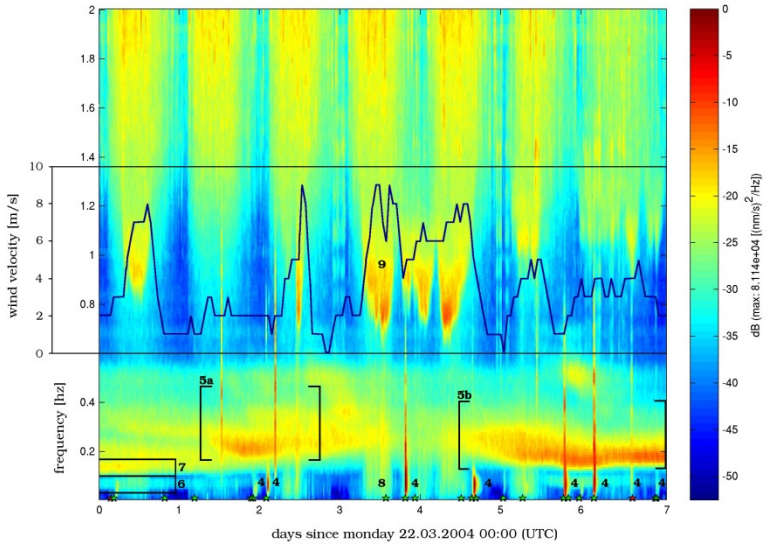
Karlsruhe Institute of Technology

Seismic noise: A challenge and opportunity for seismological monitoring in densely populated areas

Jörn Groos, Joachim Ritter

17.11.2010, ECGS-FKPE Workshop Induced Seismicity, Luxembourg

Geophysical Institute, Department of Physics



Overview

- Challenge and Opportunities
- Characteristics of the urban seismic noise
- Statistical time series classification
- Site evaluation in the Upper Rhine Graben
- Conclusions

Challenge

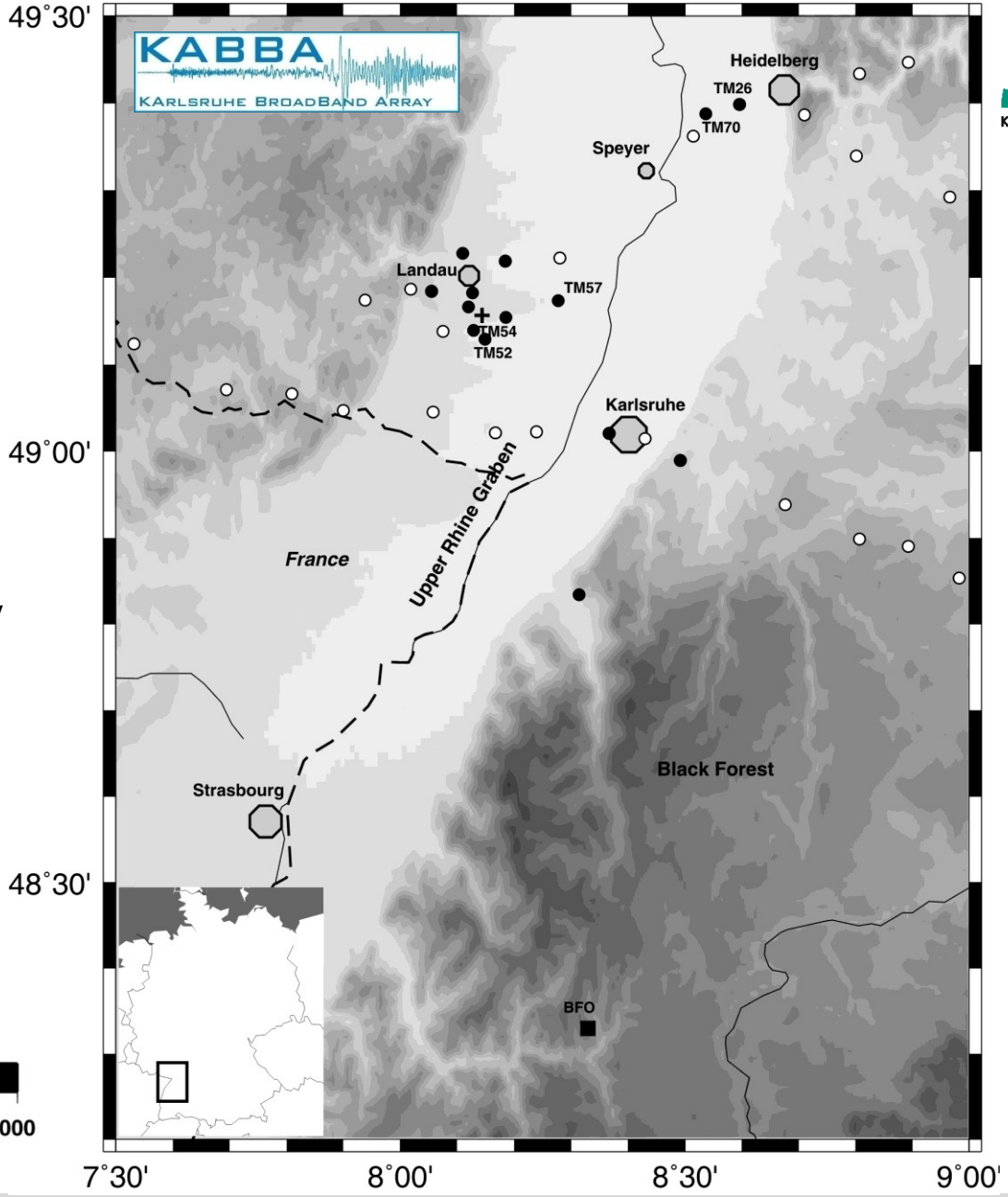
cities

TIMO station sites
2004-2006

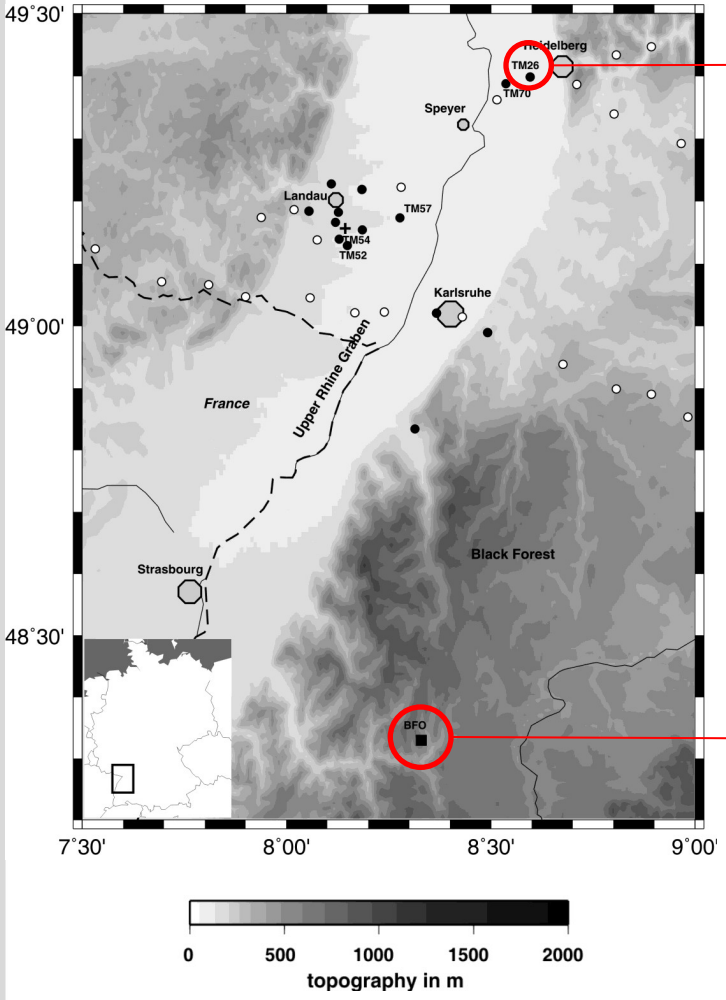
TIMO2 station sites
2009-present

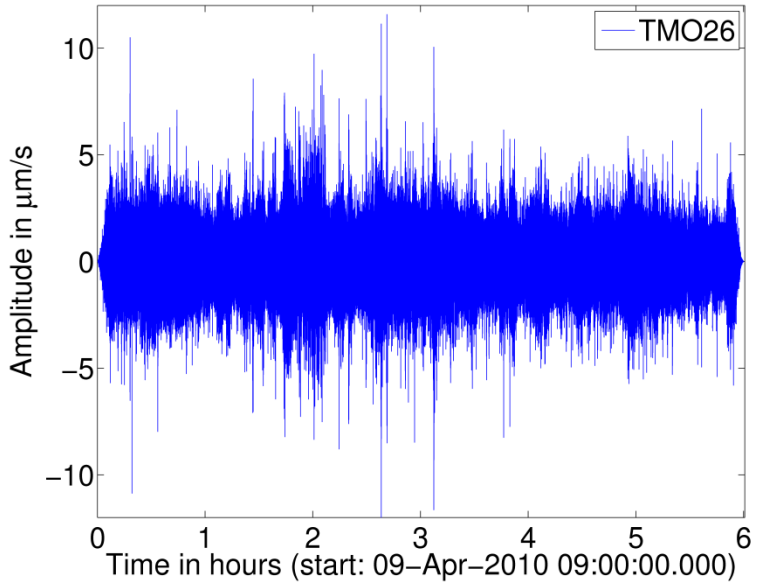
Black Forest Observatory
BFO

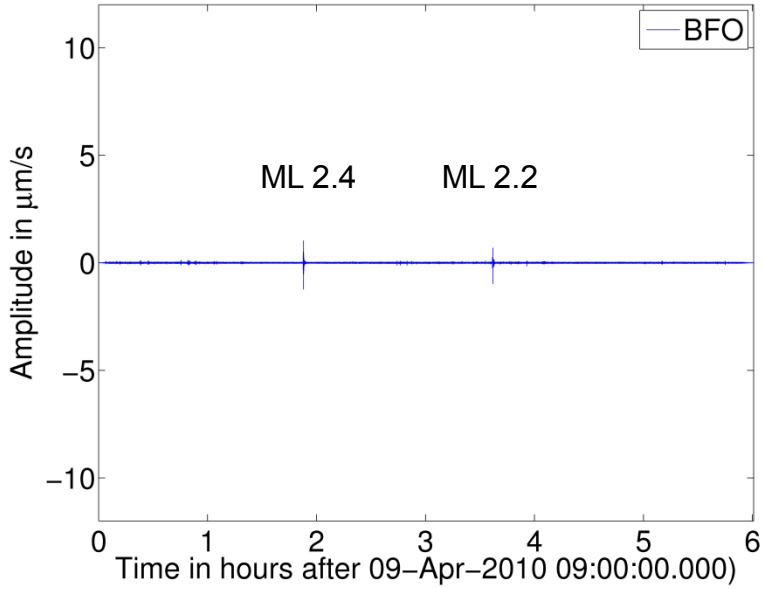
Earthquake epicentres



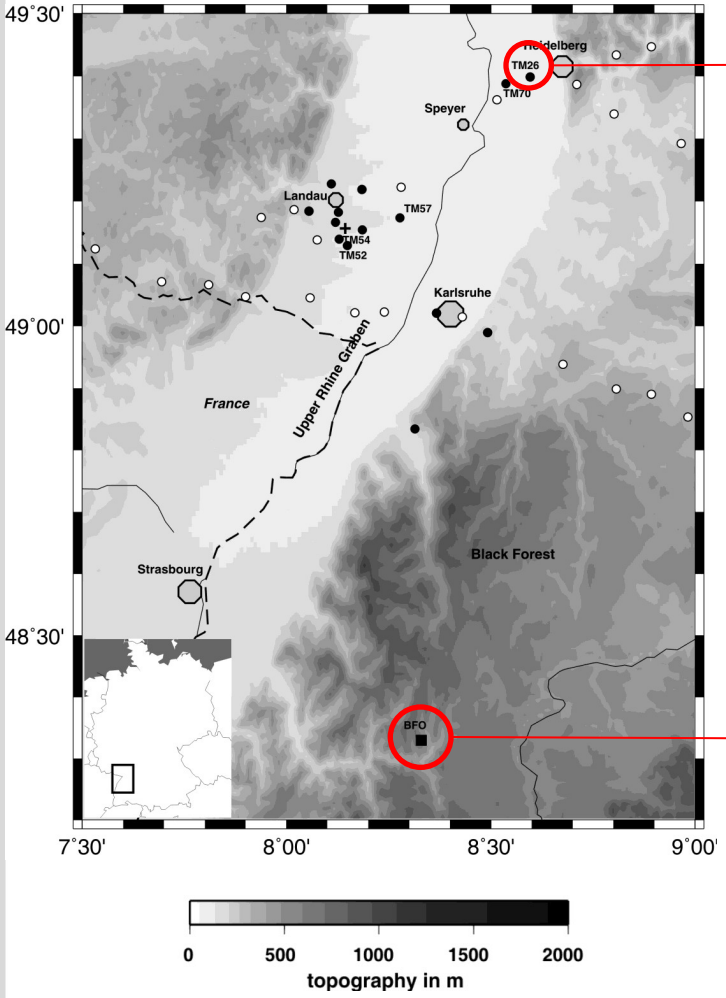
Challenge

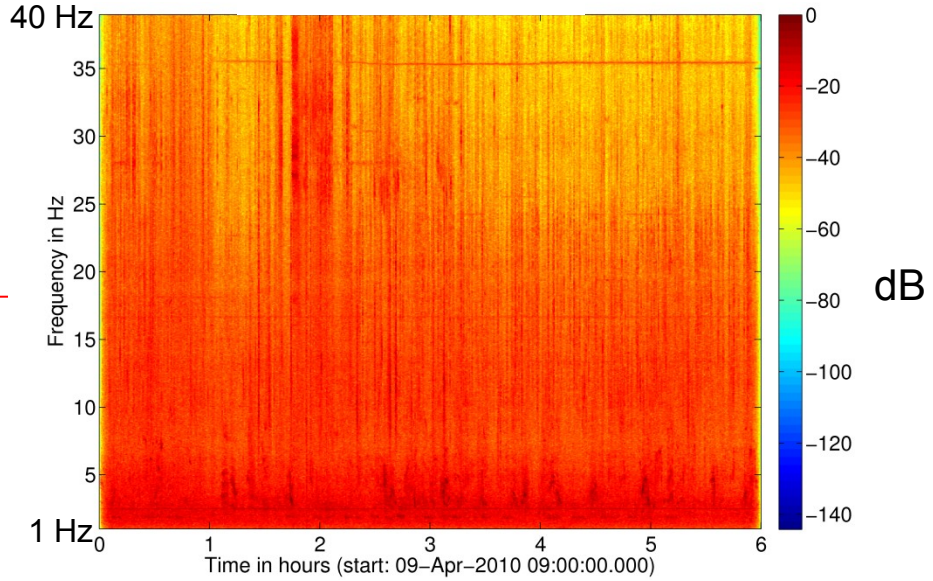

49°30'
49°00'
48°30'
7°30'
8°00'
8°30'
9°00'
Heidelberg
TM26
TM70
Speyer
Landau
TM57
TM54
TM52
Karlsruhe
France
Upper Rhine Graben
Black Forest
Strasbourg
BFO
0
500
1000
1500
2000
topography in m

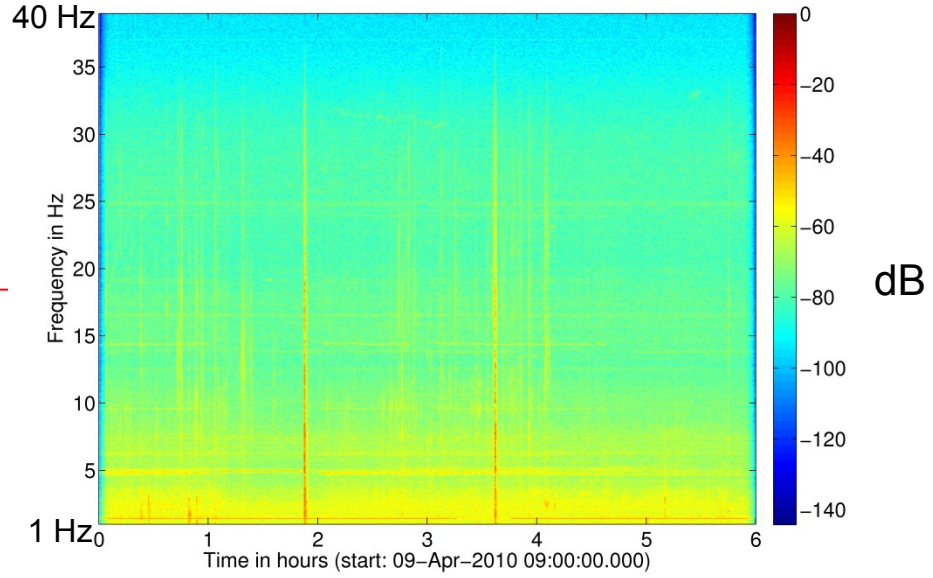

TMO26
Amplitude in µm/s
Time in hours (start: 09–Apr–2010 09:00:00.000)


BFO
ML 2.4
ML 2.2
Amplitude in µm/s
Time in hours after 09–Apr–2010 09:00:00.000)

Challenge

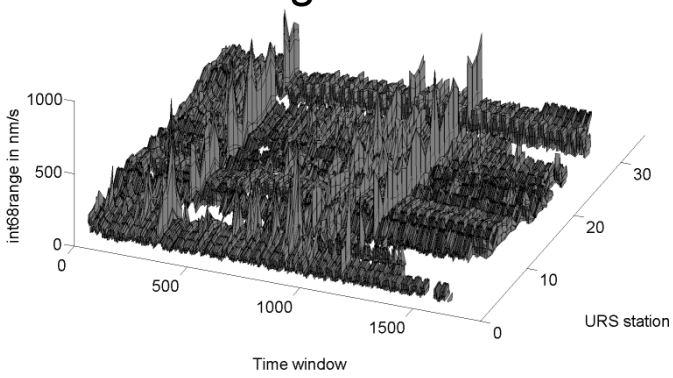

49°30'
49°00'
48°30'
7°30'
8°00'
8°30'
9°00'
Heidelberg
TM26
TM70
Speyer
Landau
TM57
TM54
TM52
Karlsruhe
France
Upper Rhine Graben
Black Forest
Strasbourg
BFO
0
500
1000
1500
2000
topography in m

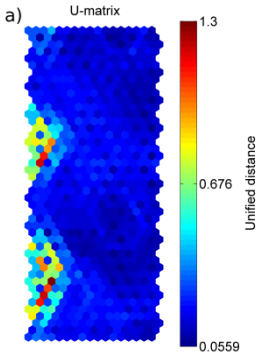

40 Hz
35
30
25
20
15
10
5
1 Hz
Frequency in Hz
0
1
2
3
4
5
6
Time in hours (start: 09–Apr–2010 09:00:00.000)
0
−20
−40
−60
−80
−100
−120
−140
dB

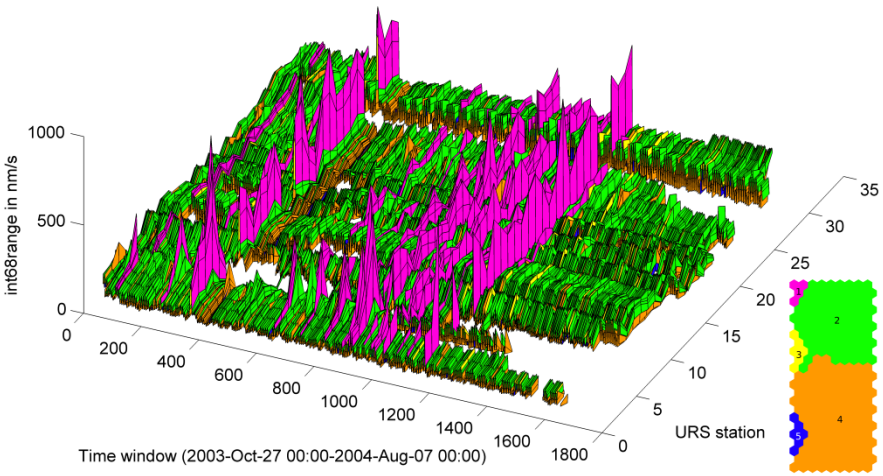

40 Hz
35
30
25
20
15
10
5
1 Hz
Frequency in Hz
0
1
2
3
4
5
6
Time in hours (start: 09–Apr–2010 09:00:00.000)
0
−20
−40
−60
−80
−100
−120
−140
dB

Opportunities

Pattern recognition

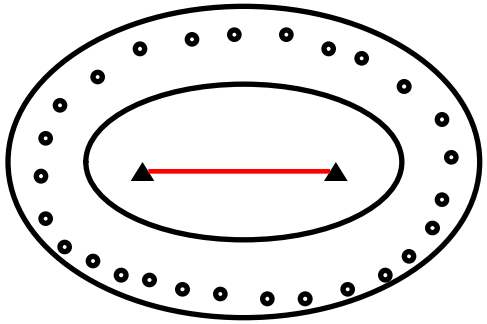


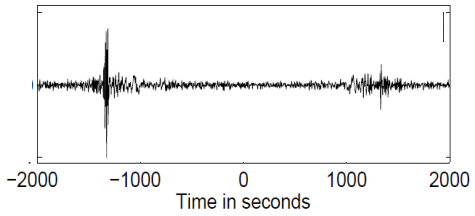


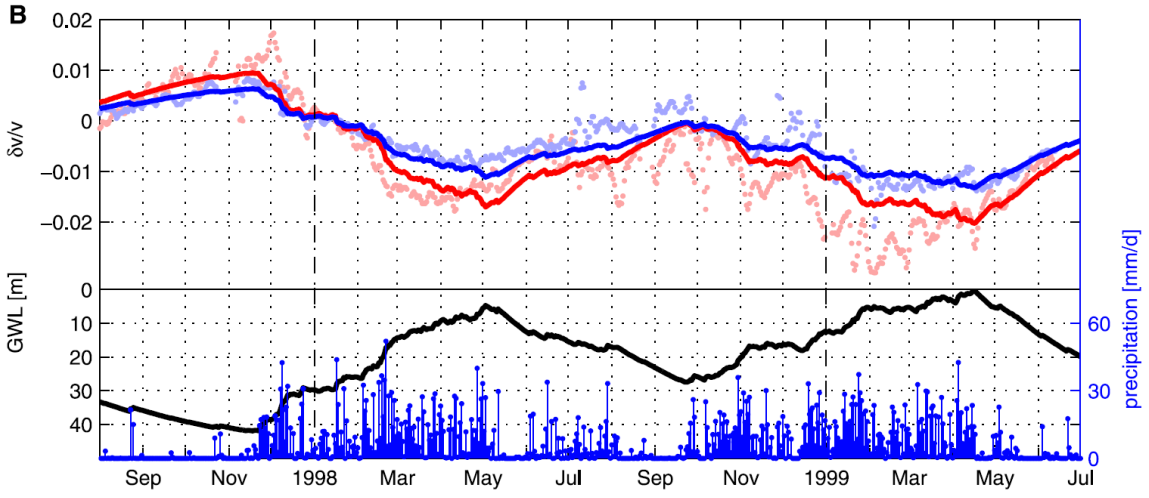


Groos, 2010.

Seismic interferometry

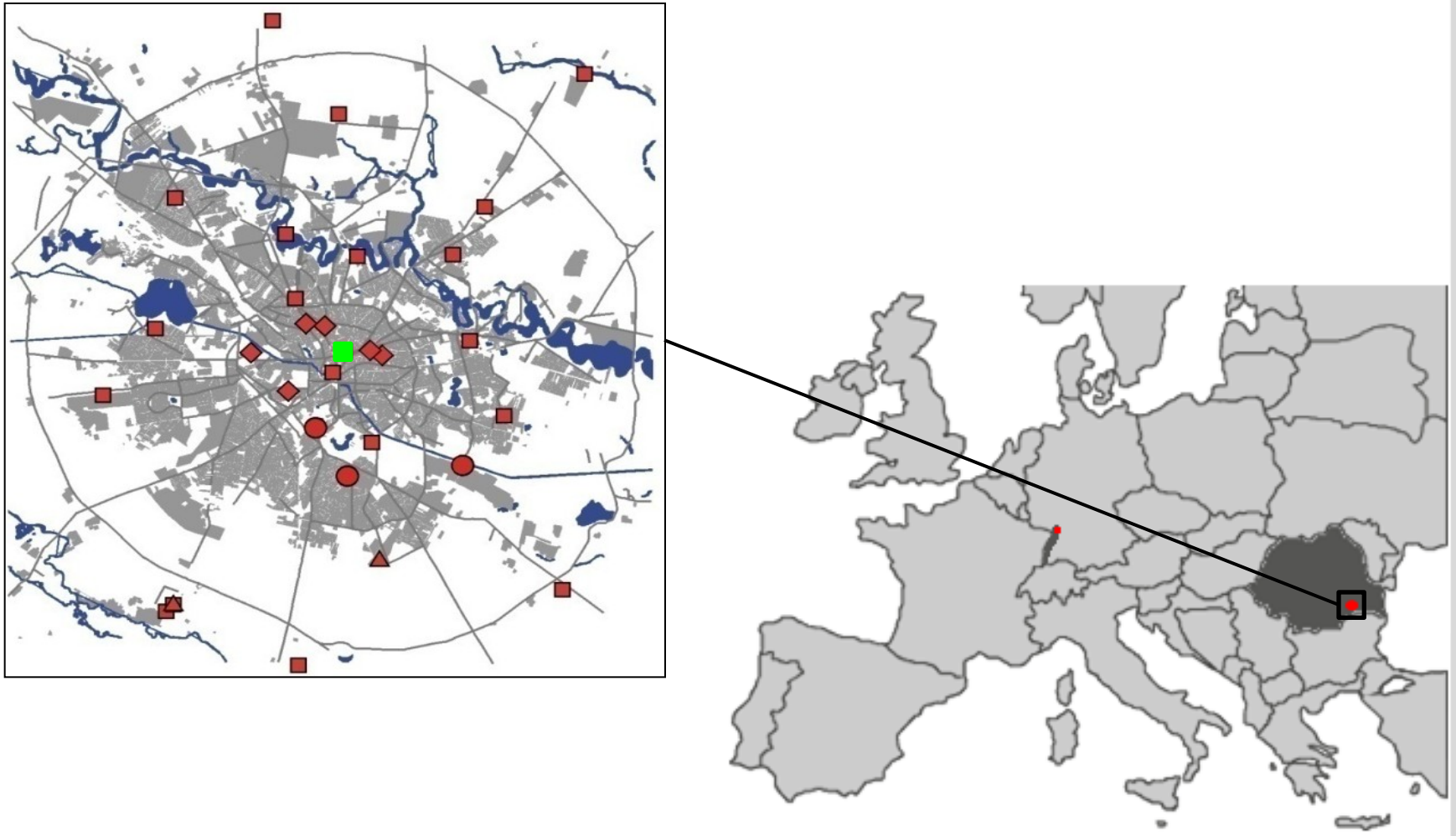




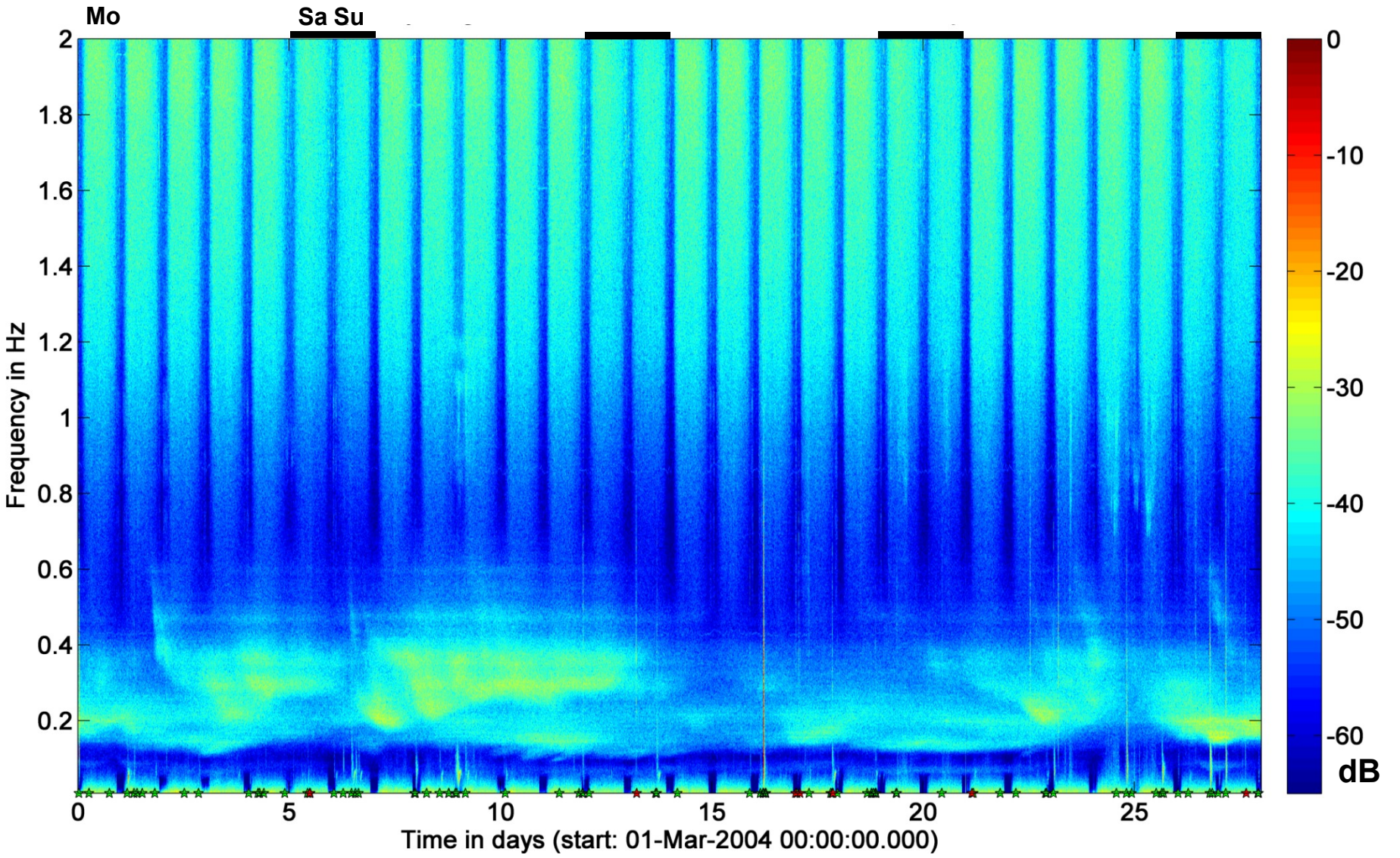


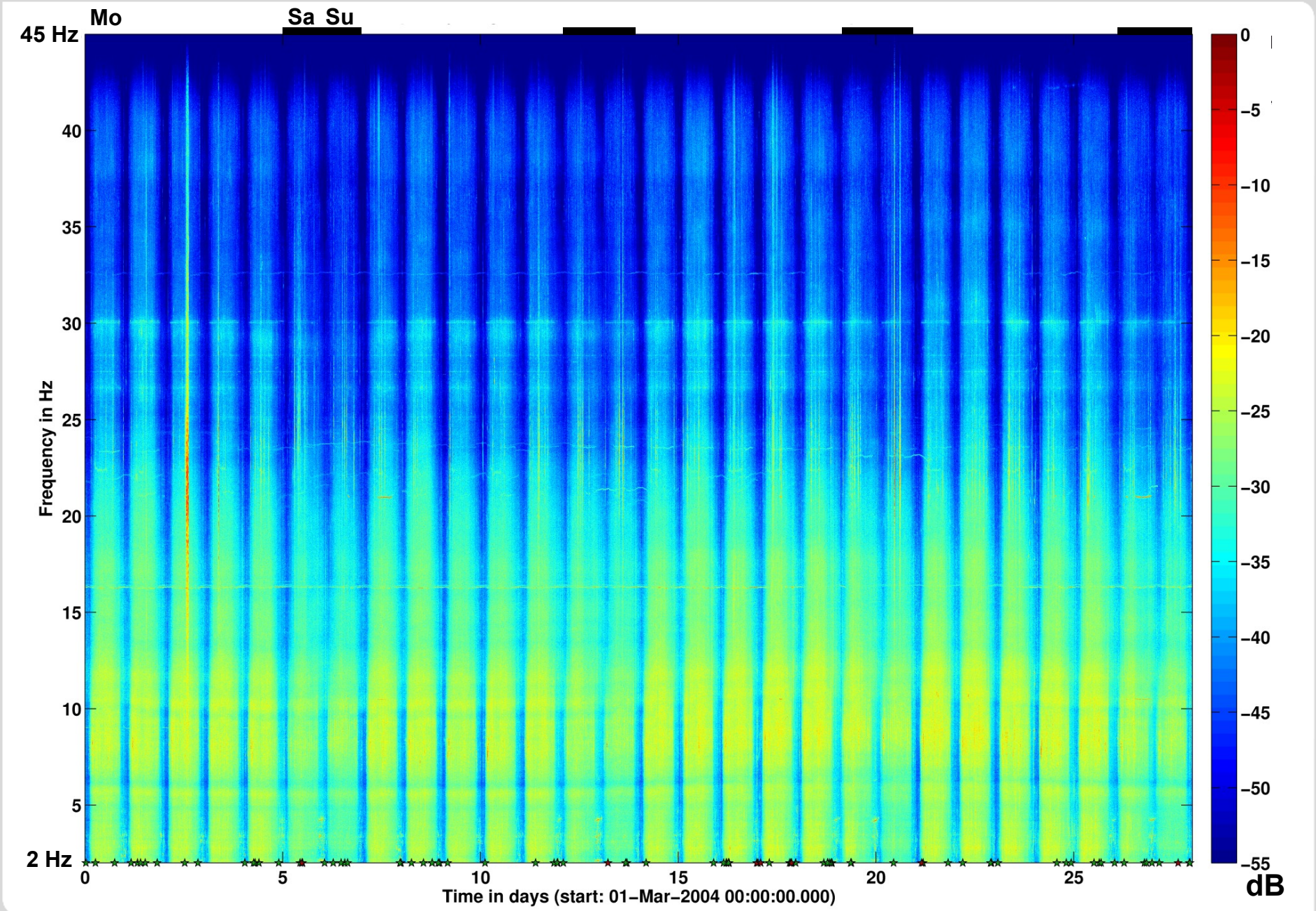
Sens-Schönfelder & Wegler, GRL, 33, 2006.

Characteristics of the urban seismic noise

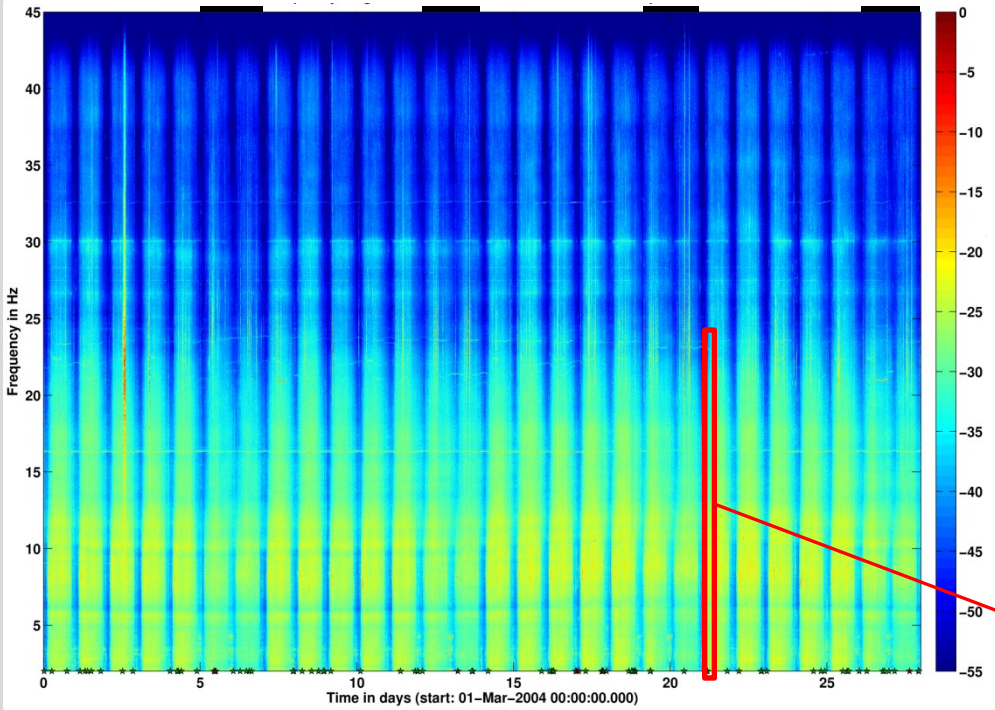


Urban Seismic Noise 8 mHz – 2Hz

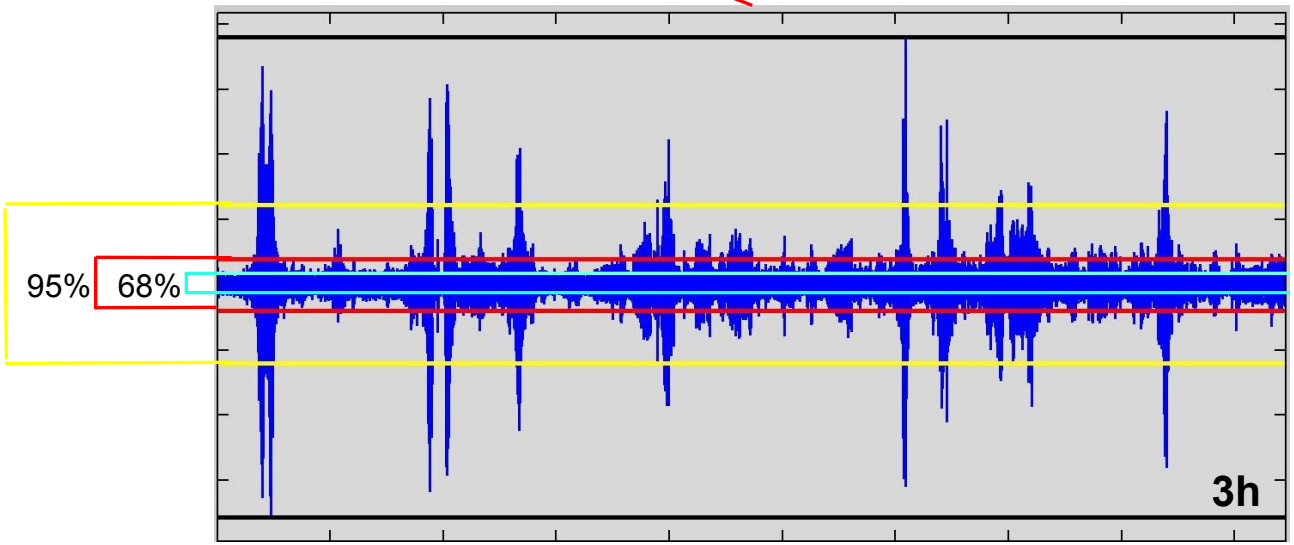



Mo
Sa Su
45 Hz
2 Hz
Frequency in Hz
40
35
30
25
20
15
10
5
0
5
10
15
20
25
Time in days (start: 01–Mar–2004 00:00:00.000)
0
–5
–10
–15
–20
–25
–30
–35
–40
–45
–50
–55
dB

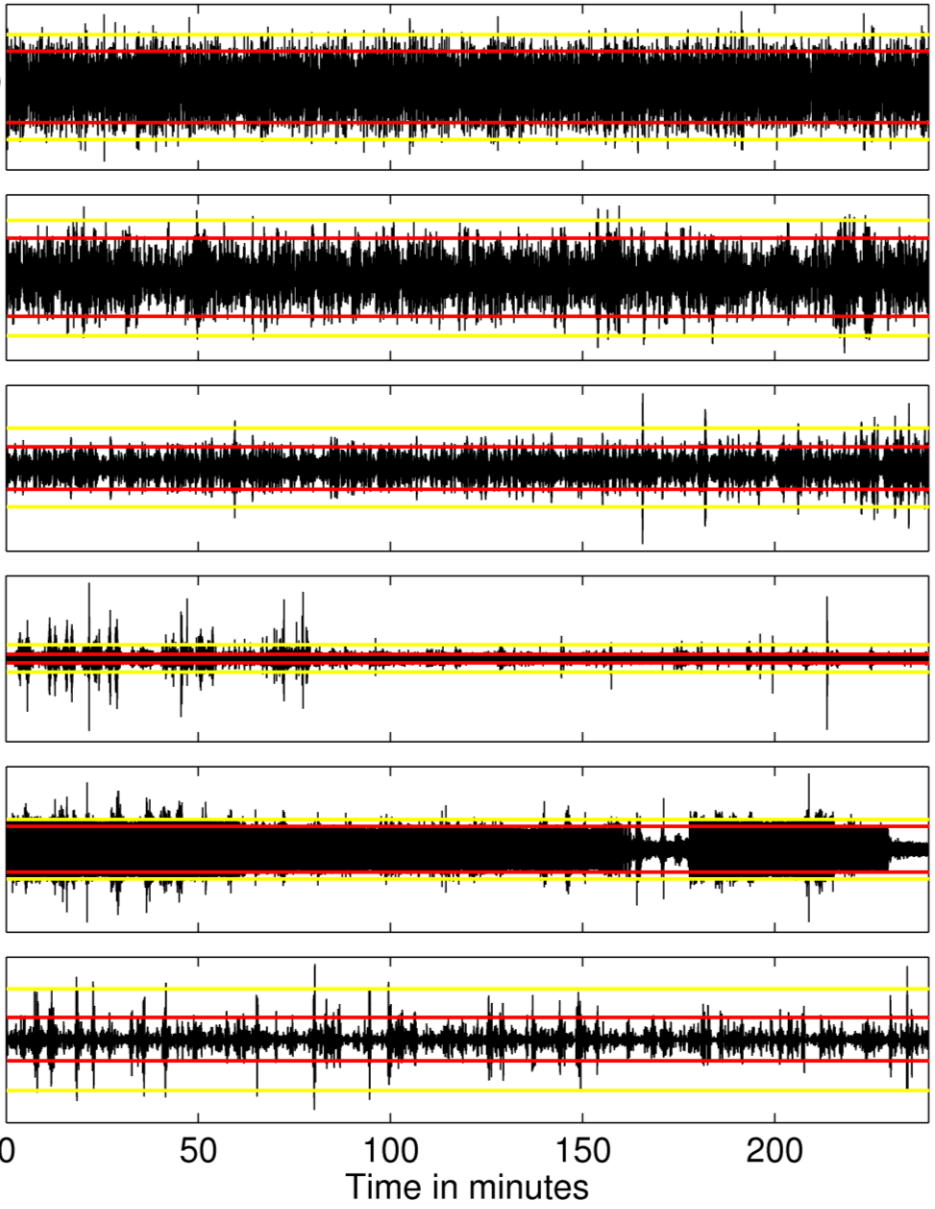
Problem

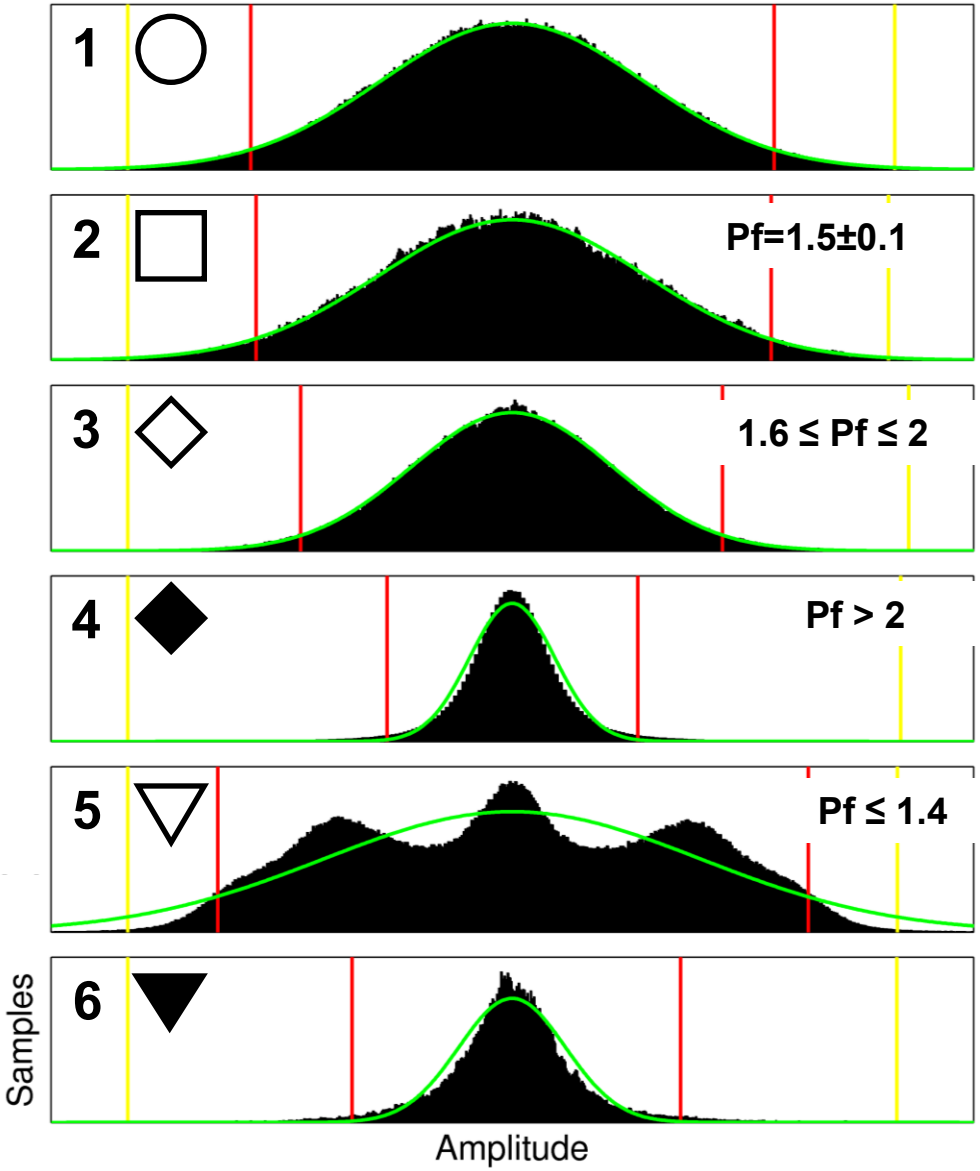


Peakfactor **Pf=** $\frac{[99.73\%]}{[95.45\%]}$



Definition of noise classes

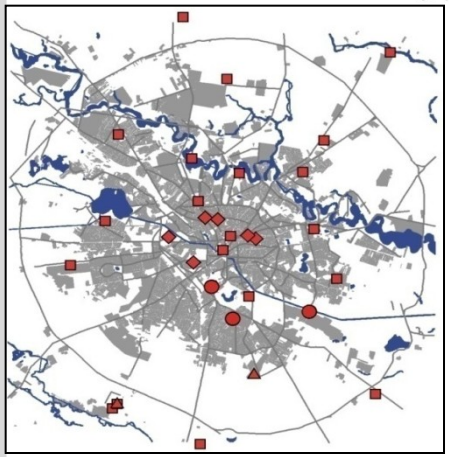


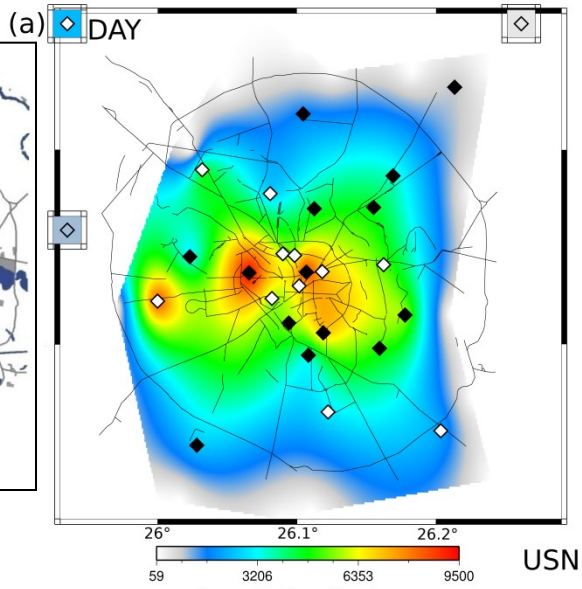


Peakfactor **Pf=** $\frac{[99.73\%]}{[95.45\%]}$

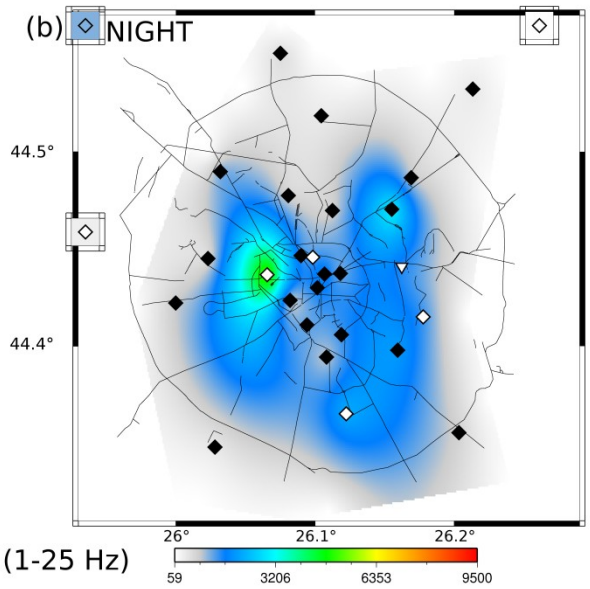
Groos & Ritter, GJI,179, 2009.

The urban seismic noise in Bucharest





Range of 68%-interval in nm/s



USN(1-25 Hz)

Range of 68%-interval in nm/s

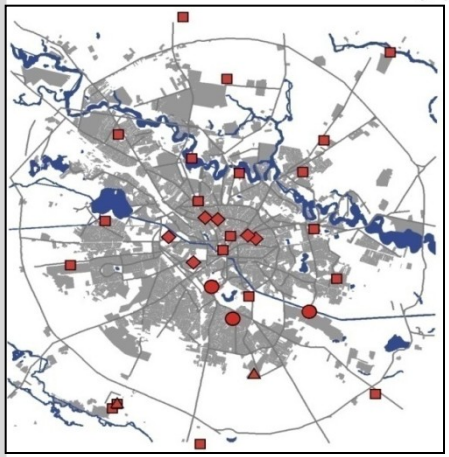
○ Noiseclass 1: normal distribution

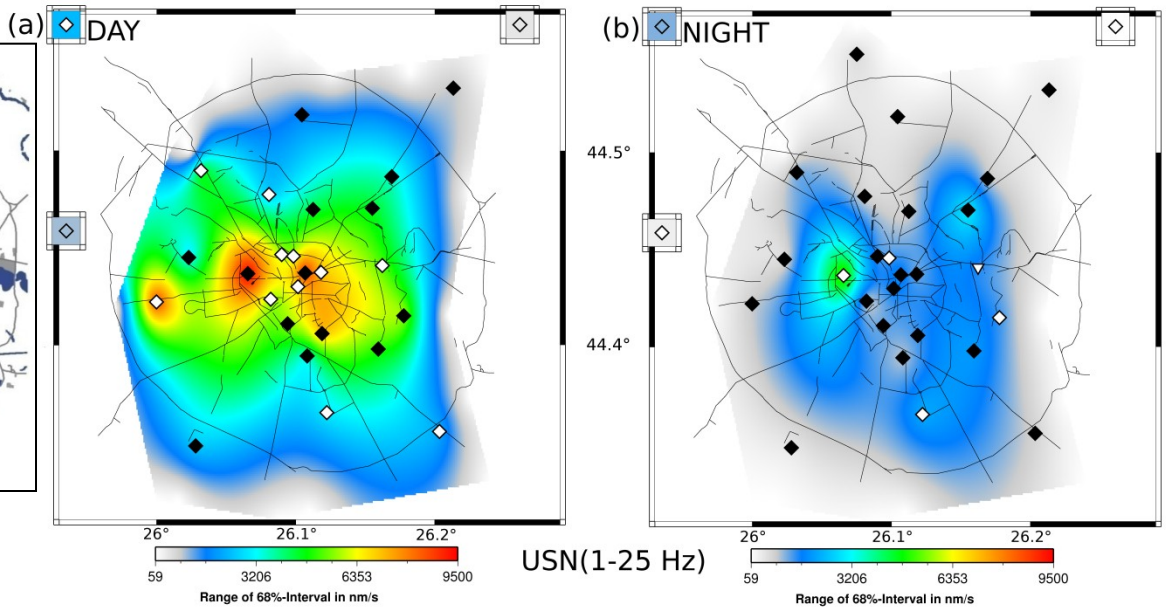
□ Noiseclass 2: nearly normal distribution

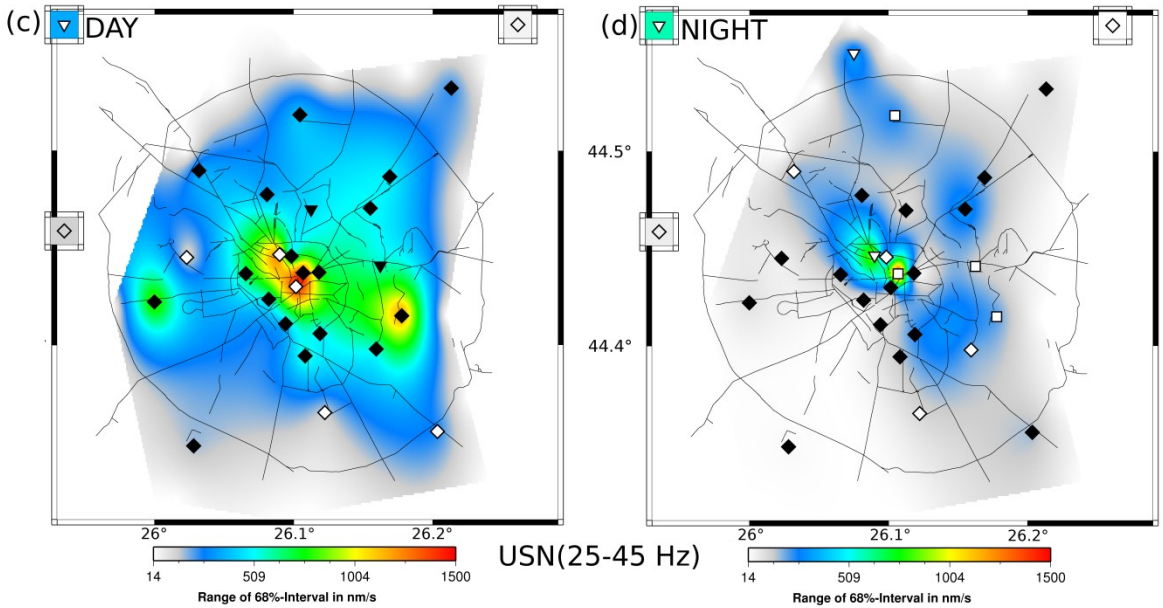
◇ Noiseclass 3: symmetric distribution, positive kurtosis (+)

◆ Noiseclass 4: symmetric distribution, positive kurtosis (++)

The urban seismic noise in Bucharest



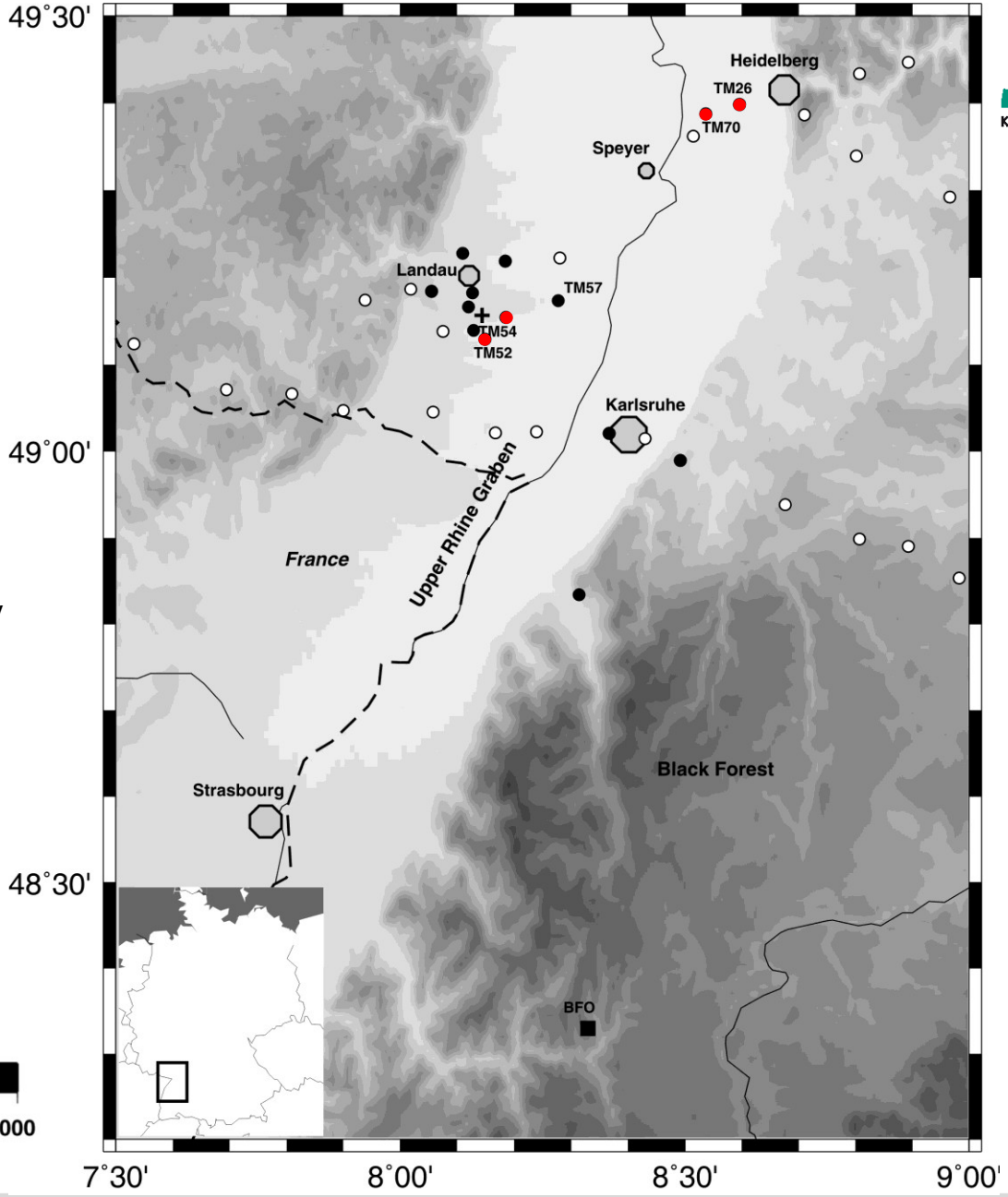


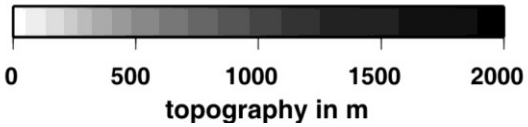


○ Noiseclass 1: normal distribution
□ Noiseclass 2: nearly normal distribution
◇ Noiseclass 3: symmetric distribution, positive kurtosis (+)
◆ Noiseclass 4: symmetric distribution, positive kurtosis (++)
▽ Noiseclass 5: symmetric distribution, negative kurtosis
▼ Noiseclass 6: asymmetric or other distribution

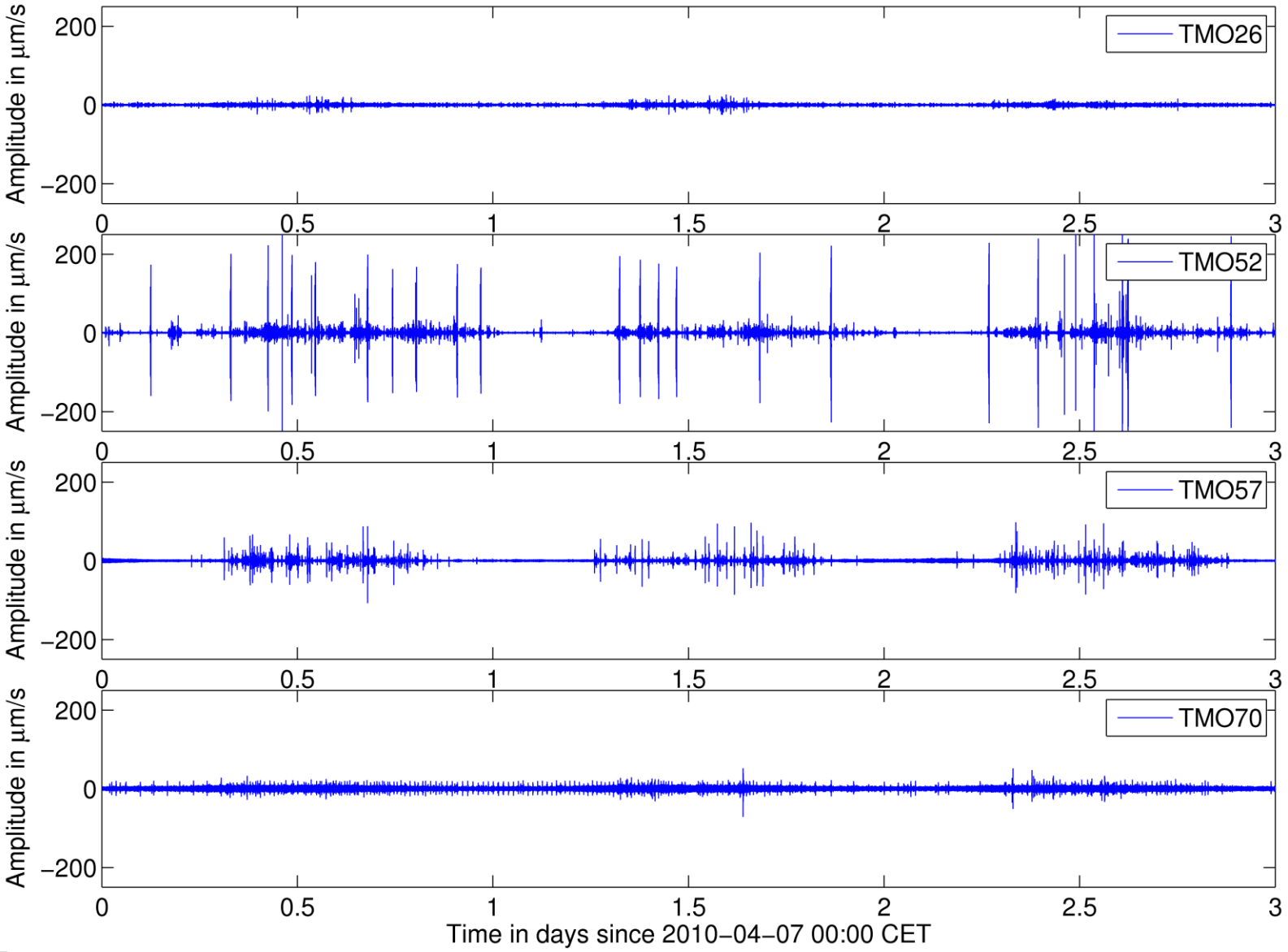
Site evaluation

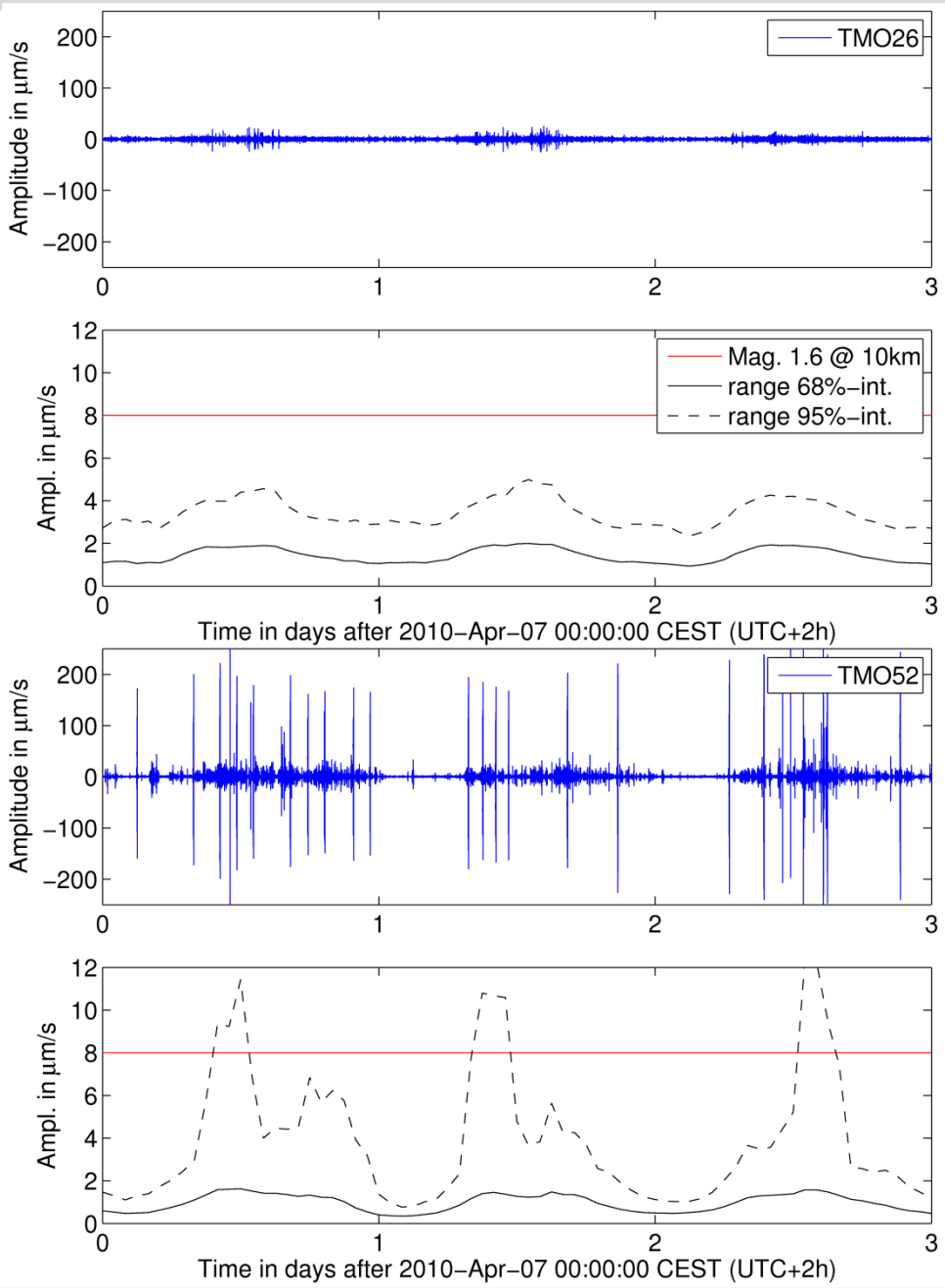
- cities
- TIMO station sites 2004-2006
- TIMO2 station sites 2009-present
- Black Forest Observatory BFO
- Earthquake epicentres



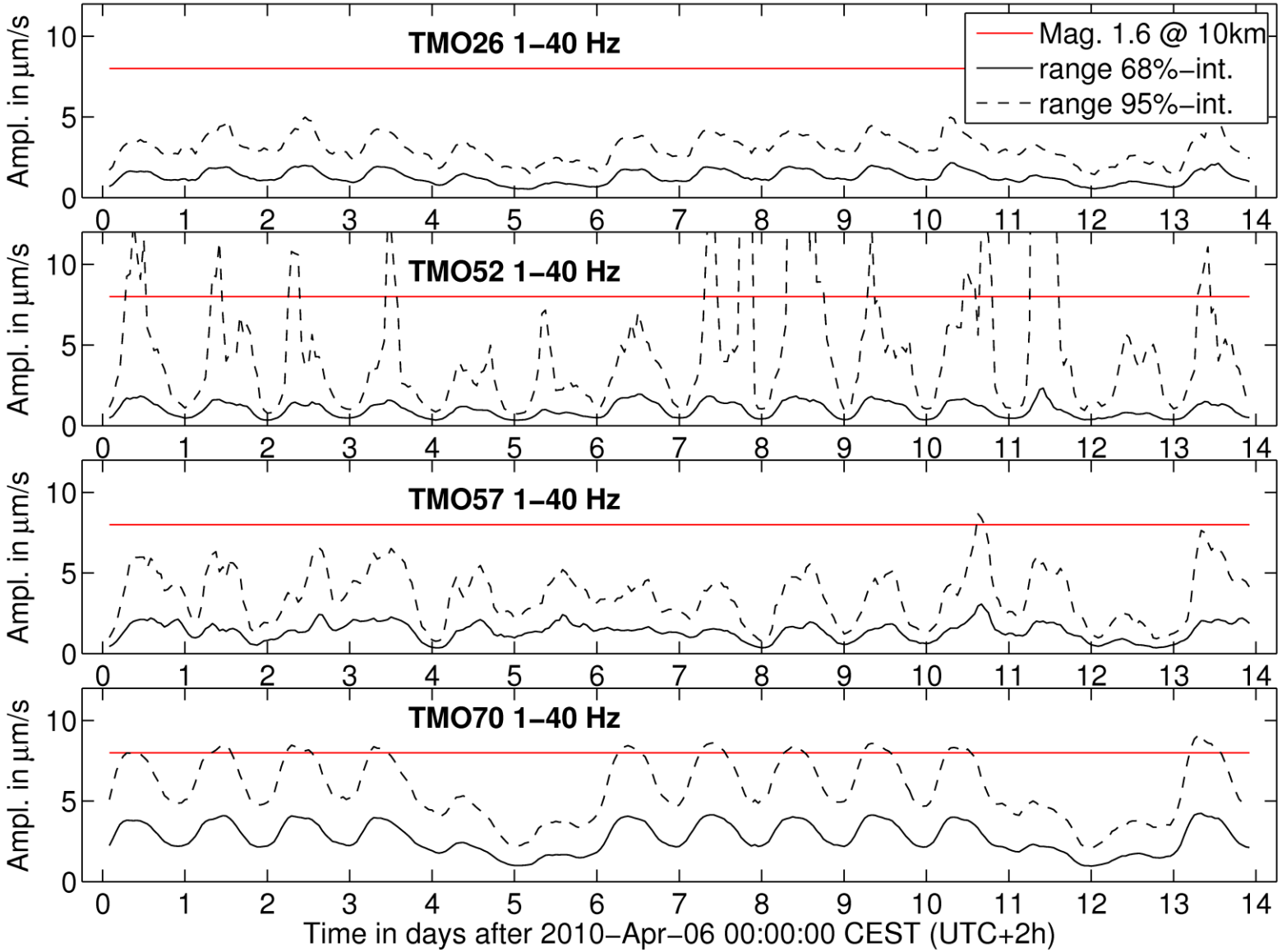


Seismic noise (1-40 Hz) in the Upper Rhine Graben

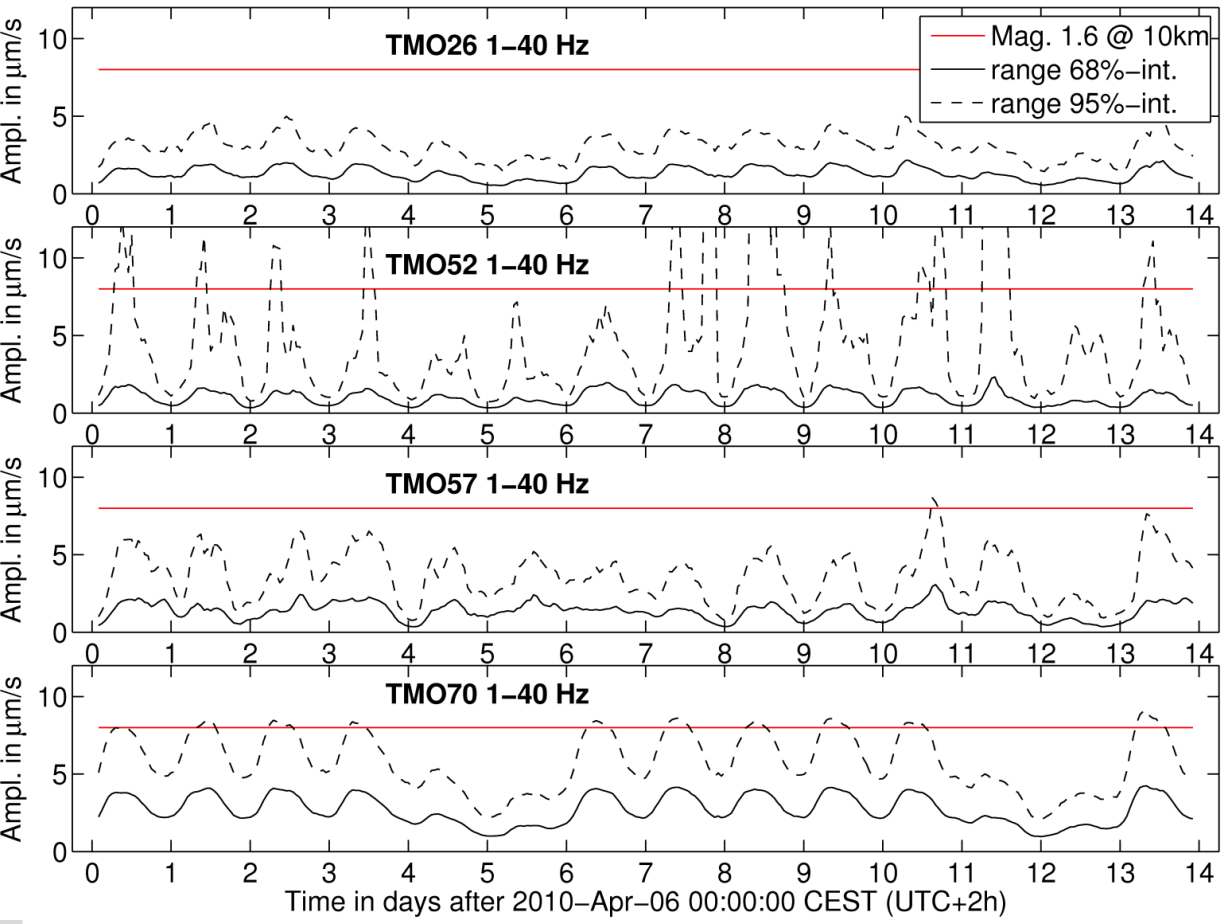


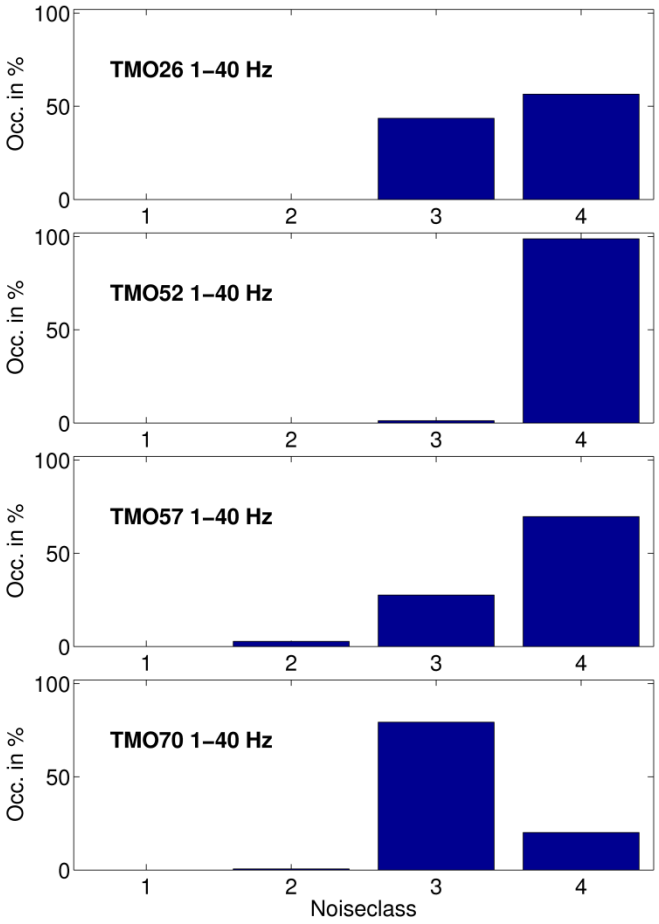

TMO26
Amplitude in µm/s
200
100
0
−100
−200
0
1
2
3
Mag. 1.6 @ 10km
range 68%−int.
range 95%−int.
Ampl. in µm/s
12
10
8
6
4
2
0
Time in days after 2010−Apr−07 00:00:00 CEST (UTC+2h)
TMO52
Amplitude in µm/s
Ampl. in µm/s
Time in days after 2010−Apr−07 00:00:00 CEST (UTC+2h)

Seismic noise amplitudes (1-40 Hz) in the Upper Rhine Graben



Seismic noise (1-40 Hz) amplitudes and classification in the Upper Rhine Graben





○ Noiseclass 1: normal distribution

□ Noiseclass 2: nearly normal distribution

◇ Noiseclass 3: symmetric distribution, positive kurtosis (+)

◆ Noiseclass 4: symmetric distribution, positive kurtosis (++)

Conclusions

- Human activity is the dominant source of seismic noise above 1 Hz
- Largest noise amplitudes in the frequency range 1-25 Hz
- Large spatial variations of the noise amplitudes above 1 Hz
- Large spatial variations of the statistical properties above 1 Hz
- **Individual site selection based on statistical noise properties**