspheric Structure of Caledonian, Archaean and Proterozoic Provinces, Sep. 2014 - Oct. 2016, Sweden and Finland, (Scientific Technical Report STR - Data; 17/02) (GIPP Experiment and Data Archive), Potsdam: GFZ German Research Centre for Geosciences. DOI: http://doi.org/10.2312/GFZ.b103-17029

7. Acknowledgments

This study was funded by DFG RI1133/11-1 and TI316/3-1 with additional support by the GFZ expedition fund. Seismological instruments were kindly provided by the Geophysical Instrument Pool Potsdam (GIPP) at GFZ. We thank Werner Scherer, Thomas Zieke, Lars Kilian and Dr. Benjamin Heit for technical support during the field work. Local support was supplied by the University of Oulu (thanks to Hanna Silvennoinen, Jouni Nevalainen, Henrik Jänkävaara, Elena Kozlovskaya) for Finland and University of Uppsala (Sara Andersson, Joanna Holmgren, Andreas Björk, Ólafur Gudmundsson) for Sweden. Figures were prepared using GMT (Wessel et al., 2013), MATLAB and ObsPy (Krischer et al., 2015)

8. References

Peterson, J. (1993): *Observations and modelling of background seismic noise*. Open-file report 93-322, U. S. Geological Survey, Albuquerque, New Mexico. URL: https://pubs.usgs.gov/of/1993/0322/report.pdf [last accessed 9 October 2017]

Plesinger, A.; Hellweg, M.; Seidl, D. (1986): *Interactive high-resolution polarization analysis of broadband seismograms*. Journal of Geophysics 59, pp. 129-139.

Krischer, L.; Megies, T.; Barsch, R.; Beyreuther, M.; Lecocq, T.; Caudron, C.; Wassermann, J. (2015): *ObsPy: a bridge for seismology into the scientific Python ecosystem*. Computational Science & Discovery, 8, 014003, http://doi.org/10.1088/1749-4699/8/1/014003

Wessel, P.; Smith, W. H. F.; Scharroo, R.; Luis, J.; Wobbe, F. (2013): *Generic Mapping Tools: Improved version released*. Eos Transaction 94(45), 409–420. http://doi.org/10.1002/2013EO450001

Appendix

STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

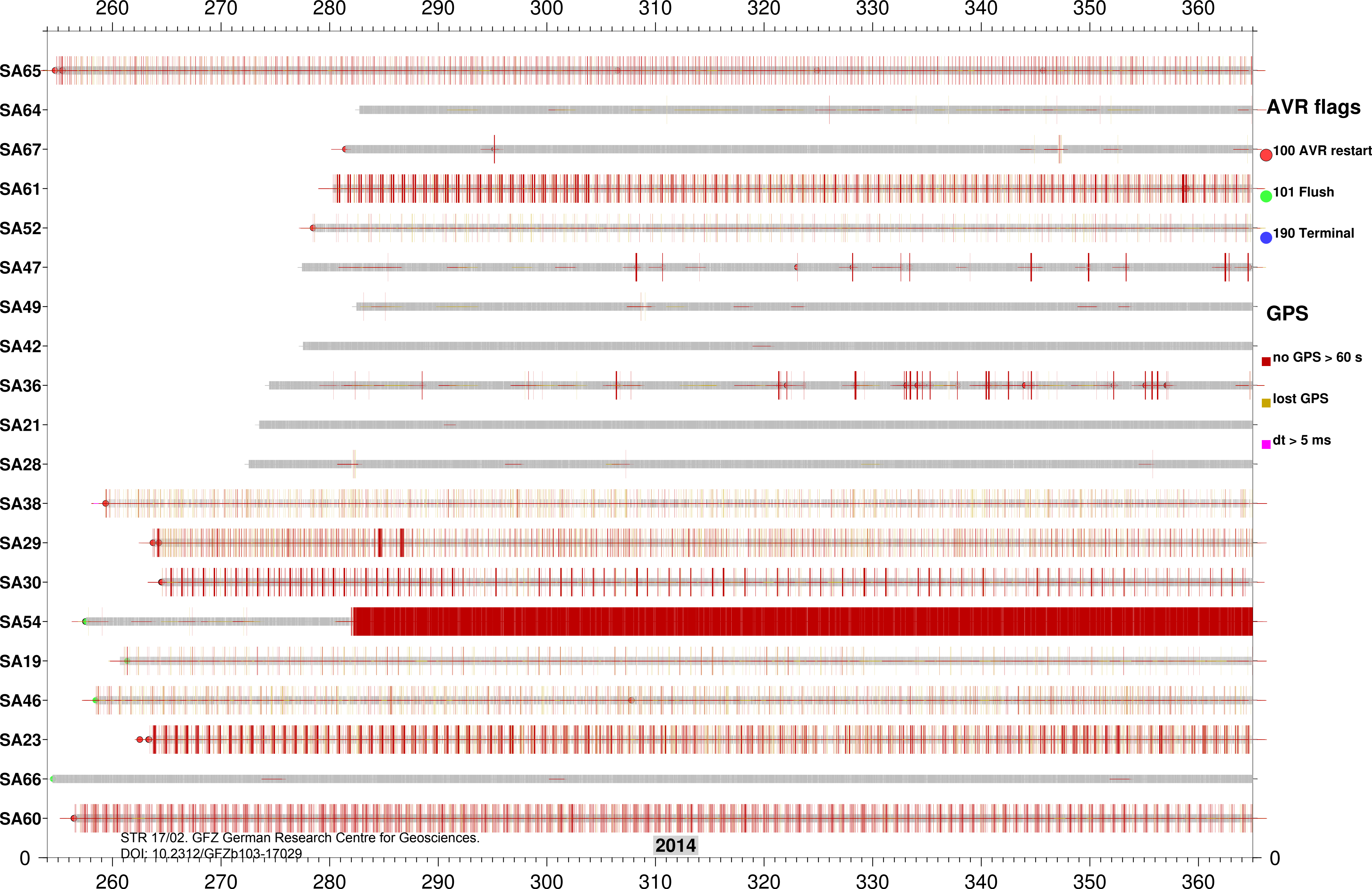
Service Trip in May 2015		*Service Trip in September 2015*		*Service Trip in May 2016*	*Dismantling in September 2016*	
official station name	**Instrument / EDL**	**Internal station name**	**Problems**	**Remedial Action**	**Notes**	**HD Run Time**
SA28	Trillium 240s / #3247	SAF01 / Pudasjärvi	o.k.			29-09-2014 to 19-05-2015
			o.k.			19-05-2015 to 19-09-2015
	#3028		station off: power off → battery empty Decreasing voltage from 15-12-2016	EDL has been changed New # 3028		19-09-2015 to 26-12-2016
			EDL all lights were blinking		data exist only for day 131 for 15 minutes! Removal	10-05-2016
SA21 SA21A	Guralp 120 s / #3250	SAF02 / Tervola	flooded instruments, electrical circuit, Seismometer damaged, Data saved, Data loss since 7.5.2015 for about two weeks	Deployments have been removed, EDL and Seismometer back in Potsdam, EDL box with battery etc. still there	redeployment in September	30-09-2014 to 11-05-2015
	Guralp 120 s / #3397			**redeployment on same site with same seismometer but in different building**		
			o.k.	seismometer re-leveled		19-09-2015 to 11-05-2016
			o.k.		removal	11-05-2016 to 06-10-2016
SA36	Trillium 120s / #3246	SAF03 / Pyhajoki	Only bit noise recorded → not recognized during deployment and 1st service trip!		data useless	01-10-2014 to 19-05-2015
				EDL has been changed by Univ. Oulu on 06-07-2015, new # 3070	still bit noise!	same HD
	#3070			breakout box replaced → now working (seismometer incl. Cable are o.k.)		19-05-2015 to 18-09-2015
			station off: battery empty	battery and charger has been changed Lightning protection removed	data exist for only 5 days	18-09-2015 to 23-09-2015
			o.k.		station was misoriented to the west! Removal	10-05-2016 to 05-10-2016
SA42	Guralp 120 s / #3245	SAF04 / Palmantie	o.k.		windy station site → affects horizontal components, close to big lake	02-10-2014 to 18-05-2015
			no power at arrival, poorly connected lightning protection, battery not chargeable anymore	charger, battery and EDL power cable have been replaced, lightning protection removed	data exist for only 9 days	18-05-2015 to 27-05-2015
	#3401		no seismic signal	EDL and fuse of breakout box have been changed, new #3401		27-05-2015 to 10-05-2016

			o.k.		removal	10-05-2016 to 05-10-2016
SA49	Guralp 120 s / #3254	SAF05 / Södra Vallgrund	GPS cable slightly bitten by animal	cable repaired with tape		09-10-2014 to 16-05-2015
			o.k.			16-05-2015 to 17-09-2015
			o.k.			17-09-2015 to 09-05-2016
			o.k.		removal	09-05-2016 to 03-10-2016
SA47	Guralp 120 s / #3240	SAF06 / Pulkkinen	no GPS signal, data logger turned on permanently since February (unusual blinking of GPS and ADC signal) → no data since February	EDL has been changed, new # 3163		04-10-2014 to 17-05-2015
	#3163		o.k.			17-05-2015 to 17-09-2015
			o.k.		condensation water on ceiling → potential source for peaks in signal	17-09-2015 to 09-05-2016
			o.k.		removal	09-05-2016 to 04-10-2016
SA52	Trillium 240s / #3253	SAF07 / Pelmaa	o.k.			05-10-2014 to 18-05-2015
			o.k.		removal	18-05-2015 to 17-09-2015
			levels of seismometer not centered	levels re-centered		17-09-2015 to 09-05-2016
			o.k.		removal	09-05-2016 to 04-10-2016
SA61	Trillium 120s / #3249	SAF08 / Mäntykallo	o.k.		close to coast, deployed outside	06-10-2014 to 16-05-2015
			o.k.		High-freq noise on channel 3 maybe due to radar antenna on roof top	16-05-2015 to 17-09-2015
	#3403		GPS signal off, no continuous data HD corrupt	EDL has been changed: new #3403 HD has been changed	last GPS lock on 10-01-2016 Data useless from 01-01-2016 to 09-05-2016!	17-09-2015 to 31-12-2015
			o.k.		removal	09-05-2016 to 03-10-2016
SA67	Guralp 120 s / #3251	SAF09 / Tuorla	o.k. → in Modmon program “Header → ADC” value: USER2 = 2.1V (should be < 1V)	level of seismometer checked (o.k), another EDL has been tested (same result) → initial EDL kept also no waveform clipping could be find		07-10-2014 to 15-05-2015
			o.k.	seismometer re-leveled		15-05-2015 to 16-09-2015

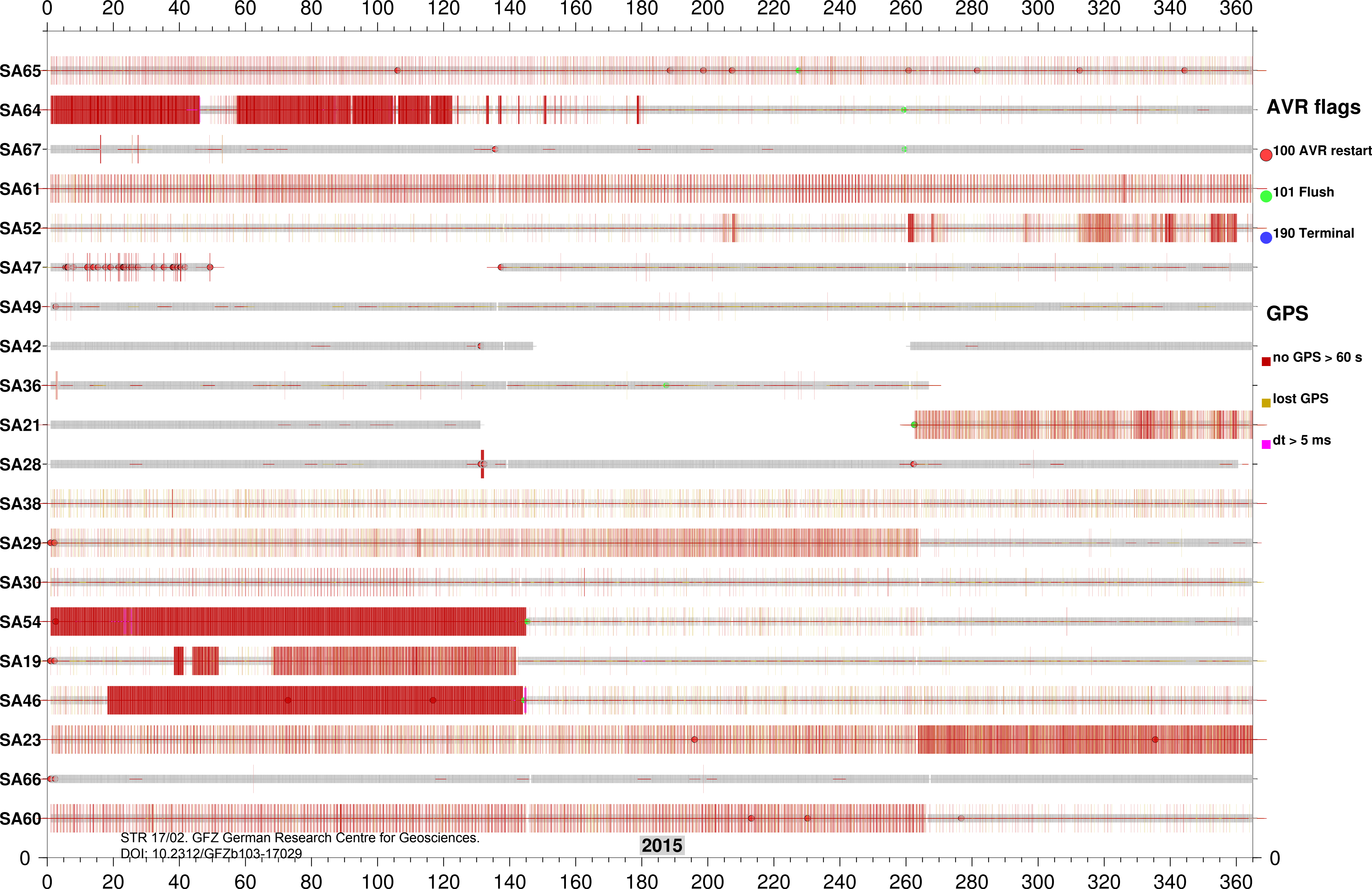
			o.k.			16-09-2015 to 08-05-2016
			o.k.		removal	08-05-2016 to 02-10-2016
SA64	Trillium 240s / #3252	SAF10 / Lammi	cable bitten by animal	cable repaired with tape		08-10-2014 to 15-05-2015
			o.k.			15-05-2015 to 16-09-2015
			o.k.			16-09-2015 to 08-05-2016
			o.k.		removal	08-05-2016 to 02-10-2016
SA23	Guralp 120 s / #3219	BRD / Bredsel	o.k.			20-09-2014 to 22-05-2015
			o.k., unstable GPS signal	GPS antenna redeployed to be in horizontal position		22-05-2015 to 20-09-2015
			o.k., GPS still unstable but sufficient	GPS cable replaced by short one (5m)		20-09-2015 to 12-05-2016
			o.k.		removal	12-05-2016 to 22-09-2016
SA19	Trillium 120s / #3226	ERT / Ertspän	no GPS signal since February due to snow mass	cable fixed again	noisy station → located in cellar next to water pump, also used for food storage	18-09-2014 to 22-05-2015
			o.k.	GPS cable prepared for winter	noise caused by pump, not walking people	22-05-2015 to 20-09-2015
			o.k.			20-09-2015 to 11-05-2016
			o.k.		removal	11-05-2016 to 23-09-2016
SA29	Trillium 240s / #3241	LIL / Lillträsk	o.k.			21-09-2014 to 23-05-2015
			o.k., unstable GPS signal but sufficient	seismometer re-leveled, 10m GPS cable replaced by 5m GPS cable		23-05-2015 to 21-09-2015
			o.k.			21-09-2015 to 12-05-2016
			o.k.		removal	12-05-2016 to 24-09-2016
SA30	Guralp 120 s / #3220	JAV / Jävrebodarna	o.k.		noisy station → located beneath living room and next to water pump, also used for food storage, ground in cellar slightly wet, but no problem for instruments	21-09-2014 to 23-05-2015
			o.k.		water pump has only little effect here (ERT is worse)	23-05-2015 to 21-09-2015

			o.k.			21-09-2015 to 13-05-2016
			o.k.		removal	13-05-2016 to 24-09-2016
SA38	Guralp 120 s / #3218	ORT / Örträsk	o.k.		quiet station → house is empty most of the time	16-09-2014 to 23-05-2015
			o.k.	GPS antenna relocated to the west side of the house		23-05-2015 to 21-09-2015
			o.k.			21-09-2015 to 13-05-2016
			o.k.		removal	13-05-2016 to 24-09-2016
SA46	Trillium 120s / #3222	BRE / Bredbyn	GPS cable bitten by animal → no signal, last lock on 18-01-2015	GPS cable replaced		15-09-2014 to 24-05-2015
			o.k.	25m GPS cable replaced by 5m cable		24-05-2015 to 22-09-2015
			o.k.			22-09-2015 to 14-05-2016
			o.k.		removal	14-05-2016 to 25-09-2016
SA54	Trillium 240s / #3224	HEM / Hemsön	no GPS signal	GPS cable + antenna replaced	station in bedrock (-15 m) but close to sea	14-09-2014 to 25-05-2015
			o.k.		noise at 32 Hz (generator)	25-05-2015 to 23-09-2015
			o.k.			23-09-2015 to 14-05-2016
			o.k.		removal	14-05-2016 to 26-09-2016
SA60	Guralp 120 s / #3216	ARN / Arnevikon	o.k.		GPS sometimes unlocked, checked with GPS handhold → to few satellites	13-09-2014 to 25-05-2015
			o.k.	seismometer re-leveled, 25m GPS cable replaced by 5m cable		25-05-2015 to 23-09-2015
			station have been removed by ~ 4 meters to the north by KIT technicians!	power cable repaired		23-09-2015 to 15-05-2016
			station off: unplugged from power supply But only for the last 5 days		removal	15-05-2016 to 21-09-2016
SA66	Trillium 120s / #3244	BJO / Björbo	o.k.		quiet station	11-09-2014 to 26-05-2015
			o.k.			26-05-2015 to 24-09-2015
			o.k.			24-09-2015 to 16-05-2016

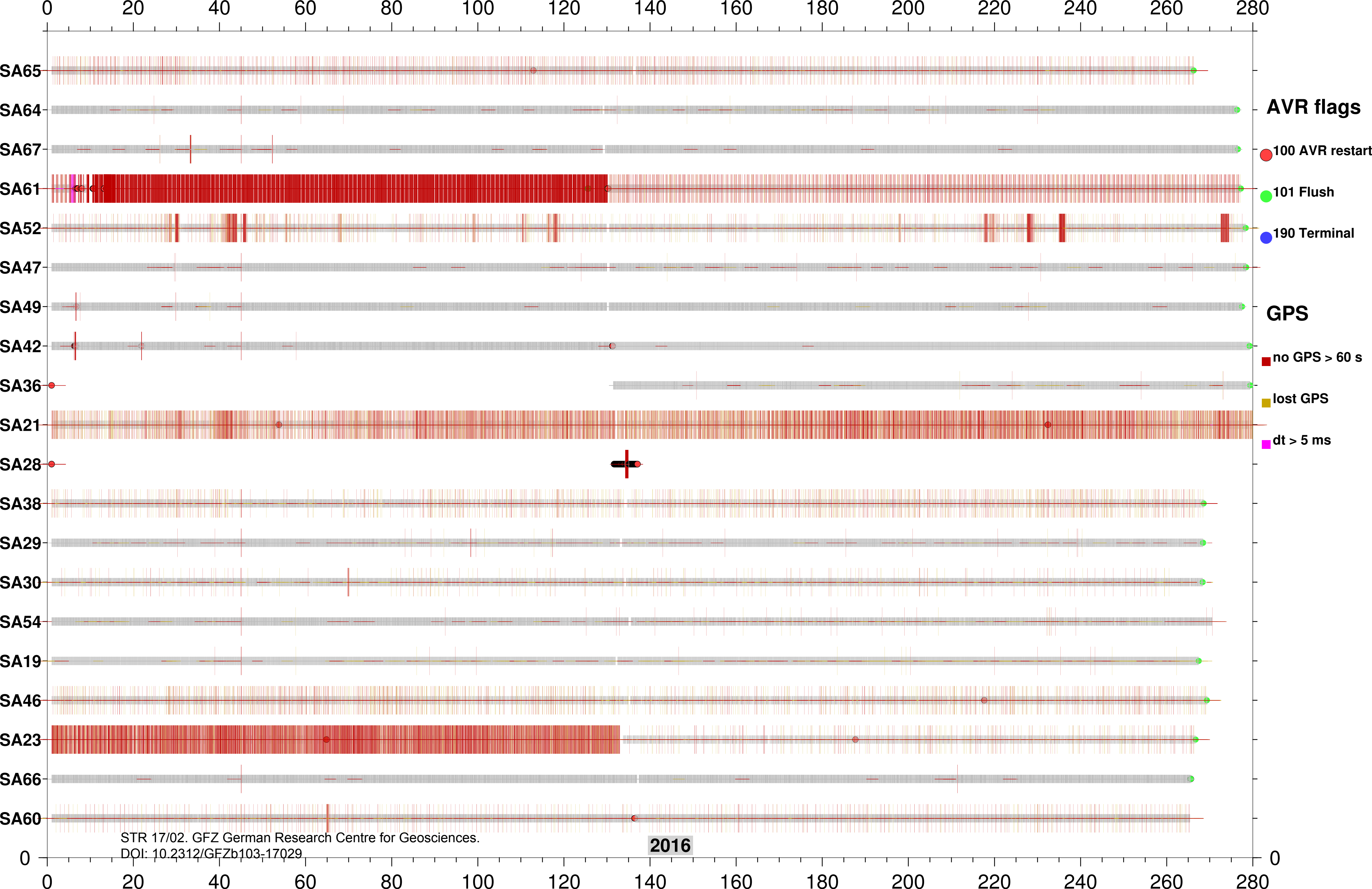
			o.k.		removal	16-05-2016 to 21-09-2016
SA65	Guralp 120 s / #3215	SVA / Svabensverk	o.k.			12-09-2014 to 15-08-2015
			o.k.	seismometer re-leveled	50Hz spike in data caused by buzzing charger	15-08-2015 to 24-09-2015
			o.k.	seismometer re-leveled		24-09-2015 to 15-05-2016
			o.k.		removal	15-05-2016 to 22-09-2016



STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029



STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029



STR 17/02. GFZ German Research Centre for Geosciences.
DOI: 10.2312/GFZb103-17029

ISSN 2190-7110