ISOLA course Brasilia 2013

2012 Montes Claros, Brazil seismic sequence

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- On 19-May-2012, an earthquake M=4 occurred in Montes Claros, central-east Brazil

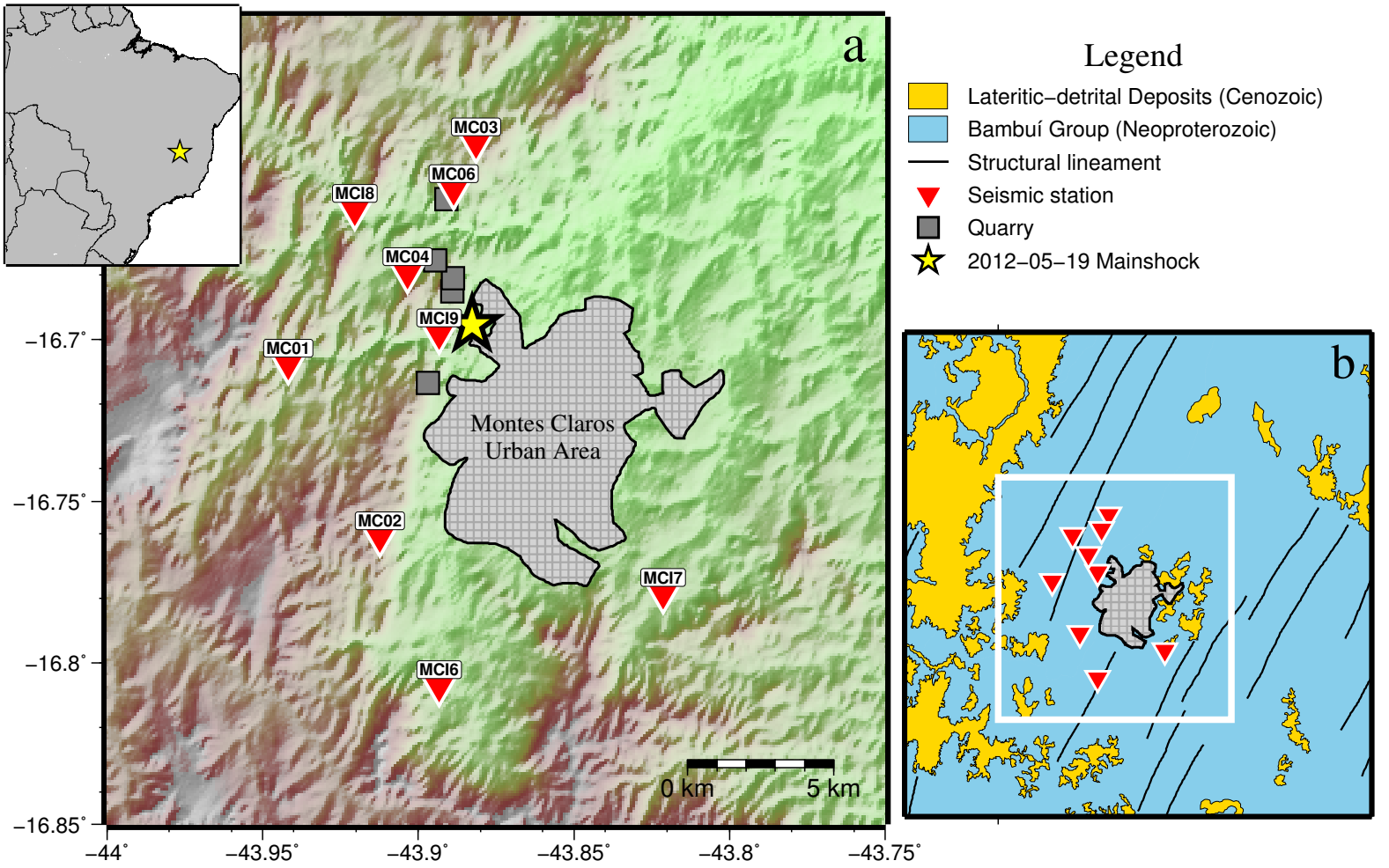
- Shortly afterwards a local seismic network was deployed to study the aftershocks sequence

- Unknown nature and geometry of seismic source/fault

- Not enough stations for computation of focal mechanism through first motion polarities

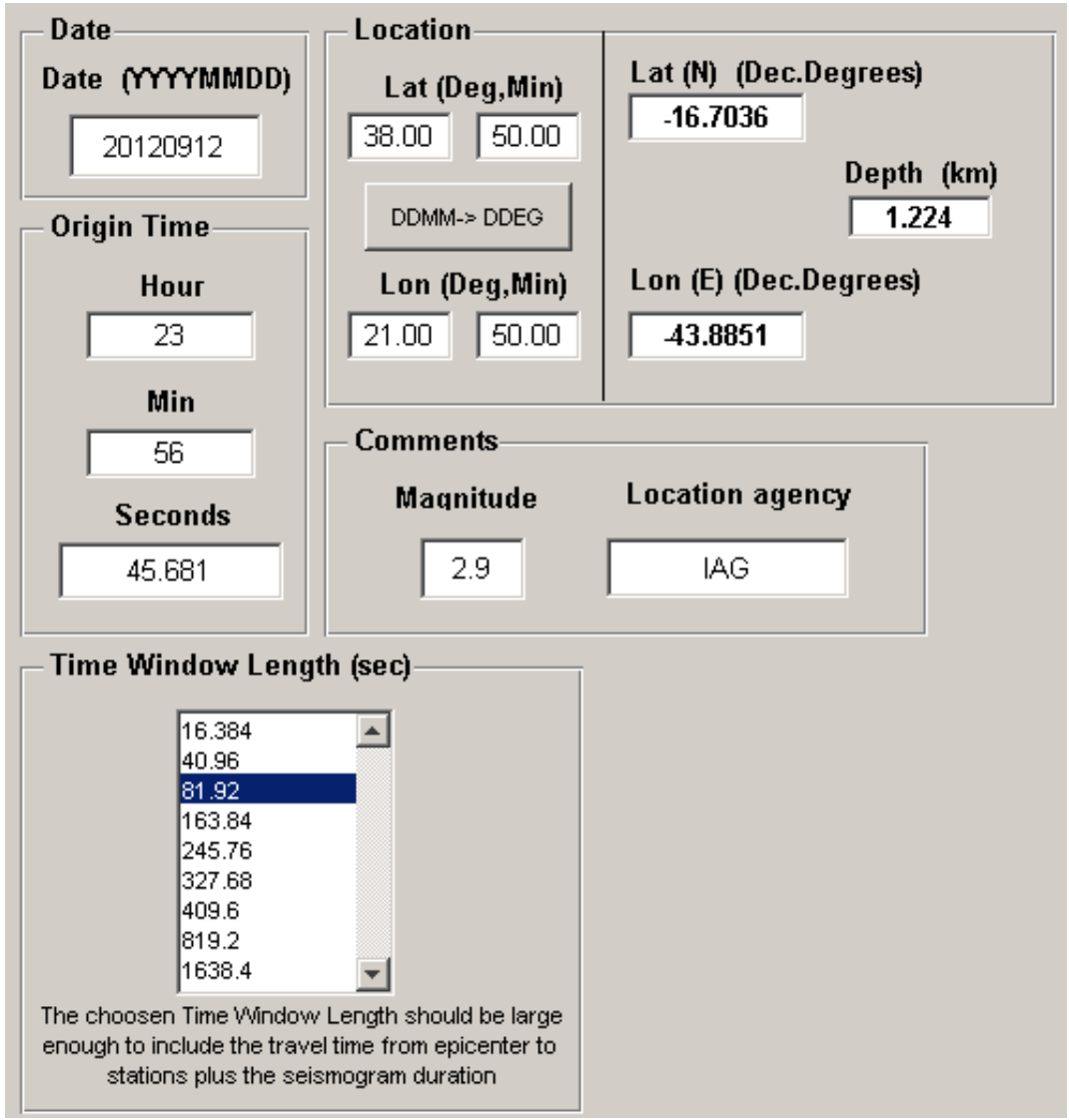
- Solution: waveform modelling with **ISOLA**

Study Area

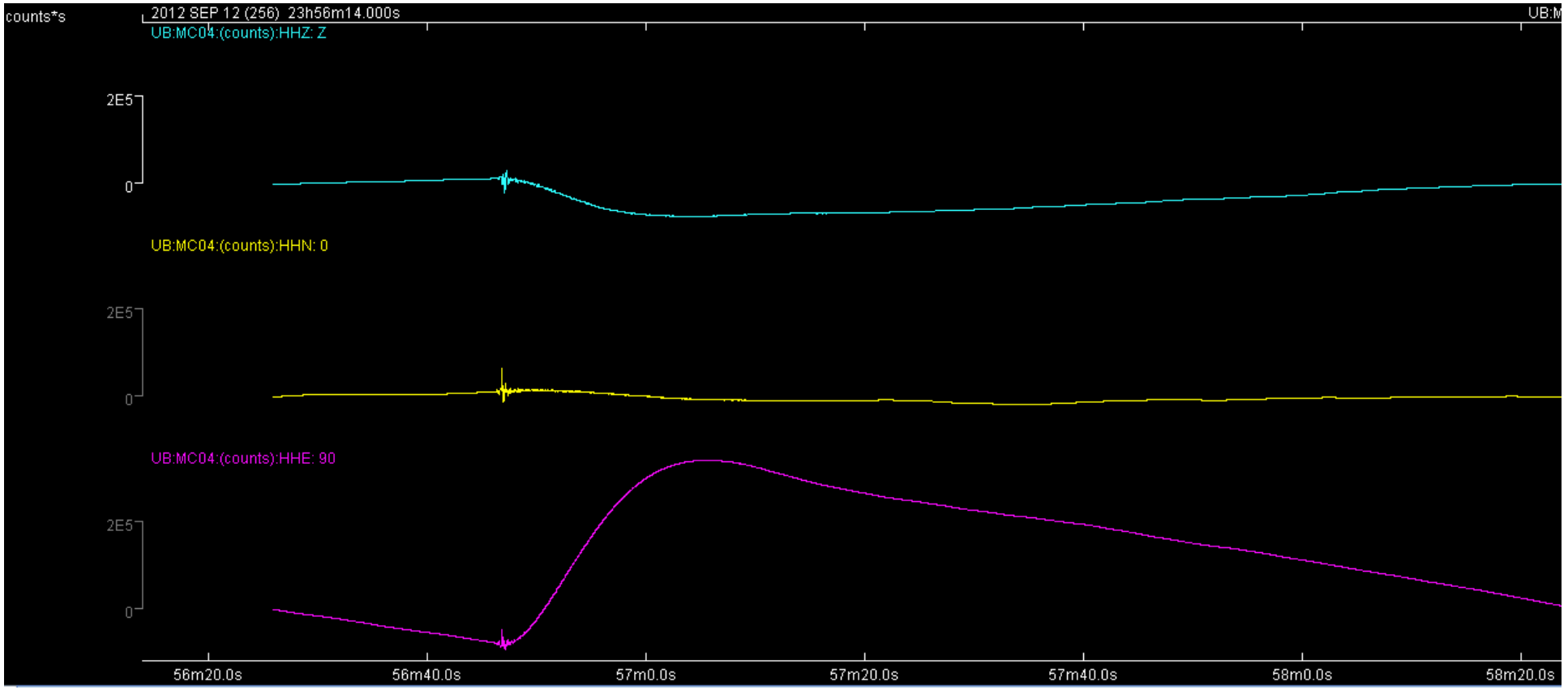


Agurto et al., 2014 (in prep)

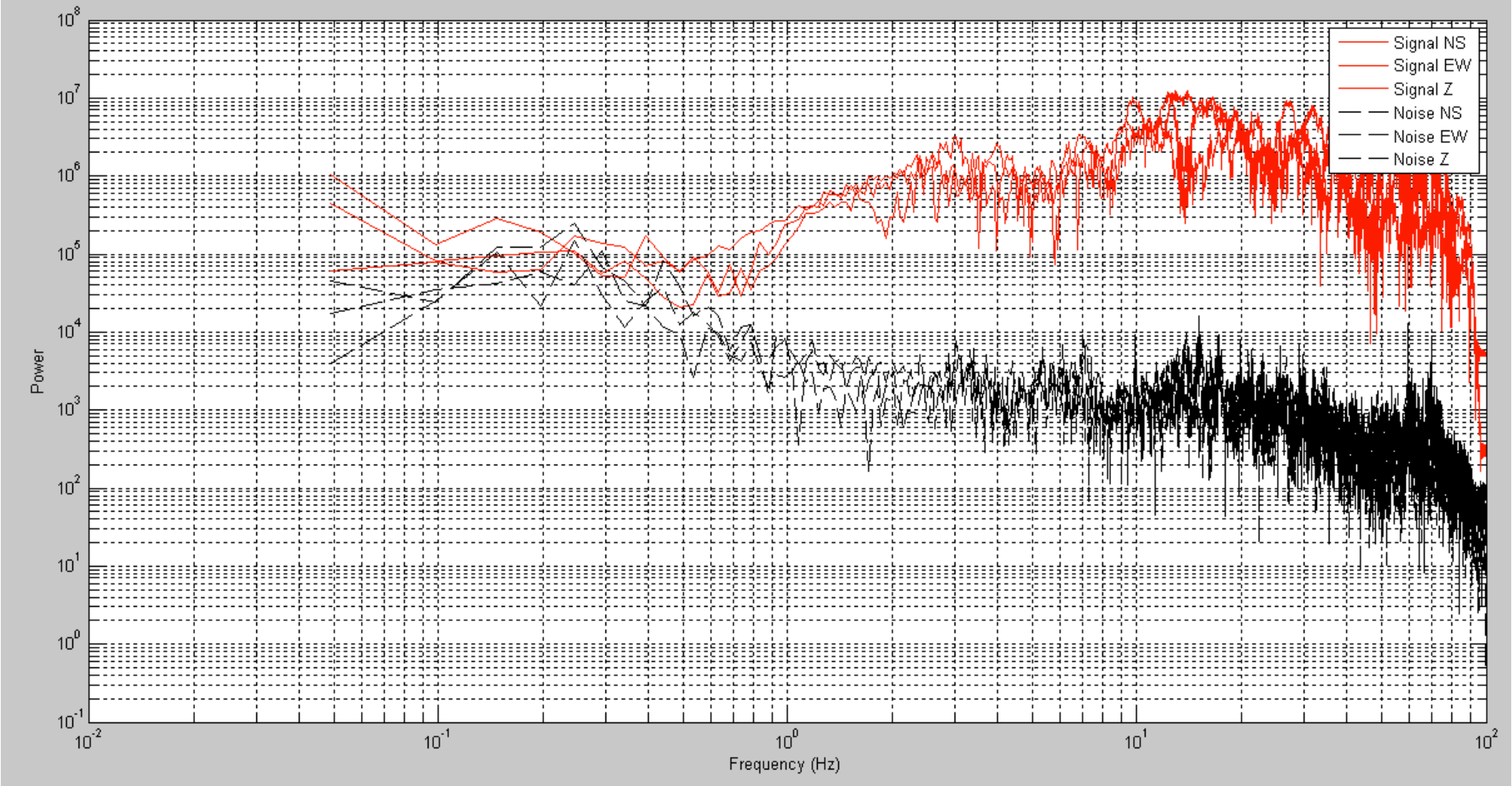
Event info window for analysed aftershock



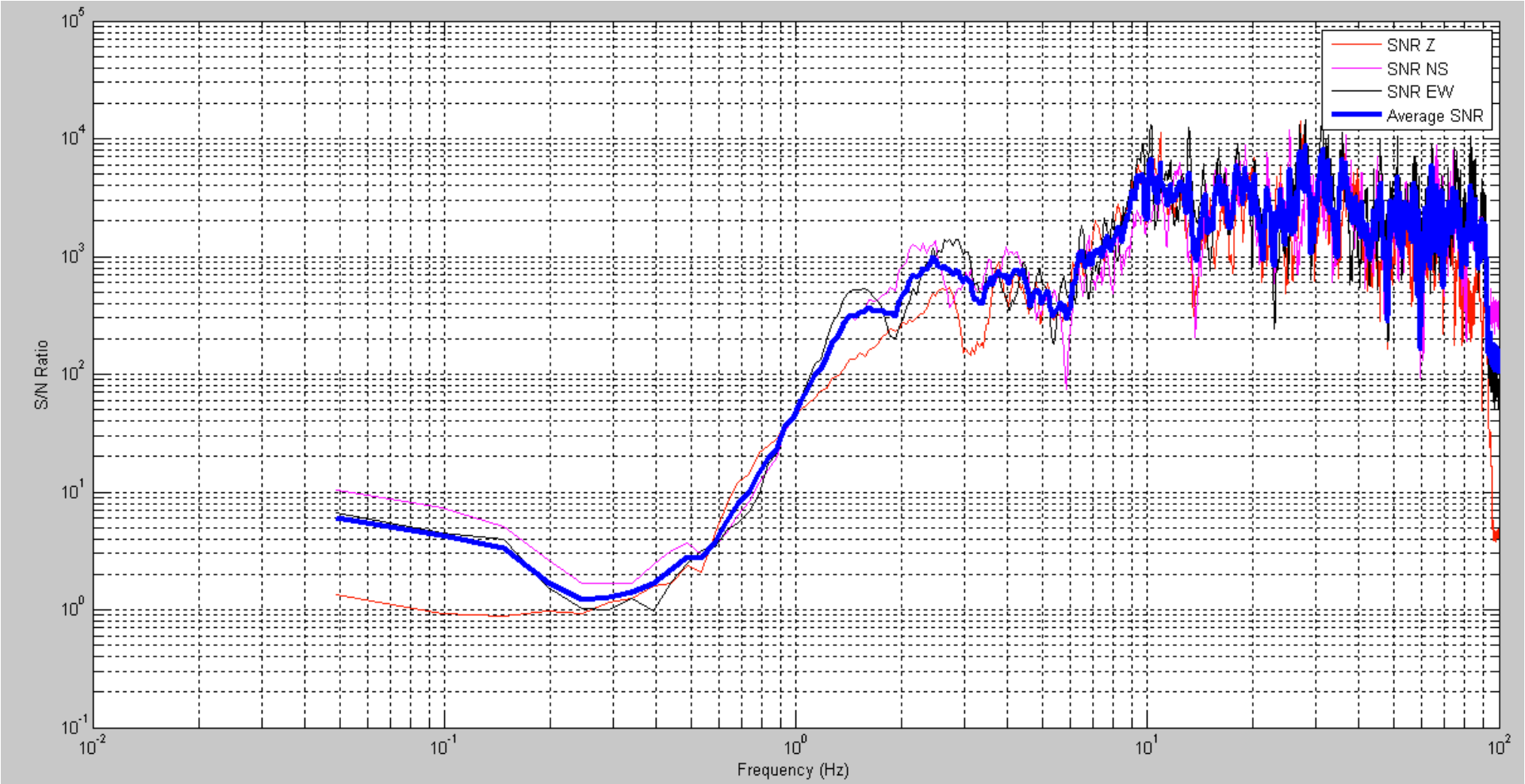
Disturbances due to near-field effects in station MC04



Example S/N Spectra Station MCI8



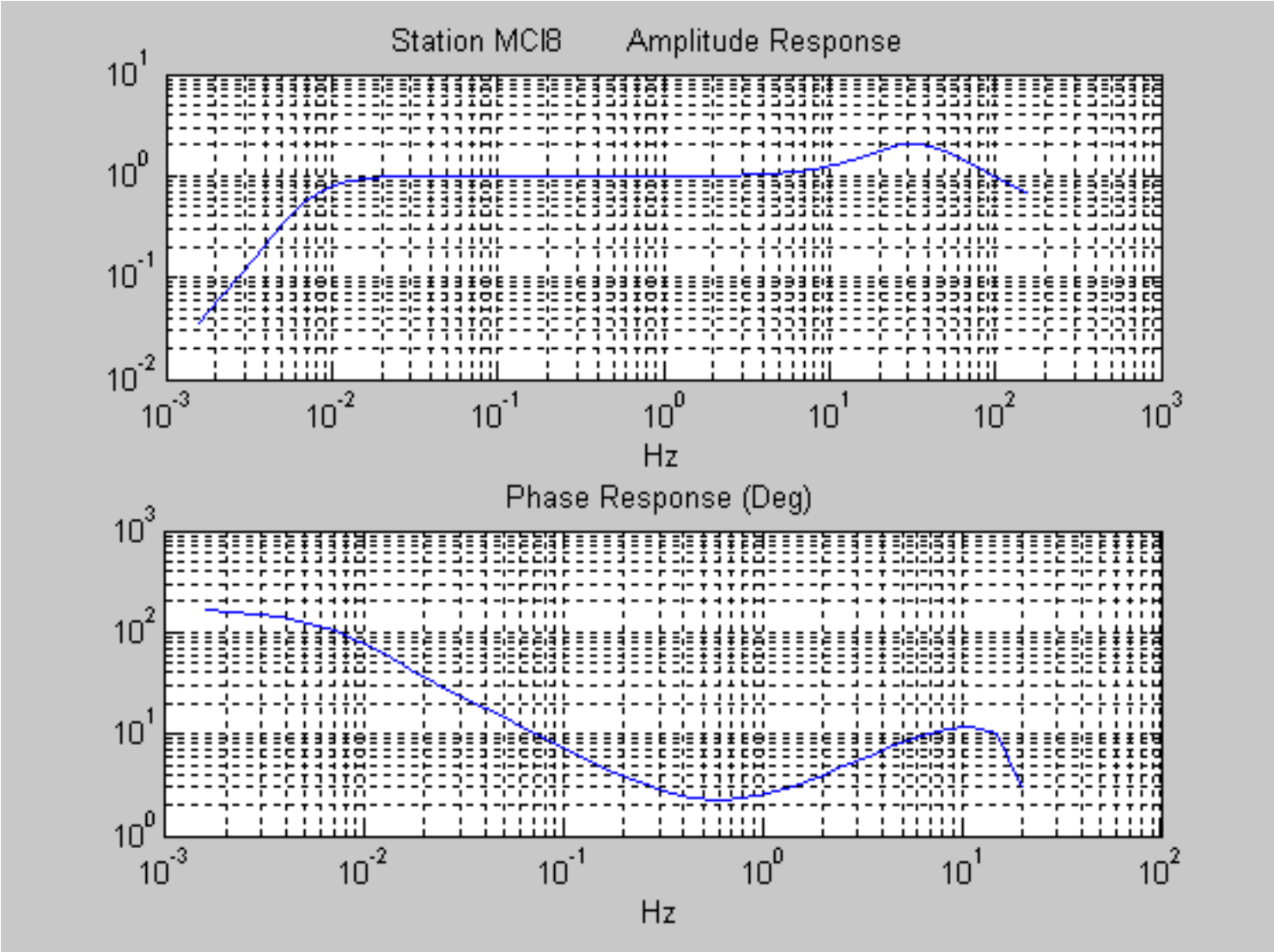
S/N Spectra Station MCI8



P&Z Parameters

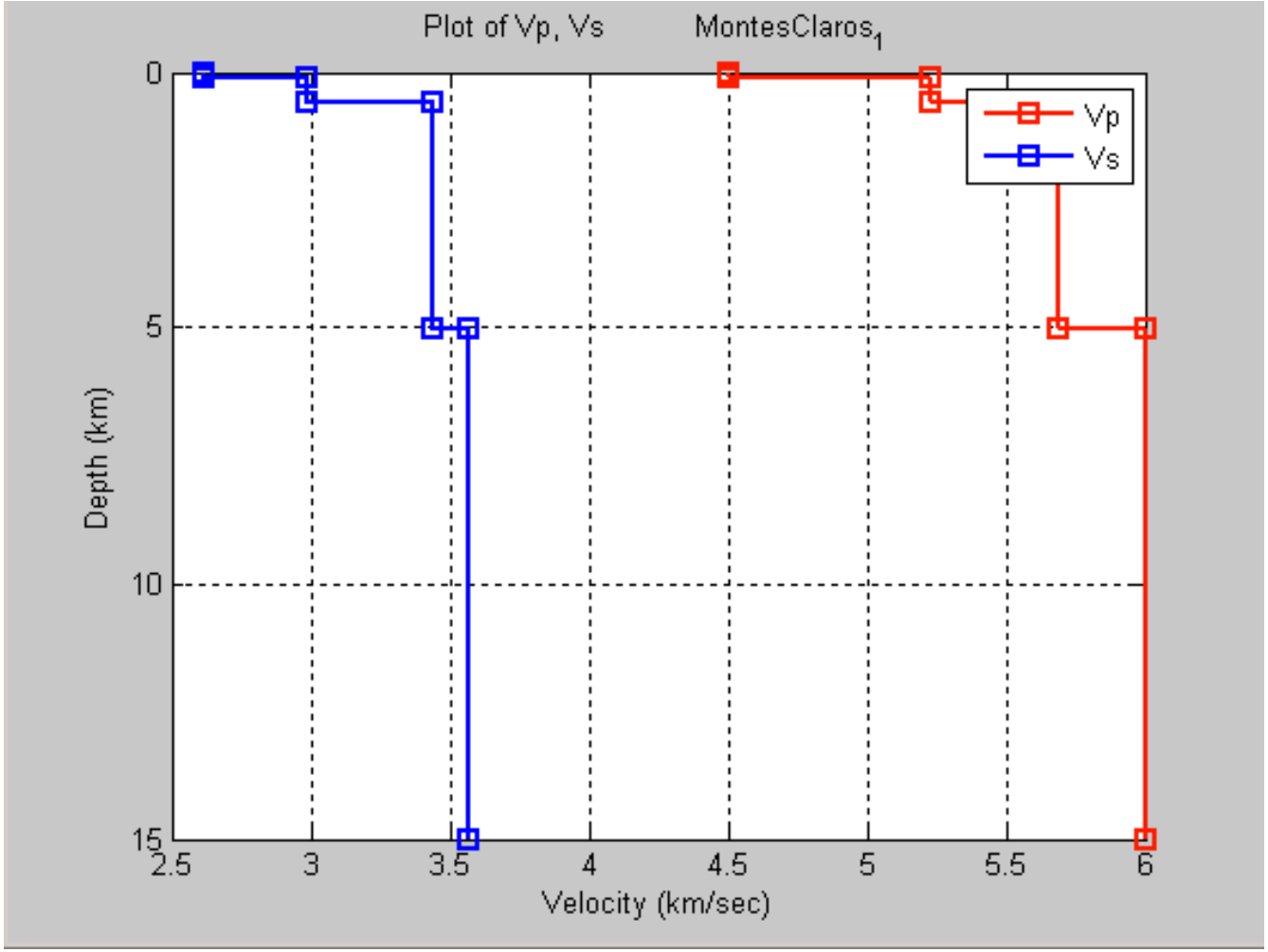
```
* NETWORK   (KNETWK): BL
* STATION    (KSTNM): MCI8
* LOCATION   (KHOLE):
* CHANNEL   (KCMPNM): HHZ
* CREATED           : 2013-12-02T22:19:40
* START             : 2012-05-29T00:00:00
* END               : 2013-06-23T01:01:00
* DESCRIPTION       : Montes Claros 8, MG (Fzda Vitoria)
* LATITUDE          : -16.659670
* LONGITUDE         : -43.920410
* ELEVATION         : 696.0
* DEPTH             : 0.0
* DIP               : 0.0
* AZIMUTH           : 0.0
* SAMPLE RATE       : 200.0
* INPUT UNIT        : M
* OUTPUT UNIT       : COUNTS
* INSTTYPE          : Trillium 120PA
* INSTGAIN          : 1.201000e+03 (M/S)
* COMMENT           : N/A
* SENSITIVITY       : 4.804000e+08 (M/S)
* A0                : 4.113703e+09
* ***********************************
ZEROS   6
        +0.000000e+00   +0.000000e+00
        +0.000000e+00   +0.000000e+00
        +0.000000e+00   +0.000000e+00
        -9.000000e+01   +0.000000e+00
        -1.607000e+02   +0.000000e+00
        -3.108000e+03   +0.000000e+00
POLES   8
        -3.852000e-02   +3.658000e-02
        -3.852000e-02   -3.658000e-02
        -1.780000e+02   +0.000000e+00
        -1.350000e+02   -1.600000e+02
        -1.350000e+02   +1.600000e+02
        -6.710000e+02   +1.154000e+03
        -6.710000e+02   -1.154000e+03
        -1.333890e+04   +0.000000e+00
CONSTANT        +1.976223e+18
```

P&Z Parameters

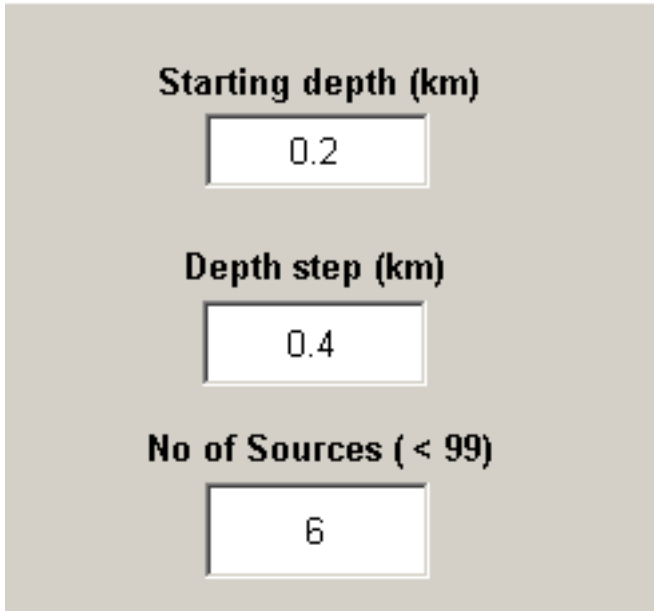


Crustal Velocity Model

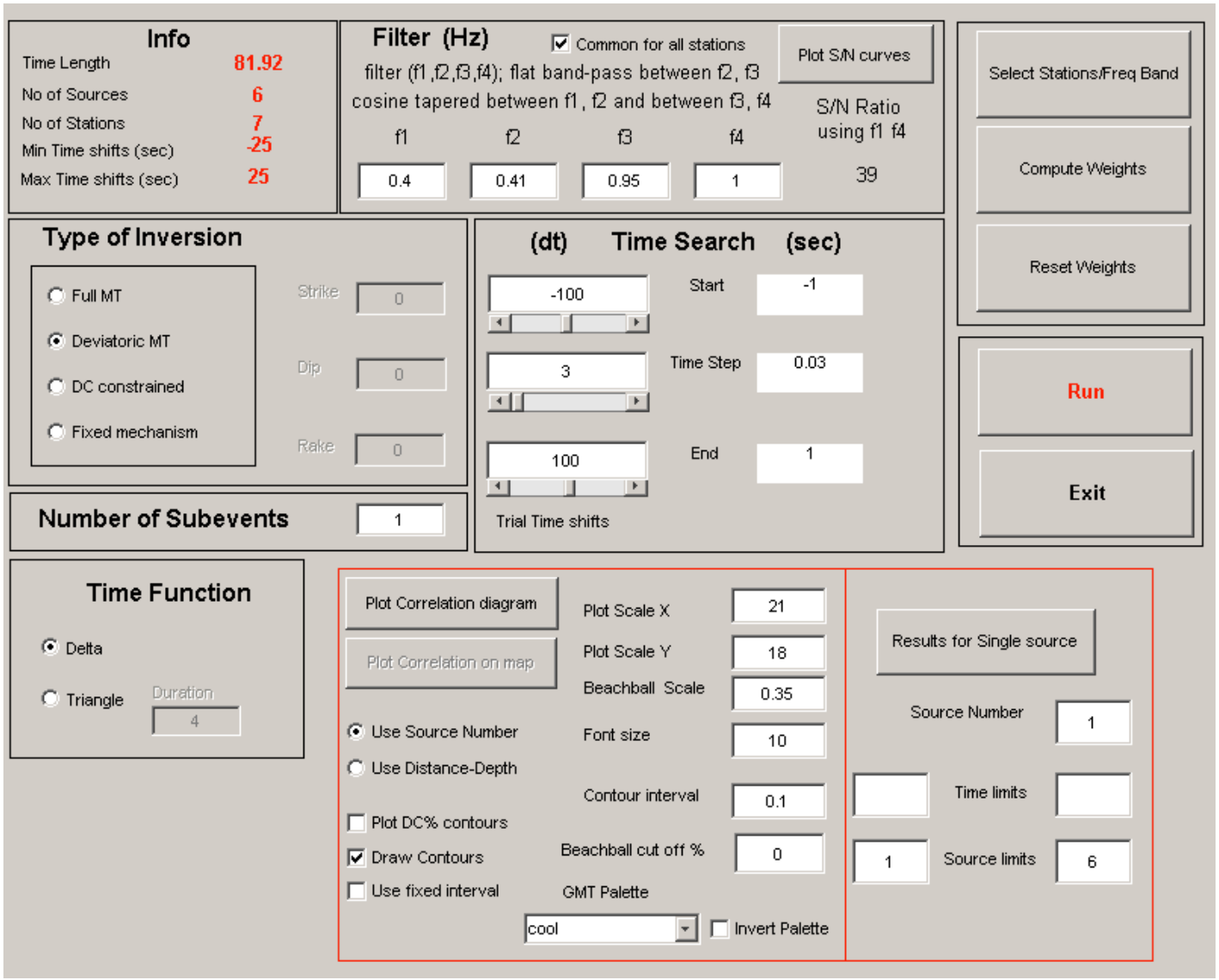
Previously obtained from simultaneous inversion with Velest



Trial Sources

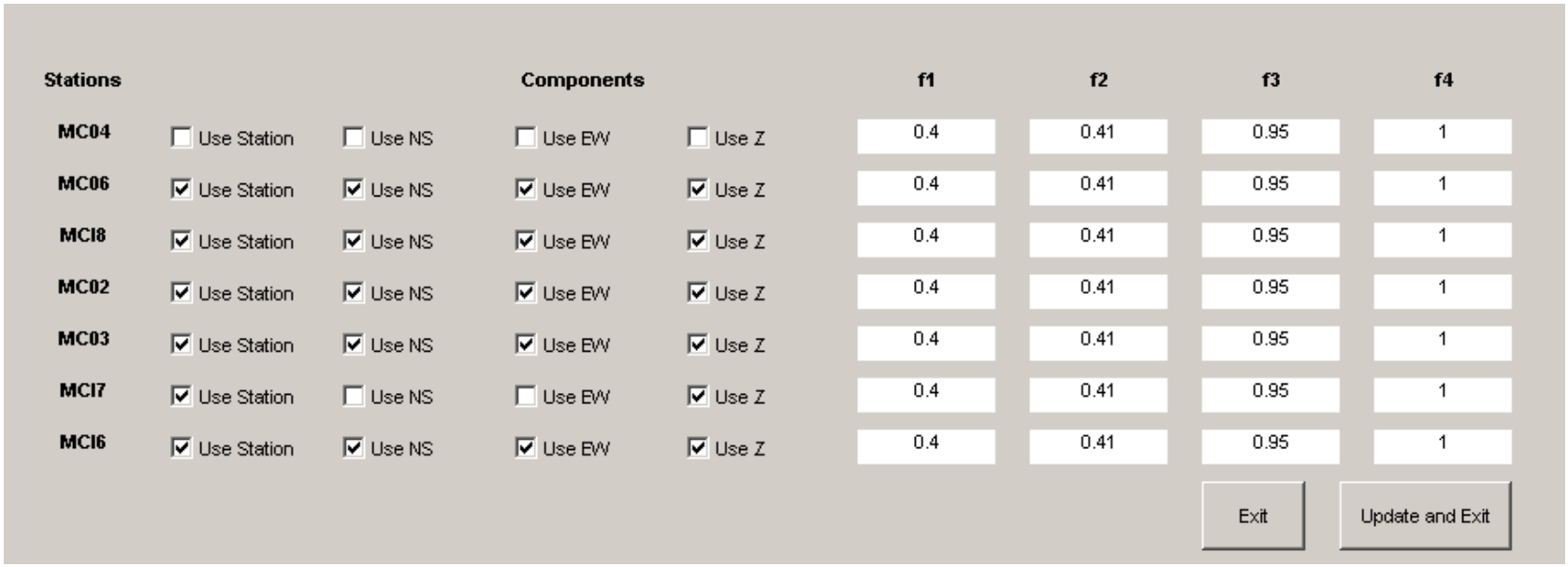


Inversion window

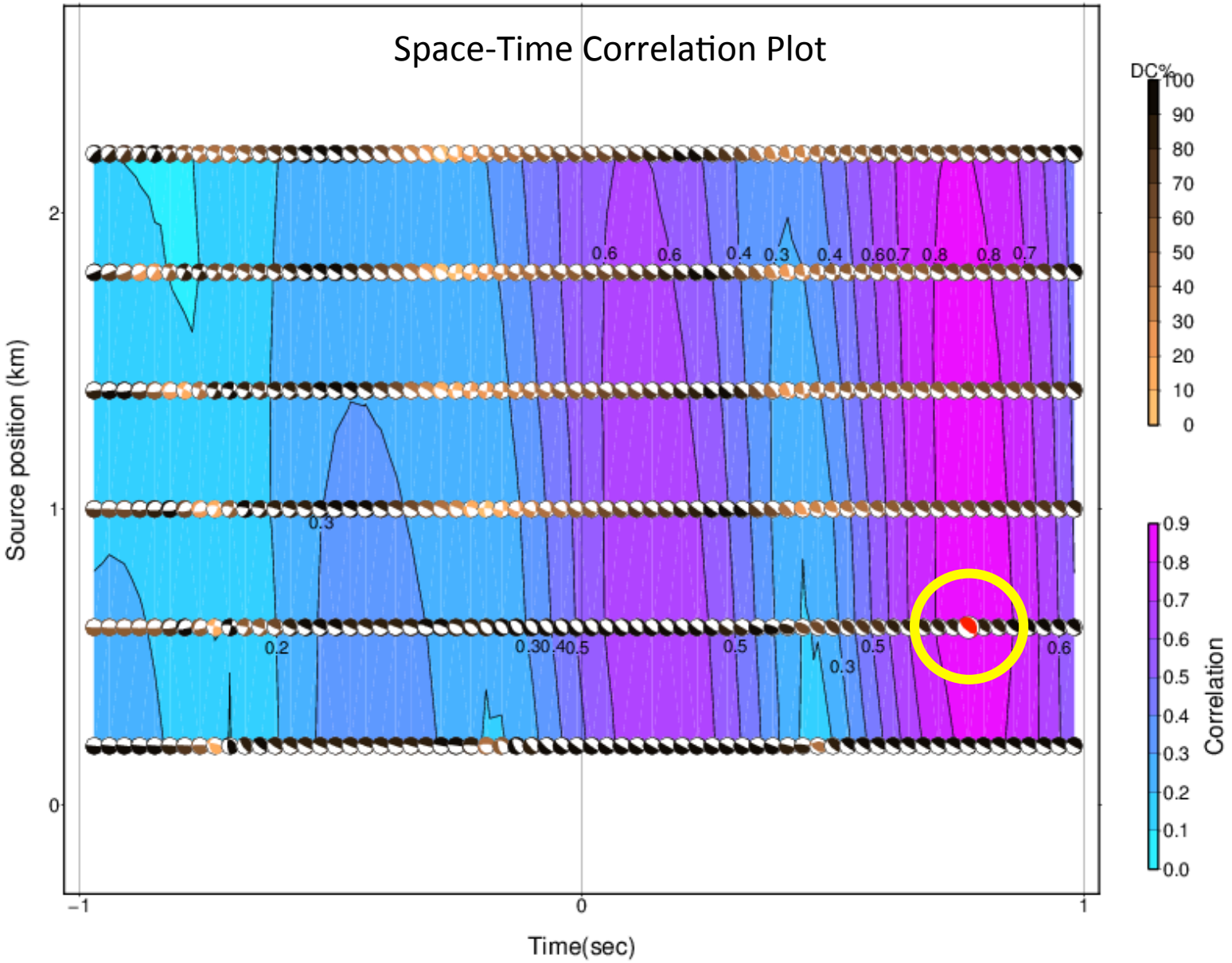


Inversion window

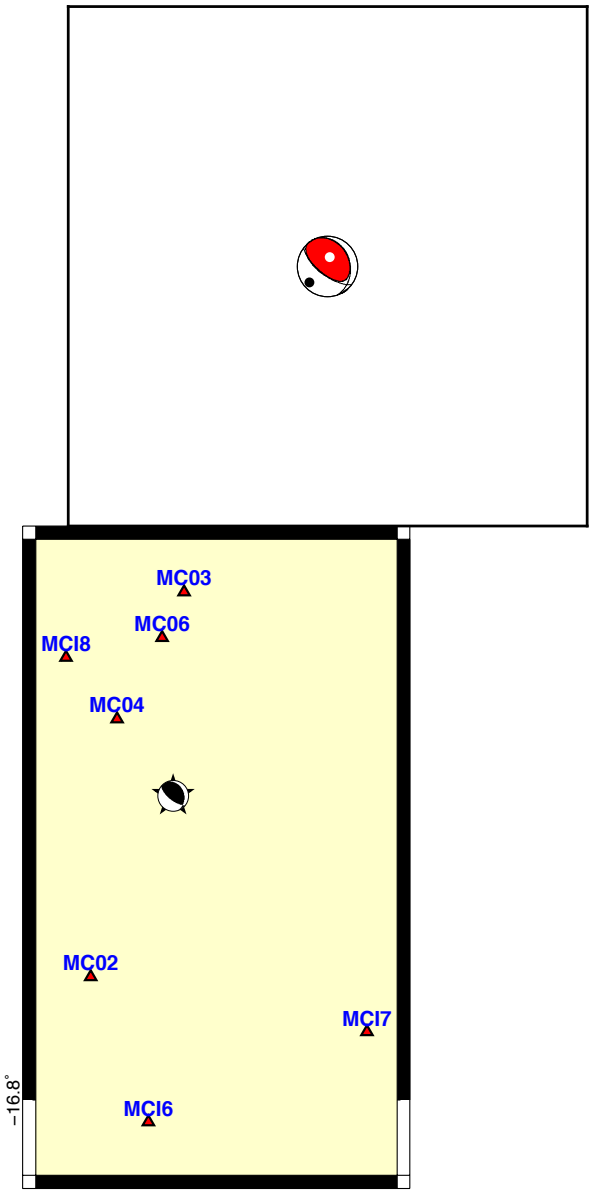
Station MC04 was discarded for presence of near-field disturbances; components N and E of MCI7 were not used due to bad fitting of waveforms.



Inversion Results



Inversion Results



MOMENT TENSOR SOLUTION

HYPOCENTER LOCATION (IAG)

Origin time 20120912 23:56:45.681
Lat -16.7036 Lon -43.8851 Depth 1.224

CENTROID

Trial source number : 2 (Fixed Epicenter inversion)
Centroid Lat (N)-16.7036 Lon (E)-43.8851
Centroid Depth (km) : 0.6
Centroid time : +0.77 (sec) relative to origin time

Moment (Nm) : 4.082e+012
Mw : 2.3
VOL% :0
DC% :86.6
CLVD% :13.4

		SNR	CN	FMVAR	STVAR
Var.red.:	(for stations used in inversion): 0.72	39	2.7	17±8	0.09
Var.red.	(for all stations) : 0.4				

Strike	Dip	Rake
128	66	75
Strike	Dip	Rake
342	28	121

P-axis	Azimuth	Plunge
	229	20
T-axis	Azimuth	Plunge
	12	65

Mrr	Mtt	Mpp
3.005	-0.922	-2.083
Mrt	Mrp	Mtp
2.441	-1.230	1.441

Exponent (Nm): 12

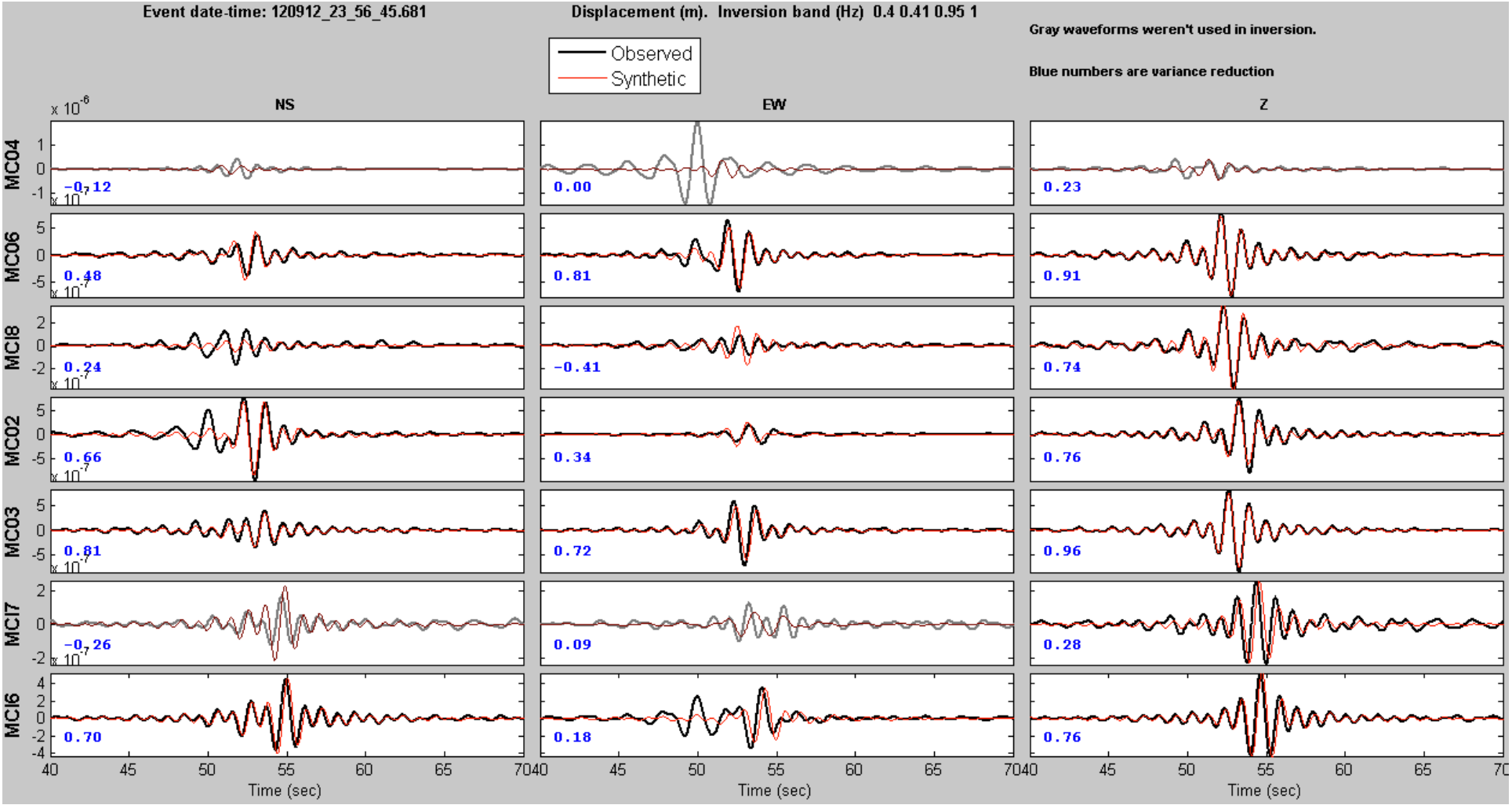
Frequency band used in inversion (Hz)
0.4 - 0.41 -- 0.95 - 1

Stations-Components Used-Distance

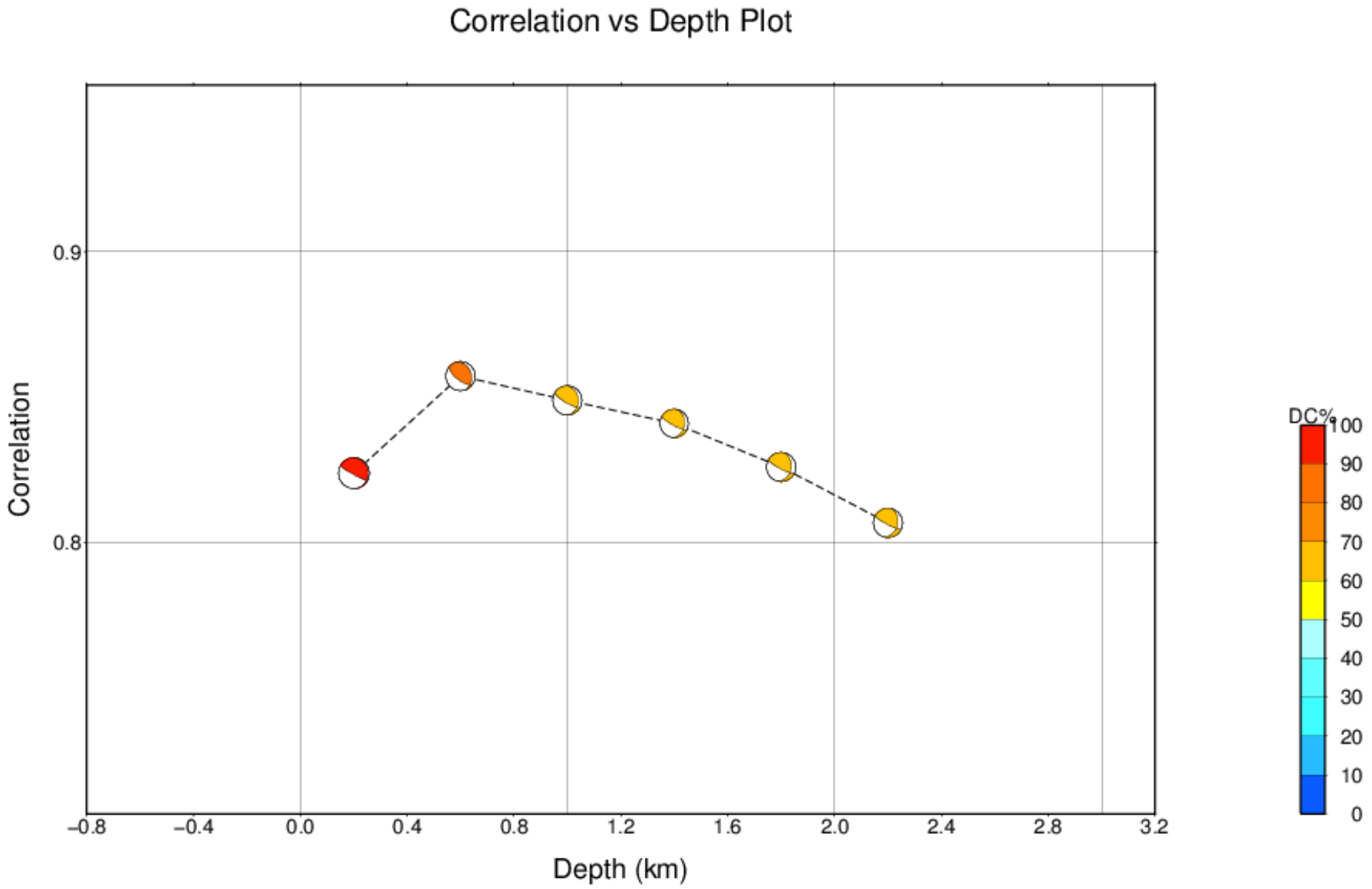
	NS	EW	Z	D(km)
MC04	-	-	-	3
MC06	+	+	+	6
MCI8	+	+	+	6
MC02	+	+	+	7
MC03	+	+	+	7
MCI7	-	-	+	11
MCI6	+	+	+	11

Inversion Results

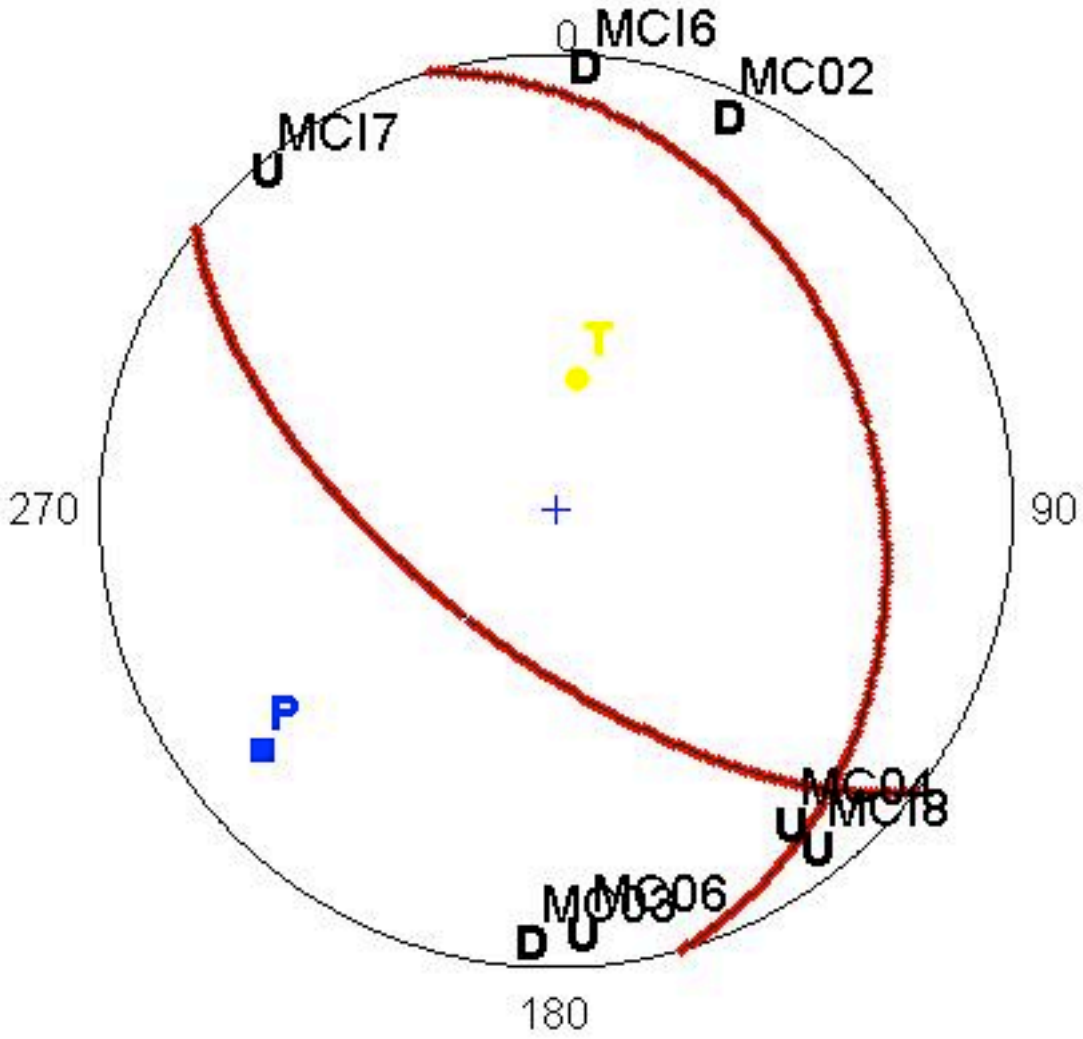
Waveforms fitting



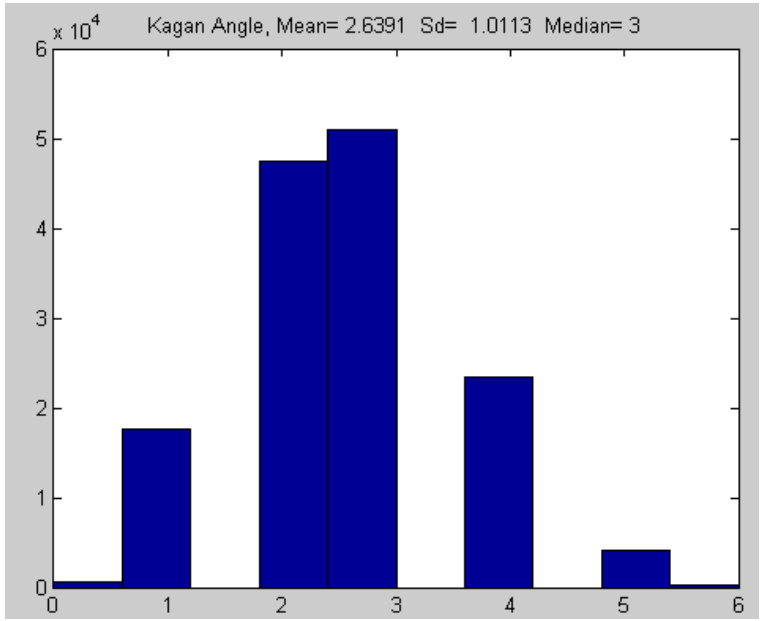
Inversion Results

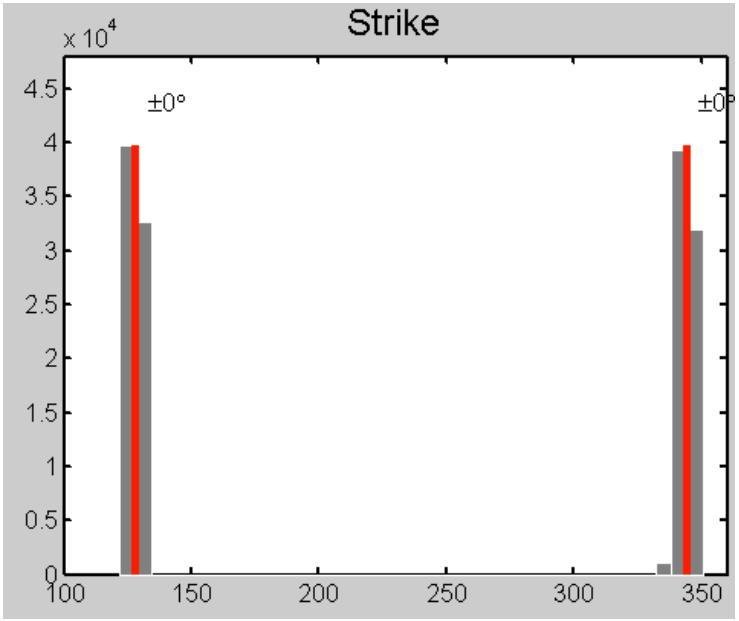


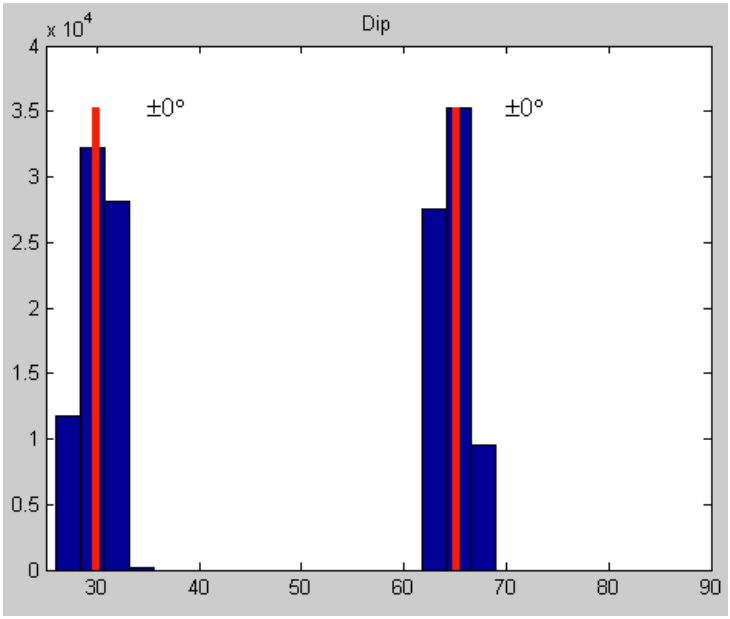
Polarities check

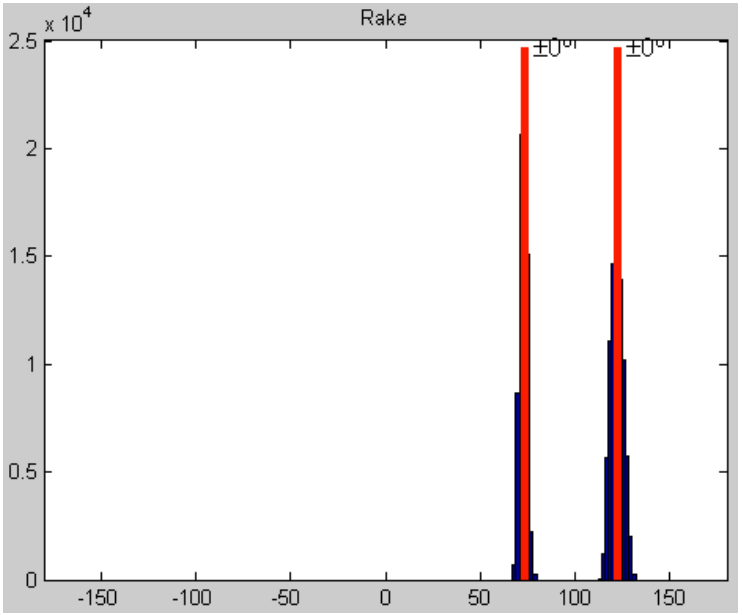


Some statistical tests…uncertainty estimation

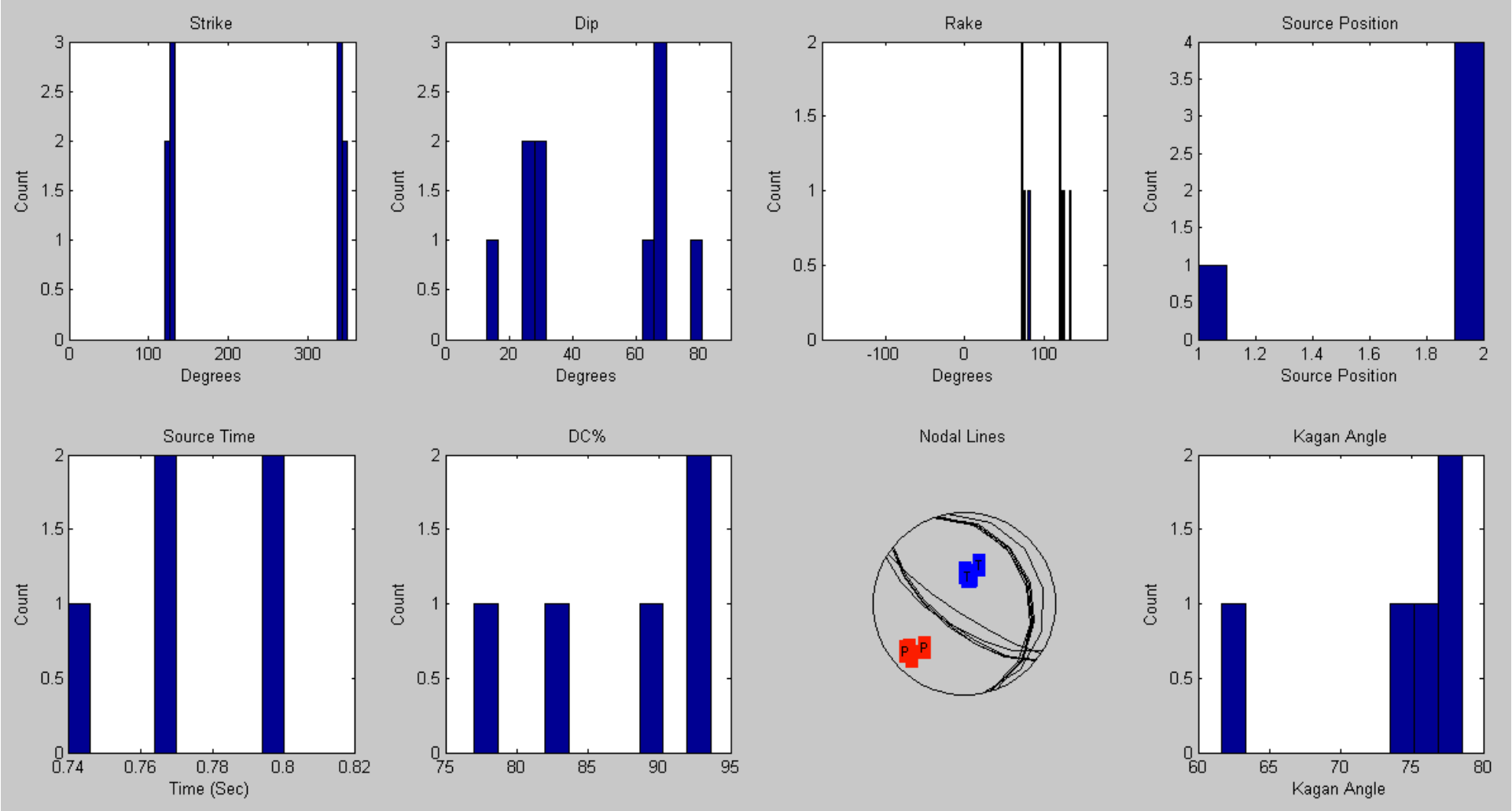






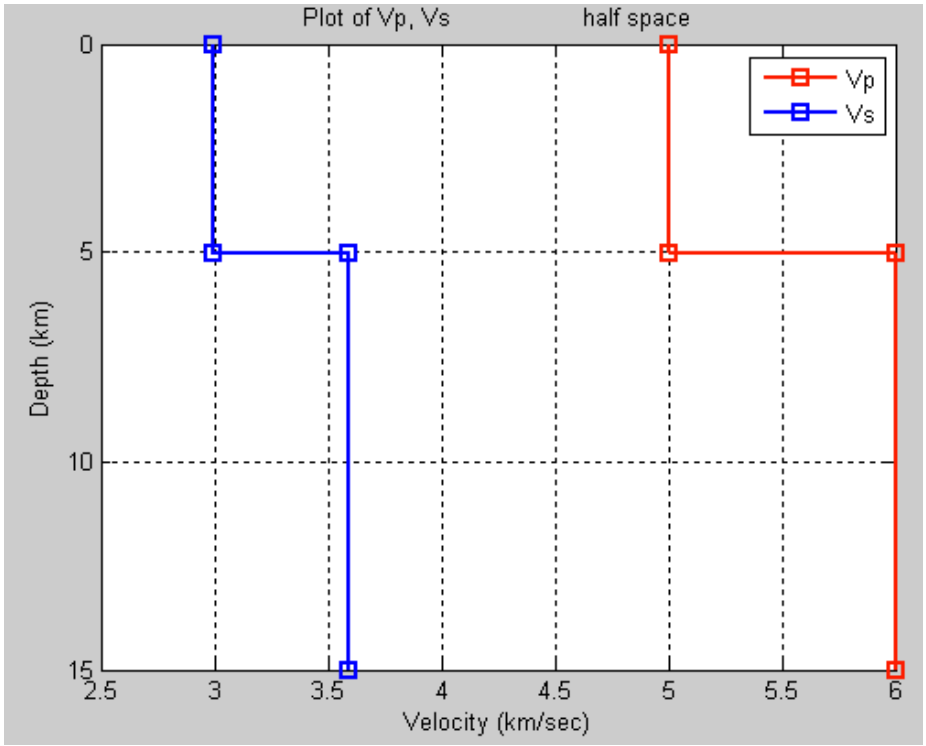


Some statistical tests…Jackniffing



Testing the importance of the velocity model

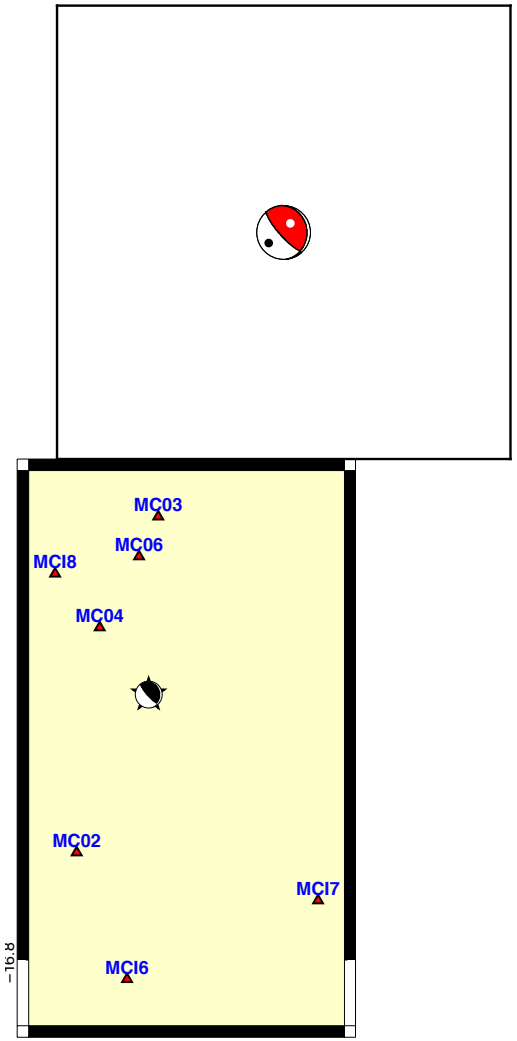
Using a simpler velocity model…



Testing the importance of the velocity model

…we get different results:

- lower variance reduction
- different magnitude and centroid depth
- slightly different focal mechanism



MOMENT TENSOR SOLUTION

HYPOCENTER LOCATION (IAG)

Origin time 20120912 23:56:45.681
Lat −16.7036 Lon −43.8851 Depth 1.224

CENTROID

Trial source number : 1 (Fixed Epicenter inversion)
Centroid Lat (N)−16.7036 Lon (E)−43.8851
Centroid Depth (km) : 0.2
Centroid time : +0.56 (sec) relative to origin time

Moment (Nm) : 4.784e+012
Mw : 2.4
VOL% :0
DC% :99
CLVD% :1

	SNR	CN	FMVAR	STVAR
Var.red.:(for stations used in inversion):0.32	49	4.4	21±13	0.10

Var.red.(for all stations) :0.32

Strike	Dip	Rake
138	78	81
Strike	Dip	Rake
355	15	126

P-axis	Azimuth	Plunge
	235	32
T-axis	Azimuth	Plunge
	37	56

Mrr	Mtt	Mpp
1.949	−0.162	−1.787
Mrt	Mrp	Mtp
3.007	−3.093	0.874

Exponent (Nm): 12

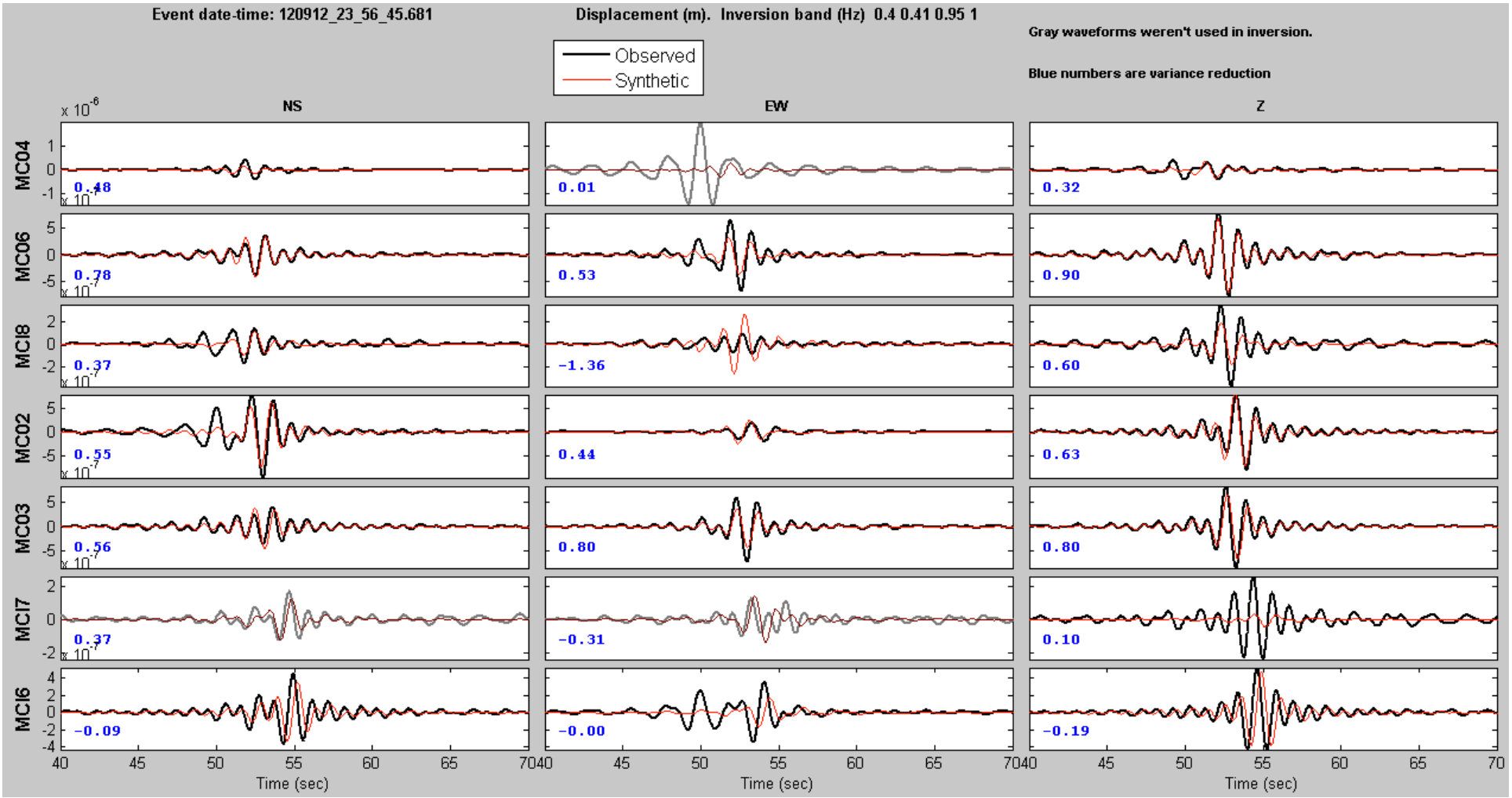
Frequency band used in inversion (Hz)
0.4 - 0.41 -- 0.95 - 1

Stations-Components Used-Distance

	NS	EW	Z	D(km)
MC04	+	−	+	3
MC06	+	+	+	6
MCI8	+	+	+	6
MC02	+	+	+	7
MC03	+	+	+	7
MCI7	−	−	+	11
MCI6	+	+	+	11

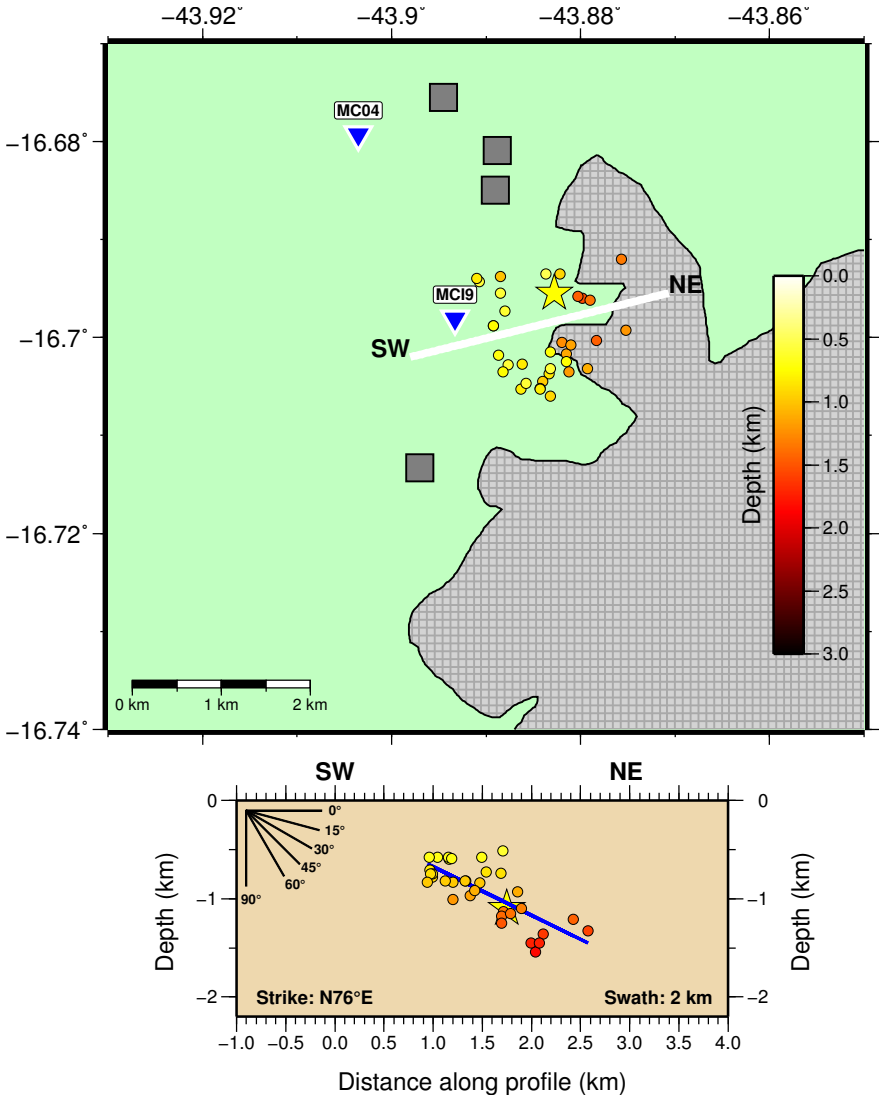
Testing the importance of the velocity model

- slightly worse waveform fitting (still very good!)



Discussion and Conclusion

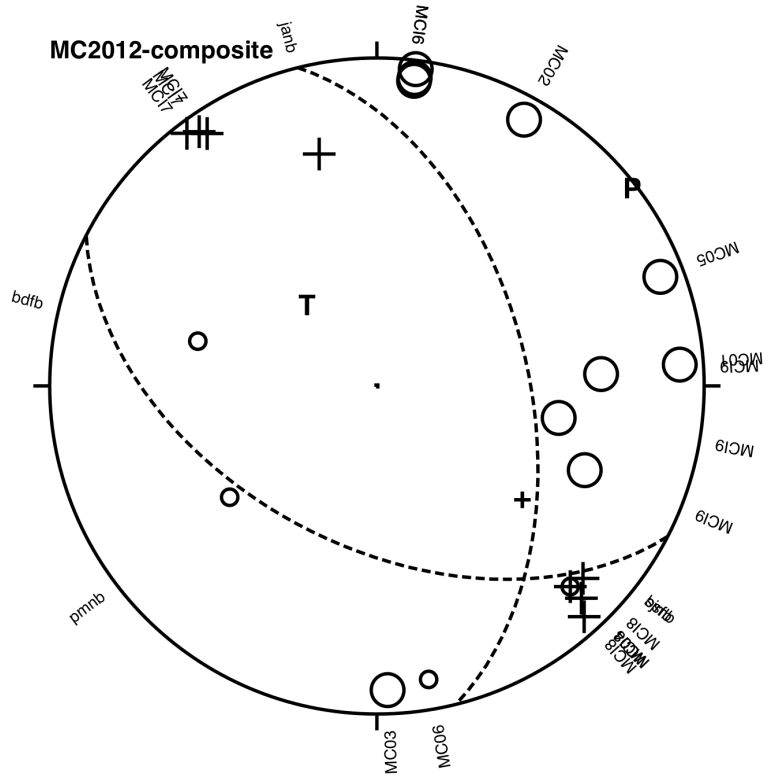
Aftershocks distribution indicate NNW structure, dipping to the E, coinciding with one of the nodal planes of the obtained focal mechanism



Agurto et al., 2014 (in prep)

Discussion and Conclusion

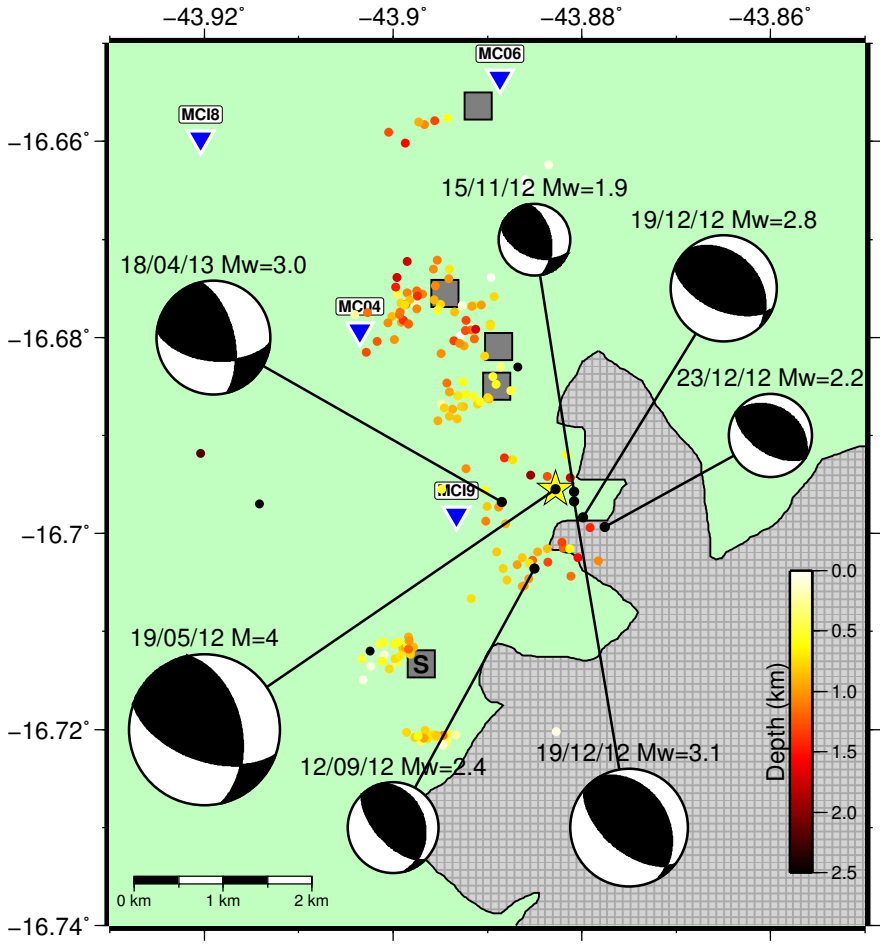
Mainshock composite focal mechanism from first motion polarities shows similar geometry…



Assumpção et al., 2013

Discussion and Conclusion

Inversions performed on other aftershocks show consistency



Agurto et al., 2014 (in prep)

Discussion and Conclusion

- The 2012-2013 Montes Claros seismic sequence was originated on a previously unknown reverse fault NNW-striking, dipping to the E
- Inverted aftershocks moment magnitudes range 1.9 - 3.1 M_W; and suggest a relation $M_W \approx M_R - 0.5$
- Successful usage of ISOLA software to determine moment tensor of local aftershocks down to $M_W = 1.9$
- Detailed velocity model is an important (although not critical) aspect to consider, specially in cases of small earthquakes ($M < 4$).