Slovenian Environment Agency - ARSO
Seismology Office

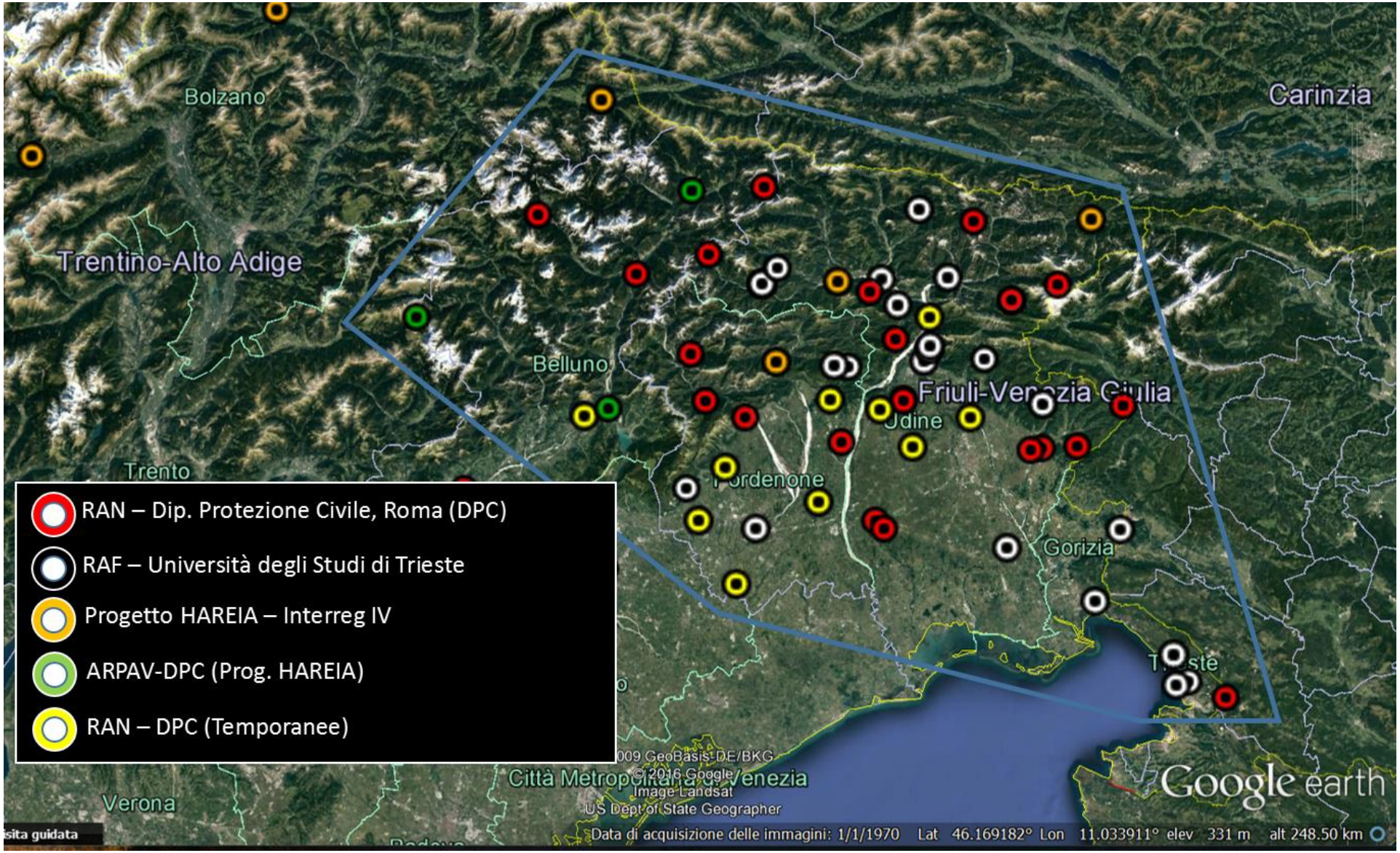
European Antelope User Group Meeting 2018

May 7-9, 2018
Ljubljana, Slovenia

Ground motion data analysis in Antelope

Giovanni Costa - SeisRaM group
Department of Mathematics and Geosciences – University of Trieste

SeisRaM


Bolzano
Carinzia
Trentino-Alto Adige
Belluno
Friuli-Venezia Giulia
Udine
Trento
Pordenone
Gorizia
Trieste
Verona
Città Metropolitana di Venezia
RAN – Dip. Protezione Civile, Roma (DPC)
RAF – Università degli Studi di Trieste
Progetto HAREIA – Interreg IV
ARPAV-DPC (Prog. HAREIA)
RAN – DPC (Temporanee)
009 GeoBasis-DE/BKG
© 2016 Google
Image Landsat
US Dept of State Geographer
Google earth
Data di acquisizione delle immagini: 1/1/1970 Lat 46.169182° Lon 11.033911° elev 331 m alt 248.50 km

The SeisRaM group of Trieste Univrsity developed an automated routine in Antelope Software environment, that determines in near time seismic source parameters (Gallo et al. 2014, Costa et al. 2014) and strong motion parameters from recorded waveforms. These parameters are computed within *few minutes* after the earthquakes and rapidly revised.

This automatic routine, over time, has been optimized improving the quality of results and it is running at Italian Civil Department, at Italian strong motion network data center.

PGA, PGV, PGD, PSA03, PSA10, PSA30, Housner, Arias, RMSA, duration, intensity of zero crossing, Saragoni index, damage factor,…

dbmw (fortran code)

orb2db

db.wfdisc
db.origin
db.event
db.netmag

Select origin

Select N,E,Z component

Ml > magmin
Dismin < dist < distmax

reject

db tables

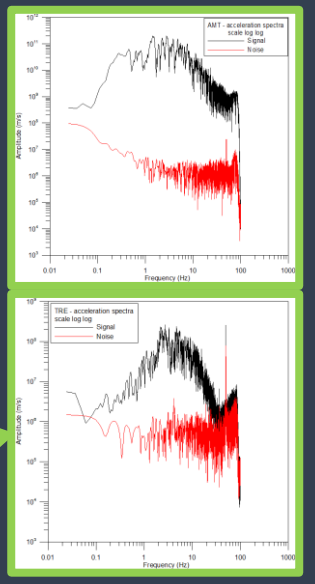
db.arrival
db.assoc

Extract noise and S-wave window

Apply rmean , detrend, d2 instrumental response

Define low-high pass corner frequencies (f1, f2)

f2 > f1
f1 < fmin, f2 > fmax



Apply bandpass Butterworth filter

db.calibration
db.site
db.sensor
db.instrument

Compute instrument response

Compute displacement, velocity, acceleration Fourier spectra

Compute displacement, velocity, acceleration waveforms

Compute response spectra, ground motion parameters *

db.wfparam
db.wfdamage

db.stamw
db.netmw
db.netmag

Determine the seismic moment, Mw, f0, stress drop, equivalent radius

Estimate velocity and displacement spectra at the source

Correct spectra for geometrical spreading and anelastic attenuation

Compute Fourier spectrum

Compute transversal component

* PGA, PGV, PGD, PSA03, PSA10, PSA30, Housner, Arias, RMSA, duration, intensity of zero crossing, Saragoni index, damage factor,…

dbgm (C code)

db.chanpos

db.wfdisc
db.origin
db.event
db.netmag

orb2db
orb2wf

db tables

Select origin

Standard Component Orientation

yes

no

Channels rotation

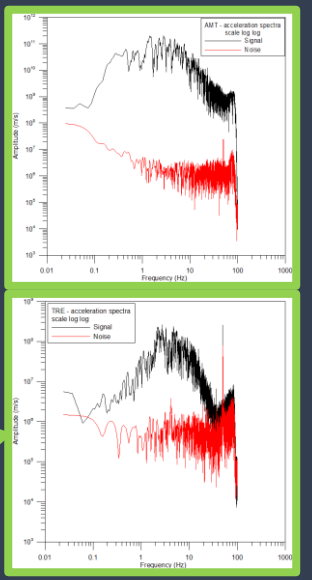
Select N,E,Z component

MI > magmin
Dismin < dist < distmax

reject

no

f2 > f1
f1 < fmin, f2 > fmax



db.arrival
db.assoc

Extract noise and S-wave window

Apply rmean , detrend, d2 instrumental response

Define low-high pass corner frequencies (f1, f2)

Apply bandpass Butterworth filter

db.calibration
db.site
db.sensor
db.instrument

Compute instrument response

Compute displacement, velocity, acceleration Fourier spectra

Compute displacement, velocity, acceleration waveforms

Compute response spectra, ground motion parameters *

db.gmp

* PGA, PGV, PGD, EPA, PSA03, PSA10, PSA30, Housner, Arias, RMSA, duration, intensity of zero crossing, Saragoni index, damage factor,...

db tables

db.origin

UTS.trigger

UTS.proc

UTS.sms
~~Wfmax~~
Alert
dbgm
SPT
db2shake.py
~~db2kml~~

DMG
database

python

Alert

C

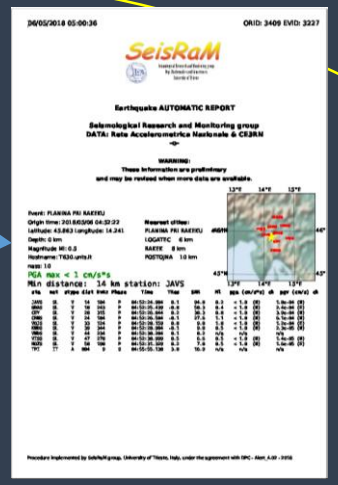
dbgm

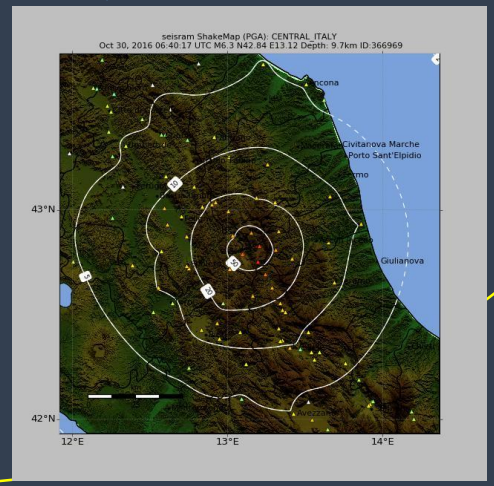
python- gmt

SPT

python

db2shake





Automatic, real time report for Civil Defence

03/04/2014 12:05:11 ORID: 618 EVID: 389

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

Earthquake AUTOMATIC REPORT

Dipartimento della Protezione Civile - Rome - Italy
Rete Accelerometrica Nazionale
RAN

WARNING:
These information are preliminary
and may be revised when more data are available.

Event: NORTHERN_ITALY
Origin time: 2012/05/29 07:00:03
Latitude: 44.851 Longitude: 11.086
Magnitude MI: 5.8
AGENCY: INGV

Seismic Moment: 1.13e+18 Nm
Mw: 5.8
AGENCY: UniTS

Records analyzed by procedure: 197
Selected limits: max distance=150. km min PGA= 0.1 cm/s*s
min PGA to show response spectra= 0.1 cm/s*s
Records inside the selected limits: 185 response spectra inside the limits: 185

Nearest station: MRN distance: 3.81 km
HGZ - PGA=895.78 cm/s*s, PGV=21.64 cm/s

Procedure implemented by SeisRaM group, University of Trieste, Italy - ver: SPT_1.24 - 2014 - costa@units.it

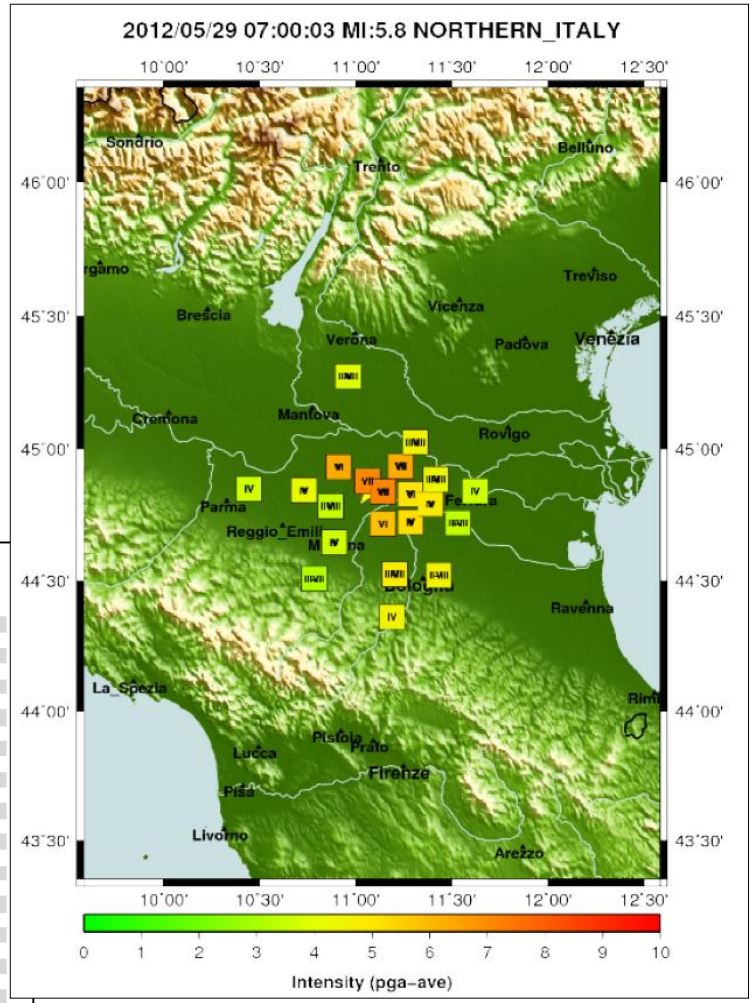
SeisRaM

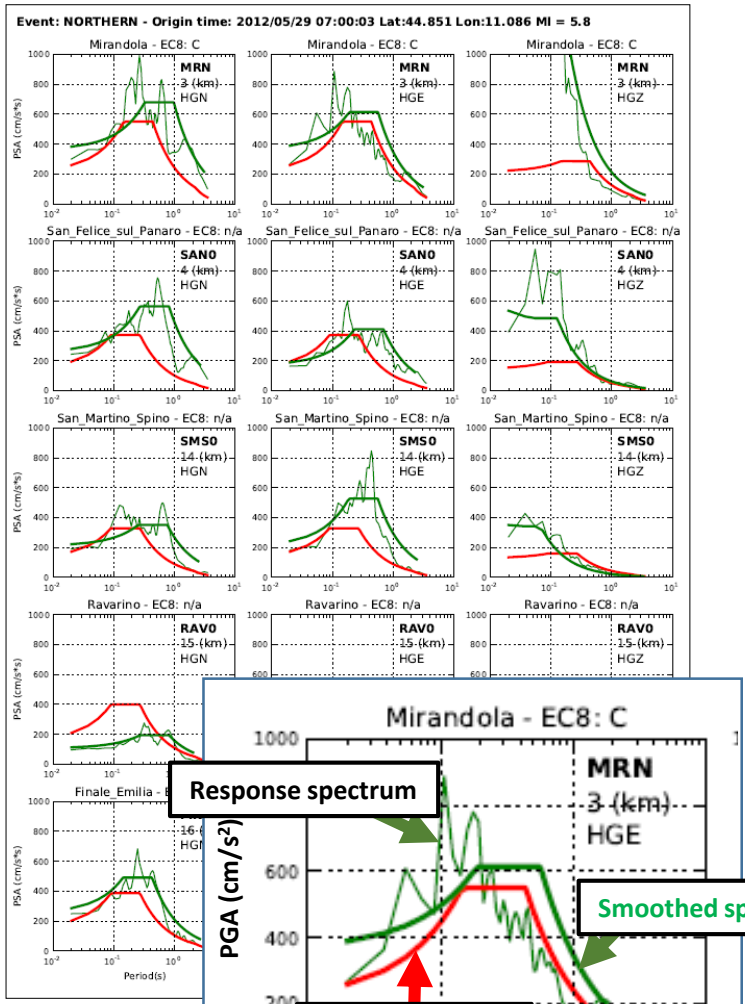
Event: KNEZAK - Origin time: 2014/04/22 08:58:27 Lat:45.633 Lon:14.258 MI = 4.7 Agency: UniTS
Seismic moment: 2.670e+16 Nm - Mw = 4.5 Agency: UniTS

sta	chan	dista	filter	PGA	EPA	PGV	PGD	PSA03	PSA10	PSA30	EC8	location
		km	Hz	cm/s*s	cm/s*s	cm/s	cm	cm/s*s	cm/s*s	cm/s*s		
KNDS	HHN	15	0.1-50.0	37.72	18.21	0.82	0.05	46.81	3.25	0.34	na	Knezji Dol, SL
KNDS	HHE	15	0.1-50.0	23.92	13.69	0.69	0.06	27.62	3.59	0.28	na	Knezji Dol, SL
KNDS	HHZ	15	0.1-50.0	17.14	6.61	0.33	0.02	15.04	0.78	0.11	na	Knezji Dol, SL
CEY	HHN	17	0.1-50.0	47.72	10.45	0.75	0.05	17.87	3.40	0.32	na	Cerknica, SL
CEY	HHE	17	0.1-50.0	30.33	9.38	0.70	0.04	11.35	1.94	0.22	na	Cerknica, SL
CEY	HHZ	17	0.1-50.0	17.83	4.48	0.27	0.02	9.18	0.86	0.12	na	Cerknica, SL
SKDS	HGN	21	0.1-50.0	30.76	9.61	0.62	0.04	15.55	2.15	0.20	na	Skadanscina, SL
SKDS	HGE	21	0.1-50.0	19.71	7.32	0.44	0.03	14.50	1.60	0.14	na	Skadanscina, SL
SKDS	HGZ	21	0.1-50.0	13.09	4.50	0.27	0.02	10.94	0.76	0.10	na	Skadanscina, SL
SKDS	HHN	21	0.2-50.0	30.33	9.88	0.65	0.03	15.58	2.16	0.22	na	Skadanscina, SL
SKDS	HHE	21	0.2-50.0	21.62	7.46	0.43	0.02	14.51	1.65	0.16	na	Skadanscina, SL
SKDS	HHZ	21	0.1-50.0	13.35	4.49	0.27	0.02	10.97	0.77	0.10	na	Skadanscina, SL
JAVS	HHN	33	0.1-50.0	6.13	2.86	0.14	0.02	4.66	0.80	0.15	na	Javornik, SL
JAVS	HHE	33	0.1-50.0	11.36	6.15	0.31	0.03	10.40	1.63	0.20	na	Javornik, SL
JAVS	HHZ	33	0.1-50.0	4.70	2.64	0.12		5.09	0.64	0.05	na	Javornik, SL
DST2	HHN	36	0.1-47.0	7.46	4.97	0.27	0.02	9.90	1.04	0.12	A	DST-Trieste_station
DST2	HHE	36	0.1-46.4	9.09	4.13	0.20	0.01	8.00	0.61	0.10	A	DST-Trieste_station
DST2	HHZ	36	0.1-47.8	4.49	2.65	0.12		5.70	0.47	0.05	A	DST-Trieste_station
GBAS	HHN	37	0.1-50.0	3.23	1.26	0.07		2.35	0.33	0.05	na	Gornja Brezovica, SL
GBAS	HHE	37	0.1-50.0	3.71	1.43	0.07		3.31	0.40	0.03	na	Gornja Brezovica, SL
GBAS	HHZ	37	0.1-50.0	2.43	0.96	0.06		1.56	0.38	0.03	na	Gornja Brezovica, SL
TRI	HHN	39	0.1-47.3	12.38	1.97	0.15		2.33	0.46	0.05	A	TRI-Trieste_station
TRI	HHE	39	0.1-45.6	13.66	3.60	0.19		4.30	0.31	0.08	A	TRI-Trieste_station
TRI	HHZ	39	0.1-47.5	31.18	4.24	0.34		5.12	0.30	0.08	A	TRI-Trieste_station
GBRS	HHN	45	0.1-50.0	11.89	3.11	0.20		2.86	0.56	0.06	na	Gornja Briga, SL
GBRS	HHE	45	0.1-50.0	15.31	3.81	0.25		4.30	0.46	0.07	na	Gornja Briga, SL
GBRS	HHZ	45	0.1-50.0	4.42	1.12	0.07		1.75	0.47	0.06	na	Gornja Briga, SL
VISS	HHN	49	0.1-50.0	3.78	2.32	0.13	0.01	4.22	1.16	0.09	na	Visnje, SL
VISS	HHE	49	0.1-50.0	3.68	2.00	0.10		2.71	0.69	0.05	na	Visnje, SL

dista = epicentral distance
filter = automatic band pass butterworth filter
EC8 = site classification (Eurocode from ITACA)

PGA,PGV,PGD = peak ground acceleration, velocity and displacement
EPA = effective ground acceleration (Kramer, 1996)
PSA03,PSA10,PSA30 = spectral acceleration (0.3, 1.0, 3.0 sec)

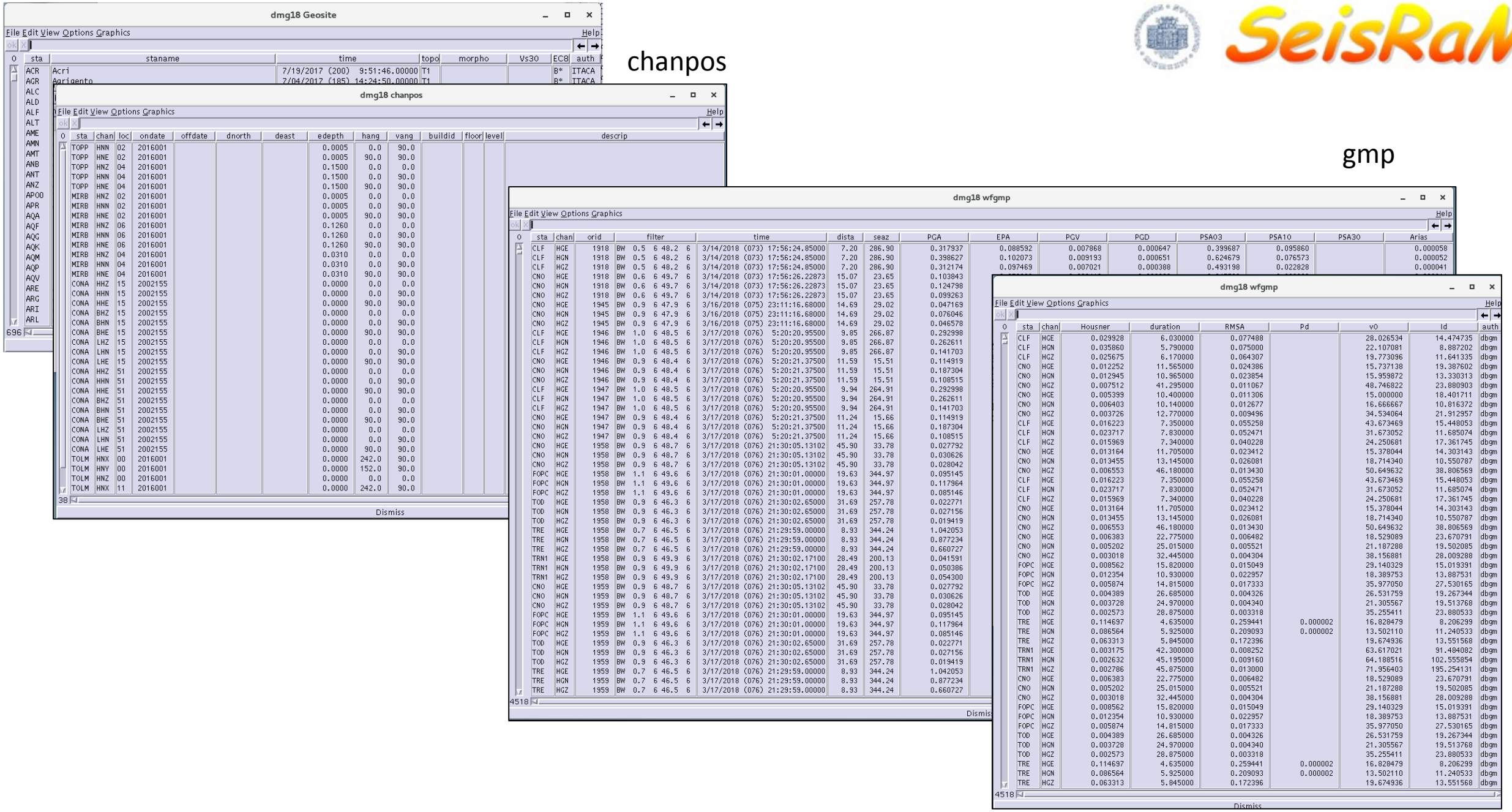




geosite

chanpos

gmp



KMI Rockhound - Station TOL1 Tolmezzo 11, SN: 100398

SeisRaM

Hardware

Hardware Parameter	Value	Info
Unit ID	TOL1	?
Network ID	RF	?
Site ID	Tolmezzo 11	?
Comment	Tolmezzo sottotetto	?
Number of Channels	7	?
'dig1' name	dig1	?
dig1 Sensor Range	2g	?
dig1 VCh1 ID	HNX	?
dig1 VCh2 ID	HNY	?
dig1 VCh3 ID	HNZ	?
dig1 VCh4 ID	C4	?
dig1 VCh5 ID	C5	?
dig1 VCh6 ID	C6	?
dig1 VCh7 ID	C7	?
dig1 Ch1 Sensor Type (Physical)	32 All	?
dig1 Ch2 Sensor Type (Physical)	32 All	?
dig1 Ch3 Sensor Type (Physical)	32 All	?
dig1 Ch4 Sensor Type (Physical)	32 All	?
dig1 Ch1 Sensor SN (Physical)	68001	?
dig1 Ch2 Sensor SN (Physical)	68093	?
dig1 Ch3 Sensor SN (Physical)	68122	?
dig1 Ch4 Sensor SN (Physical)	0	?
dig1 Ch1 Sensor natural frequency (Physical)	206.0	?
dig1 Ch2 Sensor natural frequency (Physical)	212.0	?

dig1 Ch1 Offset East (Physical)	0	All	?
dig1 Ch2 Offset East (Physical)	0	All	?
dig1 Ch3 Offset East (Physical)	0	All	?
dig1 Ch4 Offset East (Physical)	0	All	?
dig1 Ch1 Offset Up (Physical)	0	All	?
dig1 Ch2 Offset Up (Physical)	0	All	?
dig1 Ch3 Offset Up (Physical)	0	All	?
dig1 Ch4 Offset Up (Physical)	0	All	?
dig1 VCh1 Location code	11	All	?
dig1 VCh2 Location code	11	All	?
dig1 VCh3 Location code	11	All	?
dig1 VCh4 Location code	11	All	?
dig1 VCh5 Location code	11	All	?
dig1 VCh6 Location code	11	All	?
dig1 VCh7 Location code	11	All	?
dig1 VCh1 Network code	RF	All	?
dig1 VCh2 Network code	RF	All	?
dig1 VCh3 Network code	RF	All	?
dig1 VCh4 Network code		All	?
dig1 VCh5 Network code		All	?
dig1 VCh6 Network code		All	?
dig1 VCh7 Network code		All	?
dig1 VCh1 Station code	TOLM	All	?
dig1 VCh2 Station code	TOLM	All	?
dig1 VCh3 Station code	TOLM	All	?
dig1 VCh4 Station code		All	?

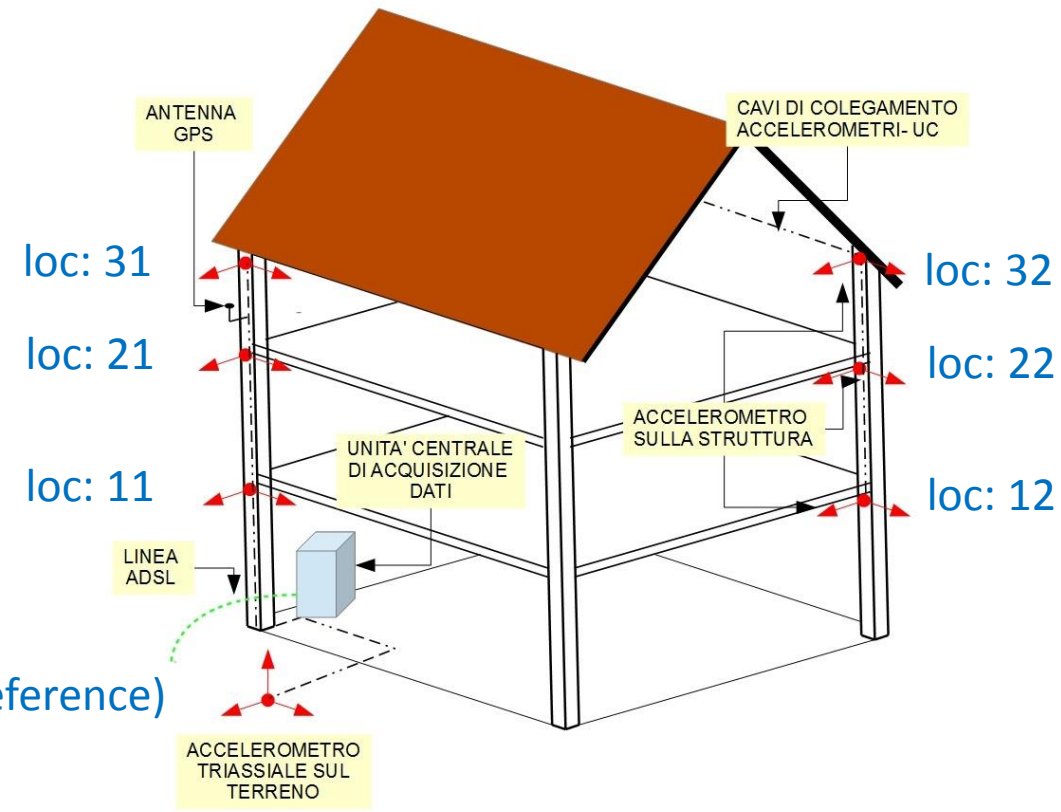
TOL0

TOL1

loc: XX

floor

vertical



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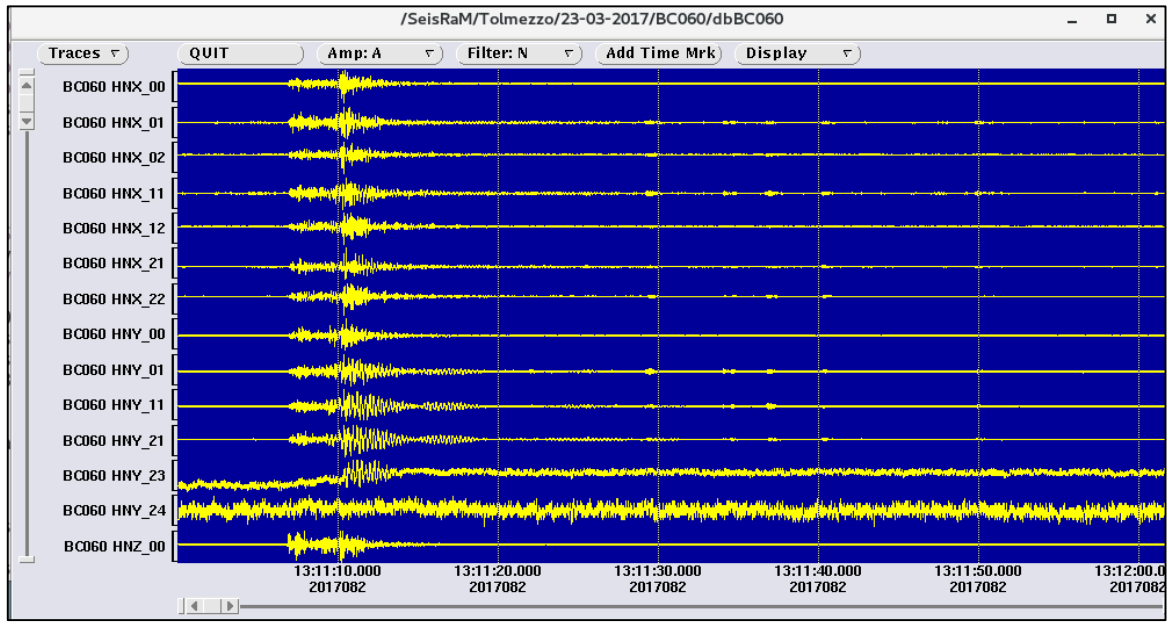

File Edit View Options Graphics Process Help

0	sta	chan	time	endtime	nsamp	samprate
	BC060	HNY_01	3/23/2017 (082) 13:11:00.00000	3/23/2017 (082) 13:12:01.99200	15499	249.9999881
	BC060	HNX_01	3/23/2017 (082) 13:11:00.00000	3/23/2017 (082) 13:12:01.99200	15499	249.9999881
	BC060	HNX_02	3/23/2017 (082) 13:11:00.00000	3/23/2017 (082) 13:12:01.99200	15499	249.9999881
	BC060	HNY_11	3/23/2017 (082) 13:11:00.00000	3/23/2017 (082) 13:12:01.99200	15499	249.9999881
	BC060	HNX_11	3/23/2017 (082) 13:11:00.00000	3/23/2017 (082) 13:12:01.99200	15499	249.9999881
	BC060	HNX_12	3/23/2017 (082) 13:11:00.00000	3/23/2017 (082) 13:12:01.99200	15499	249.9999881
	BC060	HNY_21	3/23/2017 (082) 13:11:00.00000	3/23/2017 (082) 13:12:01.99200	15499	249.9999881
	BC060	HNX_21	3/23/2017 (082) 13:11:00.00000	3/23/2017 (082) 13:12:01.99200	15499	249.9999881
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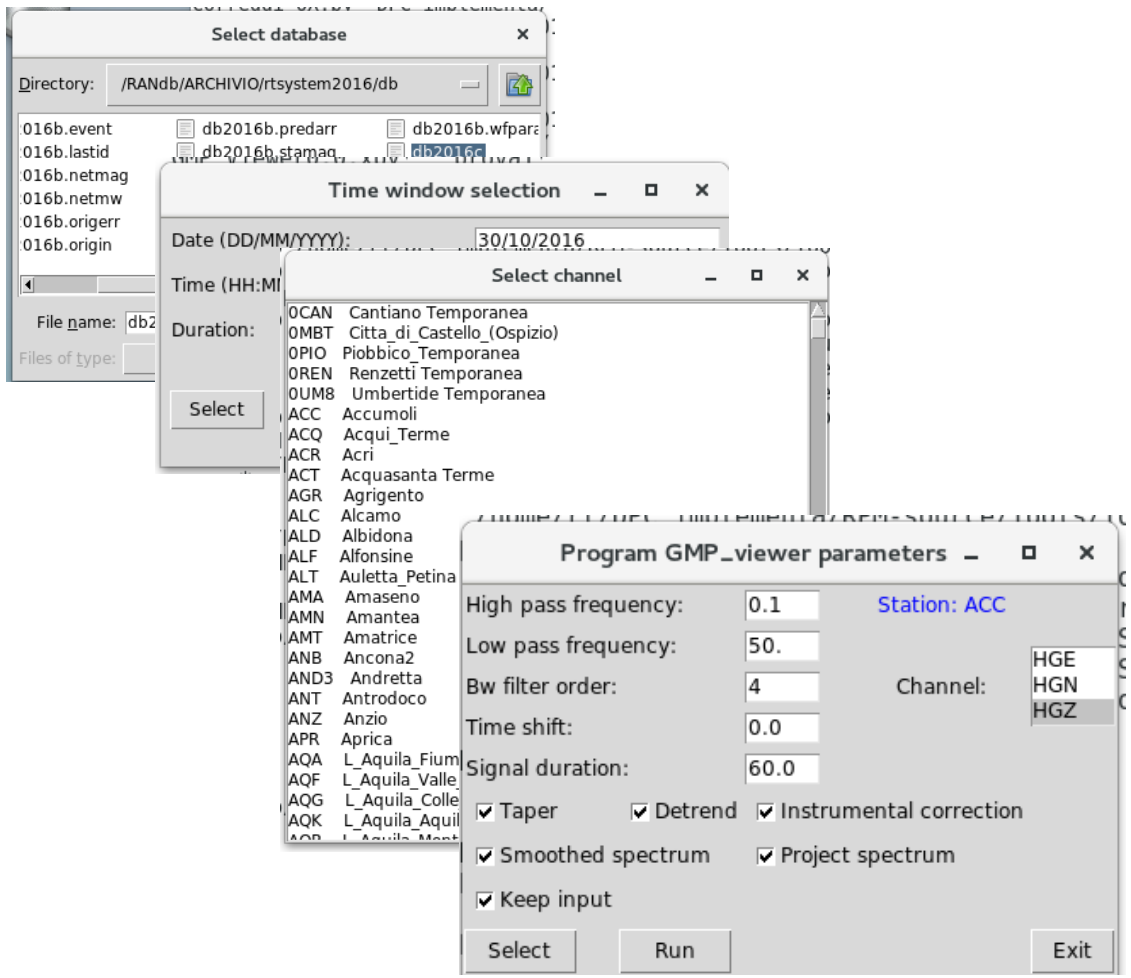
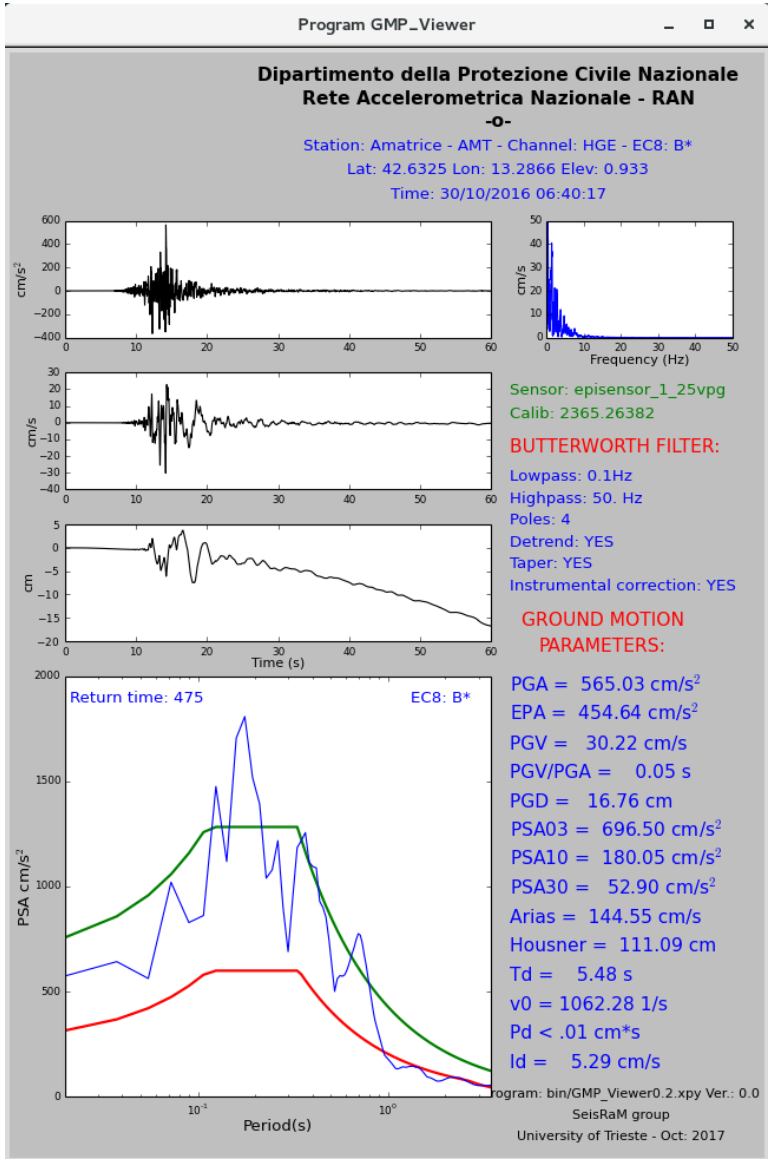
	BC060	HNX_00	3/23/2017 (082) 13:11:00.00000	3/23/2017 (082) 13:12:01.99200	15499	249.9999881
	BC060	HNZ_00	3/23/2017 (082) 13:11:00.00000	3/23/2017 (082) 13:12:01.99200	15499	249.9999881

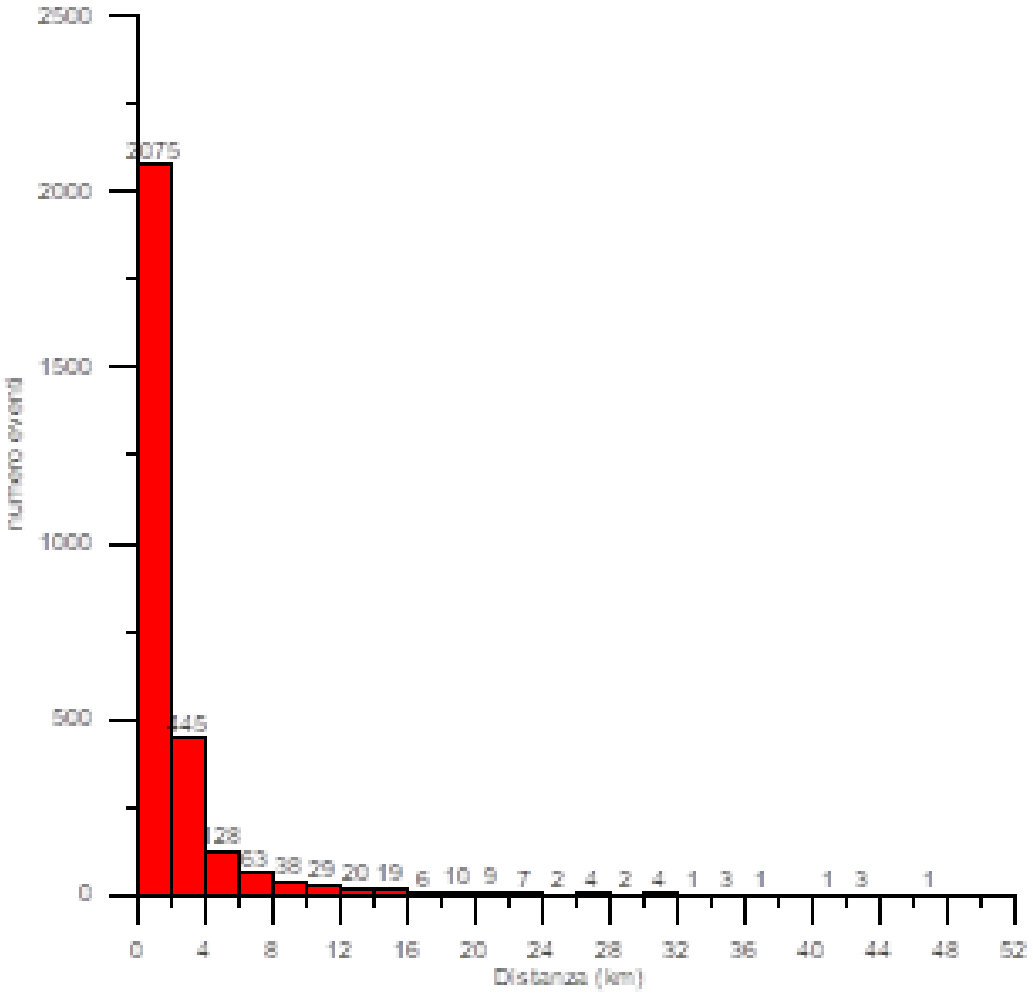
14

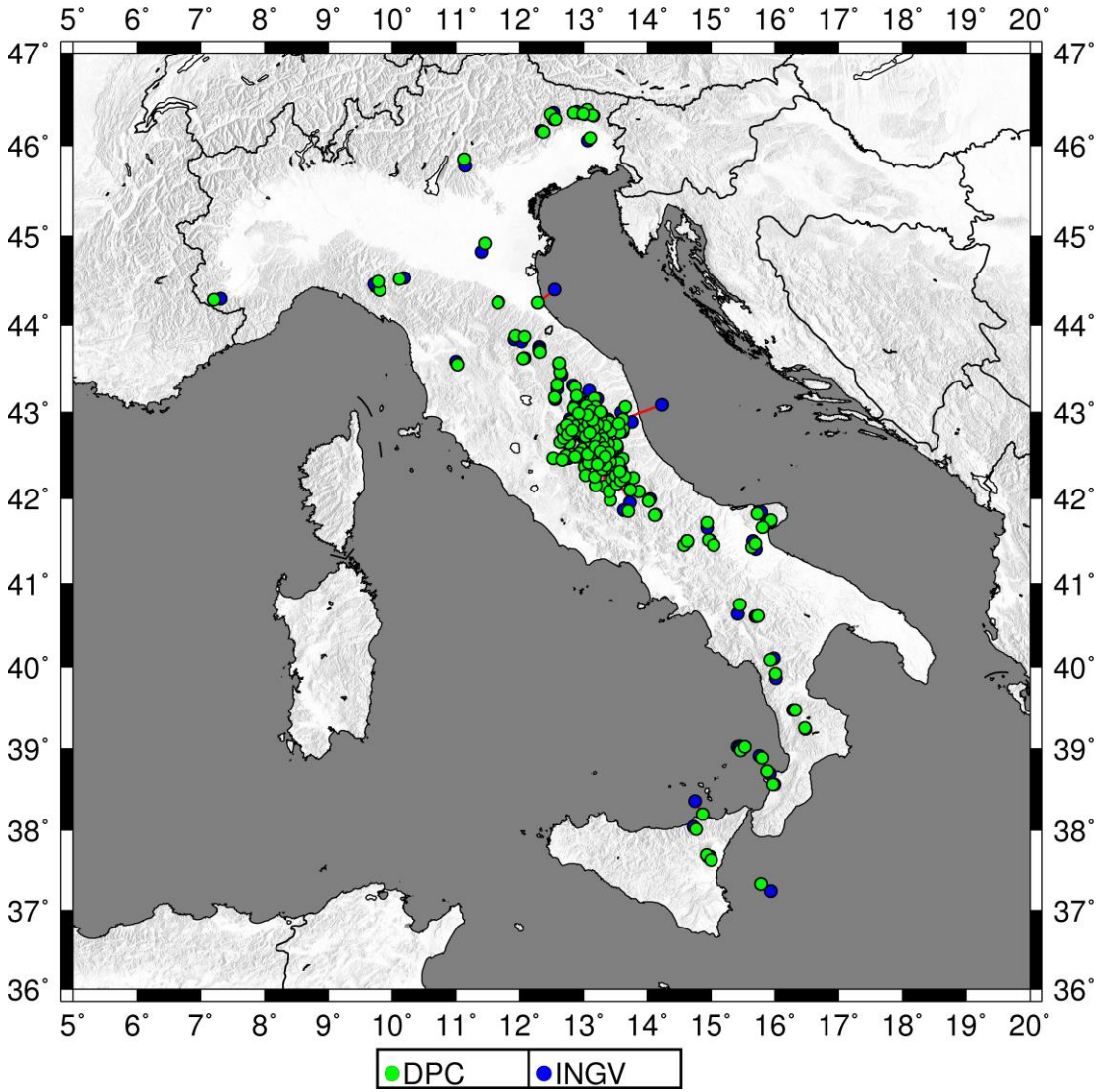
Dismiss

GMP_Viewer0.4.xpy (Obspy)



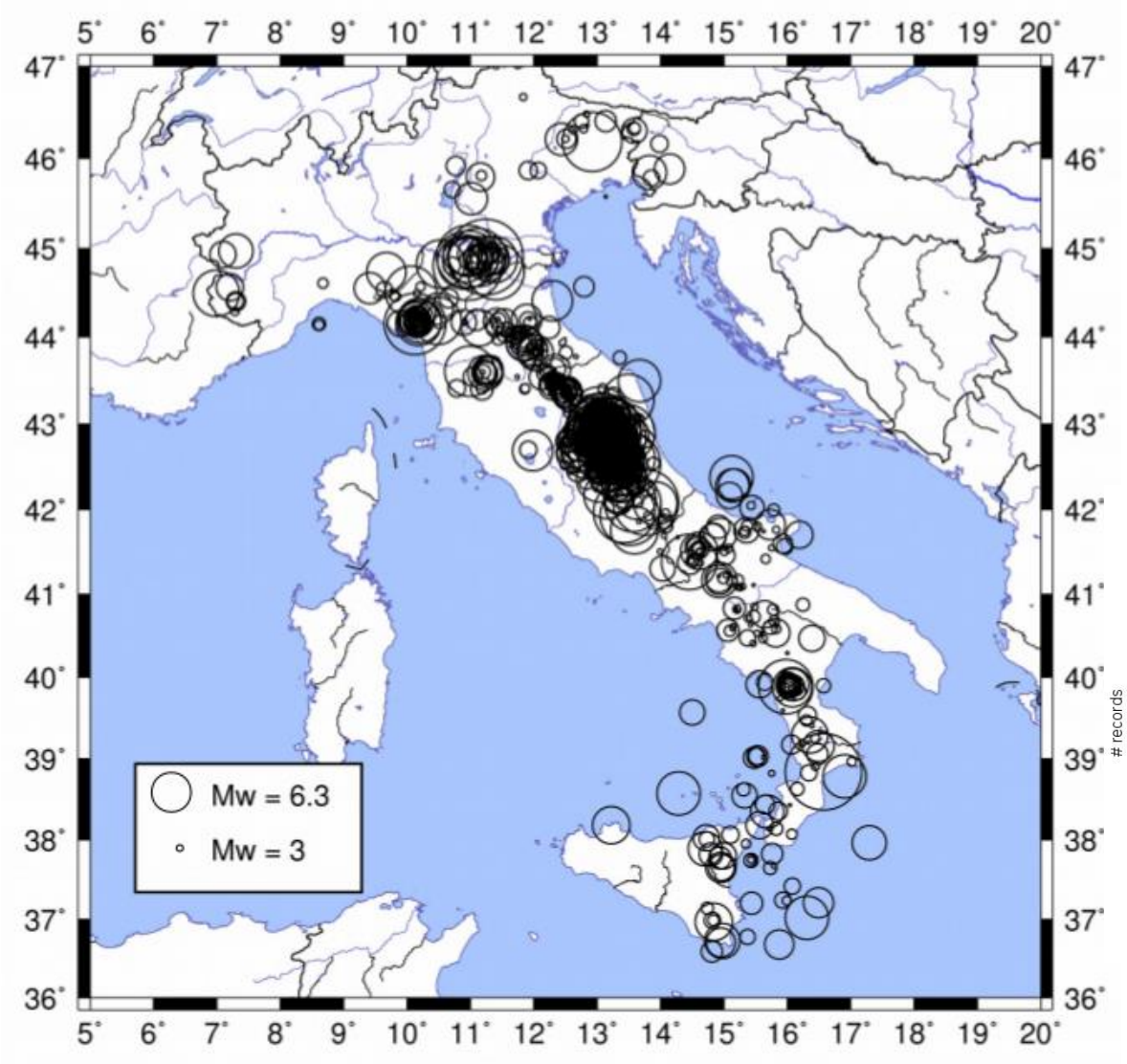



2500
2000
1500
1000
500
0
Numero eventi
2075
445
128
63
38
29
20
19
6
10
9
7
2
4
2
4
1
3
1
1
3
1
0
4
8
12
16
20
24
28
32
36
40
44
48
52
Distanza (km)


5° 6° 7° 8° 9° 10° 11° 12° 13° 14° 15° 16° 17° 18° 19° 20°
47° 46° 45° 44° 43° 42° 41° 40° 39° 38° 37° 36°
DPC
INGV

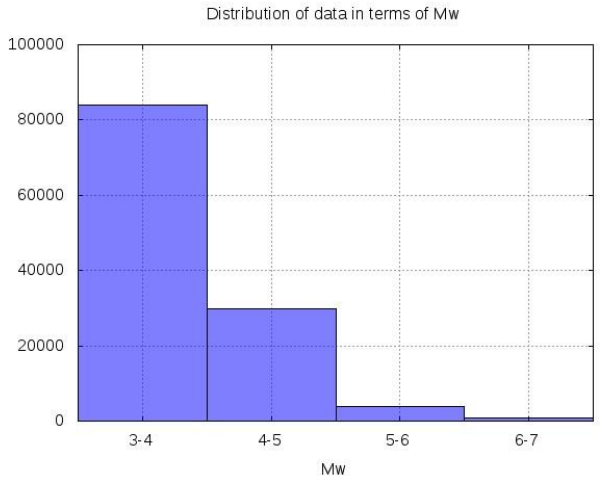
Dataset

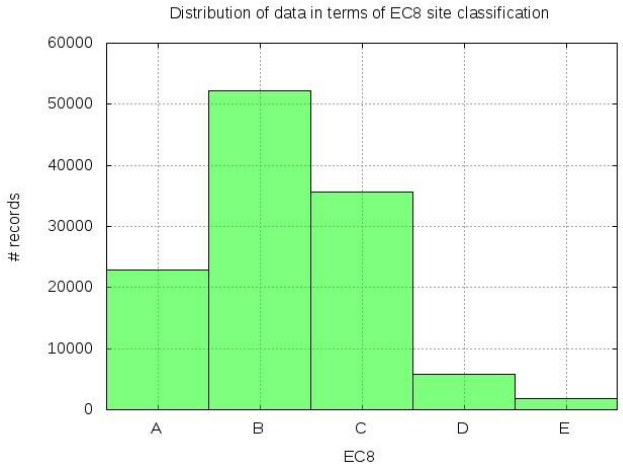
Time-span : 2011-2017



The entire database counts 1985 earthquakes with a moment magnitude between 3.0 and 6.4 of the strongest event of Amatrice sequence occurred the 30th of October, 2016.

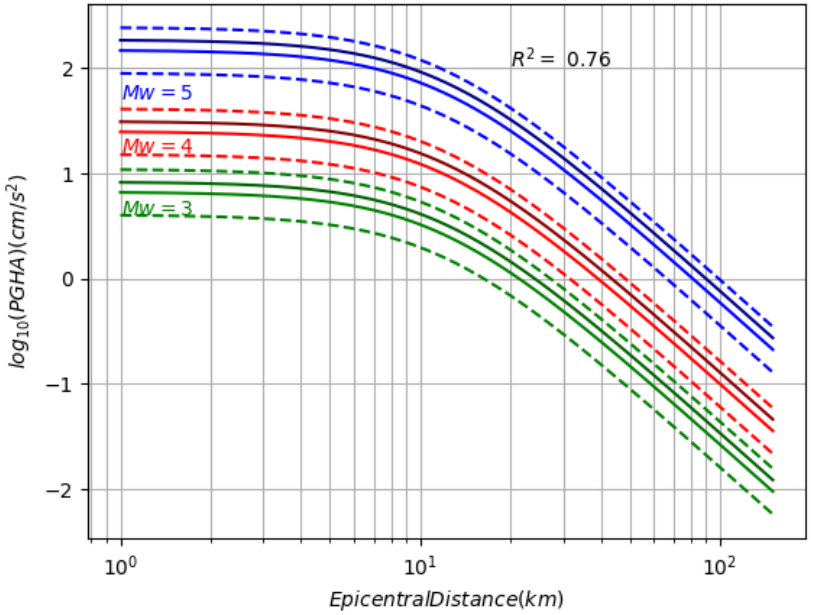
The total number of records are 118021 up to 150 km.

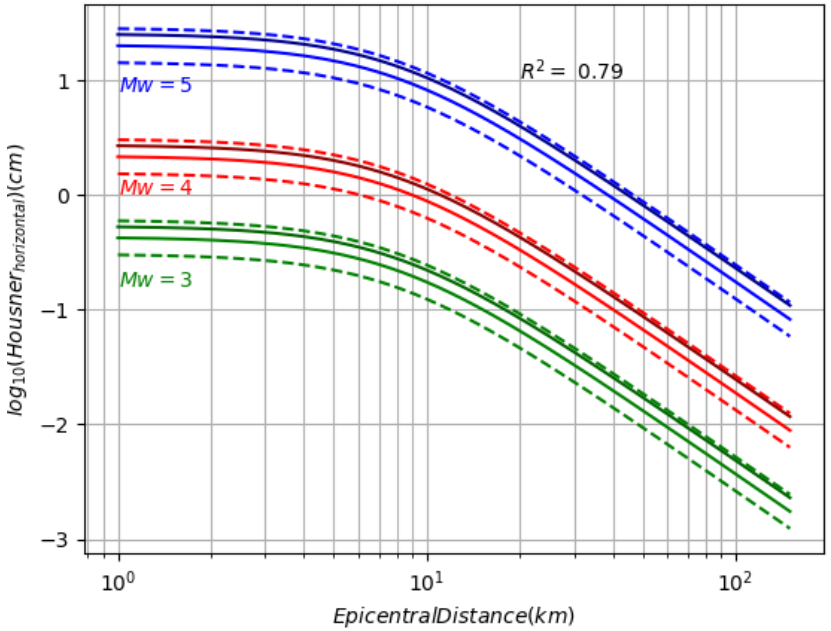




GMPE functional form:

$$Log_{10}Y = a + b\,Mw + c\,Mw^{\wedge}2 + clog_{10}((R^2 + d^2)^{1/2}) + s1SA + s2SB + s3SC + s4SD + s5SE$$





Ground motion parameters analyzed:

PGA
PGV
PGD
PSA03
PSA10
PSA30
Arias Intensity
Housner Intensity

RAN database 2011 -2017

SeisRaM

$$Log_{10}Y = a + b\,Mw + c\,Mw\text{^}2 + clog_{10}((R^2 + d^2)^{1/2}) + s1SA + s2SB + s3SC + s4SD + s5SE + fn*Fn + fss*FSS + fR*FR$$

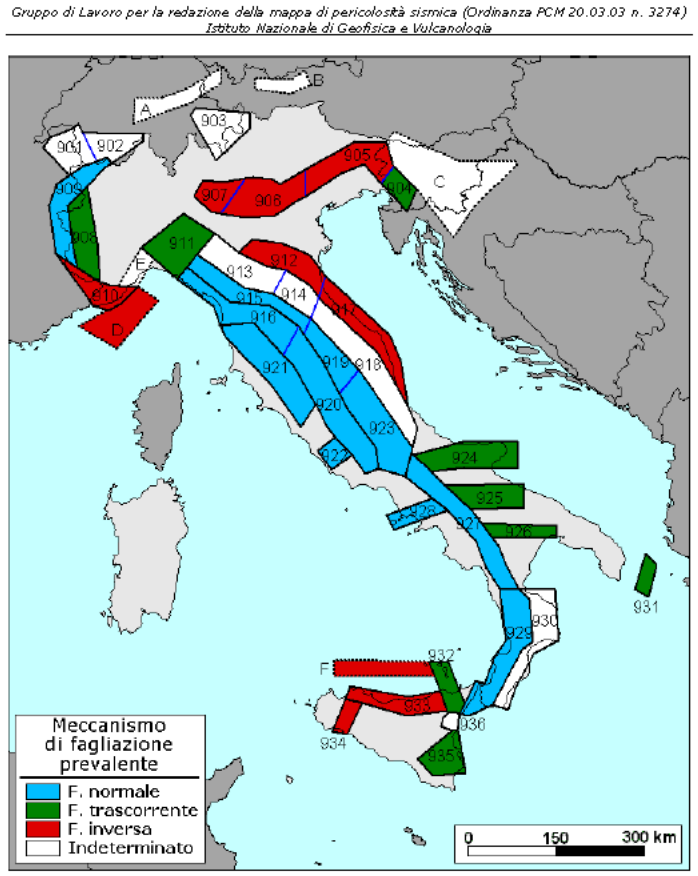
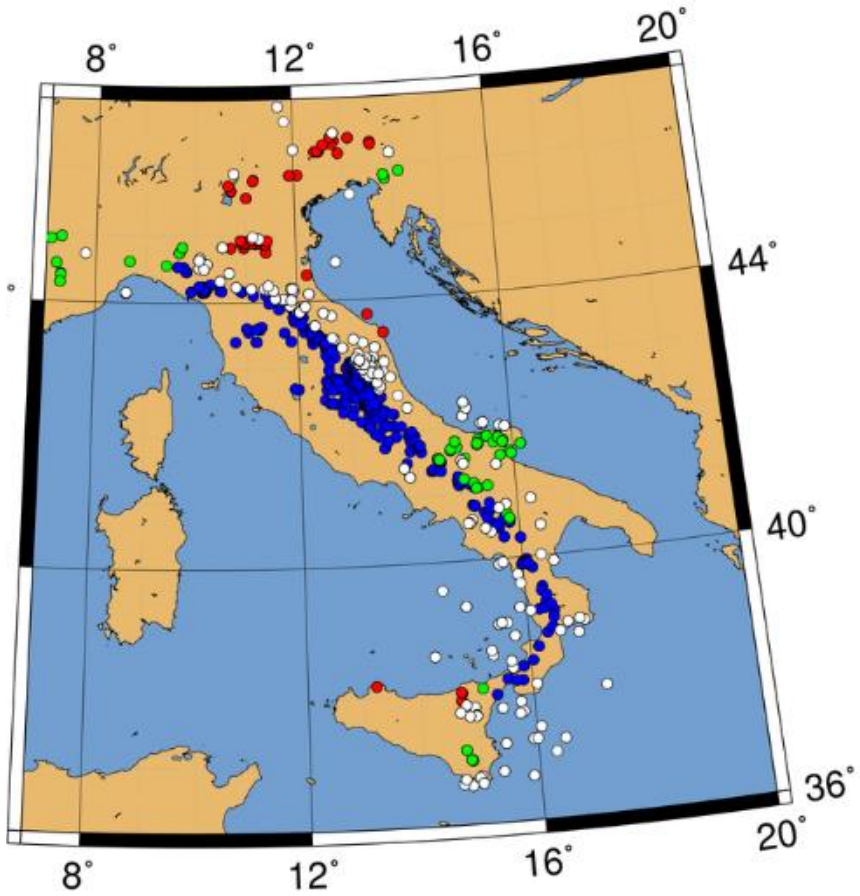
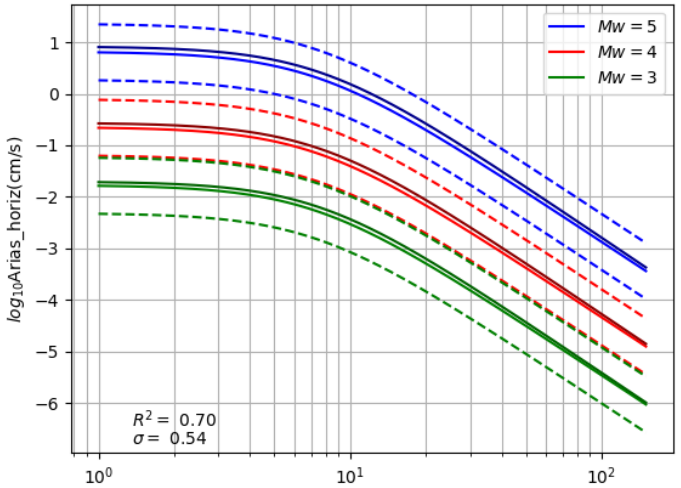
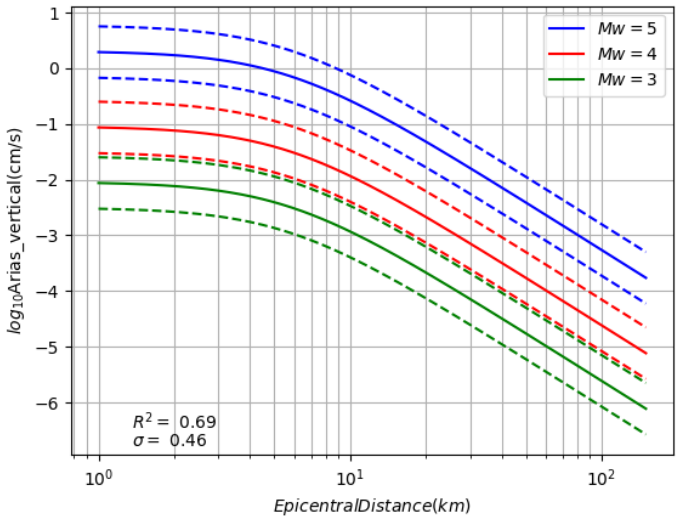


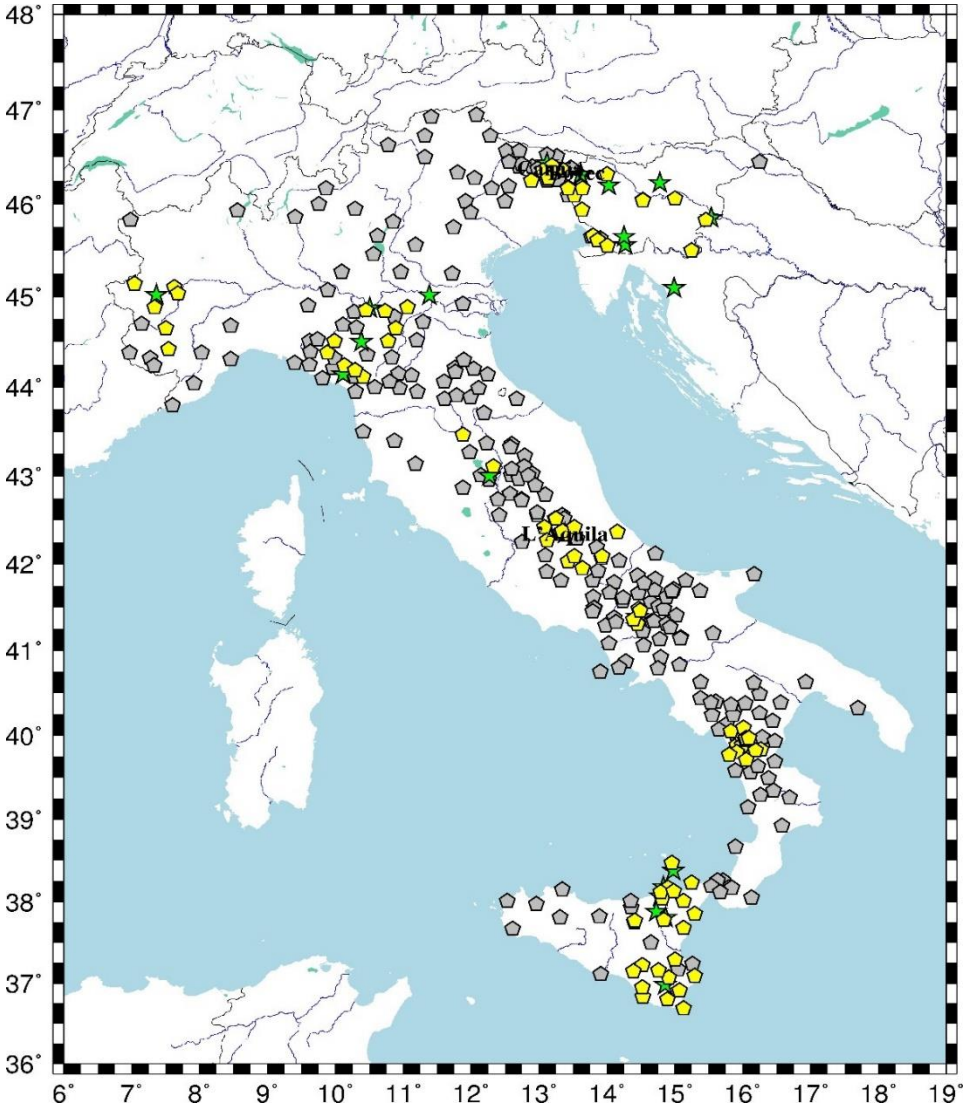
Figura 17 – Meccanismo di fagliazione prevalente atteso per le diverse zone sismogenetiche che compongono ZS9. L'assegnazione è basata su una combinazione dei meccanismi focali osservati con dati geologici a varie scale.







Input Data



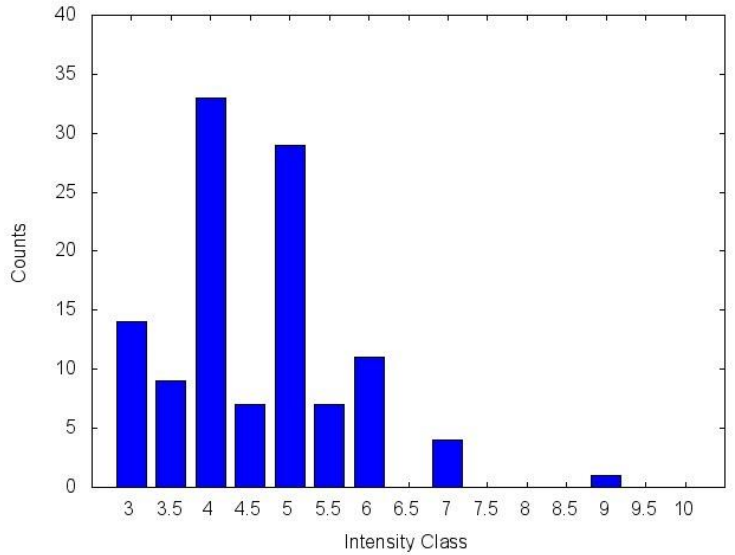
Data collected using the CE3RN (Central Eastern European Earthquake and Research Network) and the RAN (National Accelerometric Network managed by the Civil Defence of Rome) stations

Macroseismic data collected from the ARSO macroseismic archive (for the slovenian events) and from the DBMI15 (for the italian events).

Maximum distance of 4 km, with an average value of :
(1.8 ± 1.8) km

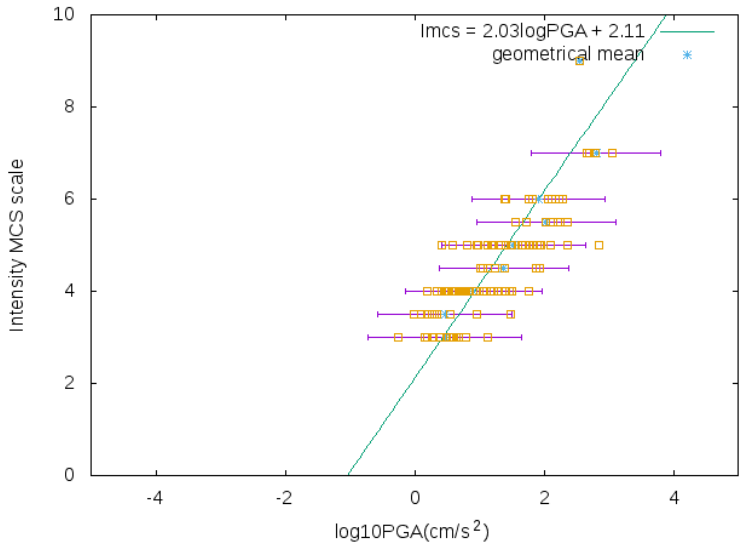
115 pairs of intensity - GMPs values

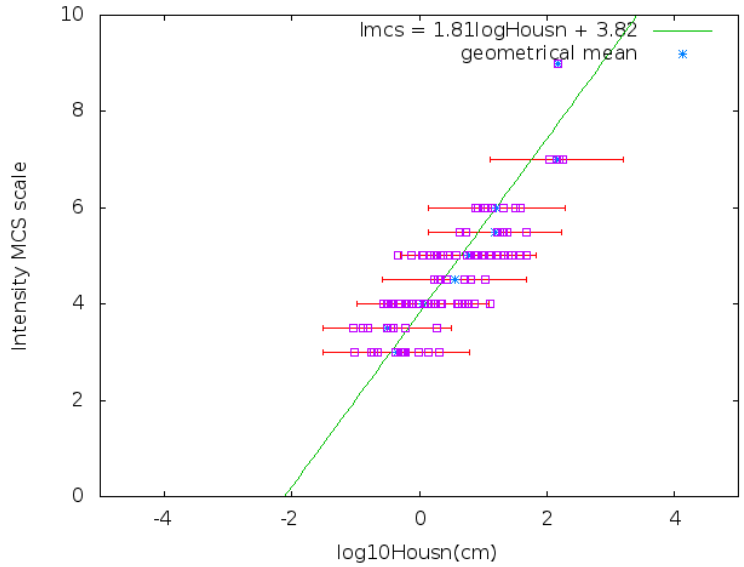
Data set used for the regression law estimation. The green stars are the epicentral location of the studied events and the grey pentagons are the station sites, where we have calculated the GMPs values and the yellow one are those with an observed intensity associated.



GMPs data divided into 0.5 intensity classes

Results





	NLLS				ODR			
GMPs	a	b	R^2	σ	a	b	R^2	σ
max PGD	1.60 ± 0.17	6.27 ± 0.21	0.93	0.55	1.71 ± 0.18	6.35 ± 0.22	0.92	0.28
max PGV	1.84 ± 0.24	4.85± 0.23	0.89	0.66	2.03 ± 0.27	4.82 ± 0.25	0.89	0.3
max PGA	2.03 ± 0.34	2.11 ± 0.59	0.84	0.8	2.39 ± 0.39	1.55 ± 0.70	0.92	0.28
max Arias	1.07 ± 0.15	5.35 ± 0.23	0.88	0.7	1.17 ± 0.16	5.38 ± 0.25	0.88	0.46
max Housner	1.81 ± 0.23	3.82 ± 0.28	0.9	0.63	1.98 ± 0.25	3.70 ± 0.30	0.9	0.29
max PSA03	1.94 ± 0.34	1.83 ± 0.67	0.83	0.84	2.31 ± 0.41	1.19 ± 0.80	0.82	0.35
max PSA10	1.69 ± 0.22	3.36 ± 0.33	0.89	0.65	1.86 ± 0.24	3.17 ± 0.35	0.9	0.31
max PSA30	1.64 ± 0.17	4.89 ± 0.19	0.92	0.54	1.76 ± 0.18	4.87 ± 0.19	0.93	0.27

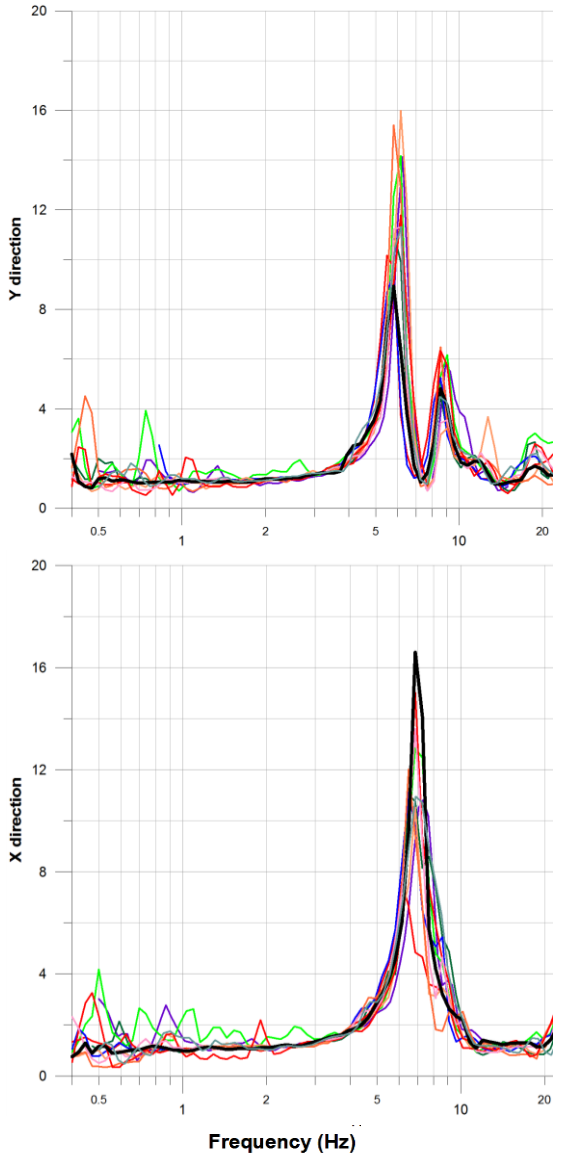
a, b and R^2 values are consistent between the two different algorithms.

The main differences are the standard deviations lower using ODR than the NLLS.

Tolmezzo

TOL0

TOL1

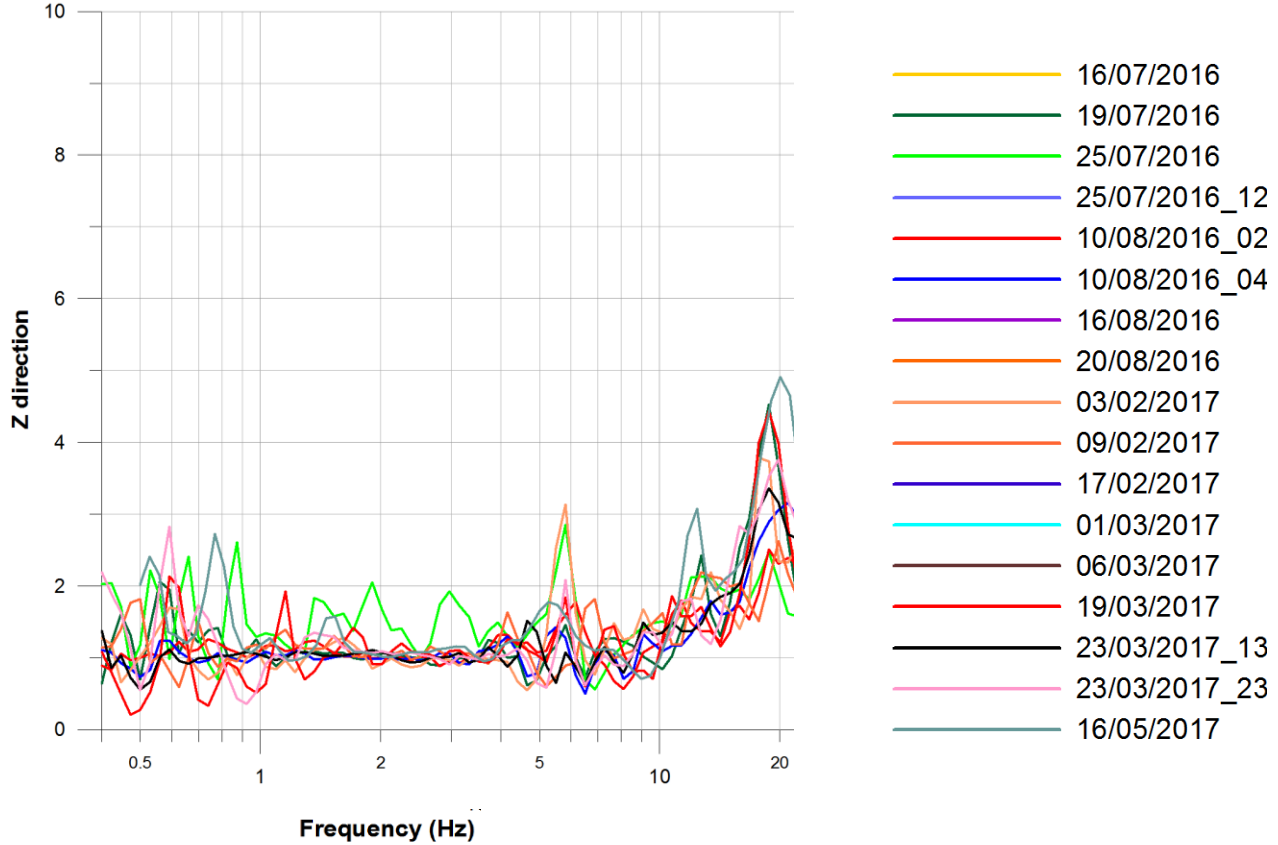


25/06/2016
19/07/2016
25/07/2016
10/08/2016_02
10/08/2016_04
03/02/2017
09/02/2017
19/03/2017
23/03/2017
23/03/2017_23
16/05/2017

Tolmezzo

TOL0

TOL1



16/07/2016
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09/02/2017
17/02/2017
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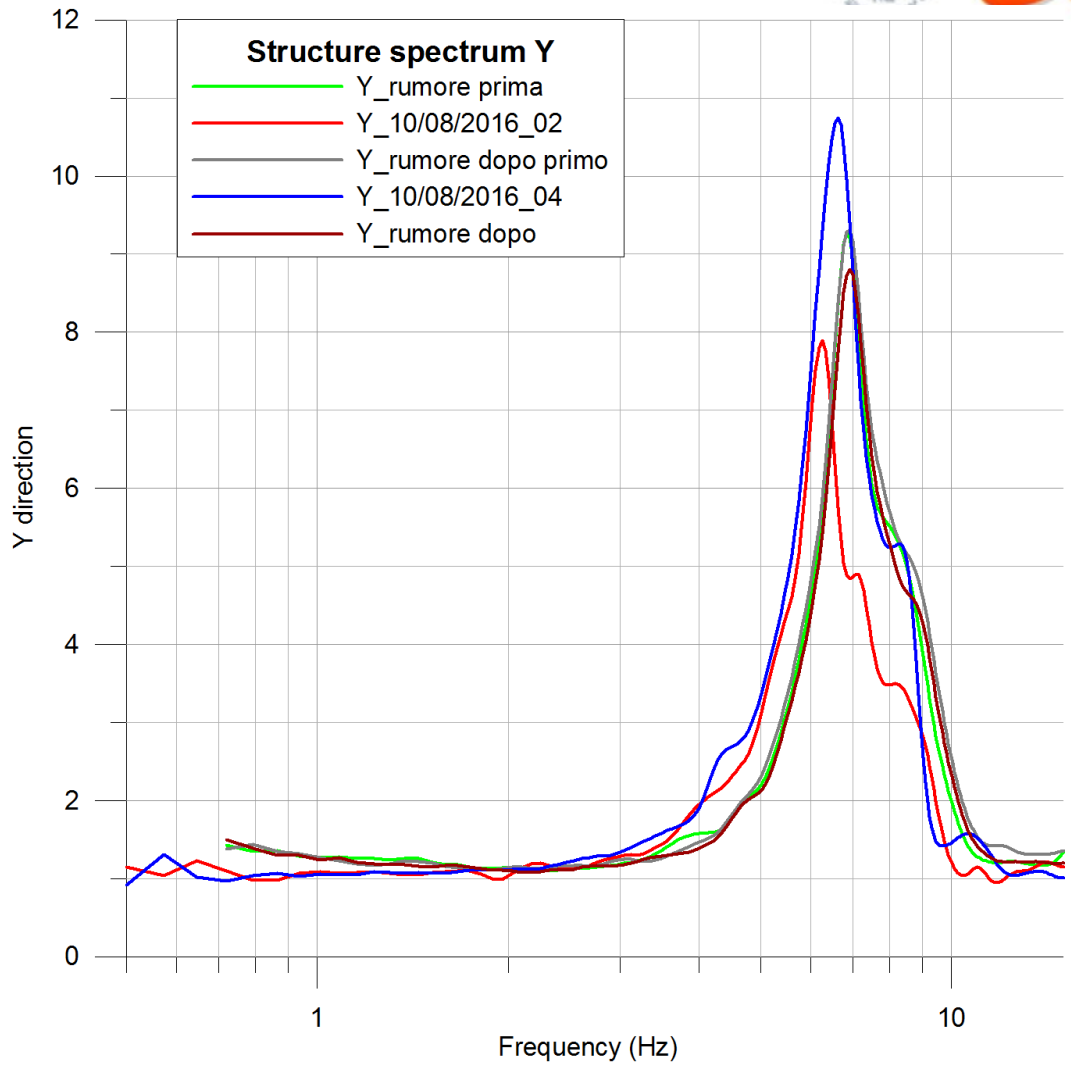
16/05/2017

Tolmezzo

TOL0

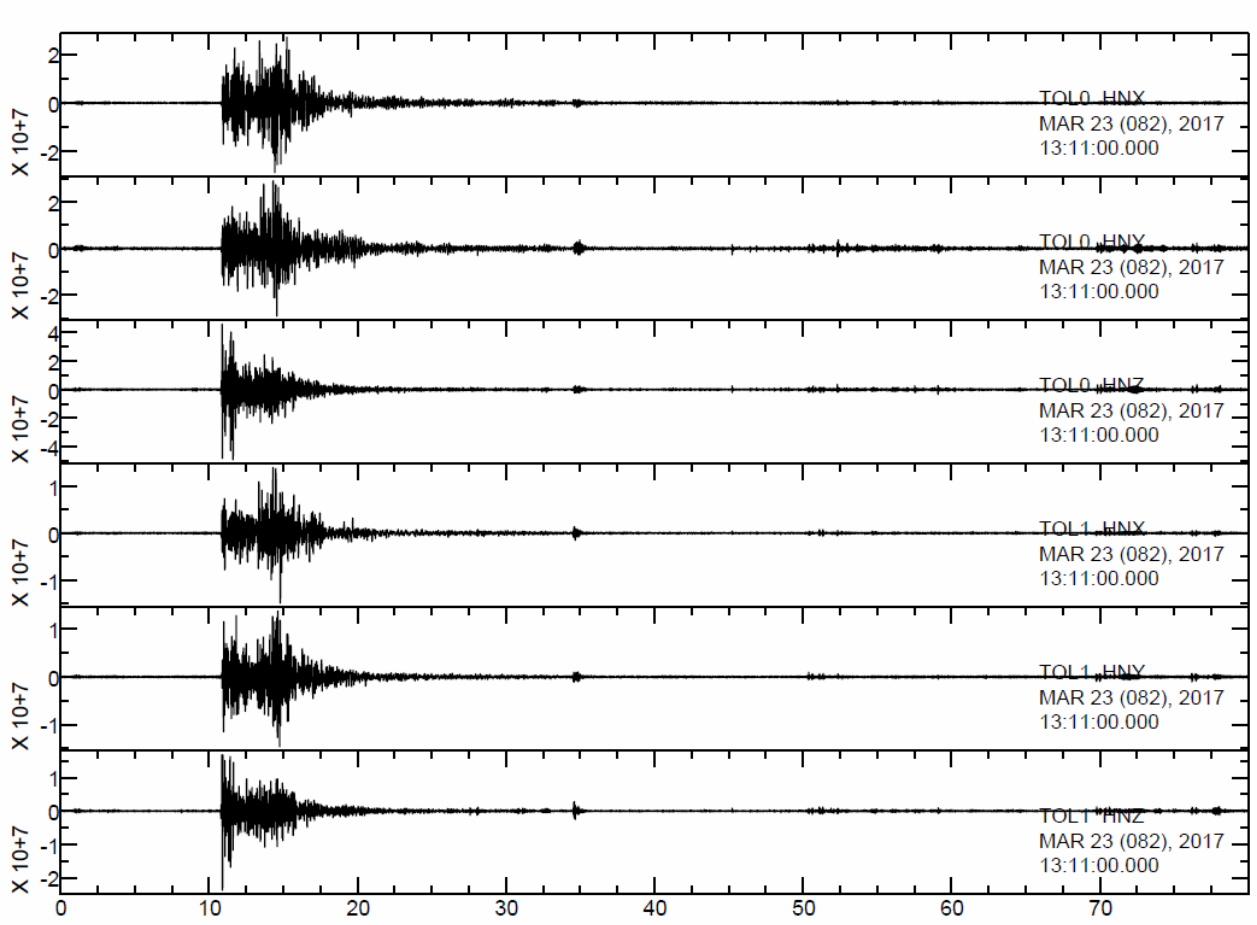
TOL1



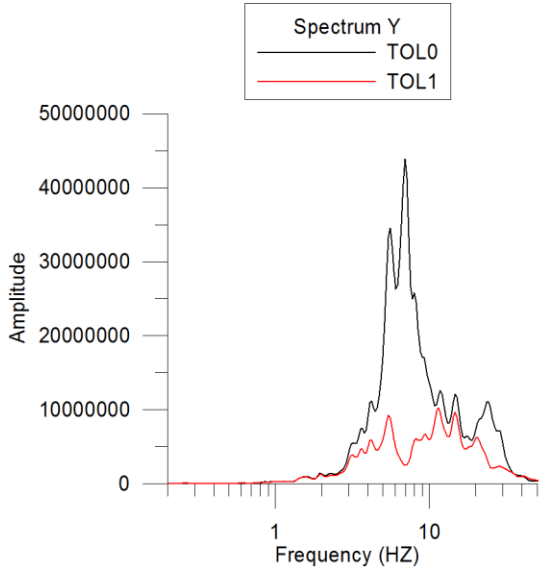
Tolmezzo - evento del 23/03/2017 con M_L 3.0

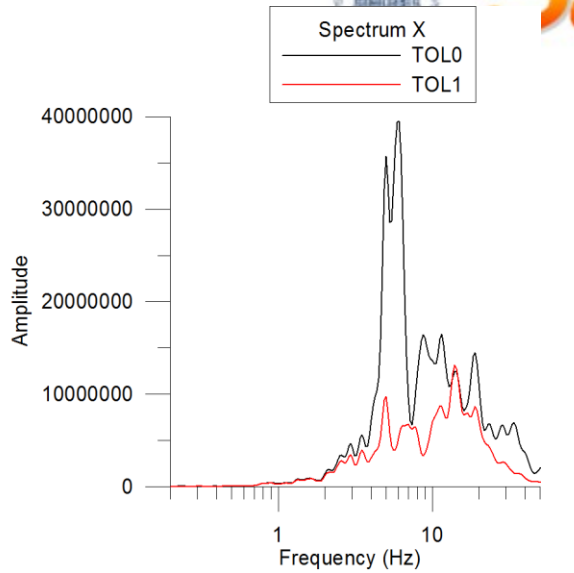
TOL0

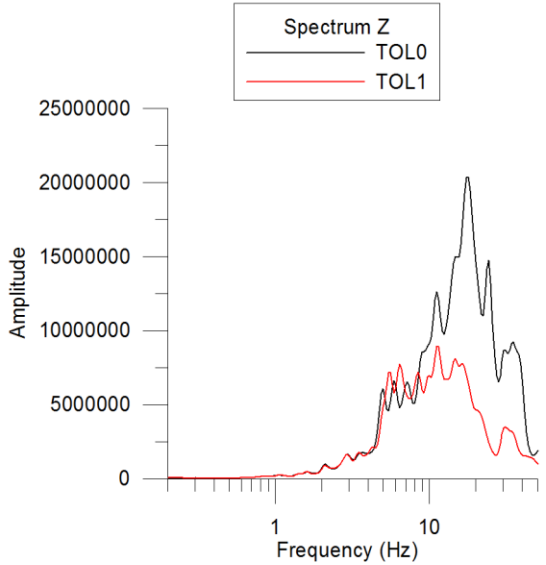
TOL1



Tolmezzo - evento del 23/03/2017 con M_L 3.0

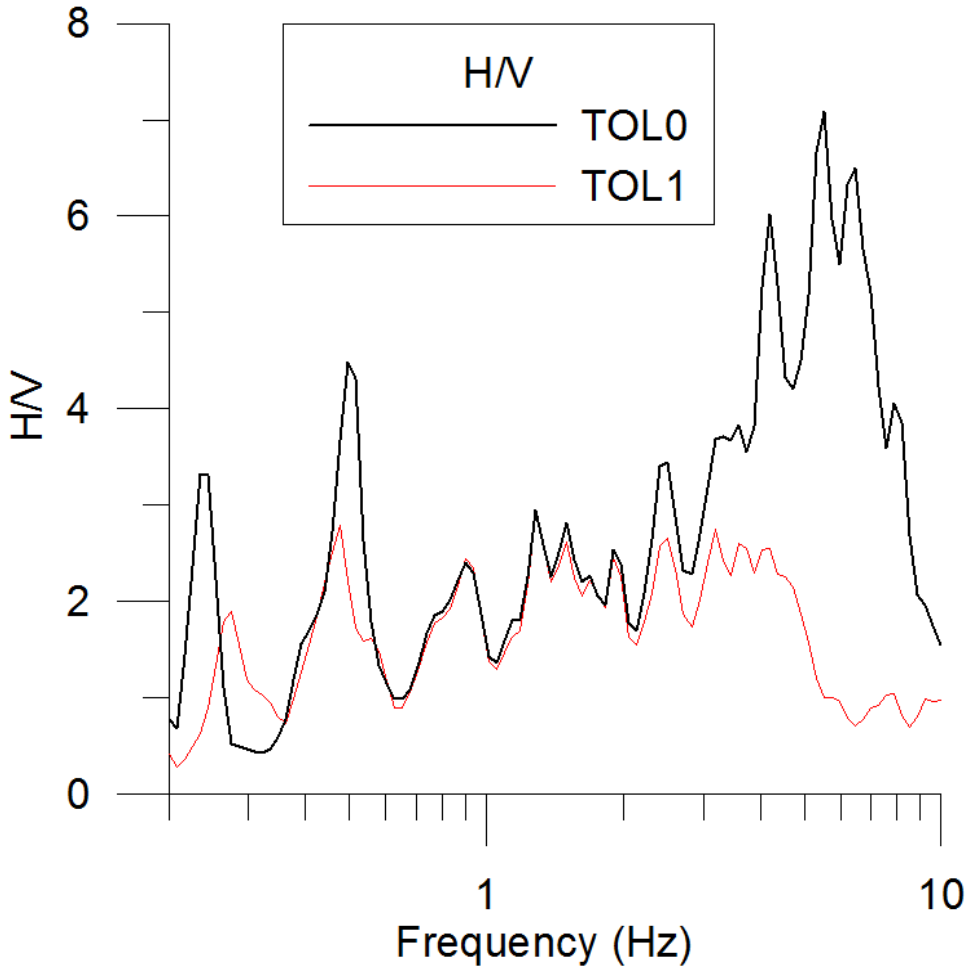






Tolmezzo - evento del 23/03/2017 con M_L 3.0

SeisRaM



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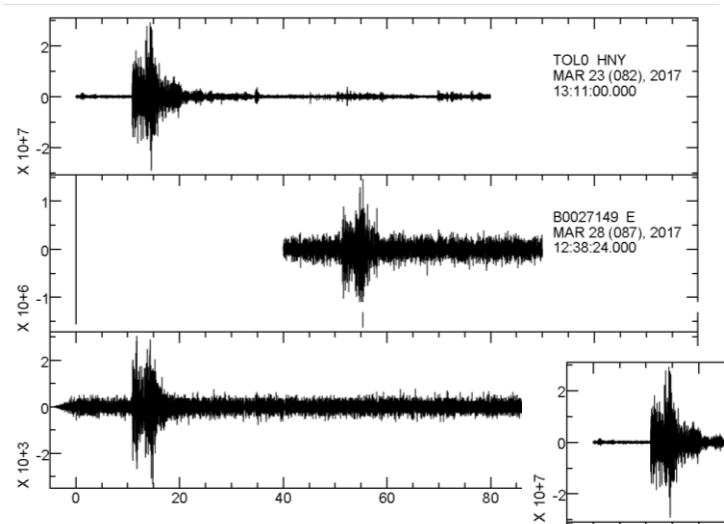
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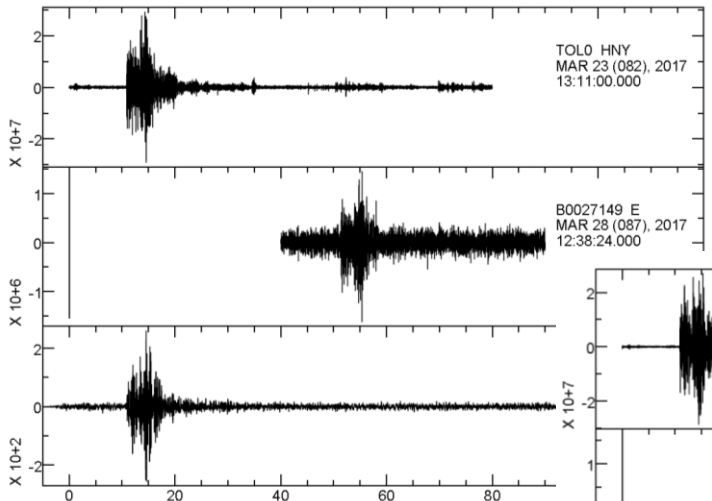
X 10+6
X 10+3
0
20
40
60
80


Suricat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X 10+2
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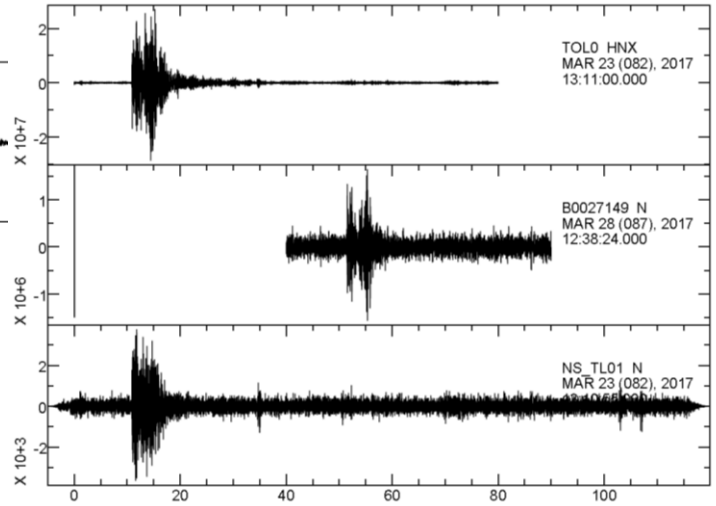
80


MAE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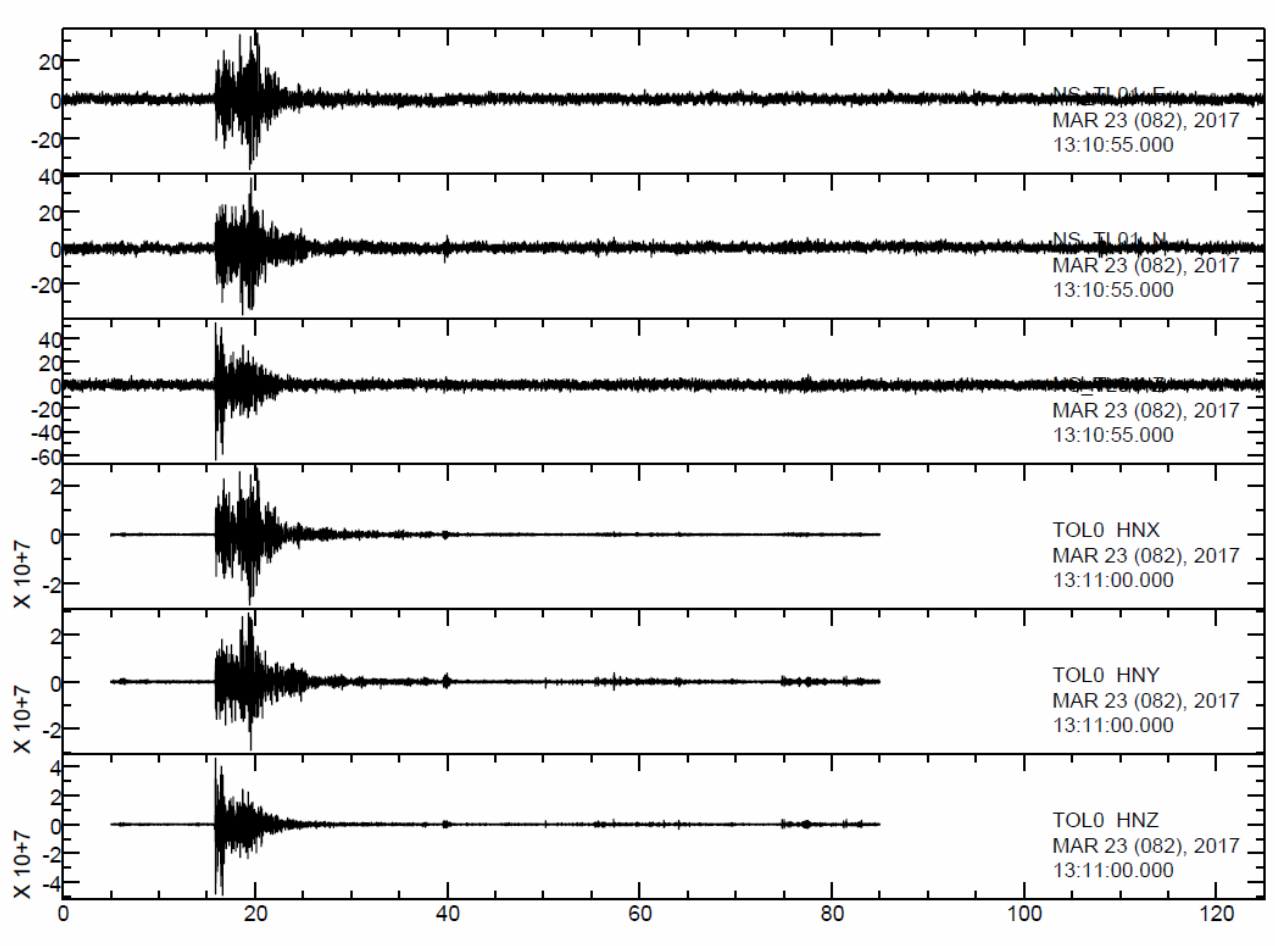
Tolmezzo - evento del 23/03/2017 con M_L 3.0



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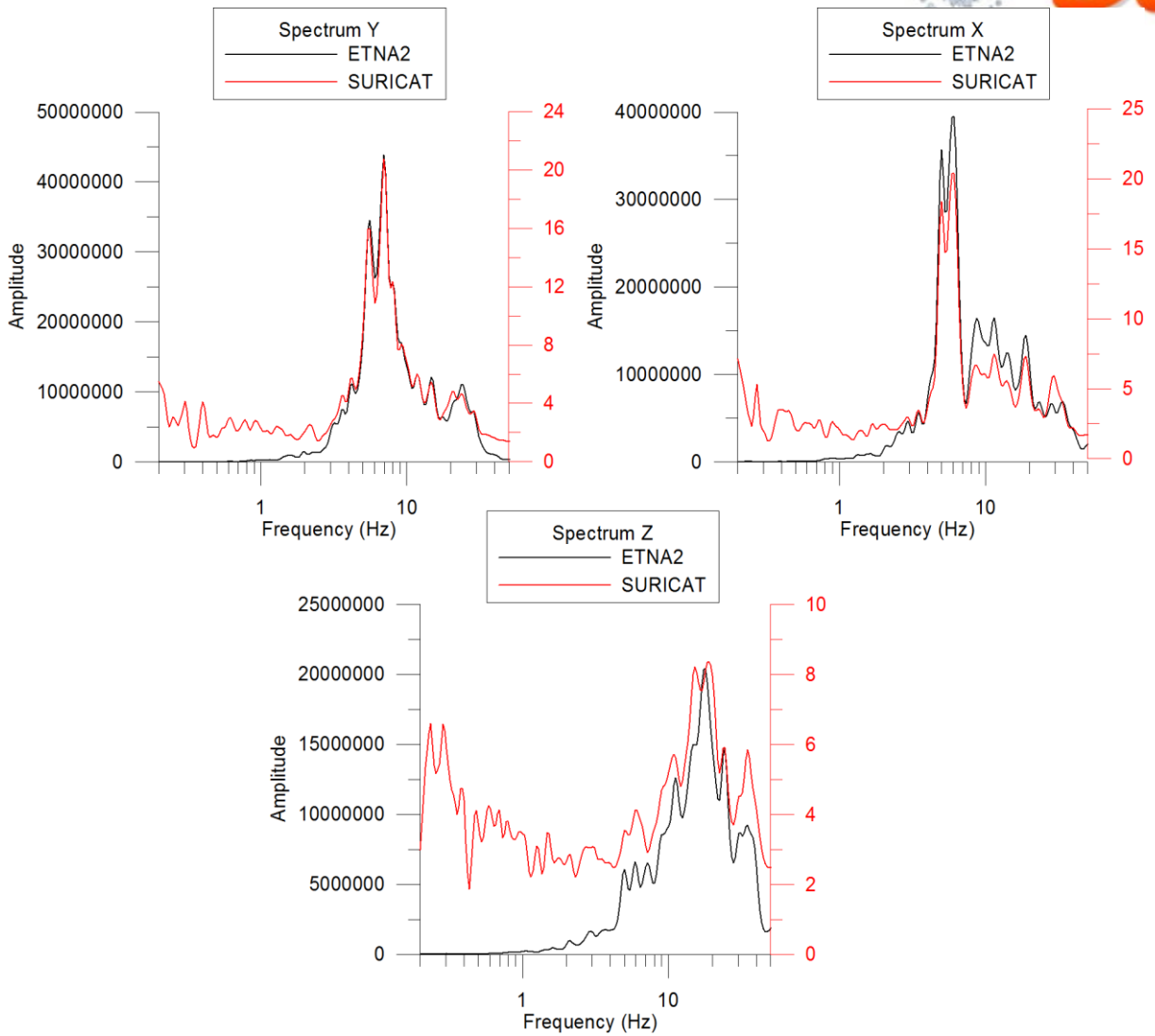

Tolmezzo - evento del 23/03/2017 con M_L 3.0

SeisRaM