M_w Estimation for Regional Seismic Events in the Friuli Area (NE Italy)

Department of Earth Sciences, University of Trieste, Italy

AUG, Trieste – February 27-28, 2007

The rationale behind this work

- Within an Interreg IIIb Project between Austria and Italy, with the support from Slovenia, a real-time transfrontier network of seismic stations (broadband, strong motion) has been implemented at the contact Alps-Dinarides and runs with the BRTT Antelope© system.

- The need for an independent estimate of magnitude has arisen, since the single national and regional networks each use a different magnitude (different local, duration, coda etc.) and there is no moment estimate for events with magnitude < 5 from transnational agencies. This is also a task of the Project ProCiv-INGV 2004-06: S4.

- By estimating in real time the moment magnitude for the events recorded by the network, all events could have a common independent parameter, that would also allow and easier comparison with events from other regions.

Method used to determine the seismic moment

(Andrews 1986)

Spectral amplitude at receiver

$$A(f) = D(f)E(f)G(R)$$

Brune (1970) Source Spectrum

$$D(f) = \frac{M_0}{4\pi k \rho \upsilon^3}\left[1 + \left(\frac{f}{f_0}\right)^2\right]^{-1}$$

Attenuation

$$E(f) = e^{-\left(\frac{\pi T f}{Q(f)}\right)}$$

Geometrical spreading

$$G(R) = \frac{1}{R}$$

$$SV2 = 2\int_0^\infty V^2(f)\,df$$

$$SV2 = \frac{1}{4}\Omega^2 (2\pi f_0)^3$$

$$\Omega = \frac{M_0}{4\pi k \rho \upsilon^3}$$

$$SD2 = 2\int_0^\infty D^2(f)\,df$$

$$SD2 = \frac{1}{4}\Omega^2 (2\pi f_0)$$

Method (cont'd)

$$SV2 = \frac{1}{4}\Omega^2 (2\pi f_0)^3$$

$$SD2 = \frac{1}{4}\Omega^2 (2\pi f_0)$$

$$\Omega = \sqrt{4 (SD2)^{3/2} (SV2)^{-1/2}}$$

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{SV2}{SD2}}$$

$$M_0 = 4\pi\rho\upsilon^3\Omega k$$

$$M_w = \frac{2}{3}\cdot\log_{10}(M_0) - 6{,}1$$

$$r = \frac{2.34\beta}{2\pi f_0}$$

The signal and the instrument response are extracted from the database of the Antelope© system at DST

Average and instrument response are removed and bandpass filter applied

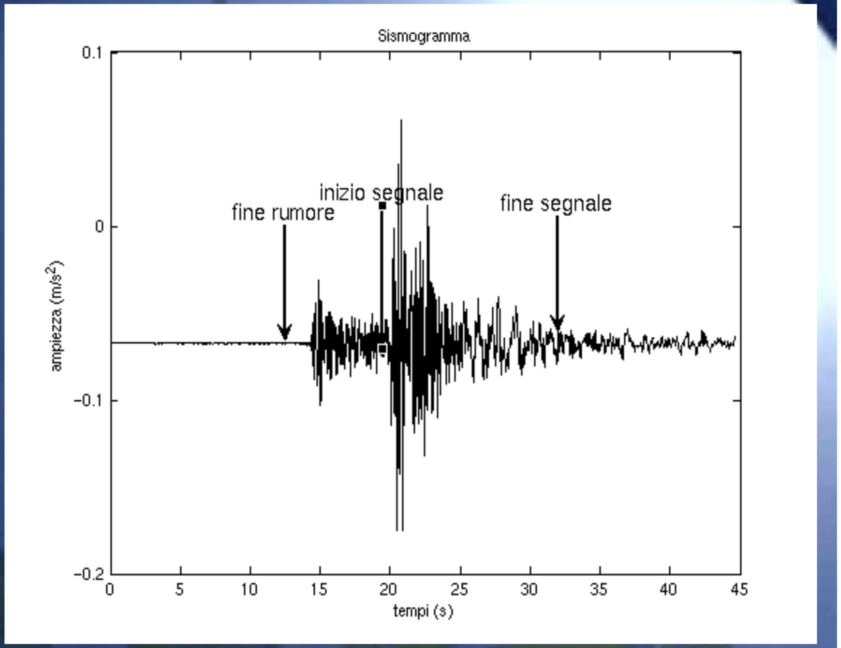
EW and NS components are combined to obtain the trasversal one to minimize P-wave interferences

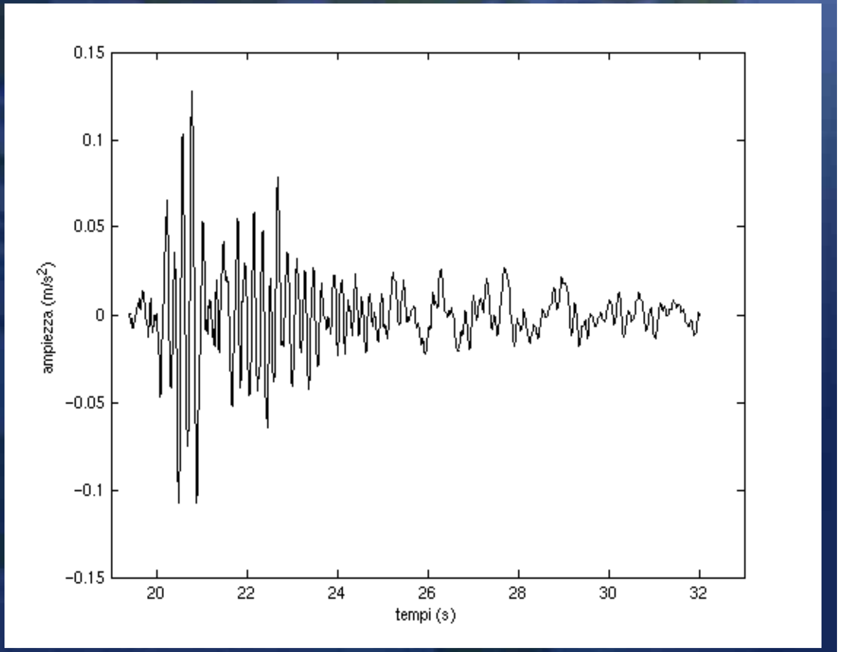
Carnia 2002 event recorded at Gemona)

“noise” window and “S” window are retrieved and sinusoidal tapering at edges applied

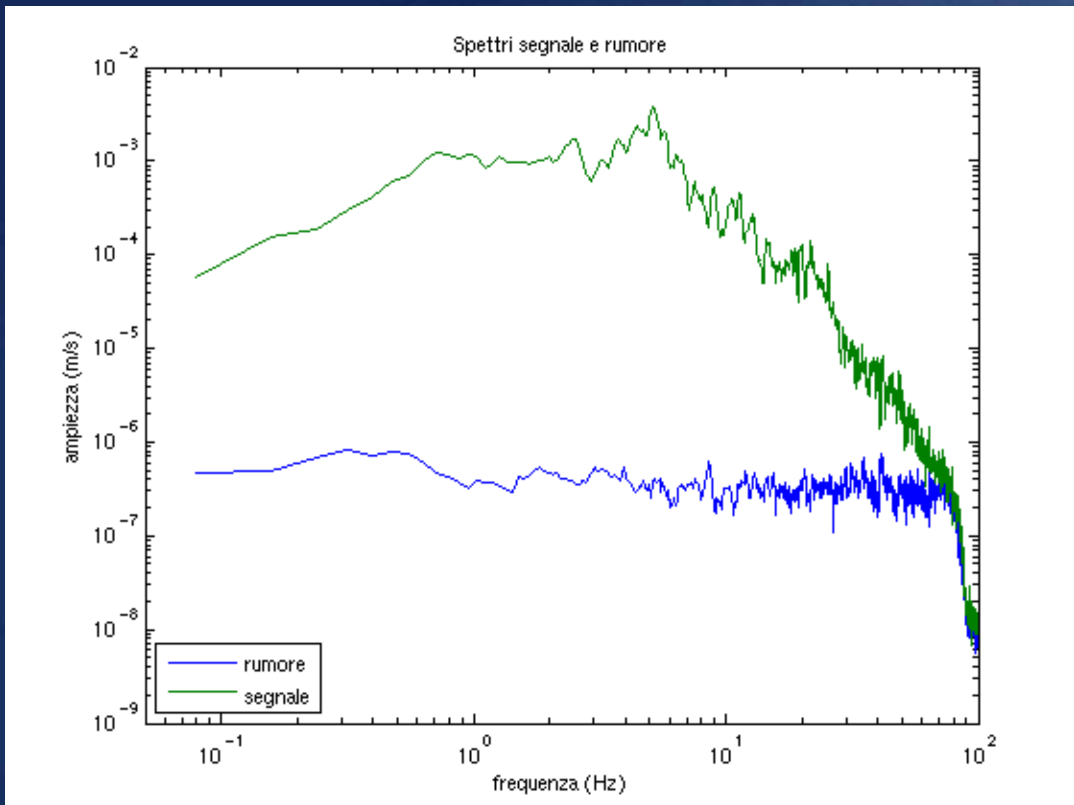
Extracted noise

Extracted S-wave signal





Signal-to-Noise spectral ratio is used to determine the frequency window



Requirements

at least a point with S/R>2.5

S/R>2.5 for f_{inf}

S/R>5.0 for f_{sup}

f_{sup}<10Hz

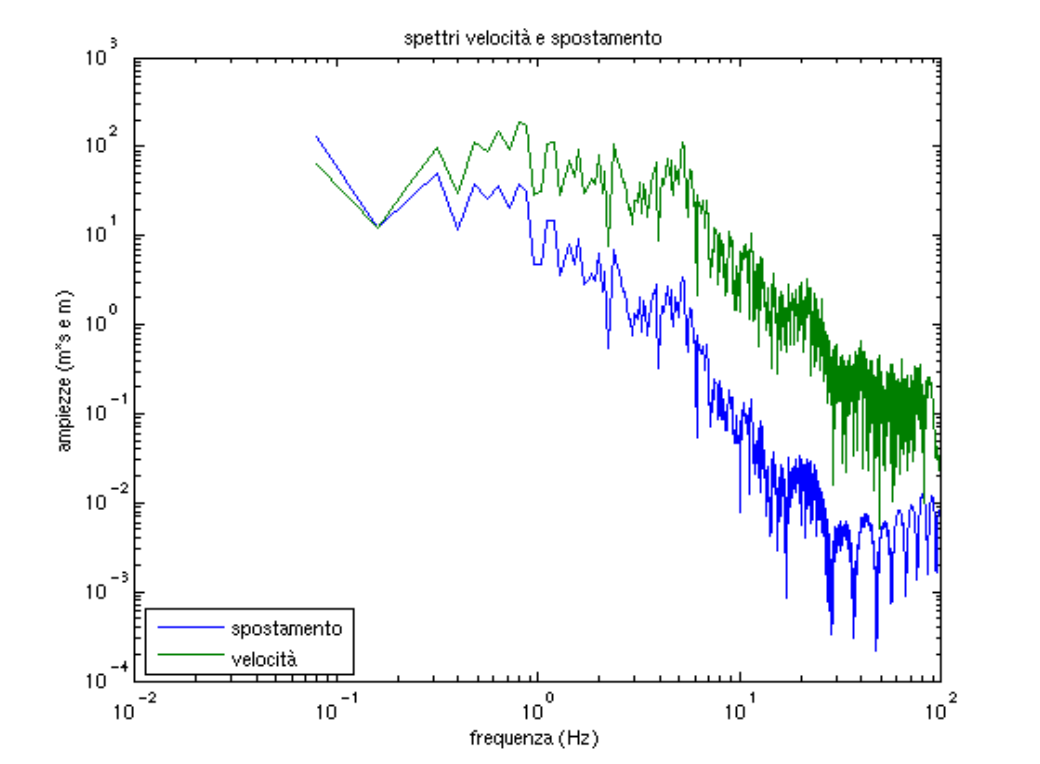
If the requirements are not met an error message is printed and the signal is rejected

From the signals in acceleration or velocity

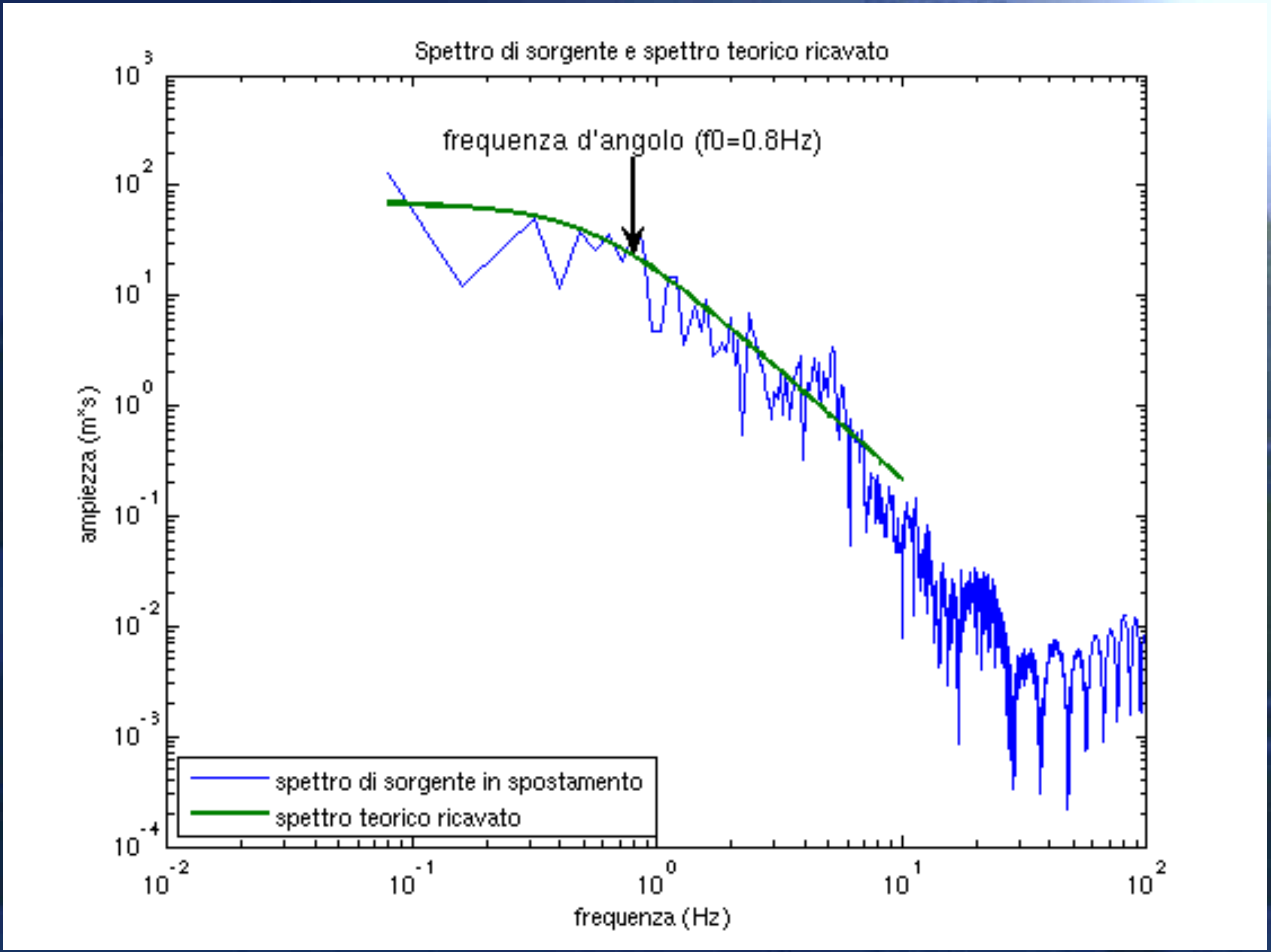
Integrate to obtain
velocities and displacements

•FFT
•Correction for geometrical spreading
and anelastic attenuation

Velocity and displacement spectra estimated
AT THE SOURCE



Example of Estimated Source Spectrum and Theoretical Fit



Constraints

$$f_0 > 2 \cdot f_{\inf}$$

$$f_0 < f_{\sup}$$

$$1 \cdot 10^4\, Pa < \Delta\sigma < 1 \cdot 10^8\, Pa$$

where

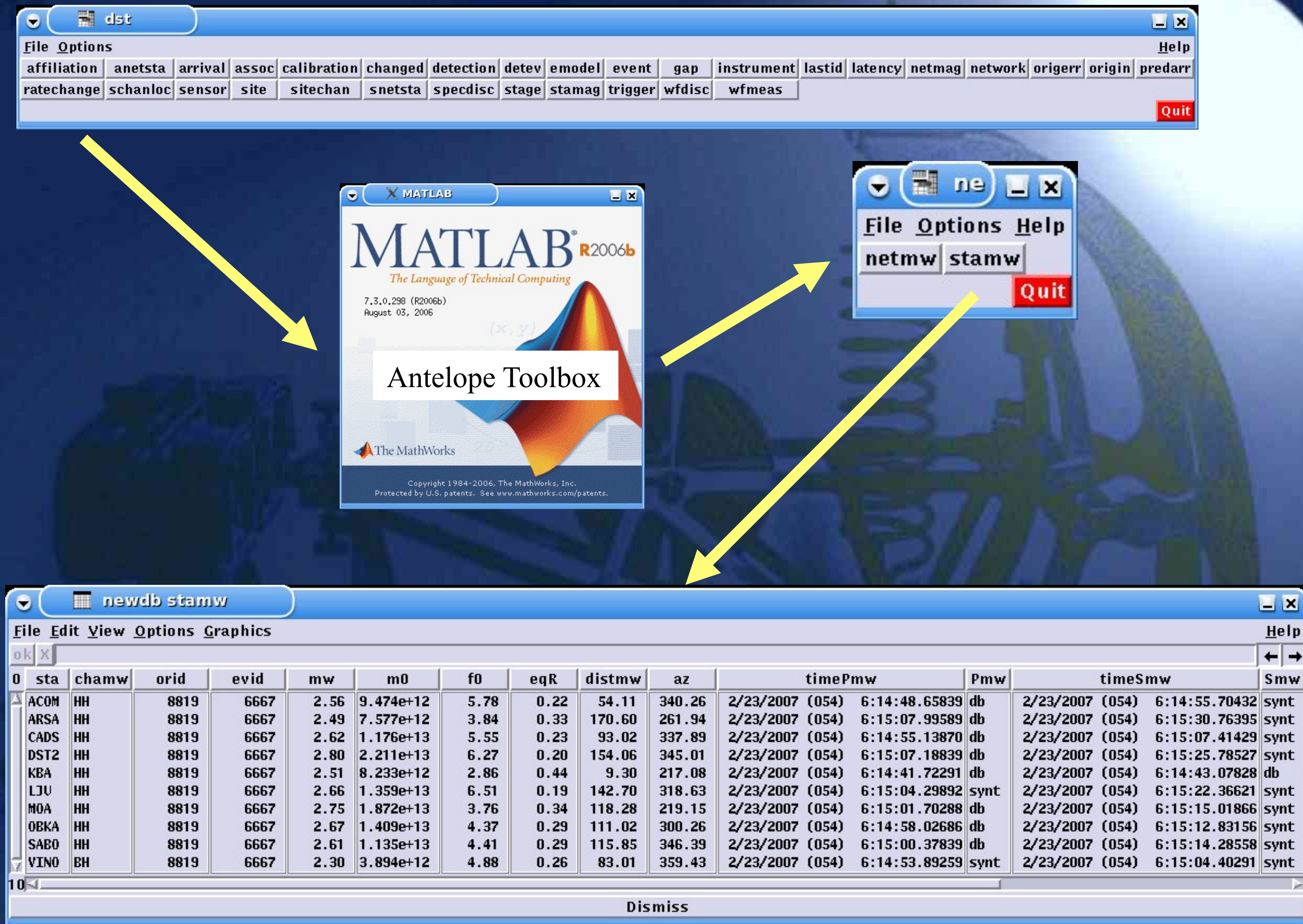
$$\Delta\sigma = \frac{7M_0}{16}\left(\frac{2\pi f_0}{2{,}34\beta}\right)^3$$

If these constraints are NOT met an message is printed and the signal rejected

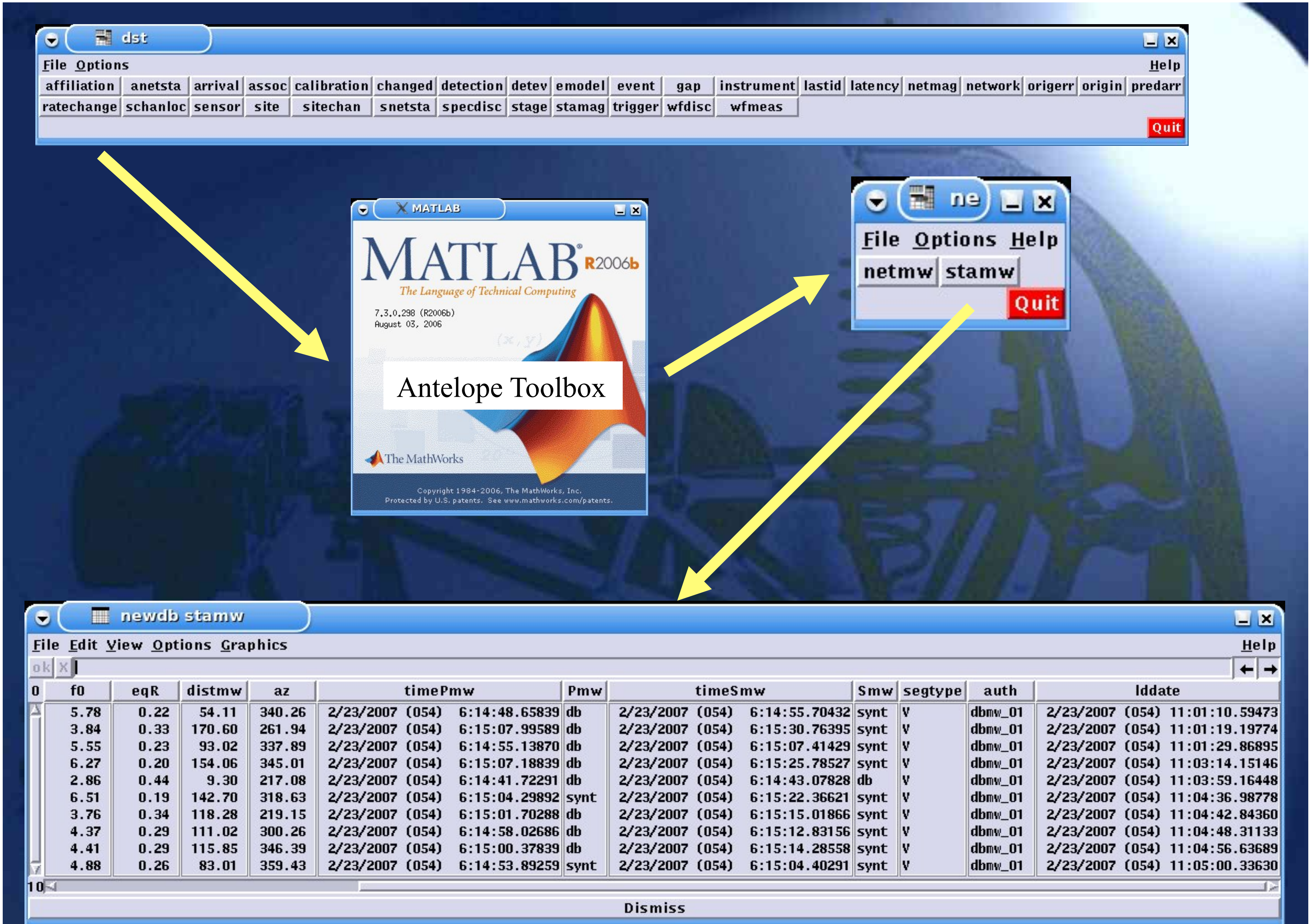
NOTE: These constraints are still being tested!

Example of computed table

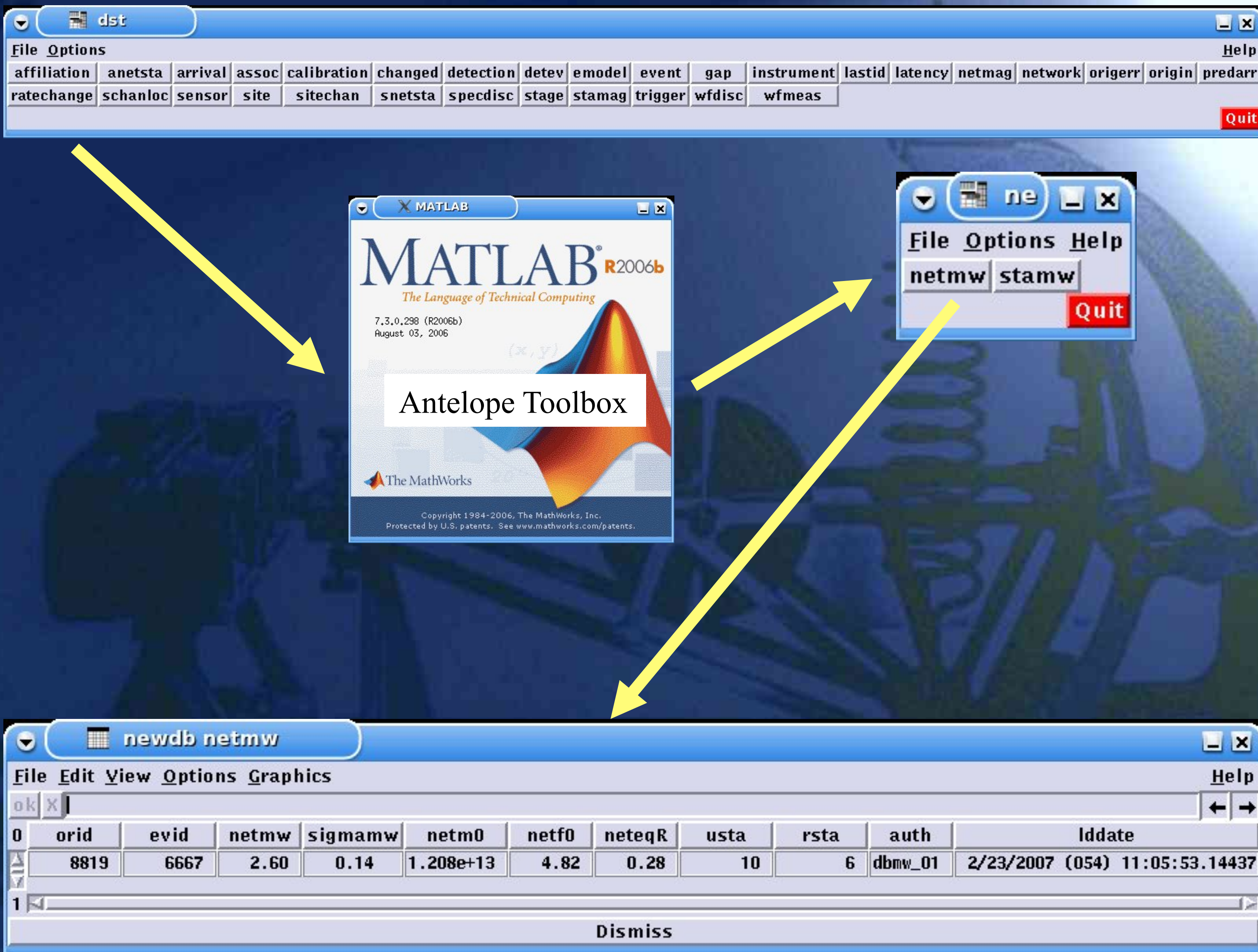
Message	Station	Channel	Type	f inf	f sup	f0	M0	Mw	Distance	Azimuth
OK	MOGG	HG	A	0.1	9.9	1.2	1.42E+16	4.7	35,154	106
OK	GEPF	HG	A	0.1	9.9	0.6	5.90E+16	5.1	37,849	83
OK	CESC	HG	A	0.1	9.9	0.2	2.97E+17	5.6	44,068	95
att.,stress drop"	STOL	HG	A	0.1	9.8	1.1	3.74E+16	5.0	21,748	102
OK	MASA	HG	A	0.1	9.9	0.5	1.07E+17	5.3	21,914	45
OK	PRAD	HG	A	0.1	10.0	0.4	4.31E+16	5.0	57,238	82
Sup min inf	CARC	HG	A	0.0	0.0	0.0	0.00E+00	0.0	73,941	352
OK	LJU	HG	A	0.0	10.0	0.4	1.99E+17	5.4	74,376	294
OK	MAJA	HG	A	0.1	9.9	0.4	6.96E+16	5.1	45,585	71
OK	OBKA	HH	V	0.0	10.0	0.3	1.60E+17	5.4	72,374	253
OK	CADS	HH	V	0.2	9.8	1.1	2.55E+16	4.8	12,618	322
OK	TRI	HH	V	0.0	10.0	0.6	2.64E+16	4.9	67,750	352
OK	KNDS	HH	V	0.0	10.0	0.4	1.06E+17	5.3	103,812	327
OK	CEY	HH	V	0.0	10.0	0.5	6.64E+16	5.1	87,657	317
OK	CRES	HH	V	0.0	9.5	0.4	1.18E+17	5.3	149,148	292
OK	ARSA	HH	V	0.0	10.0	0.2	2.00E+17	5.4	175,230	235
OK	KBA	HH	V	0.0	10.0	0.5	2.46E+16	4.8	86,367	165
OK	DST2	HH	V	0.0	9.9	0.6	3.52E+16	4.9	73,662	350
OK	VINO	BH	V	0.1	9.9	1.1	1.58E+16	4.7	27,772	76
Average values						0.6±0.3		5.1±0.3		



0	sta	chamw	orid	evid	mw	m0	f0	eqR	distmw	az	timePmw	Pmw	timeSmw	Smw
	ACOM	HH	8819	6667	2.56	9.474e+12	5.78	0.22	54.11	340.26	2/23/2007 (054) 6:14:48.65839	db	2/23/2007 (054) 6:14:55.70432	synt
	ARSA	HH	8819	6667	2.49	7.577e+12	3.84	0.33	170.60	261.94	2/23/2007 (054) 6:15:07.99589	db	2/23/2007 (054) 6:15:30.76395	synt
	CADS	HH	8819	6667	2.62	1.176e+13	5.55	0.23	93.02	337.89	2/23/2007 (054) 6:14:55.13870	db	2/23/2007 (054) 6:15:07.41429	synt
	DST2	HH	8819	6667	2.80	2.211e+13	6.27	0.20	154.06	345.01	2/23/2007 (054) 6:15:07.18839	db	2/23/2007 (054) 6:15:25.78527	synt
	KBA	HH	8819	6667	2.51	8.233e+12	2.86	0.44	9.30	217.08	2/23/2007 (054) 6:14:41.72291	db	2/23/2007 (054) 6:14:43.07828	db
	LJU	HH	8819	6667	2.66	1.359e+13	6.51	0.19	142.70	318.63	2/23/2007 (054) 6:15:04.29892	synt	2/23/2007 (054) 6:15:22.36621	synt
	MOA	HH	8819	6667	2.75	1.872e+13	3.76	0.34	118.28	219.15	2/23/2007 (054) 6:15:01.70288	db	2/23/2007 (054) 6:15:15.01866	synt
	OBKA	HH	8819	6667	2.67	1.409e+13	4.37	0.29	111.02	300.26	2/23/2007 (054) 6:14:58.02686	db	2/23/2007 (054) 6:15:12.83156	synt
	SABO	HH	8819	6667	2.61	1.135e+13	4.41	0.29	115.85	346.39	2/23/2007 (054) 6:15:00.37839	db	2/23/2007 (054) 6:15:14.28558	synt
	VINO	BH	8819	6667	2.30	3.894e+12	4.88	0.26	83.01	359.43	2/23/2007 (054) 6:14:53.89259	synt	2/23/2007 (054) 6:15:04.40291	synt
10														



0	f0	eqR	distmw	az	timePmw	Pmw	timeSmw	Smw	segtype	auth	lddate
	5.78	0.22	54.11	340.26	2/23/2007 (054) 6:14:48.65839	db	2/23/2007 (054) 6:14:55.70432	synt	V	dbmw_01	2/23/2007 (054) 11:01:10.59473
	3.84	0.33	170.60	261.94	2/23/2007 (054) 6:15:07.99589	db	2/23/2007 (054) 6:15:30.76395	synt	V	dbmw_01	2/23/2007 (054) 11:01:19.19774
	5.55	0.23	93.02	337.89	2/23/2007 (054) 6:14:55.13870	db	2/23/2007 (054) 6:15:07.41429	synt	V	dbmw_01	2/23/2007 (054) 11:01:29.86895
	6.27	0.20	154.06	345.01	2/23/2007 (054) 6:15:07.18839	db	2/23/2007 (054) 6:15:25.78527	synt	V	dbmw_01	2/23/2007 (054) 11:03:14.15146
	2.86	0.44	9.30	217.08	2/23/2007 (054) 6:14:41.72291	db	2/23/2007 (054) 6:14:43.07828	db	V	dbmw_01	2/23/2007 (054) 11:03:59.16448
	6.51	0.19	142.70	318.63	2/23/2007 (054) 6:15:04.29892	synt	2/23/2007 (054) 6:15:22.36621	synt	V	dbmw_01	2/23/2007 (054) 11:04:36.98778
	3.76	0.34	118.28	219.15	2/23/2007 (054) 6:15:01.70288	db	2/23/2007 (054) 6:15:15.01866	synt	V	dbmw_01	2/23/2007 (054) 11:04:42.84360
	4.37	0.29	111.02	300.26	2/23/2007 (054) 6:14:58.02686	db	2/23/2007 (054) 6:15:12.83156	synt	V	dbmw_01	2/23/2007 (054) 11:04:48.31133
	4.41	0.29	115.85	346.39	2/23/2007 (054) 6:15:00.37839	db	2/23/2007 (054) 6:15:14.28558	synt	V	dbmw_01	2/23/2007 (054) 11:04:56.63689
	4.88	0.26	83.01	359.43	2/23/2007 (054) 6:14:53.89259	synt	2/23/2007 (054) 6:15:04.40291	synt	V	dbmw_01	2/23/2007 (054) 11:05:00.33630
10											


dst
File Options
Help
affiliation anetsta arrival assoc calibration changed detection detev emodel event gap instrument lastid latency netmag network origerr origin predarr
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MATLAB
MATLAB R2006b
The Language of Technical Computing
7.3.0.298 (R2006b)
August 03, 2006
Antelope Toolbox
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ne
File Options Help
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newdb netmw
File Edit View Options Graphics
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0 orid evid netmw sigmamw netm0 netf0 neteqR usta rsta auth lddate
8819 6667 2.60 0.14 1.208e+13 4.82 0.28 10 6 dbmw_01 2/23/2007 (054) 11:05:53.14437
1
Dismiss

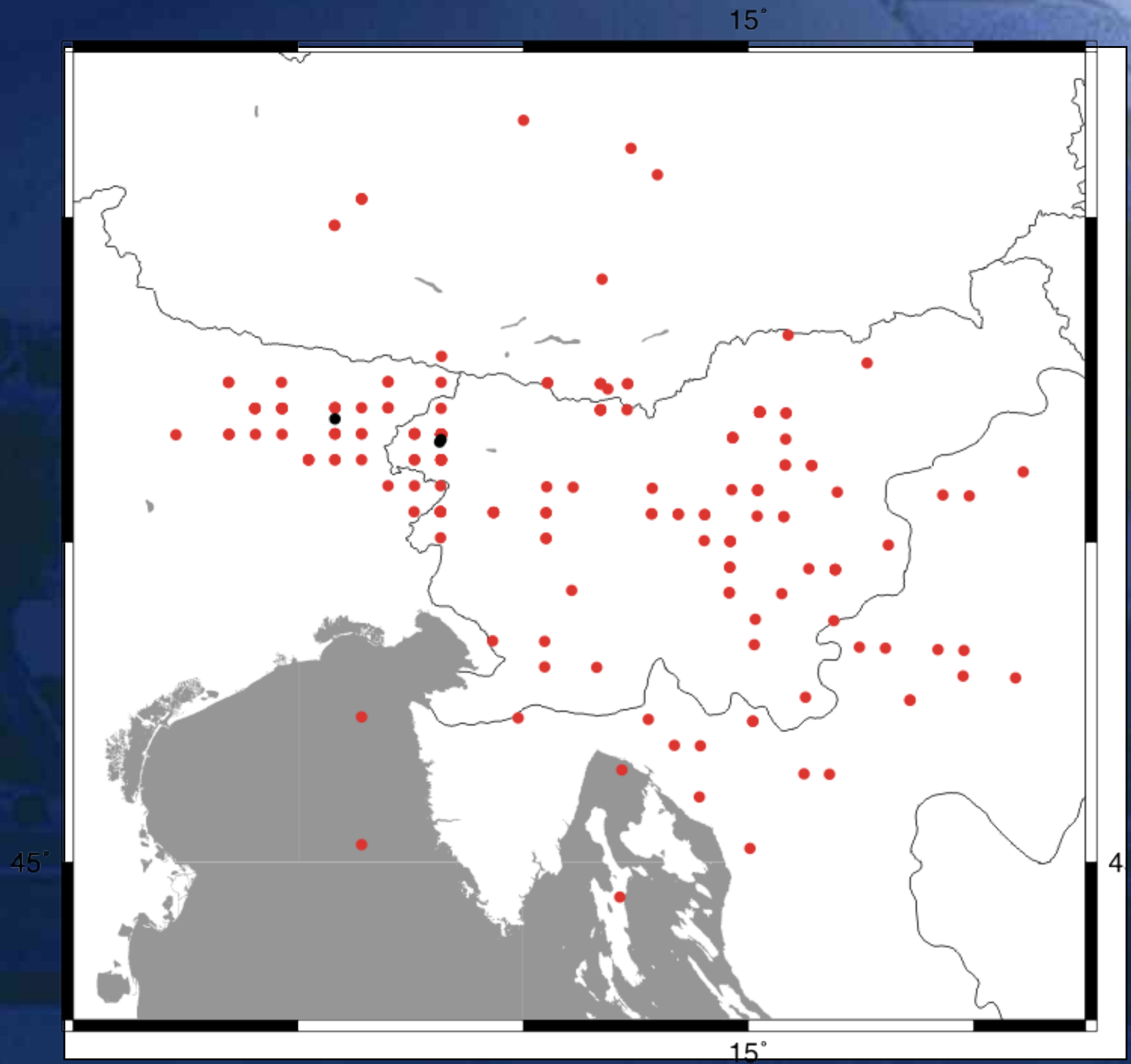
pf file

```
pf_revision_time 1150848000.000
# Parameter file for dbmw
# latency and maxwaittime are only needed for orbmw
# but to allow the usage of the same parameter file for both
# realtime (orbmw) computations and postprocessing (dbmw)
# they are included in the parameterfile
# they are ignored when running dbmw

latency        30.0    # group latency
maxwaittime    60.0    # A hard timeout value in seconds for reading waveform packets.
                       #  If no waveform packets for the selected channels are received
                       #  within this time period, then the waveform reading loop is
                       #  interrupted and any further processing for that event is
                       #  aborted.

v_r                4.0        # velocity for surface waves used to determine surface wave arrival time

auto_arr    no      # start of measuring time window yes = computed arrival
            #                            no  = db arrival

time_window_factor      1.0      # The waveform for processing the magnitude is determined by a time
                                 # window starting from the arrival defined by the time0 parameter
                                 # to time_factor*(S_time-P-time) seconds after the first P-arrival.

distmin          0        # distance range in km
distmax     200     #

q         800      # attenuation value

# the M0 formula implemented is: M0=4*pi*OMEGA*c1*c2^3*c3
c1         0.63     # avarage directivity
c2         3400     # velocity S wave m/s
c3         2700     # average density

# the MW formula implemented is:  MW=c4*log10(M0)-c5
c4        0.667
c5        6.1

filter BW 0.05 5 10 5

mag &Tbl{
# stations parameters for computing magnitudes
#   calib   deconvolve apply    snr    twin
#sta  expr    db   response    filter thresh noise c2  c3      c4   c5 minclip maxclip
ARSA   HH    yes     no        no       2.0   60.0  0.0     0.0  1.0  1.0  0.0
CEY    HH    yes     no        no       2.0   60.0  0.0     0.0  1.0  1.0  0.0
CRES   HH    yes     no        no       2.0   60.0  0.0     0.0  1.0  1.0  0.0
..................................................................................
........
...............
MASA   HG    yes     no        no       2.0   60.0  0.0     0.0  1.0  1.0  0.0
}
pf_revision_time 1150848000
```

log file

```
23-Feb-2007 12:01:03  - Program Mw starts - DST Trieste - ver. 001 June 2006
23-Feb-2007 12:01:03 Orid: 8819
 Origin time: 23 February 2007 06:14:39.419 Lat. 47.011 Lon. 13.270 Ml =   3.11
  ACOM chan: HH Distance: 5.410785e+01 Az: 3.402557e+02 P 06:14:48.658 db S 06:14:55.704 synt
    noise  window start: 06:14:28.622 stop: 06:14:46.658
    S      window start: 06:14:54.780 stop: 06:15:13.740
    signal window start: 06:14:28.622 stop: 06:15:15.740

arrP  1.172211289e+09 otime  1.172211279e+09 trtime  1.628496170e+01

    Mw= 2.56 M0= 9.47e+12 f0=  5.78  OK  stype= V delfrq= 0.0528 fmin= 0.5277 fmax= 9.9736

   AQU chan: HH Distance: 512.16 out of limits ( 0.00 , 200.00 )
  ARSA chan: HH Distance: 1.706005e+02 Az: 2.619437e+02 P 06:15:07.996 db S 06:15:30.764 synt
    noise  window start: 06:14:09.129 stop: 06:15:05.996
    S      window start: 06:15:27.906 stop: 06:16:27.631
    signal window start: 06:14:09.129 stop: 06:16:29.631

arrP  1.172211308e+09 otime  1.172211279e+09 trtime  5.134459305e+01

    Mw= 2.49 M0= 7.58e+12 f0=  3.84  OK  stype= V delfrq= 0.0167 fmin= 0.6364 fmax= 9.9812

  CADS chan: HH Distance: 9.301553e+01 Az: 3.378922e+02 P 06:14:55.139 db S 06:15:07.414 synt
    noise  window start: 06:14:22.134 stop: 06:14:53.139
    S      window start: 06:15:05.842 stop: 06:15:38.419
    signal window start: 06:14:22.134 stop: 06:15:40.419

arrP  1.172211295e+09 otime  1.172211279e+09 trtime  2.799492645e+01

    Mw= 2.62 M0= 1.18e+13 f0=  5.55  OK  stype= V delfrq= 0.0307 fmin= 1.1972 fmax= 9.9770

   CEY chan: HH Distance: 1.650012e+02 Az: 3.284280e+02 P 06:15:07.777 db S 06:15:29.079 synt
    noise  window start: 06:14:10.776 stop: 06:15:05.777
    S      window start: 06:15:26.243 stop: 06:16:24.079
    signal window start: 06:14:10.776 stop: 06:16:26.079

arrP  1.172211308e+09 otime  1.172211279e+09 trtime  4.965950775e+01

  Station rejected:                 no freqmax found!

  CRES chan: HH Distance: 210.83 out of limits ( 0.00 , 200.00 )
  DOBS chan: HH Distance: 1.913175e+02 Az: 3.004683e+02 P 06:15:12.776 synt S 06:15:36.999 synt
    noise  window start: 06:14:07.003 stop: 06:15:10.776
    S      window start: 06:15:33.663 stop: 06:16:40.771
    signal window start: 06:14:07.003 stop: 06:16:42.771

arrP  1.172211313e+09 otime  1.172211279e+09 trtime  5.757920837e+01

  Station rejected:     freqmax<freqmin after Q correction
```

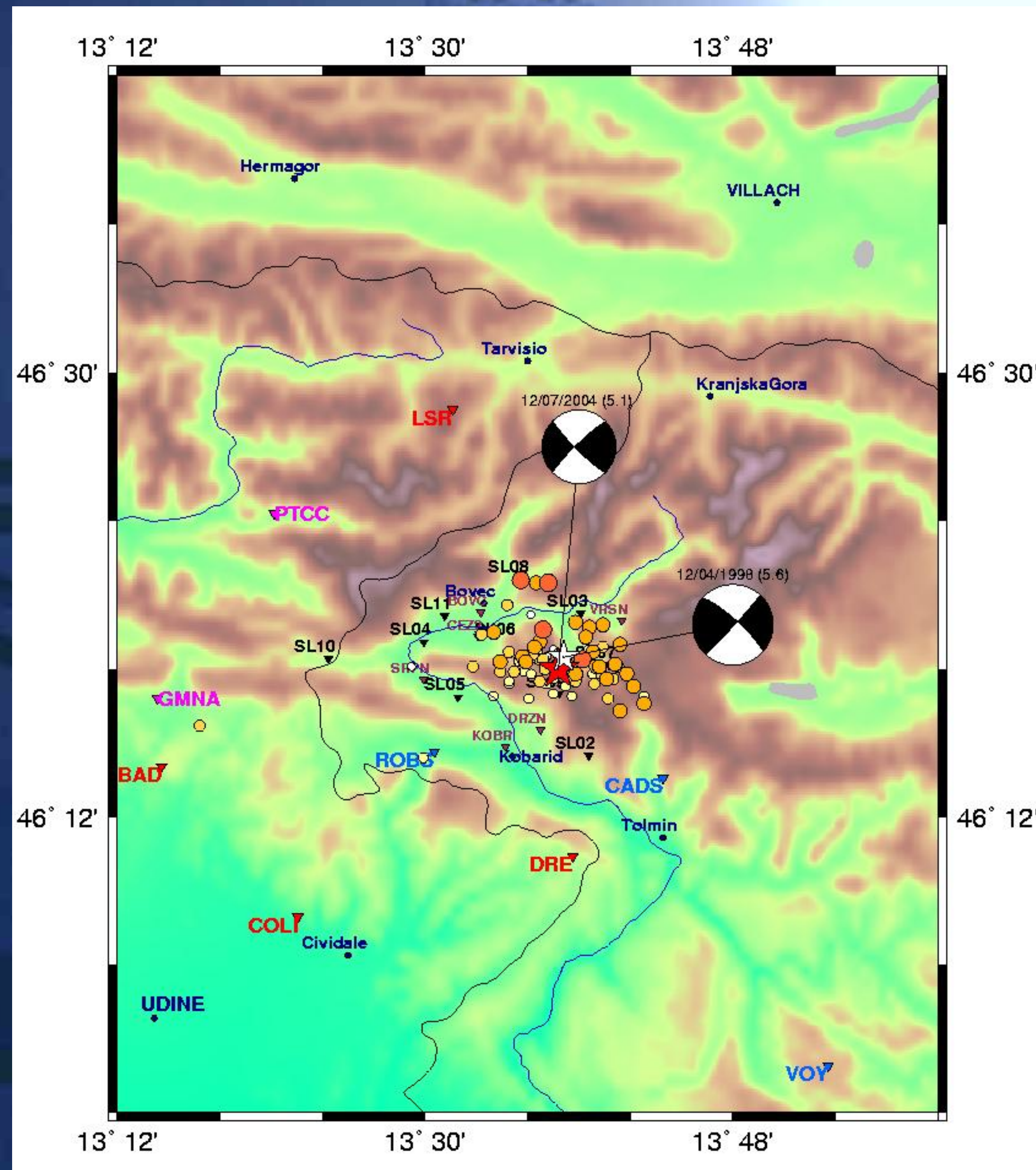
Processed Events
(3 major ones (Ml>4.5) and 193 minor ones) Preliminary Antelope locations on large grids is shown



BOVEC

Date	12/07/2004
Hour	13:04:10 GMT
Latitude	46.30
Longitude	13.61
Deepth (km)	12
Mw	5.2
Mb	5.0
Ms	4.9
Scalar Moment (Nm)	7.11e+16 (Harvard)

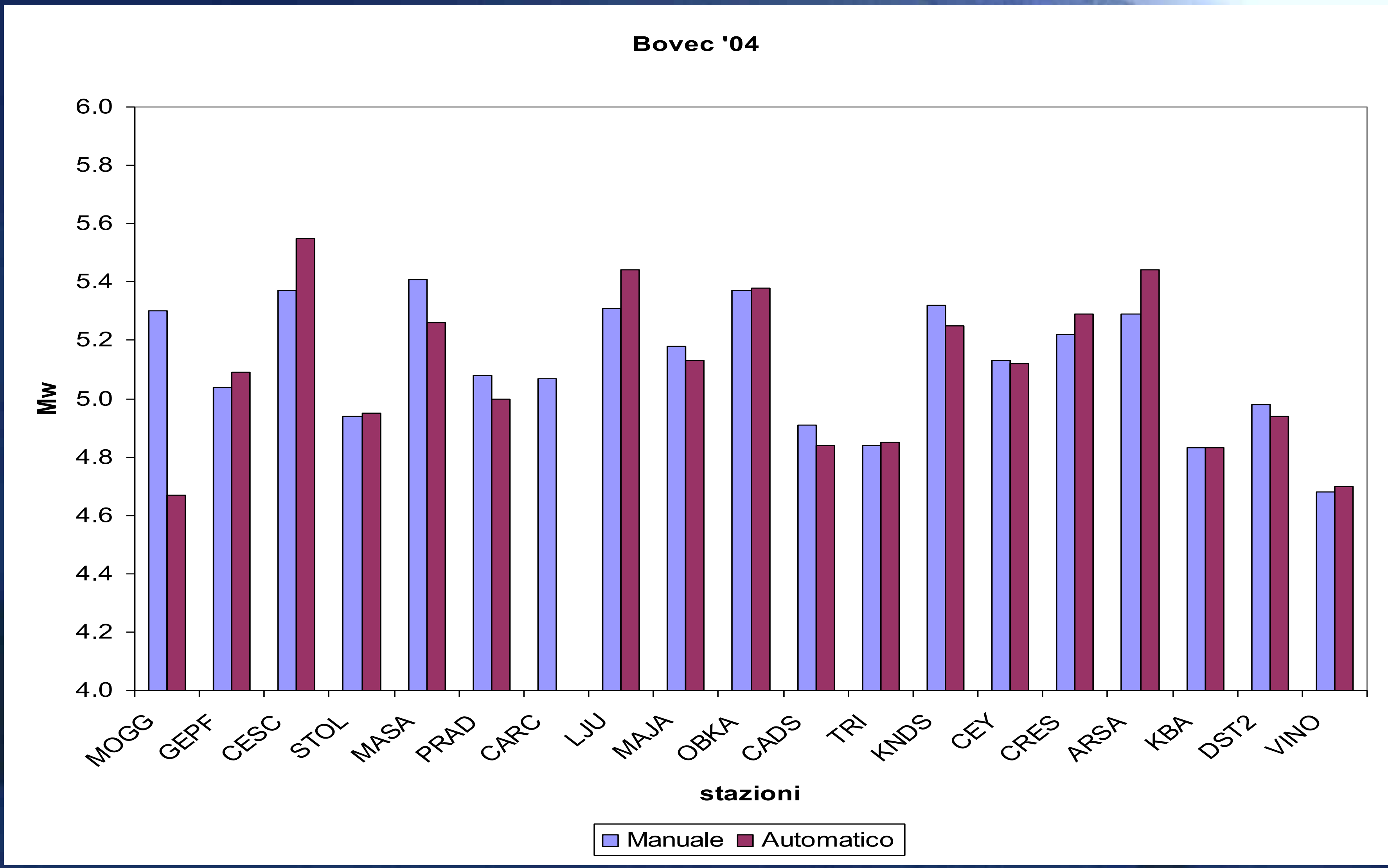
The magnitude uncertainties are of the order 0.3-0.5



RISULTATI MANUALI										
Messaggio	stazione	canale	Tipo	f inf	f sup	f0	M0	Mw	distanza	Azimut
OK	MOGG	HG	A	0.1	9.9	0.3	1.22E+17	5.3	35,154	106
OK	GEPF	HG	A	0.1	9.9	0.6	4.97E+16	5.0	37,849	83
OK	CESC	HG	A	0.1	9.9	0.3	1.56E+17	5.4	44,068	95
att.,sd"sospetto"	STOL	HG	A	0.1	9.8	1.2	3.58E+16	4.9	21,748	102
OK	MASA	HG	A	0.1	9.9	0.4	1.79E+17	5.4	21,914	45
OK	PRAD	HG	A	0.1	10.0	0.3	5.73E+16	5.1	57,238	82
OK	CARC	HG	A	0.0	9.9	0.7	5.50E+16	5.1	73,941	352
OK	LJU	HG	A	0.0	10.0	0.6	1.27E+17	5.3	74,376	294
OK	MAJA	HG	A	0.1	9.9	0.3	8.12E+16	5.2	45,585	71
OK	OBKA	HH	V	0.0	10.0	0.3	1.57E+17	5.4	72,374	253
OK	CADS	HH	V	0.2	9.8	1.0	3.21E+16	4.9	12,618	322
OK	TRI	HH	V	0.0	10.0	0.6	2.54E+16	4.8	67,750	352
OK	KNDS	HH	V	0.0	10.0	0.4	1.31E+17	5.3	103,812	327
OK	CEY	HH	V	0.0	10.0	0.5	6.97E+16	5.1	87,657	317
OK	CRES	HH	V	0.0	10.0	0.5	9.48E+16	5.2	149,148	292
OK	ARSA	HH	V	0.0	10.0	0.3	1.21E+17	5.3	175,230	235
OK	KBA	HH	V	0.0	10.0	0.5	2.41E+16	4.8	86,367	165
OK	DST2	HH	V	0.0	10.0	0.6	4.09E+16	5.0	73,662	350
OK	VINO	BH	V	0.1	9.9	1.1	1.45E+16	4.7	27,772	76
Valori medi						0.5±0.3	8.35E+16	5.1±0.2		

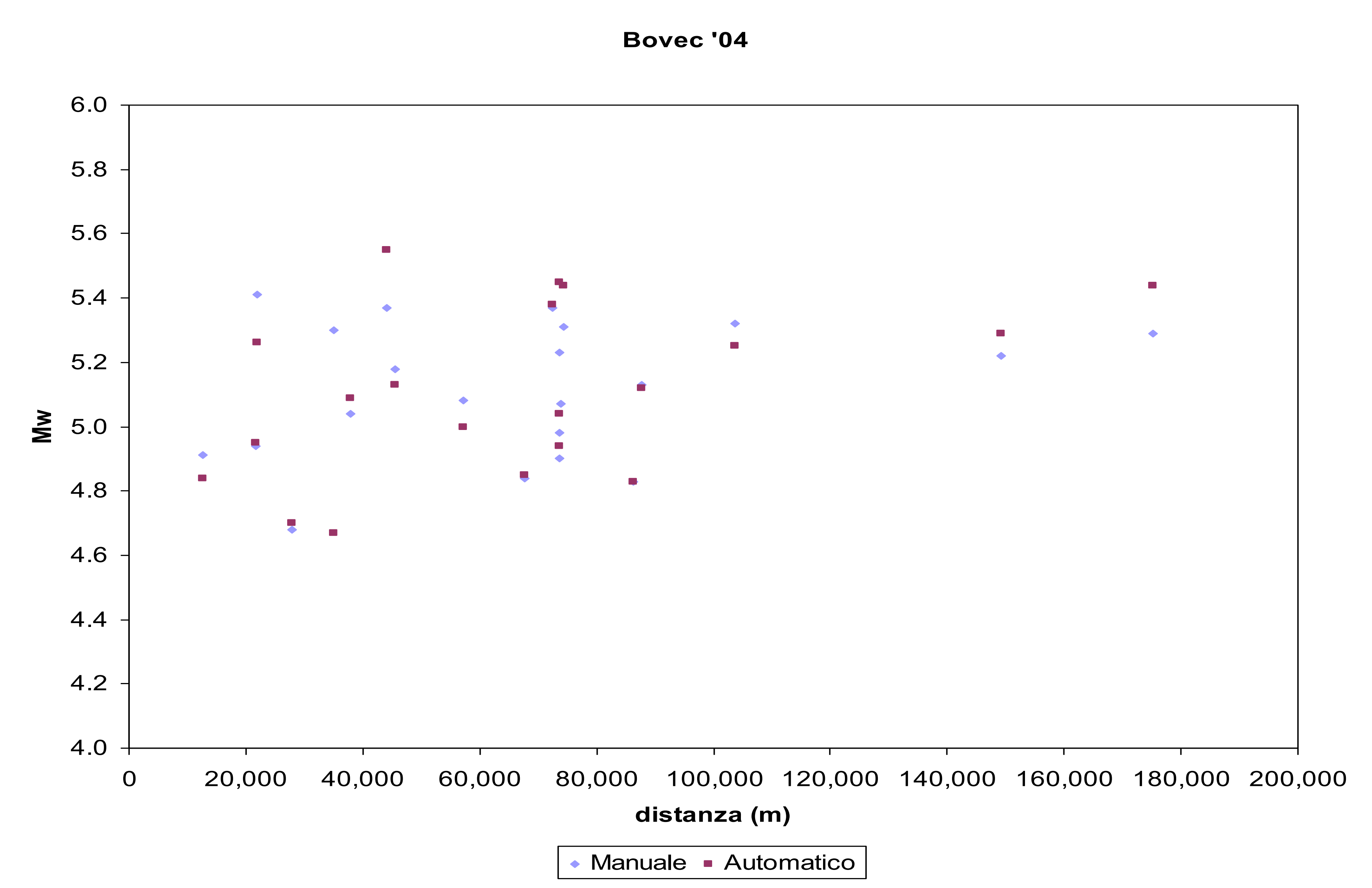
RISULTATI AUTOMATICI										
Messaggio	**stazione**	**canale**	**Tipo**	**f inf**	**f sup**	**f0**	**M0**	**Mw**	**distanza**	**Azimut**
OK	MOGG	HG	A	0.1	9.9	1.2	1.42E+16	4.7	35,154	106
OK	GEPF	HG	A	0.1	9.9	0.6	5.90E+16	5.1	37,849	83
OK	CESC	HG	A	0.1	9.9	0.2	2.97E+17	5.6	44,068	95
att.,sd"sospetto"	STOL	HG	A	0.1	9.8	1.1	3.74E+16	5.0	21,748	102
OK	MASA	HG	A	0.1	9.9	0.5	1.07E+17	5.3	21,914	45
OK	PRAD	HG	A	0.1	10.0	0.4	4.31E+16	5.0	57,238	82
sup min inf	CARC	HG	A	0.0	0.0	0.0	0.00E+00	0.0	73,941	352
OK	LJU	HG	A	0.0	10.0	0.4	1.99E+17	5.4	74,376	294
OK	MAJA	HG	A	0.1	9.9	0.4	6.96E+16	5.1	45,585	71
OK	OBKA	HH	V	0.0	10.0	0.3	1.60E+17	5.4	72,374	253
OK	CADS	HH	V	0.2	9.8	1.1	2.55E+16	4.8	12,618	322
OK	TRI	HH	V	0.0	10.0	0.6	2.64E+16	4.9	67,750	352
OK	KNDS	HH	V	0.0	10.0	0.4	1.06E+17	5.3	103,812	327
OK	CEY	HH	V	0.0	10.0	0.5	6.64E+16	5.1	87,657	317
OK	CRES	HH	V	0.0	9.5	0.4	1.18E+17	5.3	149,148	292
OK	ARSA	HH	V	0.0	10.0	0.2	2.00E+17	5.4	175,230	235
OK	KBA	HH	V	0.0	10.0	0.5	2.46E+16	4.8	86,367	165
OK	DST2	HH	V	0.0	9.9	0.6	3.52E+16	4.9	73,662	350
OK	VINO	BH	V	0.1	9.9	1.1	1.58E+16	4.7	27,772	76
Valori medi						0.6±0.3	8.71E+16	5.1±0.3		

Comparison between "manual" and "automatic" results



M_W as a function of distance

No station corrections applied for these tests



Carnia 2004

Date 02/14/02 Region AUSTRIA Ml 4.9 Mw 4.7
Centroid Location:
Or. Time 3:18: 5.2 Lat. 46.47 N Long. 13.12 E Dep 21.

Best Double Couple M0: 1.2*10**23

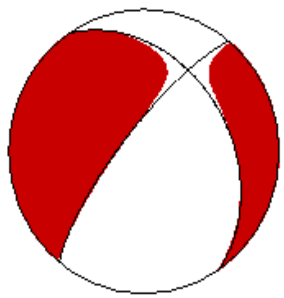
	str:	dip:	slip:
P1	327	38	-158
P2	219	77	-54

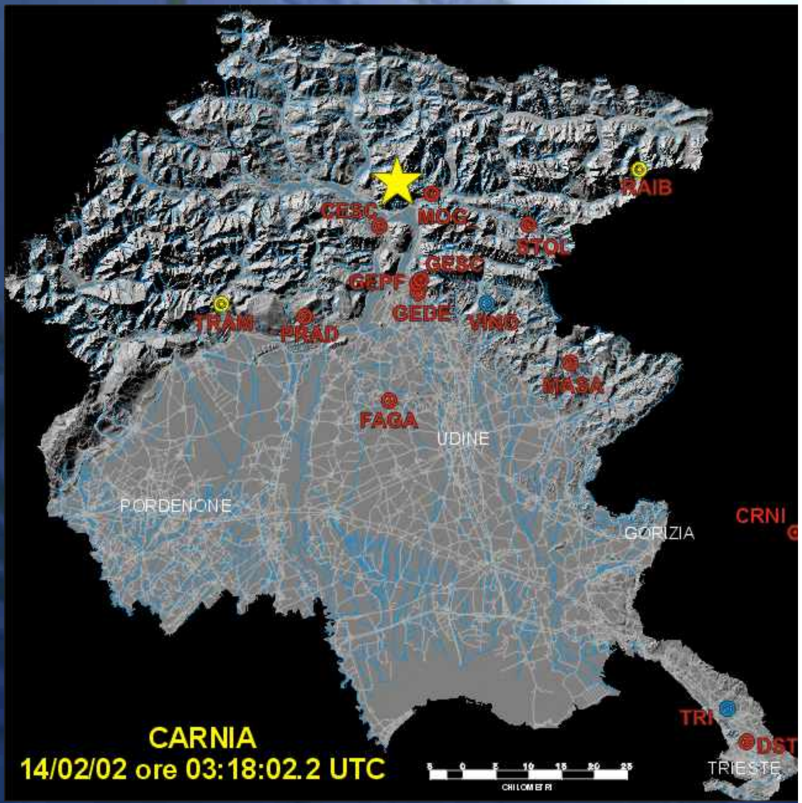
Moment Tensor (10**23 dyn-cm)
mrr: -0.43 mtt: -0.51 mff: 0.94
mrt: 0.64 mrf: 0.60 mtf: 0.09

Principal Axes

	val:	plg:	az:
T	1.23	23	282
N	-0.06	35	30
P	-1.17	46	165

021402A



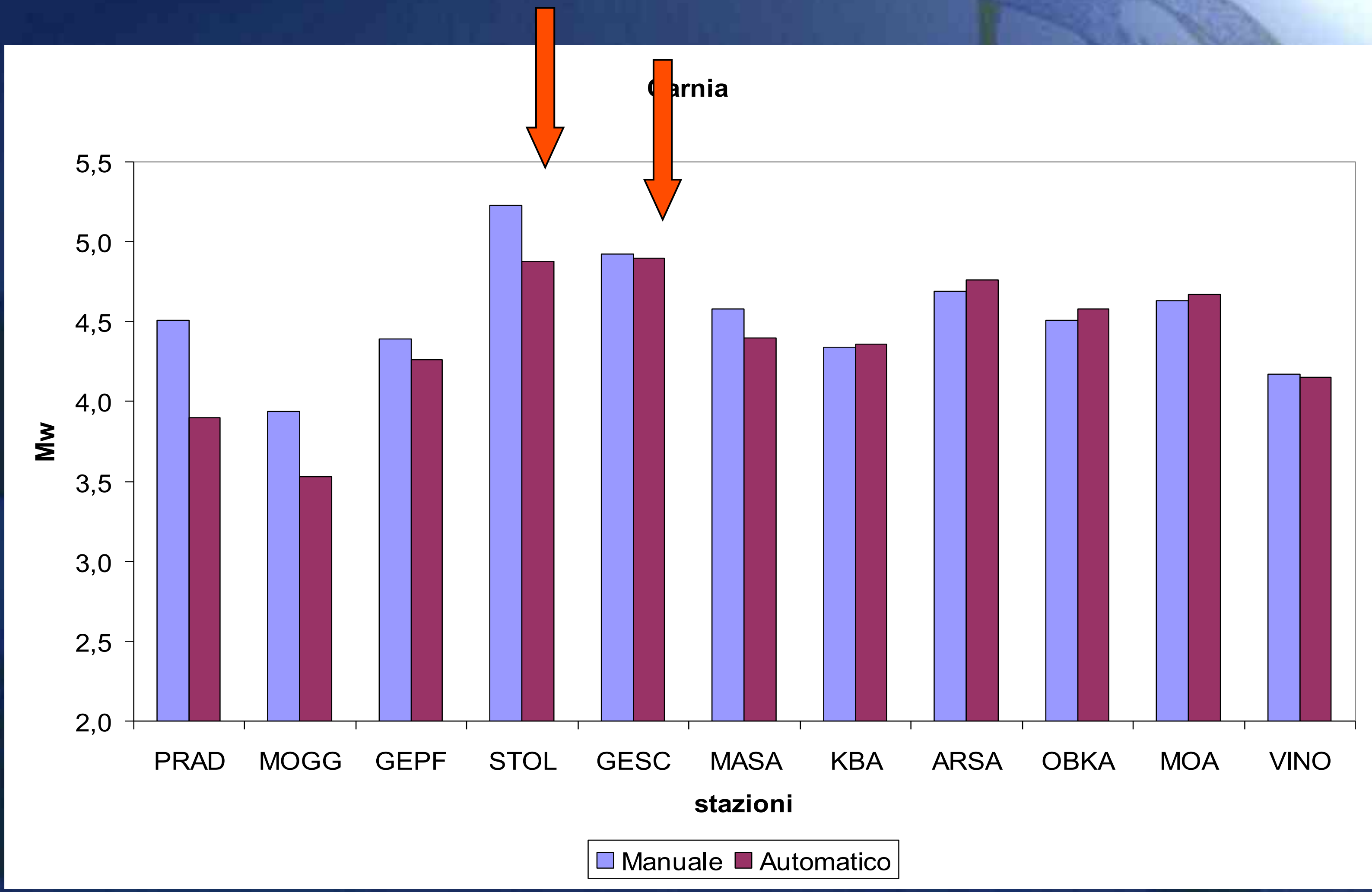


RISULTATI MANUALI										
Messaggio	**stazione**	**Canale**	**tipo**	**f inf**	**fsup**	**f0**	**M0**	**Mw**	**distanza**	**Azimut**
OK	PRAD	HG	A	0.1	9.9	0.6	8.18E+15	4.5	25,735	55
OK	MOGG	HG	A	1.0	8.6	2.4	1.12E+15	3.9	3,161	217
OK	GEPF	HG	A	0.3	9.7	0.7	5.33E+15	4.4	11,738	9
OK	STOL	HG	A	0.2	9.8	0.6	9.59E+16	5.2	14,656	280
OK	GESC	HG	A	0.3	9.6	0.6	3.37E+16	4.9	11,218	9
OK	MASA	HG	A	0.1	9.9	1.0	1.03E+16	4.6	30,446	318
OK	KBA	HH	V	0.0	10.0	2.1	4.50E+15	4.3	77,698	190
OK	ARSA	HH	V	0.0	10.0	0.6	1.48E+16	4.7	201,522	243
OK	OBKA	HH	V	0.0	10.0	1.4	8.11E+15	4.5	105,834	263
OK	MOA	HH	V	0.0	10.0	1.2	1.21E+16	4.6	181,128	207
OK	VINO	BH	V	0.2	9.2	1.2	2.54E+15	4.2	16,519	328
Valori medi						1.1±0.6	1.79E+16	4.5±0.3		

RISULTATI AUTOMATICI										
messaggio	**staz**	**canale**	**tipo**	**f inf**	**f sup**	**f0**	**M0**	**Mw**	**dist**	**azimut**
OK	PRAD	HG	A	0.1	9.9	2.5	9.84E+14	3.9	25,735	55
f0sulliminf	MOGG	HG	A	1.0	8.6	1.6	2.72E+14	3.5	3,161	217
OK	GEPF	HG	A	0.3	9.7	0.8	3.42E+15	4.3	11,738	9
att,sd"sospetto"	STOL	HG	A	0.2	9.8	1.4	2.94E+16	4.9	14,656	280
OK	GESC	HG	A	0.3	9.6	0.5	3.10E+16	4.9	11,218	9
OK	MASA	HG	A	0.1	9.9	1.5	5.43E+15	4.4	30,446	318
OK	KBA	HH	V	0.0	10.0	1.3	4.88E+15	4.4	77,698	190
OK	ARSA	HH	V	0.0	10.0	0.5	1.94E+16	4.8	201,522	243
OK	OBKA	HH	V	0.0	10.0	1.3	1.03E+16	4.6	105,834	263
OK	MOA	HH	V	0.0	10.0	1.1	1.40E+16	4.7	181,128	207
OK	VINO	BH	V	0.2	9.9	1.3	2.29E+15	4.2	16,519	328
valori medi						1.3±0.6	1.10E+16	4.4±0.4		

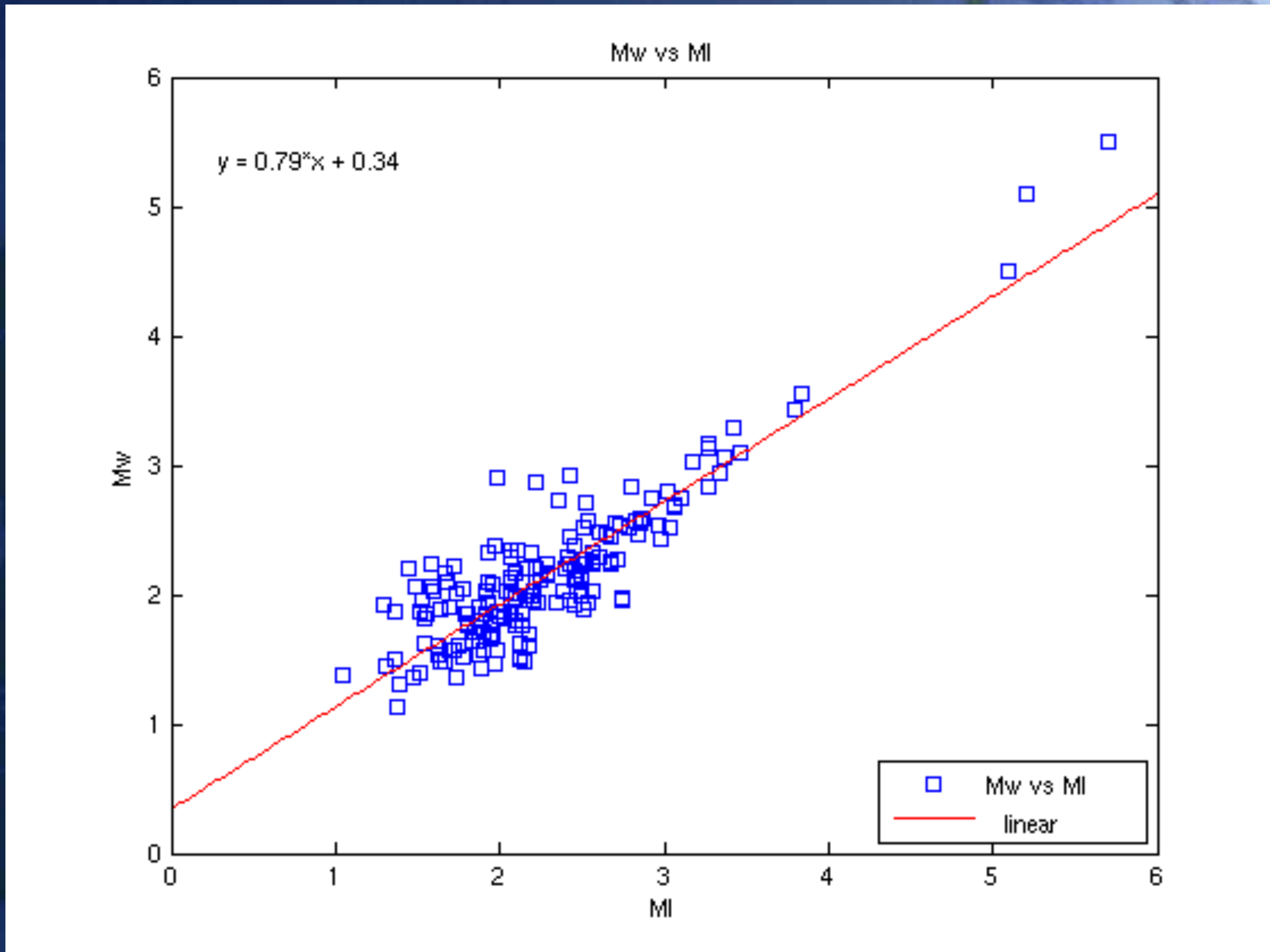
Site Effects

STOL (Stolvizza) e GESC (Gemona Scugelars)
Stations used to study site effects



Comparison with M_L (Antelope©)

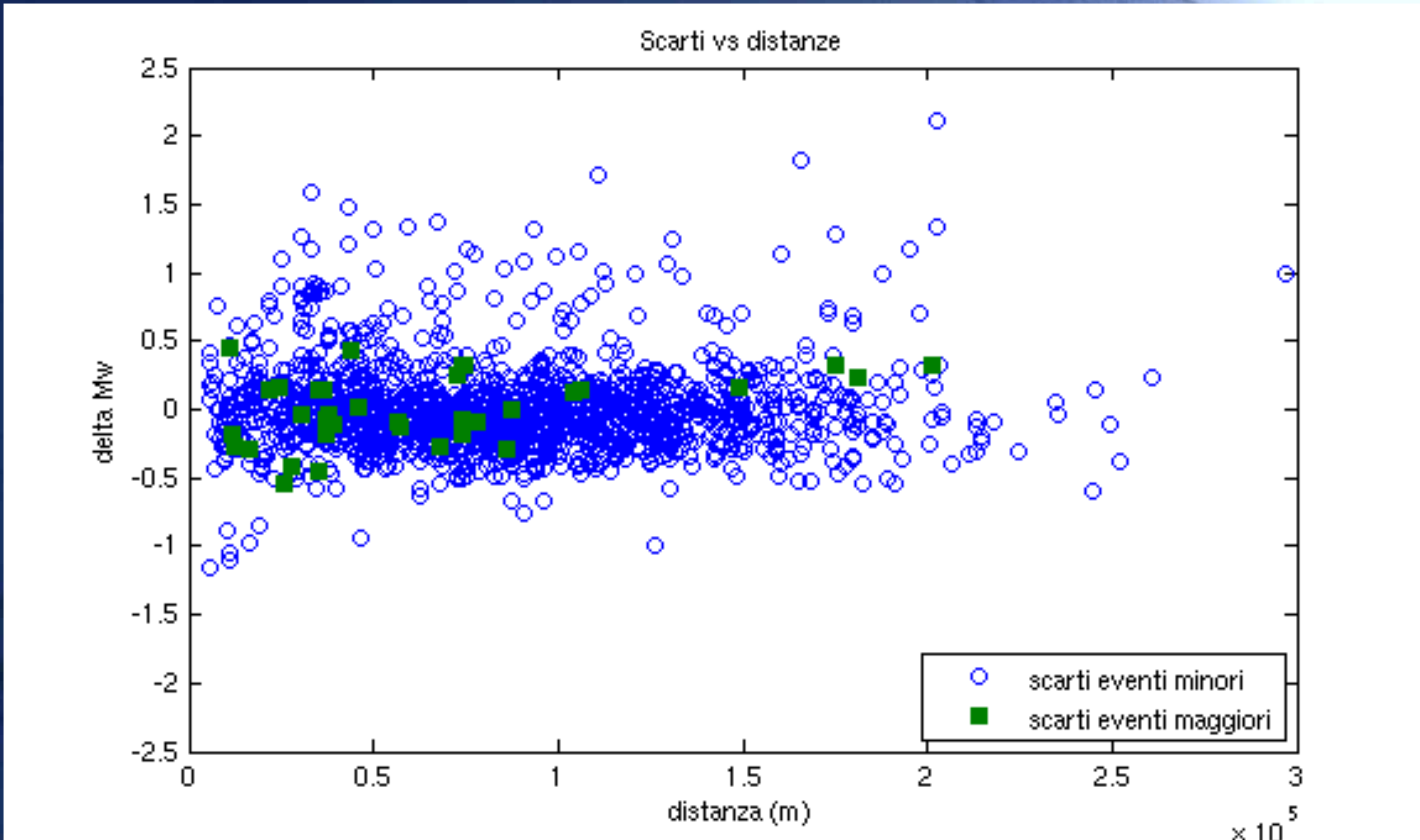
Small Events (193 events 3576 traces)
(~18 stations/event)

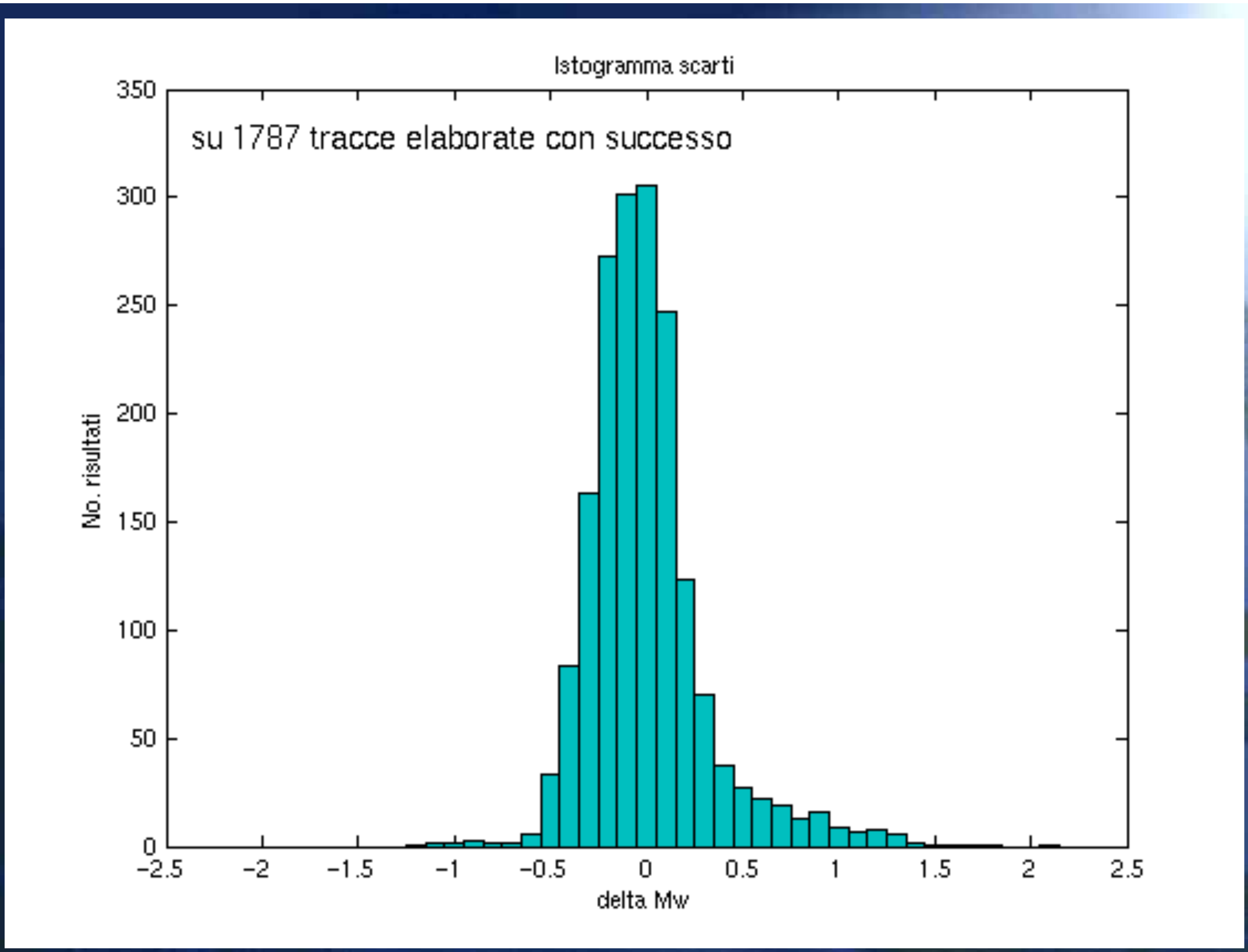


Single-station deviations with respect to average as a function of distance

(trace by trace, with 1787 traces successfully processed ~50% of total)

$$s(d) = M_W(d) - \overline{M_W}$$





± 0.2	60.0%
± 0.3	77.5%
± 0.5	91.5%
± 1.1	98.5%

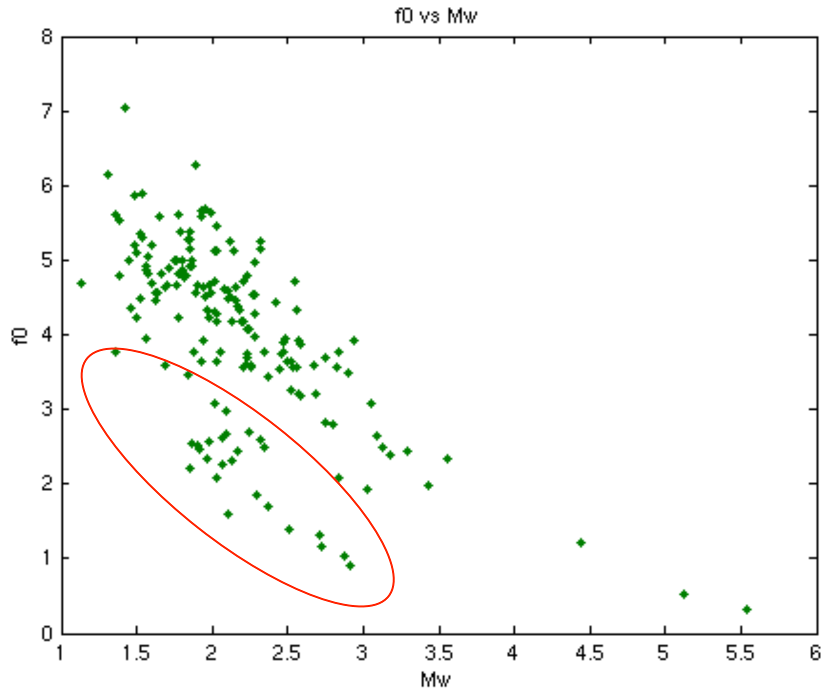
The bias towards positive values could be explained with site effects at some stations

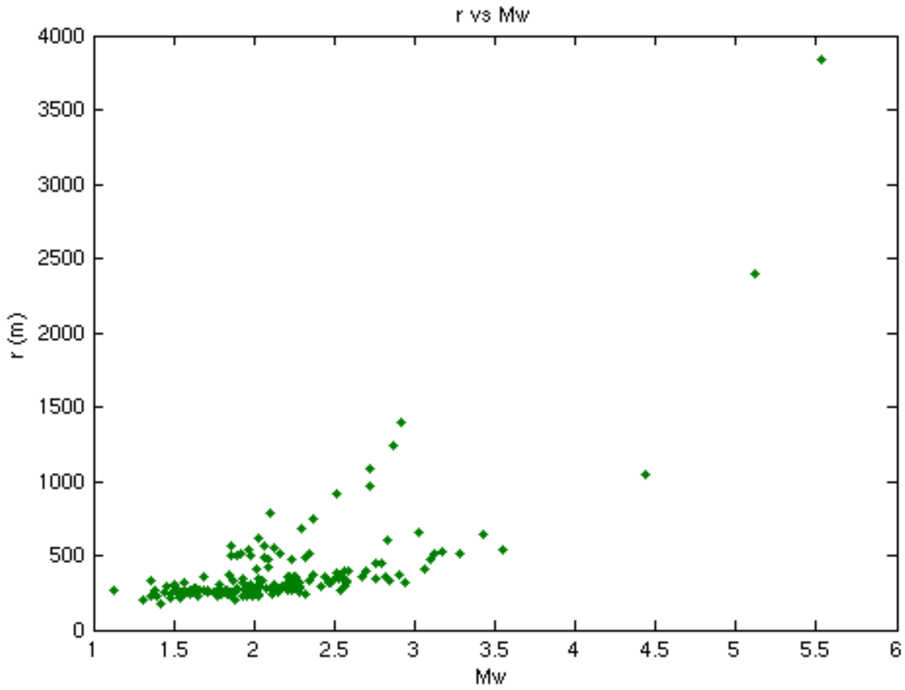
Corner Frequency (f_0)

High dispersion (Di Bona-Rovelli,1988)

Equivalent radius (r)

$$r = \frac{2.34\beta}{2\pi f_0}$$





For the Bovec 1998 event: $S=4^2\pi$~50km^2

Bajc et al. (2001): 10kmx6km~60km^2

(Inversion result)

Conclusions

•The method has given moment magnitude values in very good agreement with independent estimates for those events that have it.

•For all events the retrieved moment magnitudes are compatible, even for the smallest considered ones, with the local magnitudes given by the Antelope© system.

•The standard deviation of the single station moment magnitude estimates with respect to the average event estimate is rather low and does not depend on distance.

•For the Bovec 1998 event, for which there is an independent fault size estimate, the equivalent radius value derived with this method validates our procedure.

•Some (~20) events seem to have an anomalous equivalent radius, pointing to an either anomalously low stress drop or to possible unreliable corner frequency determination (reasons to be assessed, work in progress).

•The procedure is ready to be used in real-time on the Antelope© system.