

# Focal Mechanism Framework in Antelope

Antelope Users Group Meeting 2016  
May, 18 - 20 – Rome, Italy

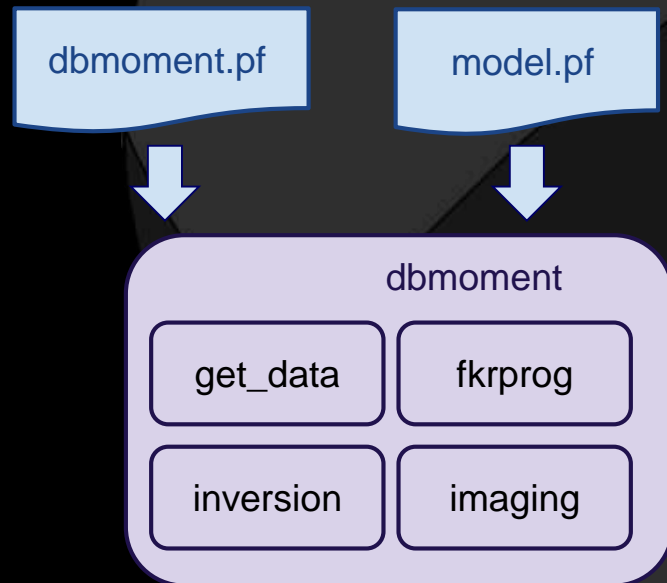
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jreyes1108@gmail.com

# Introduction

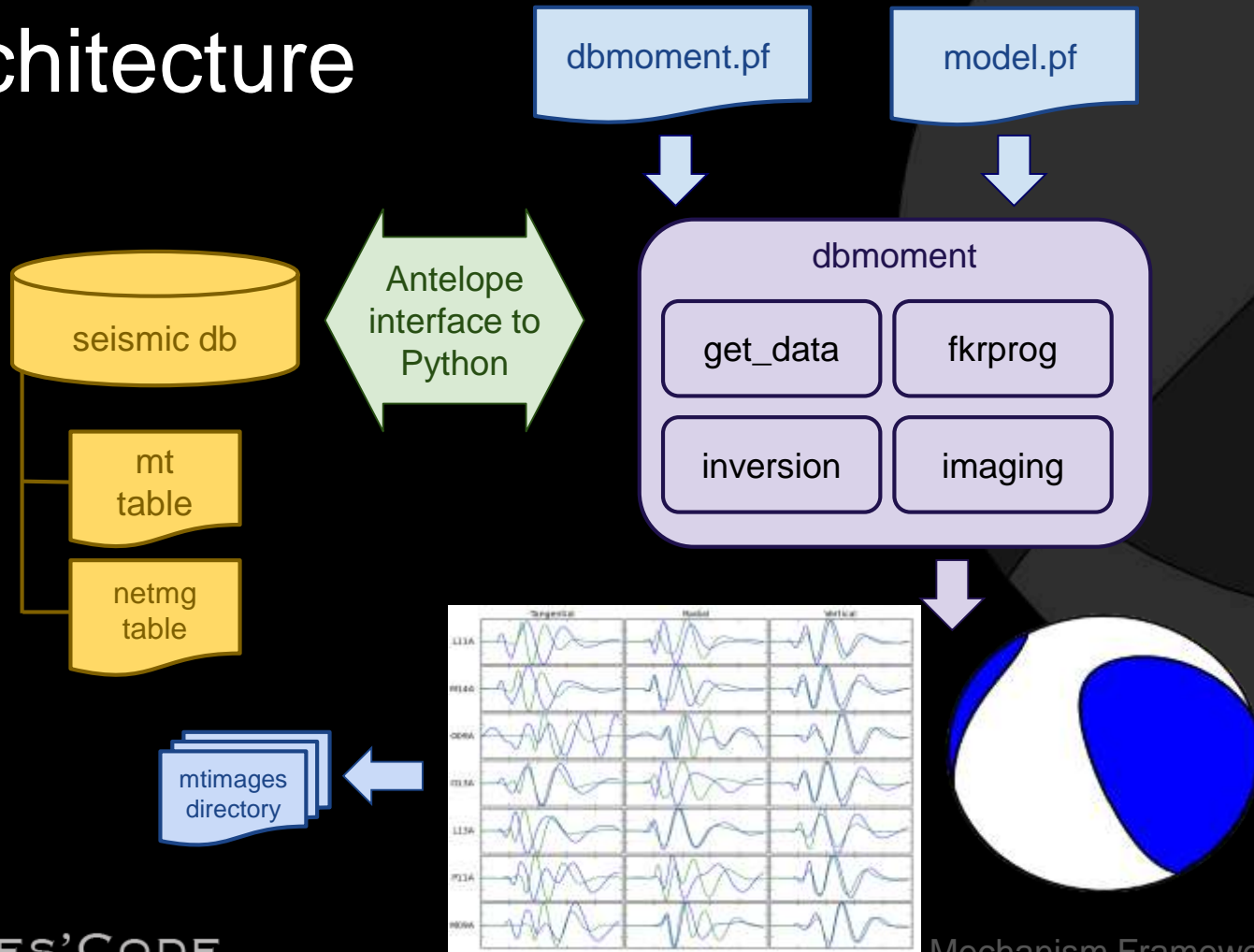
The time domain seismic moment tensor inversion software package written by Dreger has been packaged for inclusion into the Antelope Environmental Monitoring System. The new infrastructure was written natively in Python language.

# Architecture

Internally, our code has been designed to be as modular as possible. The configuration parameters got consolidated and simplified. Unavoidably every seismic region will require a dedicated velocity model.



# Architecture



# Velocity Model

```
name          SOCAL_MODEL
decay         6.0
start_frequency 1
end_frequency 512
samplerate    4
cmax          10000
c1            30
c2            2.9
cmin          2.5
velocity_reduction 10
distance_min  0
distance_max  500
distance_step 5
# MODEL PARAMETERS
# Layer: thickness(km), p-velocity(km/s), s-velocity(km/s), density(g/cc), Q-alpha, Q-beta
model &Literal{
    5.5  5.5  3.18  2.4  600  300
    8.0  6.3  3.64  2.67  600  300
    19.0  6.7  3.87  2.8  600  300
    400.0  7.8  4.5  3.3  600  300
}
```

# Execution

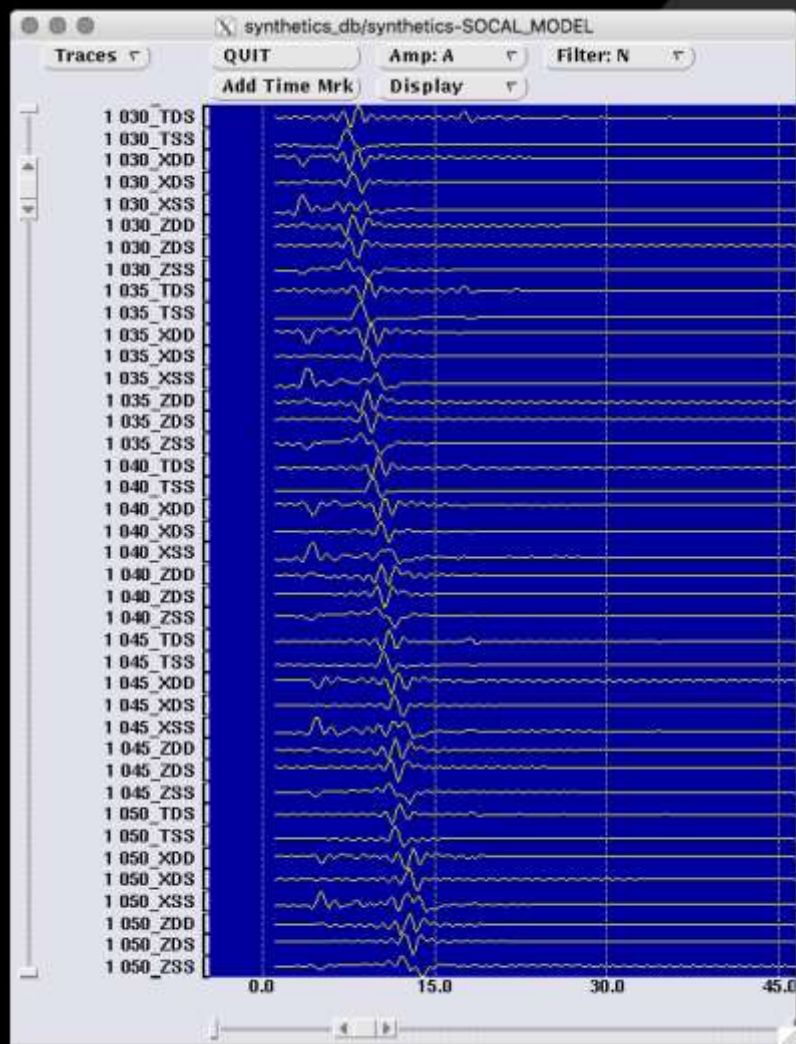
`dbmoment [-xvd] [-m MODEL.pf] [-c min_variance] [-p pfname] [-z 'STA1:5,STA2:5'] [-s select] [-r reject] database ORID`

`dbmoment -e [-xvd] [-m MODEL.pf] [-c min_variance] [-p pfname] [-z 'STA1:5,STA2:5'] [-s select] [-r reject] database EVID`

## Options:

- `-e` id is EVID
- `-v` Verbose output
- `-d` Debug output
- `-x` Debug output each station plot
- `-c MIN_FIT` Set min. variance reduction threshold
- `-z ZCOR` Set some Zcor values for stations
- `-p PF` Parameter file path
- `-m MODEL` Forced this MODEL file
- `-f FILTER` Forced a filter on the data
- `-s SELECT` Only select these stations
- `-r REJECT` Reject these stations

# Synthetics



# Output

5.1 Mw 8/12/1998 14:10:23.000

8/12/1998 14:10:23.000

EQ 1 Quality 0

Location:

Lat: 38.795

Lon: -121.999

Depth: 8.000

Filter: RW0 EQ 4.0 EQ 4

Model: SGCAL\_MODEL

Mw: 5.1

Strike (273) Dip (86) Nod (14) Dip (88) Nod (79)

Pd: 97%

Pcnd: 1%

WV: 1.450e-07

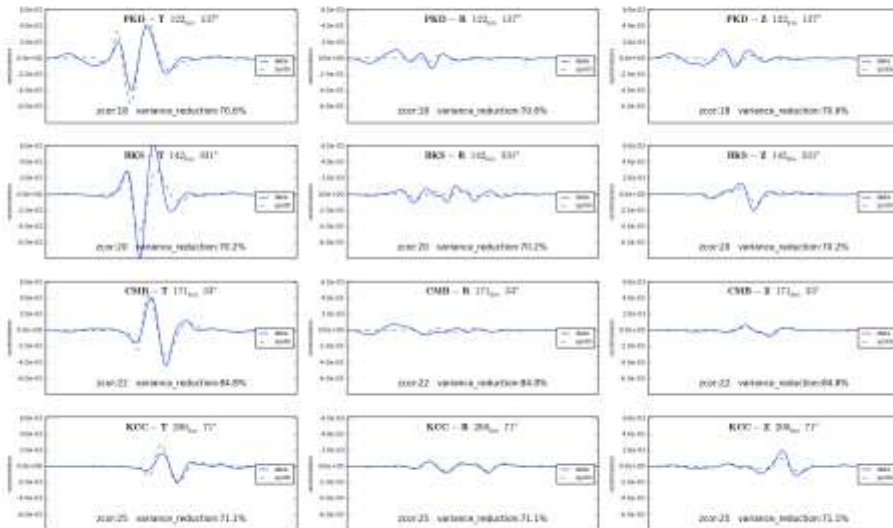
Wknd: 7.357e+03

WdPnd: 1.092e+09

Mu: 8.2181e+25

Mu: 5.952 118 Mu: 22.000 Mu: 011.769

Mu: 1088.586 Mu: 917.618 Mu: 16.485



Waveform traces calculated using the Earthquake Software by Douglas Engel of San Jose State University, Department of Geology, and Center for Earthquake Research and Information, University of Maryland. Station codes are appropriate for the 1998-1999 release of the International Earthquake Catalogue (IEC).

Generated by [www.earthquakecatalogue.com](http://www.earthquakecatalogue.com) on 8/12/1998 14:10:23.000



# Examples

```
system:~ reyes$ run_dbmoment_example
```

```
RUN DBMOMENT DEMO
```

```
ANTELOPE VERSION: /opt/antelope/5.6
```

```
YOU CAN ALSO RUN WITH EXPLICIT PATH: run_dbmoment_example /foo/bar/temp/folder
```

```
CHANGE TO DIRECTORY: [/Users/reyes/dbmoment_example/]
```

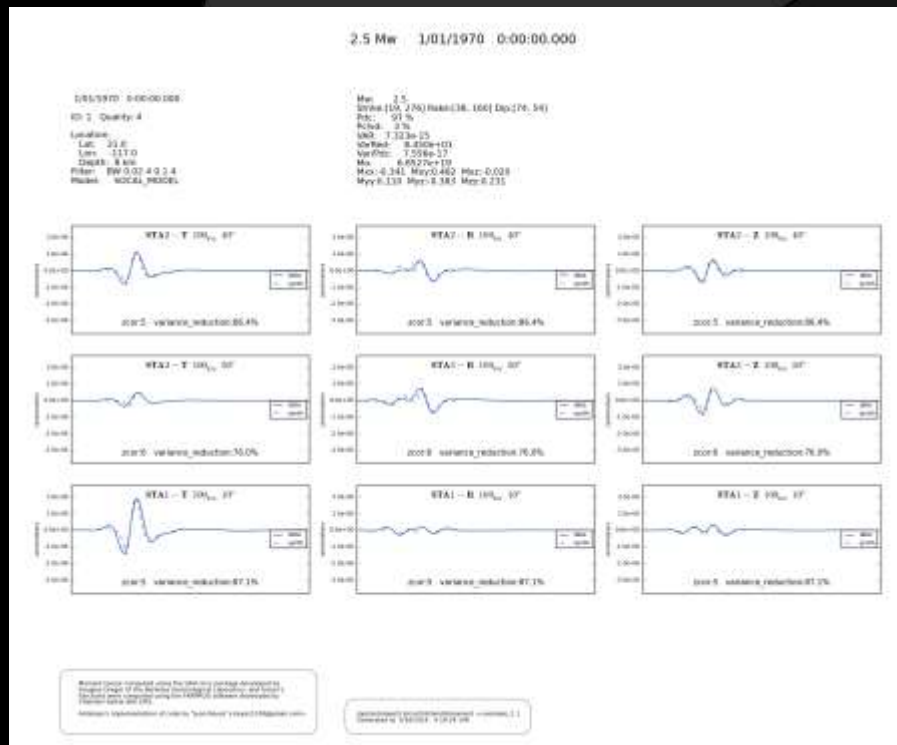
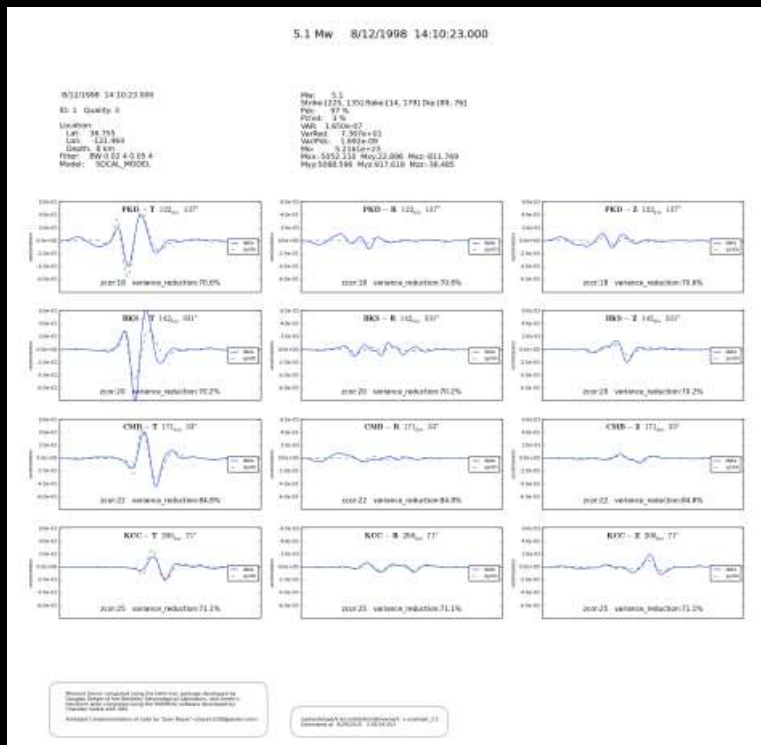
```
REMOVE TEMP FOLDER: [/Users/reyes/dbmoment_example//.dbmoment]
```

```
REMOVE TEMP FOLDER: [/Users/reyes/dbmoment_example//synthetics_db]
```

```
COPY [/opt/antelope/5.6/contrib/example/dbmoment/EXAMPLE_1/example_1] TO [/Users/reyes/dbmoment_example/]
```

```
COPY [/opt/antelope/5.6/contrib/example/dbmoment/EXAMPLE_2/example_2] TO [/Users/reyes/dbmoment_example/]
```

# Output



# Databases and Maps

qtmapevents example\_1

qtmapevents

Describe a moment tensor for a given origin.  
This table is designed to accommodate the moment tensor information in the form as distributed through the USGS/NEIC GeoJSON web site.  
See: <http://earthquake.usgs.gov/earthquakes/feed/v1.0/geojson.php>

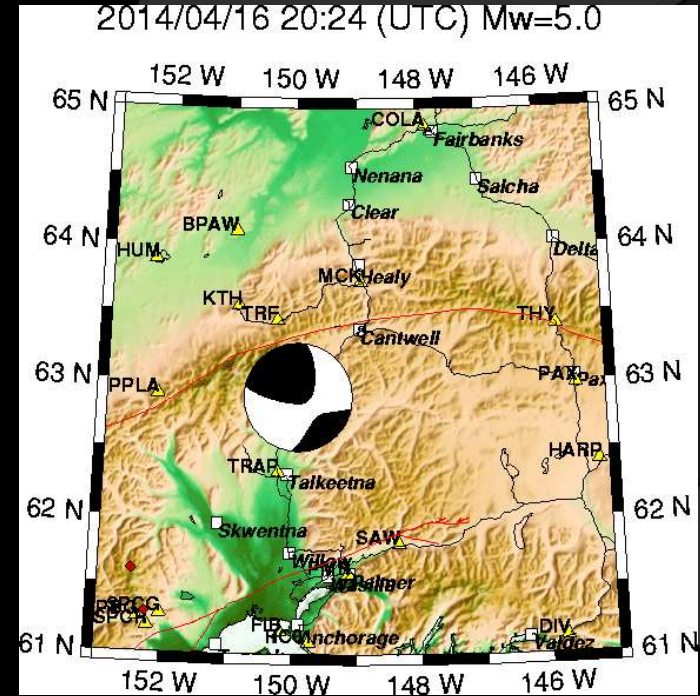
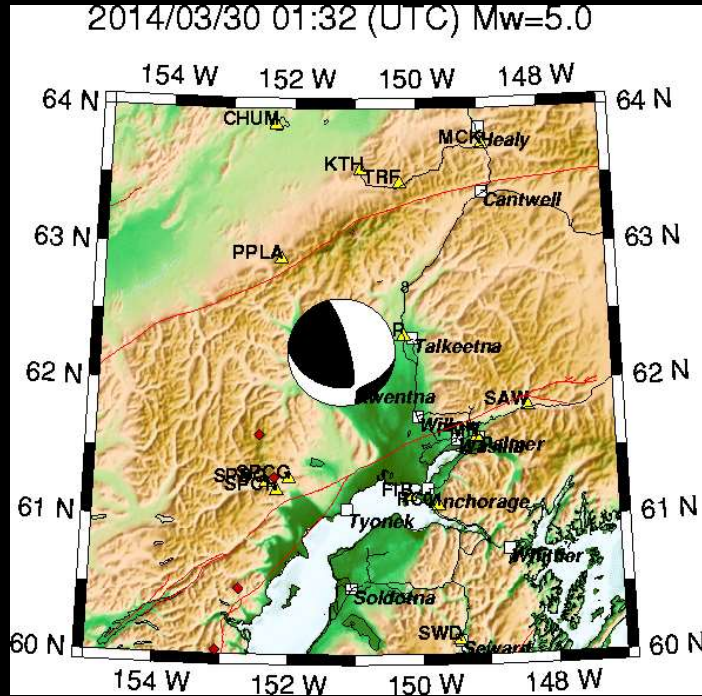
Primary key: **mtid**  
Foreign keys: **orid**  
Record Size (bytes): 532

mtid	pubid	qmtid	orid	tmpp	tmrp	tmrr	tmrt
tmtp	tmtr	taxlength	taxplg	taxazm	paxlength	paxplg	paxazm
naxlength	naxplg	naxazm	str1	pkc	str1	dip1	rake1
str2	dip2	rake2	drdepth	drtime	drlat	drlon	drmag
drmag2	estatus	rstatus	utime	auth	lddate		

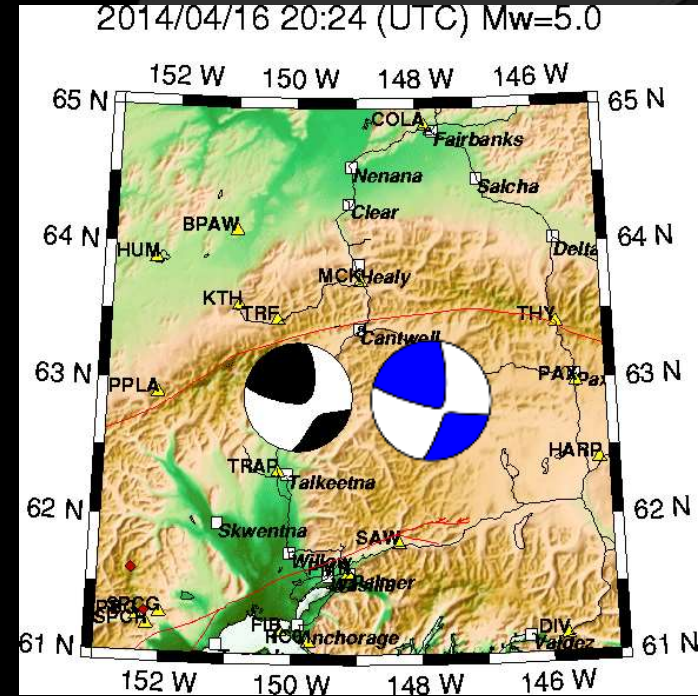
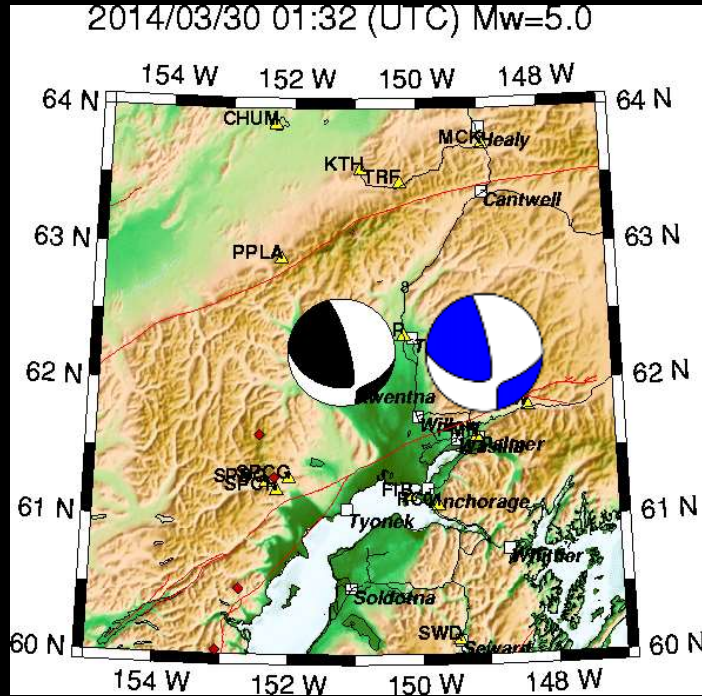
Dismiss Quit



# Comparisons ALASKA

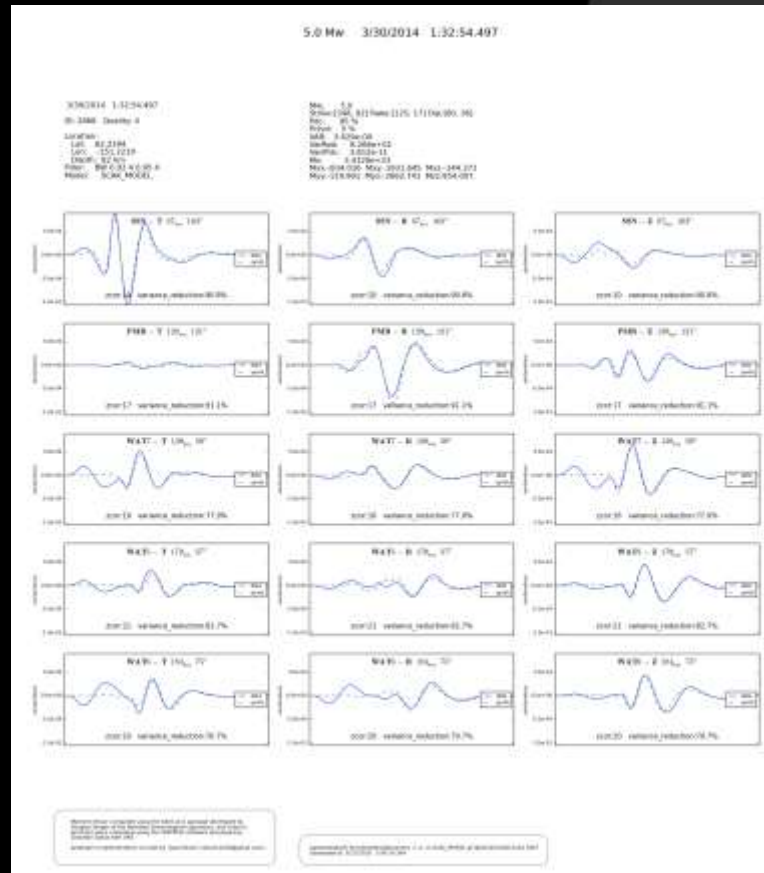


# Comparisons ALASKA





# Comparisons ALASKA



# Comparisons TransportableArray

Oklahoma 4.7  
2011-11-05

## USGS/SLU Regional Moment Solution

### OKLAHOMA

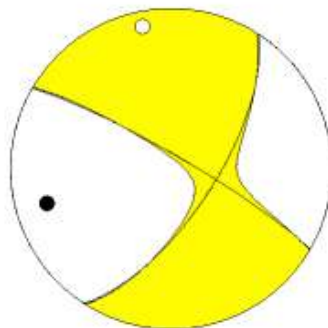
11/11/05 07:12:45.13

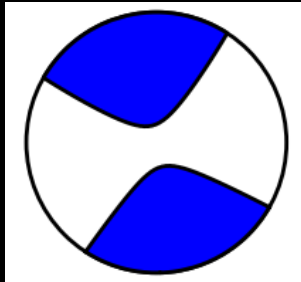
Epicenter: 35.553 -96.748  
MW 4.8

USGS/SLU REGIONAL MOMENT TENSOR  
Depth 4 No. of sta: 45  
Moment Tensor; Scale  $10^{16}$  Nm  
Mrr=-0.12 Mtt= 1.66  
Mpp=1.54 Mrt= 0.51  
Mrp=-0.60 Mtp= 0.82

Principal axes:  
T Val= 1.92 Plg=11 Azm=348  
N 0.08 66 104  
P -2.00 21 254

Best Double Couple:  $M_0=2.0 \cdot 10^{16}$   
NP1: Strike= 33 Dip=68 Slip=-172  
NP2: 300 83 -23





Mw: 4.9  
 Strike:[31, 121] Rake:[178, 2] Dip:[88, 88]  
 Pdc: 78 %  
 Pclvd: 22 %  
 VAR: 1.143e-08  
 VarRed: 9.097e+01  
 Var/Pdc: 1.464e-10  
 Mo: 2.27856e+23  
 Mxx:2149.965 Mxy:-1041.353 Mxz:142.987  
 Myy:-1894.060 Myz:-40.750 Mzz:-255.905



# USGS/SLU Regional Moment Solution

## OKLAHOMA

11/11/05 07:12:45.13

Epicenter: 35.553 -96.749  
 MW 4.8

### USGS/SLU REGIONAL MOMENT TENSOR

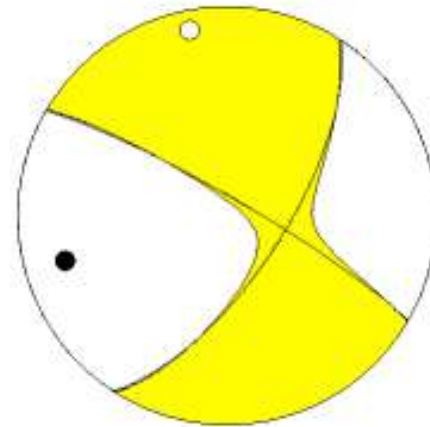
Depth 4 No. of sta: 45  
 Moment Tensor; Scale 10\*\*16 Nm  
 Mrr=-0.12 Mtt= 1.66  
 Mpp=-1.54 Mrt= 0.51  
 Mrp=-0.60 Mtp= 0.82

### Principal axes:

T	Val=	Plg=	Azm=
T	1.92	11	348
N	0.08	66	104
P	-2.00	21	254

### Best Double Couple:Mo=2.0\*10\*\*16

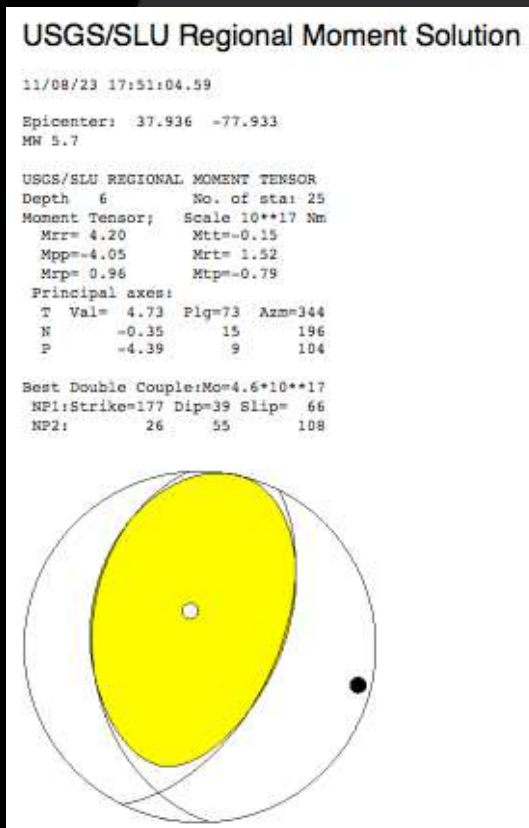
NP1:Strike= 33 Dip=68 Slip=-172  
 NP2: 300 83 -23





# Comparisons TransportableArray

Virginia 5.7  
2011-08-23



8/23/2011 17:51:04.590

ID: 265866 Quality: 4

Location:

Lat: 37.936

Lon: -77.933

Depth: 6 km

Filter: BW 0.02 4 0.05 4

Model: SOCAL\_MODEL

Mw: 5.7

Strike: [26, 185] Rake: [105, 75] Dip: [47, 45]

Pdc: 98 %

Pcld: 2 %

VAR: 3.666e-07

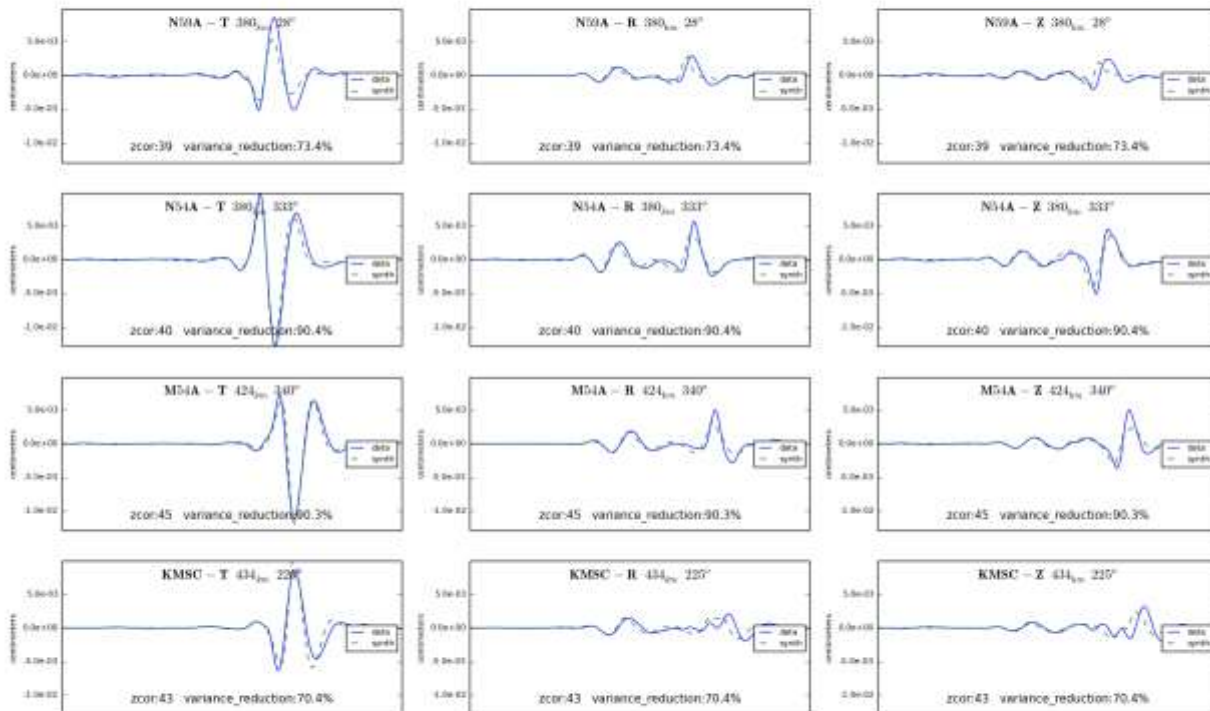
VarRed: 0.429e+01

VarPdc: 3.733e-09

Mx: 3.74608e+24

Mx: -1163.780 My: 10063.607 Mz: 7024.665

My: -34792.345 Myz: 67.655 Mz: 35956.125



## USGS/SLU Regional Moment Solution

11/08/23 17:51:04.59

Epicenter: 37.936 -77.933

MW 5.7

## USGS/SLU REGIONAL MOMENT TENSOR

Depth 6 No. of sta: 25

Moment Tensor; Scale  $10^{+17}$  Nm

Mrr= 4.20 Mtt=-0.15

Mpp=-4.05 Mrt= 1.52

Mrp= 0.96 Mtp=-0.79

Principal axes:

T Val= 4.73 P1q=73 Azm=344

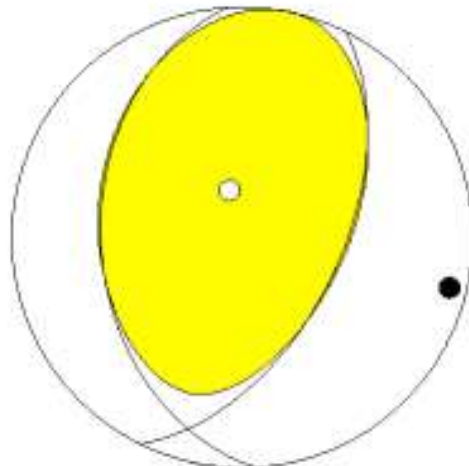
N -0.35 15 196

P -4.39 9 104

Best Double Coupler:  $M_0=4.6 \times 10^{+17}$ 

NP1: Strike=177 Dip=39 Slip= 66

NP2: 26 55 108



# Comparisons TransportableArray

Southern Texas 4.8  
2011-10-20

## USGS/SLU Regional Moment Solution

### SOUTHERN TEXAS

11/10/20 12:24:40.58

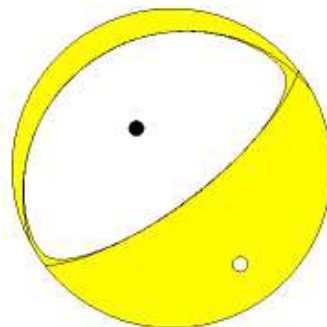
Epicenter: 28.803 -98.154  
MW 4.8

#### USGS/SLU REGIONAL MOMENT TENSOR

Depth 5 No. of sta: 22  
Moment Tensor; Scale  $10^{+16}$  Nm  
Mrr=-1.05 Mtt= 0.73  
Mpp= 0.32 Mrt=-1.14  
Mrp=-0.91 Mtp= 0.46

Principal axes:  
T Val= 1.78 Plg=27 Azm=145  
N 0.03 3 53  
P -1.80 63 318

Best Double Couple:Mo= $1.8 \cdot 10^{+16}$   
NP1:Strike= 53 Dip=72 Slip= -93  
NP2: 241 18 -82



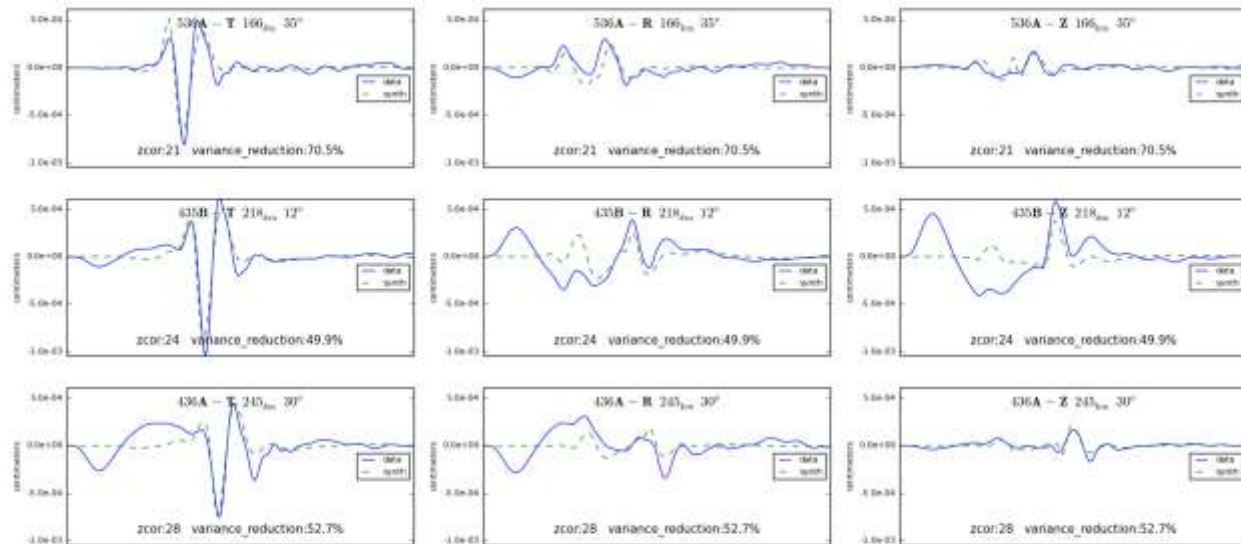
10/20/2011 12:24:41.600

ID: 267274 Quality: 2

## Location:

Lat: 28.865  
 Lon: -98.079  
 Depth: 5 km  
 Ffcr: 0.01 d 0.05 4  
 Model: SOCAL\_MODEL

Mw: 4.7  
 Strike:[244, 53] Rake:[-84, -99] Dip:[57, 33]  
 Pdc: 88 %  
 Polvd: 12 %  
 VAR: 8.725e-09  
 VarRed: 5.379e+01  
 VarPdc: 9.961e-11  
 Mo: 1.39514e+23  
 Mxx:943.740 Myy:-629.896 Mzz:537.164  
 Myz:280.062 Myx:-183.567 Mzx:-1223.802



## USGS/SLU Regional Moment Solution

## SOUTHERN TEXAS

11/10/20 12:24:40.58

Epicenter: 28.803 -98.154  
 MW 4.8

## USGS/SLU REGIONAL MOMENT TENSOR

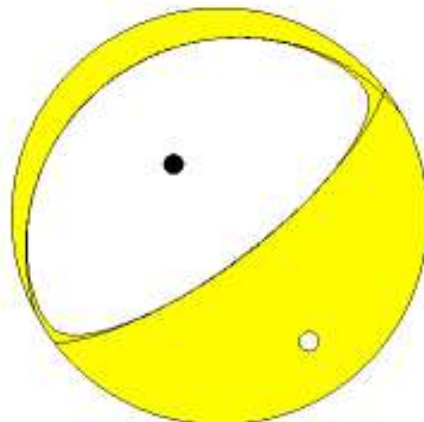
Depth 5 No. of sta: 22  
 Moment Tensor; Scale 10\*\*16 Nm  
 Mrr=-1.05 Mtt= 0.73  
 Mpp= 0.32 Mrt=-1.14  
 Mrp=-0.91 Mtp= 0.46

## Principal axes:

T Val= 1.78 Plg=27 Azm=145  
 N 0.03 3 53  
 P -1.80 63 318

Best Double Couple:Mo=1.8\*10\*\*16

NP1:Strike= 53 Dip=72 Slip= -93  
 NP2: 241 18 -82



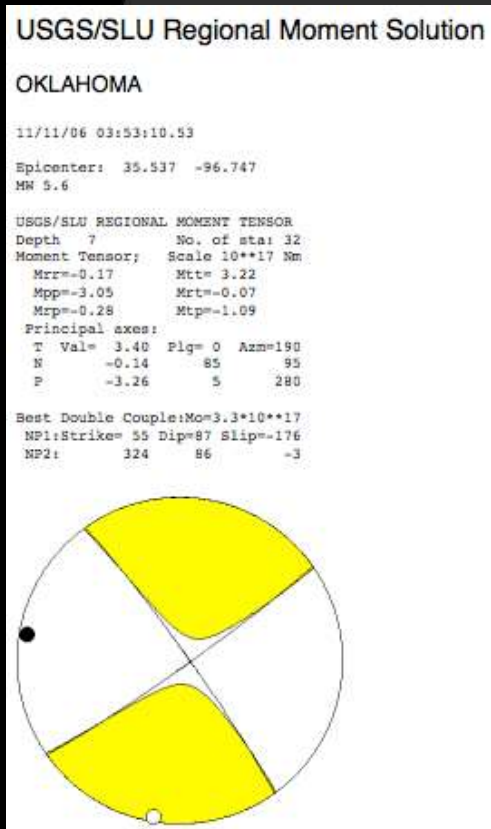
Moment tensor computed using the t3d-tvc package developed by  
 Douglas Dreger of the Berkeley Seismological Laboratory, and Green's  
 functions were computed using the F90FDC software developed by  
 Charles Satake, earth.109.

Antenna's implementation of code by "Jean-Frederic" (jfrederic108@gmail.com)

0p0/antenna5.5.com/antenna5/antenna5 + + 4 + 1989 0.01 + 0.06 4 usarray 163753  
 Generated at 5/14/2016 21:31:37.432

# Comparisons TransportableArray

Oklahoma 5.6  
2011-11-06





Mw: 5.7  
 Strike:[237, 146] Rake:[-171, -5] Dip:[85, 81]  
 Pdc: 91 %  
 Pclvd: 9 %  
 VAR: 2.568e-06  
 VarRed: 8.958e+01  
 Var/Pdc: 2.810e-08  
 Mo: 3.63997e+24  
 Mxx:32795.212 Mxy:13642.491 Mxz:3110.743  
 Myy:-33245.207 Myz:-6370.573 Mzz:449.995



# USGS/SLU Regional Moment Solution

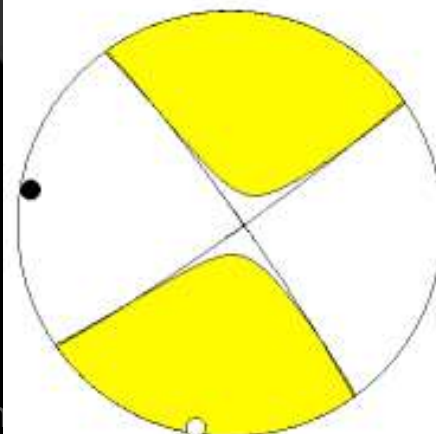
## OKLAHOMA

11/11/06 03:53:10.53

Epicenter: 35.537 -96.747  
 MW 5.6

USGS/SLU REGIONAL MOMENT TENSOR  
 Depth 7 No. of sta: 32  
 Moment Tensor; Scale  $10^{**17}$  Nm  
 Mrr=-0.17 Mtt= 3.22  
 Mpp=-3.05 Mrt=-0.07  
 Mrp=-0.28 Mtp=-1.09  
 Principal axes:  
 T Val= 3.40 Plg= 0 Azm=190  
 N -0.14 85 95  
 P -3.26 5 280

Best Double Couple:Mo=3.3\*10\*\*17  
 NP1:Strike= 55 Dip=87 Slip=-176  
 NP2: 324 86 -3





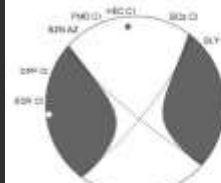








Computer-generated solution; not reviewed



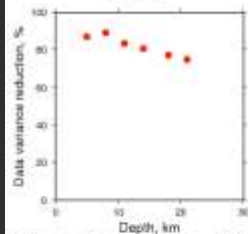
Hypocentral Location:		Moment Tensor:	
Event ID:	20190811083019	Moment:	4.76e+24 dyn-cm
Origin Time:	20190811 08:30:19	Scale:	1.0e+24 dyn-cm
Latitude:	33.0979	Strk:	-4.13
Longitude:	-113.5219	Len:	0.960
Depth (CI):	4.4 km	Max:	0.865
Depth (MT, not published):	5 km	Min:	0.229
		Std:	0.227
		Max:	4.924
		Minimum Reduction:	0%

## Best-Fit Double-Couple Solution

Decomposition Statistics:		Plane Strike-Slip Ratio (%)	
Scale:	1.0e+24 dyn-cm	SFF:	1.00
Axis Value (Plane Solution):		SRF:	0.00
T:	3.160e-9	NSF:	0.00
N:	4.762e-9		
F:	-4.377e-9		

## Station Compensation:

Type:	Percent
Std:	7%
CI:	23.923
Min:	0.001



Waveform data (solid line) and synthetic data (dashed line) from the moment tensor inversion:



Mw: 5.8  
 Strike:[134, 41] Rake:[-148, -4] Dip:[86, 58]  
 Pdc: 73 %  
 Pclvd: 27 %  
 VAR: 4.155e-06  
 VarRed: 8.955e+01  
 Var/Pdc: 5.656e-08  
 Mo: 5.18957e+24  
 Mxx:-40074.086 Mxy:5581.297 Mxz:-18011.894  
 Myy:47737.180 Myz:-20165.020 Mzz:-7663.094

# Comparisons TransportableArray

Colorado 5.3  
2011-08-23

## USGS/SLU Regional Moment Solution

### COLORADO

11/08/23 05:46:19.15

Epicenters: 37.118 -104.622  
MW 5.3

#### USGS/SLU REGIONAL MOMENT TENSOR

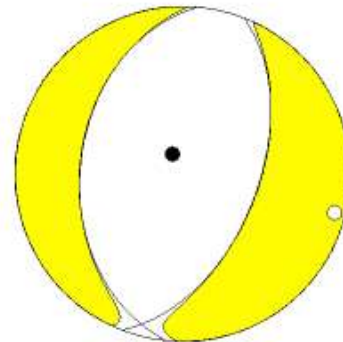
Depth 3 No. of sta: 42  
Moment Tensor; Scale  $10^{16}$  Nm  
Mrf=-9.21 Mtt= 0.15  
Mpp= 9.07 Mrt=-1.85  
Mrp=-2.02 Mtp= 2.26

#### Principal axes:

T Val= 9.91	P1q= 7	Azm=104
N -0.21	8	195
P -9.70	79	332

Best Double Couple:Mo= $9.8 \cdot 10^{16}$

NP1:Strike= 21 Dip=53 Slip= -80  
NP2: 185 38 -103



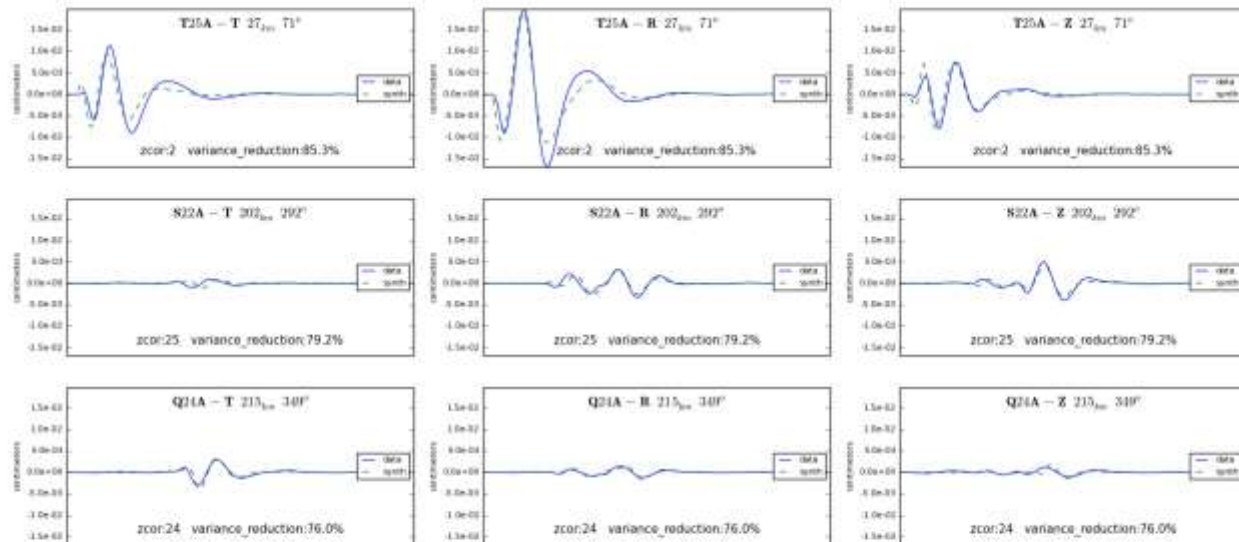
8/23/2011 5:46:18.250

ID: 265845 Quality: 4

## Location:

Lat: 37.063  
 Lon: -104.701  
 Depth: 4 km  
 Filer: 8W 0.02 4 0.05 4  
 Model: SOCAL\_MODEL

Mw: 5.3  
 Strike:[354, 216] Rake:[-118, -56] Dip:[55, 44]  
 Pdc: 54 %  
 Polvd: 45 %  
 VAR: 7.562e-07  
 VarRed: 8.255e+01  
 VarPdc: 1.391e-08  
 Mo: 1.06183e+24  
 Mxx:1214.061 Mxy:-2379.114 Mxz:4634.829  
 Myy:8356.645 Myz:3124.339 Mzz:-9570.706



## USGS/SLU Regional Moment Solution

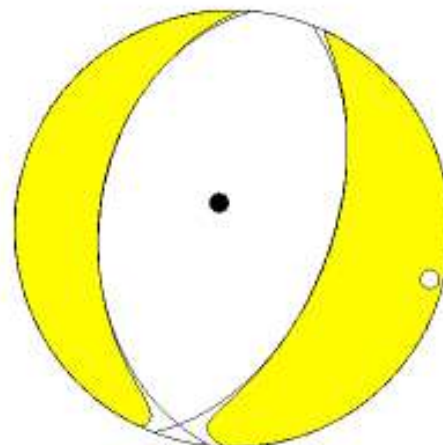
## COLORADO

11/08/23 05:46:19.15

Epicenter: 37.118 -104.622  
 MW 5.3

USGS/SLU REGIONAL MOMENT TENSOR  
 Depth 3 No. of sta: 42  
 Moment Tensor; Scale 10\*\*16 Nm  
 Mrr=-9.21 Mtt= 0.15  
 Mpp= 9.07 Mrt=-1.85  
 Mrp=-2.02 Mtp= 2.26  
 Principal axes:  
 T Val= 9.91 Plg= 7 Azm=104  
 N -0.21 8 195  
 P -9.70 79 332

Best Double Couple: Mo=9.8\*10\*\*16  
 NP1: Strike= 21 Dip=53 Slip= -80  
 NP2: 185 38 -103



Moment tensor computed using the tnt-mv2 package developed by  
 Douglas Dreger of the Berkeley Seismological Laboratory, and Green's  
 functions were computed using the F90FDC software developed by  
 Charles Satake and J.1999.

Antelope's implementation of code by 'Jean-Francois' (jeff@earth.berkeley.edu)

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 Generated at 5/15/2016 22:08:31.434



Q & A