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Scientific Technical Report STR14/03 - Data

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MINAS, temporary MINi ArrayS within the frame of IPOC

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MINAS, temporary **MINi ArrayS** within the frame of **IPOC**

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Abstract

*The integrated plate boundary in Chile (**IPOC**) combines 15 broadband stations with strong-motion sensors, GPS, strain sensors and magneto-telluric stations. The Chilean subduction zone setting provides a high background rate of seismicity (crustal, intermediate depth, and plate interface) in a region with exceptionally low ambient noise, particularly at higher frequencies.*
*We have deployed seismic mini-arrays in the vicinity of **IPOC** stations PB02 and PB07, and installed a third array to the east of these stations near the village of Quillagua, such that all three arrays form a triangle. Each array has 10 elements and an aperture in the km range. The study area lies just to the north of the northern boundary of the rupture area of the Tocopilla earthquake of 2007 (Mw=7.7) and just above or slightly to the east of the downdip limit of plate interface seismicity. Installing the mini-arrays in the area of the existing **IPOC** has the following advantages:*

- *Independent knowledge of background structure and seismicity from existing and ongoing studies.*
- *Should any transients or other unusual signals be found in the array data, we can look for anomalous signals in geodetic and MT recordings, which will help to narrow down possible underlying mechanisms.*

Coordinates:	**S1**	69.60 W / 23.38 S
	S2	69.88 W / 21.33 S
	S3	69.86 W / 21.61 S

Keywords: Geophysics, temporary seismic network, small aperture networks

Related resources: This report provides additional information on the seismic network with code 5E, archived at the GEOFON Data Centre: doi:10.14470/ab466166.

1. Introduction

Three temporary (2 years) 10 element small-aperture arrays have been installed within the **IPOC** network for:

- Detection/location of seismic signals without clear signal onset (e.g. tremors).
- Determination of slowness and azimuth of scattered energy (secondary arrivals); if present measurements from all three mini-arrays can be combined to estimate locations of scatterers.
- Test of array methods for enhancing ambient noise Green's function estimates, e.g. by stacking. Also we can cross-check actual propagation directions against the great-circle path assumption.
- Test of methods for tracking ruptures using high frequency arrivals from moderate size earthquakes.
- Improve detection threshold for classic (impulsive) earthquakes.

2. Data Acquisition

2.1 Experiment design and schedule

Layout of the three small-aperture arrays with a diameter of 3 km and 10 elements each is shown in Fig.1 below. All together 30 solar powered off-line stations have been installed. The three arrays forming a triangle with distances between 40-50 km. To reduce temperature variation and meteorological noise, instruments and sensors were buried in holes of 2 m depth. Continuous GPS timing on all stations. On the 3 outermost points of each array, Trillium compact (120 s) sensors were utilized. All other stations are equipped with MARK L4-3D 1Hz geophones.

Recorder:	EarthDataLogger (**EDL**)		
Samplerate:	200 Hz		
Sensor:	**Mark L4-3D** 1 Hz	**Trillium compact** 120 s	(Trillium output ± 20V)
EDL Gain:	10	1	(EDL input ± 8V)
EDL Sensitivity:	0,1 µV/count	1 µV/count	
Sensor Gain:	180 Vs/m	750 Vs/m	

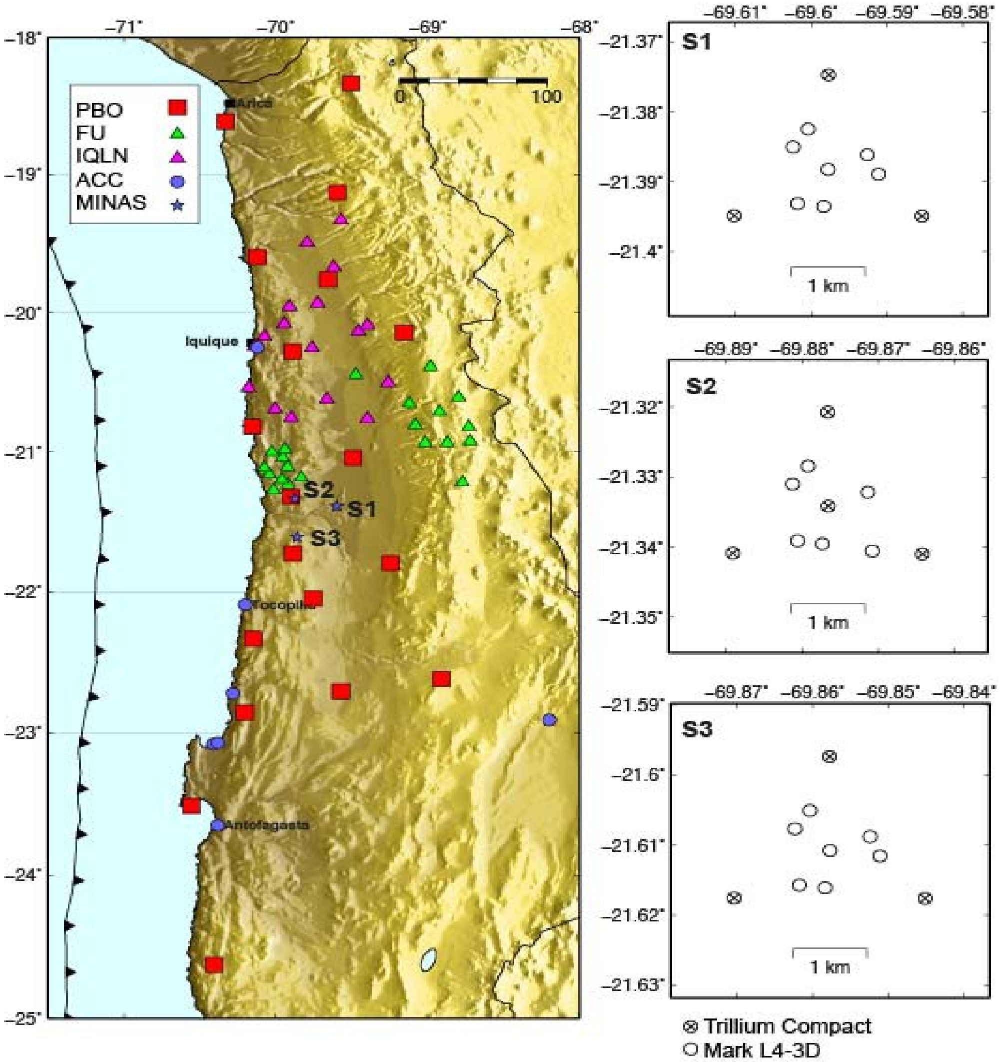

Fig. 1: map with the location of the three arrays: S1, S2 and S3 (left). On the right side the geometry of each array.

IPOC projects http://www.ipoc-network.org/

MINAS	location of the **S1, S2, S3** arrays within the **IPOC** network
PBO	**IPOC** multiparameter sites
FU	temporary local seismological networks operated by the Free University Berlin
IQLN	temporary local seismological network around Iquique
ACC	strong motion installations

2.2 Geometry/Location and Instrumentation

Name	Latitude	Longitude	Height	Sensor	Sen. Nr.	EDL Nr.
S101	-21.38822	-69.59772	767	Mark L4-3D 1Hz	1329	3118
S102	-21.38611	-69.59256	770	Mark L4-3D 1Hz	1329	3117
S103	-21.39354	-69.59834	766	Mark L4-3D 1Hz	1339	3140
S104	-21.38501	-69.60239	773	Mark L4-3D 1Hz	1187	3097
S105	-21.38893	-69.59113	772	Mark L4-3D 1Hz	1342	3141
S106	-21.39311	-69.60178	765	Mark L4-3D 1Hz	1349	3144
S107	-21.38247	-69.60039	770	Mark L4-3D 1Hz	1331	3119
S108	-21.37467	-69.59770	764	Trillium compact 120s	TR729	3230
S109	-21.39488	-69.58540	775	Trillium compact 120s	TR733	3232
S110	-21.39483	-69.61014	760	Trillium compact 120s	TR716	3227
S201	-21.33413	-69.87654	902	Trillium compact 120s	TR736	3233
S202	-21.33216	-69.87133	902	Mark L4-3D 1Hz	1189	3098
S203	-21.33952	-69.87733	910	Mark L4-3D 1Hz	1192	3116
S204	-21.33100	-69.88124	923	Mark L4-3D 1Hz	1348	3143
S205	-21.34055	-69.87075	895	Mark L4-3D 1Hz	1346	3142
S206	-21.33911	-69.88061	906	Mark L4-3D 1Hz	1190	3115
S207	-21.32843	-69.87923	914	Mark L4-3D 1Hz	1336	3139
S208	-21.32073	-69.87662	941	Trillium compact 120s	TR728	3229
S209	-21.34098	-69.86420	900	Trillium compact 120s	TR727	3228
S210	-21.34085	-69.88913	915	Trillium compact 120s	TR732	3231
S301	-21.61079	-69.85767	1267	Mark L4-3D 1Hz	1182	3095
S302	-21.60878	-69.85239	1246	Mark L4-3D 1Hz	1178	3085
S303	-21.61613	-69.85837	1200	Mark L4-3D 1Hz	1176	3082
S304	-21.60767	-69.86230	1270	Mark L4-3D 1Hz	1335	3122
S305	-21.61155	-69.85114	1254	Mark L4-3D 1Hz	1174	3080
S306	-21.61570	-69.86171	1294	Mark L4-3D 1Hz	1180	3093
S307	-21.60510	-69.86037	1258	Mark L4-3D 1Hz	1331	3120
S308	-21.59738	-69.85775	1223	Trillium compact 120s	TR709	3184
S309	-21.61758	-69.84521	1305	Trillium compact 120s	TR676	3179
S310	-21.61757	-69.87029	1332	Trillium compact 120s	TR545	3107

Table 1: Coordinates and instrumentation of the MINAS stations.

2.3 Acquisition parameters

Sensor Spacing for a small-aperture array of 10 elements with diameter of 3 km

	X[m]	Y[m]	degree	radius[m]
1	0	0	0	0
2	546	237	67	595
3	-69	-591	-173	595
4	-480	354	-54	596
5	684	-78	97	688
6	-411	-552	-143	688
7	-273	633	-23	689
8	0	1500	0	1500
9	1299	-750	120	1500
10	-1299	-750	-120	1500

Table 2: relative coordinates of the 10 elements of a 3km array. Cartesian in m (left) and polar in m and degrees (right).

3. Data Processing

The original data acquired by the EDL are stored as MSEED files on hard disc. File length is 1h and compression mode STEIM1. To fit to the GEOFON data archive structure, these files were put together to form daily files. During the copy process, also the compression mode was changed from STEIM1 to STEIM2 to reduce file size, and also the data representation was changed from little to big endian (software: **ms2ms** Ver. 0.55, G.Asch). All logging-files generated by the EDL recorder (ASCII) have been converted to MSEED files for easy integration into the GEOFON archiving system (software: **EDLaux_mseed**, **EDLmsg_mseed, EDLpll**, G.Asch).

4. Data Description

Data Streams:	**HHZ** [.pri0]	**HHN** [.pri1]		**HHE** [.pri2]
Sample rate:	200 Hz	200 Hz		200 Hz
SEED standard: [FDSN, 2012]				
LOG Files:	**AE1**	supply voltage	1Hz	[.batteryV2]
	AE2	Logger temperature	1Hz	[.EDLTemp]
	GST	GPS status	ASCII	[.gst]
	PLL	Clock state, event	ASCII	[.pll]
	DGC[1)]	Clock state, time series	1Hz	[.pll] (calculated)
	LOG	EDL message file	ASCII	[.msg]

[1)]while clock state (Δ**t** between ext. GPS and int. Clock in µsec) is event driven in the EDL's **PLL**-file, **DGC** is the derived time series with linear interpolated samples at a rate of 1Hz and 1 µsec resolution.

4.1 File format

MSEED (STEIM2, 4k) HHZ, HHN, HHE, AE1, AE2, DGC
MSEED (CHAR, 4k) GST, PLL, LOG

Network Id : **5E**

4.2 Data content and structure:

GEOFON data archive structure

HHZ, HHN, HHE, AE1, AE2, DGC MSEED data streams

PLL	DDMMYYYY␣HHMMSS␣A␣B			1:1 copy of the EDL **PLL** file		
	A:	-1	no GPS	B:	Δ µsec Clock ↔ GPS	
		0	GPS lock			
		>0	sec since last lock			

GST	DDMMYYYY␣HHMMSS␣A␣B 1:1 copy of the EDL **GST** file					
	A:	0	GPS lock	B:	0	Antenna ok
		1	GPS unlock		1	not connected
					2	shorted

LOG 1:1 copy of the EDL **MSG** file

5. Data Quality/Accuracy

For completeness of the recorded data, see the fig. 2 at the end of this document
Red bars indicate data gaps. Site S109 was vandalized and batteries and solar panels were stolen. All the other gaps are due to instrumental problems of the EDL. The internal back up battery for the GPS receiver was the main source of timing problems and resulting data gaps. The GPS quality is shown in fig. 3. The probabilistic power spectral density (McNamara and Bouland, 2004) calculated using obspy PPSD (Beyreuther et al., 2010) for all stations over the recorded time is given in fig. 4-6.

6. Data Availability/Access

Data is archived at the GEOFON Data Centre as 5E seismic network (Asch et al., 2011). The access to these data is restricted until May 2017

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Addendum

A small bash shell script to convert Tab. 2 into geographic coordinates. The script requires the program project from the GMT (Wessel and Smith, 1991) software suite.

```
#!/bin/sh
gmtset D_FORMAT=%14.5f
# C holds the geographic position of the central station of the array
export C="-69.85773/-21.61085"
#echo " 1    0     0     0     0"
echo;echo "C "$C; echo

echo " 2   546   237    67   595
       3   -69  -591  -173   595
       4  -480   354   -54   596
       5   684   -78    97   688
       6  -411  -552  -143   688
       7  -273   633   -23   689
       8     0  1500     0  1500
       9  1299  -750   120  1500
      10 -1299  -750  -120  1500" |
gawk -v c=$C '{ if ($4 < 0.) $4 += 360;
     system ("project -C"c" -G"$5/1000." -L0/"$5/1000." -A"$4" -Q")}' |
     gawk '{ if ($3 > 0) print NR/2, $1, $2}'
echo
```


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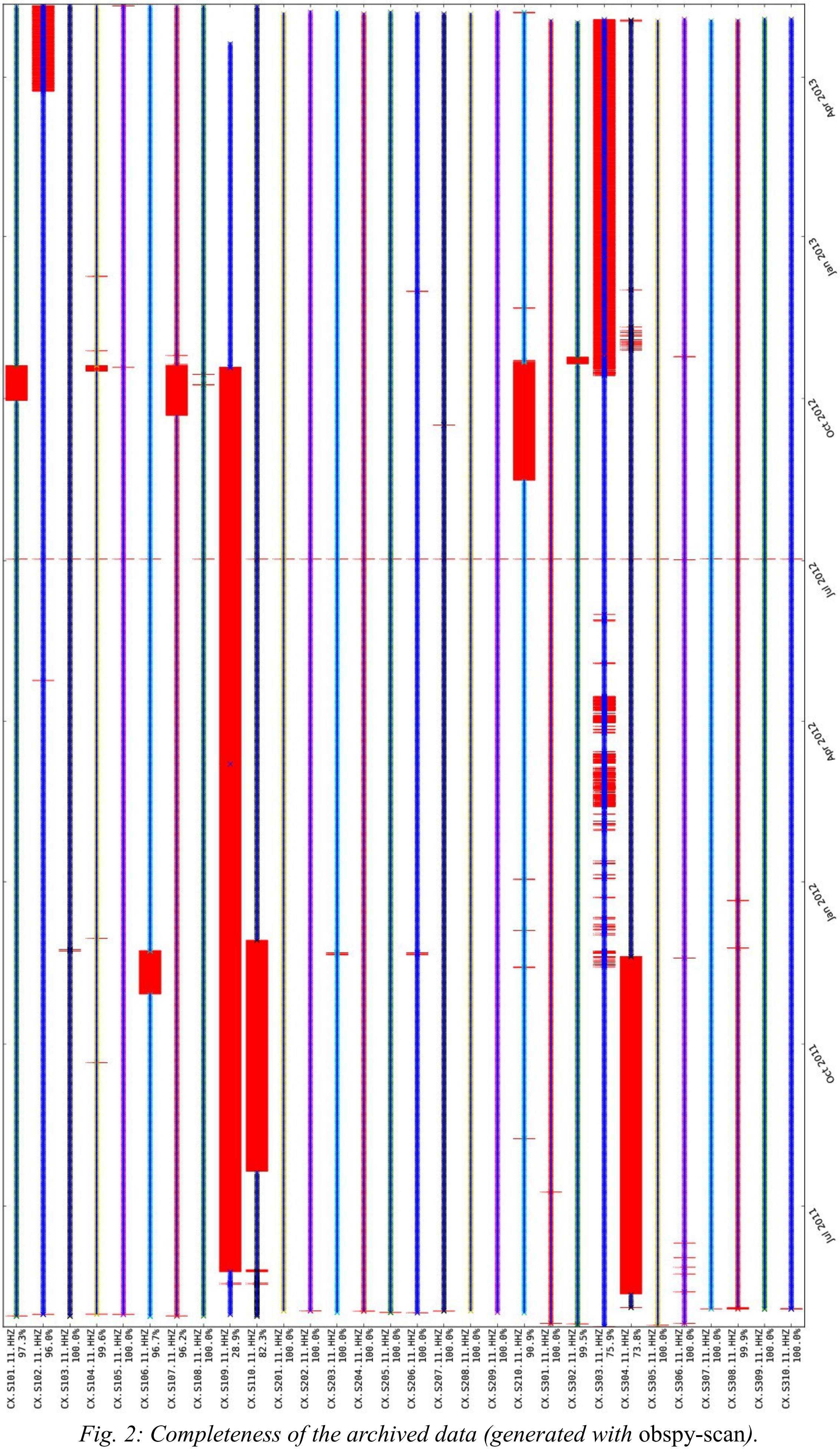

Fig. 2: Completeness of the archived data (generated with obspy-scan*).*

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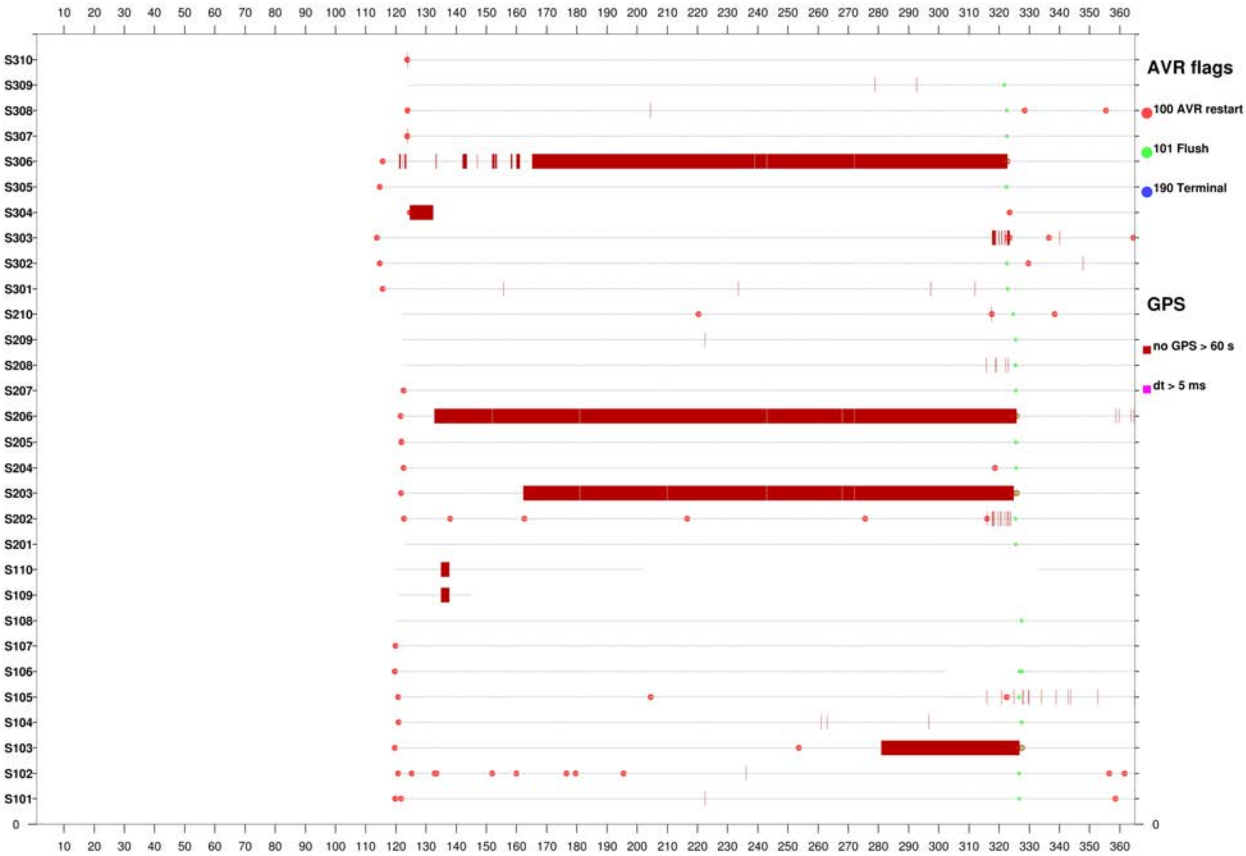
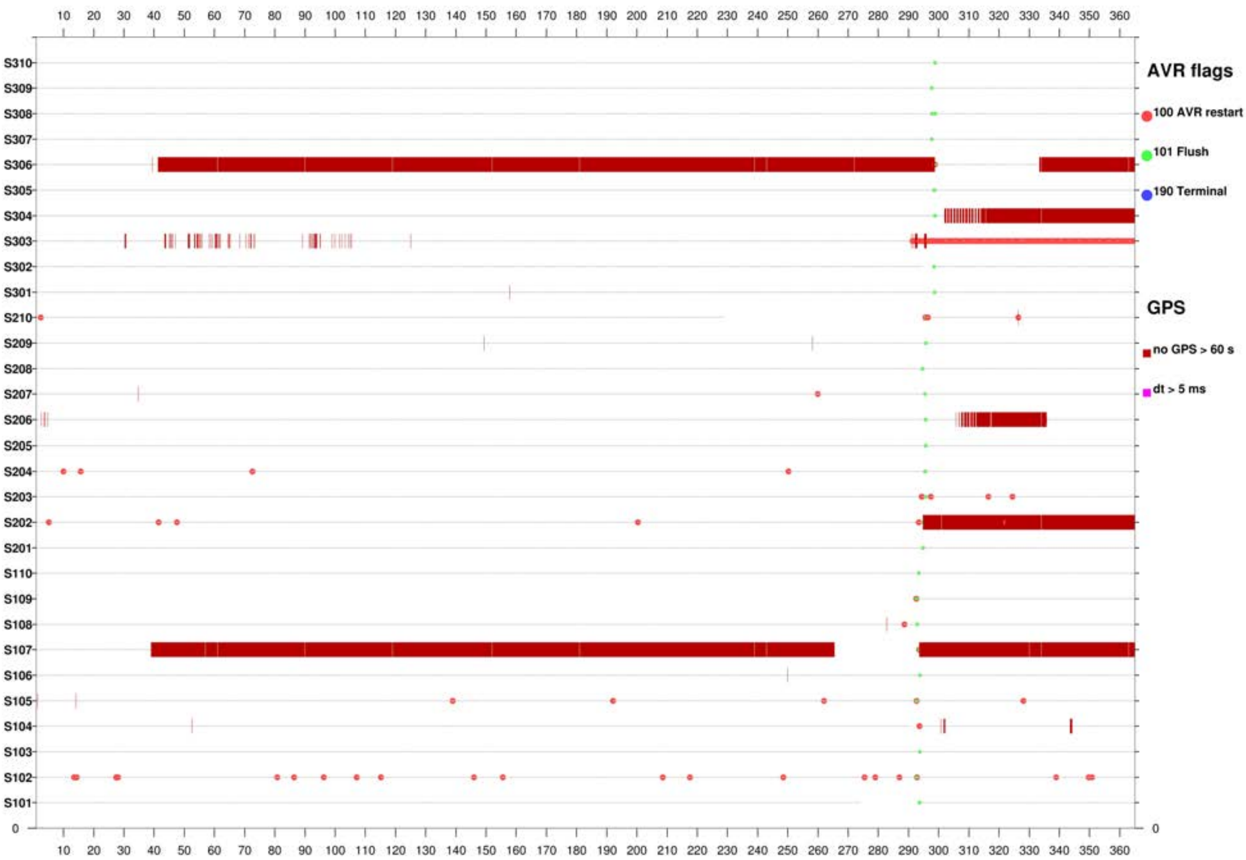


2011 (top) *EarthDataLogger GPS quality* (bottom) **2012**



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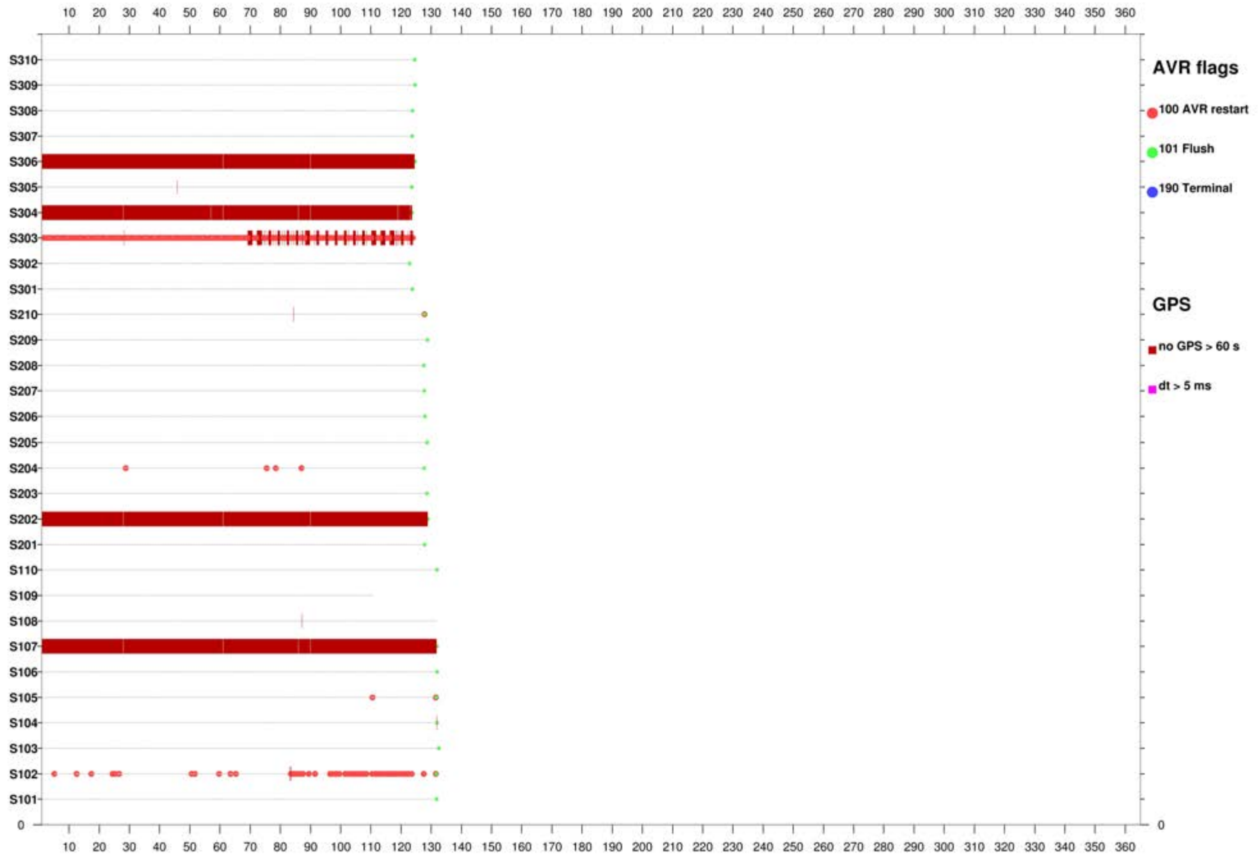

Fig. 3: **2013** *EarthDataLogger GPS quality (*edl_stat *by T.Ryberg)*

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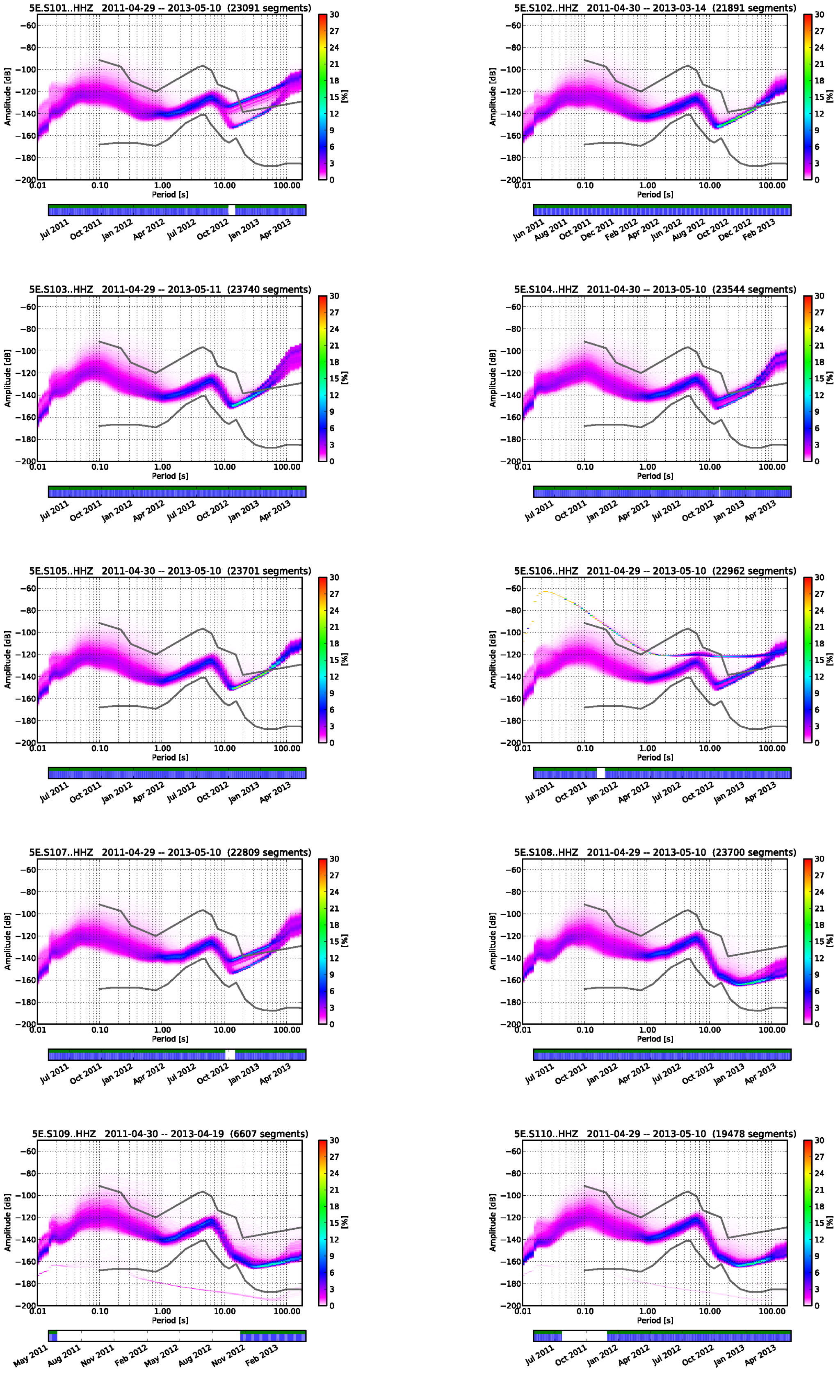

Fig. 4: Probabilistic Power Spectral Densities for Subarray S1 (obspy PPSD).

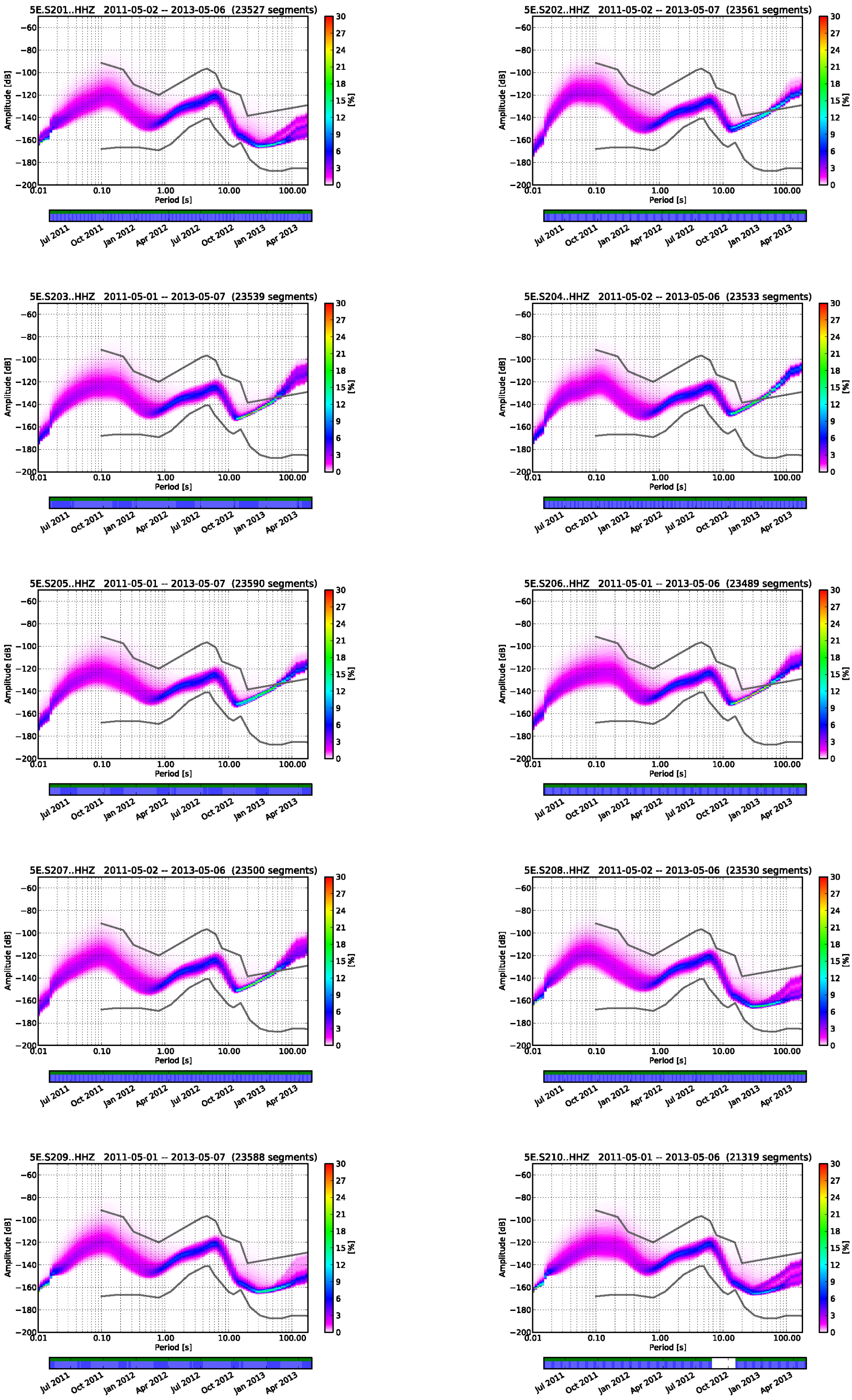

Fig. 5: Probabilistic Power Spectral Densities for Subarray S2 (obspy PPSD).

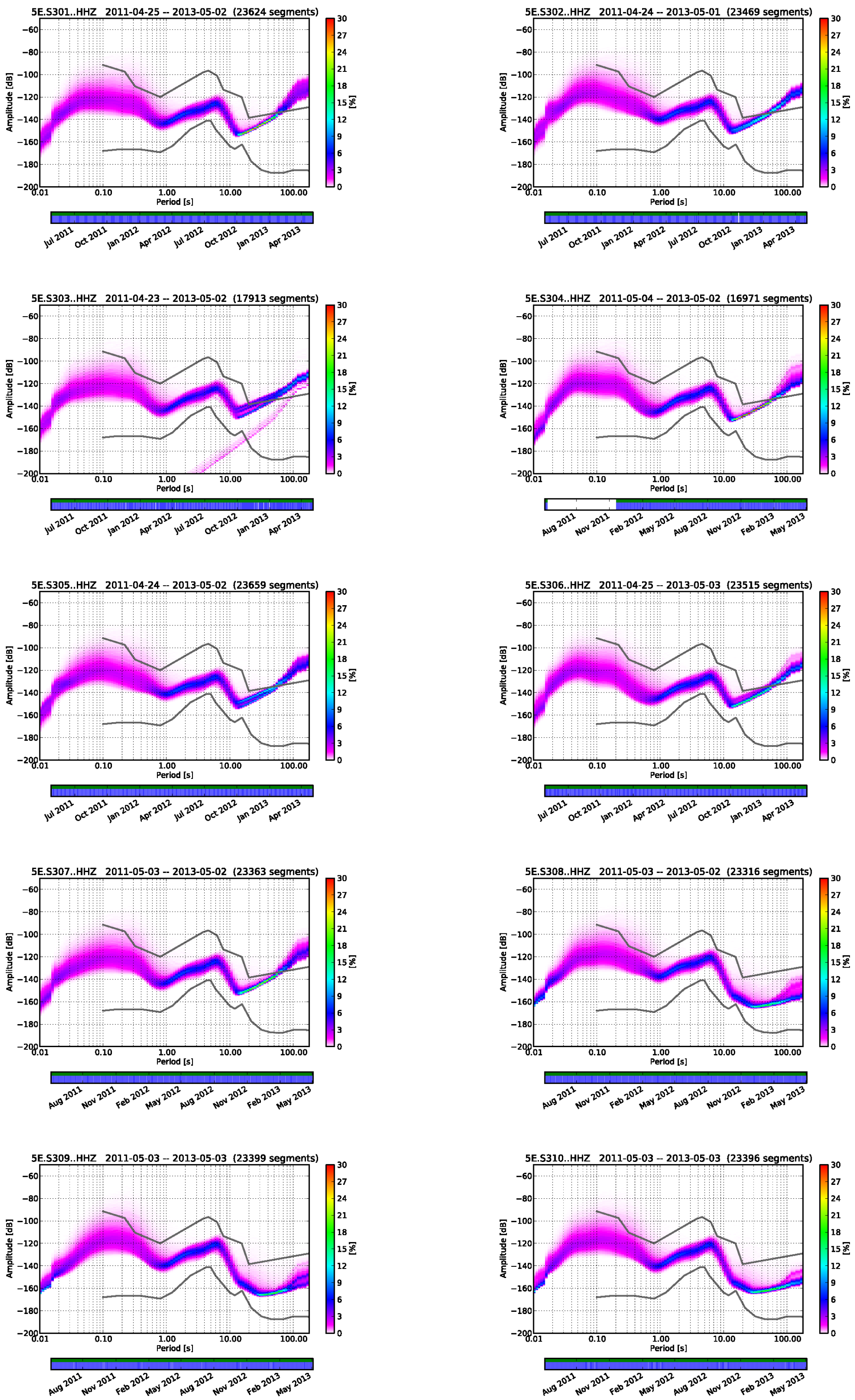

Fig. 6: Probabilistic Power Spectral Densities for Subarray S3 (obspy PPSD).

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