



PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile



CONFERENZA DELLE REGIONI E
DELLE PROVINCE AUTONOME

Attuazione dell'articolo 11 della legge 24 giugno 2009, n.77

MICROZONAZIONE SISMICA

Livello 3

Regione Emilia-Romagna
Comune di Sant'Agostino (FE)



Relazione Illustrativa – Allegato 2

Rapporti di Prova

Regione	Soggetto realizzatore	Data
Emilia-Romagna	Geotema S.r.l.	02/05/2019

MISURE DI MICROTREMORE

STATION INFORMATION

Station code: SSSSS

Model: SARA SL06

Sensor: SARA SS20PACK (integrated 2.0 Hz sensors)

Notes: -

PLACE INFORMATION

Place ID: HVSR1ter

Address: Via Banche - Dosso (FE)

Latitude: 44° 45.892'N

Longitude: 11° 19.859'E

Coordinate system: WGS84

Elevation: -

Weather: -

Notes: -

SIGNAL AND WINDOWING

Sampling frequency: 250 Hz

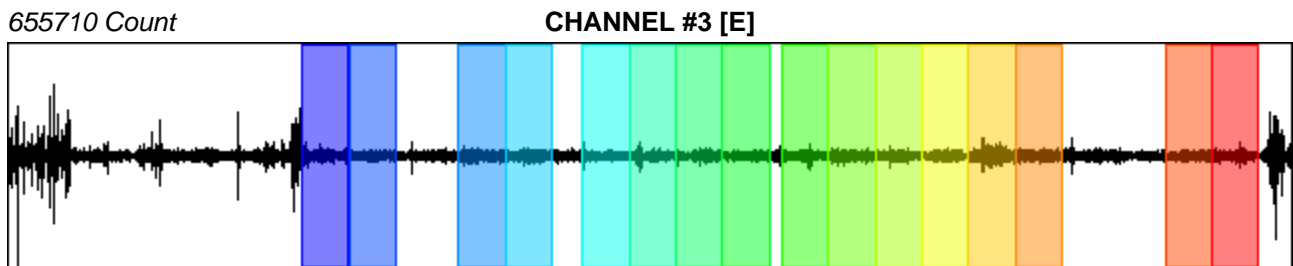
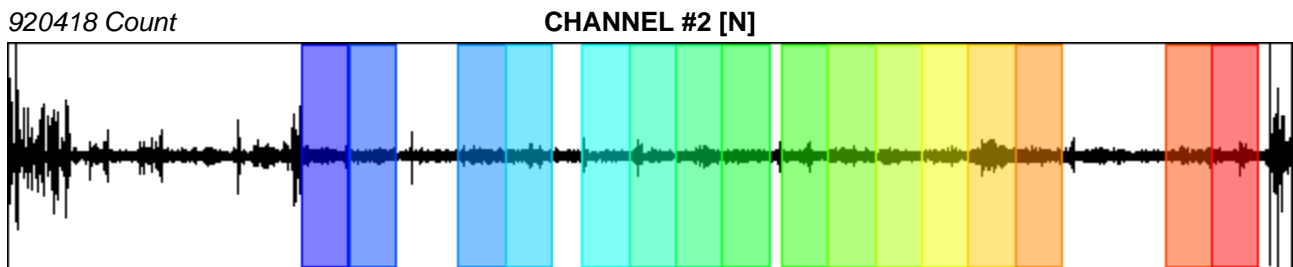
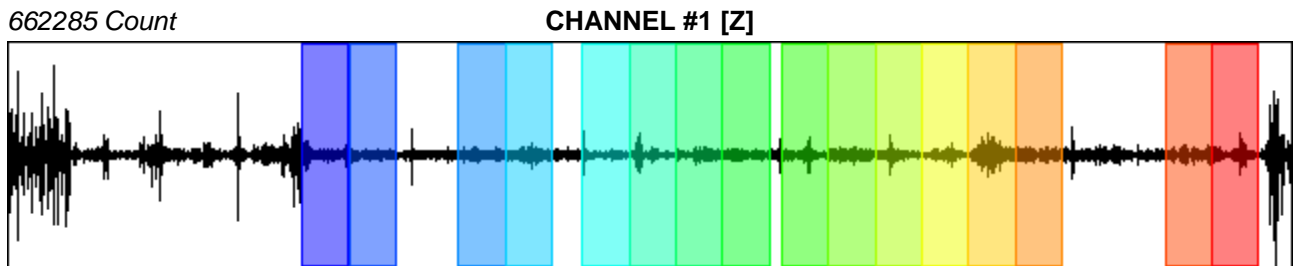
Recording start time: 2018/11/26 14:00:16

Recording length: 82.55 min

Windows count: 16

Average windows length: 179.53

Signal coverage: 58%



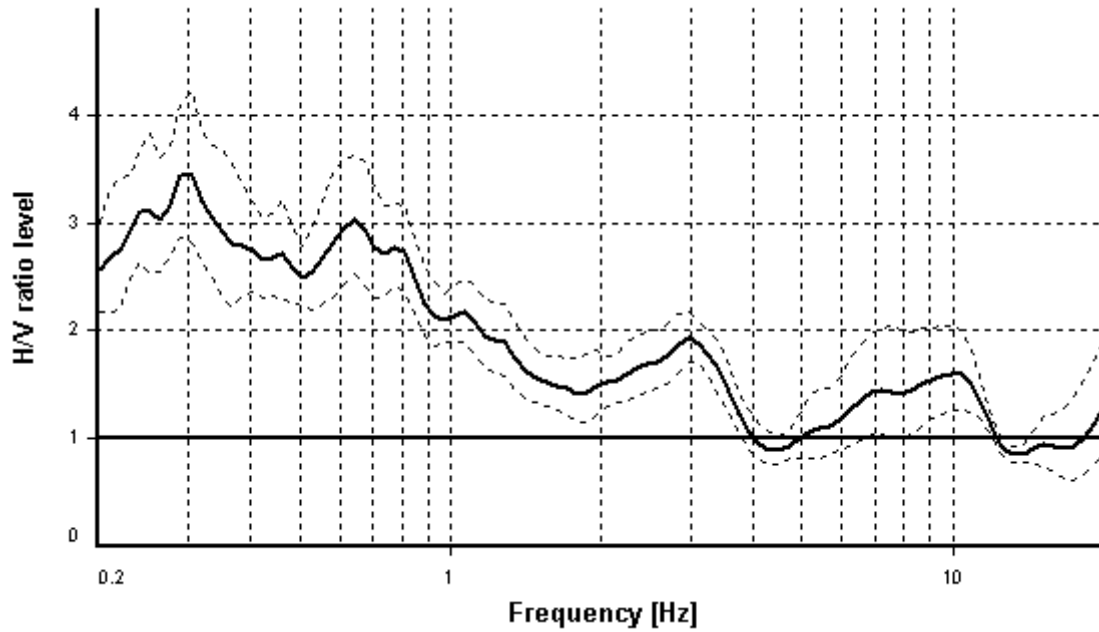
HVSR ANALYSIS

Tapering: Enabled (Bandwidth = 5%)

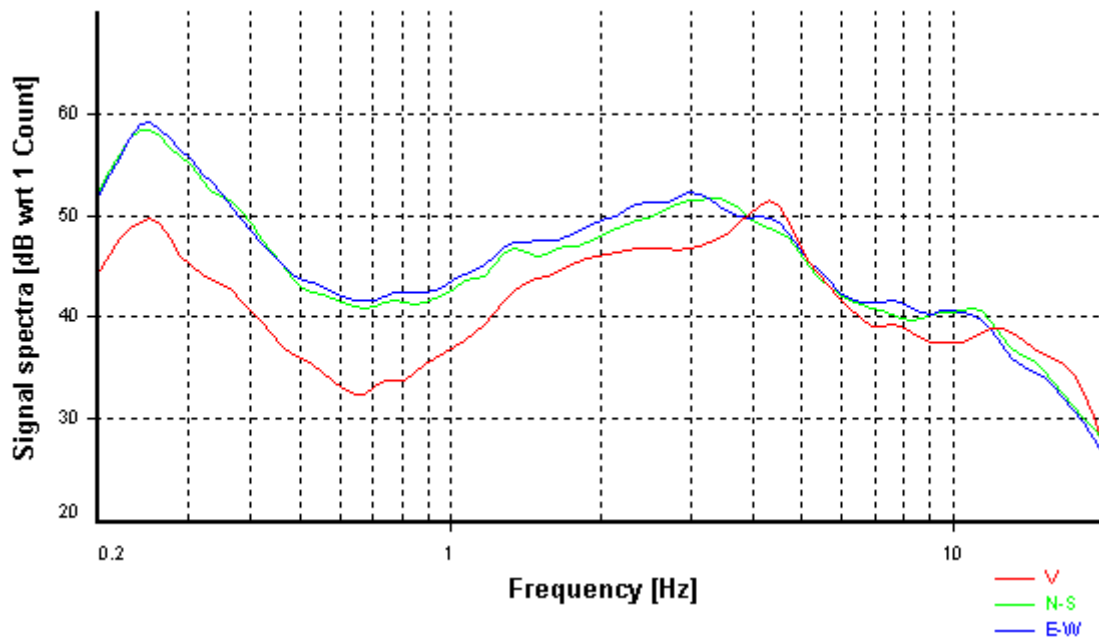
Smoothing: Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

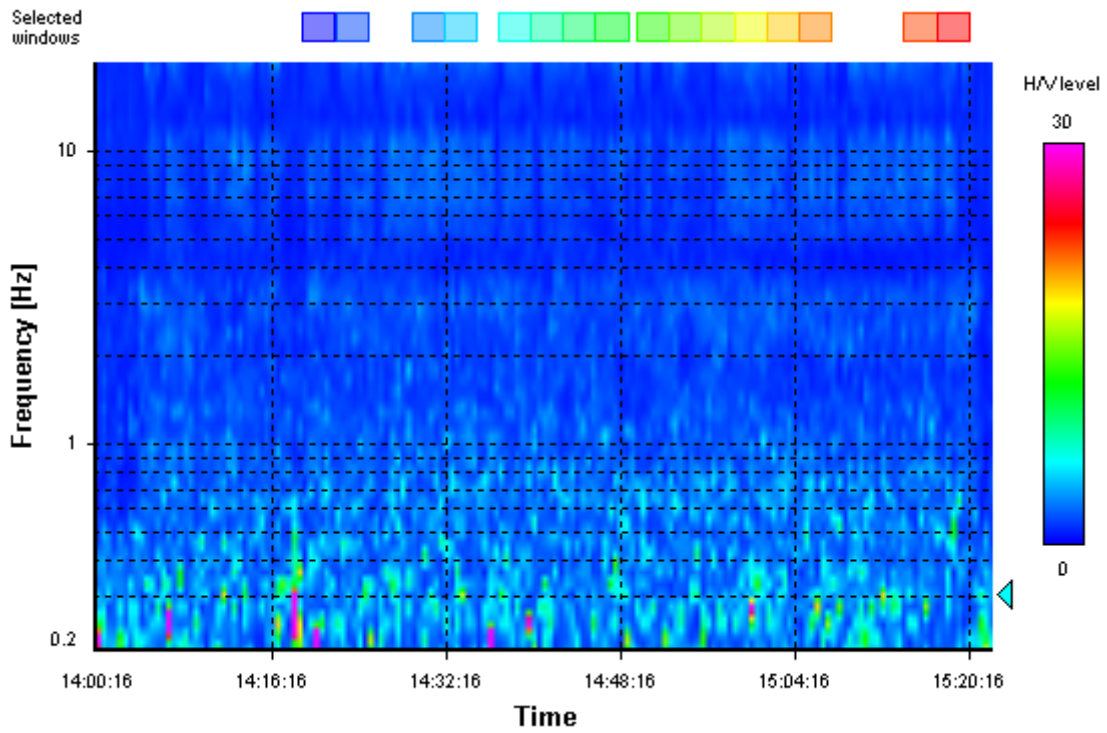
HVSR average



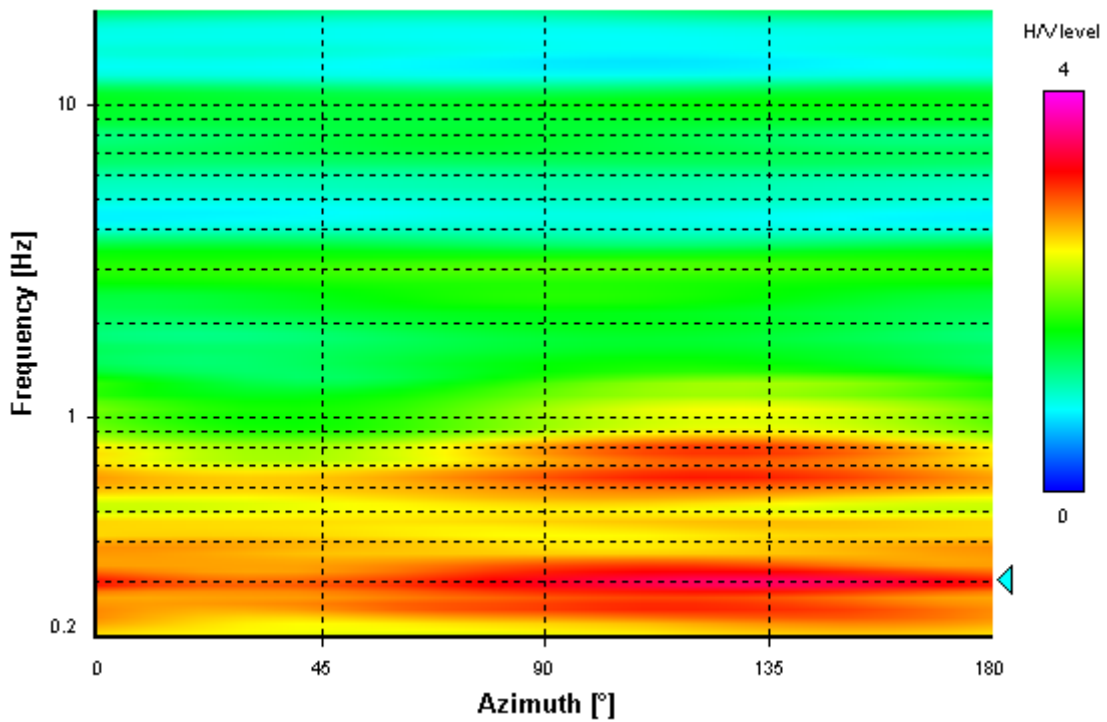
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



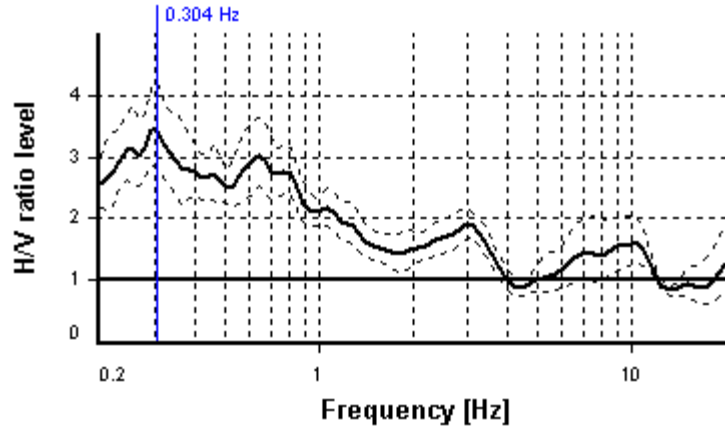
SESAME CRITERIA

Selected f_0 frequency

0.304 Hz

A_0 amplitude = 3.447

Average $f_0 = 0.311 \pm 0.065$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	16 valid windows (length > 32.9 s) out of 16	OK
$n_c(f_0) > 200$	873.19 > 200	OK
$\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 24	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	0 Hz	NO
$A_0 > 2$	3.45 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	4.55% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.06477 >= 0.0608	NO
$\sigma_A(f_0) < \theta(f_0)$	1.22736 < 2.5	OK
Overall criteria fulfillment		NO

STATION INFORMATION

Station code: SSSSS

Model: SARA SL06

Sensor: SARA SS20PACK (integrated 2.0 Hz sensors)

Notes: -

PLACE INFORMATION

Place ID: HVSR2bis

Address: Via Giuseppe Verdi - Dosso (FE)

Latitude: 44° 46.015'N

Longitude: 11° 20.114'E

Coordinate system: WGS84

Elevation: 20 m s.l.m.

Weather: -

Notes: -

SIGNAL AND WINDOWING

Sampling frequency: 100 Hz

Recording start time: 2018/05/26 08:05:00

Recording length: 235 min

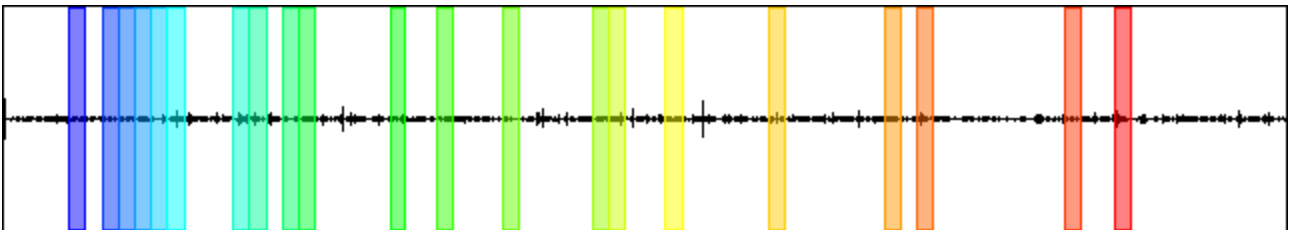
Windows count: 21

Average windows length: 178.11

Signal coverage: 26.53%

1839618 Count

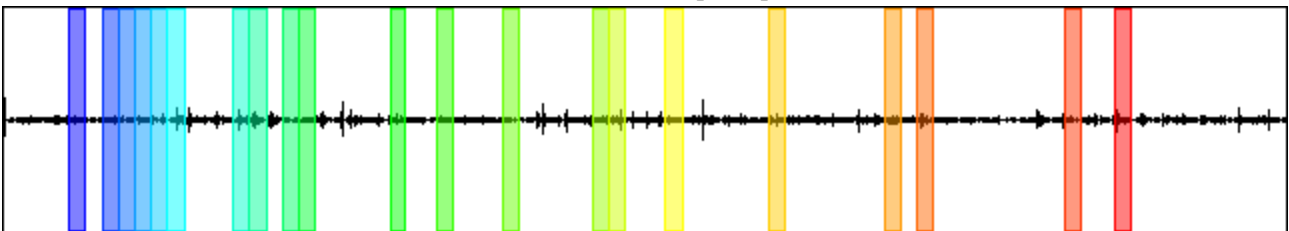
CHANNEL #1 [EHZ]



-965975 Count

567218 Count

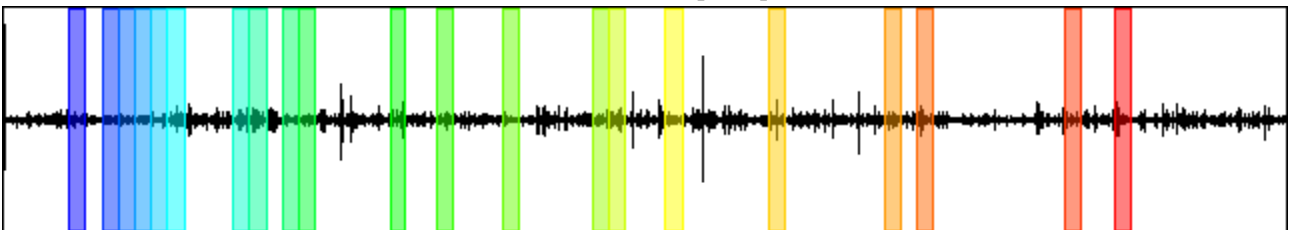
CHANNEL #2 [EHN]



-948593 Count

425867 Count

CHANNEL #3 [EHE]



-417108 Count

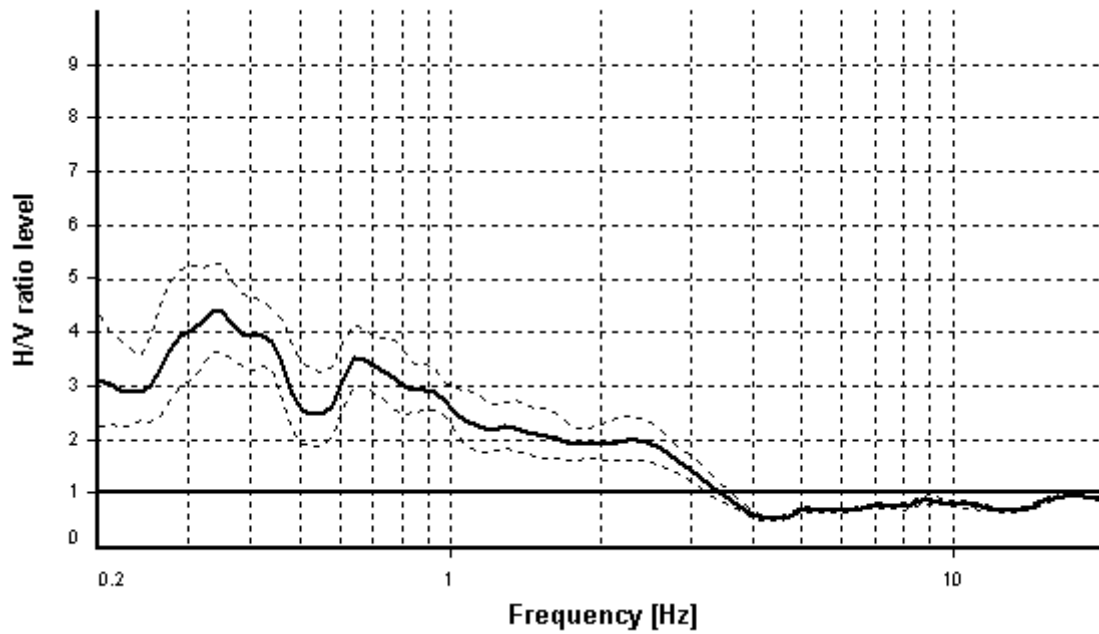
HVSR ANALYSIS

Tapering: Enabled (Bandwidth = 5%)

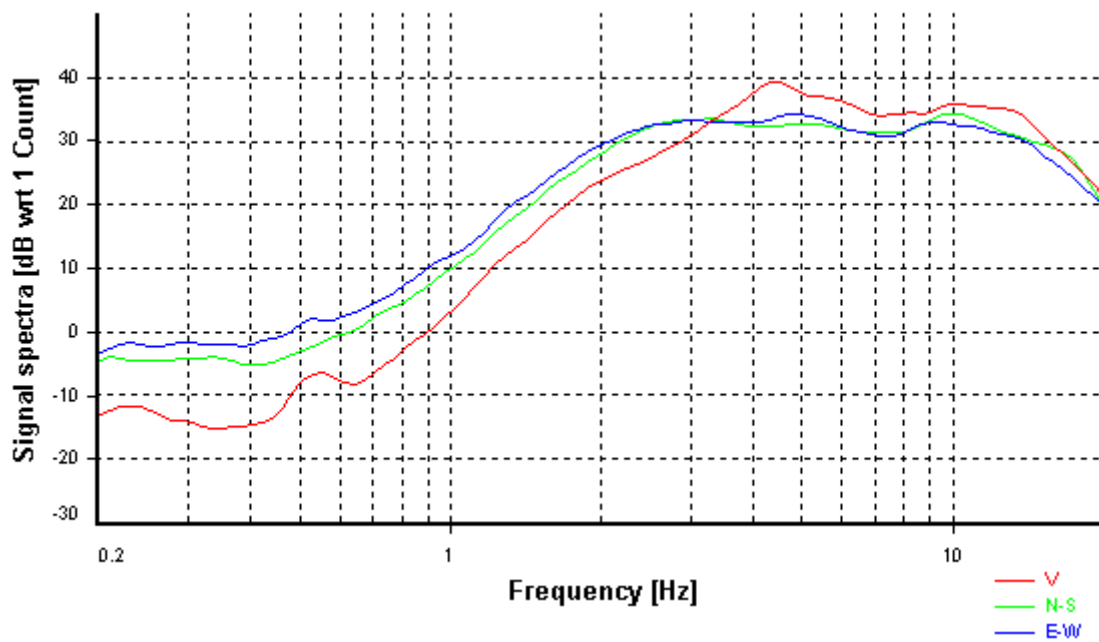
Smoothing: Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

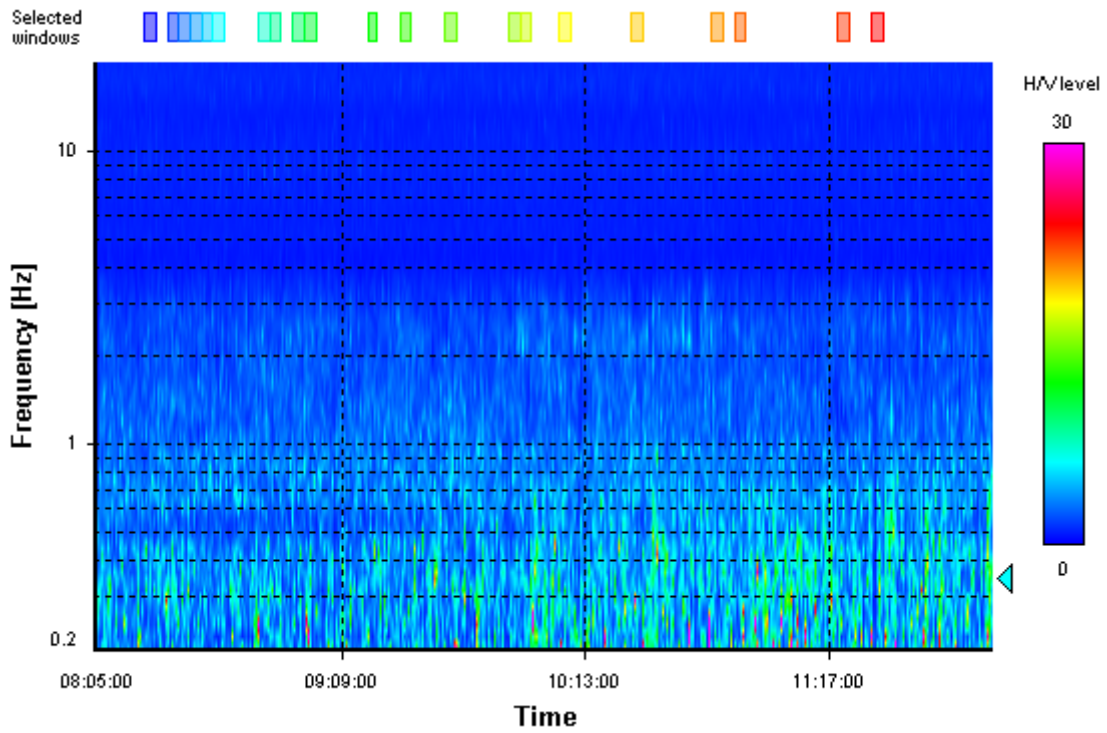
HVSR average



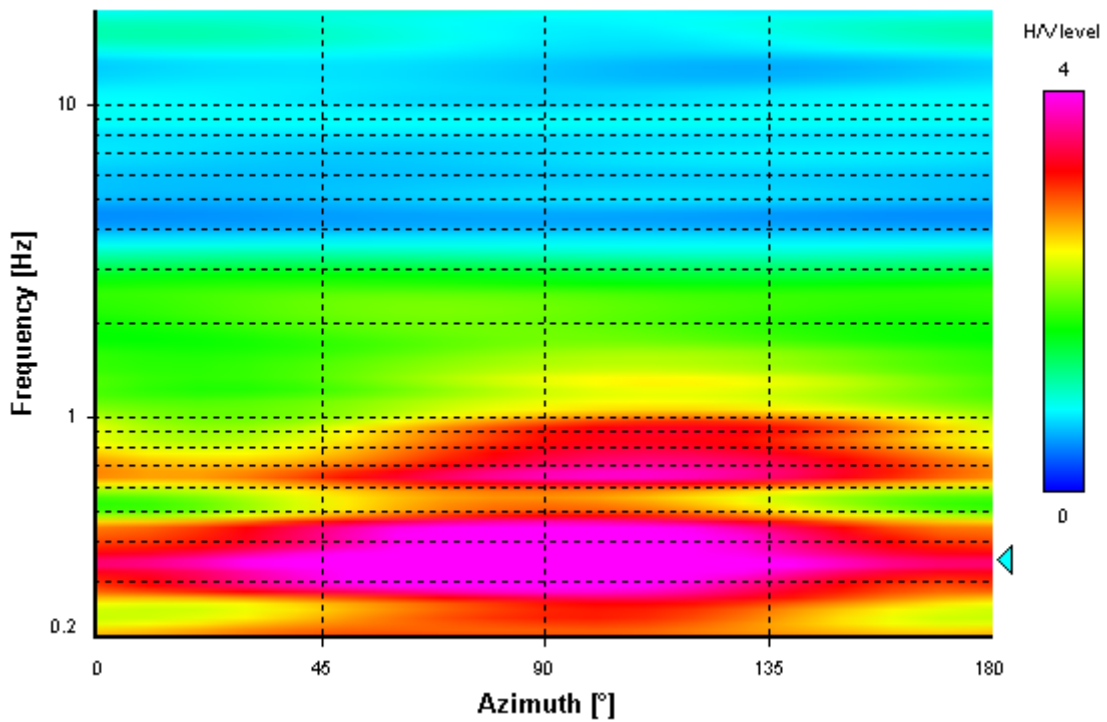
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



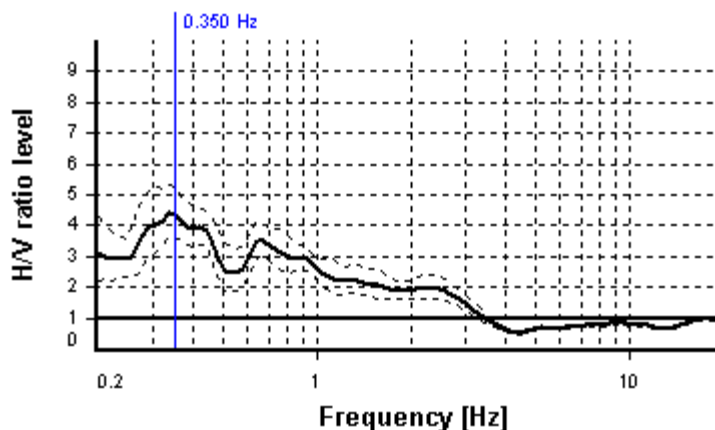
SESAME CRITERIA

Selected f_0 frequency

0.350 Hz

A_0 amplitude = 4.365

Average $f_0 = 0.341 \pm 0.044$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	21 valid windows (length > 28.61 s) out of 21	OK
$n_c(f_0) > 200$	1307.27 > 200	OK
$\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 27	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	1.22718 Hz	OK
$A_0 > 2$	4.37 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	4.55% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.04375 < 0.0699	OK
$\sigma_A(f_0) < \theta(f_0)$	1.2066 < 2.5	OK
Overall criteria fulfillment		OK

STATION INFORMATION

Station code: SSSSS

Model: SARA SL06

Sensor: SARA SS20PACK (integrated 2.0 Hz sensors)

Notes: -

PLACE INFORMATION

Place ID: HVSR3bis

Address: Via Monte Cassino - Dosso (FE)

Latitude: 44° 46.356'N

Longitude: 11° 20.409'E

Coordinate system: WGS84

Elevation: 20 m s.l.m.

Weather: -

Notes: -

SIGNAL AND WINDOWING

Sampling frequency: 100 Hz

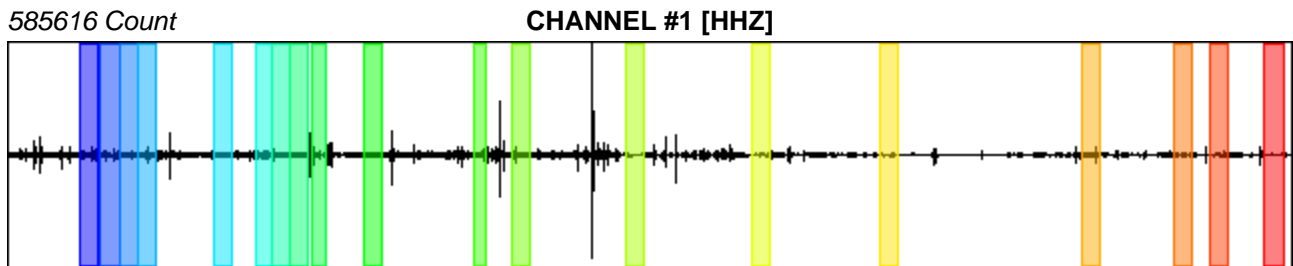
Recording start time: 2018/05/26 08:30:00

Recording length: 210 min

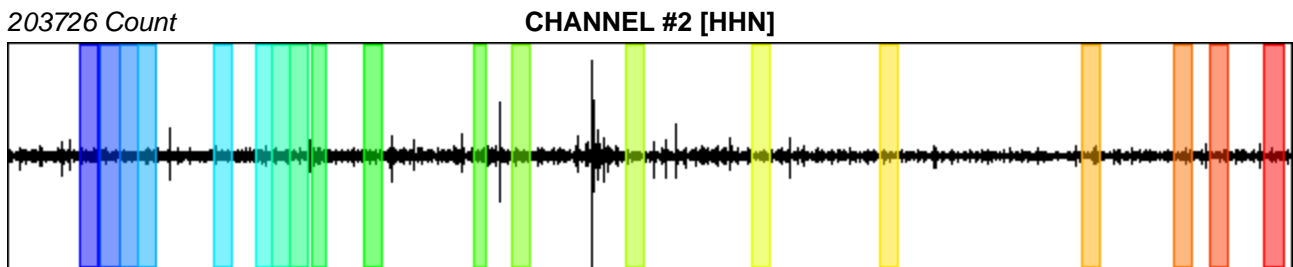
Windows count: 19

Average windows length: 172.76

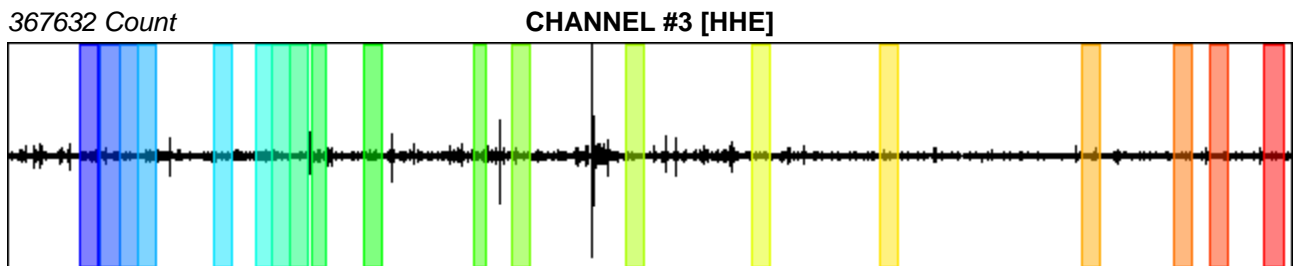
Signal coverage: 26.05%



-542921 Count



-239498 Count



-336731 Count

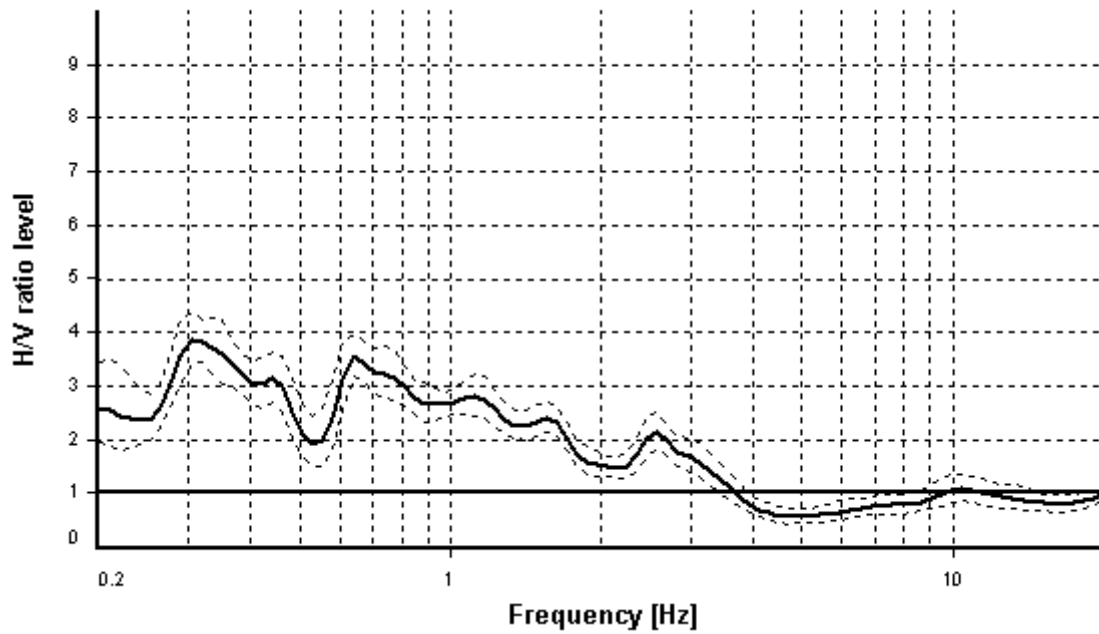
HVSR ANALYSIS

Tapering: Enabled (Bandwidth = 5%)

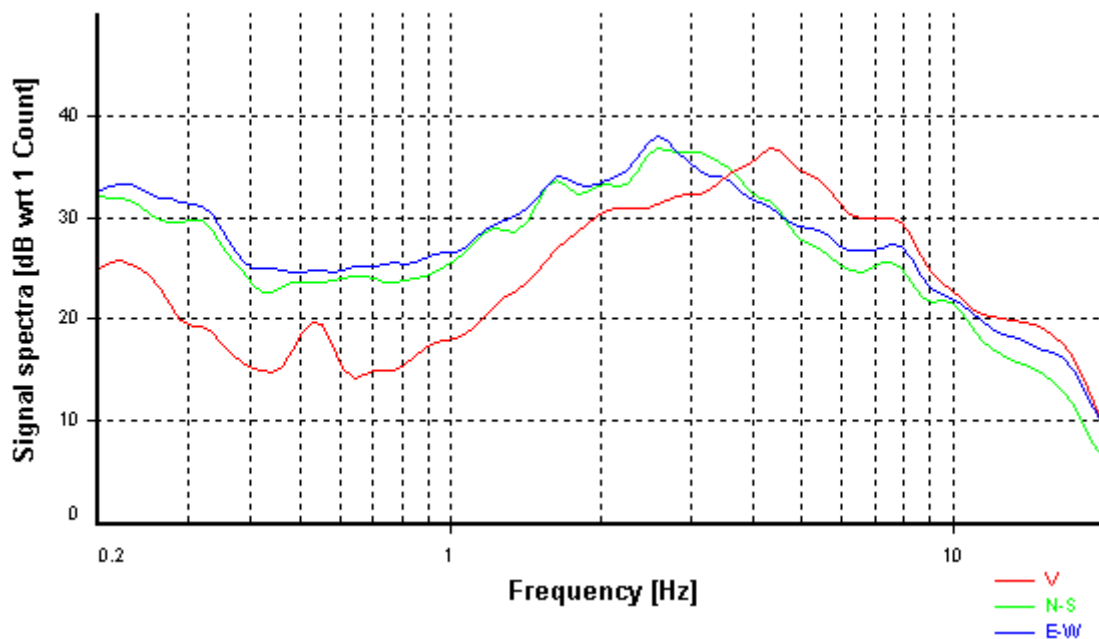
Smoothing: Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

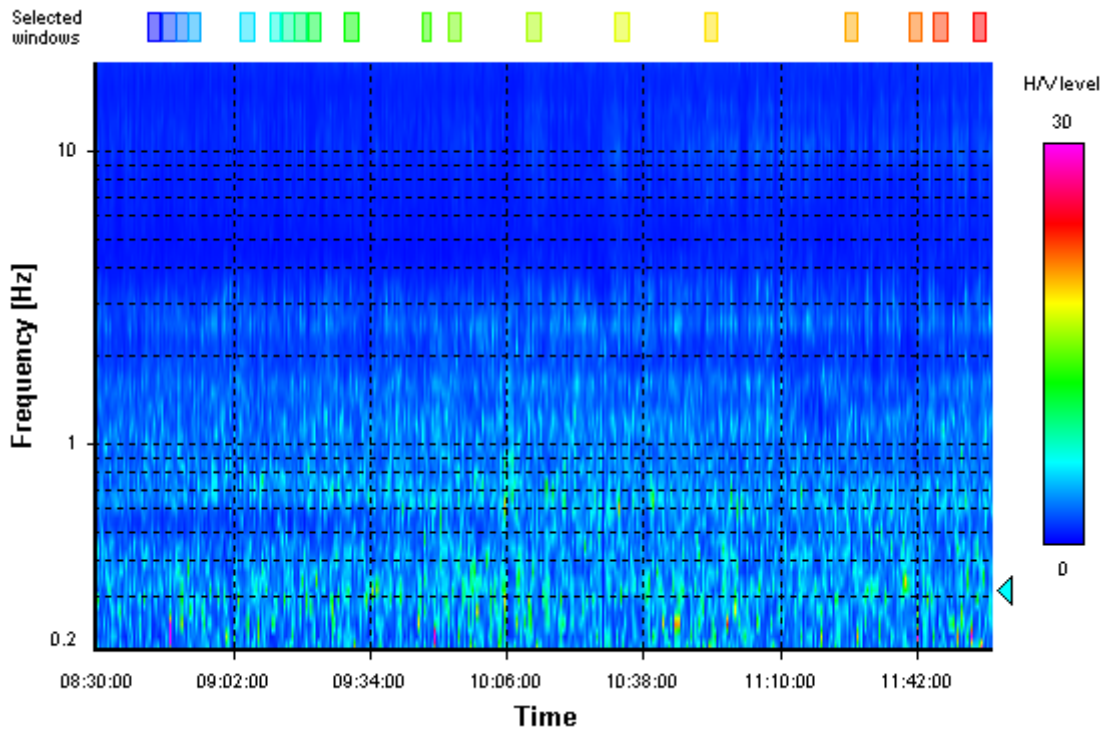
HVSR average



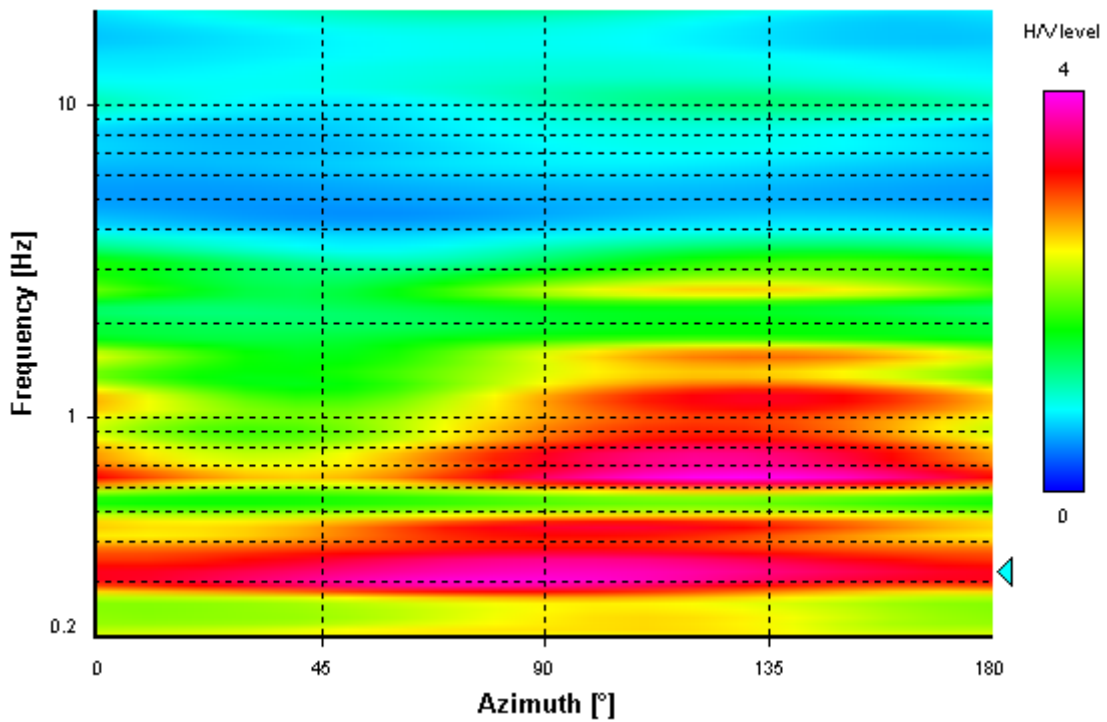
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



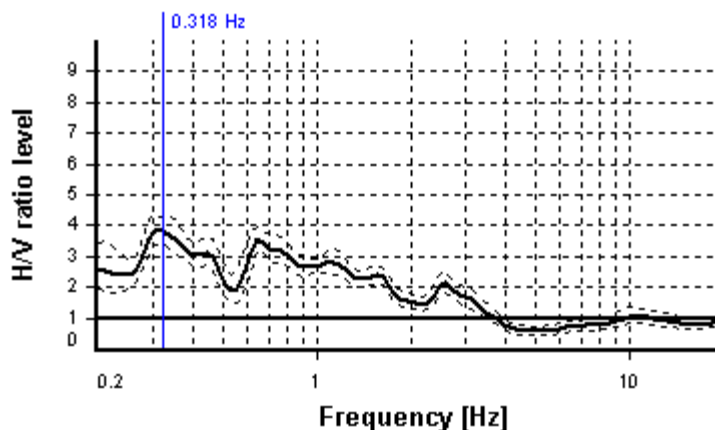
SESAME CRITERIA

Selected f_0 frequency

0.318 Hz

A_0 amplitude = 3.814

Average $f_0 = 0.320 \pm 0.039$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	19 valid windows (length > 31.4 s) out of 19	OK
$n_c(f_0) > 200$	1045.31 > 200	OK
$\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 25	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	0.53122 Hz	OK
$A_0 > 2$	3.81 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	4.55% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.03889 < 0.06369	OK
$\sigma_A(f_0) < \theta(f_0)$	1.10574 < 2.5	OK
Overall criteria fulfillment		OK

STATION INFORMATION

Station code: SSSSS

Model: SARA SL06

Sensor: SARA SS20PACK (integrated 2.0 Hz sensors)

Notes: -

PLACE INFORMATION

Place ID: HVSR7

Address: Via Statale - Sant'Agostino (FE)

Latitude: 44° 47.186'N

Longitude: 11° 22.176'E

Coordinate system: WGS84

Elevation: 13 m s.l.m.

Weather: -

Notes: -

SIGNAL AND WINDOWING

Sampling frequency: 100 Hz

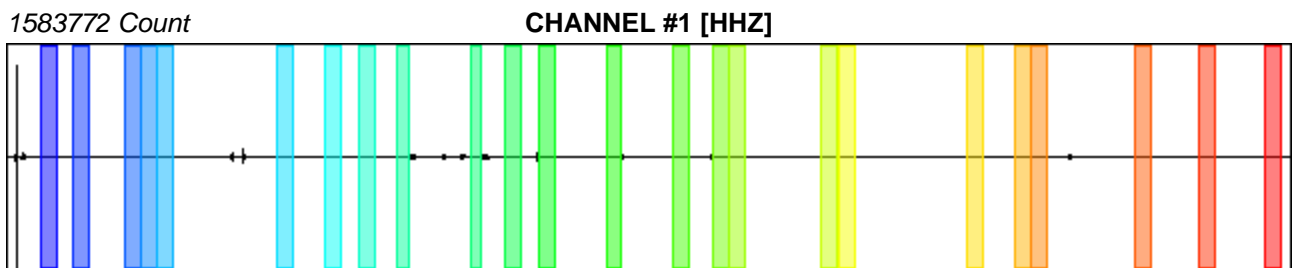
Recording start time: 2018/05/27 09:00:00

Recording length: 240 min

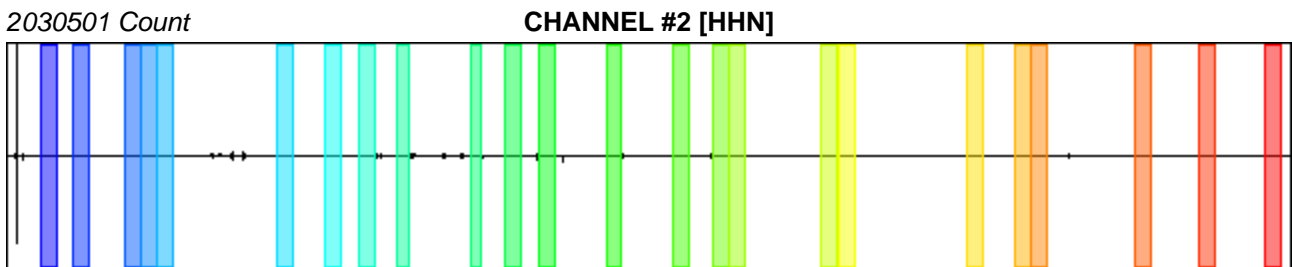
Windows count: 24

Average windows length: 173.53

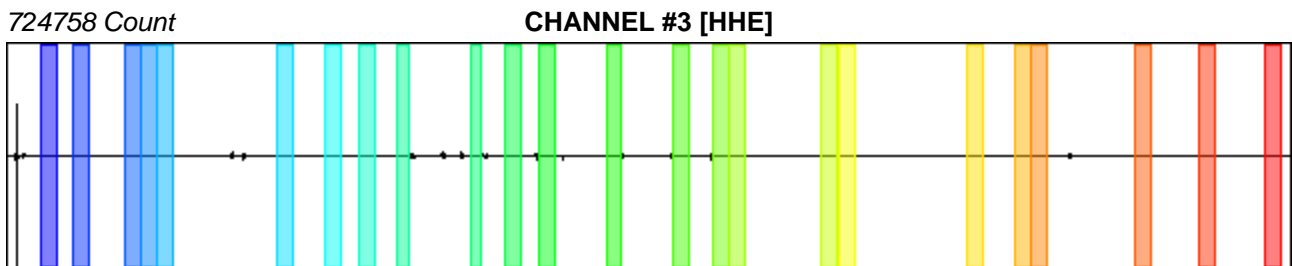
Signal coverage: 28.92%



-1917708 Count



-1597831 Count



-1583162 Count

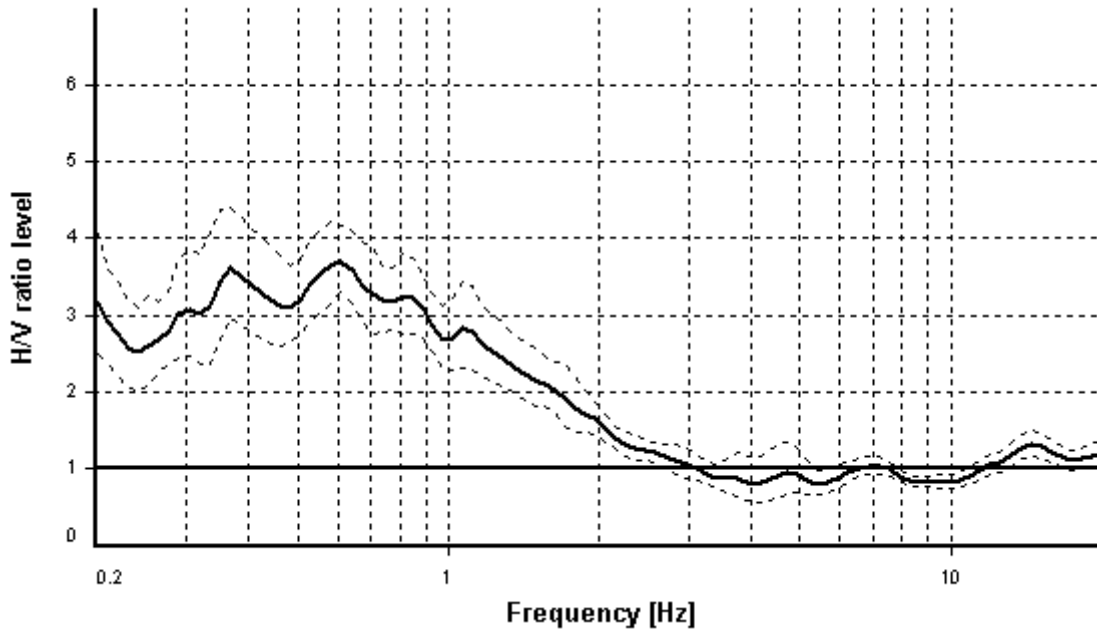
HVSR ANALYSIS

Tapering: Disabled

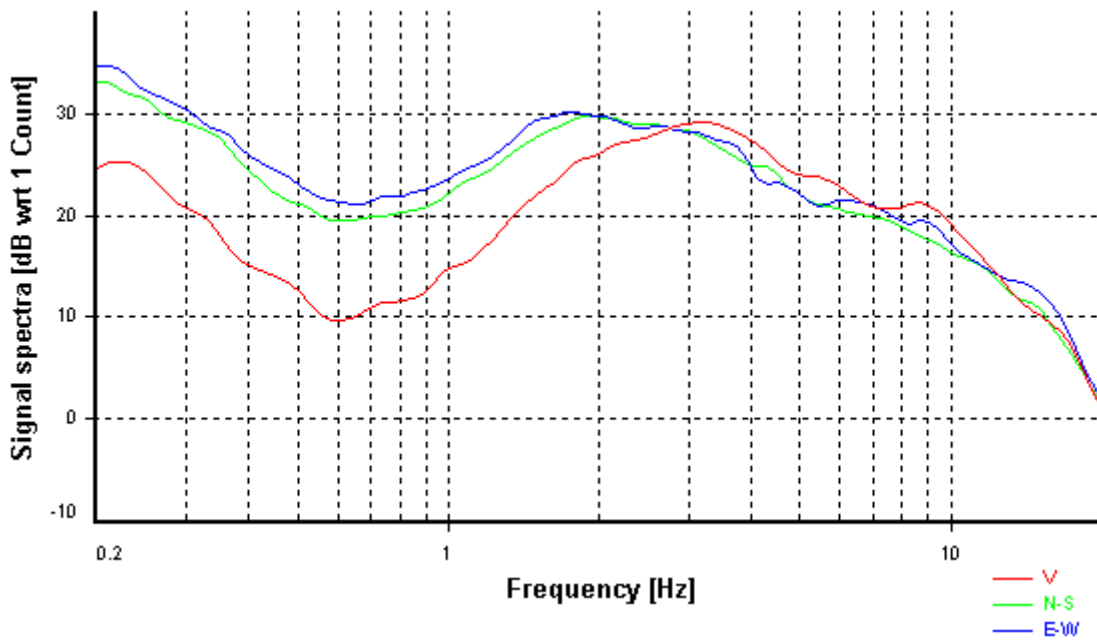
Smoothing: Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

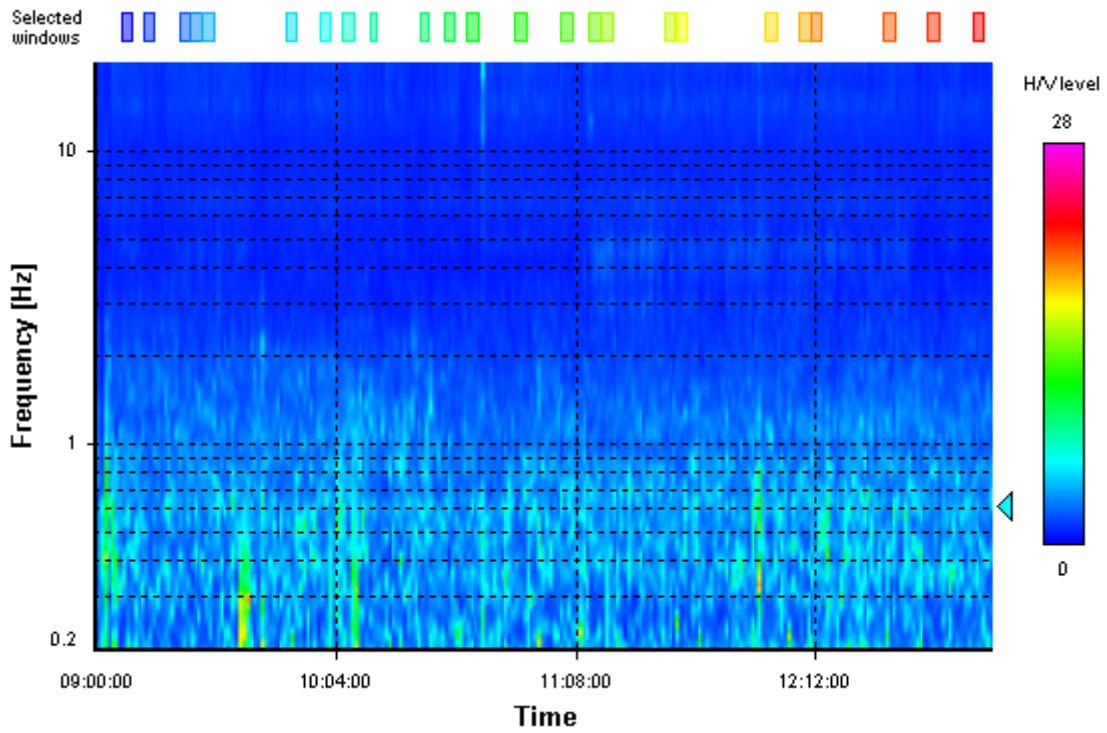
HVSR average



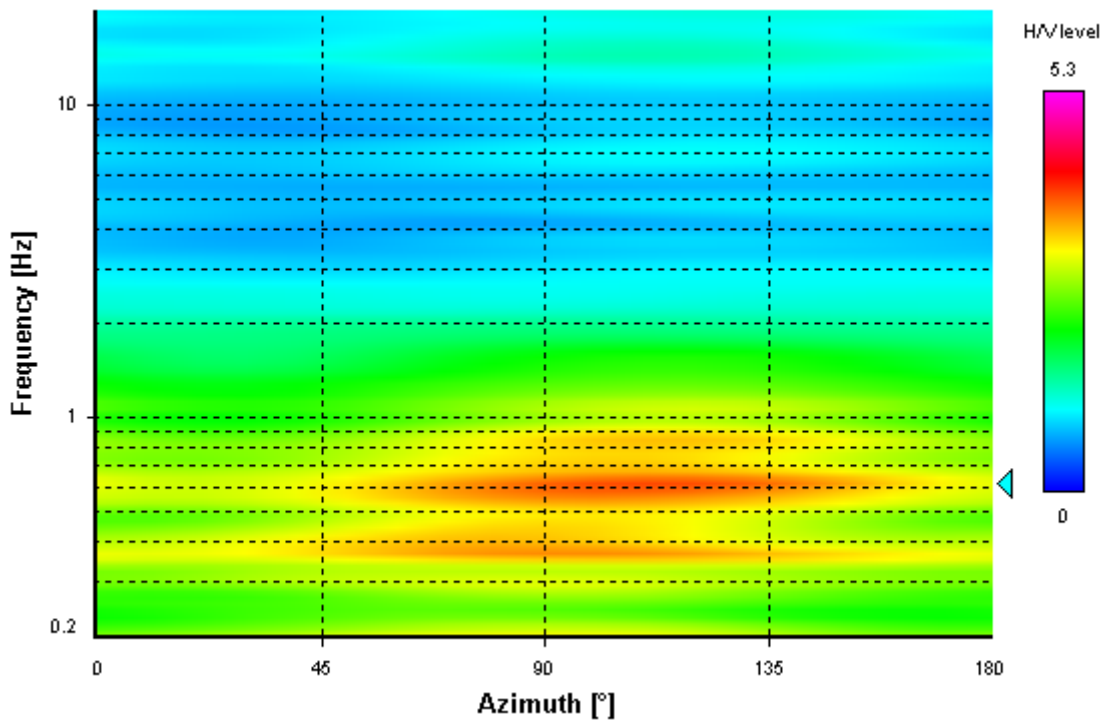
Signal spectra average



HVSR time-frequency analysis (60 seconds windows)



HVSR directional analysis



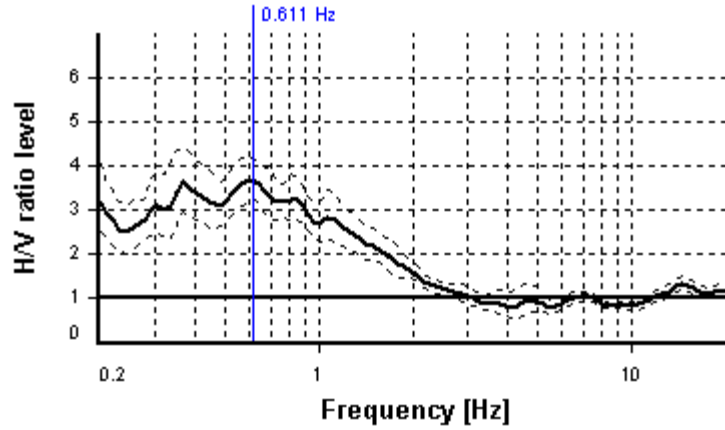
SESAME CRITERIA

Selected f_0 frequency

0.611 Hz

A_0 amplitude = 3.704

Average $f_0 = 0.598 \pm 0.124$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	24 valid windows (length > 16.37 s) out of 24	OK
$n_c(f_0) > 200$	2543.64 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 29	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	1.78043 Hz	OK
$A_0 > 2$	3.7 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	4.55% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.12387 >= 0.09162	NO
$\sigma_A(f_0) < \theta(f_0)$	1.12529 < 2	OK
Overall criteria fulfillment		NO

STATION INFORMATION

Station code: SSSSS

Model: SARA SL06

Sensor: SARA SS20PACK (integrated 2.0 Hz sensors)

Notes: -

PLACE INFORMATION

Place ID: HVSR11_bis

Address: Via Martiri della Libertà - San Carlo (FE)

Latitude: 44° 47.894'N

Longitude: 11° 23.535'E

Coordinate system: WGS84

Elevation: 0 m s.l.m.

Weather: -

Notes: -

SIGNAL AND WINDOWING

Sampling frequency: 125 Hz

Recording start time: 2018/11/26 14:53:11

Recording length: 72.33 min

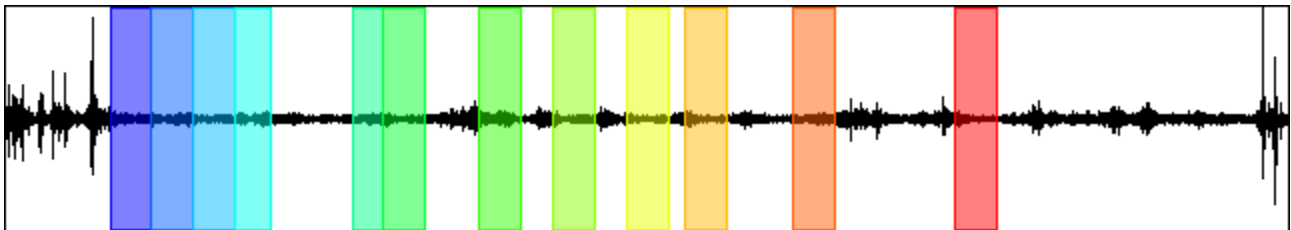
Windows count: 12

Average windows length: 135.38

Signal coverage: 37.44%

720812 Count

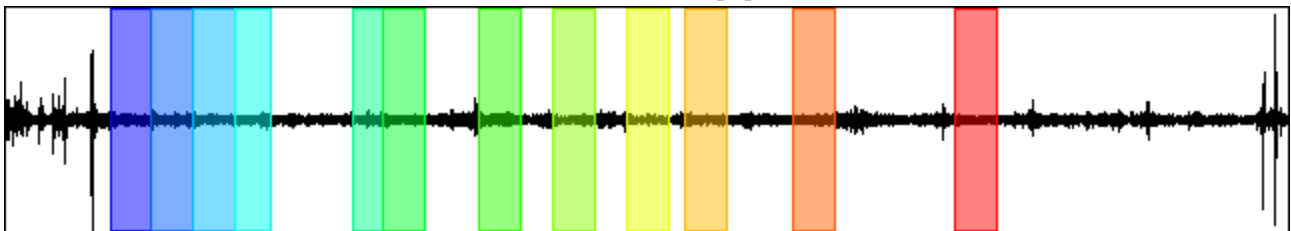
CHANNEL #1 [Z]



-550575 Count

667380 Count

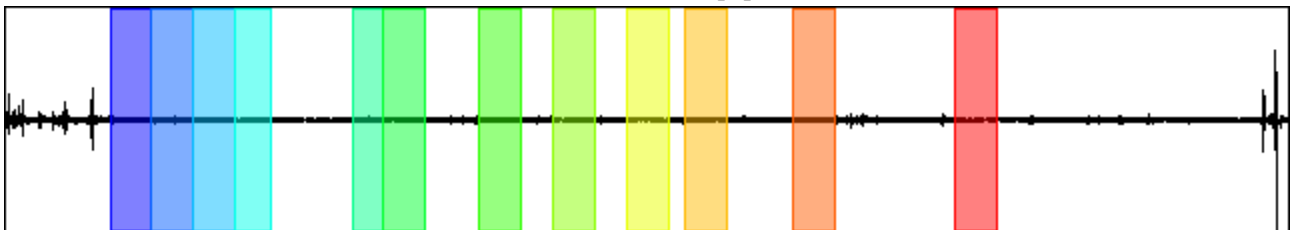
CHANNEL #2 [N]



-708287 Count

1285596 Count

CHANNEL #3 [E]



-2046714 Count

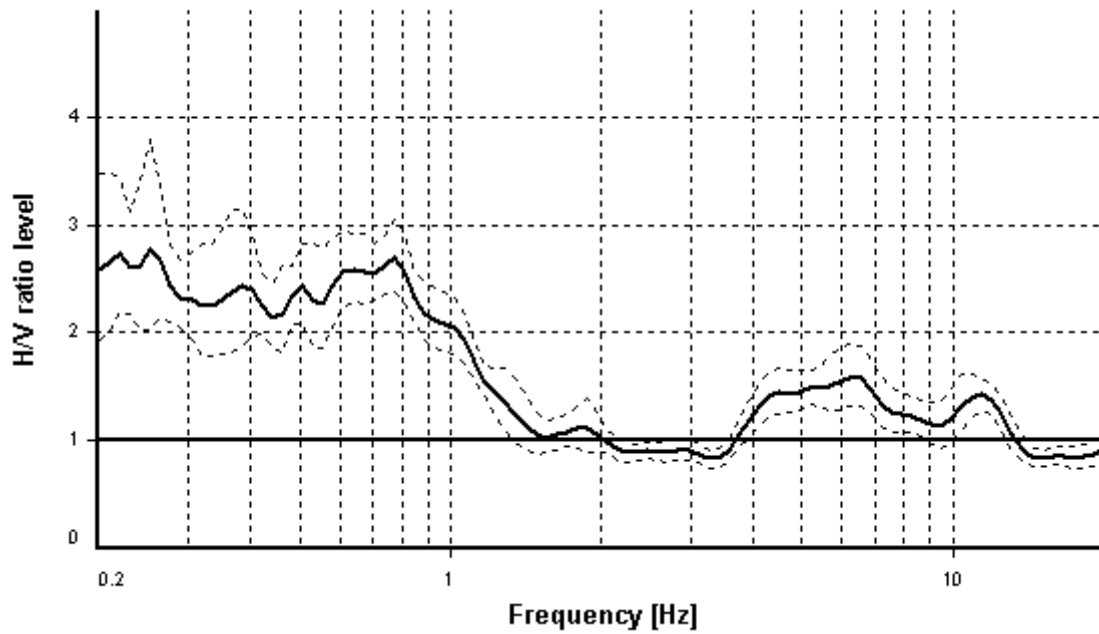
HVSR ANALYSIS

Tapering: Enabled (Bandwidth = 5%)

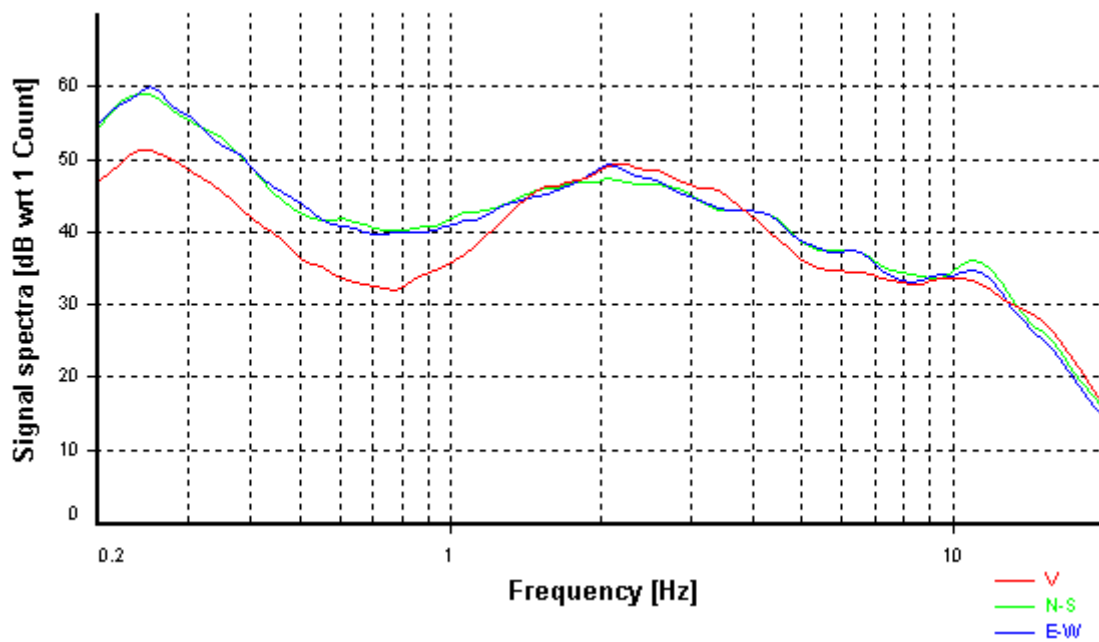
Smoothing: Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

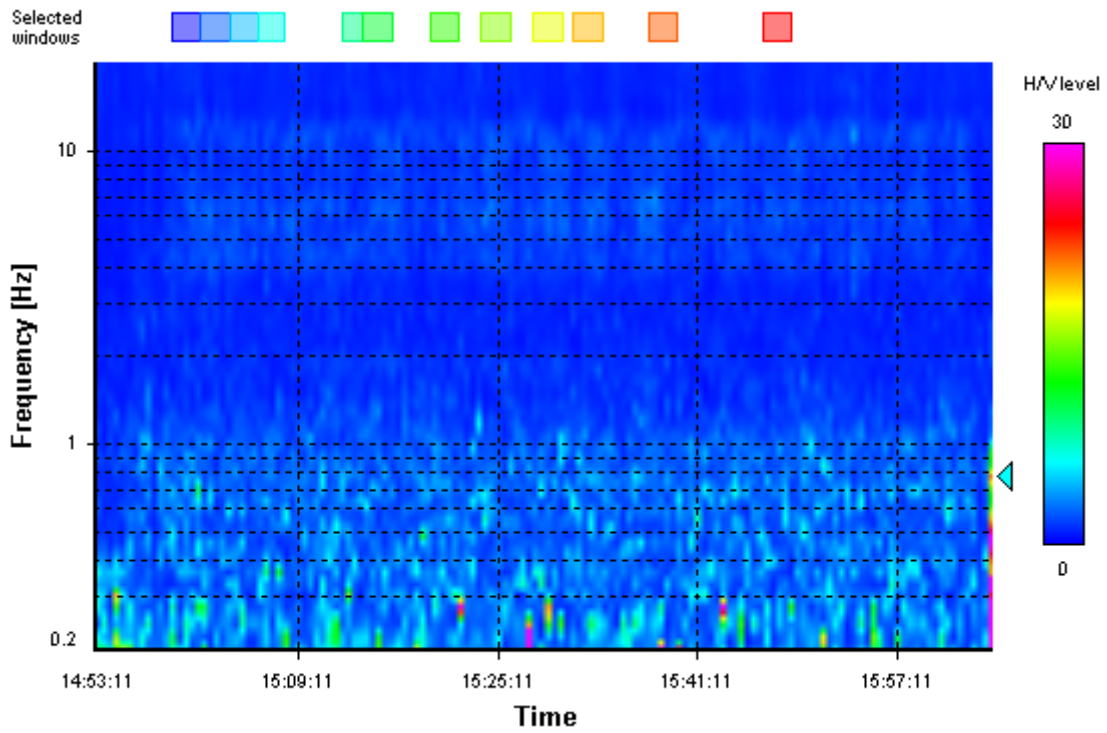
HVSR average



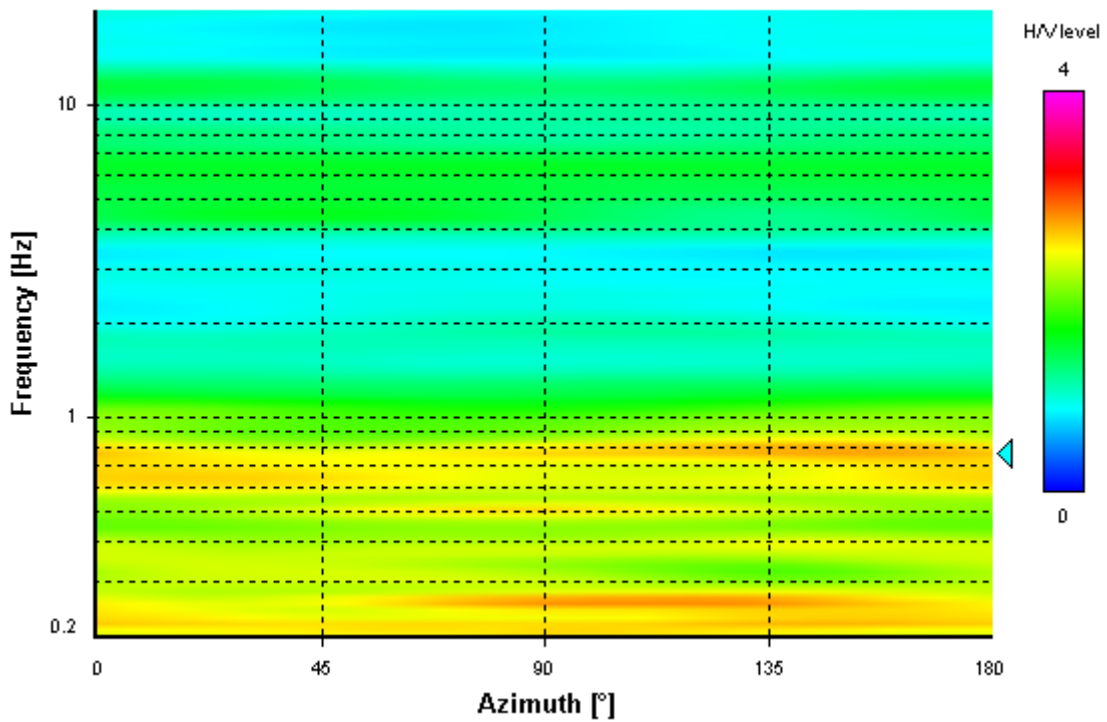
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



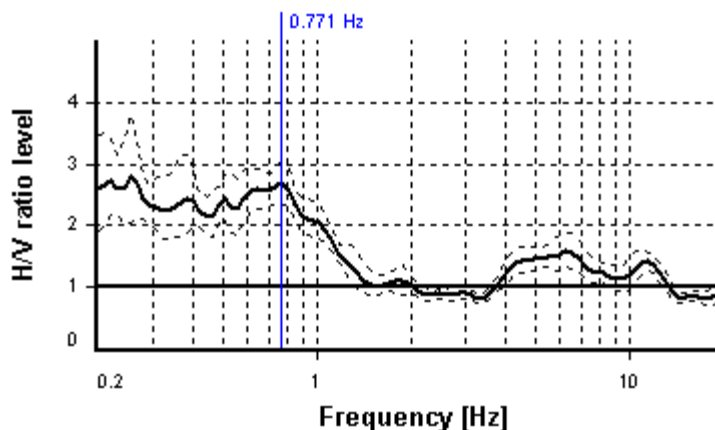
SESAME CRITERIA

Selected f_0 frequency

0.771 Hz

A_0 amplitude = 2.699

Average $f_0 = 0.710 \pm 0.087$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	12 valid windows (length > 12.98 s) out of 12	OK
$n_c(f_0) > 200$	1252.03 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 29	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	1.28561 Hz	OK
$A_0 > 2$	2.7 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.08745 < 0.11561	OK
$\sigma_A(f_0) < \theta(f_0)$	1.13439 < 2	OK
Overall criteria fulfillment		OK

STATION INFORMATION

Station code: SSSSS

Model: SARA SL06

Sensor: SARA SS20PACK (integrated 2.0 Hz sensors)

Notes: -

PLACE INFORMATION

Place ID: HVSR12

Address: Via Martiri della Libertà - San Carlo (FE)

Latitude: 44° 48.137'N

Longitude: 11° 24.063'E

Coordinate system: WGS84

Elevation: 0 m s.l.m.

Weather: -

Notes: -

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

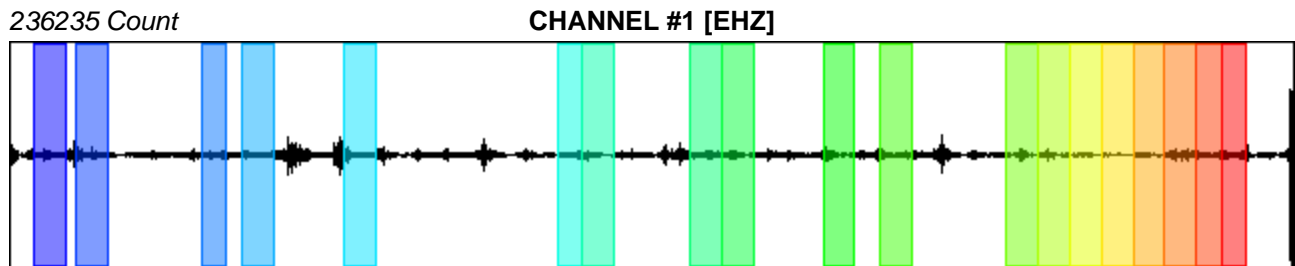
Recording start time: 2018/05/21 15:00:00

Recording length: 54.21 min

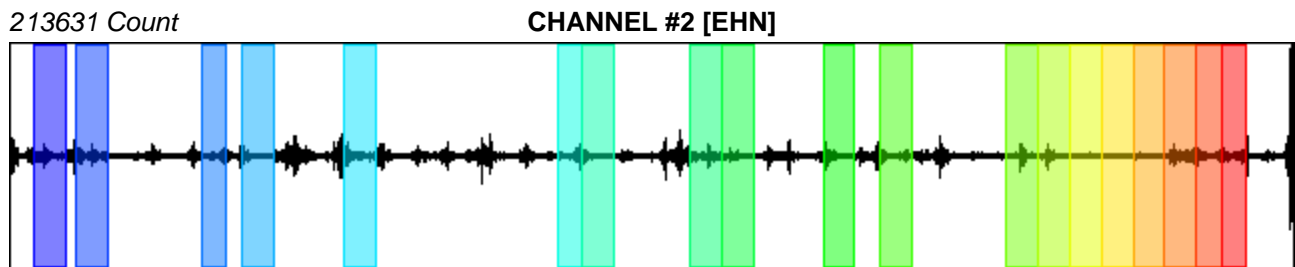
Windows count: 19

Average windows length: 76.35

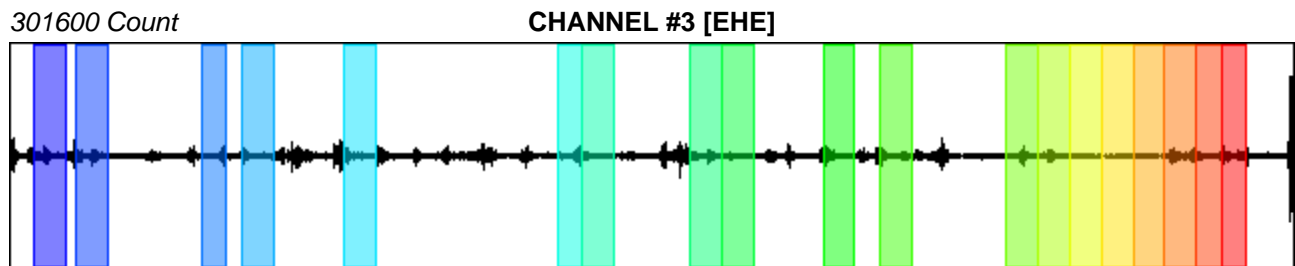
Signal coverage: 44.6%



-400608 Count



-151186 Count



-188779 Count

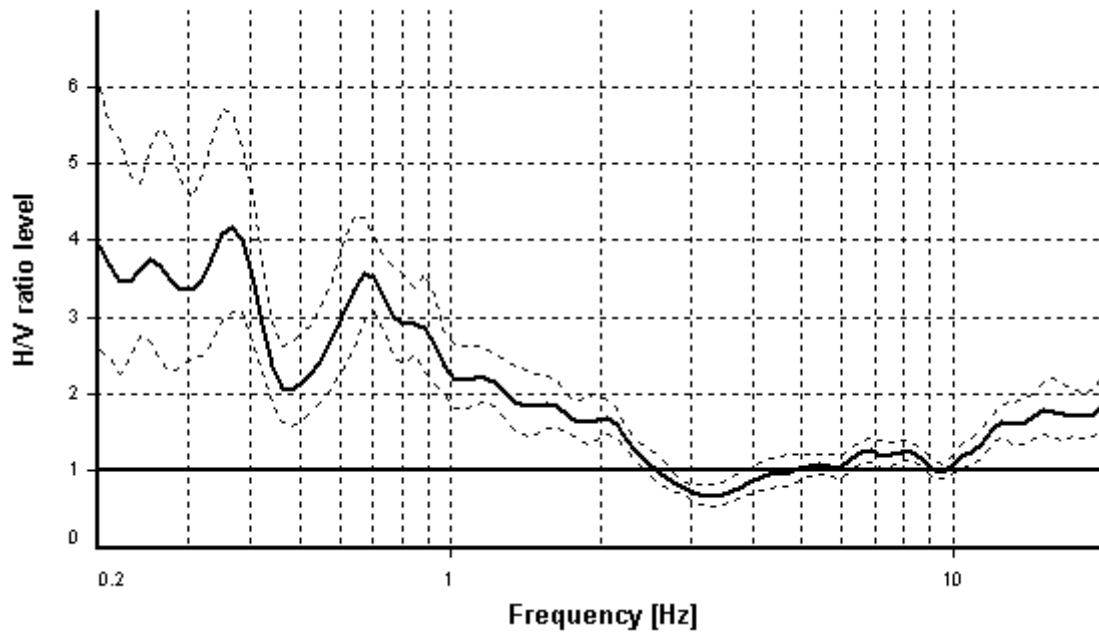
HVSR ANALYSIS

Tapering: Enabled (Bandwidth = 5%)

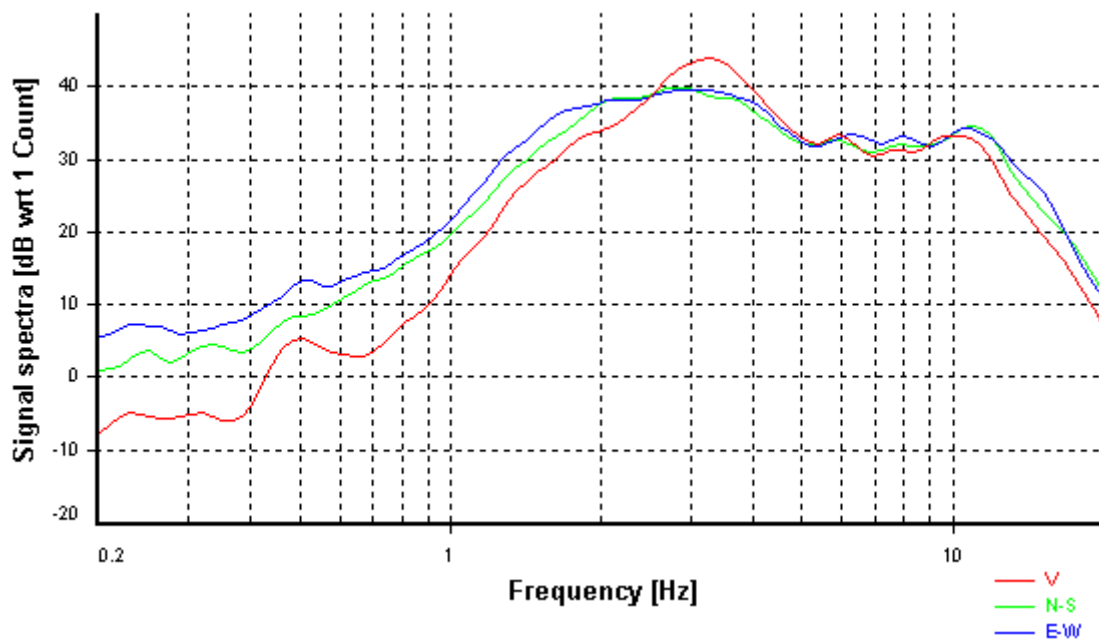
Smoothing: Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

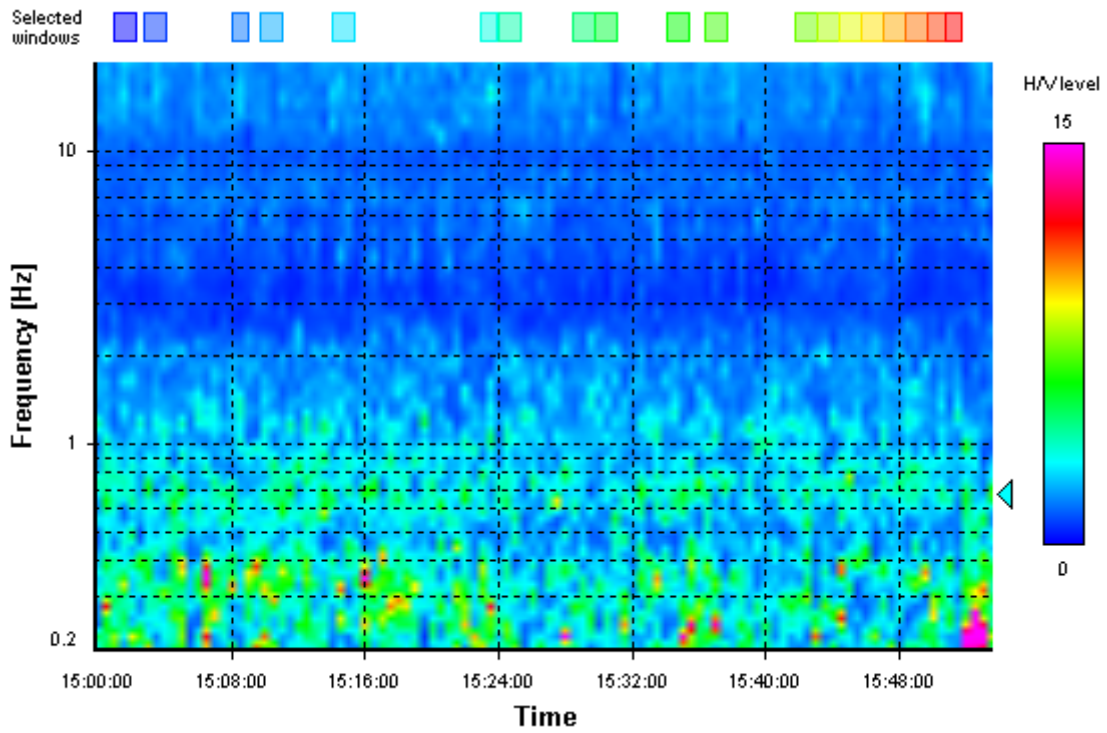
HVSR average



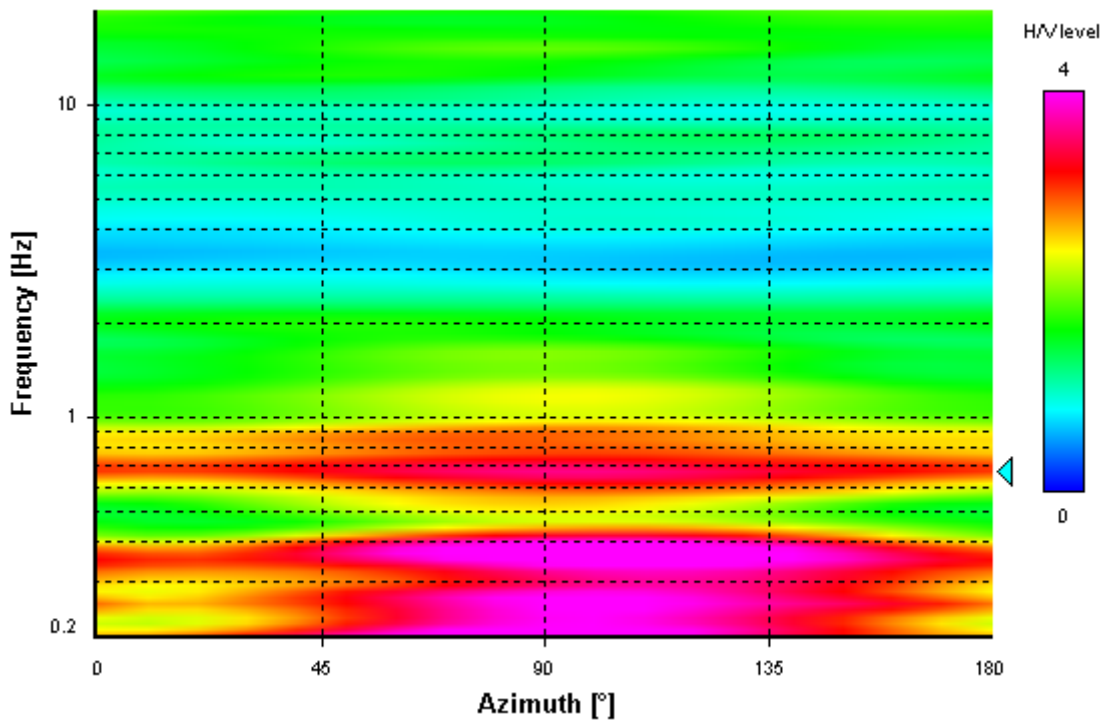
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



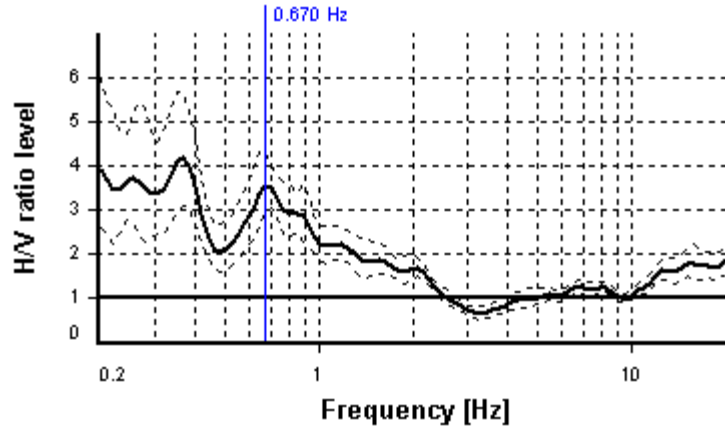
SESAME CRITERIA

Selected f_0 frequency

0.670 Hz

A_0 amplitude = 3.562

Average $f_0 = 0.696 \pm 0.075$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	19 valid windows (length > 14.92 s) out of 19	OK
$n_c(f_0) > 200$	972.46 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 29	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	1.69951 Hz	OK
$A_0 > 2$	3.56 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	4.76% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.07541 < 0.10055	OK
$\sigma_A(f_0) < \theta(f_0)$	1.20674 < 2	OK
Overall criteria fulfillment		OK

STATION INFORMATION

Station code: SSSSS

Model: SARA SL06

Sensor: SARA SS20PACK (integrated 2.0 Hz sensors)

Notes: -

PLACE INFORMATION

Place ID: HVSR12bis

Address: Via Martiri della Libertà - San Carlo (FE)

Latitude: 44° 48.174'N

Longitude: 11° 24.215'E

Coordinate system: WGS84

Elevation: 13 m s.l.m.

Weather: -

Notes: -

SIGNAL AND WINDOWING

Sampling frequency: 125 Hz

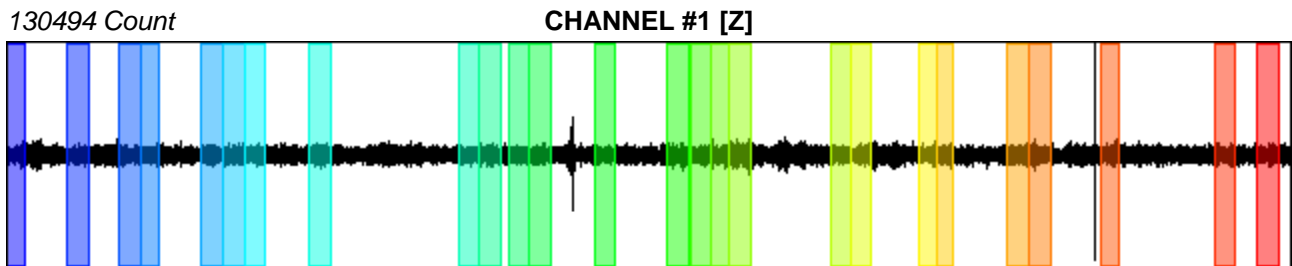
Recording start time: 2018/11/26 17:52:48

Recording length: 180 min

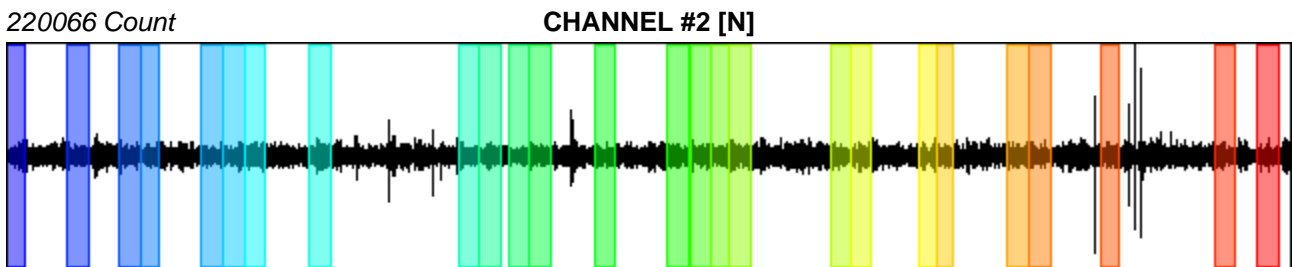
Windows count: 26

Average windows length: 171.72

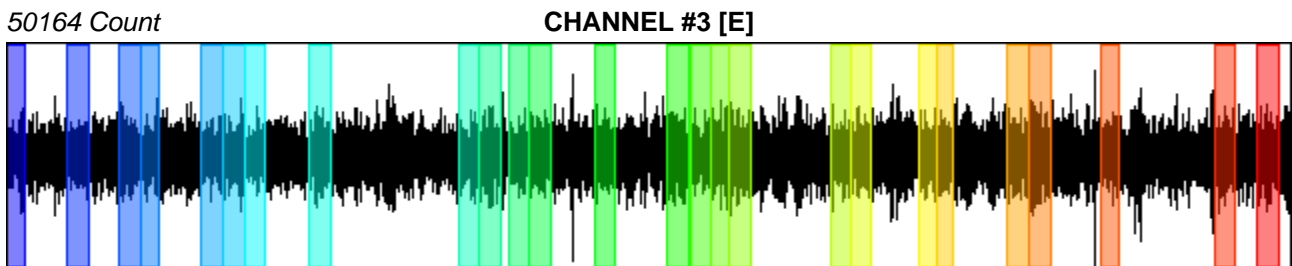
Signal coverage: 41.34%



-124109 Count



-191622 Count



-65179 Count

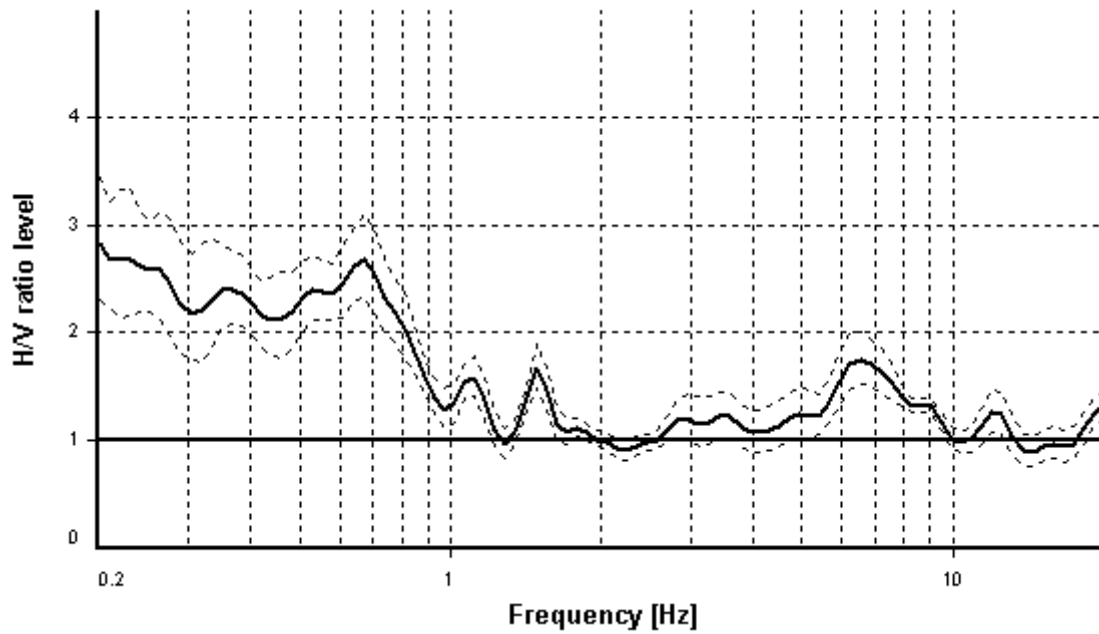
HVSR ANALYSIS

Tapering: Disabled

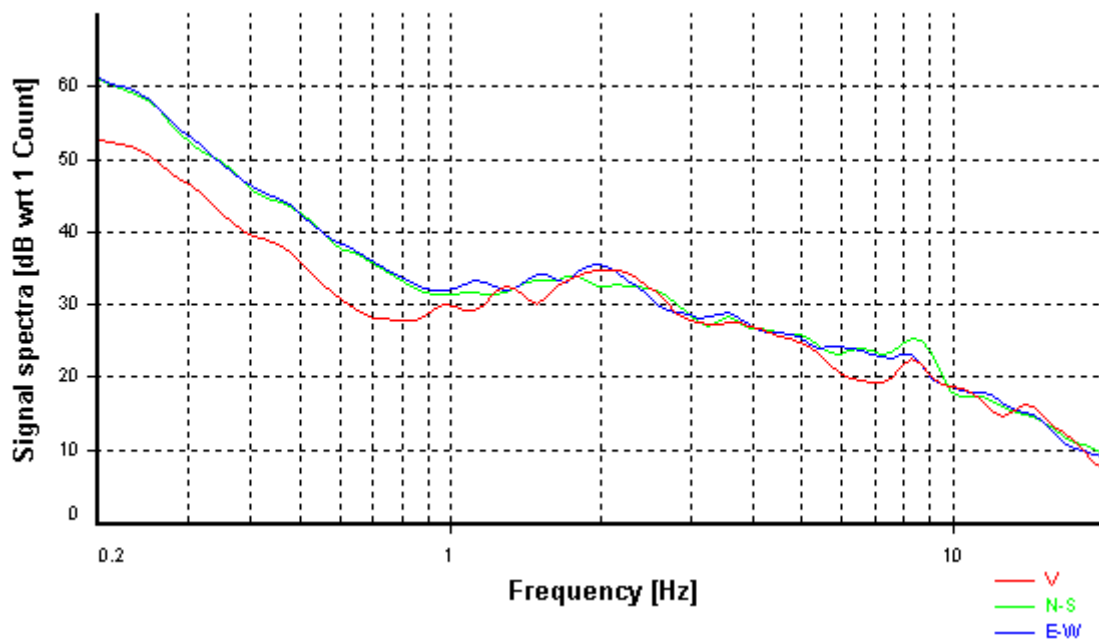
Smoothing: Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

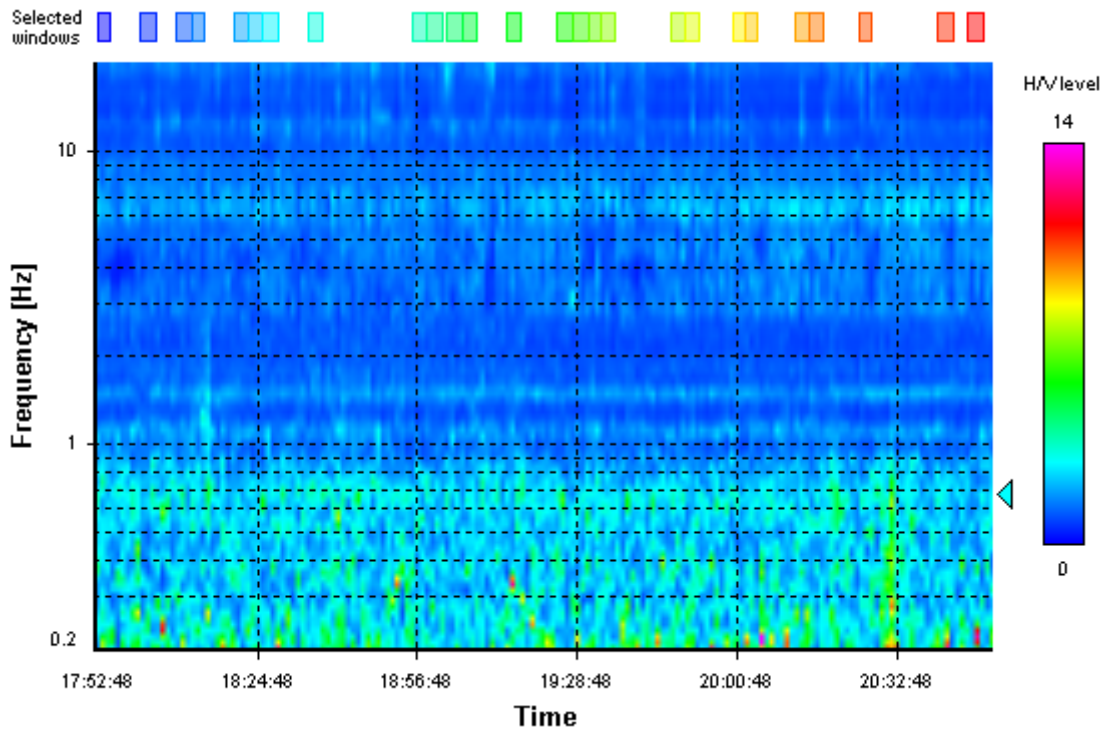
HVSR average



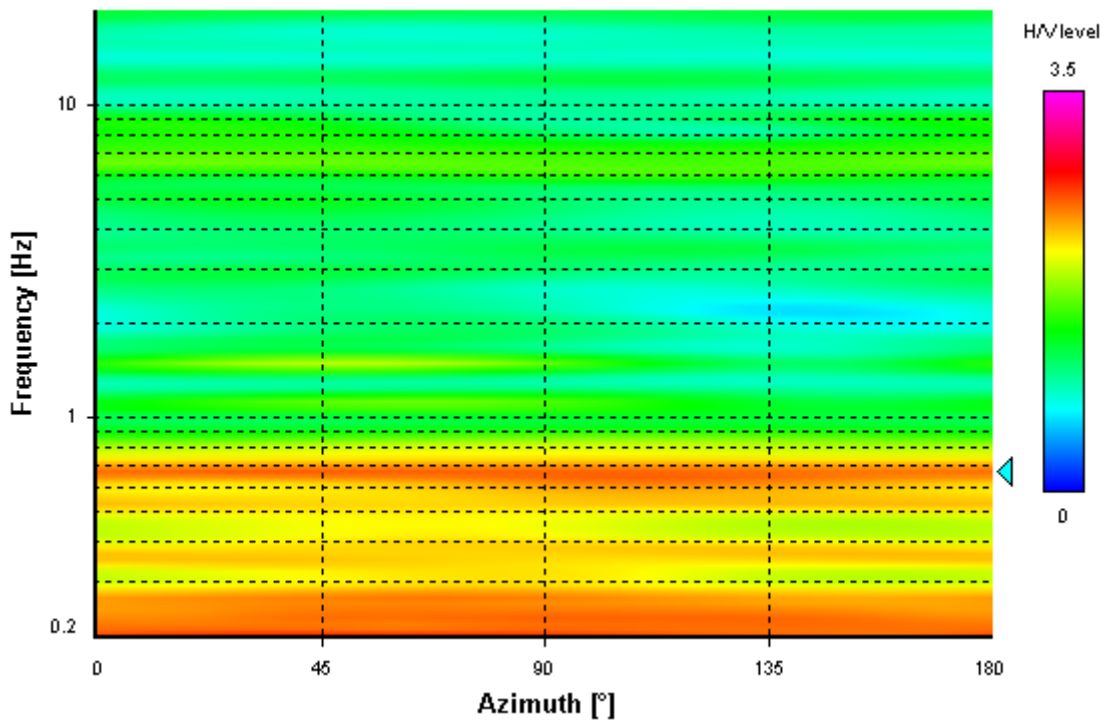
Signal spectra average



HVSR time-frequency analysis (60 seconds windows)



HVSR directional analysis



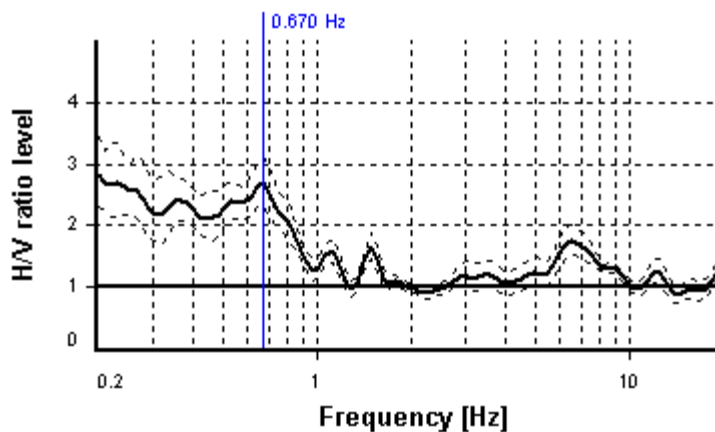
SESAME CRITERIA

Selected f_0 frequency

0.670 Hz

A_0 amplitude = 2.680

Average $f_0 = 0.603 \pm 0.088$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	26 valid windows (length > 14.92 s) out of 26	OK
$n_c(f_0) > 200$	2992.88 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 29	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	0.97252 Hz	OK
$A_0 > 2$	2.68 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.08753 < 0.10055	OK
$\sigma_A(f_0) < \theta(f_0)$	1.15871 < 2	OK
Overall criteria fulfillment		OK

STATION INFORMATION

Station code: SSSSS

Model: SARA SL06

Sensor: SARA SS20PACK (integrated 2.0 Hz sensors)

Notes: -

PLACE INFORMATION

Place ID: HVSR13

Address: Via Morandi - San Carlo (FE)

Latitude: 44° 48.214'N

Longitude: 11° 24.475'E

Coordinate system: WGS84

Elevation: 17 m s.l.m.

Weather: -

Notes: -

SIGNAL AND WINDOWING

Sampling frequency: 100 Hz

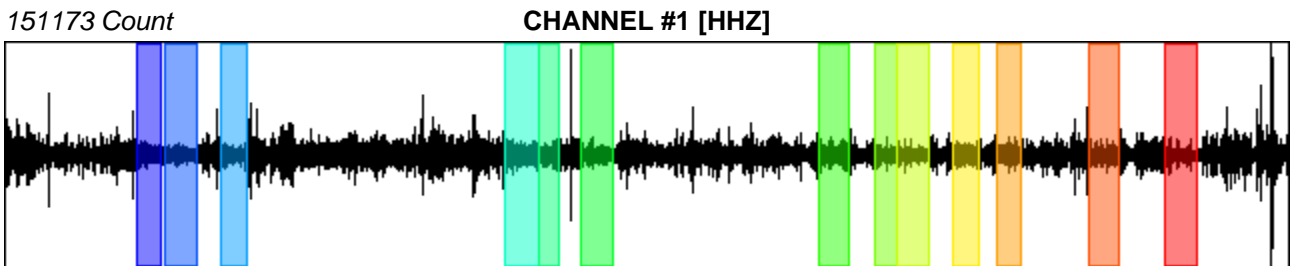
Recording start time: 2018/05/17 08:00:00

Recording length: 120 min

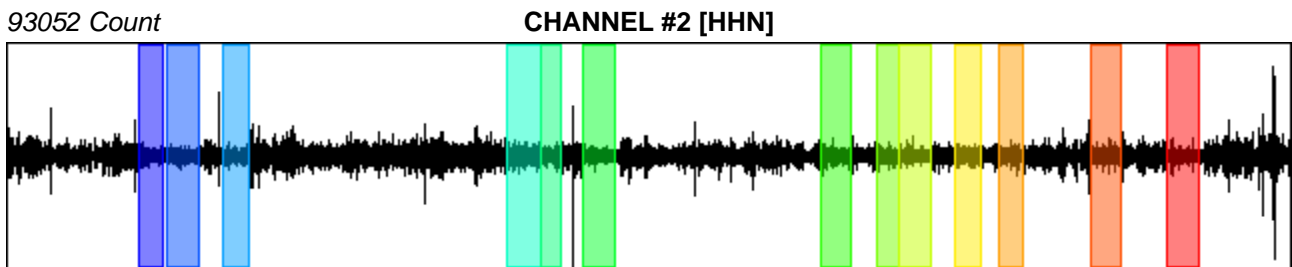
Windows count: 13

Average windows length: 156.05

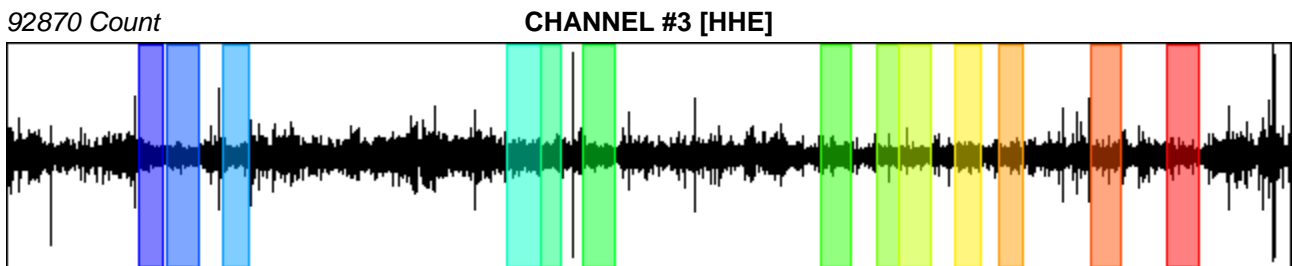
Signal coverage: 28.18%



-151979 Count



-115879 Count



-88675 Count

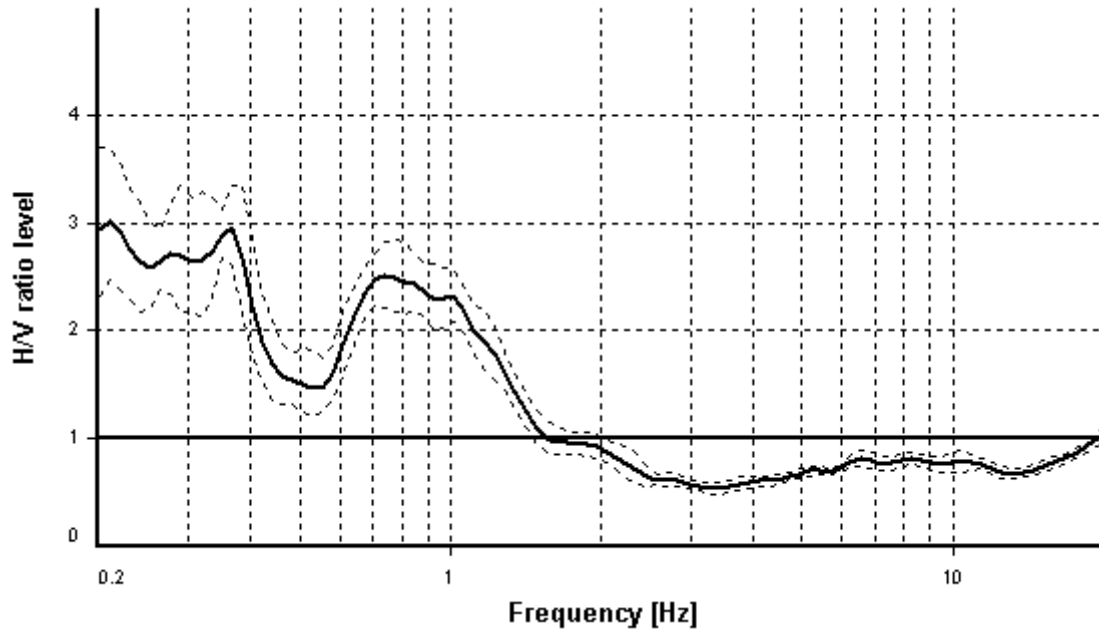
HVSR ANALYSIS

Tapering: Enabled (Bandwidth = 5%)

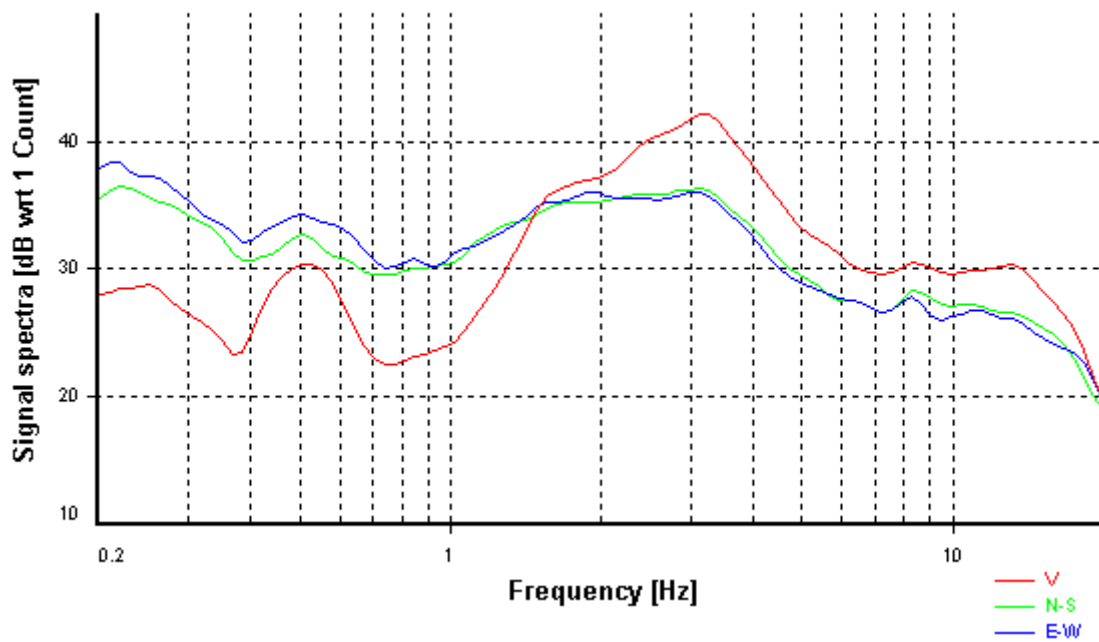
Smoothing: Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

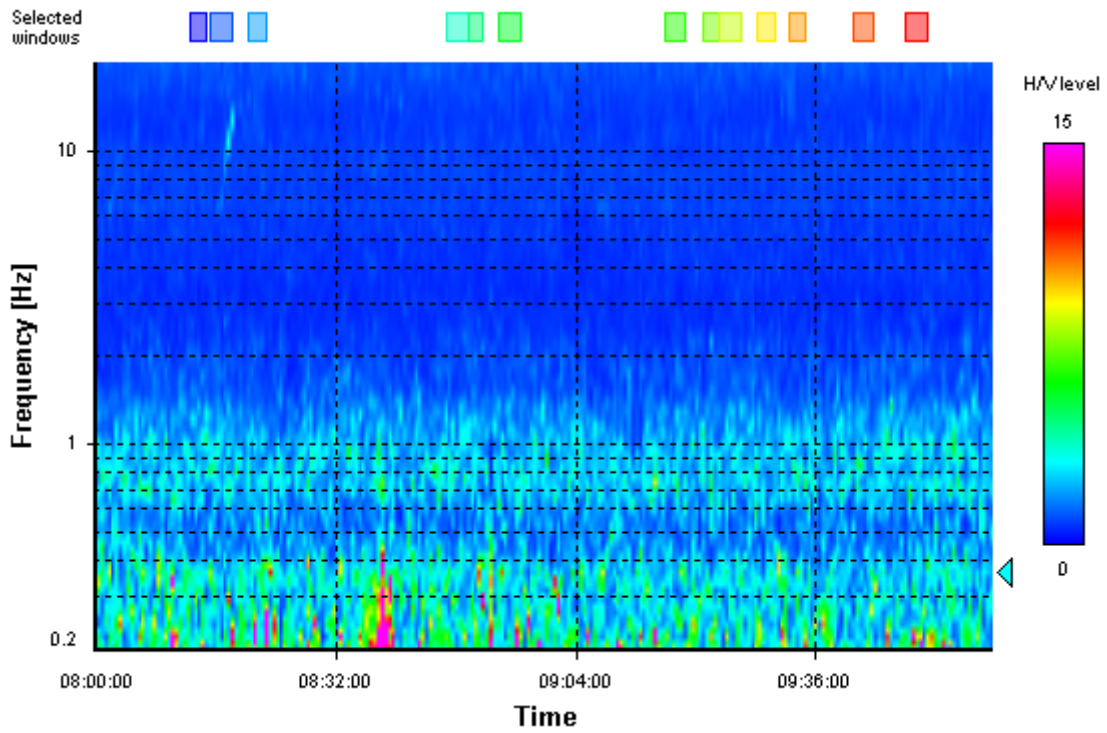
HVSR average



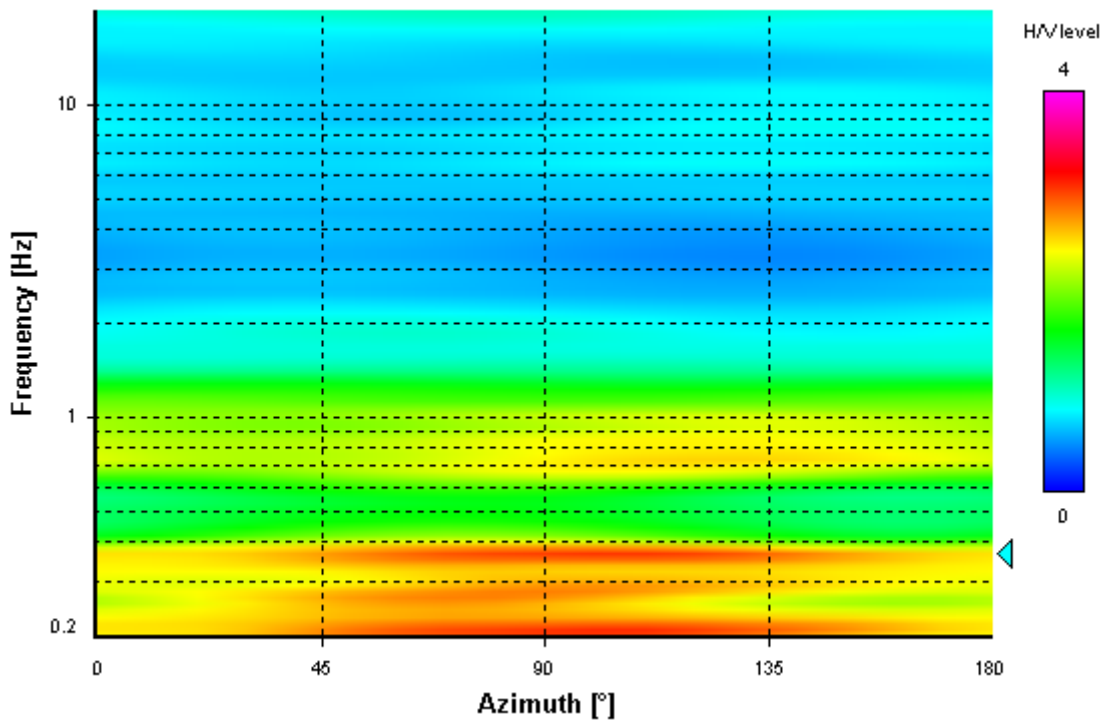
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



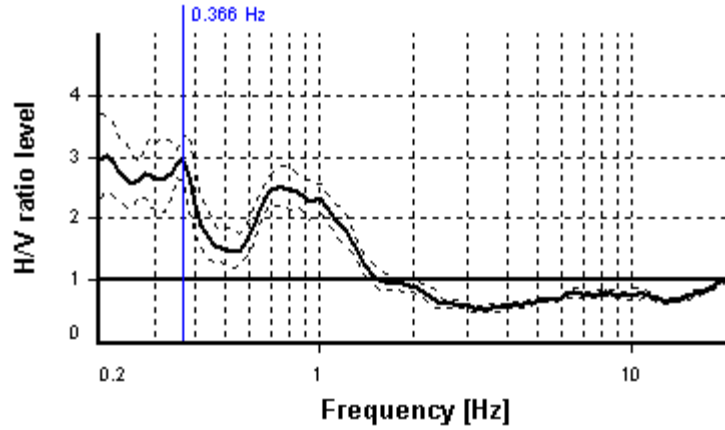
SESAME CRITERIA

Selected f_0 frequency

0.366 Hz

A_0 amplitude = 2.960

Average $f_0 = 0.325 \pm 0.045$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	13 valid windows (length > 27.31 s) out of 13	OK
$n_c(f_0) > 200$	742.8 > 200	OK
$\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 28	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	0.53122 Hz	OK
$A_0 > 2$	2.96 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	4.55% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.04468 < 0.07323	OK
$\sigma_A(f_0) < \theta(f_0)$	1.13504 < 2.5	OK
Overall criteria fulfillment		OK

STATION INFORMATION

Station code: SSSSS

Model: SARA SL06

Sensor: SARA SS20PACK (integrated 2.0 Hz sensors)

Notes: -

PLACE INFORMATION

Place ID: HVSR14bis

Address: Via Rossini - San Carlo (FE)

Latitude: 44° 48.359'N

Longitude: 11° 24.872'E

Coordinate system: WGS84

Elevation: 17 m s.l.m.

Weather: -

Notes: -

SIGNAL AND WINDOWING

Sampling frequency: 125 Hz

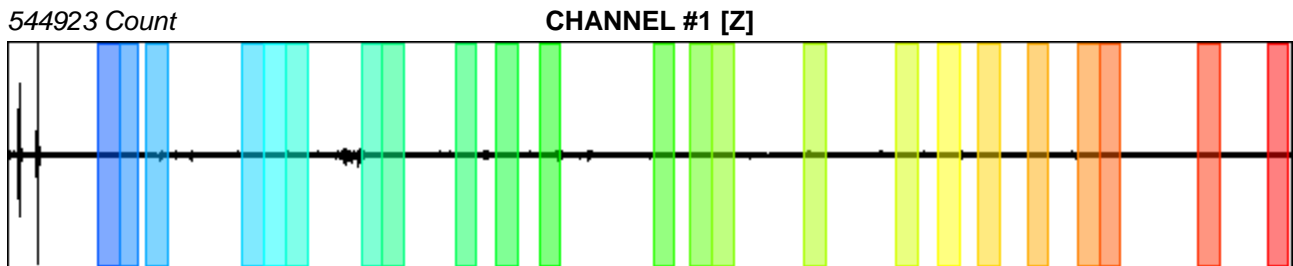
Recording start time: 2018/11/26 17:18:49

Recording length: 180 min

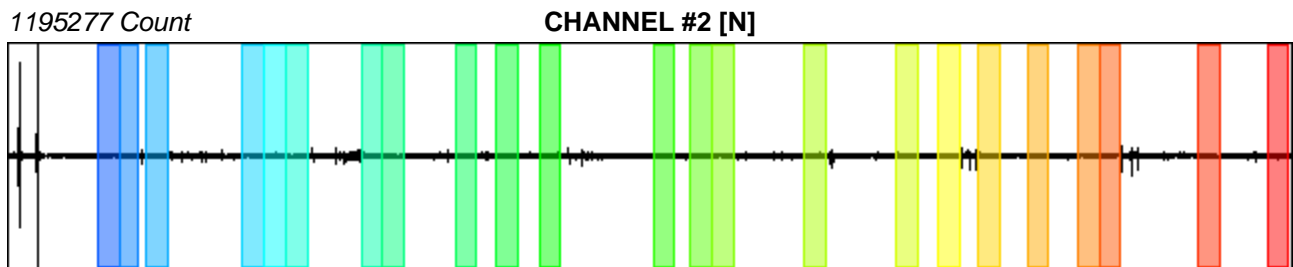
Windows count: 23

Average windows length: 177.63

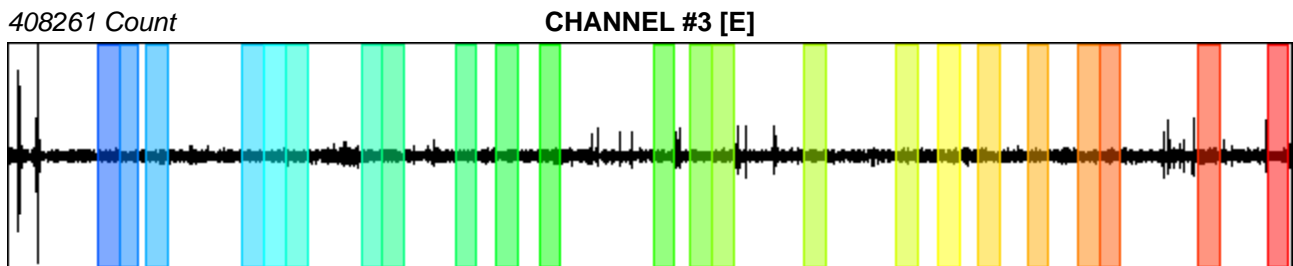
Signal coverage: 37.83%



-534319 Count



-1188384 Count



-393037 Count

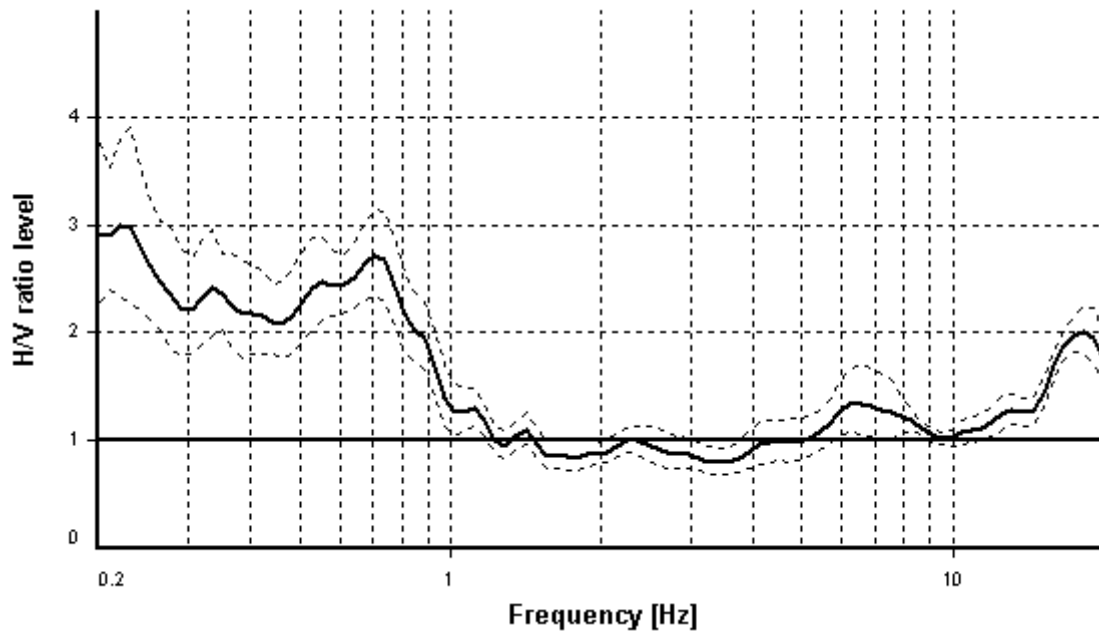
HVSR ANALYSIS

Tapering: Disabled

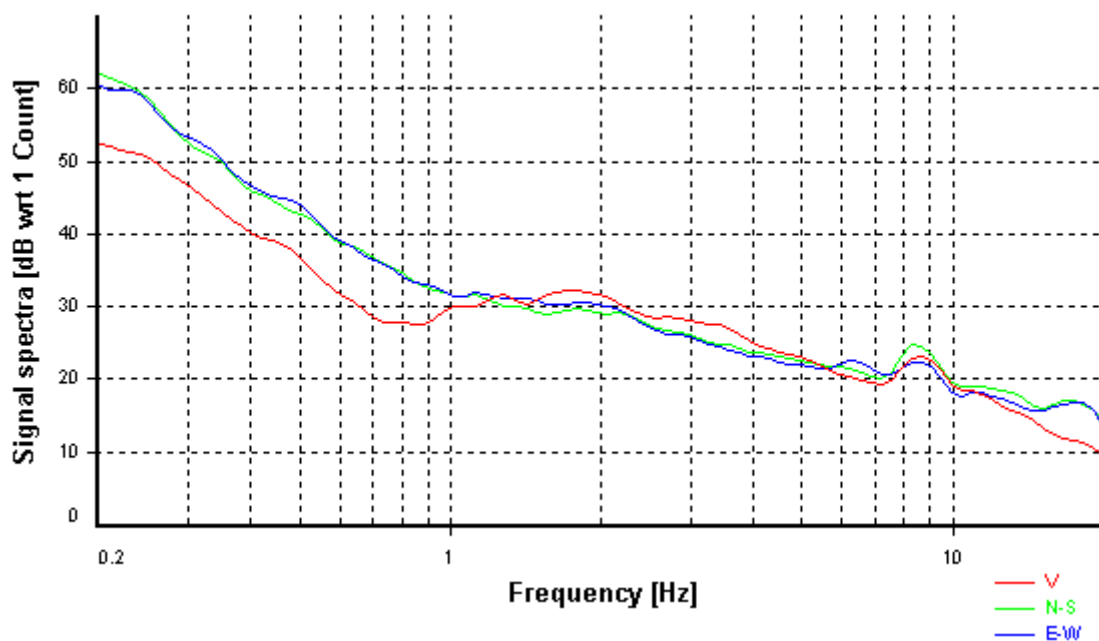
Smoothing: Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

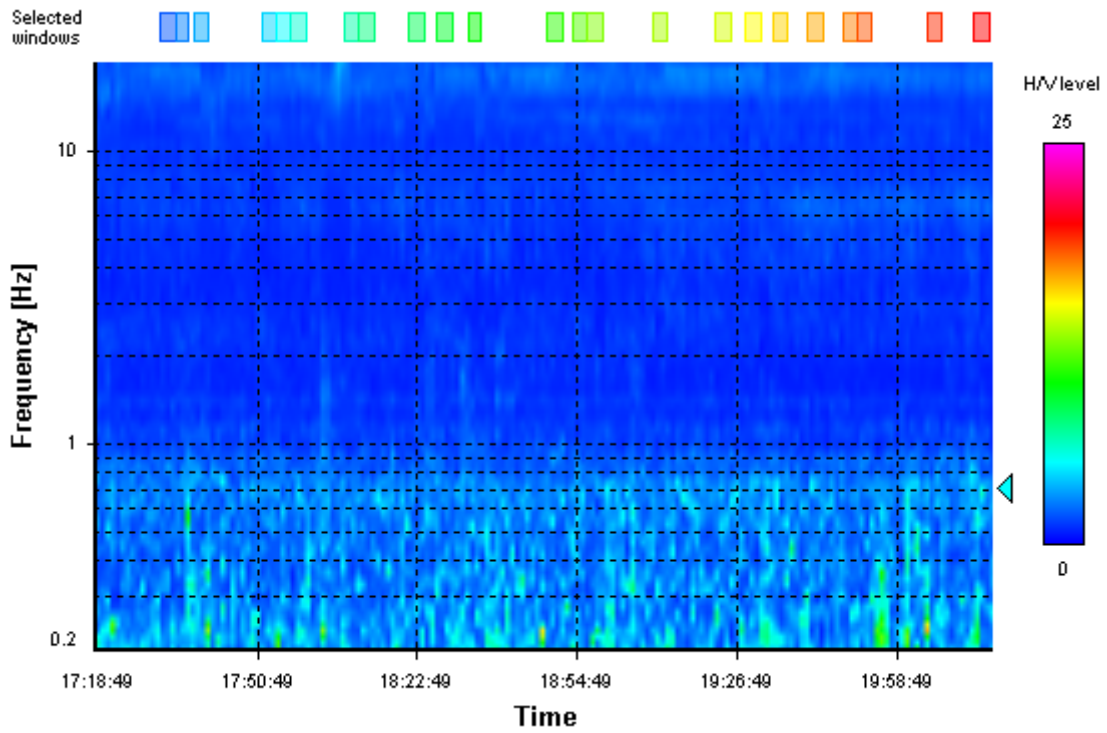
HVSR average



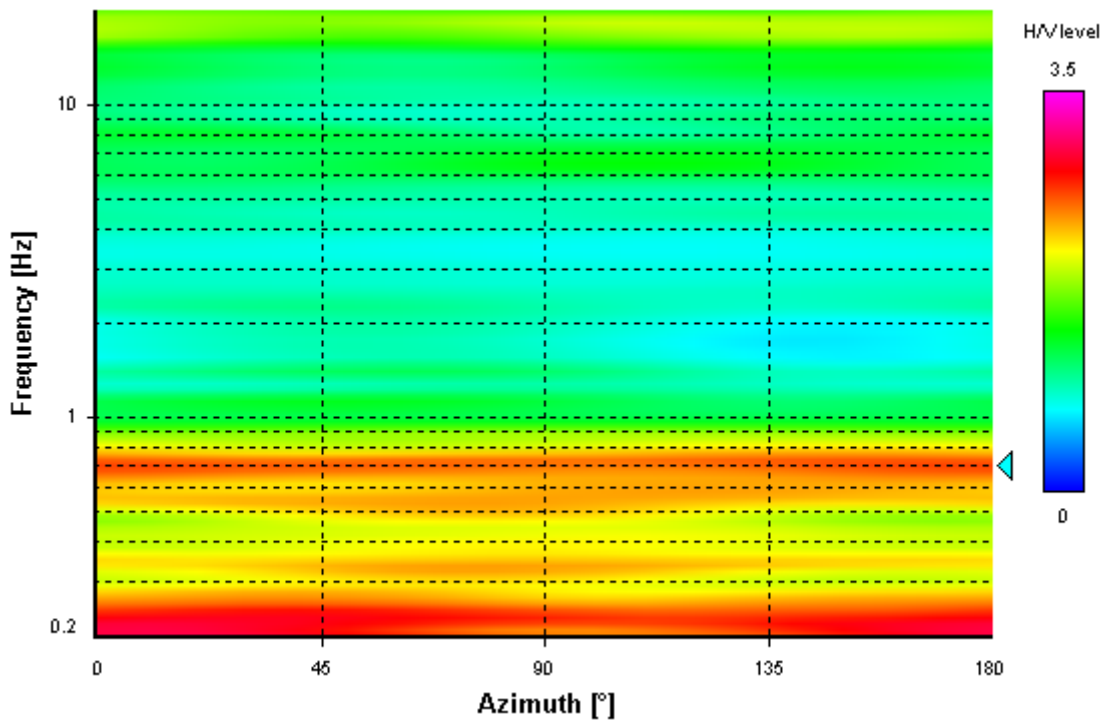
Signal spectra average



HVSR time-frequency analysis (60 seconds windows)



HVSR directional analysis



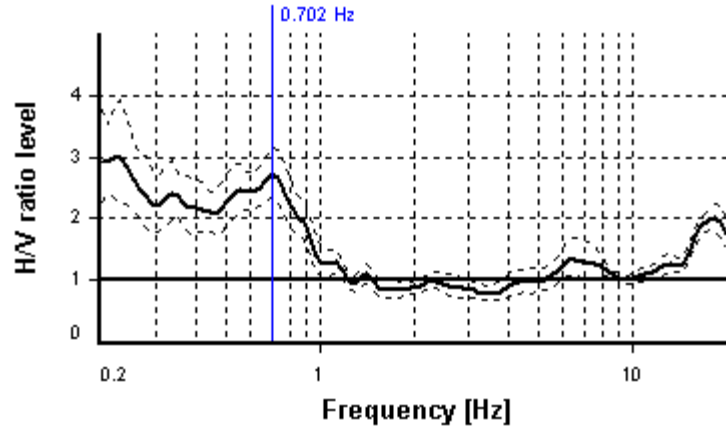
SESAME CRITERIA

Selected f_0 frequency

0.702 Hz

A_0 amplitude = 2.714

Average $f_0 = 0.664 \pm 0.085$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	23 valid windows (length > 14.24 s) out of 23	OK
$n_c(f_0) > 200$	2869.01 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 29	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	1.01883 Hz	OK
$A_0 > 2$	2.71 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.08542 < 0.10534	OK
$\sigma_A(f_0) < \theta(f_0)$	1.16199 < 2	OK
Overall criteria fulfillment		OK