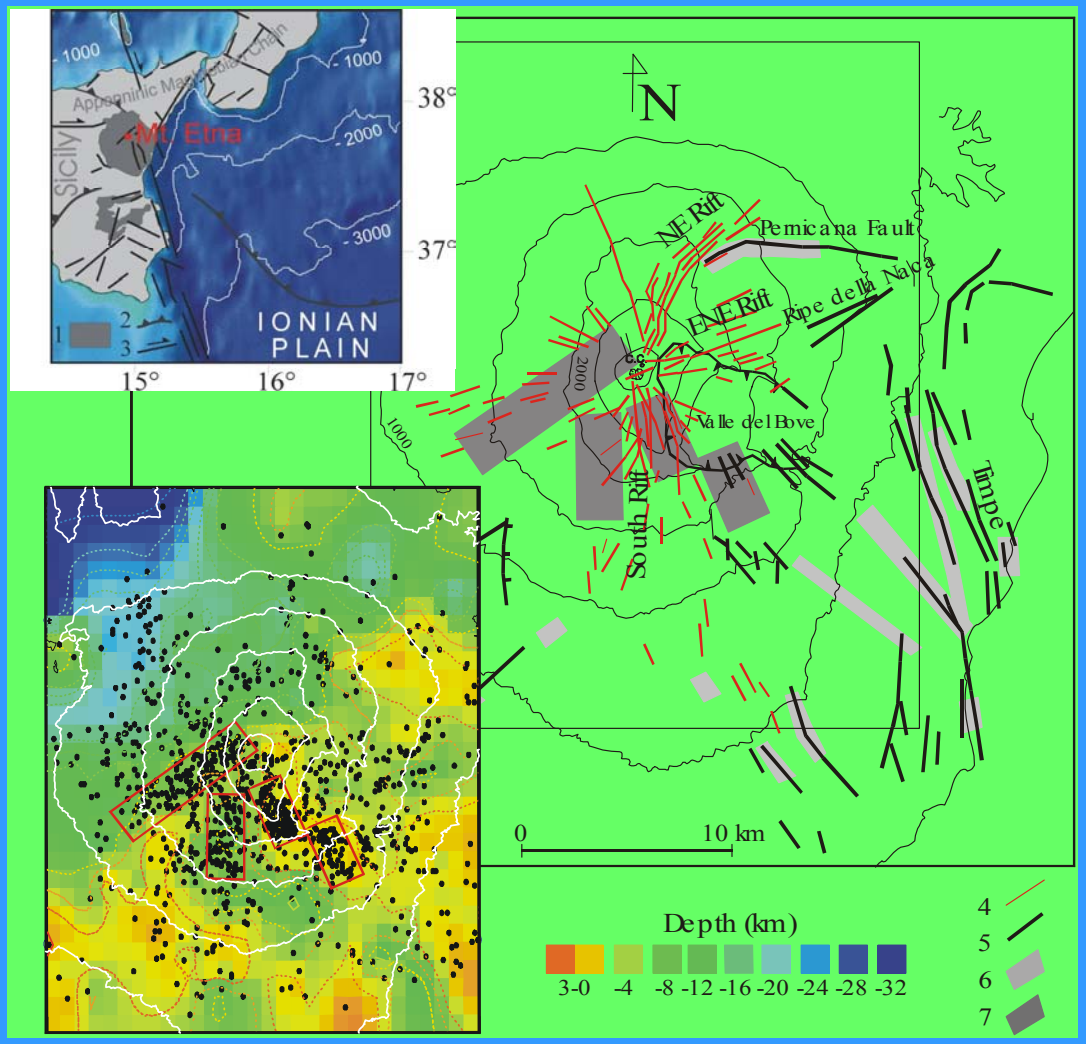
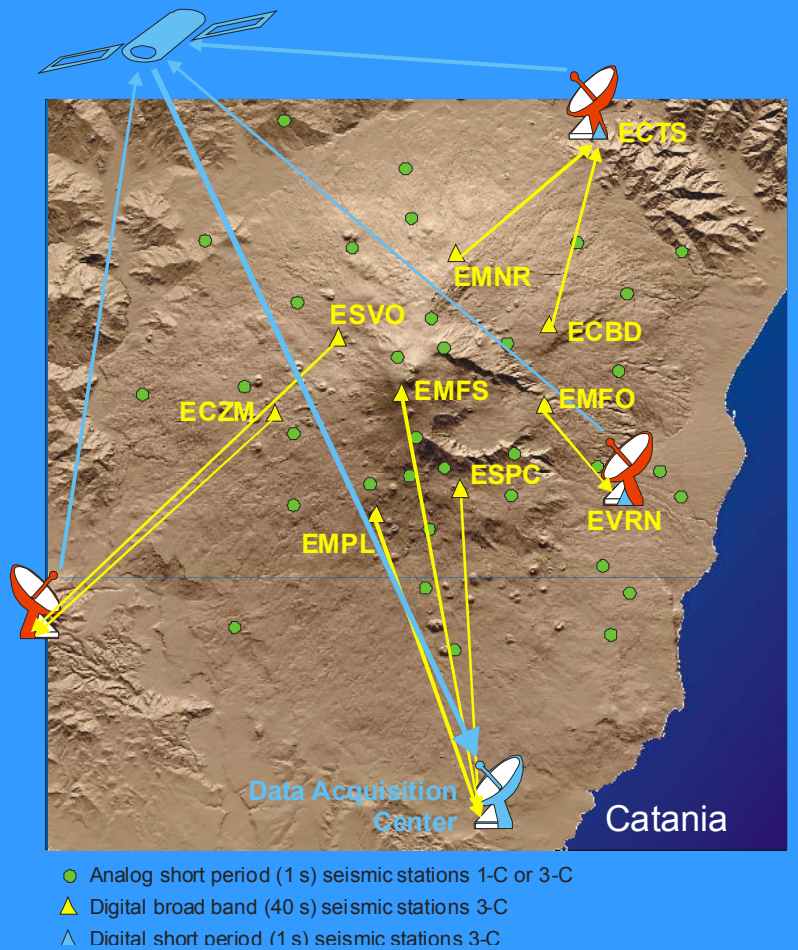
UR1 Terremoti Etnei

- Membri del gruppo
  - Salvatore D'Amico
  - Elisabetta Giampiccolo
  - Stefano Gresta
  - Horst Langer (coord).
  - Domenico Patanè
  - Antonio Rovelli
  - Giuseppina Tusa
  - Tiziana Tuvè

Seismicity & Tectonics

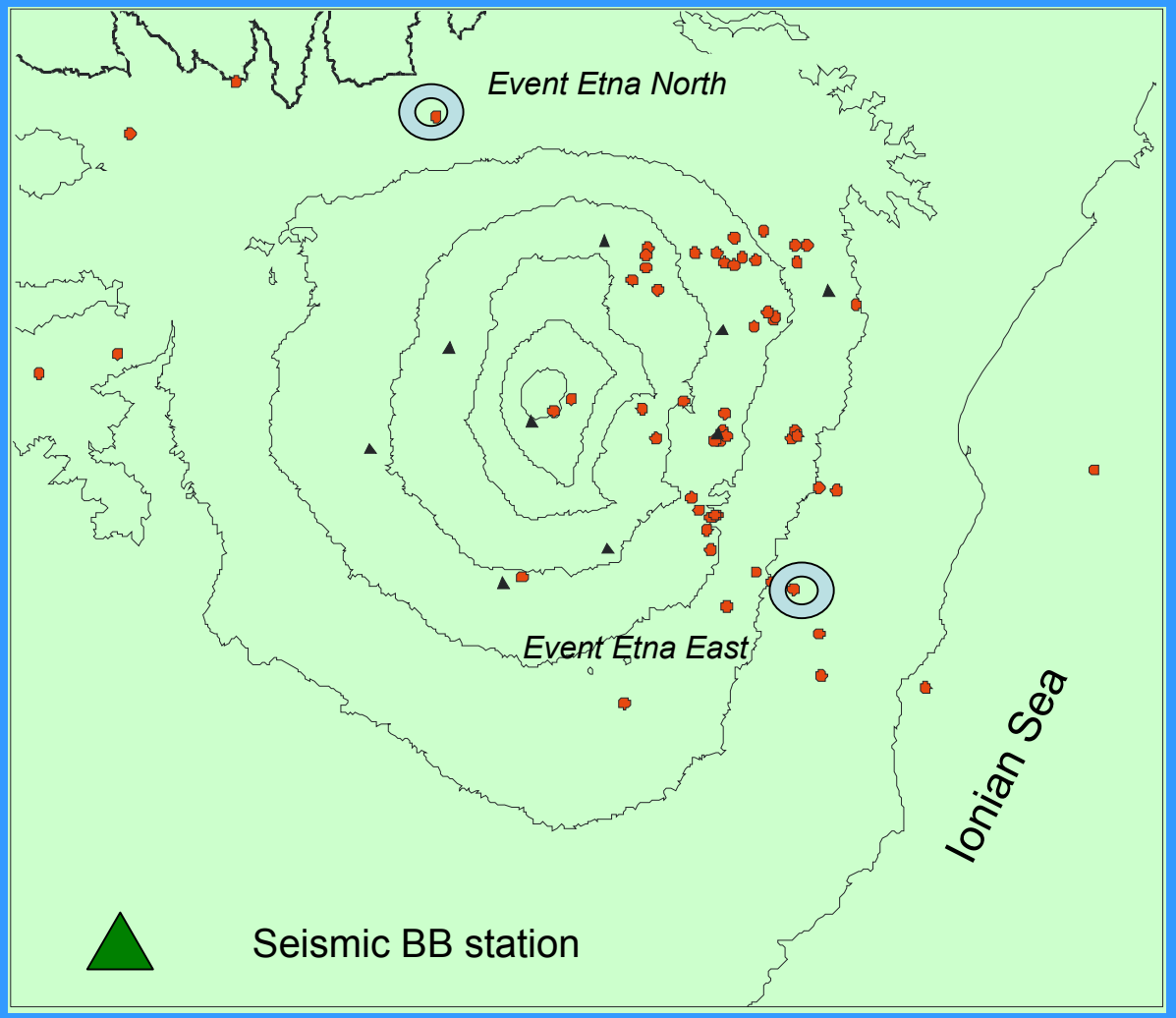


Seismic Network



Epicenter map of 60 selected events (2003-2005)

From the end of 2003 the number of permanent BB-stations in Eastern Sicily increased, improving also the coverage of Mt Etna. At present 12 BB-stations are operating in the area.



Selected events for waveform processing

20-dic-03	02:50:57.47	15.085	37.735	5.85	2.6	19	91	0.17	0.3	0.2	0.6 Km S M. Fontane
20-dic-03	02:57:38.23	15.082	37.735	6.04	2.6	21	88	0.15	0.3	0.4	0.6 Km SW M. Fontane
23-dic-03	12:14:12.54	15.083	37.705	5.37	2.8	29	56	0.15	0.2	0.2	0.5 km S M. Fior di Cosimo
10-feb-04	18:57:09.35	15.083	37.811	0.33	2.5	13	99	0.19	0.6	1.4	0.8 Km ENE Villaggio Mareneve
10-feb-04	19:23:01.21	15.103	37.808	2.21	2.6	15	145	0.24	0.4	0.5	2.5 km E Villaggio Mareneve
10-feb-04	19:38:20.11	15.087	37.807	1.24	3.1	29	100	0.23	0.3	0.4	1.2 Km E Villaggio Mareneve
10-feb-04	19:59:38.28	15.092	37.806	0.03	2.9	23	113	0.25	0.2	0.4	1.5 Km ESE Villaggio Mareneve
10-feb-04	20:29:18.33	15.096	37.809	2.1	2.9	17	122	0.22	0.4	0.5	1.9 km E Villaggio Mareneve
15-feb-04	01:18:28.77	15.087	37.746	5.49	2.5	29	66	0.14	0.2	0.2	0.6 Km NNE M. Fontane
06-mar-04	04:04:53.05	15.072	37.811	0.04	2.8	22	81	0.27	0.2	0.7	Villaggio Mareneve
13-mar-04	14:17:26.08	15.135	37.657	9.38	2.7	32	181	0.23	0.5	0.5	1 km S Linera
22-mar-04	19:08:51.82	15.036	37.629	9.47	2.5	9	210	0.17	1.4	1.9	1.5 km NE Nicolosi
23-mar-04	02:36:41.73	14.738	37.762	25.94	2.7	36	169	0.2	0.6	0.4	8 km SW Bronte
23-mar-04	02:55:36.19	14.778	37.77	27.26	3.1	39	163	0.23	0.5	0.3	5 km SW Bronte
01-apr-04	10:50:51.65	15.045	37.748	3.38	2.7	30	52	0.15	0.2	0.3	1 Km SE M. Simone
15-apr-04	17:58:48.09	15.009	37.752	1.06	2.6	33	33	0.16	0.1	0.3	1 km E Crateri Centrali
19-apr-04	14:56:14.25	15.107	37.82	0.47	2.5	12	117	0.16	0.4	0.3	4 km SW Linguaglossa
27-apr-04	21:30:11.46	15.275	37.723	14.82	2.6	24	153	0.21	0.6	0.9	7 km E Giarre
17-mag-04	08:54:49.38	15.154	37.79	8.83	2.6	24	167	0.1	0.4	0.5	1.4 km ESE Vena
17-mag-04	21:52:25.46	15.111	37.678	6.89	2.9	35	77	0.22	0.3	0.3	1.5 km SSE Zafferana Etnea
17-mag-04	23:09:58.57	15.122	37.675	7.63	2.8	26	98	0.16	0.4	0.4	2.5 km SSE Zafferana Etnea
18-mag-04	05:40:50.15	15.103	37.682	3.63	2.5	20	107	0.13	0.3	0.4	1 km S Zafferana Etnea
26-mag-04	02:04:25.62	15.07	37.712	4.96	2.5	29	70	0.12	0.2	0.3	0.8 Km W M. Fior di Cosimo
01-giu-04	10:14:10.28	15.047	37.805	-0.09	3	23	75	0.24	0.2	0.3	1.5 km SE M. Nero
01-giu-04	10:32:28.75	15.04	37.8	0.38	3.5	33	68	0.22	0.2	0.3	1 km SE M. Nero
01-giu-04	11:18:31.68	15.053	37.796	0.69	3.4	30	69	0.25	0.1	0.2	1 km NW Rifugio Citelli
01-giu-04	12:46:42.06	15.048	37.813	-1.37	2.6	18	82	0.25	0.2	0.5	1.5 km E M. Nero
06-giu-04	22:05:07.68	15.092	37.817	2.5	2.7	19	89	0.22	0.4	0.4	1.7 Km NE Villaggio Turistico Mareneve
14-giu-04	17:10:29.69	15.121	37.736	9.25	3	32	109	0.22	0.2	0.3	1.4 Km NNE Milo
12-lug-04	18:48:06.47	15.136	37.64	3.09	2.7	27	150	0.2	0.3	0.2	2 Km WSW S. Maria Ammalati
15-lug-04	06:49:44.66	15.047	37.81	0.21	2.5	13	80	0.12	0.2	0.4	1.5 Km E M. Nero
19-lug-04	08:13:03.85	15.139	37.675	1.93	2.5	11	133	0.18	0.3	0.2	0.6 km N Linera
22-lug-04	02:08:52.69	15.08	37.704	3.76	3.3	40	57	0.18	0.2	0.2	2.2 km NW Zafferana
22-lug-04	02:11:27.45	15.082	37.705	2.79	3.4	41	46	0.19	0.2	0.2	2.3 km NW Zafferana
22-lug-04	02:12:30.76	15.074	37.707	4.39	3.1	34	56	0.21	0.2	0.2	3 km WNW Zafferana
23-lug-04	19:51:33.79	15.129	37.814	-0.61	2.6	15	137	0.17	0.5	0.8	2 km NNW Vena
24-lug-04	17:23:40.28	15.124	37.807	-0.18	2.5	17	139	0.28	0.2	0.3	1.5 km NW Vena
26-lug-04	15:00:41.17	15.052	37.736	2.95	2.5	30	46	0.15	0.2	0.3	1.5 km E M. Centenari
02-ago-04	22:12:29.51	14.838	37.88	31.08	2.7	35	177	0.21	0.7	0.5	6 km NW Maletto
03-ago-04	15:20:23.35	15.086	37.739	4.35	2.7	34	59	0.16	0.2	0.1	M.te Fontane
03-ago-04	16:55:54.41	15.088	37.737	5.03	2.6	35	62	0.16	0.2	0.3	0.5 km SE M.te Fontane
07-ago-04	04:26:34.15	14.984	37.68	5.68	2.6	25	107	0.14	0.3	0.4	1.4 km S M.te Vetore
15-ago-04	10:52:33.35	15.078	37.699	5.2	2.5	29	80	0.14	0.2	0.2	2.5 km NW Zafferana Etnea
17-set-04	13:42:25.57	15.189	37.635	11.1	2.8	28	274	0.18	0.5	0.3	1 km E S. Tecla
25-set-04	16:12:48.69	15.066	37.751	5.78	2.6	32	52	0.17	0.2	0.2	M. Rinatu
03-nov-04	18:57:14.73	14.784	37.859	29.36	2.6	24	172	0.22	0.8	0.4	6 Km NE Cesarò
17-gen-05	18:26:49.49	15.144	37.715	0.03	2.8	20	118	0.2	0.2	0.3	1.6 km WSW Macchia di Giarre
21-gen-05	13:43:00.06	15.135	37.716	1.87	3	21	110	0.22	0.2	0.2	2 km W di Macchia di Giarre
05-feb-05	14:36:00.76	15.088	37.668	3.74	2.6	32	97	0.11	0.2	0.2	1.5 km NW Fleri
12-mar-05	18:54:53.52	15	37.747	1.03	2.5	18	76	0.11	0.2	0.4	Crateri sommitali
21-apr-05	12:53:39.46	14.94	37.866	26.92	3	30	111	0.27	0.6	0.4	1.3 Km SSW Randazzo
23-apr-05	08:03:12.50	15.112	37.784	-0.9	3	21	116	0.29	0.2	0.3	2 km SE M. Crisimo
23-apr-05	08:06:01.23	15.113	37.785	0.02	2.5	12	121	0.18	0.2	0.3	2 km SE M. Crisimo
23-apr-05	09:00:50.79	15.102	37.781	-1.14	2.8	20	102	0.28	0.2	0.5	1.8 km SE M. Crisimo
25-apr-05	02:34:51.45	15.109	37.787	-0.04	2.5	20	117	0.18	0.2	0.2	1.8 km SE M. Crisimo
25-apr-05	06:05:52.49	15.123	37.739	-0.11	2.7	24	112	0.25	0.2	0.2	1 km NE Fornazzo
25-apr-05	15:30:07.92	15.124	37.737	-0.22	2.5	18	140	0.25	0.2	0.3	1 km E Fornazzo
26-apr-05	20:48:38.12	15.123	37.814	-1.58	2.7	21	121	0.24	0.3	0.8	2.5 km NW Vena
13-mag-05	15:19:50.71	15.08	37.691	5.19	2.6	36	44	0.21	0.2	0.2	2 Km W Zafferana Etnea

Flow chart Data Preprocessing:

Up to now we collected ca. 60 events M>2-5 with 500 3C recordings.

For the moment we have been using our standard processing scheme

Baseline correction
- Offset removel
- Trend removal (linear regression method)
- Moving average removal (windows of 3-5 s)

Numerical Integration: Tick's rule (time domain)

Note: Tick's rule offers a flat transfer function over a wide frequency range. Possible instabilities for frequencies close to Nyquist are found uncritical given the spectral characteristics of our signals.

The moving average baseline correction with a window length of 5 s represents a fair compromise between the necessity to account for the contribution of low frequencies and the needs of long-period (i. e., < 1 Hz) noise reduction (such as see microseims, volcanogenic signals , instrumental noise)

.

Further tests with alternative preprocessing schemes are on course

Integration rules…

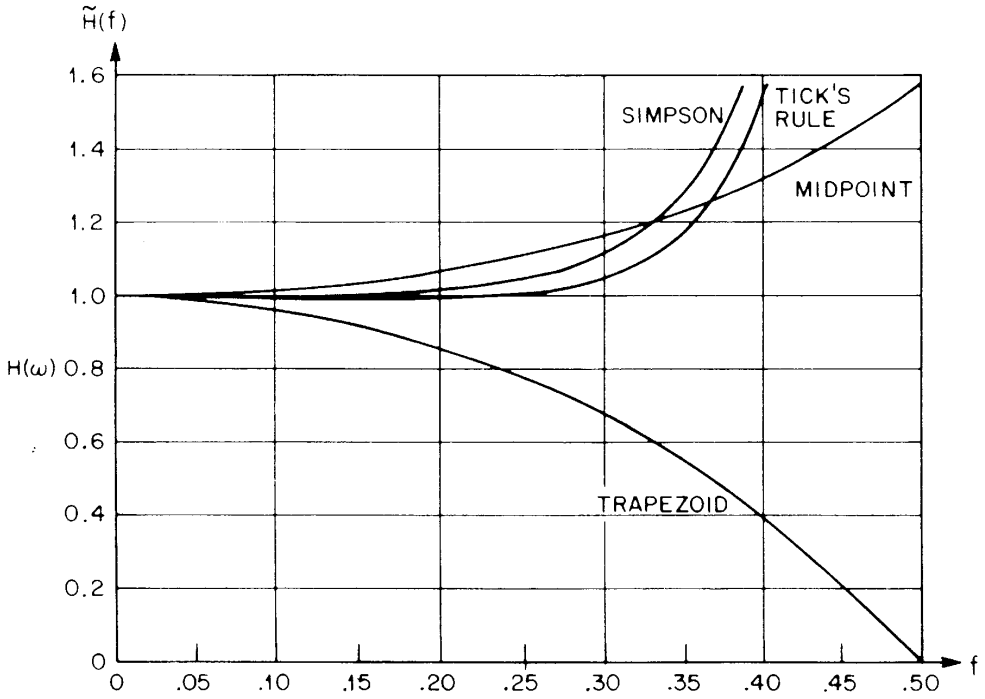


FIGURE 3.10-1 FREQUENCY RESPONSE OF INTEGRATION FORMULAS

See Hamming, 1983, “Digital filters”

Tick’s rule:

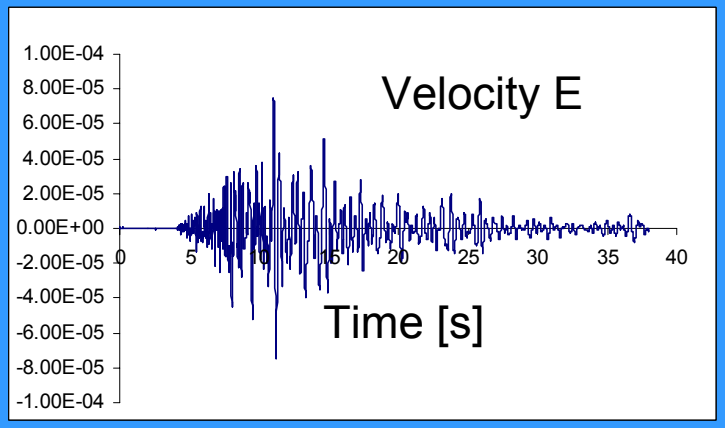
$y_n = y_{n-1} + 0.5 * (0.3584 * x_{n-1} + 1.2832 * x_n + 0.3584 * x_{n+1})$

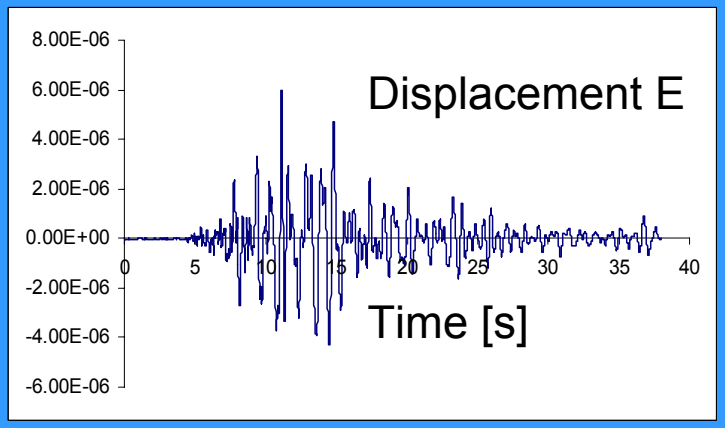
Test standard preprocessing

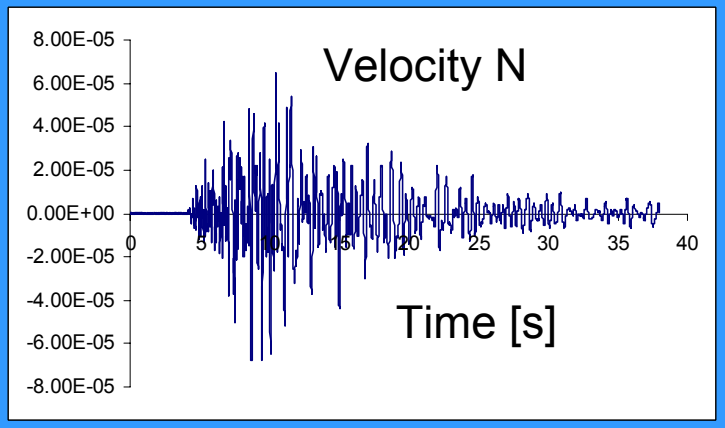
Original traces

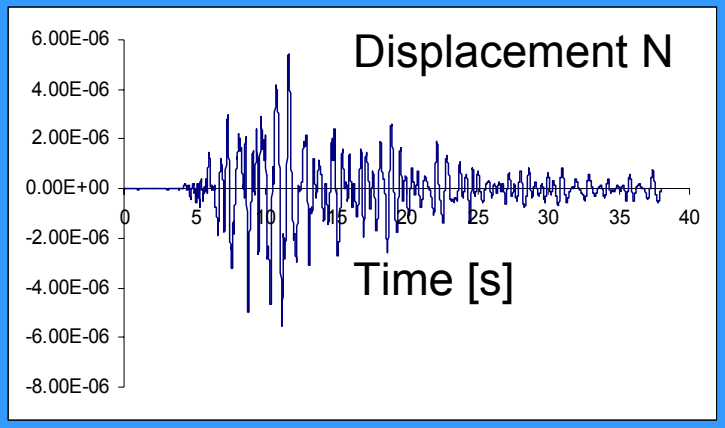
Only offset and trend removal, integrated

Amplitude [MKS]







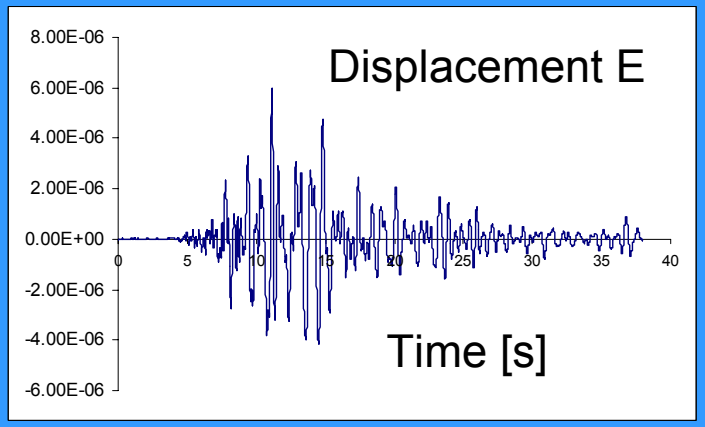


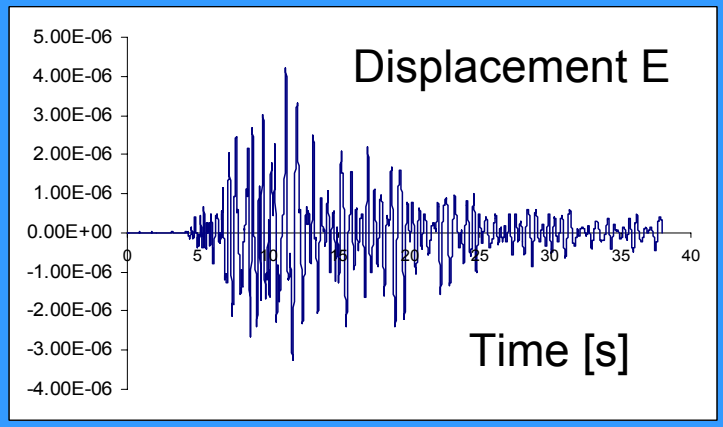
Test standard preprocessing

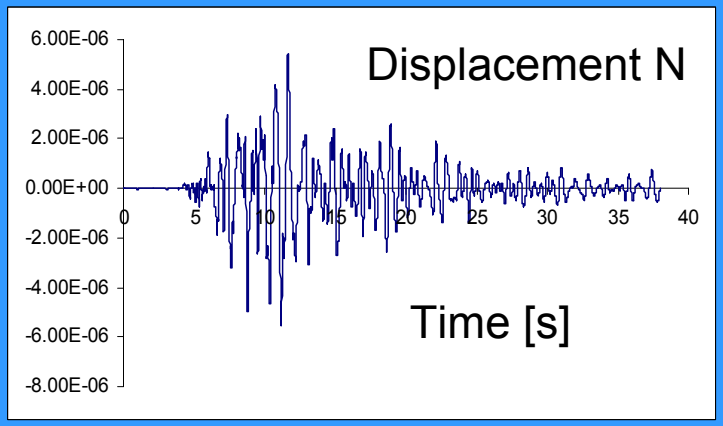
MA 5 s removed

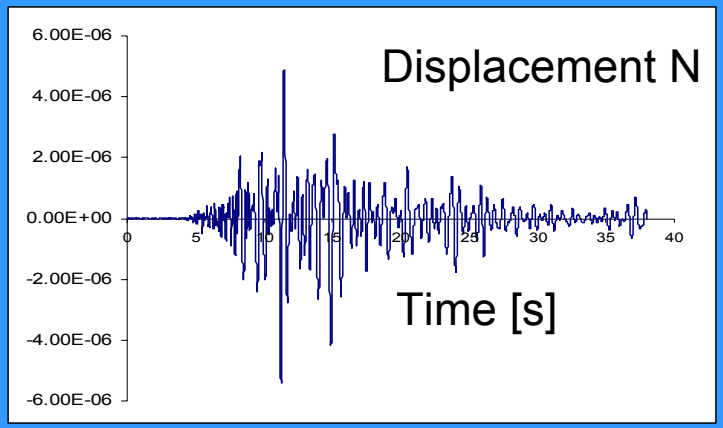
WA filtered (HP 1.25 Hz)

Amplitude [MKS]









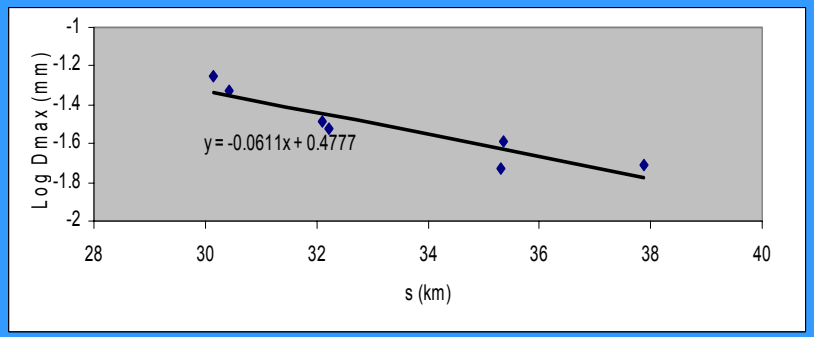
± well reproduced signal and peak amplitudes

significant parts of signal lost, peak amplitudes 20 (-50%) lowered

Attenuation Dmax (examples)

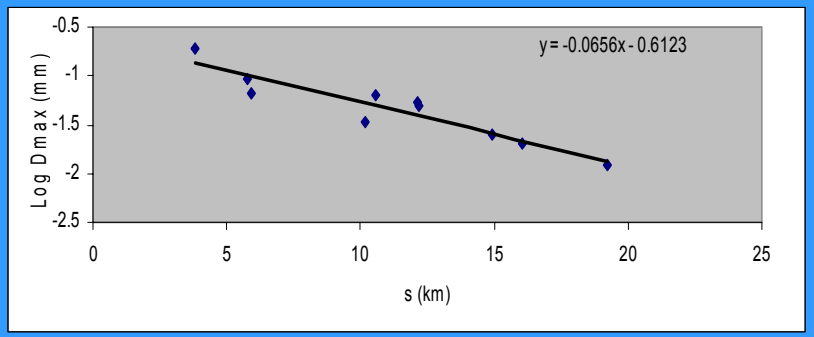
Some examples for peak displacement decay with distance. Laws might vary with zone and depth.

Event Etna North, z = 2 5km

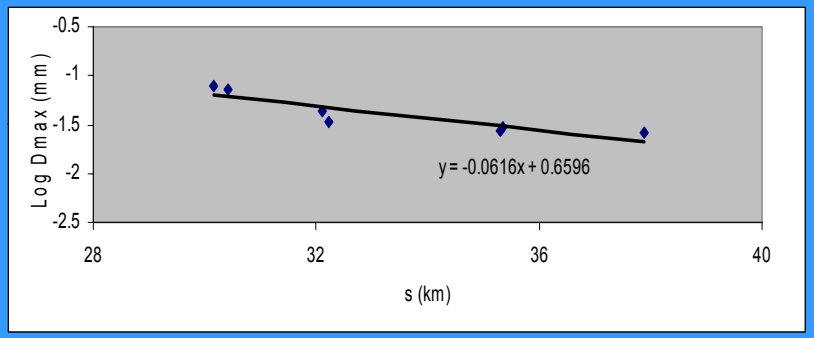


Short period (WA highpass filtered)

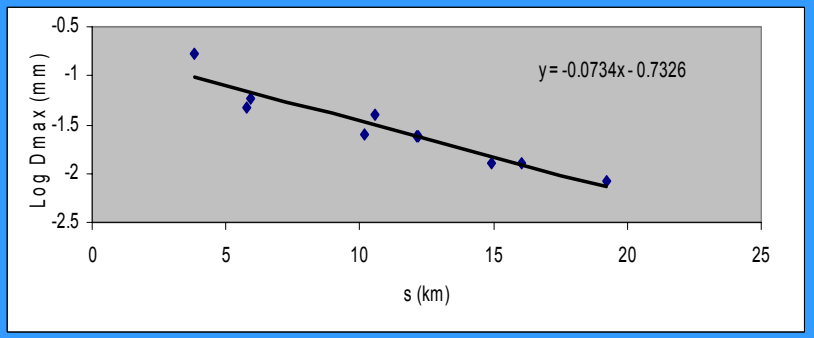
Event Etna East, z superficial



Short period (WA highpass filtered)

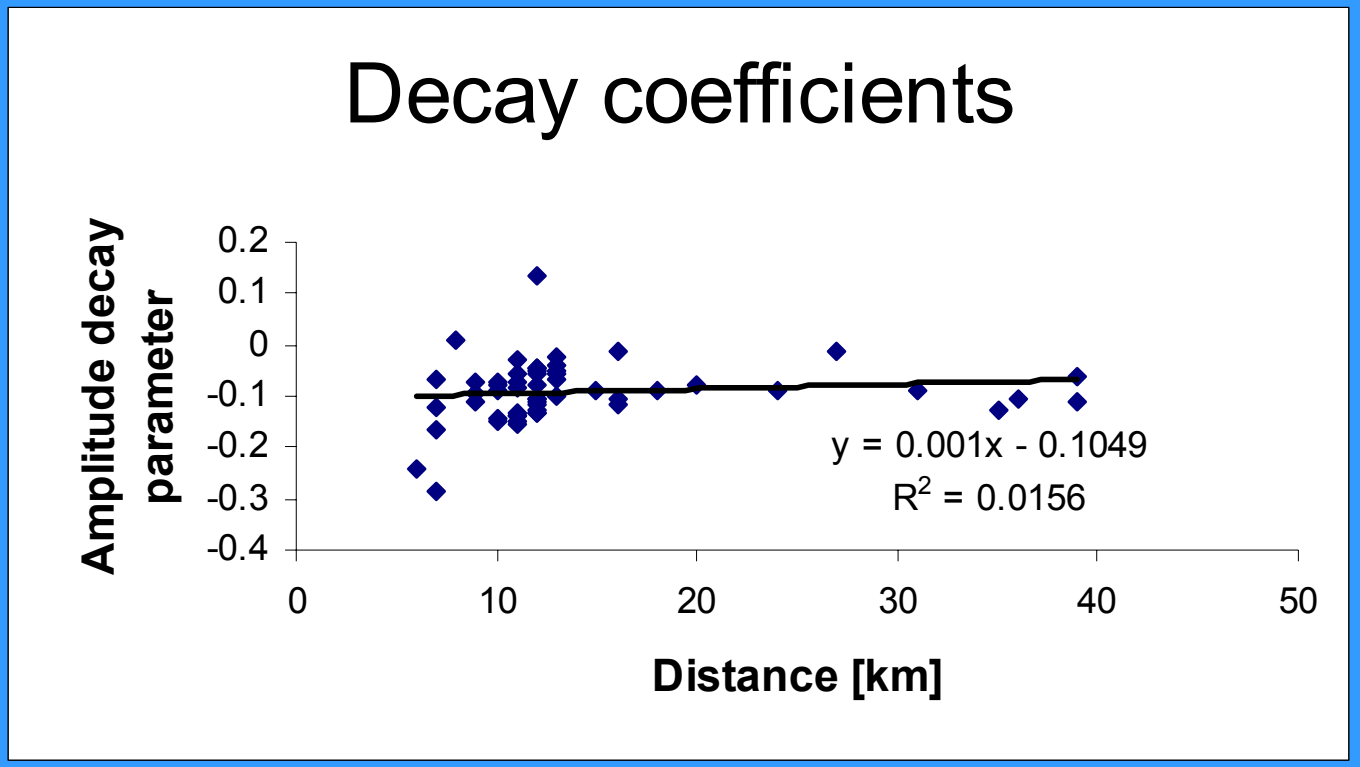


Broad Band, MA 5s removed



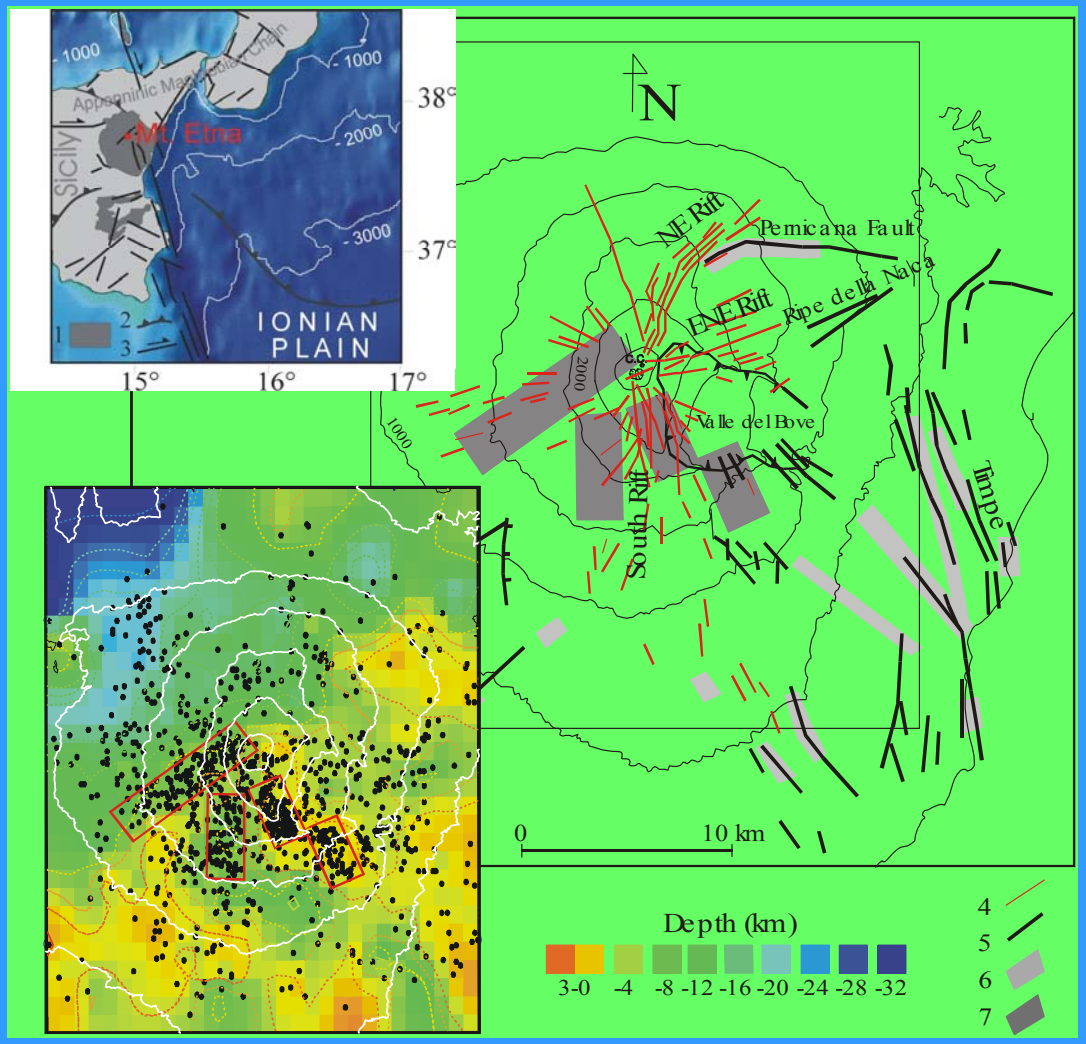
Broad Band, MA 5s removed

Preliminary decay law for Dmax



Mean : -0.091 ± 0.6 Median: -0.087, 15%Perc: -0.134, 85%: -0.0447

Seismicity & Tectonics



Typical near surface structure

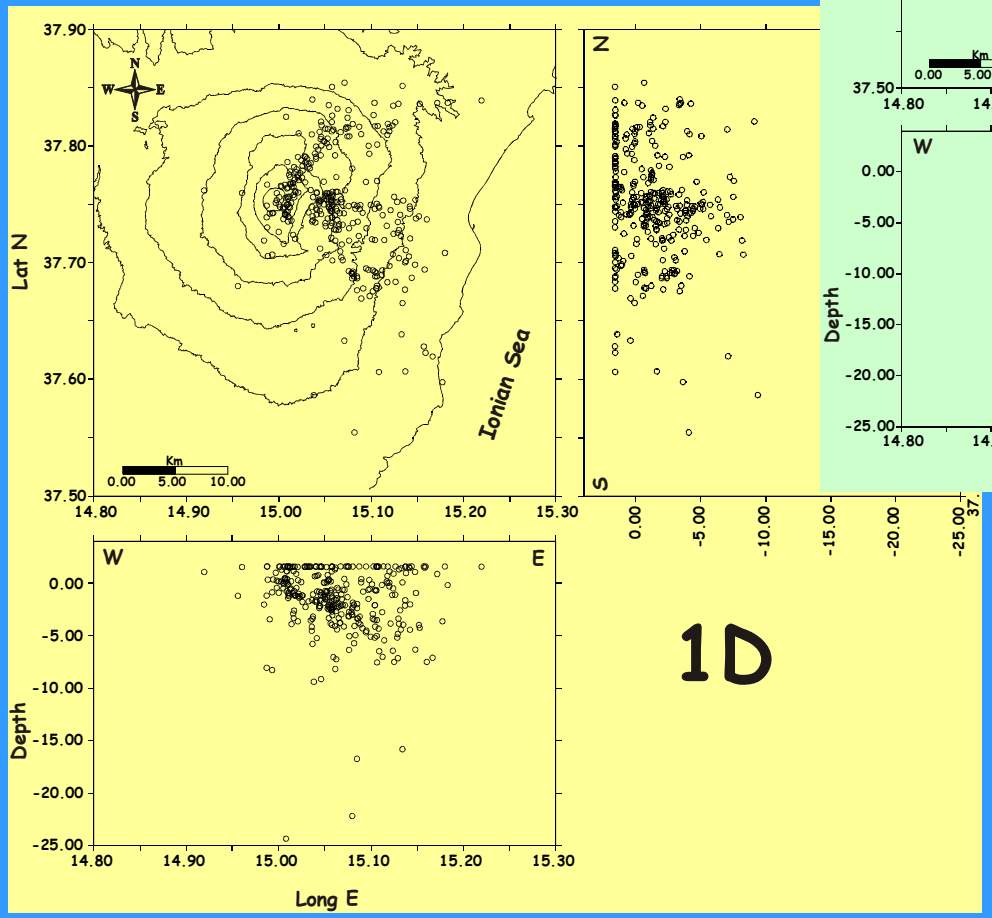
Table 3a. Geotechnical parameters for the subsurface and deeper underground at Giarre downtown.

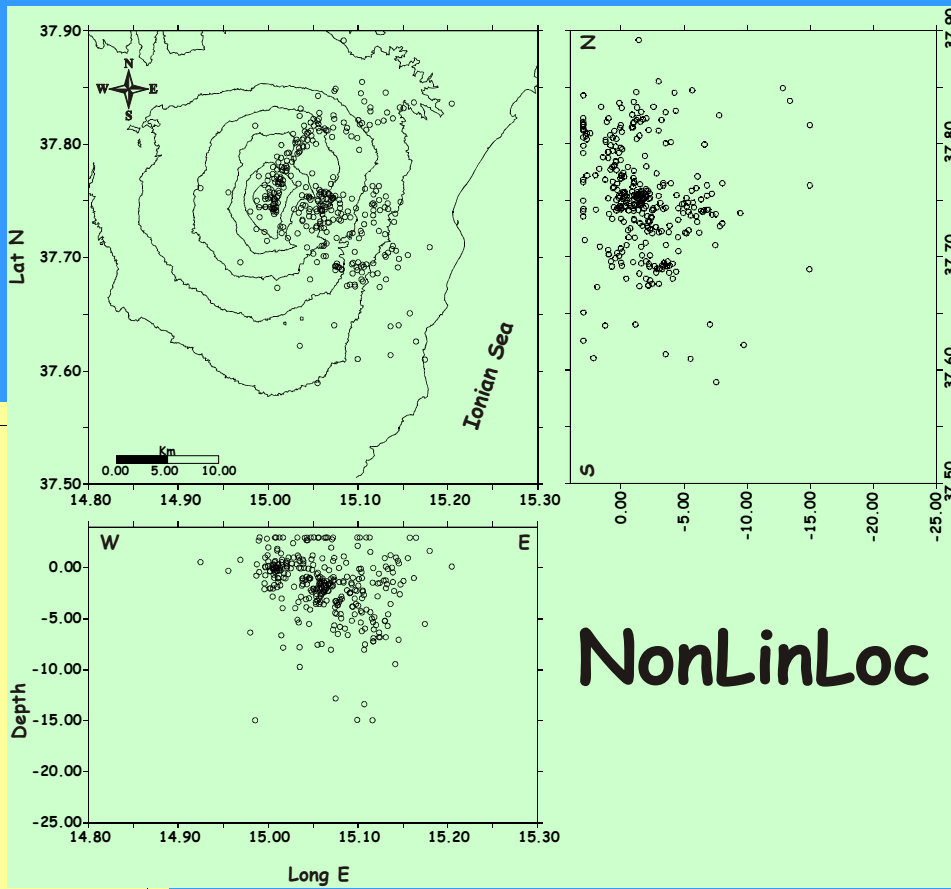
Layer	*Thickness (m)*	*c (m/s)*	*Density (*kg/m^3*)*	*Q*
Sands	10	500	1800	20
Sands, pebble	200	600	2000	30
Claystone	500	1500	2100	70
Marls	300	1700	2200	100
Limestone	5000	2600	2500	150
Basement	∞	3500	2800	300

Table 3b. Geotechnical parameters for the subsurface and deeper underground at Adrano downtown.

Layer	*Thickness (m)*	*c (m/s)*	*Density (*kg/m^3*)*	*Q*
Lavas	10	800	2000	20
Lavas	40	1000	2200	40
Clay	200	600	2100	30
Claystone	500	1500	2100	70
Marls	300	1700	2200	100
Limestone	5000	2600	2500	150
Basement	∞	3500	2800	300

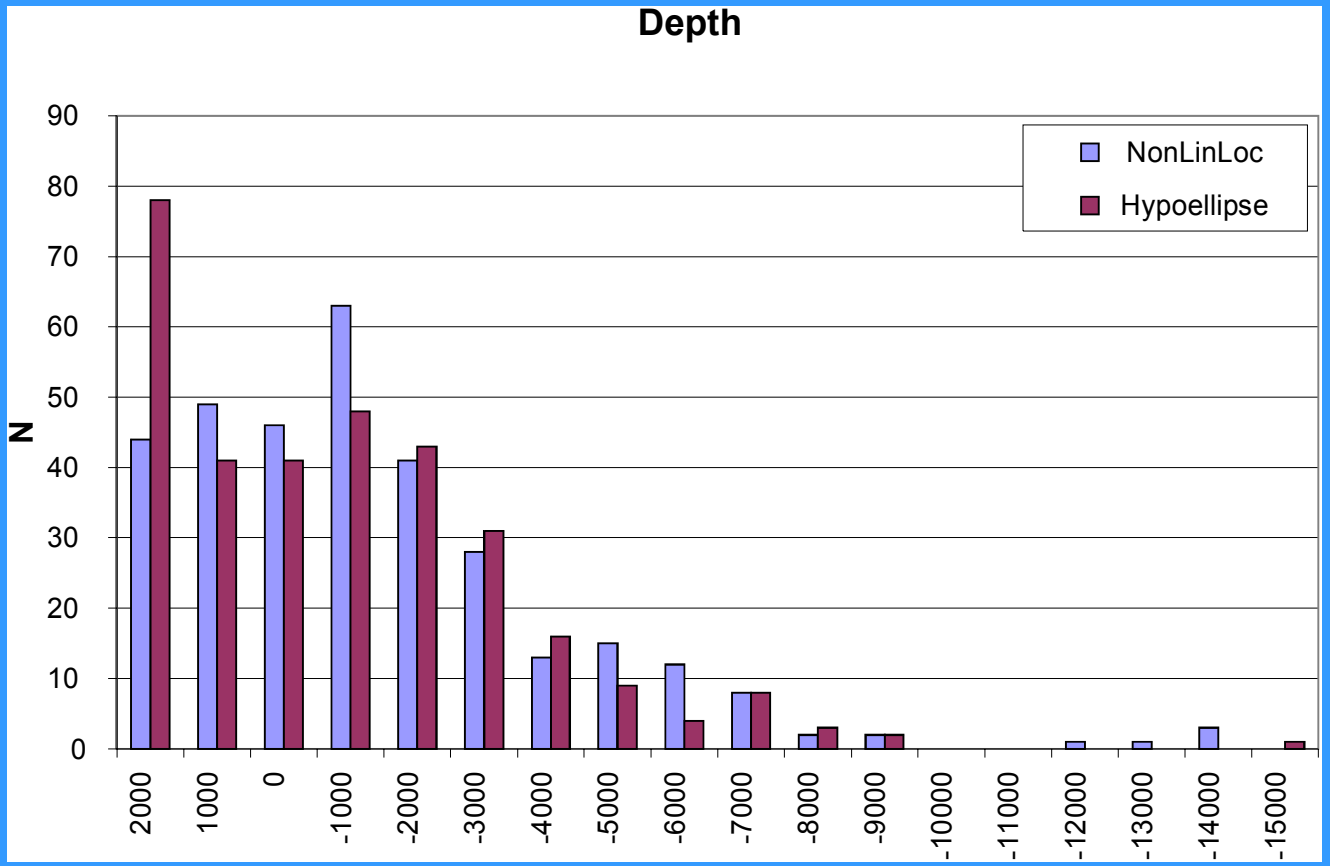
Comparison of Locations



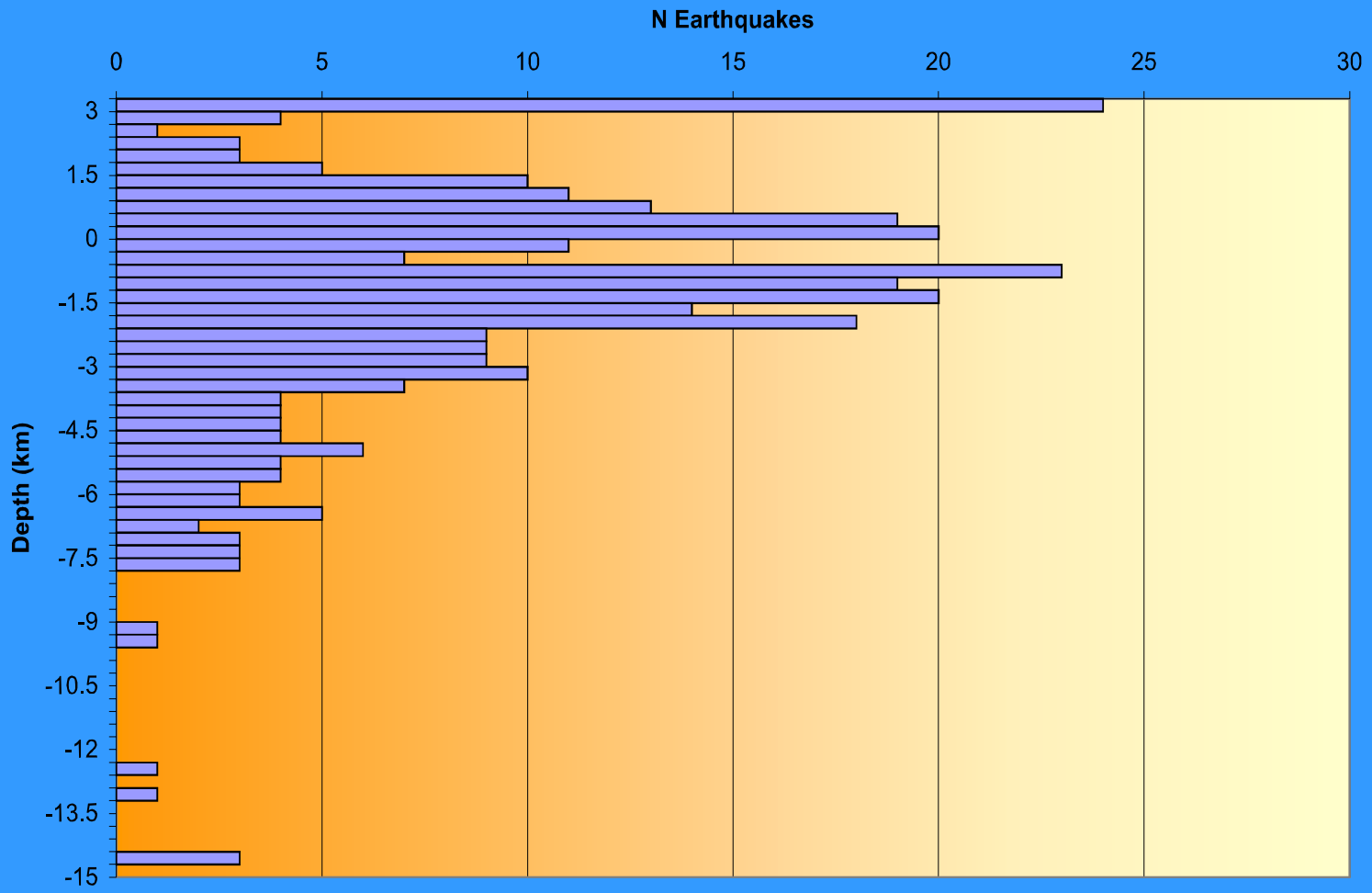


Event Relocation

Depth Distribution of Etna Events (2002-2003)



Depth section for 2002-3 events



Future Work

Wave form data

- Integration of recent events to wave form data base.
- Removal of redundancies (due to swarms)
- Estimation of station corrections
- Displacement decay as a function of depth and area.

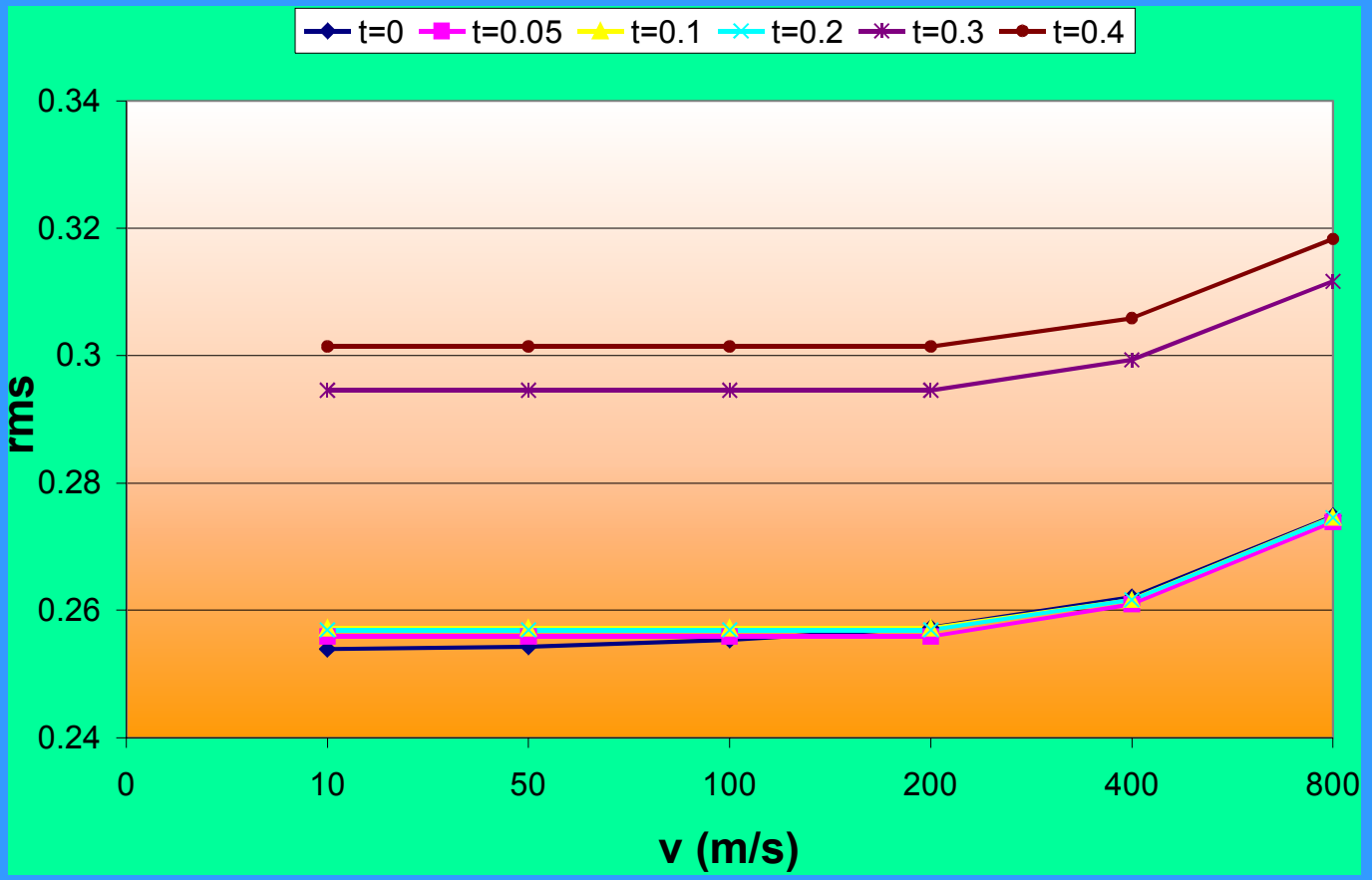
Location problems

- Realistic location error assessment (including “epistemic” error)
- Integration of data set (2004-5 events)

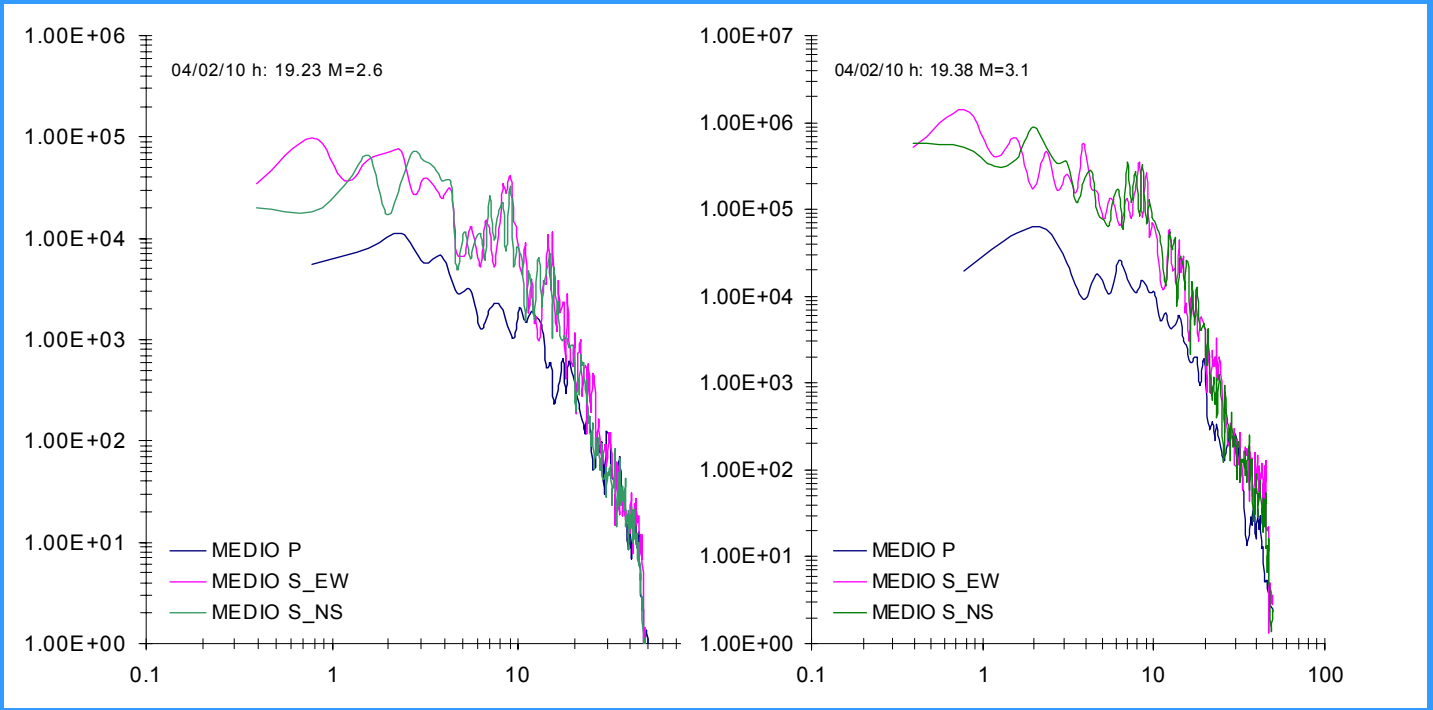
Spectral analysis

- Set up of scaling laws using broad-band S-wave recordings.

Location stability analyses

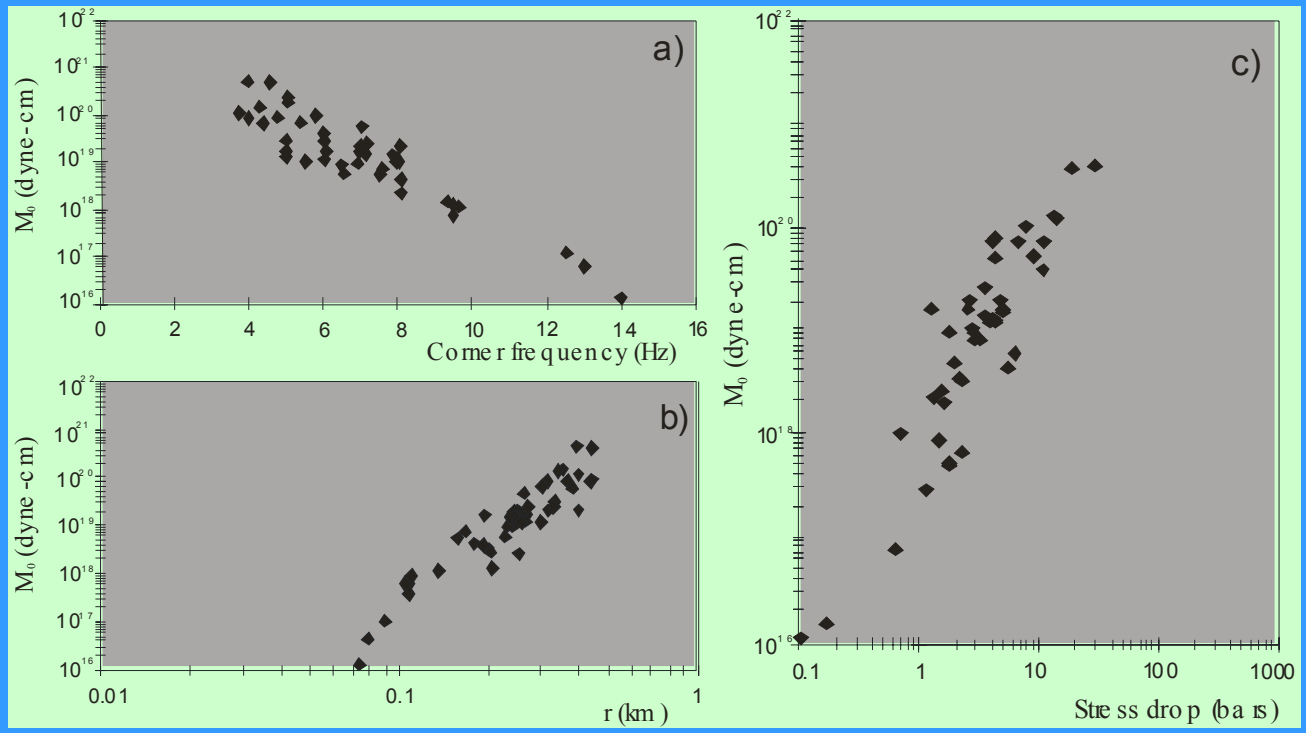


Spectral analysis



Scaling laws (SP-data)

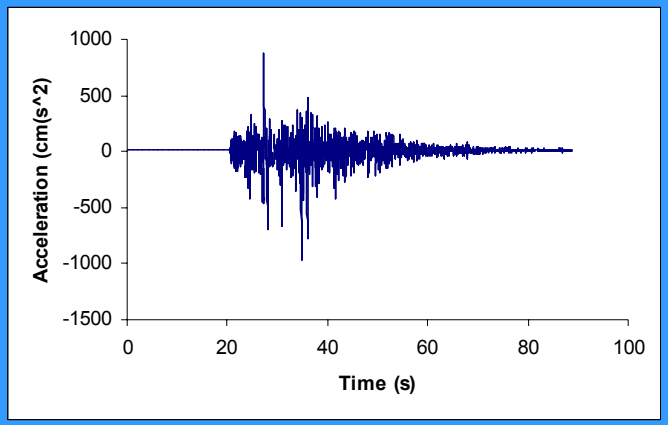
Scaling laws can be used in scenarios for hypothetical (major) events not recorded so far. For various reasons existing scaling laws on Mt. Etna account only for the short period part of the signals. The collected data set of BB-seismograms will be used for a redefinition of scaling laws accounting for the low frewuency content. This can be done more effectively by using S-waves (see next slide).

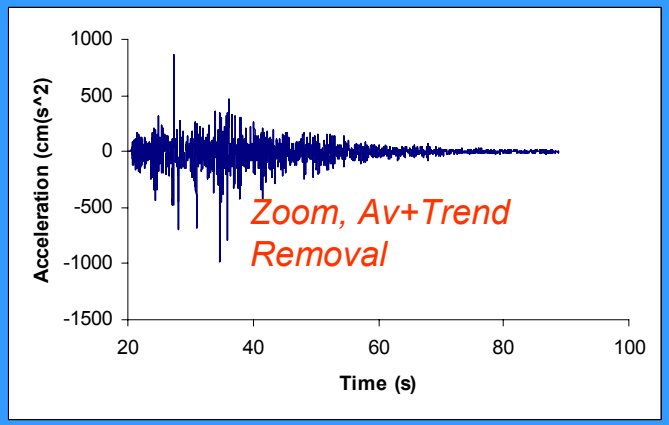


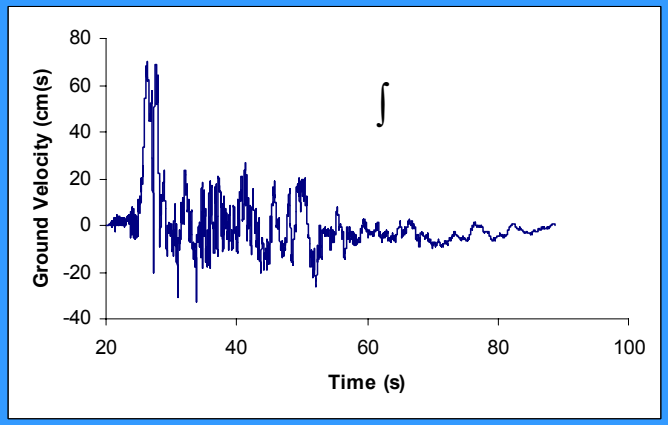
Appendix_UR1

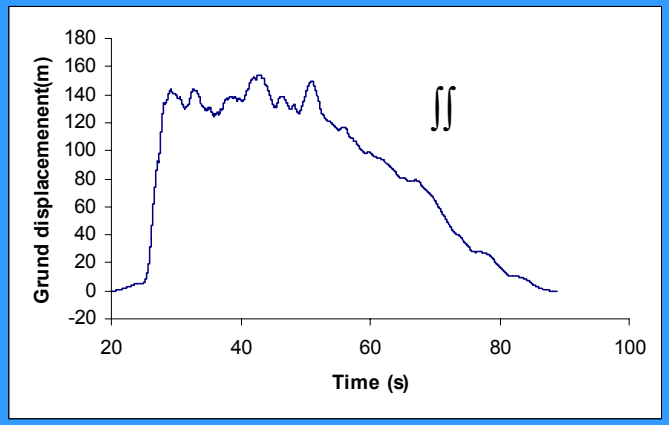
A proposito….

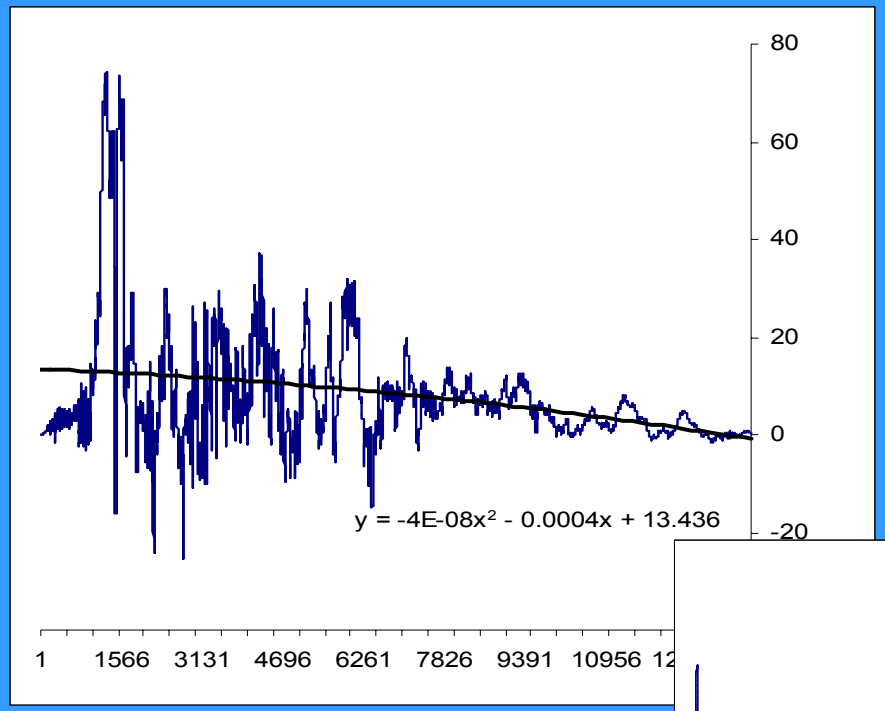
Chi-Chi (Taiwan) Earthquake, 1999, MW=7.7, L ca. 60 km

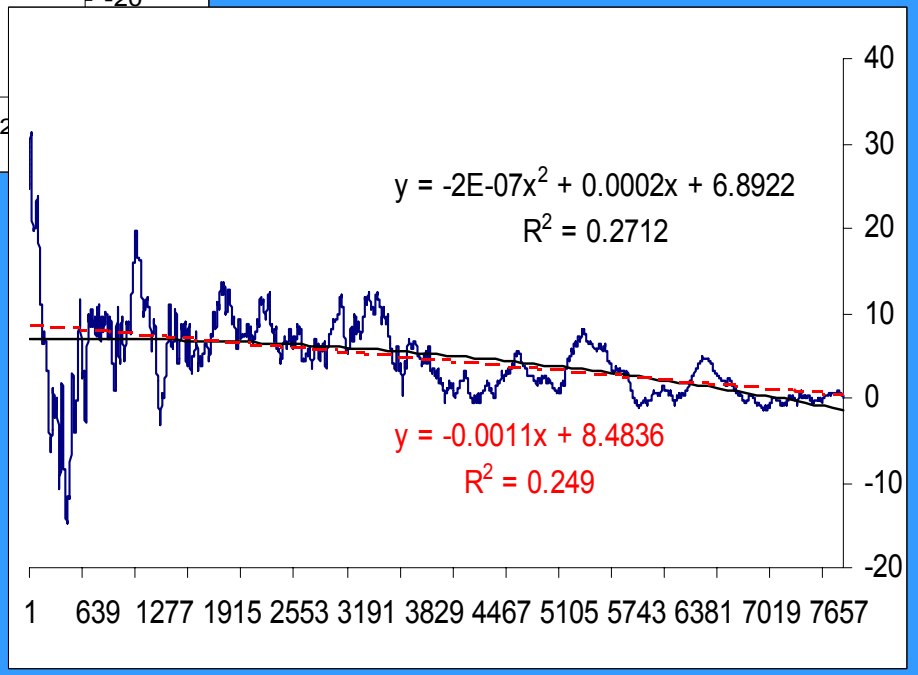









80
60
40
20
0
-20
y = -4E-08x² - 0.0004x + 13.436
1
1566
3131
4696
6261
7826
9391
10956


40
30
20
10
0
-10
-20
y = -2E-07x² + 0.0002x + 6.8922
R² = 0.2712
y = -0.0011x + 8.4836
R² = 0.249
1
639
1277
1915
2553
3191
3829
4467
5105
5743
6381
7019
7657

Some remarks

- Il segnale di TCU129 appare afflito di “signal generated noise”. Da questo fatto si arriva alle seguenti osservazioni:
- La stima dell’offset dalla parte pre-event non rappresenta la media durante il segnale stesso.
- La correttura per offset e eventuali trend dovrebbe avvenire “a monte”, cioè all’accelerogramma e non al velocigramma: ∫ offset *dt* -> trend, ∫ trend *dt* -> parabola.
- La restituzione del segnale di spostamento togliendo offset e trend direttamente dalla parte dell’acceleogramma appare ragionevole. Una tale procedura si basa essenzialmente sul segnale “as is” ed evita l’uso di informazione “a priori”.