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COGEAR

MODULE 3:

Installation of semi-permanent seismic array and data analysis

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Installation of semi-permanent seismic array and data analysis

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1. Introduction

Temporary seismic networks were deployed in Visp and Matter valley areas during both winters 07/08 and 08/09. The aim of these temporary networks was mainly to record weak ground motion due to local and regional earthquakes. The weak motion recordings are especially useful for an estimation of the relative site effects. Particularly, site-to-reference spectral ratios are useful for linear site response estimation (Borcherdt, 1970). Moreover, recordings could be utilized for improving earthquake location of local events (especially hypocentral depth could be better constrained). Finally, such semi-permanent array could serve generally as a source of information on 2D/3D seismic wave propagation effects in the area – detection of the refracted surface waves from the basin edges, estimation of the depth of the bedrock from converted phases, direct estimation of Green's functions between the stations using noise correlation techniques, etc. Nevertheless, the primary goal was an estimation of the relative site amplification in urban areas of Visp, St. Niklaus and Grächen.

From November 2007 to Mai 2008, 11 temporary seismic stations were installed - eight in Visp (Fig. 1), two in St. Niklaus and one in Grächen (Fig. 2). All stations consisted of Quanterra Q330 digitizer and LE3D-5s short period (SP) sensor, four of them were additionally equipped with a broadband (BB) STS-2 sensor. The aim of the collocation of the BB and SP sensors was to extend the frequency band of recordings for the future application of the noise correlation technique (direct retrieval of Green's function from the noise). Stations were setup to measure continuous data with a sampling rate of 200 Hz.

Further, from November 2008 to April 2009, 12 temporary seismic stations were installed - seven in Visp (Fig. 3), and the others in Matter valley (Fig. 4 - two in St. Niklaus, one in Grächen , one in Kalpetran, one at Seetalhorn). All stations consisted again of Quanterra Q330 and LE3D-5s and were recording continuous data with a sampling rate of 200 Hz.

Most of the stations installed during winter 08/09 had the same position as the stations installed during winter 07/08 (compare Fig. 1-4). Concerning Visp area, VISP1, VISP2, VISP4, VISP5 stations were located on the Rhone plain, where strong site effects are expected due to sedimentary basin (Fritsche et al., 2006). VISP6, VISP7, VISP8 were located close to the possible basin edge. Finally VISP3 and VISP9 were located on the rock outcrop and should serve as reference stations. VISP3 station was located in the cellar of a private house (see Appendix A), and the owner did not want the station installation during winter 08/09. VISP4 was located within the industrial facility of the Lonza factory. As it was an extremely noisy site (see Appendix B), it was not setup up again during winter 08/09.

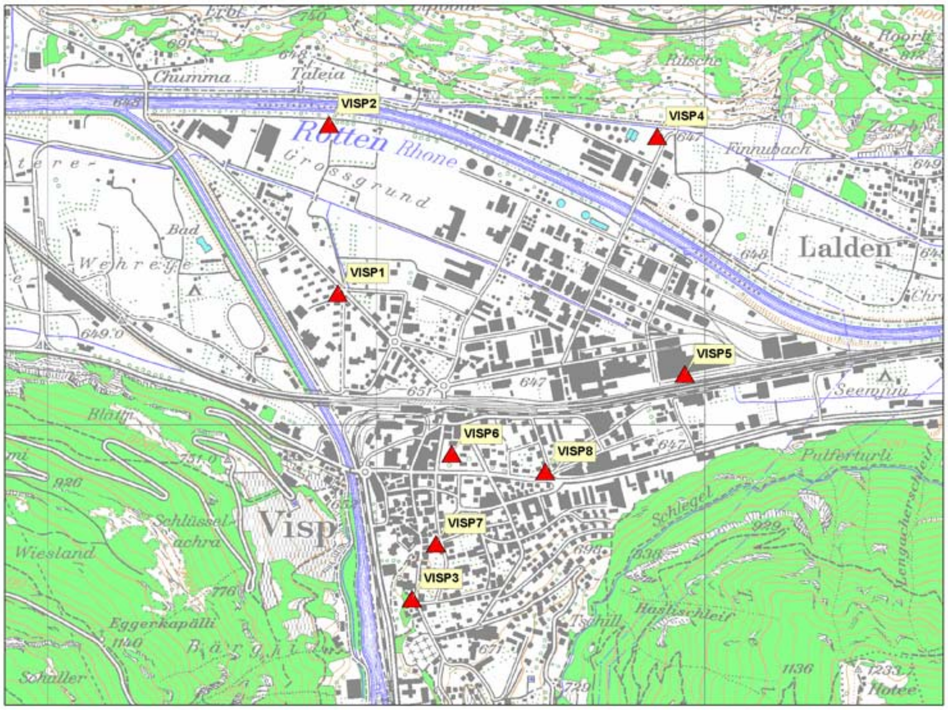

Figure 1: Temporary seismic stations in Visp from November 2007 to Mai 2008.

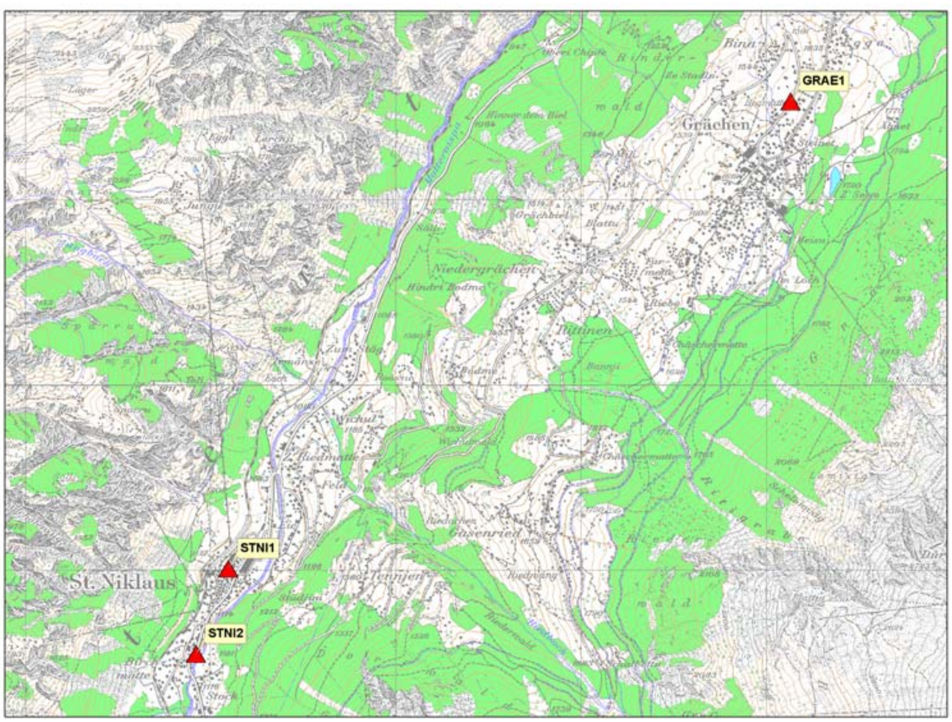

Figure 2: Temporary seismic stations in St.Niklaus / Grächen from November 2007 to Mai 2008.

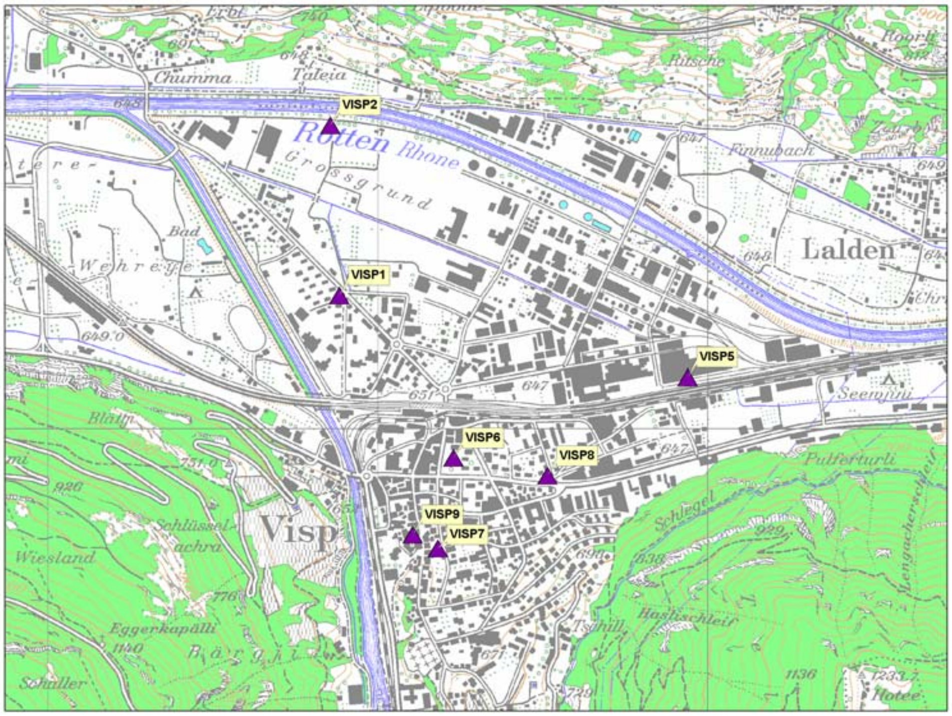

Figure 3: Temporary seismic stations in Visp from November 2008 to April 2009.

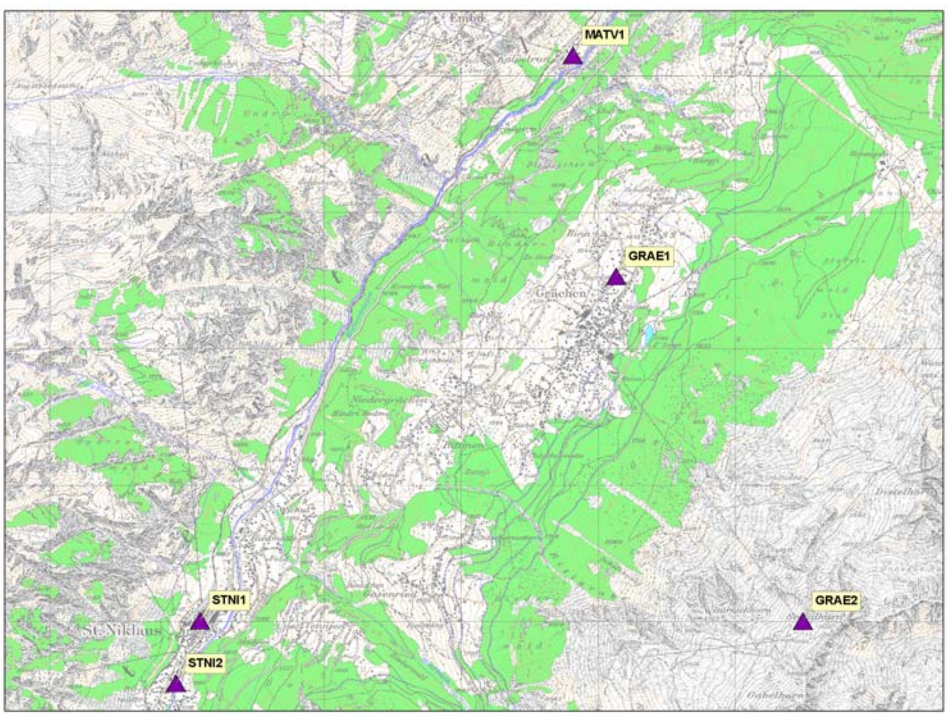

Figure 4: Temporary seismic stations in St.Niklaus / Grächen from November 2008 to April 2009.

Concerning Matter valley area, STNI1 and STNI2 stations were located in St. Niklaus on the sedimentary basin of the Matter Vispa river (site effects expected according to Fritsche et al., 2005). GRAE1 was located on the unstable soil slope in Grächen, GRAE2 on the rock slope (almost on the crest, topographic site effect expected) and MATV1 near the bottom of the Matter valley. The site MATV1 was initially expected as a reference site for the area, however, the presence of the layer of deposits has been revealed. More information (the exact position and time periods of operation, photos) about sites can be found in the Appendix A.

3. Method

Regional seismic events were identified on the recordings with the help of the Swiss earthquake catalog. Site-to-reference spectral ratios were calculated following Borcherdt (1970), under the assumption that the sources of the events are far from the array (especially compared to reference-to-site distances) and omitting both source radiation, directivity and path effects. A window containing the intense S-wave part of the seismograms was selected manually for each recording and Fourier transform was performed. The amplitude spectra of the Fourier transform were smoothed using the window proposed by Konno and Ohmachi (1998) with a bandwidth of 40 samples (b=40). Finally, the total spectral amplitude in the horizontal direction was computed and divided by the Fourier amplitude of the reference station.

4. Basic data processing

Raw velocity recordings were corrected for the baseline shift. An instrumental correction was applied just for a flat part of the instrument response. In other words, recordings were just scaled using constant calibration factor. The data at periods longer than the eigen-periods of the sensors were not interpreted.
The sensors were oriented by compass. However, it was sometimes difficult to estimate the North direction, especially in the shafts of the transformer houses. Moreover, it was recognized that some sensors were moved (turned) during operation by somebody (e.g., VISP9). Thus, an additional noise measurement was performed just before the removal of each station: An additional sensor was installed outside the object where the semi-permanent station was installed. The distance between sensors was not more than few meters. The two sensors were left to record ground motion for a few minutes simultaneously. The idea was then to calibrate the orientation of the sensor which was inside, using the data recorded by the sensor which was outside (thus reliably oriented). Particularly, a band-pass filter (0.2-4 Hz) was applied on the pair of recordings. The horizontal components of the inside sensor were progressively rotated with an azimuthal step of 1 degree. An optimum rotation was found by minimizing the difference with respect to ground motion recorded by the outside sensor (L2 norm was used as a misfit function). The procedure described above was performed only after the winter 08/09 period. The results are depicted in Figure 5. An estimation of the correction is reasonable for most of the stations (minimum difference between

outside and inside recordings for both components and their sum - minima of the three curves coincide).

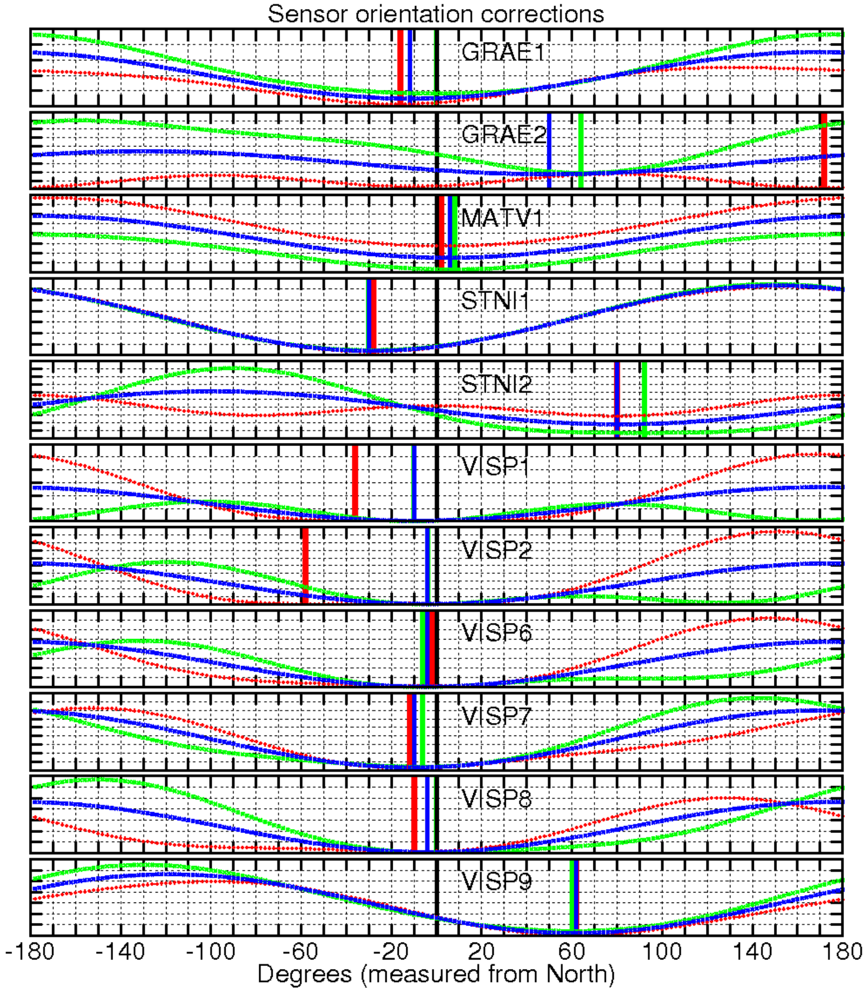

Figure 5:Relative misfit between horizontal components of outside and inside sensors depending on the rotation of the inside sensor (North component – red, East component – green, absolute horizontal component – blue). Colorful vertical bar denotes global minimum of the corresponding curve.

GRAE1	-12°
MATV1	6°
STNI1	-30°
STNI2	80°
VISP1	-10°
VISP2	-4°
VISP6	-4°
VISP7	-10°
VISP8	-4°
VISP9	62°

Table 1: Estimated corrections of the sensor orientation (measured from North).

The station GRAE2 is an exception – the outside sensor was installed on the snow cover and the motion recorded by the two sensors is not coherent. Thus, it was not possible estimate the correction for GRAE2. The sensor orientation corrections are summarized in Table 1. Stations STNI1, STNI2, VISP9 show significant (>10°) correction of the orientation.

5. Results

Three significant events were identified on the recordings from winter 07/08 and nine events on the recordings from winter 08/09. The origin dates and names are presented in Table 2. Plot of recordings of all events analyzed here can be found in Appendix B. Note the recordings are very noisy. The main source of the noise is located in the Lonza factory, probably close to the station VISP4. The frequency content of this industrial noise is localized around 2.5 Hz, 4 – 5 Hz and 9 – 10 Hz. Some of the stations placed in the transformer houses are affected by noise at frequencies close to 50 Hz (e.g., VISP7). Moreover, recordings at station STNI2 are strongly affected by the noise at frequency 16.7 Hz = 1/3 50 Hz (note the 16.7 Hz frequency is utilized in the common railway electric systems in Switzerland). This disturbance is not present in recordings from winter 2008/2009.

1	Gd. St. Bernard	M_L=3.6	17.2.2008
2	St. Niklaus	M_L=1.8	21.3.2008
3	Thusis	M_L=4.0	21.1.2008
4	Raron	M_L=0.9	15.4.2009
5	Bllaten	M_L=1.5	3.1.2009
6	Zwischenflüh	M_L=2.6	15.1.2009
7	Törbel	M_L=0.5	17.3.2009
8	Wildhaus	M_L=3.9	4.1.2009
9	Château d'Oex	M_L=2.4	15.2.2009
10	Formazza	M_L=1.9	19.4.2009
11	Macugnaga	M_L=1.8	15.1.2009
12	L'Aquila	M_w=6.3	6.4.2009

Table 2: Events identified on the recordings.

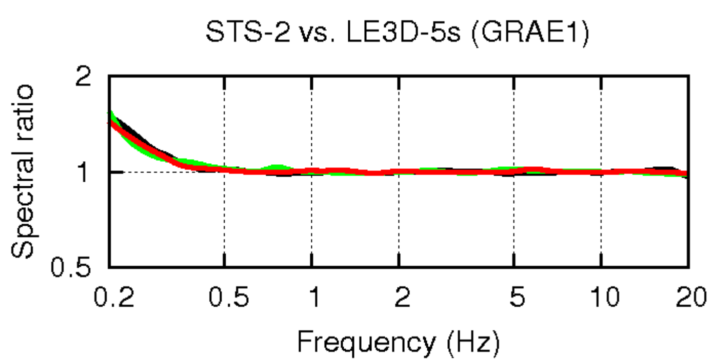

Figure 6: Spectral ratio (STS-2 / LE3D-5s) at site GRAE1 for three events of winter 07/08.

Recordings of collocated LE3D-5s and STS-2 sensors were compared (Figure 6). Spectral ratios (STS-2 to LE3D-5s) are perfectly equal to one above 0.4 Hz. Spectral ratios indicate that the transfer function of the LE3D-5s is not flat bellow 0.4 Hz, however the deviation is not large.

Resulting site-to-reference ratios (SRR) for Visp and Matter valley are plotted in Figures 7 and 8 respectively. An average H/V curve retrieved from ambient noise by classical method is also plotted for each site. Spectral ratios that are strongly deviated from the rest (because of very low signal-to-noise ratio, or broken assumption of the far field source – case of event No. 7 in Matter valley) were not considered.

Let us discuss the results for the Visp area. Station VISP9 was selected as a main reference station. VISP9 was not operating during winter 07/08, VISP3 was the reference for that time period. VISP7 was selected for an estimation of the average VISP3/VISP9 ratio since it provided most stable results with well-defined mean among the stations operating during both winters. Spectral ratios from winter 07/08 were afterwards corrected for the average VISP3/VISP9 ratio to get the ratios with respect to VISP9. Note that VISP3 has a slightly different site response from VISP9. Although the signal-to-noise ratio is low (see Appendix B) the SRR are quite stable below 5 Hz for all sites. The peak at 2.5 Hz, which is present on almost all sites, has the origin in the industrial noise, so the SRR does not represent the relative amplification close to this frequency. As the signal-to-noise ratio was systematically very low for the station VISP4, SRR for frequencies higher than 2 Hz cannot be considered at all for this station. Average SRRs are in good agreement with H/V curves below the fundamental frequencies of the sites. H/V do not agree with spectral ratios at VISP3 and VISP7 for frequencies between 1 to 5Hz. This can be partially explained by industrial noise peaks (at 2.5, 4.5, 9 Hz) and radiation from the basin (1 Hz). Both of these effects should be suppressed in the site-to-reference spectral ratios.

Concerning the sites in the Matter valley, GRAE1 was selected as the reference station, since it presents a relatively flat response and was operating during both winters. However, GRAE1 is not a rock site, so the absolute values of the spectral ratios cannot be considered directly as amplification factors. The peak at 16.7 Hz, which is present at STNI2, has the origin in the industrial noise (see above), so the SRR does not represent the relative amplification close to this frequency. Average SRRs do not generally agree with H/V curves as in Visp, since no good reference site is available. Generally, the scatter in retrieved SRRs is larger from event to event compared to Visp.

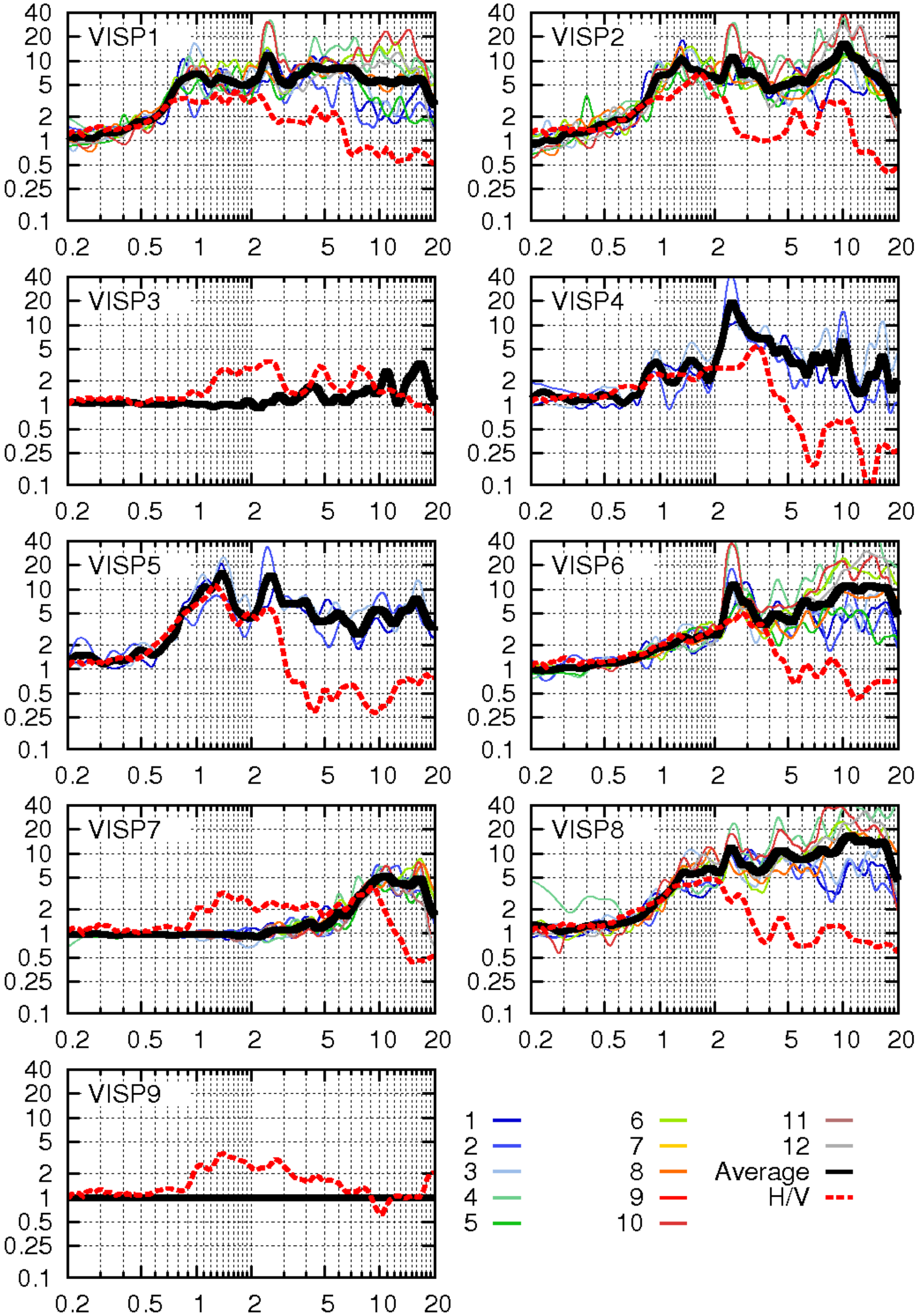

Figure 7:Comparison of average site-to-reference spectral ratios (black thick) for earthquake recordings with H/V curves (dashed red) from ambient noise for the Visp area. VISP9 was the reference station. Colours distinguish between different events.

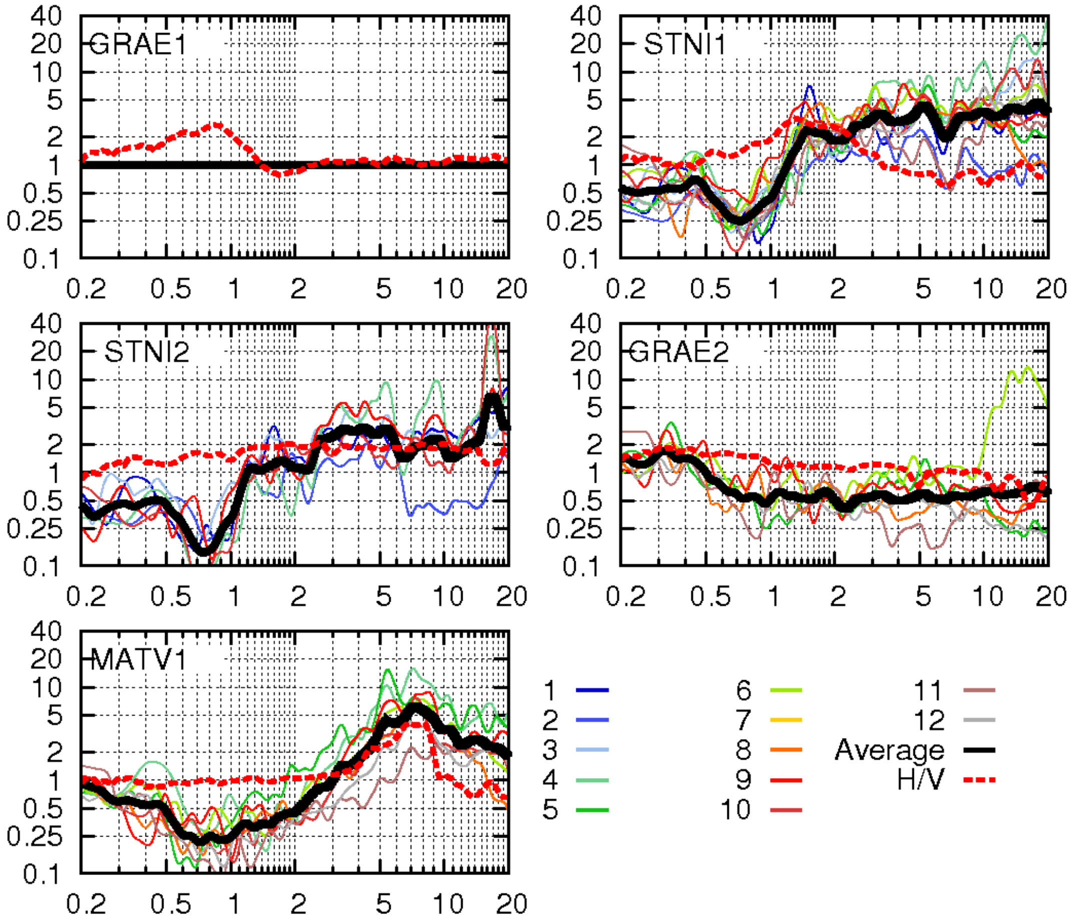

Figure 8: Comparison of average site-to-reference spectral ratios (black thick) for earthquake recordings with H/V curves (dashed red) from ambient noise for the Matter valley area. GRAE1 was the reference station. Colours distinguish between different events.

6. Discussion & Conclusions

The relative site amplification within the city of Visp was estimated. Trends in the amplification functions generally fit to current state of knowledge about the structure below city. The site effect is shifted to higher frequencies towards the old town (i.e., towards basin edge). The reliability of the absolute values of amplification functions is lower for higher frequencies (>5 Hz), except station VISP7. Above the fundamental frequency of resonance the amplification values range from 4 - 15 in the frequency band up to about 10 Hz, with an average of 6. The maximum amplification values in this frequency band are reached in the plane of the river Rhone. The remarkable agreement of H/V curves with site-to-reference spectral ratios below the fundamental frequencies of the sites implies: 1. The reference site was well selected. 2. Ambient noise seems to be dominated by shear waves below fundamental frequencies of the sites in the area. 3. A set of single station measurements of ambient noise carried out in the area presents a reliable proxy for 3D structural model – H/V curves (below the fundamental frequency) could be used for mapping of the amplification within the basin. The predominance of the body waves in the ambient noise below the fundamental frequency of the site is supported by theoretical models (Scherbaum et al., 2003).

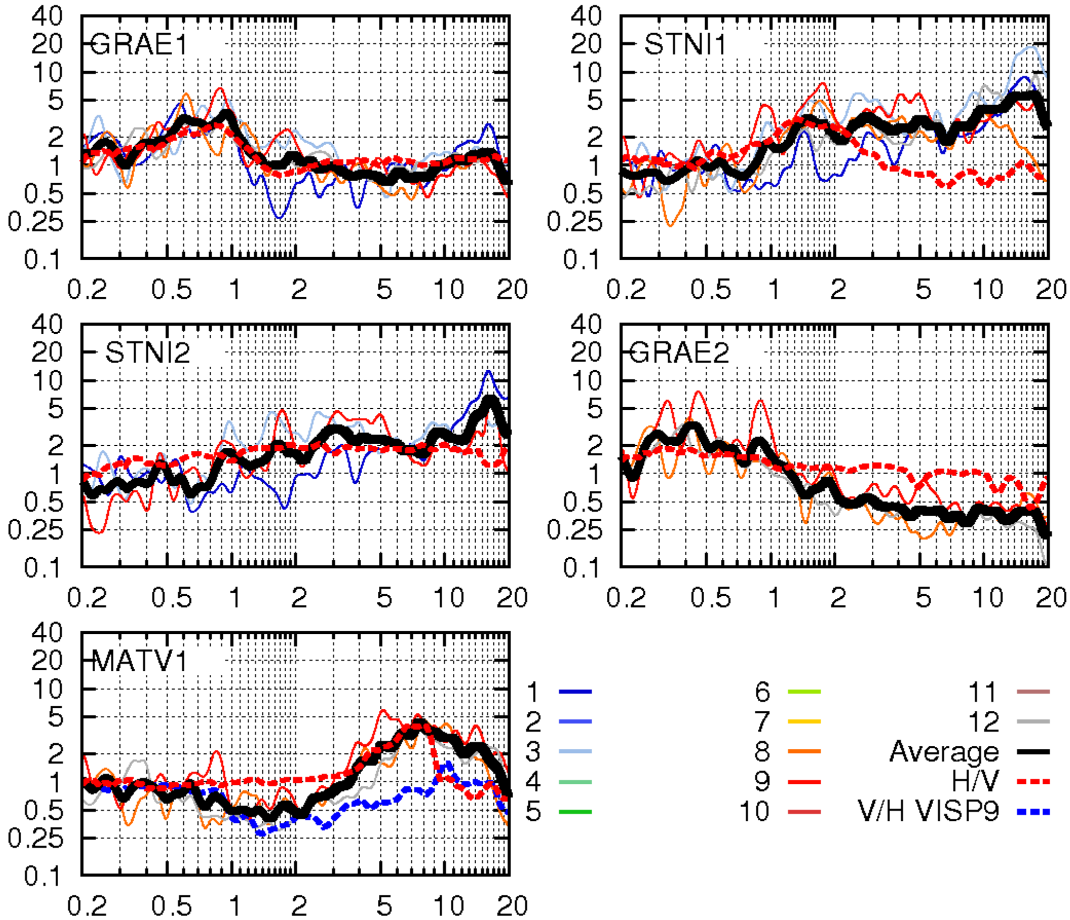

Figure 9: Comparison of average site-to-reference spectral ratios (black thick) for earthquake recordings with H/V curves (dashed red) from ambient noise for the Matter valley area. VISP9 was the reference station. Colours distinguish between different events. V/H ratio for the VISP9 station (dashed blue) is supplied for MATV1 plot.

Concerning the Matter valley, the interpretation of results is not straightforward for the following reasons: 1. No good reference site is available, so the absolute values of the spectral ratios cannot be considered as amplification factors. 2. The set of the analyzed sites is heterogeneous (soil slope, rock slope, sedimentary valley). 3. The scatter of the spectral ratios is higher than in Visp. Still, the spectral ratios give valuable information: MATV1 is located on the layer of deposits with the resonant frequency of 7.5 Hz. H/V curve represents probably well the amplification function below the fundamental frequency for MATV1. GRAE2 (mountain crest) presents weak amplification around 0.3 Hz. The amplification at the soil slope in Graechen (GRAE1) is rather low frequency

(0.2 – 1 Hz) compared to high frequency (>1 Hz) amplification of sedimentary valley in St. Niklaus.

Comparing the shapes of all amplification functions, station GRAE2 seems to be a better rock reference for frequencies above 1 Hz. GRAE2 has a de-amplification relative to GRAE1 with a factor of about 2 on average for frequencies above 1Hz. At low frequency smaller than 0.5 Hz (maybe also up to 1 Hz) the sites in the valley (STNI1, STNI2, MATV1) seem to be better rock reference sites, with a de-amplification of factor of 2 below 1 Hz when compared to GRAE1. The sites in the valley bottom show a strong de-amplification in the frequency band 0.5 to 1 Hz. Amplification at site GRAE1 occurs in the frequency band below 1 Hz (0.5 –1 Hz in the H/V ratio), and this can explain the large value of de-amplification of the sites in the valley when using station GRAE1 as reference.

An “optimum” rock reference would show a de-amplification of about a factor of 2 with respect of GRAE1 over the entire frequency band. Assuming such an “optimum” rock reference, the stations on the mountain slope would then show an amplification that might be explained by topographical effects.

Finally, and in order to extend the discussion related to the “optimum” rock reference, the two reference sites (VISP9 and GRAE1) are compared to each other. Even if the distance between the stations VISP9 and GRAE1 is considerable (10 km), spectral ratios were computed for the distant events (Events 1, 3, 8, 9, and 12 in Table 2). VISP9 was taken as the reference. The ratios are shown in Figure 9. Generally, the shapes of the amplification functions are more reasonable, and are in better agreement with H/V curves. In case of GRAE1, the amplification is well defined with respect to VISP9 (low scatter in the ratios) and agrees with H/V curve over the entire frequency band presented. Still, de-amplification is observed at GRAE2 for frequencies higher than 2 Hz (however, based just on two earthquake recordings). The scatter of ratios is naturally larger for two furthest stations STNI1 and STNI2 (15 km), nevertheless the shape of the ratios is reasonable (close to 1 for frequencies <1 Hz, from 2 to 5 for higher frequencies). Concerning MATV1, the closest station to VISP9 (9 km), the spectral ratios are close to 1 bellow 0.7 Hz. Then a de-amplification (factor of 2) is observed for the frequency band 1 – 2 Hz. Finally, the spectral ratios increase with frequency and reach almost a factor of 5 at the fundamental frequency of the site (7.5 Hz). V/H ratio for the VISP9 (reciprocal of H/V ratio, see Figure 7) is supplied for the comparison. The de-amplification at MATV1 for 1 – 2 Hz is consistent with the increase of H/V for VISP9 for this frequency band.

7. Acknowledgements

Acknowledgements go to Bergbahnen Grächen, EVWR AG, EVG Grächen AG, Lonza AG, Mr. Gurber, Mrs. Salzgeber, Mr. Schaller, Mr. Zuber, and Mr. Zurbriggen for leaving their properties (or properties under their administration) available for the measurement purposes.

8. References

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Fritsche, S., Fäh, D., Gisler, M., and Giardini, D., 2006. Reconstructing the Damage Field of the 1855 Earthquake in Switzerland: historical investigations on a well-documented event. Geophys. J. Int., 166, 719–731.

Konno, K., and Ohmachi, T., 1998. Ground-motion characteristics estimated from spectral ratio between horizontal and vertical components of microtremor, Bull. seism. Soc. Am., 88, 228–241.

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Appendix A

Station: GRAE1 - TS[1] Hegimatte

Installed:
21.11.2007 - 15.5.2008
19.11.2008 - 29.4.2009

Swiss coordinates:
631130 / 116532 ~ 1590 m.s.l

Notes:
STS-2 sensor installed at this site (21.11.2007 - 15.5.2008).

Station: GRAE2 - Bergstation neuer Sessellift Seetalhorn

Installed:
09.12.2008 - 15.4.2009

Swiss coordinates::
632493 / 114005 ~ 2865 m.s.l.

[1]Transformer station

Station: MATV1 -Kapelle Kalpetran

Installed:
19.11.2008 - 28.4.2009

Swiss coordinates:
630815 / 118153 ~ 900 m.s.l.

Station: STNI1 - St. Niklaus 1

Installed:
11.10.2007 - 15.5.2008
18.11.2008 - 28.4.2009

Swiss coordinates:
628095 / 114009 ~ 1115 m.s.l.

Station: STNI2 - TS Stock

Installed:
4.12.2007 - 14.5.2008
18.11.2008 - 28.4.2009

Swiss coordinates:
627920 / 113548 ~ 1110 m.s.l.

Notes:
STS-2 sensor installed at this site
(4.12.2007 - 14.5.2008).

Station: VISP1 - Visp Amselweg

Installed:
18.10.2007 - 14.5.2008
18.11.2008 - 29.4.2009

Swiss coordinates:
633883 / 127404 ~ 650 m.s.l

Station: VISP2 Lonza „Pumphäuschen“

Installed:
5.11.2007 - 15.5.2008
18.11.2008 - 29.4.2009

Swiss coordinates:
633856 / 127921 ~ 650 m.s.l.

Notes:
STS-2 sensor installed at this site
(5.11.2007 - 15.5.2008).

Station: VISP3 - Visp Martiniplatz

Installed:
5.11.2007 - 14.5.2008

Swiss coordinates:
634108 / 126469 ~ 665 m.s.l.

Notes:
STS-2 sensor installed at this site
(5.11.2007 - 14.5.2008).

Station: VISP4 - Lonza Rhone Nord, Gebäude M7

Installed:
27.11.07 - 15.5.2008

Swiss coordinates:
634854 / 127884 ~ 650 m.s.l

Station: VISP5 Lonza Rhone Süd, Gebäude A7

Installed:
27.11.2007 - 15.5.2008
18.11.2008 - 17.12.2008

Swiss coordinates:
634938 / 127156 ~ 650 m.s.l.

Station: VISP6 - TS Balfrin

Installed:
4.12.2007 - 14.5.2008
18.11.2008 - 28.4.2009

Swiss coordinates:
634229 / 126912 ~ 650 m.s.l.

Station: VISP7 - TS Baumgärten

Installed:
4.12.2007 - 14.5.2008
18.11.2008 - 28.4.2009

Swiss coordinates:
634181 / 126637 ~ 650 m.s.l.

Station: VISP8 - TS Sonne

Installed:
4.12.2008 - 14.5.2008
18.11.2008 - 28.4.2009

Swiss coordinates::
634514 / 126858 ~ 650 m.s.l.

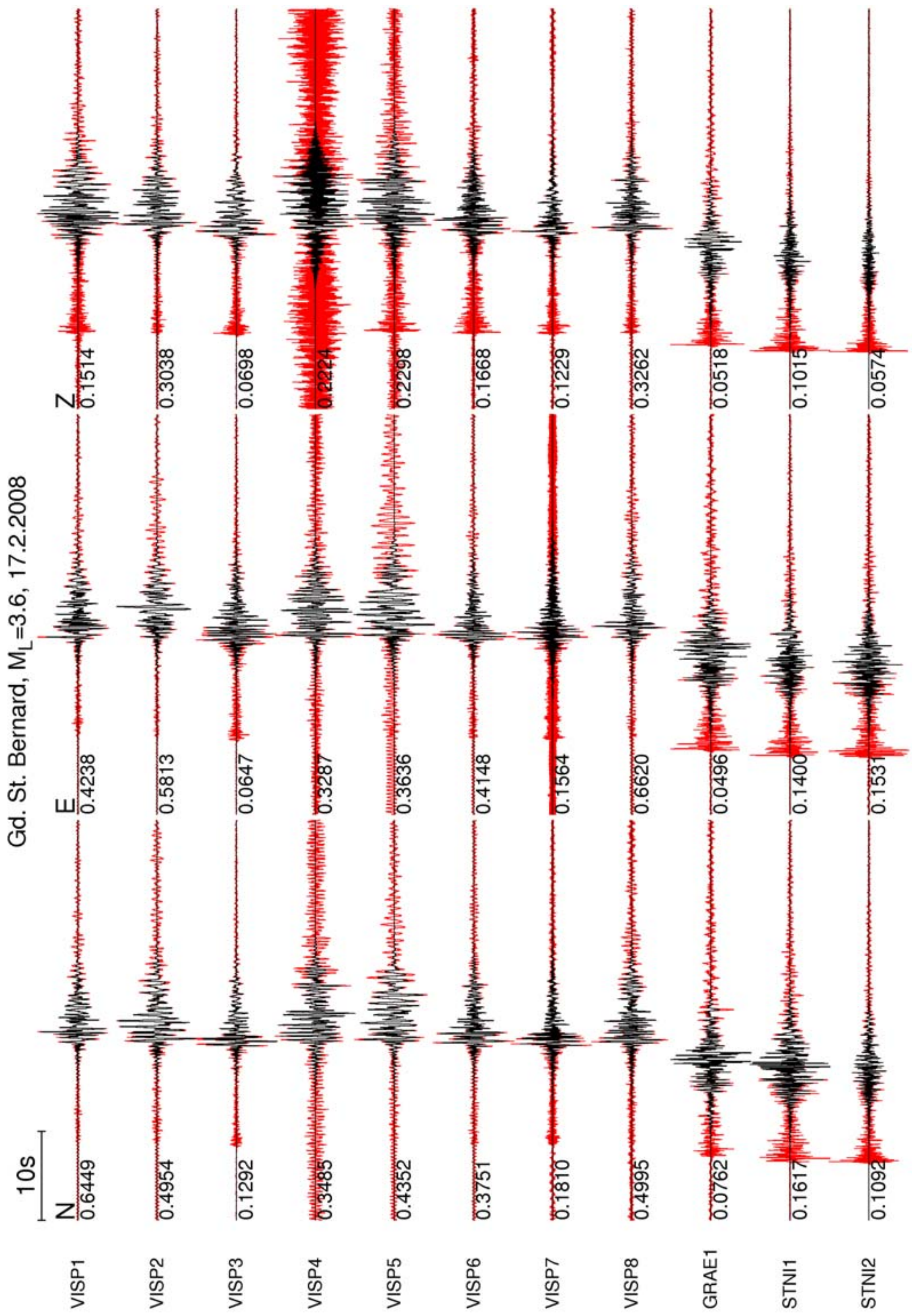
Station: VISP9 - Visp, Schützenhausgasse

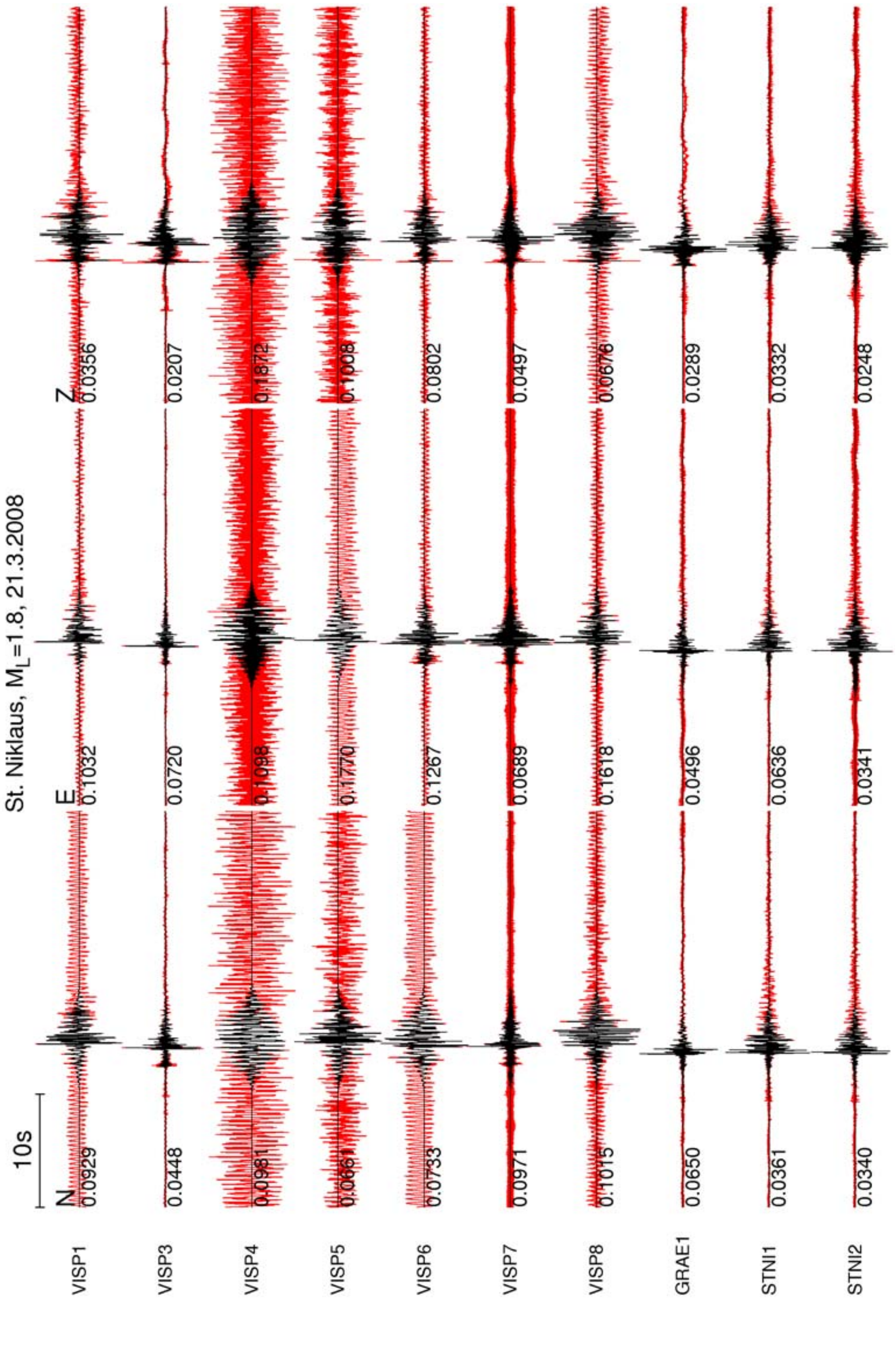
Installed:
8.12.2008-29.4.2009

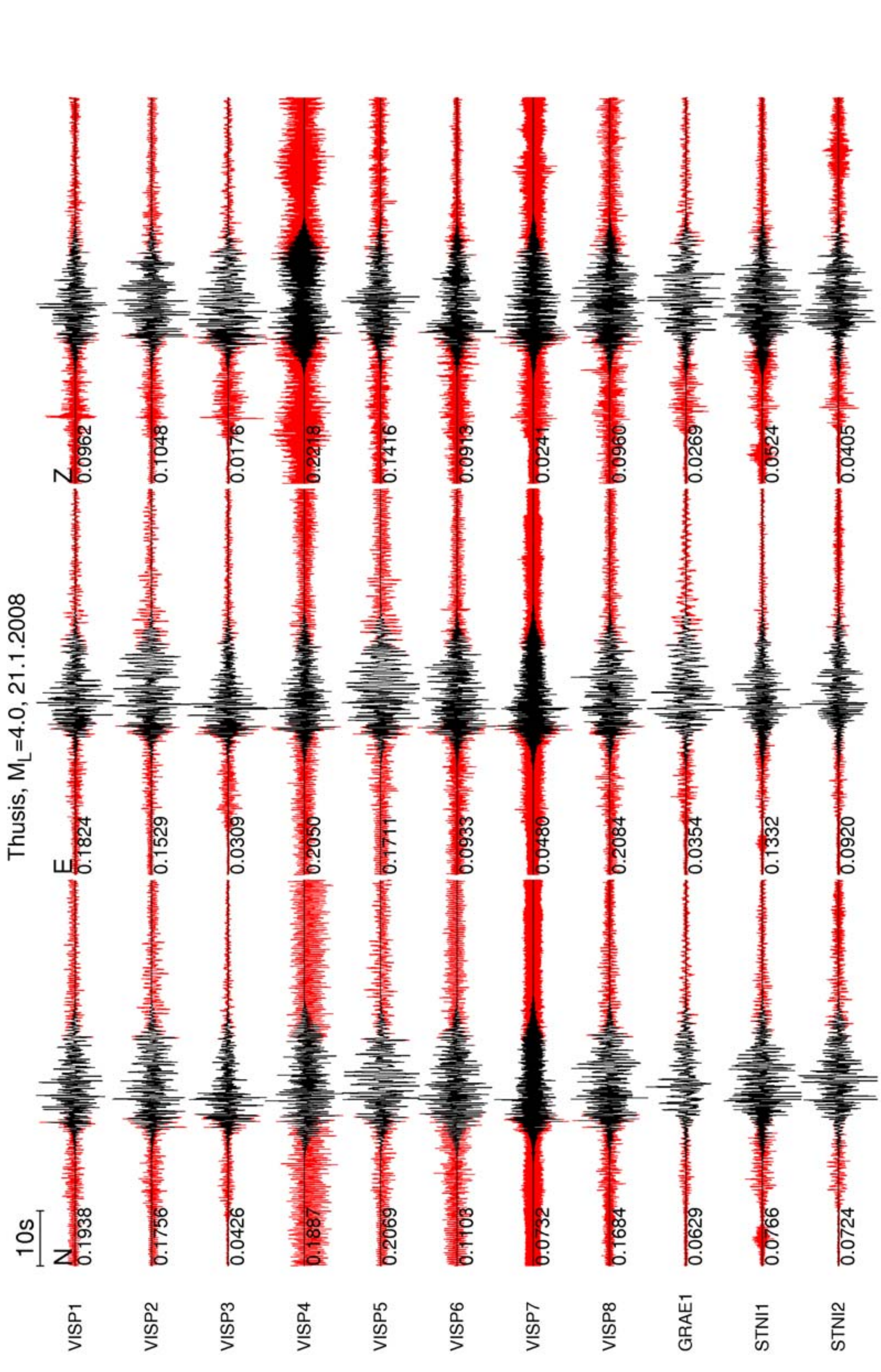
Swiss coordinates::
634105 / 126679 ~ 660 m.s.l.

Appendix B

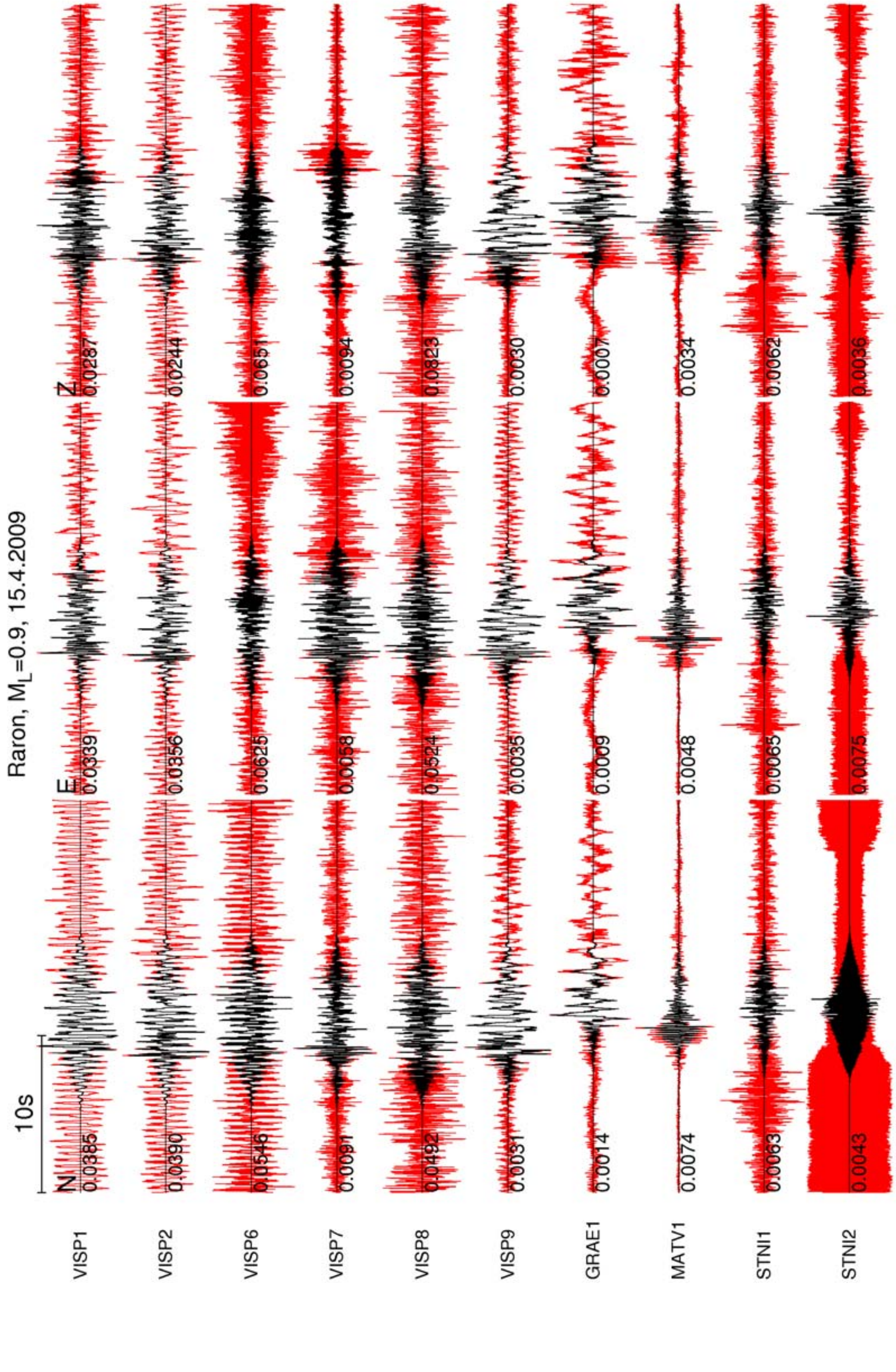
Unfiltered L3D-5s recordings of the events analyzed in this report (red: original trace, black: window used for site-to-reference spectral ratio). Traces are normalized to maximum visible value (i.e., to maximum of each red curve). Normalization constant is displayed on the beginning of each trace (in mm/s).

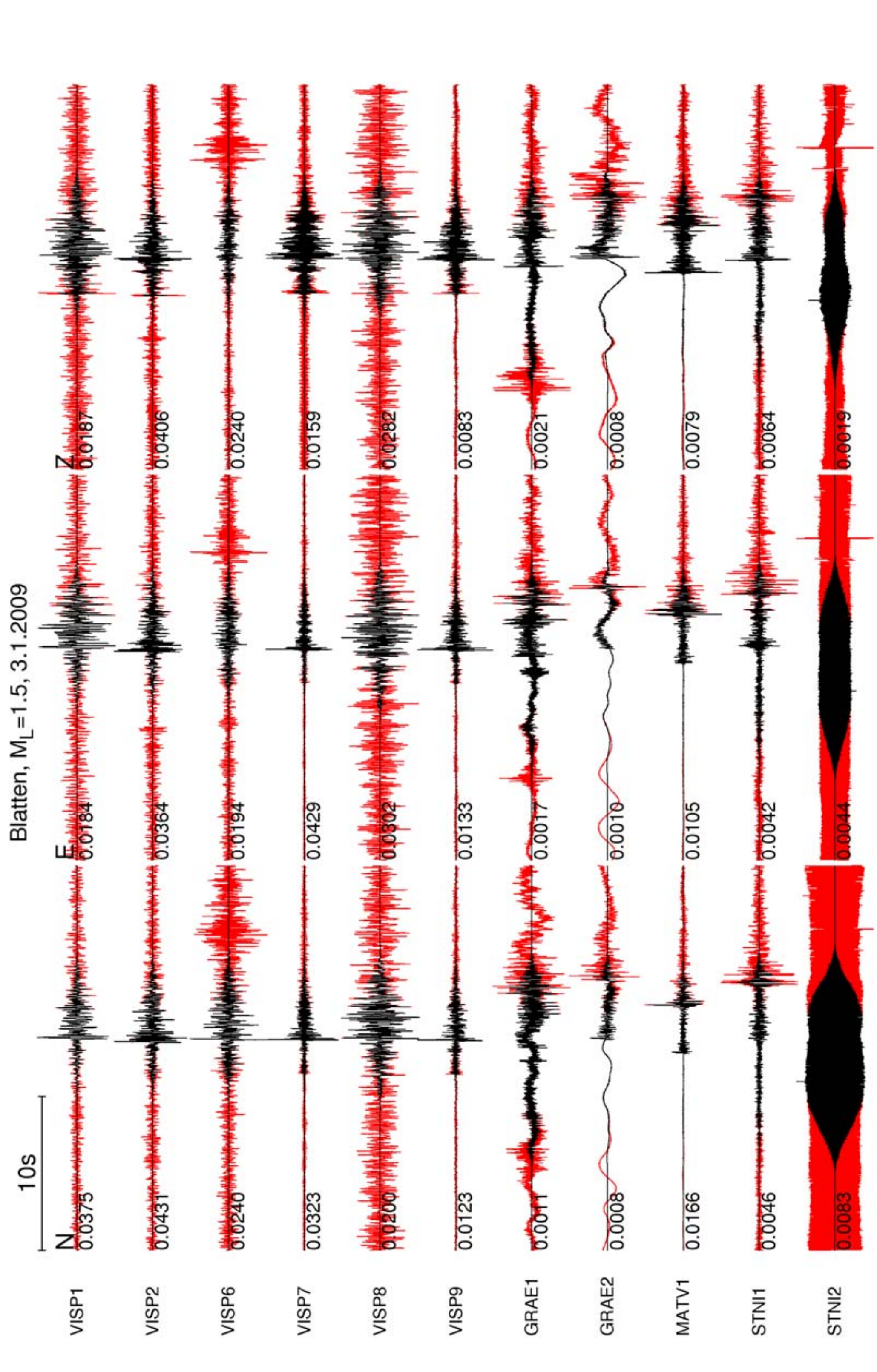


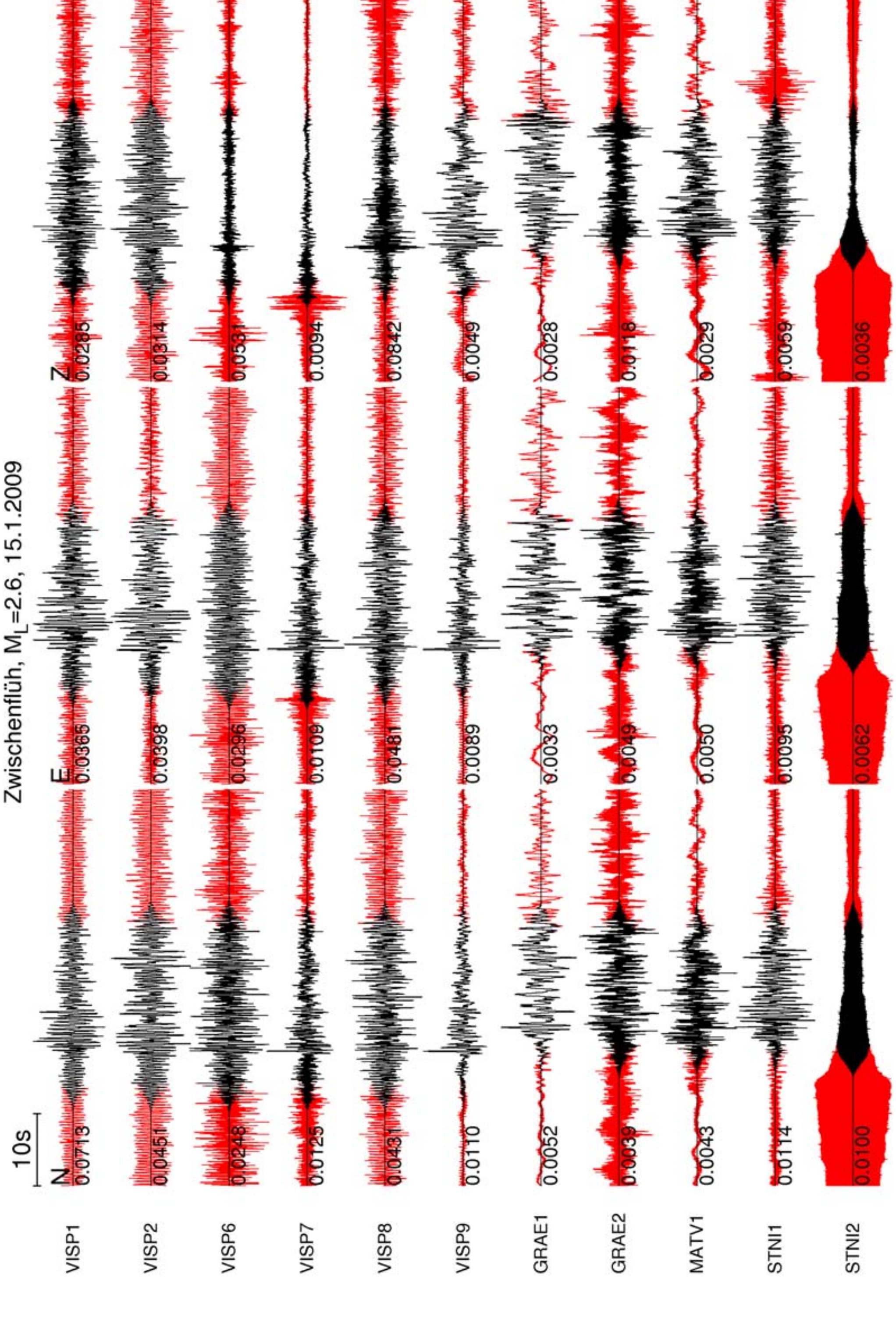

St. Niklaus, M_L=1.8, 21.3.2008
10s
N
E
Z
VISP1 0.0929 0.1032 0.0356
VISP3 0.0448 0.0720 0.0207
VISP4 0.0981 0.1098 0.1872
VISP5 0.0661 0.1770 0.1008
VISP6 0.0733 0.1267 0.0802
VISP7 0.0971 0.0689 0.0497
VISP8 0.1015 0.1618 0.0676
GRAE1 0.0650 0.0496 0.0289
STNI1 0.0361 0.0636 0.0332
STNI2 0.0340 0.0341 0.0248



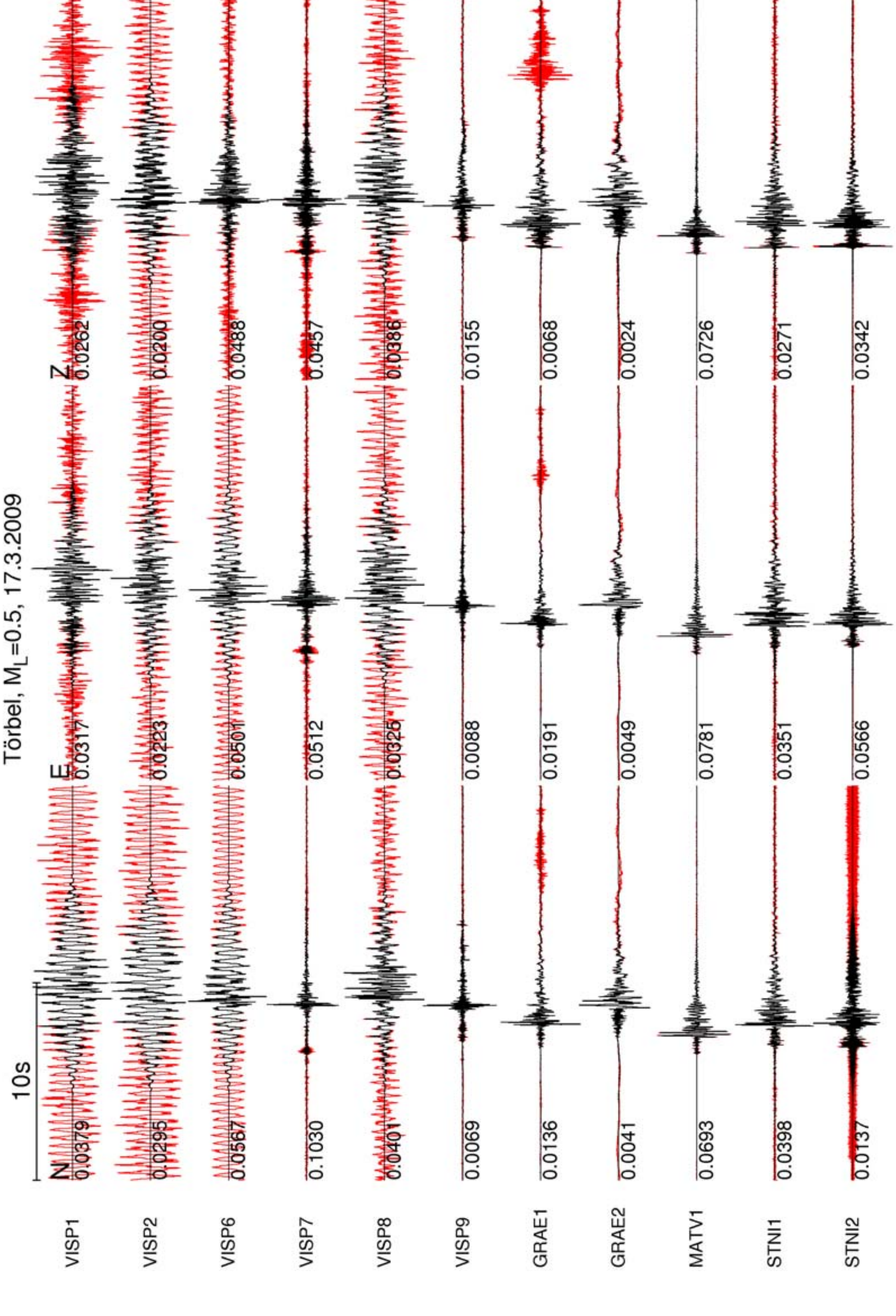
Thusis, M_L=4.0, 21.1.2008
10s
N
E
Z
VISP1
VISP2
VISP3
VISP4
VISP5
VISP6
VISP7
VISP8
GRAE1
STNI1
STNI2
0.1938
0.1756
0.0426
0.1887
0.2069
0.1103
0.0732
0.1684
0.0629
0.0766
0.0724
0.1824
0.1529
0.0309
0.2050
0.1711
0.0933
0.0480
0.2084
0.0354
0.1332
0.0920
0.0962
0.1048
0.0176
0.2218
0.1416
0.0913
0.0241
0.0960
0.0269
0.0524
0.0405


Raron, M_L=0.9, 15.4.2009
10s
N
E
Z
VISP1
VISP2
VISP6
VISP7
VISP8
VISP9
GRAE1
MATV1
STNI1
STNI2
0.0385
0.0390
0.0546
0.0091
0.0492
0.0031
0.0014
0.0074
0.0063
0.0043
0.0339
0.0356
0.0625
0.0058
0.0524
0.0035
0.0009
0.0048
0.0065
0.0075
0.0287
0.0244
0.0651
0.0094
0.0823
0.0030
0.0007
0.0034
0.0062
0.0036

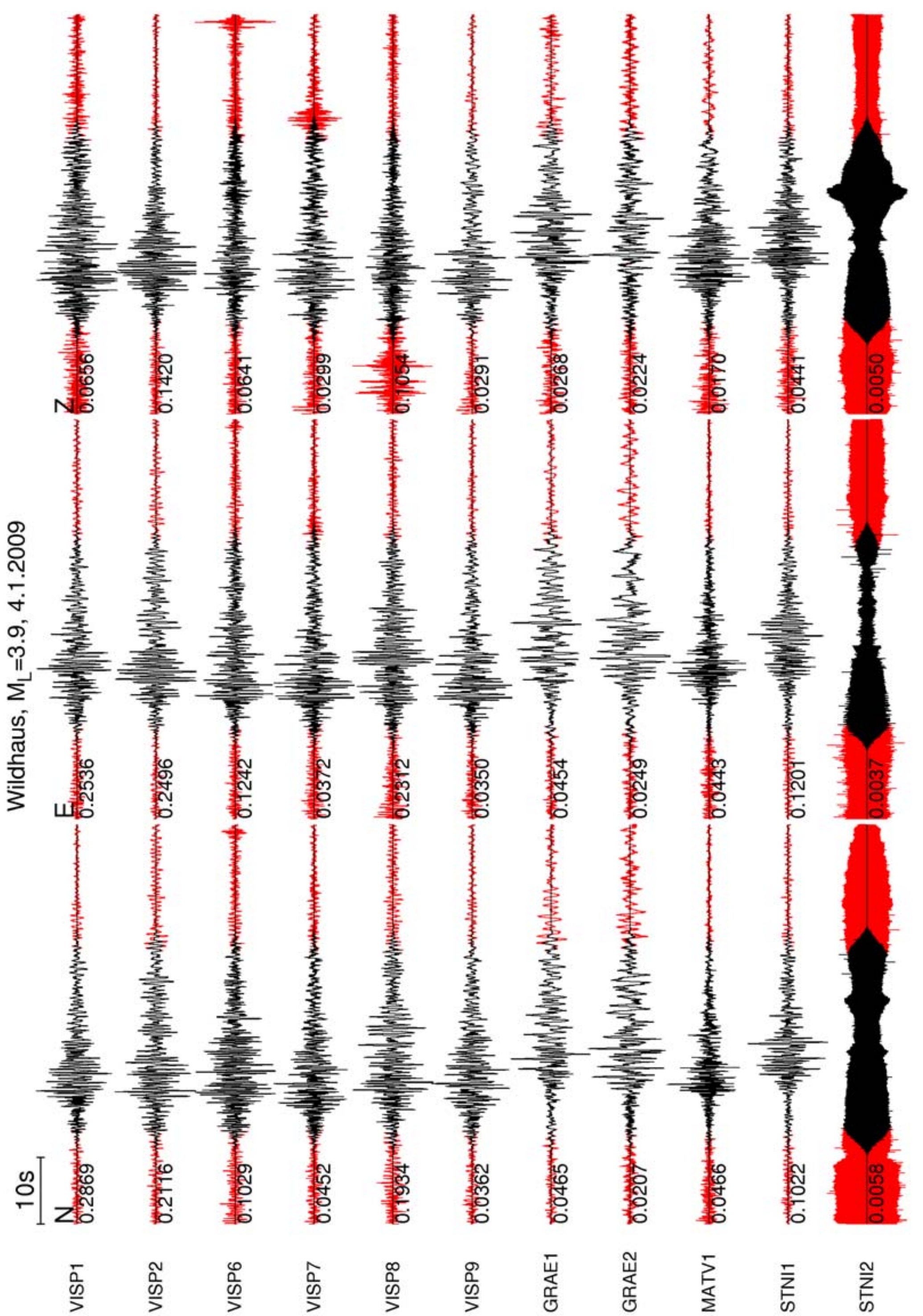

Blatten, M_L=1.5, 3.1.2009
10s
N
E
Z
VISP1
VISP2
VISP6
VISP7
VISP8
VISP9
GRAE1
GRAE2
MATV1
STNI1
STNI2
0.0375
0.0431
0.0240
0.0323
0.0200
0.0123
0.0011
0.0008
0.0166
0.0046
0.0083
0.0184
0.0364
0.0194
0.0429
0.0302
0.0133
0.0017
0.0010
0.0105
0.0042
0.0044
0.0187
0.0406
0.0240
0.0159
0.0282
0.0083
0.0021
0.0008
0.0079
0.0064
0.0019

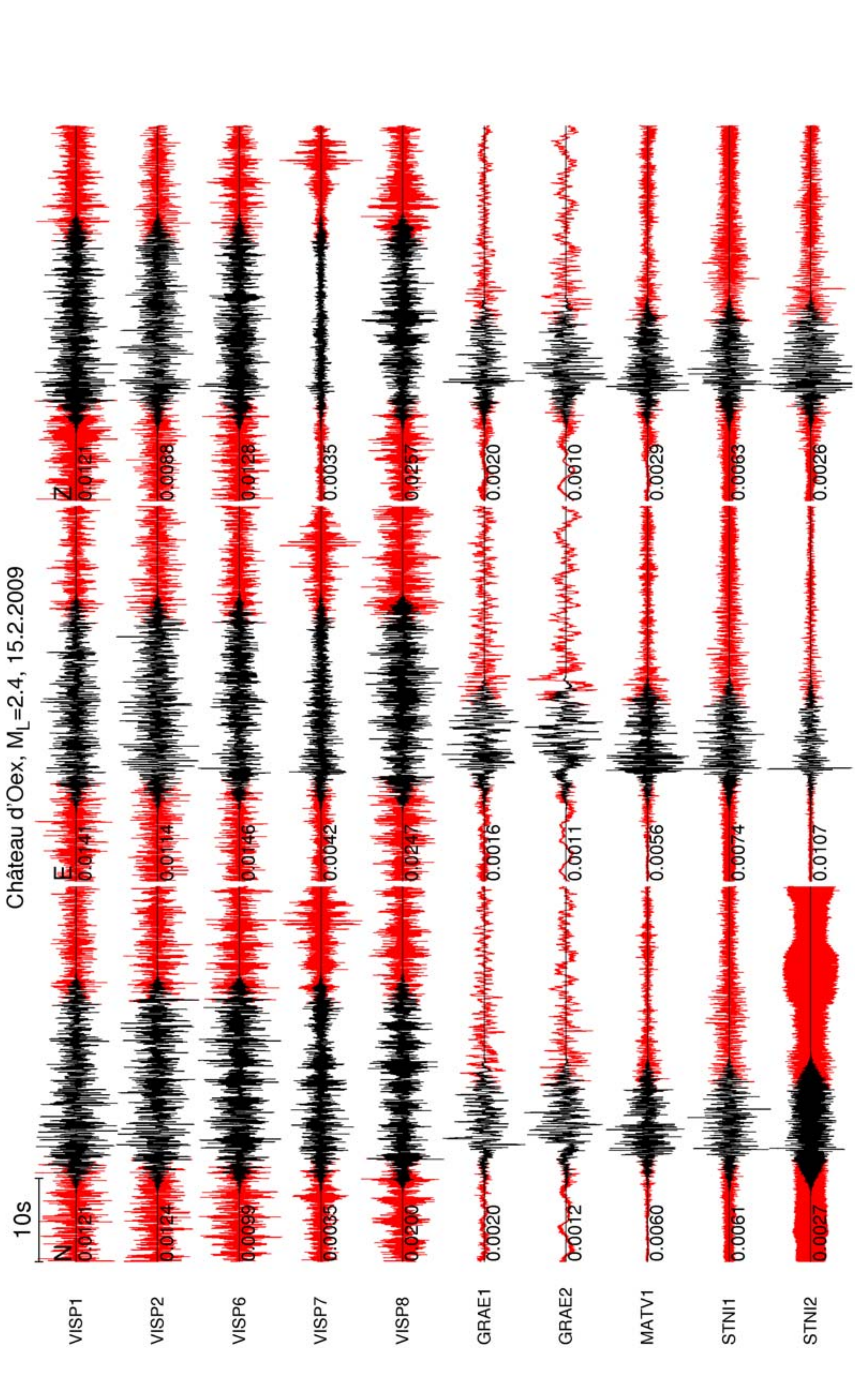


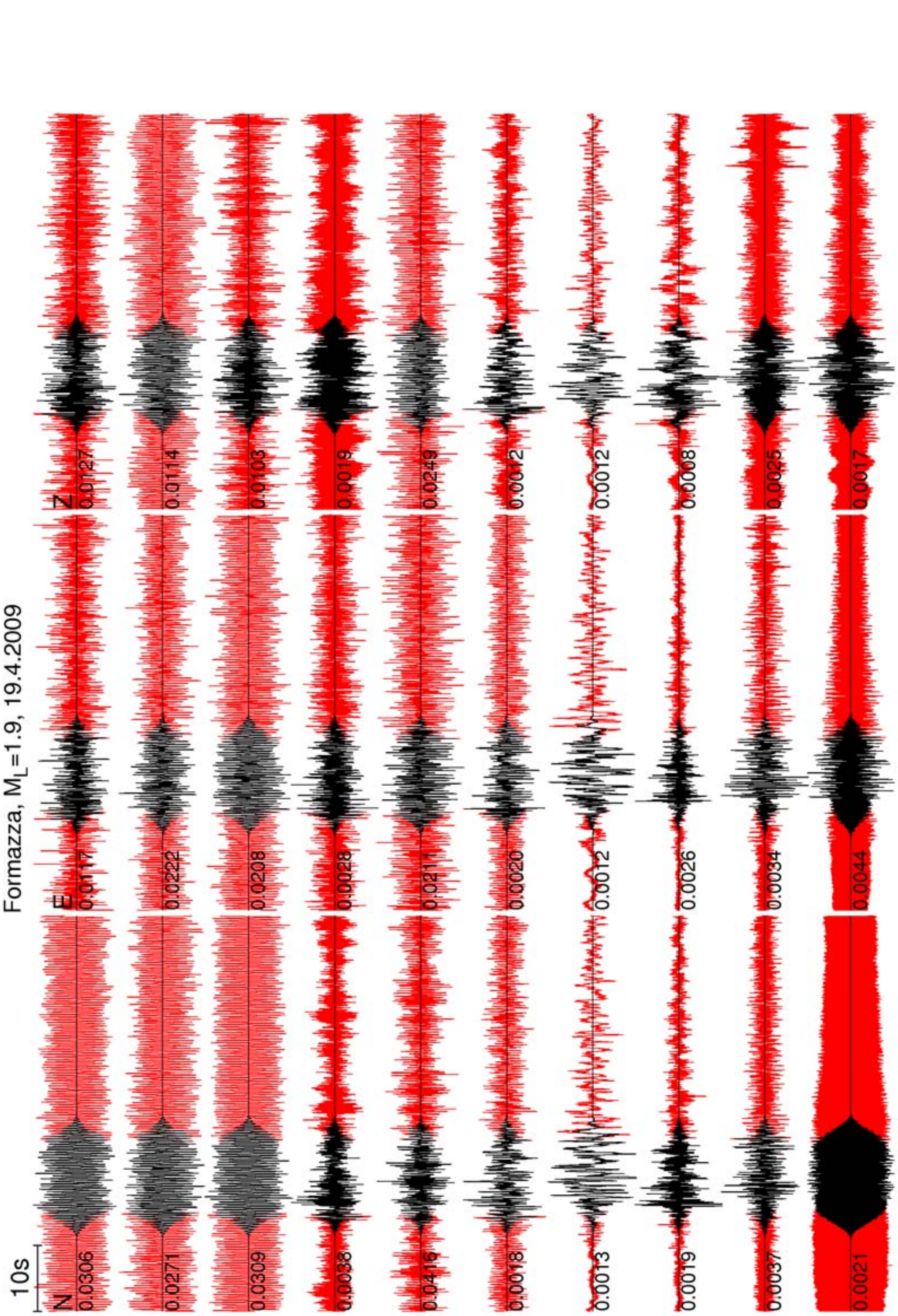
Zwischenflüh, M_L=2.6, 15.1.2009
10s
N
E
Z
VISP1 0.0713 0.0365 0.0285
VISP2 0.0451 0.0398 0.0314
VISP6 0.0248 0.0296 0.0531
VISP7 0.0125 0.0109 0.0094
VISP8 0.0431 0.0481 0.0842
VISP9 0.0110 0.0089 0.0049
GRAE1 0.0052 0.0033 0.0028
GRAE2 0.0039 0.0049 0.0118
MATV1 0.0043 0.0050 0.0029
STNI1 0.0114 0.0095 0.0059
STNI2 0.0100 0.0062 0.0036

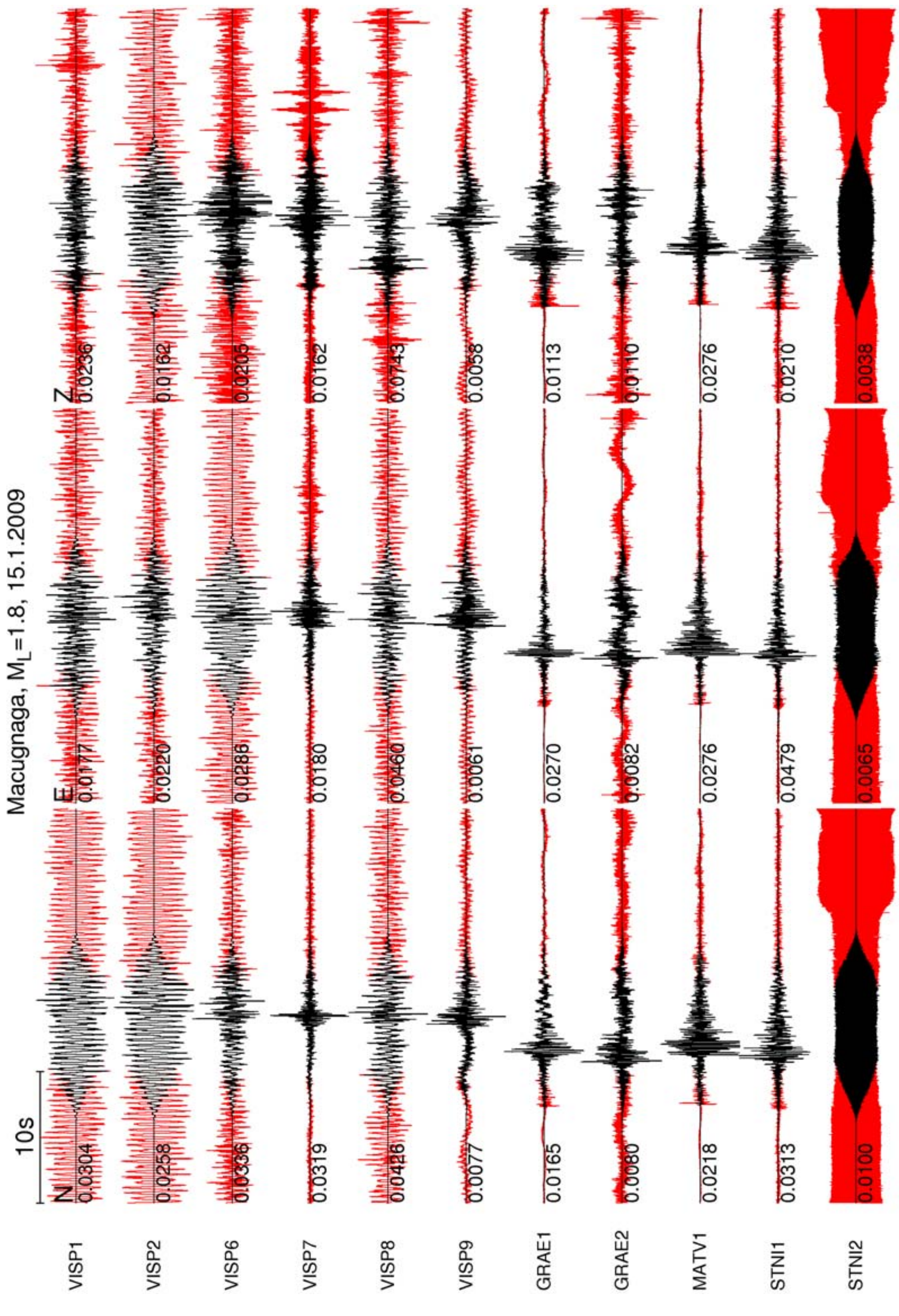


Törbel, M_L=0.5, 17.3.2009
10s
N
E
Z
VISP1 0.0379 0.0317 0.0262
VISP2 0.0295 0.0223 0.0200
VISP6 0.0567 0.0501 0.0488
VISP7 0.1030 0.0512 0.0457
VISP8 0.0401 0.0325 0.0386
VISP9 0.0069 0.0088 0.0155
GRAE1 0.0136 0.0191 0.0068
GRAE2 0.0041 0.0049 0.0024
MATV1 0.0693 0.0781 0.0726
STNI1 0.0398 0.0351 0.0271
STNI2 0.0137 0.0566 0.0342

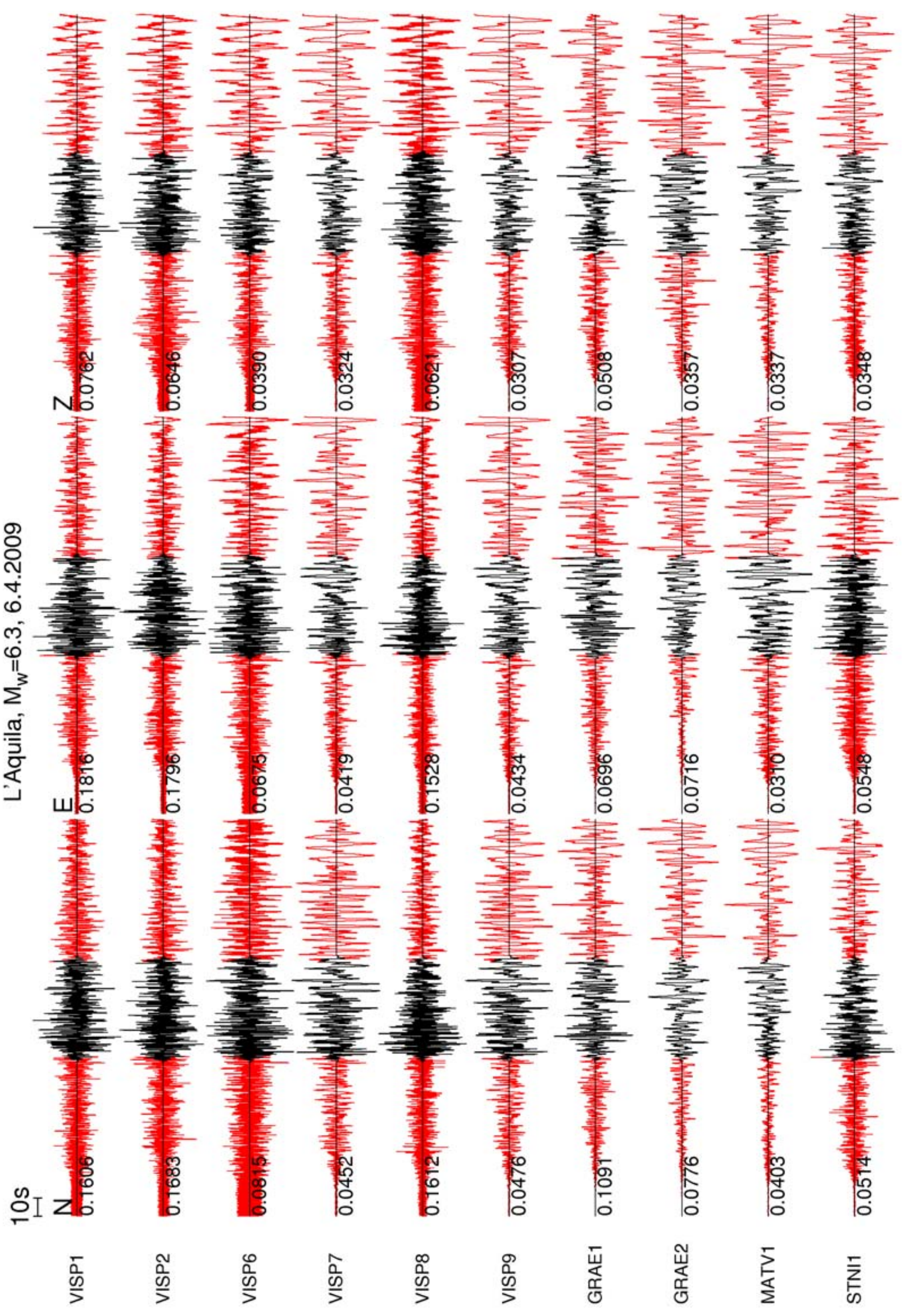

Wildhaus, M_L=3.9, 4.1.2009
10s
N
E
Z
VISP1
0.2869
0.2536
0.0656
VISP2
0.2116
0.2496
0.1420
VISP6
0.1029
0.1242
0.0641
VISP7
0.0452
0.0372
0.0299
VISP8
0.1934
0.2312
0.1054
VISP9
0.0362
0.0350
0.0291
GRAE1
0.0465
0.0454
0.0268
GRAE2
0.0207
0.0249
0.0224
MATV1
0.0466
0.0443
0.0170
STNI1
0.1022
0.1201
0.0441
STNI2
0.0058
0.0037
0.0050


Château d'Oex, M$_L$=2.4, 15.2.2009
10s
N
E
Z
VISP1
VISP2
VISP6
VISP7
VISP8
GRAE1
GRAE2
MATV1
STNI1
STNI2
0.0121
0.0124
0.0099
0.0035
0.0200
0.0020
0.0012
0.0060
0.0061
0.0027
0.0141
0.0114
0.0146
0.0042
0.0247
0.0016
0.0011
0.0056
0.0074
0.0107
0.0121
0.0088
0.0128
0.0035
0.0257
0.0020
0.0010
0.0029
0.0063
0.0026


Formazza, M_L=1.9, 19.4.2009
10s
N
E
Z
VISP1
VISP2
VISP6
VISP7
VISP8
VISP9
GRAE1
MATV1
STNI1
STNI2
0.0306
0.0271
0.0309
0.0033
0.0416
0.0018
0.0013
0.0019
0.0037
0.0021
0.0117
0.0222
0.0208
0.0028
0.0211
0.0020
0.0012
0.0026
0.0034
0.0044
0.0127
0.0114
0.0103
0.0019
0.0249
0.0012
0.0012
0.0008
0.0025
0.0017



Macugnaga, M_L=1.8, 15.1.2009
10s
N
E
Z
VISP1
VISP2
VISP6
VISP7
VISP8
VISP9
GRAE1
GRAE2
MATV1
STNI1
STNI2
0.0304
0.0258
0.0336
0.0319
0.0426
0.0077
0.0165
0.0218
0.0313
0.0100
0.0177
0.0220
0.0286
0.0180
0.0460
0.0061
0.0270
0.0082
0.0276
0.0479
0.0065
0.0236
0.0162
0.0205
0.0162
0.0743
0.0058
0.0113
0.0276
0.0210
0.0038



L'Aquila, M_W=6.3, 6.4.2009
10s
N
E
Z
VISP1
VISP2
VISP6
VISP7
VISP8
VISP9
GRAE1
GRAE2
MATV1
STNI1
0.1606 0.1816 0.0762
0.1683 0.1796 0.0646
0.0815 0.0675 0.0390
0.0452 0.0419 0.0324
0.1612 0.1528 0.0621
0.0476 0.0434 0.0307
0.1091 0.0696 0.0508
0.0776 0.0716 0.0357
0.0403 0.0310 0.0337
0.0514 0.0548 0.0348