

**International training course in full waveform inversion for moment tensors
and multiple source models**

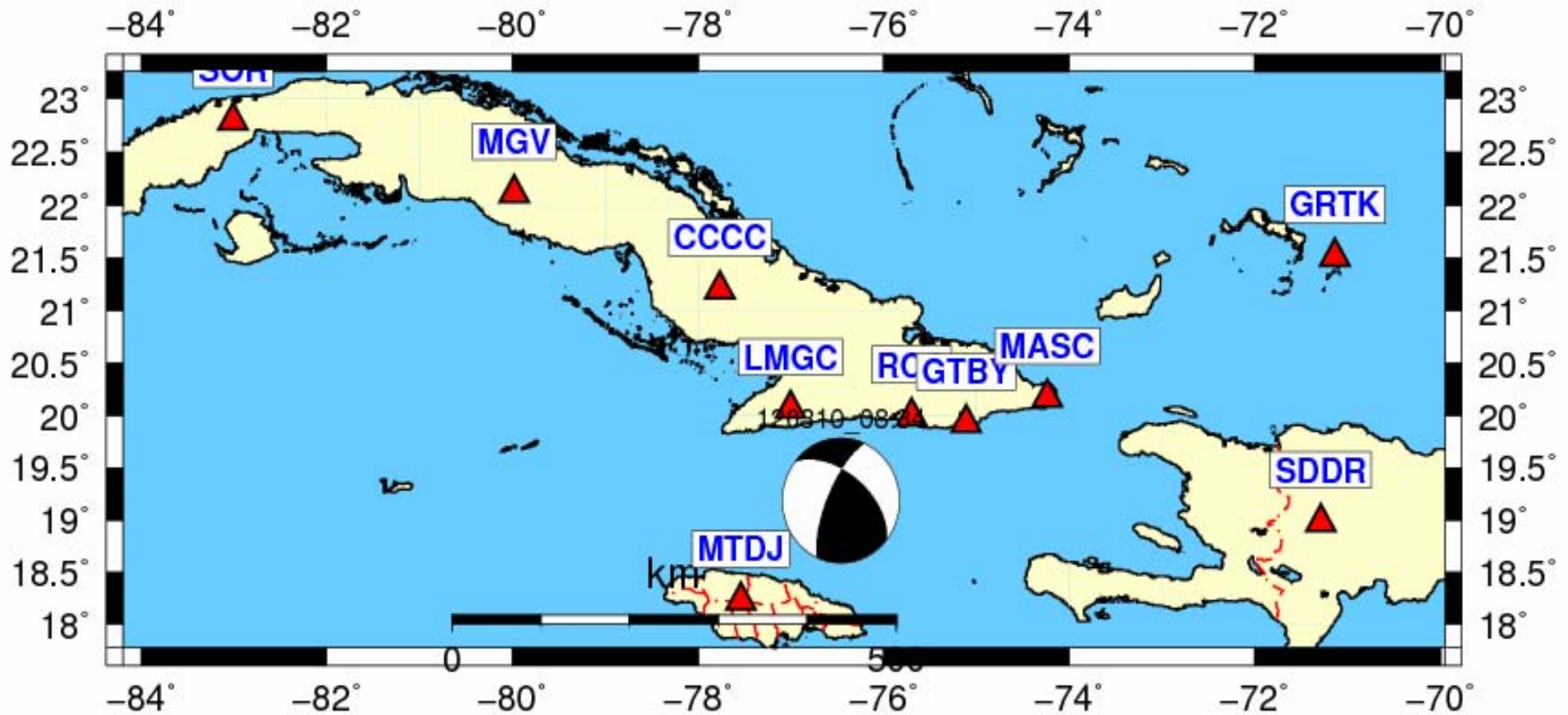
An example using ISOLA code

O'Leary Fernando González Matos
National Centre for Seismological Research of Cuba

oleary@cenais.cu

Brasília. Brazil. December, 2013.

Event ID:120310_08_34_50.80



eventinfo

Date
Date (YYYYMMDD)
20120310

Location
Lat (Deg,Min) 38.00 50.00
Lat (N) (Dec.Degrees) 19.19
Depth (km) 10
DDMM-> DDEG
Lon (Deg,Min) 21.00 50.00
Lon (E) (Dec.Degrees) -76.46

Origin Time
Hour 08
Min 34
Seconds 50.80

Comments
Magnitude 4.8
Location agency CUB

Time Window Length (sec)
16.384
40.96
81.92
163.84
245.76
327.68
409.6
819.2
1638.4

The chosen Time Window Length should be large enough to include the travel time from epicenter to stations plus the seismogram duration

Automatic form fill
e.g. 20100118 1556 8.38 38 25.19 21E55.44 8.29 5.23
Paste your EventInfo here

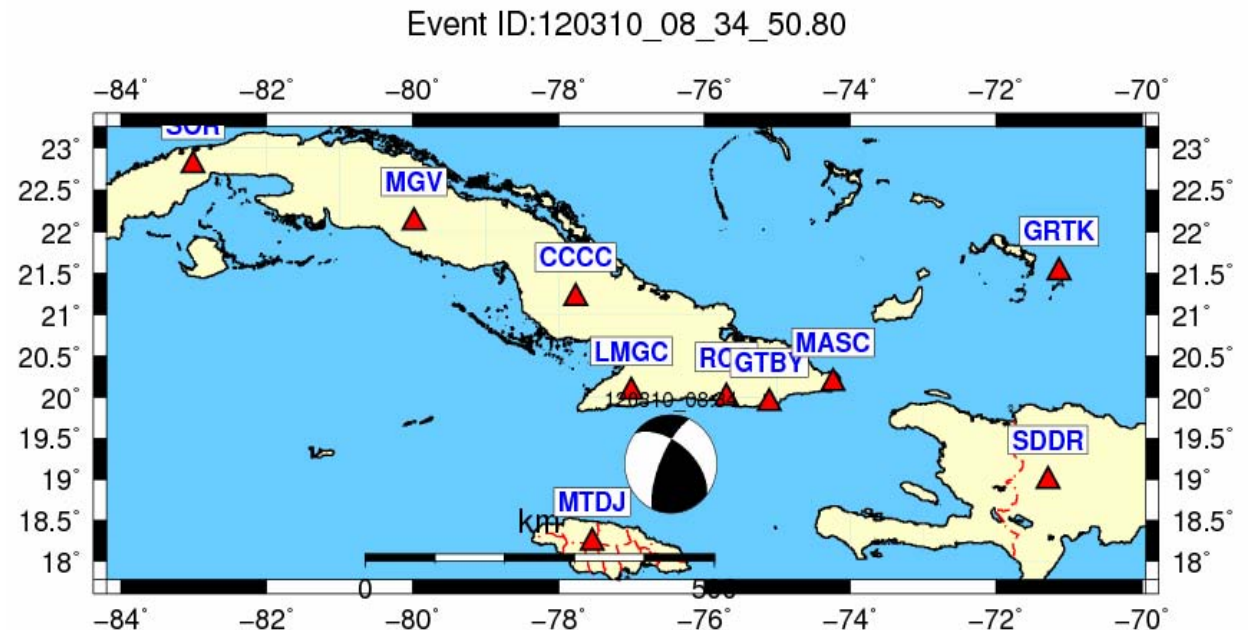
Save
Exit

	NS	EW	Z	D (km)
LMGC	+	+	+	112
RCC	+	+	+	120
MTDJ	+	+	+	156
GTBY	+	+	+	163
MASC	+	+	+	258
CCCC	+	+	+	261
MGV	-	-	-	489
SDDR	-	-	-	545
GRTK	-	-	-	613
SOR	-	-	-	789

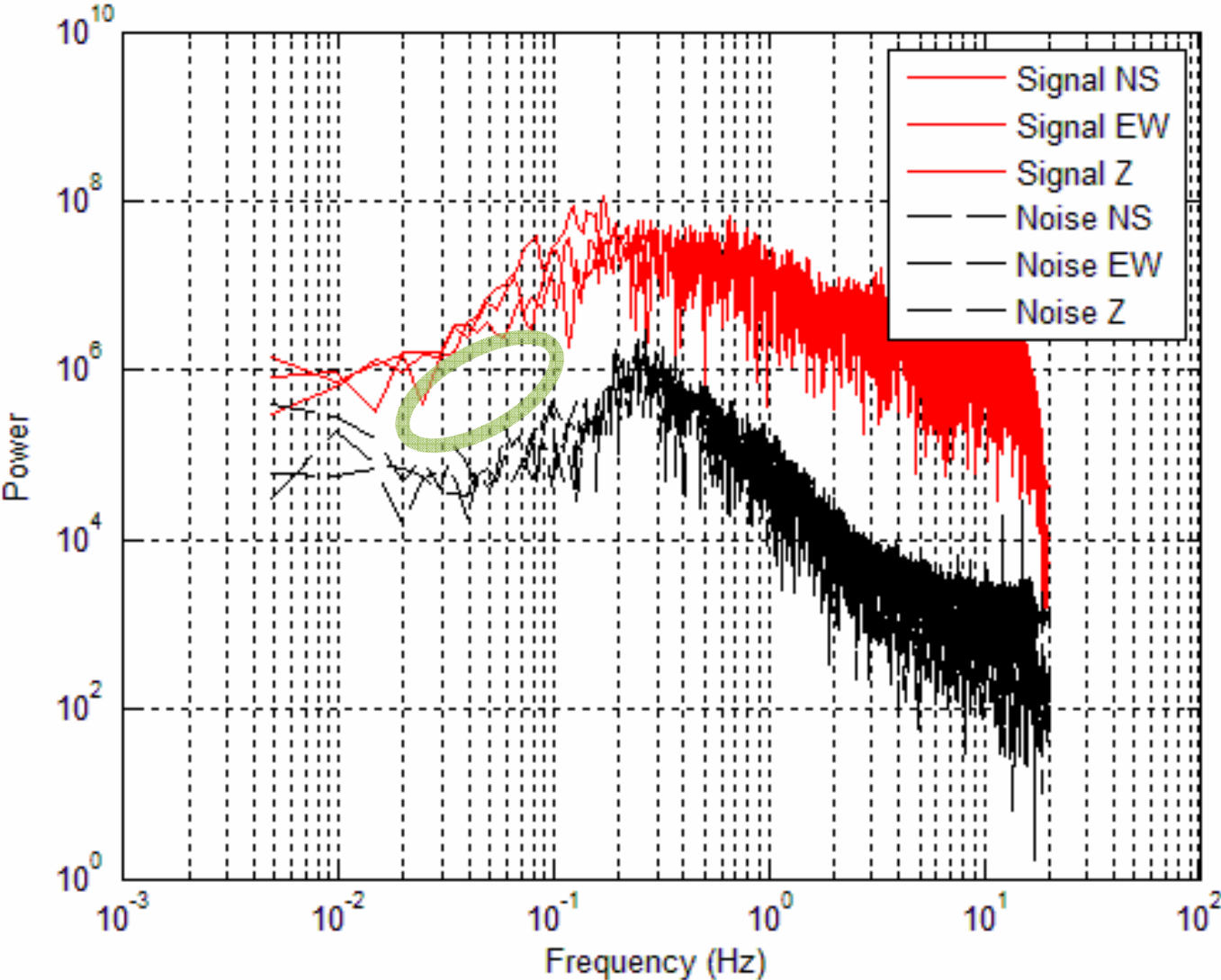
Sensor orientation verified by polarities

Z NS EW

- CCC : + + -
- LMG: + + -
- RCC: - - -
- MTDJ: - + +
- GTBY: - - -

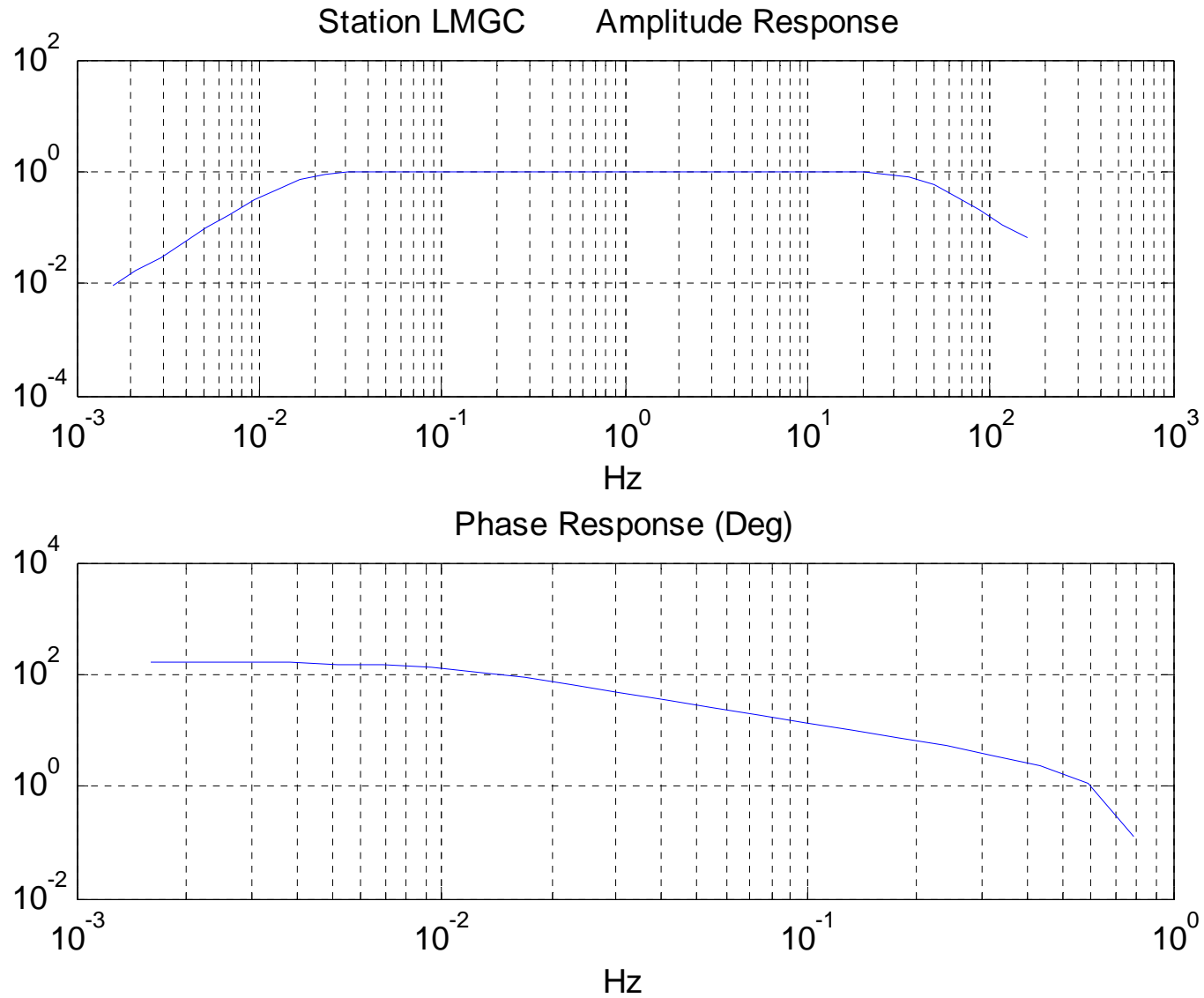


Noise-signal comparison

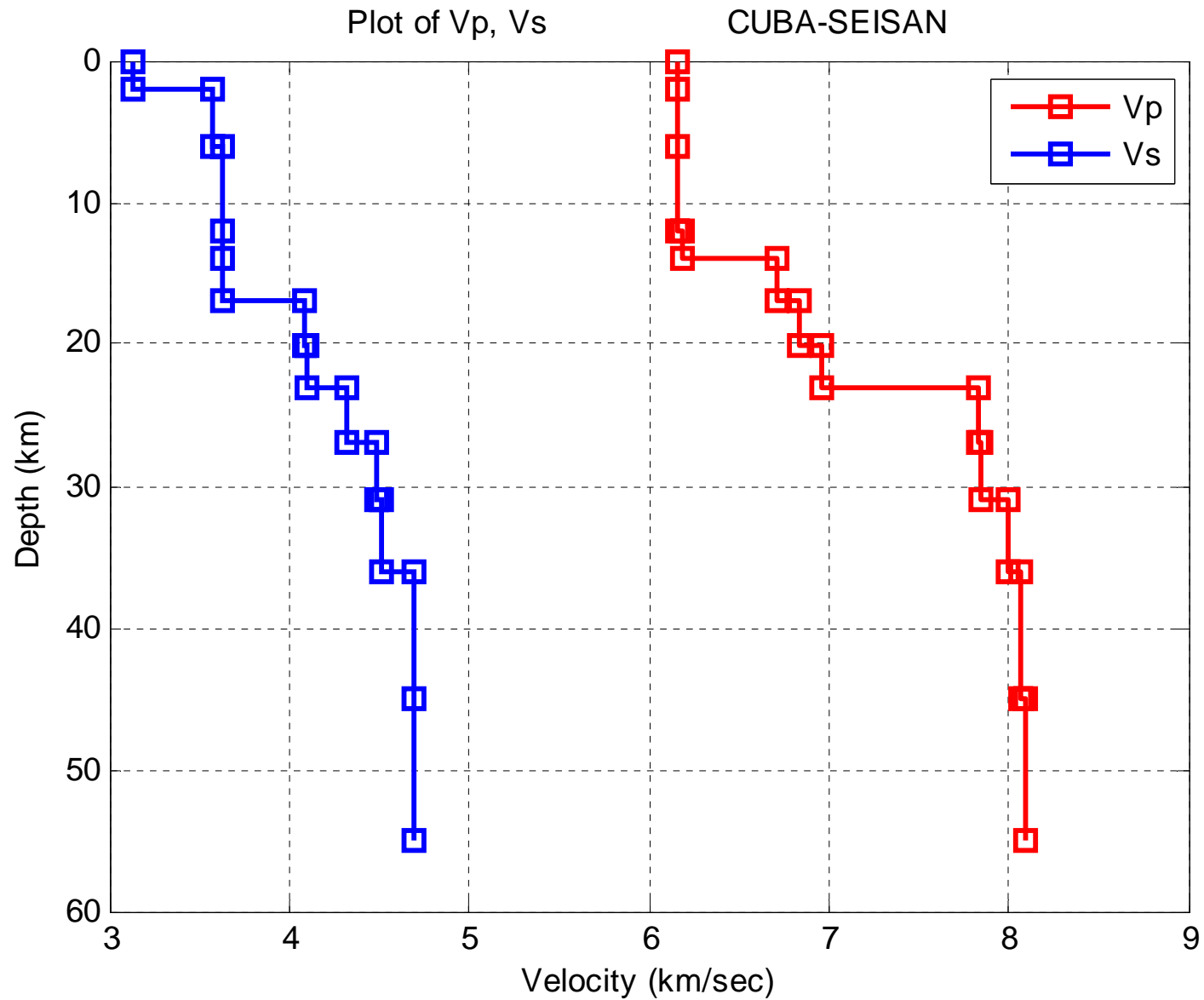


Green ellipse identify the frequency band for the inversion

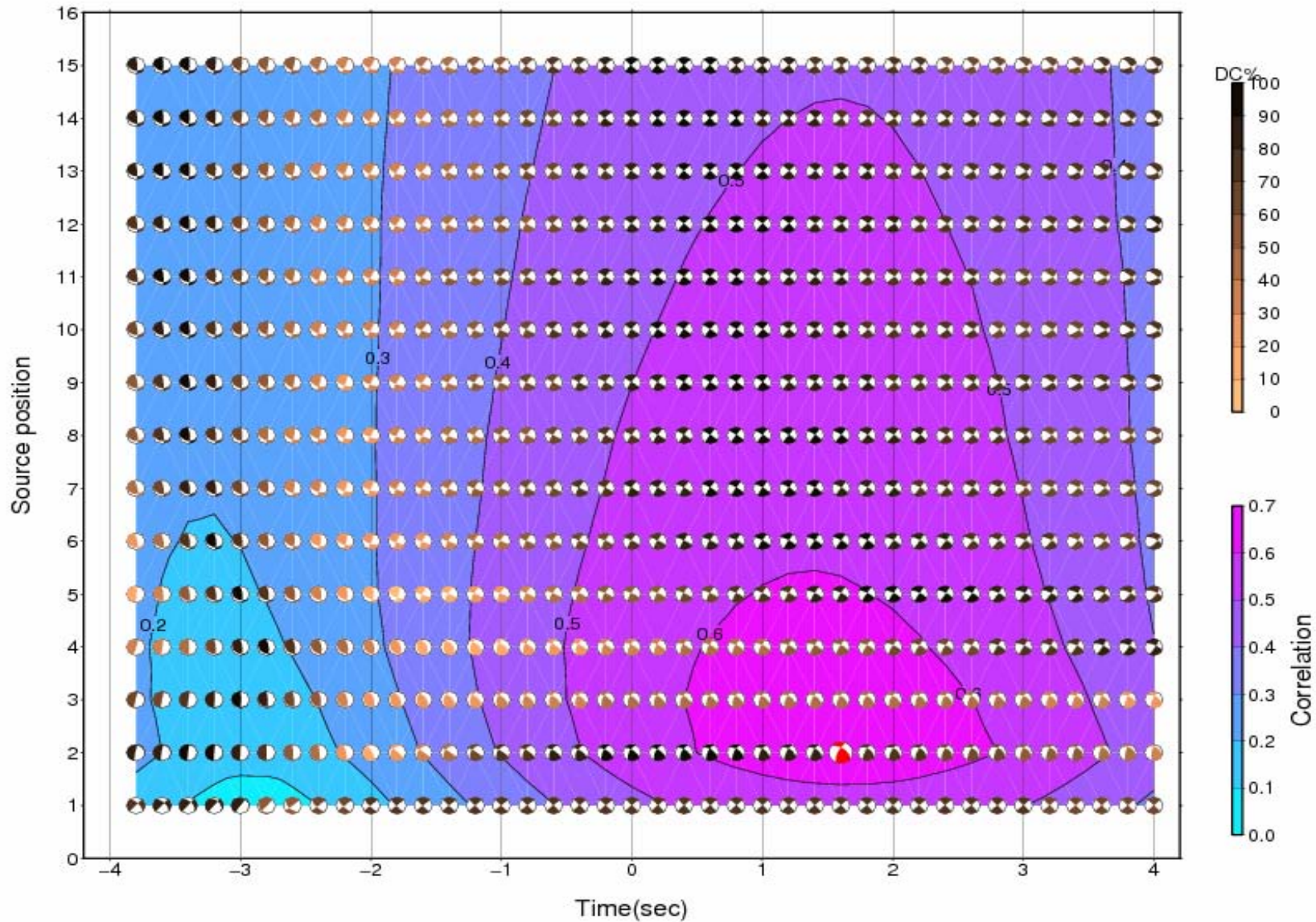
Example of the instrument response



Velocity model used



Time shift vs. source position



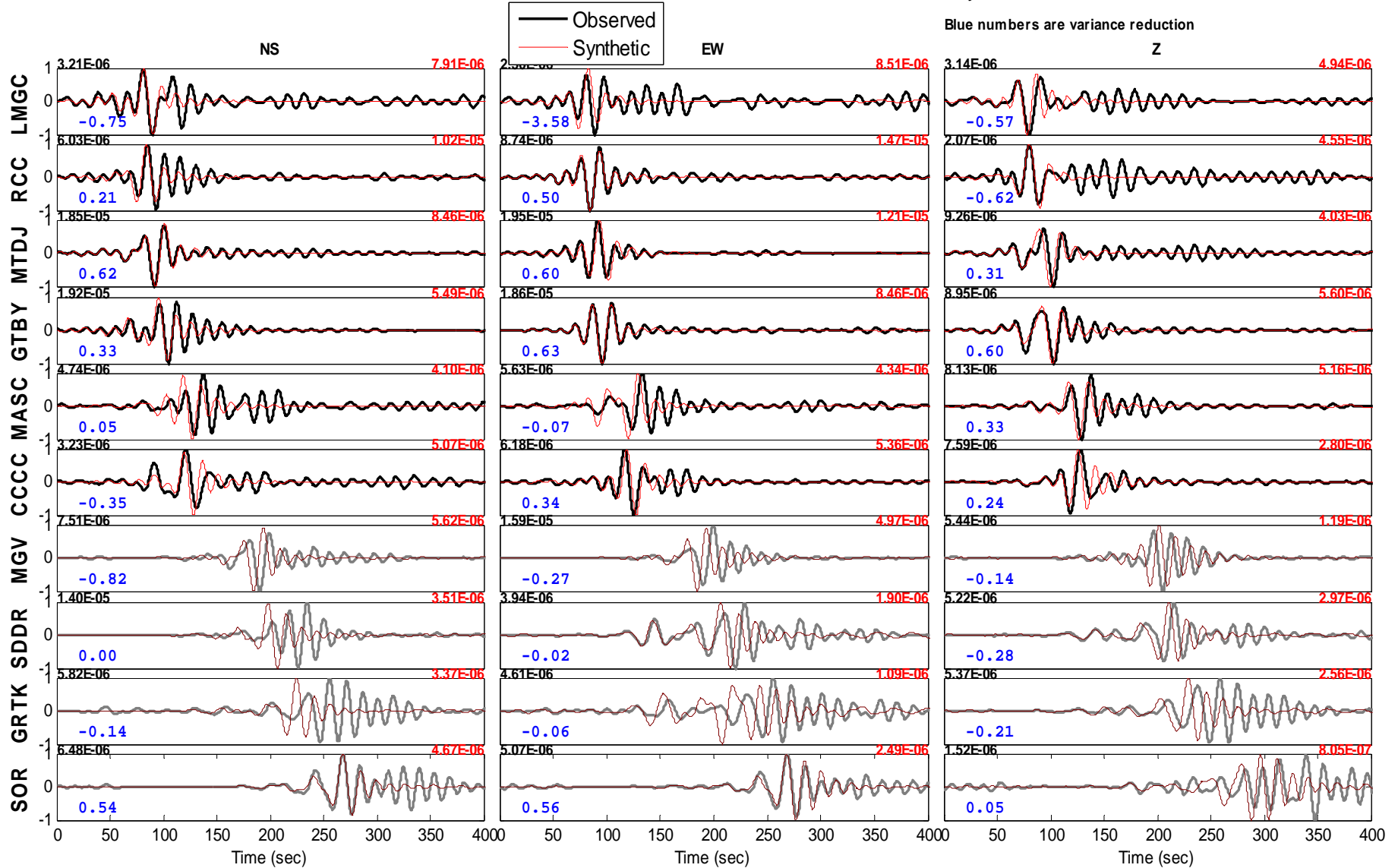
(In y-axis, 1 unit = 2 Km)

Observed and synthetic seismograms (normalized)

Event date-time: 120310_08_34_50.80

Displacement (m). Inversion band (Hz) 0.02 0.025 0.07 0.08

Gray waveforms weren't used in inversion.



MOMENT TENSOR SOLUTION

HYPOCENTER LOCATION (CUB)

Origin time 20120310 08:34:50.80
 Lat 19.19 Lon -76.46 Depth 10

CENTROID

Trial source number : 2 (Fixed Epicenter inversion)
 Centroid Lat (N)19.19 Lon (E)-76.46
 Centroid Depth (km) : 4
 Centroid time : +1.6 (sec) relative to origin time

Moment (Nm) : 1.584e+16

Mw : 4.7

VOL% : 0

DC% : 82.1

CLVD% : 17.9

Var.red.: (for stations used in inversion): 0.42

SNR CN FMVAR S

NaN 3.3 16±11

Var.red. (for all stations) : 0.26

Strike	Dip	Rake	Frequency band used in inversion (Hz)
308	54	23	0.02 - 0.025 -- 0.07 - 0.08

Strike	Dip	Rake	Stations-Components Used-Distance
204	71	141	

	NS	EW	Z	D (km)
P-axis Azimuth Plunge				

LMGC	+	+	+	112
------	---	---	---	-----

RCC	+	+	+	120
-----	---	---	---	-----

MTDJ	+	+	+	156
------	---	---	---	-----

GTBY	+	+	+	163
------	---	---	---	-----

MASC	+	+	+	258
------	---	---	---	-----

CCCC	+	+	+	261
------	---	---	---	-----

MGV	-	-	-	489
-----	---	---	---	-----

SDDR	-	-	-	545
------	---	---	---	-----

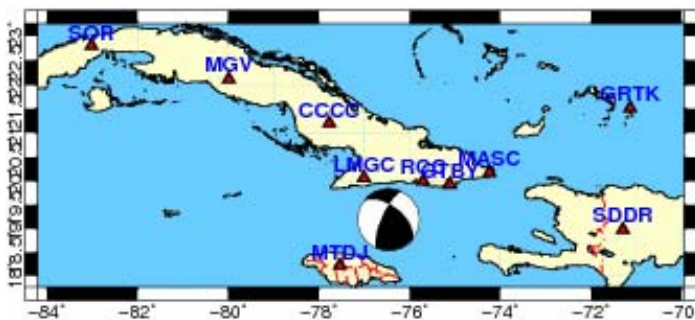
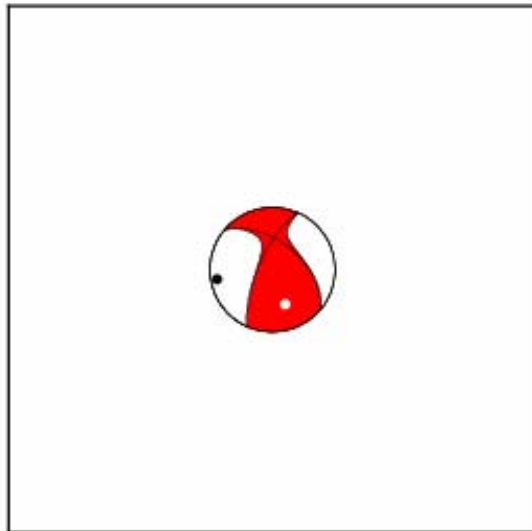
GRTK	-	-	-	613
------	---	---	---	-----

SOR	-	-	-	789
-----	---	---	---	-----

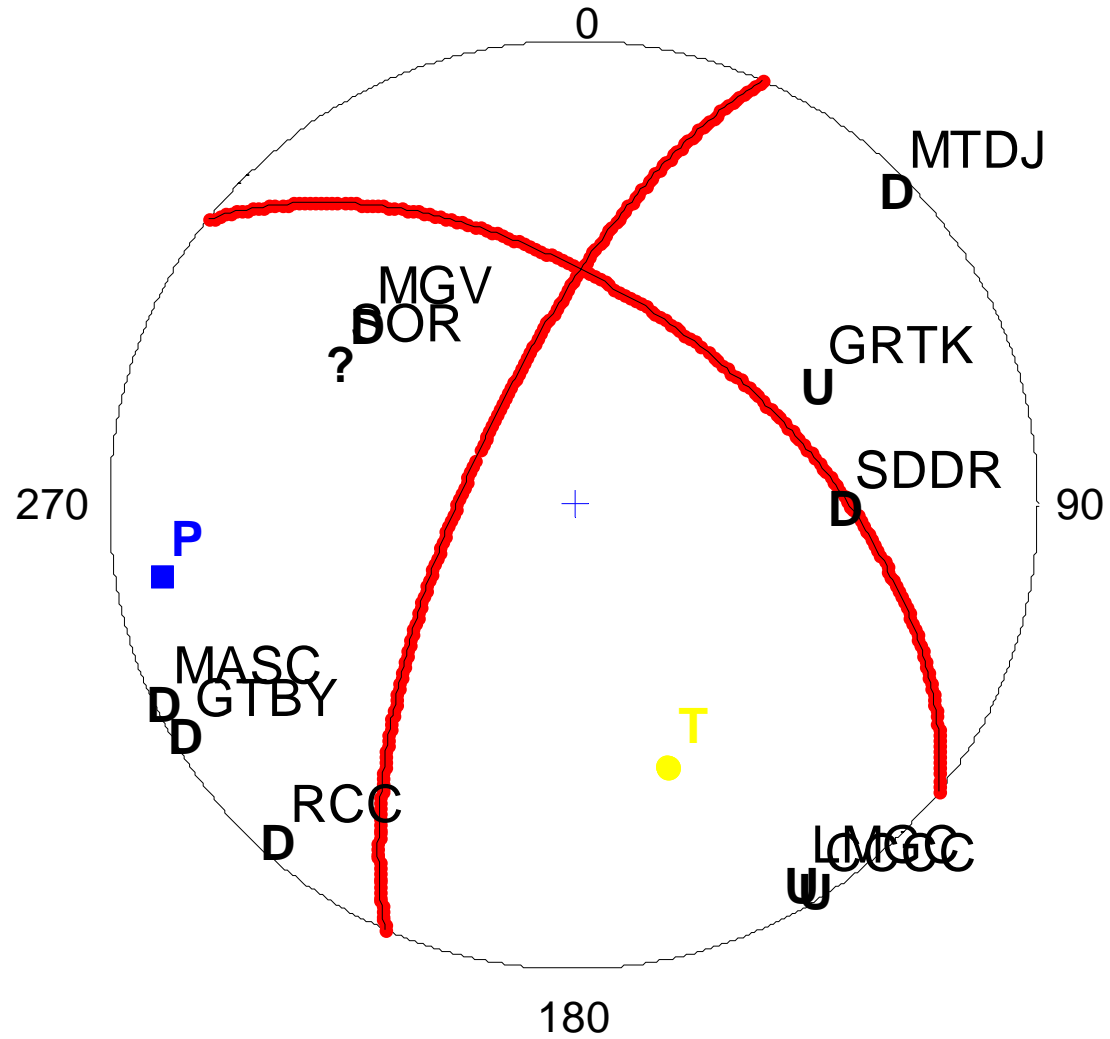
Mrr	Mtt	Mpp
0.641	0.798	-1.440

Mrt	Mrp	Mtp
-0.569	-0.564	0.552

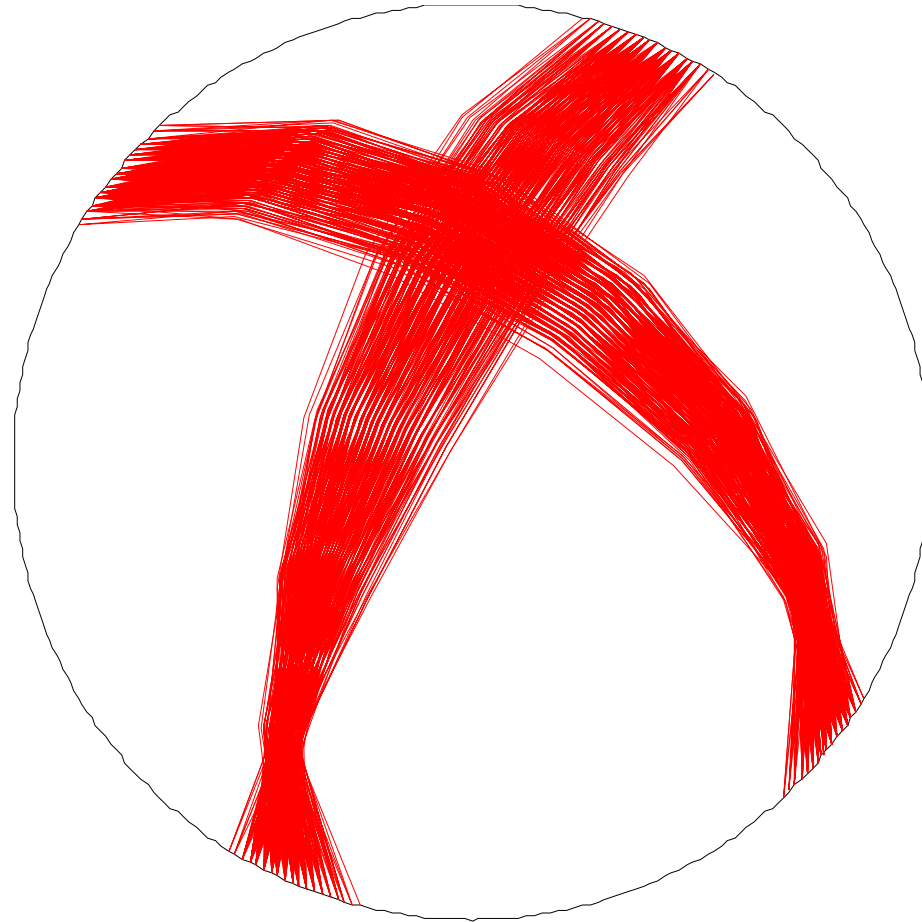
Exponent (Nm) : 16



Polarity comparison

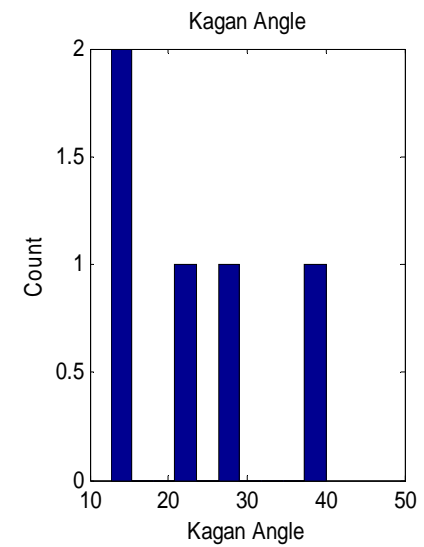
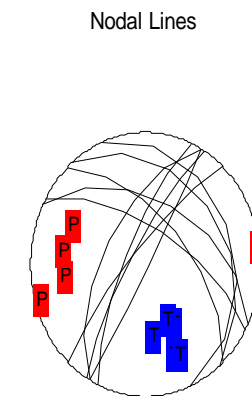
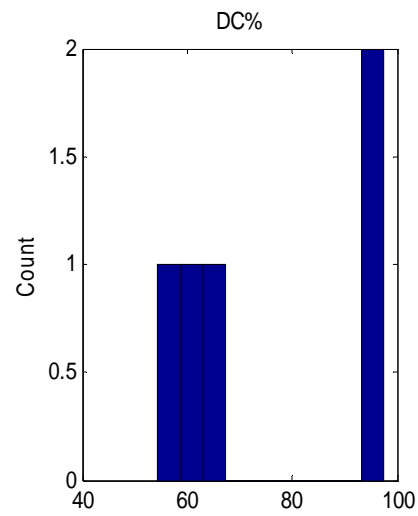
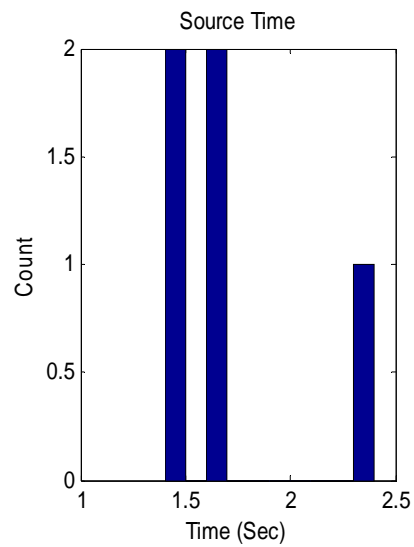
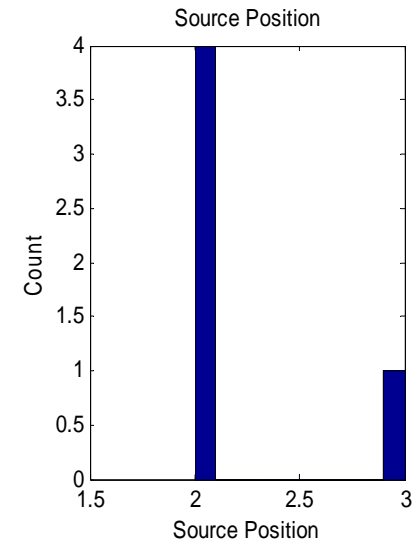
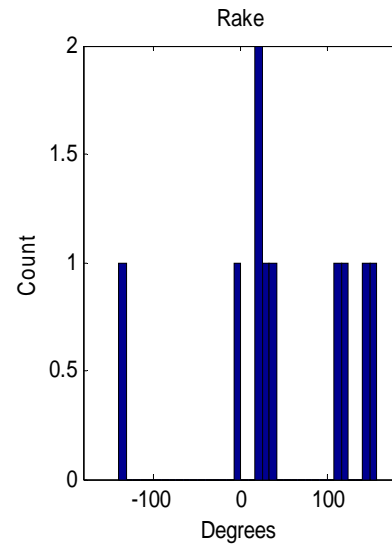
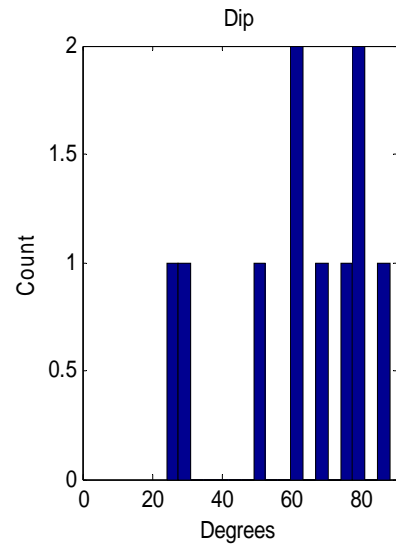
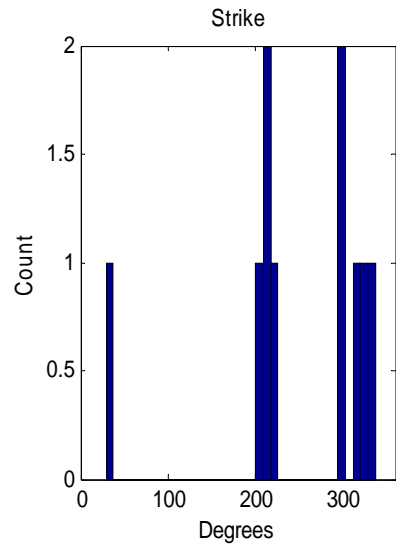


Uncertainty analysis



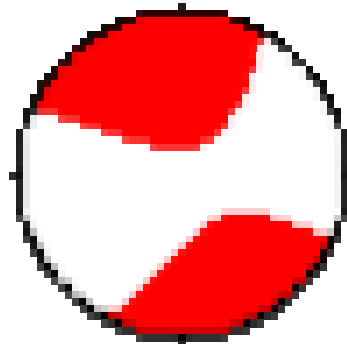
Linear approach by Zahradnik and Custodio (2012). BSSA, Vol. 102, No. 3, pp. 1235–1254,
June 2012, doi: 10.1785/0120110216

Jackknifing

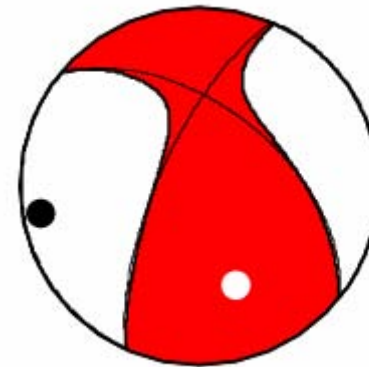


Comparison with Global CMT Catalog

Global CMT

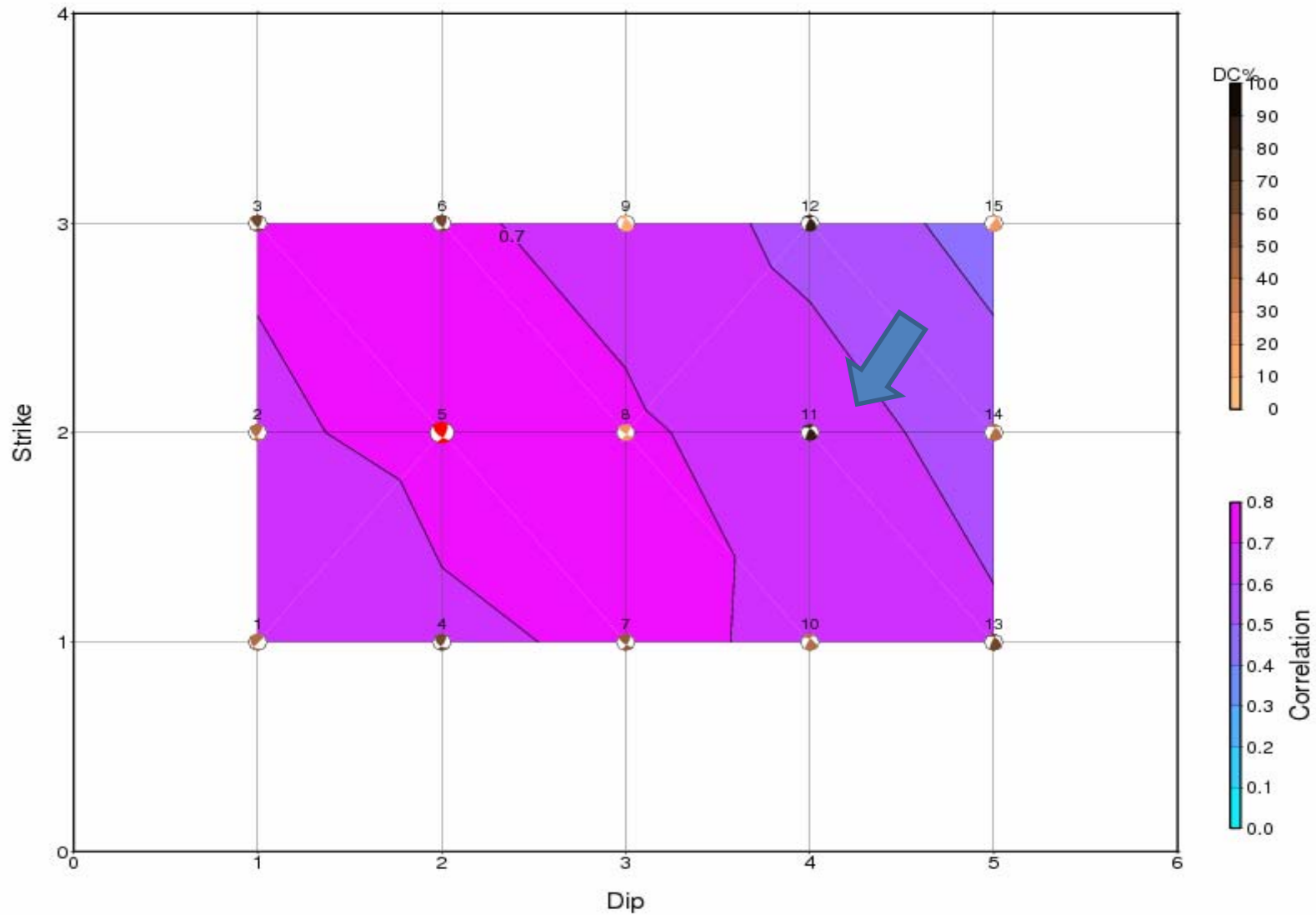


This study



- Date: 2012/ 3/10 Centroid Time: 8:34:53.6 GMT [Lat= 19.25 Lon= -76.43](#)
- Depth= 12.0 **our's = 4** Half duration= 0.8
- Centroid time minus hypocenter time: 2.8 **1.6**
- Mw = 5.0 mb = 4.8 **our's Mw = 4.7 mb = 4.6**
- Scalar Moment = 4.32e+16 **our's = 1.584e+16**
- Fault plane: strike=26 dip=75 slip=-176
- Fault plane: strike=295 dip=86 slip=-15

Grid search in horizontal plane



(depth =4km; strike=0; dip=0; increment step = 5 Km)

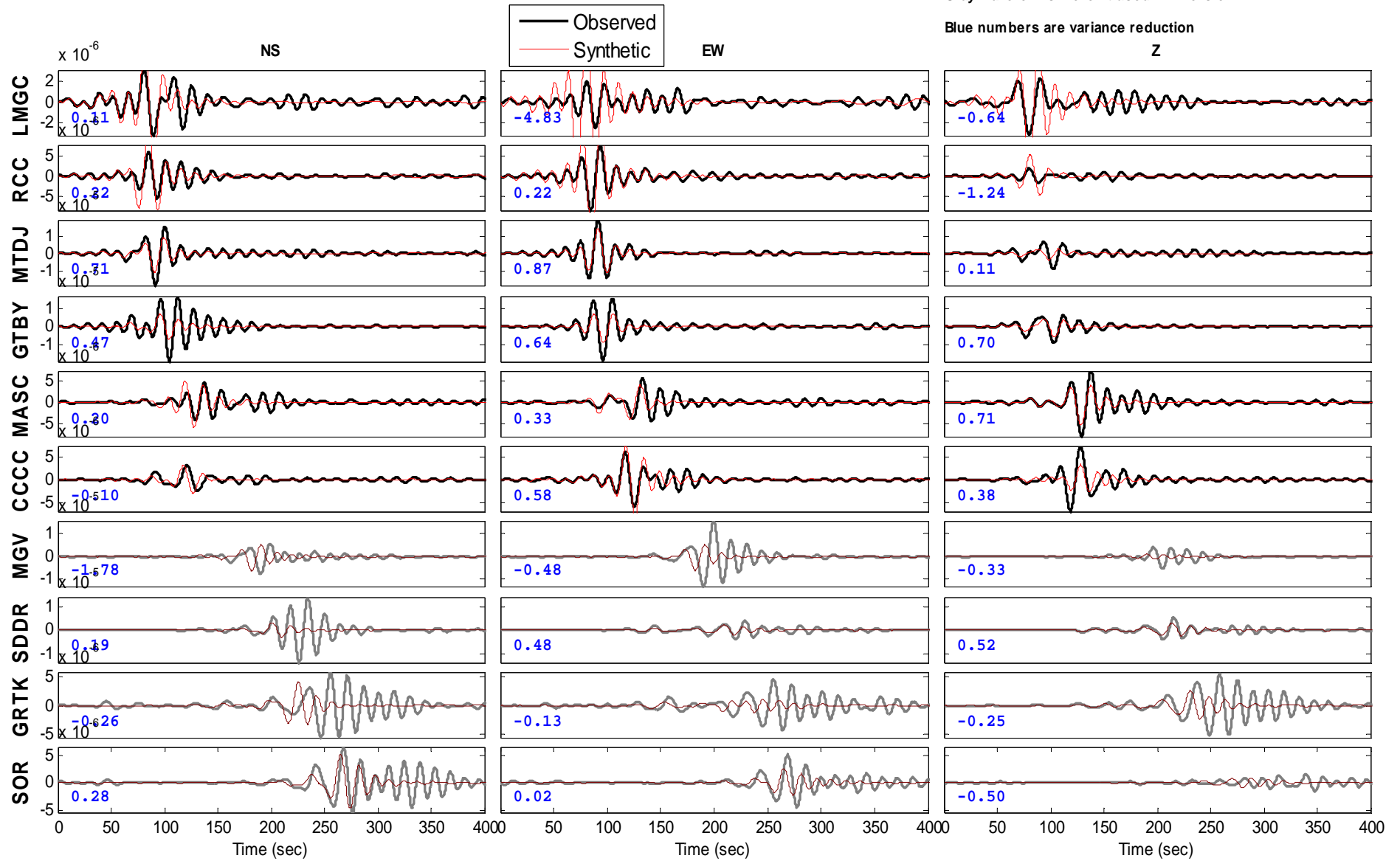
Observed and synthetic seismograms

Event date-time: 120310_08_34_50.80

Displacement (m). Inversion band (Hz) 0.02 0.025 0.07 0.08

Gray waveforms weren't used in inversion.

Blue numbers are variance reduction



MOMENT TENSOR SOLUTION

HYPOCENTER LOCATION (CUB)

Origin time 20120310 08:34:50.80
 Lat 19.19 Lon -76.46 Depth 10

CENTROID

Trial source number : 5 (Multiple Source line or plane inversion)
 Centroid Lat (N)19.19 Lon (E)-76.5551
 Centroid Depth (km) : 4
 Centroid time : +1.2 (sec) relative to origin time

Moment (Nm) : 1.762e+16

Mw : 4.8

VOL% : 0

DC% : 93.1

CLVD% : 6.9

Var.red.:(for stations used in inversion):0.53

SNR CN FVAR S

NaN 3.4 22±24

Var.red.(for all stations) :0.3

Strike	Dip	Rake	Frequency band used in inversion (Hz)
28	65	148	0.02 - 0.025 -- 0.07 - 0.08

Strike	Dip	Rake
133	61	29

Stations-Components Used-Distance

P-axis Azimuth Plunge	NS	EW	Z	D (km)
81 3	+	+	+	112
	+	+	+	120

T-axis Azimuth Plunge	NS	EW	Z	D (km)
349 40	+	+	+	156
	+	+	+	163

	+	+	+	258
	+	+	+	261

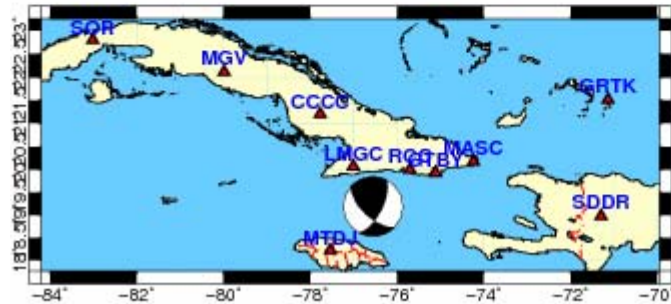
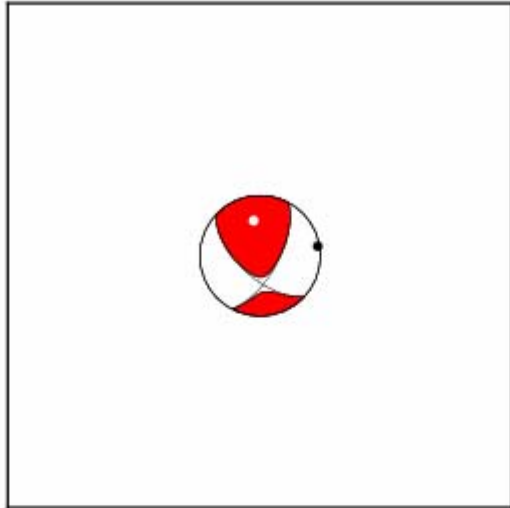
	-	-	-	489
	-	-	-	545

	-	-	-	613
	-	-	-	789

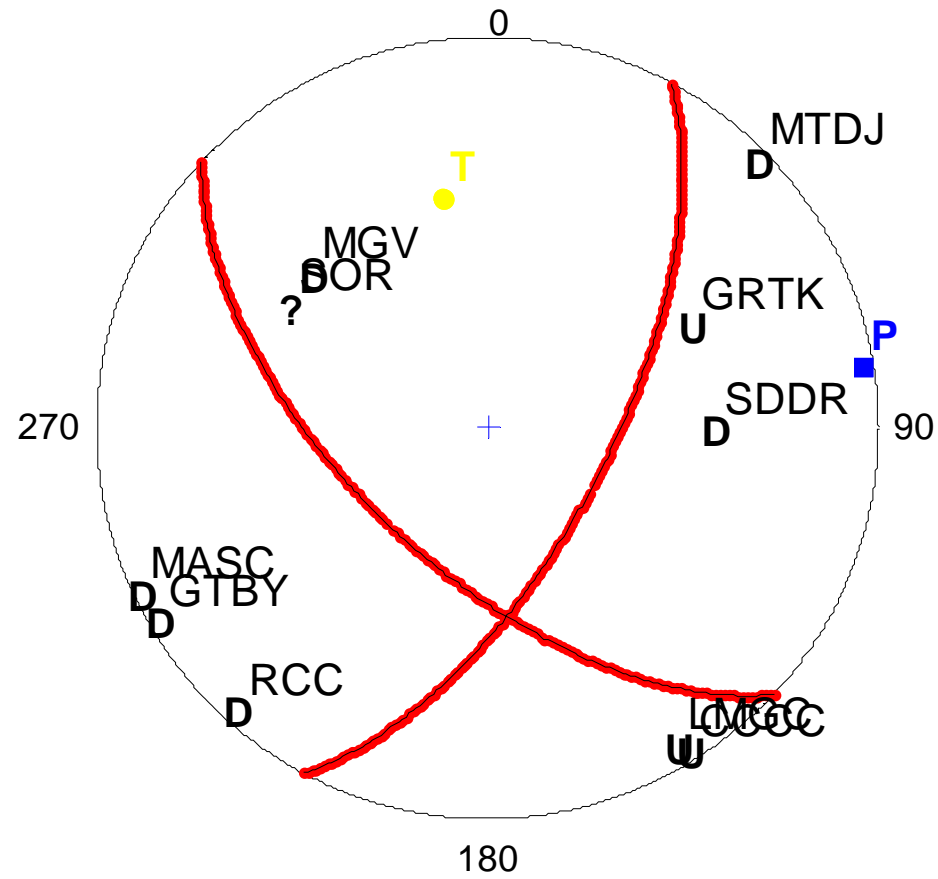
Exponent (Nm) : 16

Mrr	Mtt	Mpp
0.700	0.945	-1.645

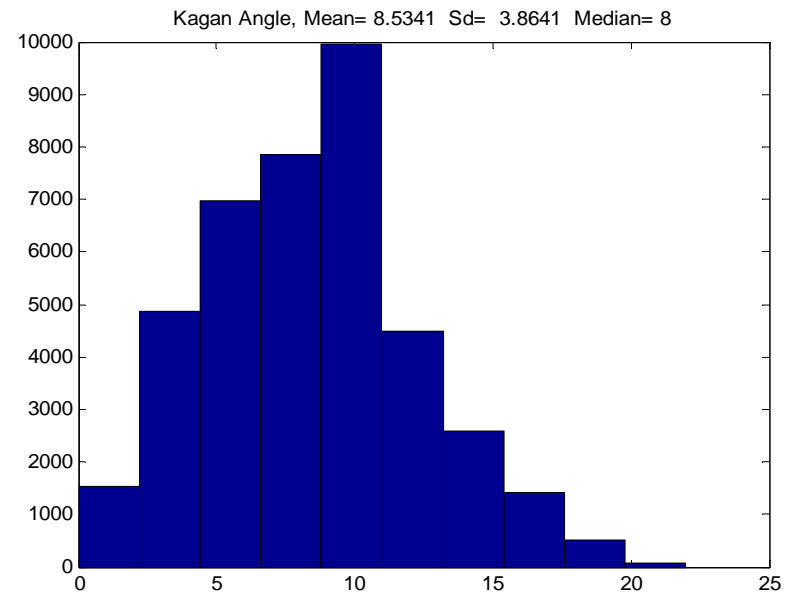
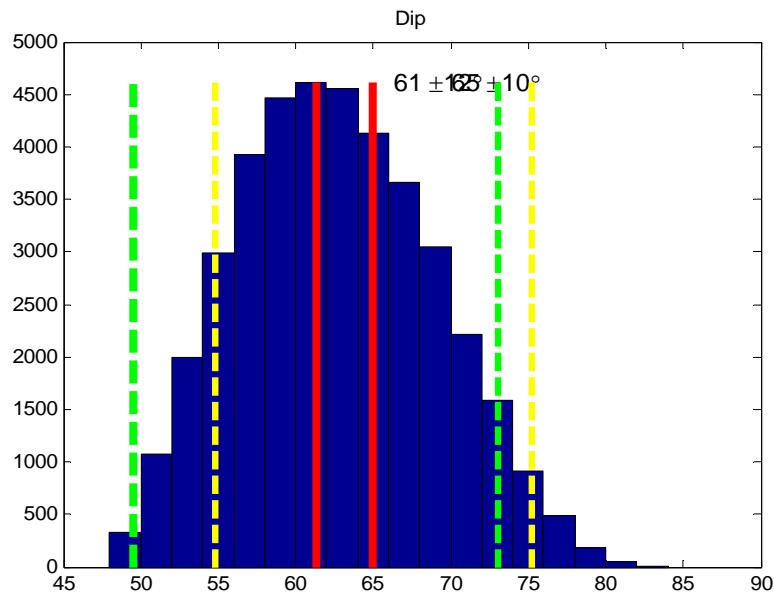
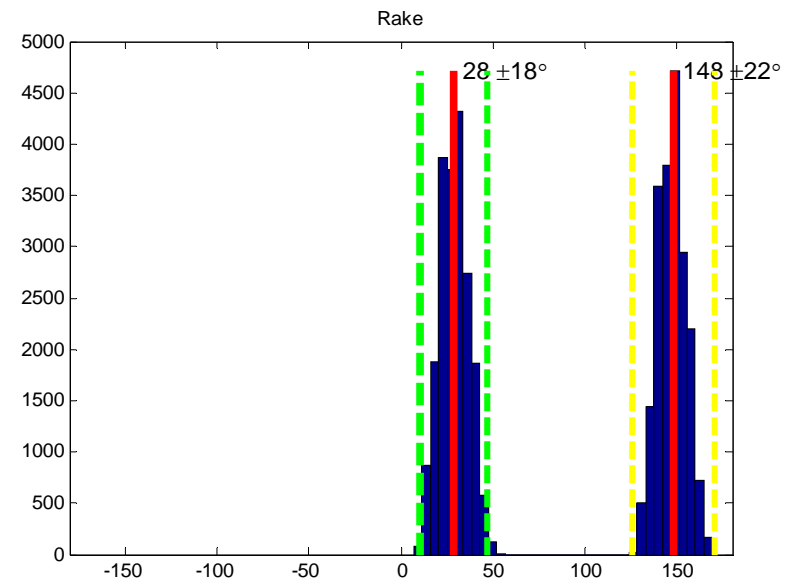
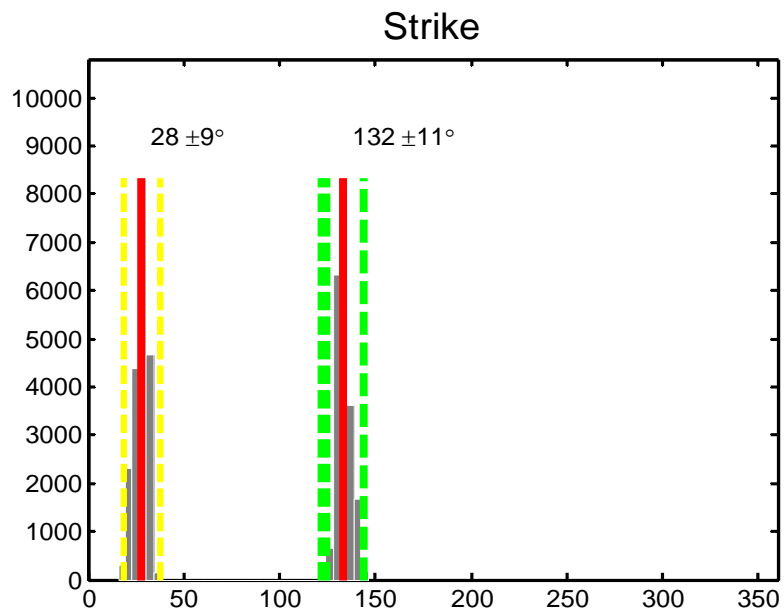
Mrt	Mrp	Mtp
0.883	0.254	0.464



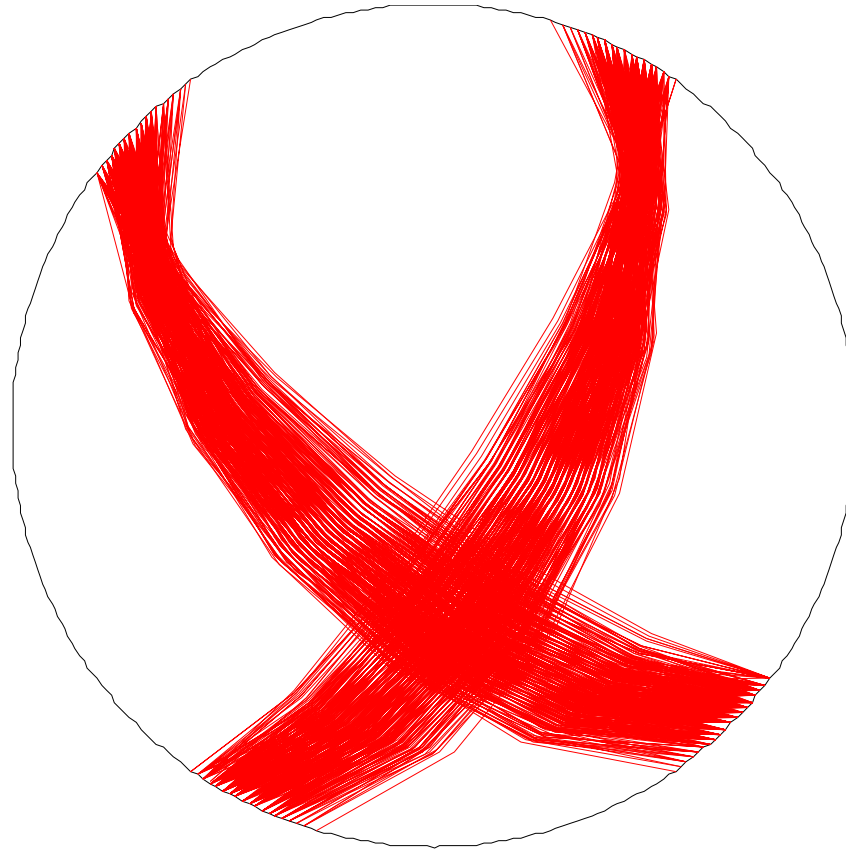
Polarity comparison



Uncertainty analysis

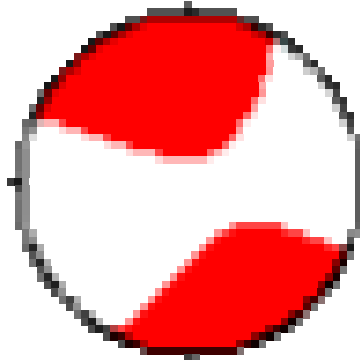


Uncertainty analysis

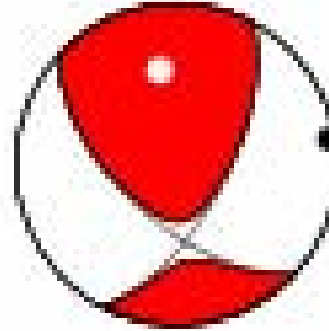


Comparison with Global CMT Catalog

Global CMT



This study



- Date: 2012/ 3/10 Centroid Time: 8:34:53.6 GMT
- Lat= 19.25 Lon= -76.43 (19.19 -76.55)
- Centroid time minus hypocenter time: 2.8 **1.2**
- Mw = 5.0 mb = 4.8 **our's Mw = 4.8 mb = 4.6**
- Scalar Moment = 4.32e+16 **our's = 1.762e+16**



Muchas gracias

Thank you very much

Muito obrigado

Děkuji moc

d'akujem moc

σας ευχαριστώ πολύ