

Antelope and ShakeMap for Romania

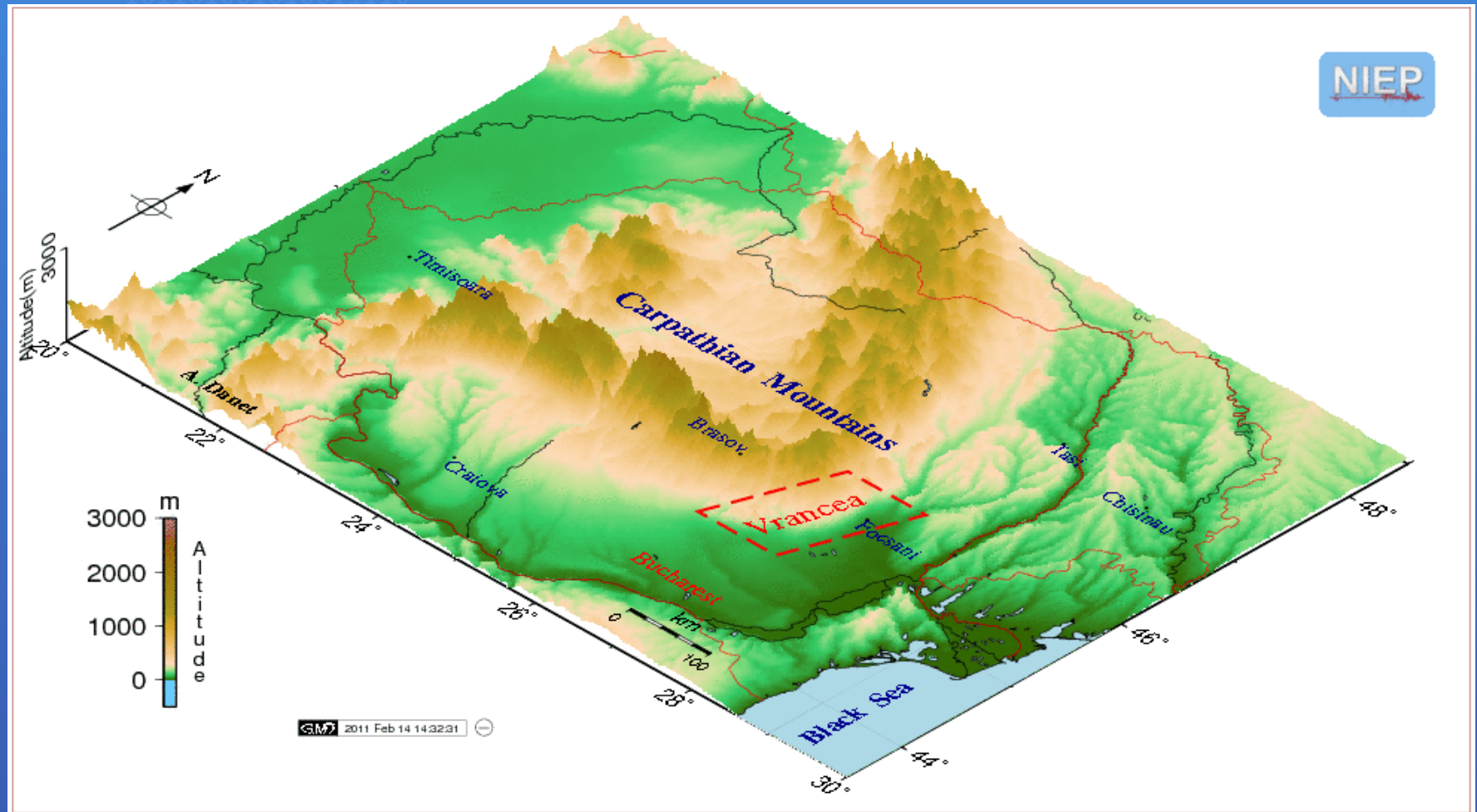
Anton Dăneț and Constantin Ionescu
National Institute for Earth Physics, Bucharest

European Quatterra and Antelope Users Group Meeting
Bucharest, 21-23 March 2011

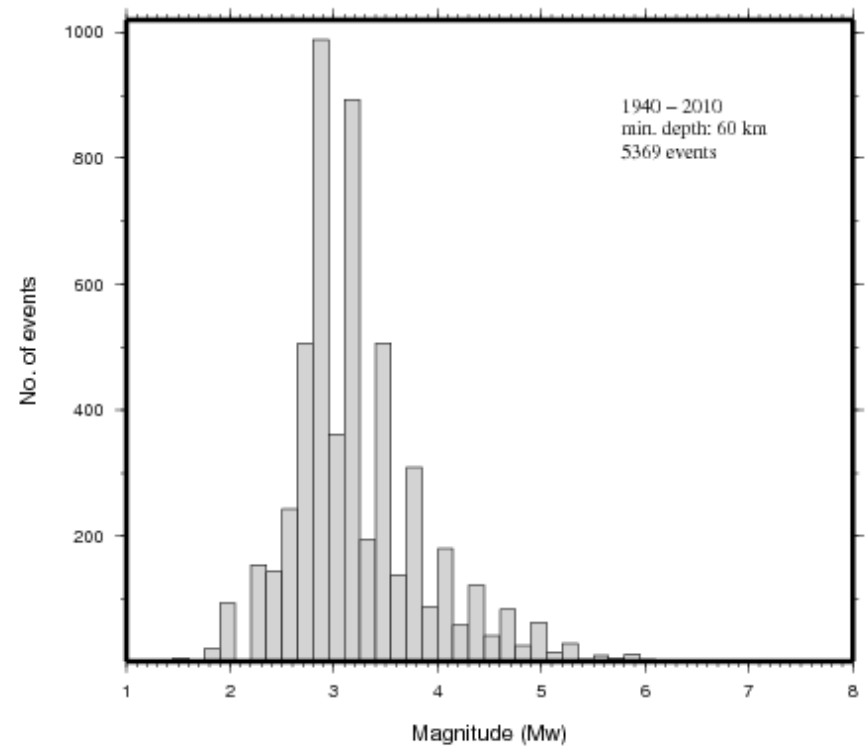
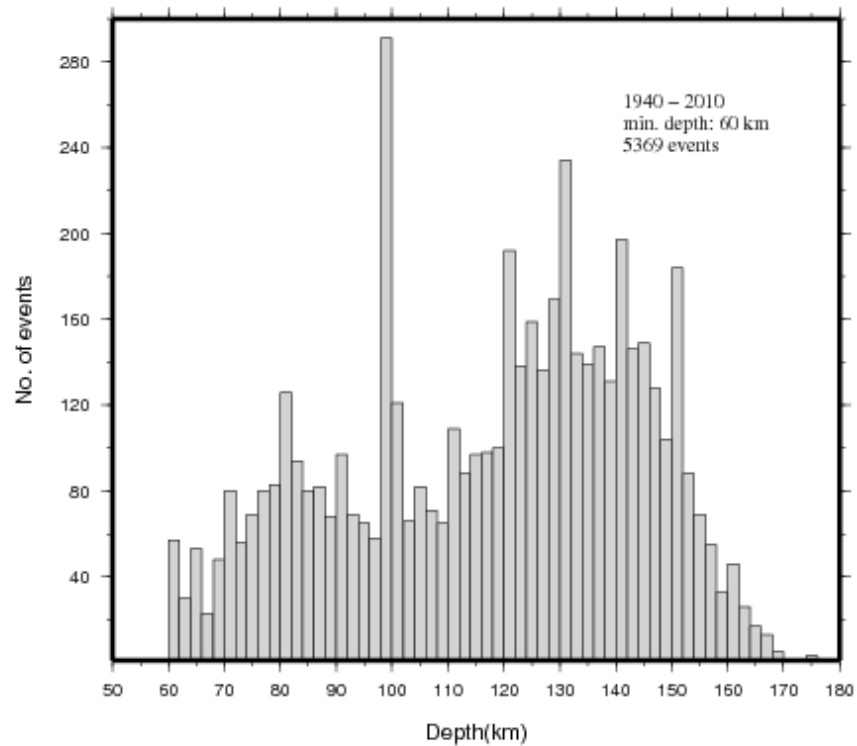
Content

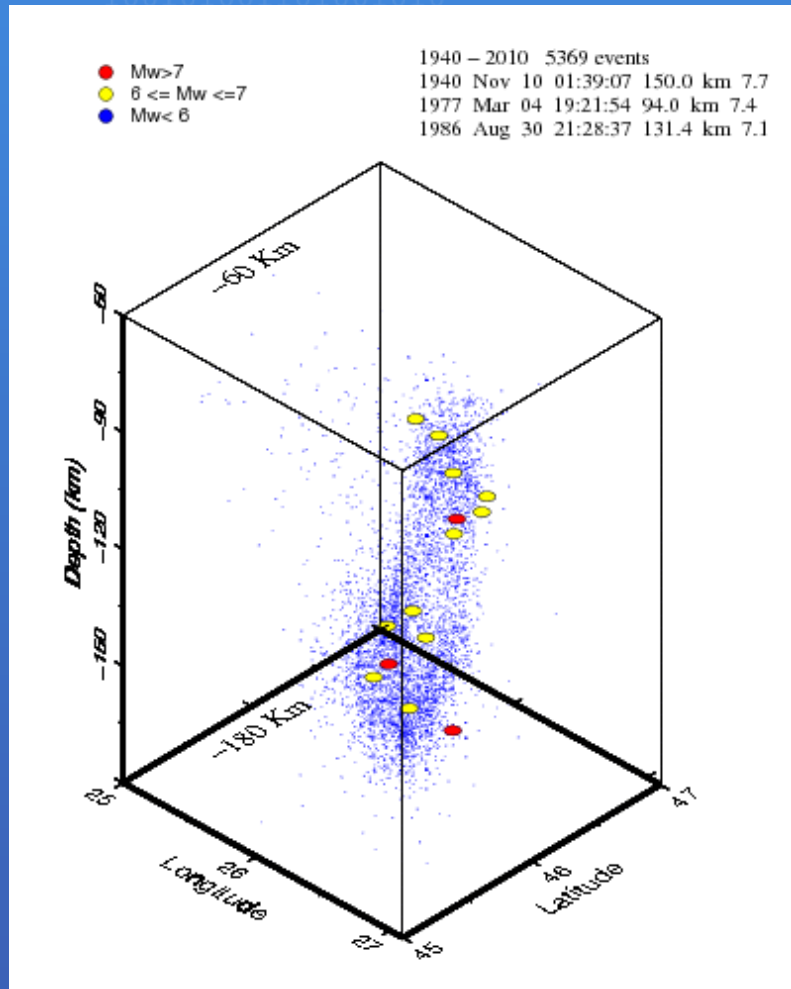
- Vrancea earthquakes
- Seismic stations and instrumentation
- Software implementation
- ShakeMap products
- Performance evaluation

Romania - Vrancea intermediate-depth (60-180Km) seismic zone



Vrancea intermediate-depth earthquakes

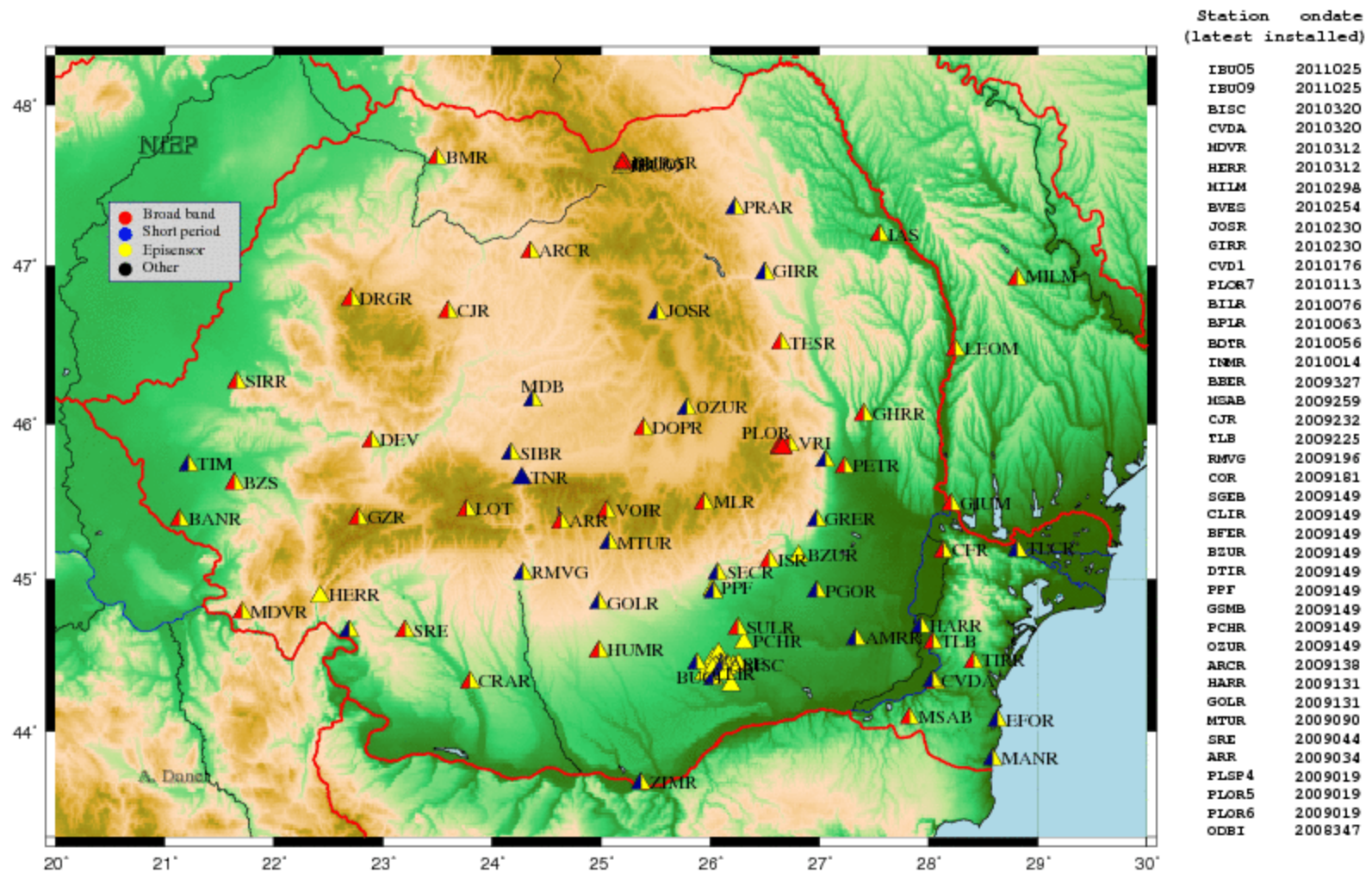




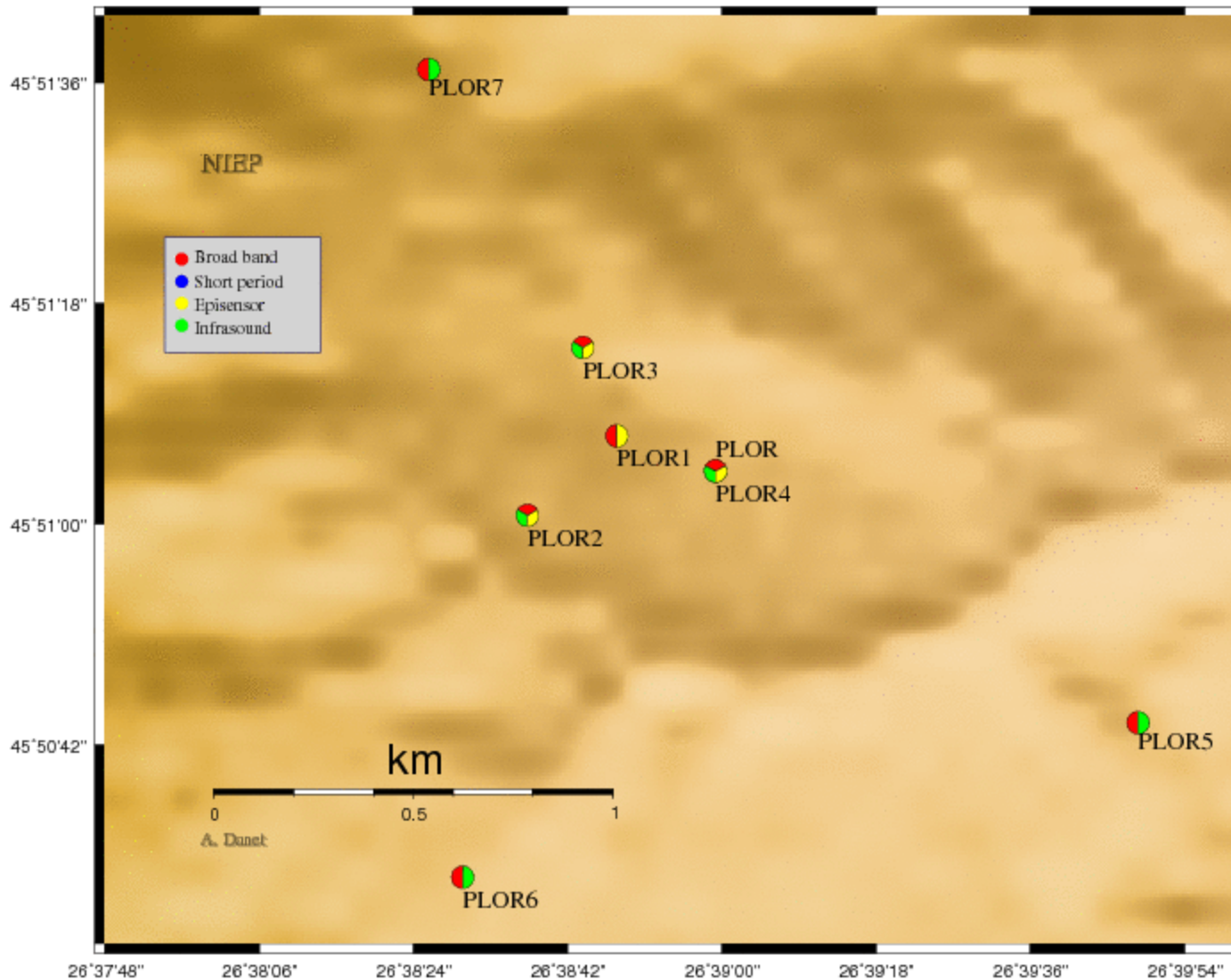
Spatial distribution of Vrancea intermediate-depth earthquakes

- 1940-2010
- 5369 events
- Mw ≥ 6 14
- Mw ≥ 5 137
- Mw ≥ 4 667

Source: ROMPLUS Catalogue

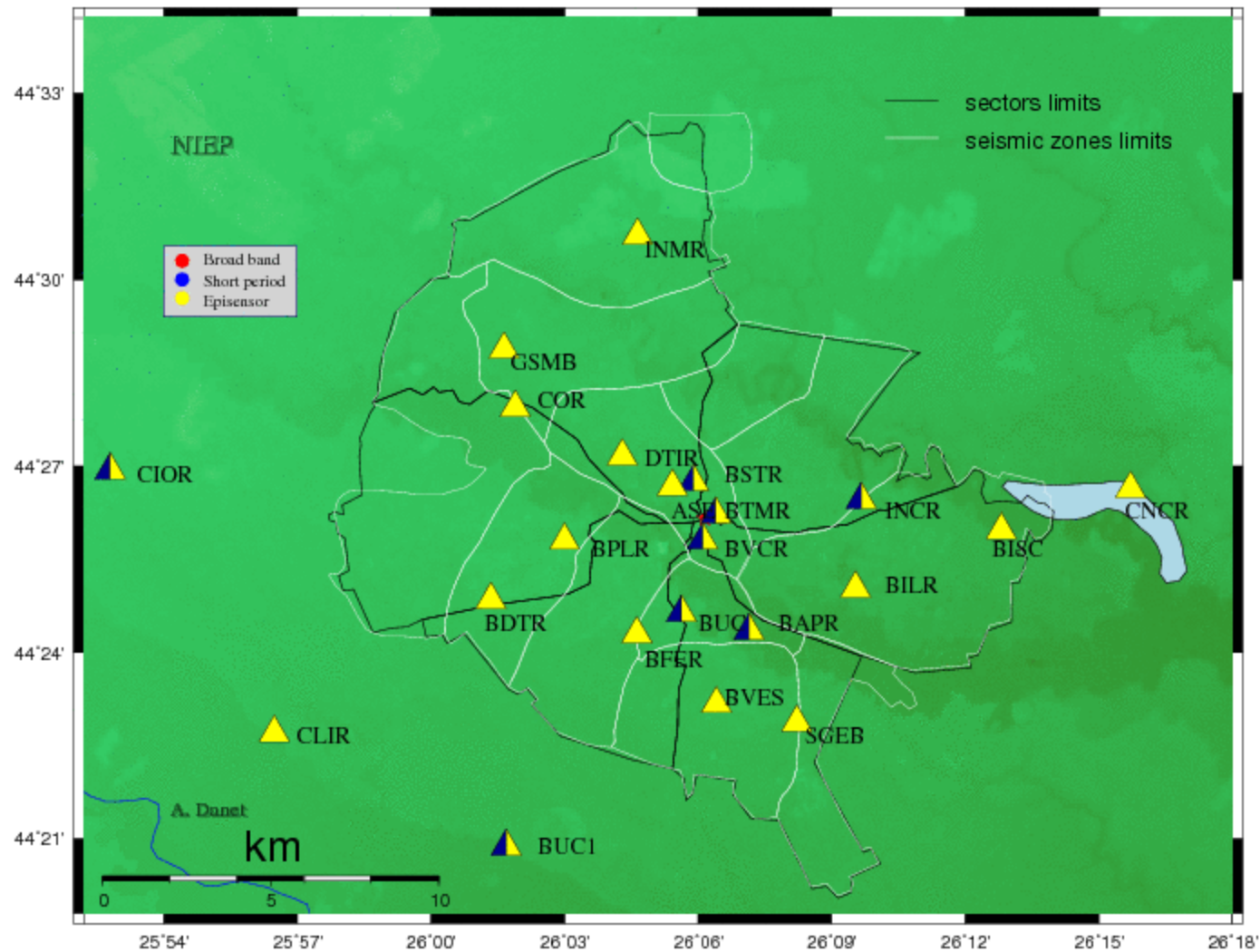


RO stations in the Romanian Seismic Network as of Sun Mar 20, 2011



Station	ondate
IPH7	2010113
PLOR7	2010113
IPL4	2009148
IPH4	2009148
IPL3	2009148
IPH6	2009148
IPH5	2009148
IPL2	2009148
PLOR5	2009019
PLOR6	2009019
PLOR	2007339
PLOR2	2007305
PLOR3	2007305
PLOR4	2007305
PLOR1	2007305

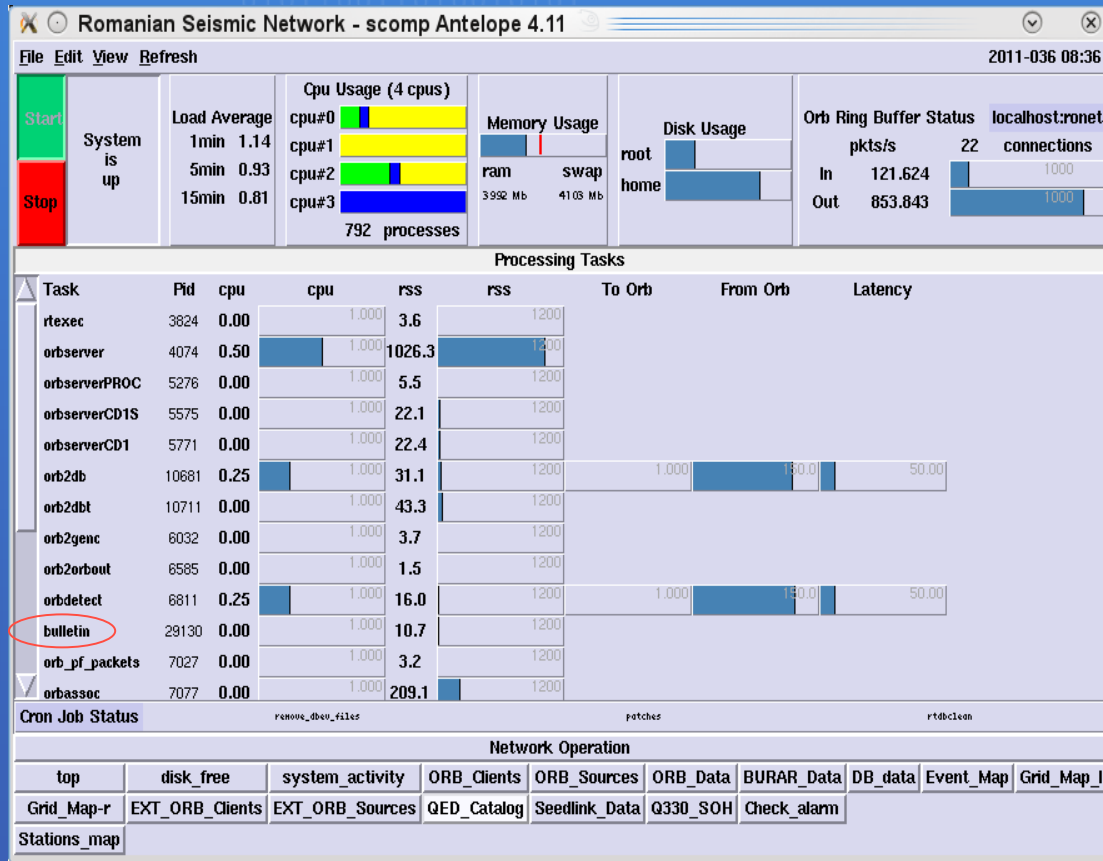
Plostina seismic array as of Sun Mar 20, 2011



Station	ondate
ASE	2011060
BISC	2010320
BVES	2010254
BILR	2010076
BPLR	2010063
BDTR	2010056
INMR	2010014
COR	2009181
CLIR	2009149
SGEB	2009149
DTIR	2009149
GSMB	2009149
BFER	2009149
BAPR	2008256
CNCR	2008256
BVCR	2008249
BSTR	2008234
CIOR	2008227
BTMR	2008193
INCR	2008051
BUC	2007295
BUC1	1997280

Bucharest seismic stations as of Sun Mar 20, 2011

Data preparation for ShakeMap



Antelope 4.11 and ShakeMap 3.5

- seismic bulletin generation
- waveform extraction (trexcerpt)
- wf. measurements: pga, pgv, psa03, psa10, psa30 (dbwfmeas and db2ewpg)
- data formatting: event.xml, db_dat.xml
- (db2shakemap_xm l)

Input to ShakeMap 3.5

1. ✓ measured instrumental ground motion for PGA, PGV, PSA
— macroseismic observations for intensity

(native observations)

2. ✓ ground motion estimates based on GMPE for PGA, PGV, PSA
and IPE for Intensity

3. — converted data, e.g. $PGA=f(MMI)$ or $MMI=g(PGA)$, aka GMICE

PSA : PSA03, PSA10, PSA30

GMPE: Ground Motion Prediction Equation

GMICE: Ground Motion Intensity Conversion Equation

IPE: Intensity Prediction Equation

— not yet implemented

Attenuation relations

- Developed by Vladimir Yu Sokolov for large Vrancea intermediate-depth earthquakes
- Cover the area 20°E - 29°E / 43.5°N - 48°N
- The area is gridded at .25° and divided into zones ; each zone/node has its own set of coefficients
- The site amplification factors are “hard coded” in these sets of coefficients
- Implemented as GMPE (VS10) and IPE (VS04) Perl modules in ShakeMap library

ShakeMap Home Page

Choose "Most Recent Event" to see maps for the most recent earthquake, or click on the "Map Archive" tab at the top of the page to view past events.

Most Recent Event

Location	Date	Time	Magnitude
ROMANIA <i>(ID 7377)</i>	Mar 17 2011	02:27:48 GMT	3.1



Please use the [comment form](#) for questions, comments, or suggestions about the ShakeMaps.
 Page maintained by the ShakeMap Working Group.
 Page last generated Thu Mar 17 04:32:45 2011.

EVENT ON
Mar 04 1977

Instrumental
Intensity

Peak Ground
Acceleration

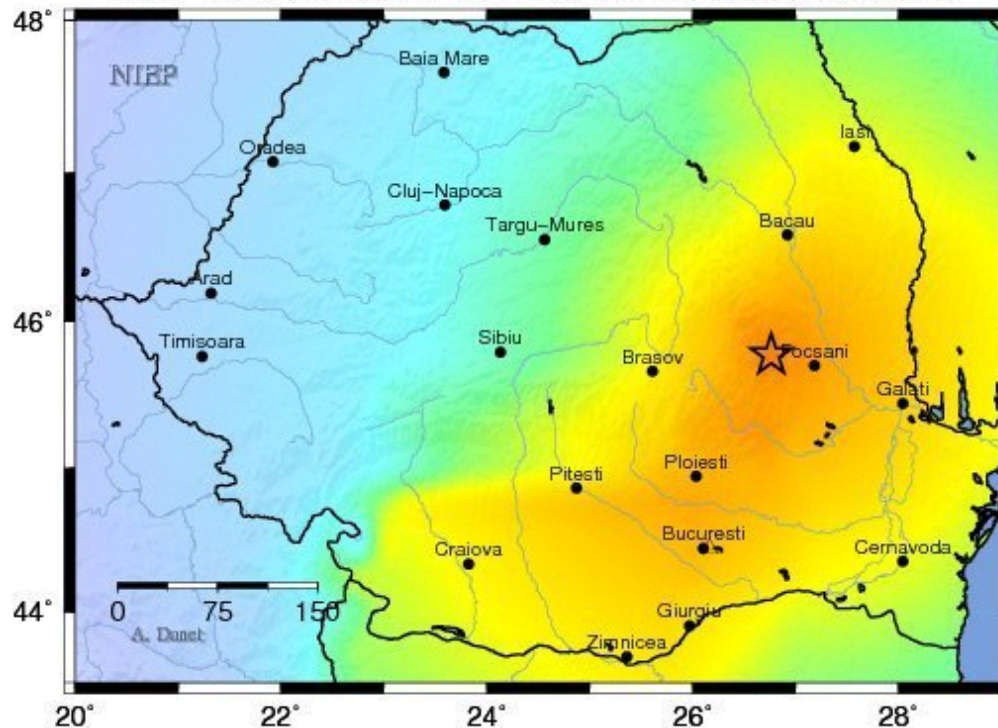
Peak Ground
Velocity

Spectral
Response

Download

NIEP ShakeMap : ROMANIA

Fri Mar 4, 1977 19:21:54 GMT M 7.4 N45.77 E26.76 Depth: 94.0km ID:177



Map Version 7 Processed Sat Feb 19, 2011 09:02:23 AM EST

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

EVENT ON
Mar 04 1977

Instrumental
Intensity

Peak Ground
Acceleration

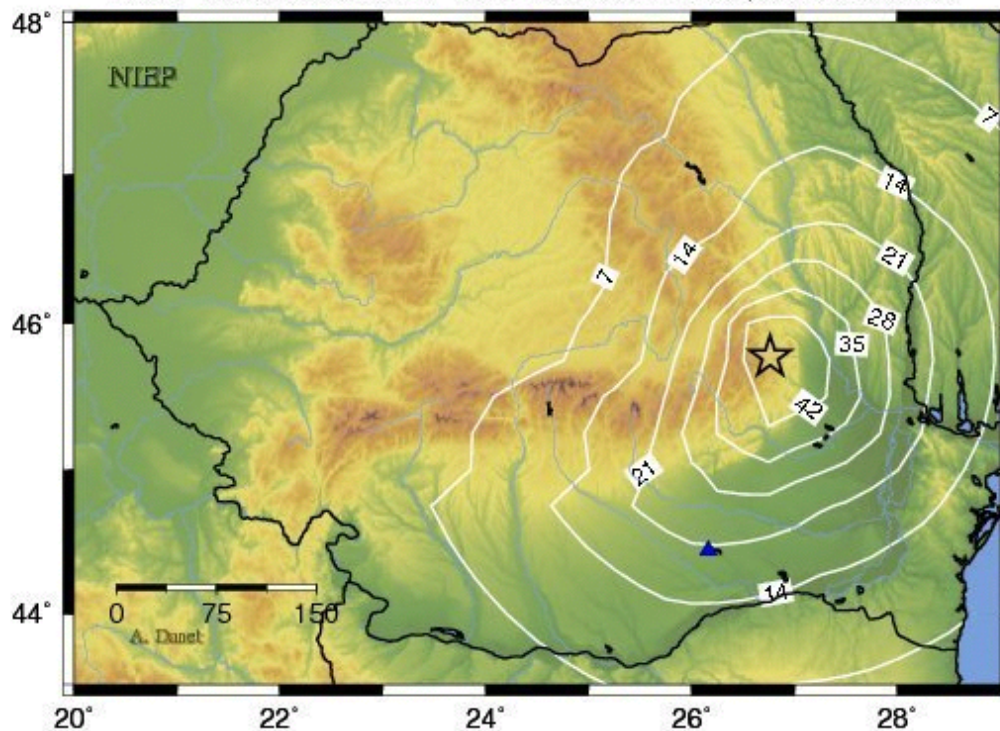
Peak Ground
Velocity

Spectral
Response

Download

NIEP Peak Accel. Map (in %g) : ROMANIA

Fri Mar 4, 1977 19:21:54 GMT M 7.4 N45.77 E26.76 Depth: 94.0km ID:177



pga(%g)

sta	dist(km)	o	u	b	(o-u)/o(%)	(o-b)/o(%)	ln(o/u)	ln(o/b)
INC	155.20	19.90	12.10	19.90	39.20	0.00	0.4975	0.0000

o – observed values
u – estimated unbiased
b – estimated biased

Earthquake

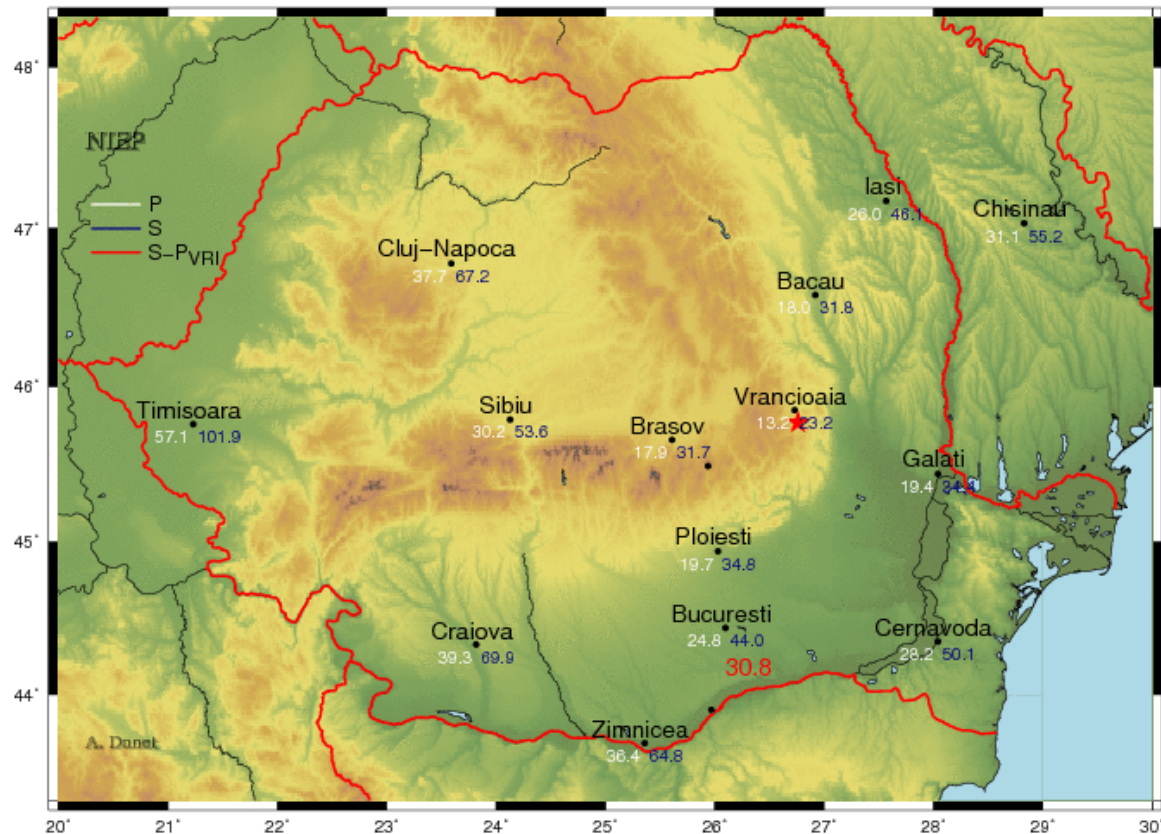
Event ID	Magnitude	Date	Time	Lat	Lon	Depth	Bpga	Bpgv
177	7.4	3/4/1977	19:21:54 GMT	N45.7700	E26.7600	94.000 km	0.52	0.00

Seismic Stations

INC:	Incerc	Lat: 44.4400 Lon: 26.1600 Distance: 155.2 km from epicenter			Agency: RO
Station Comp	Max Vel (cm/s)	Max Acc (%g)	PSA: 0.3 sec (%g)	1.0 sec (%g)	3.0 sec (%g)
EHN		19.8702			
EHE		16.6246			

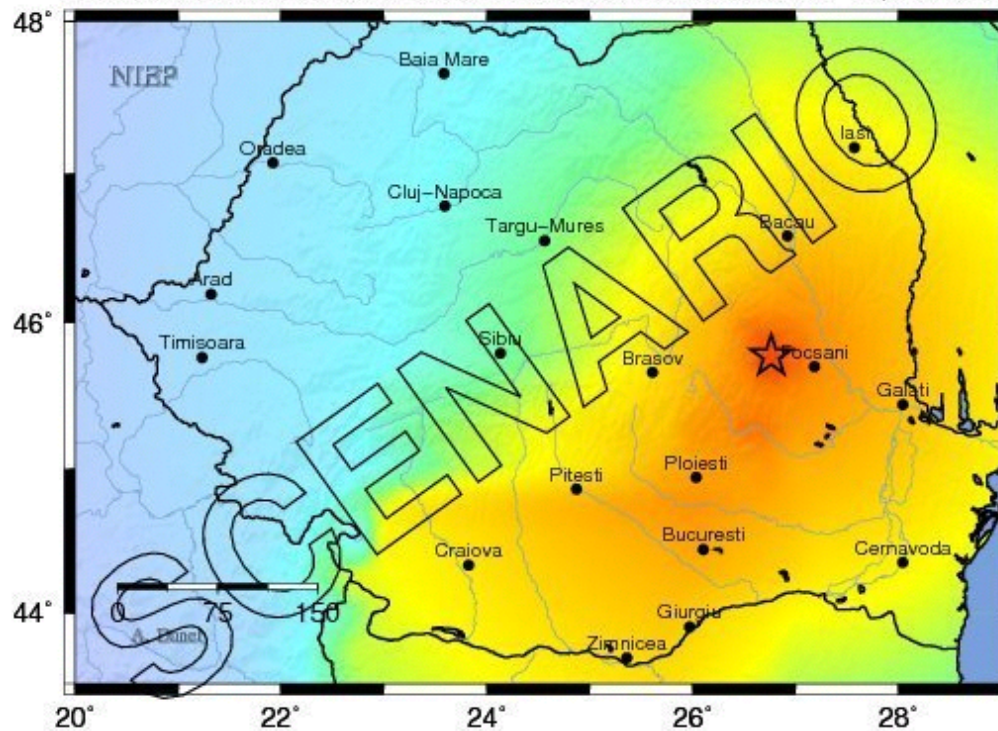
Travel times

Mar 04, 1977 19:21:54 GMT M 7.4 N:45.77 E:26.76 Depth: 94.0 km ID:177



--- Earthquake Planning Scenario ---
ShakeMap for 180 Scenario

Scenario Date: Tue Mar 4, 1980 19:21:54 GMT M 7.6 N45.77 E26.76 Depth: 94.0km



PLANNING SCENARIO ONLY --- Map Version 1 Processed Wed Dec 15, 2010 11:18:05 AM EST

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

EVENT ON
Aug 30 1986

Instrumental
Intensity

Peak Ground
Acceleration

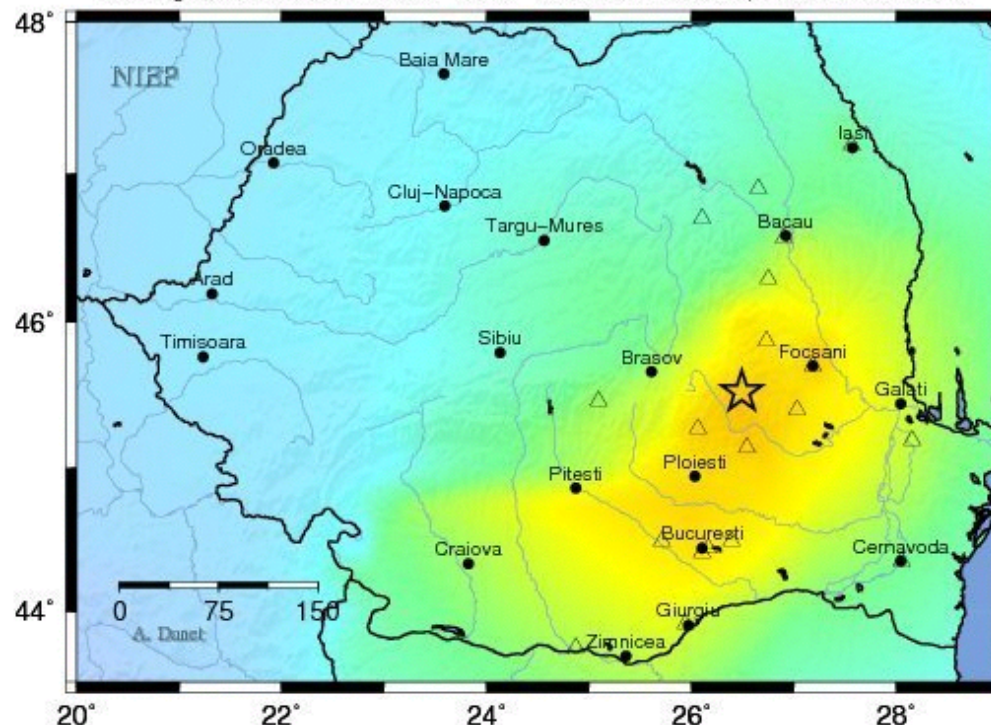
Peak Ground
Velocity

Spectral
Response

Download

NIEP ShakeMap : ROMANIA

Sat Aug 30, 1986 21:28:37 GMT M 7.1 N45.52 E26.49 Depth: 131.4km ID:186



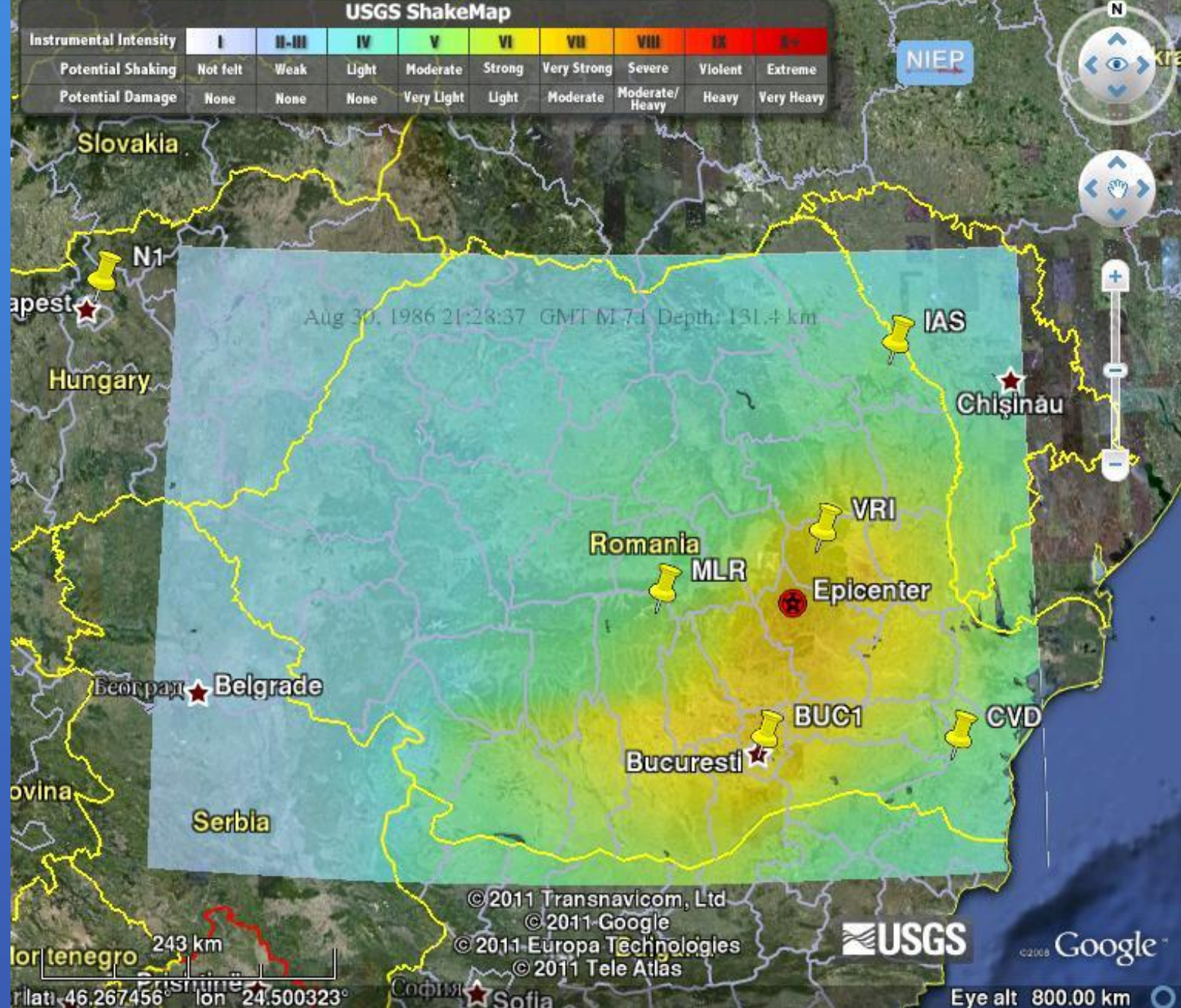
Map Version 5 Processed Thu Feb 17, 2011 11:15:25 AM EST

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

USGS ShakeMap

Instrumental Intensity	I	II-III	IV	V	VI	VII	VIII	IX	X+
Potential Shaking	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
Potential Damage	None	None	None	Very Light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy

NIEP

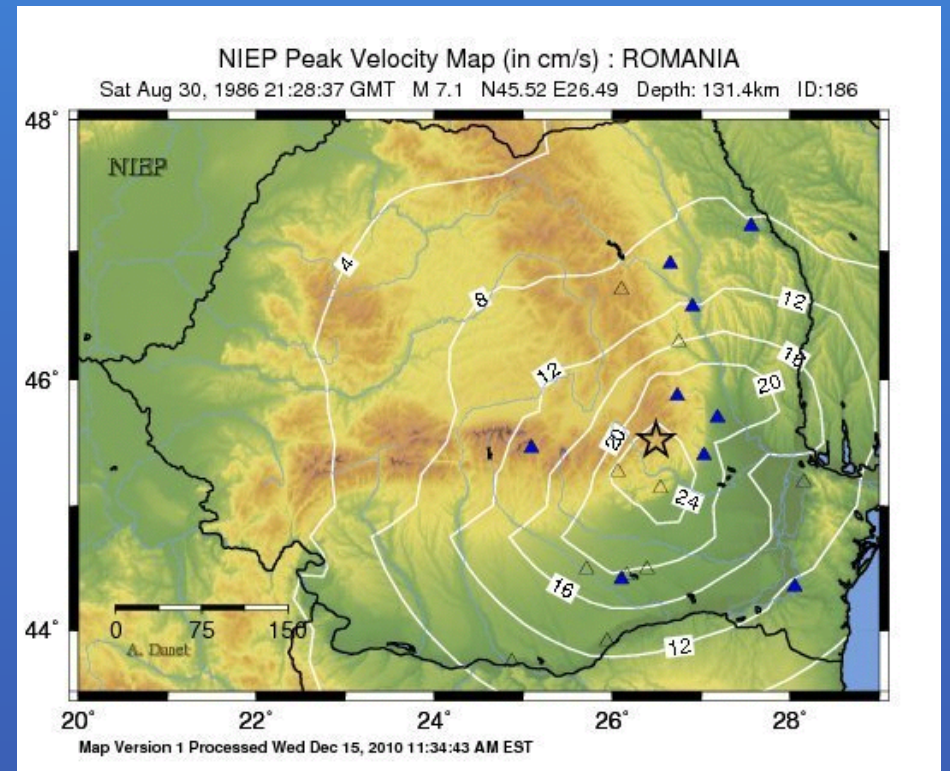
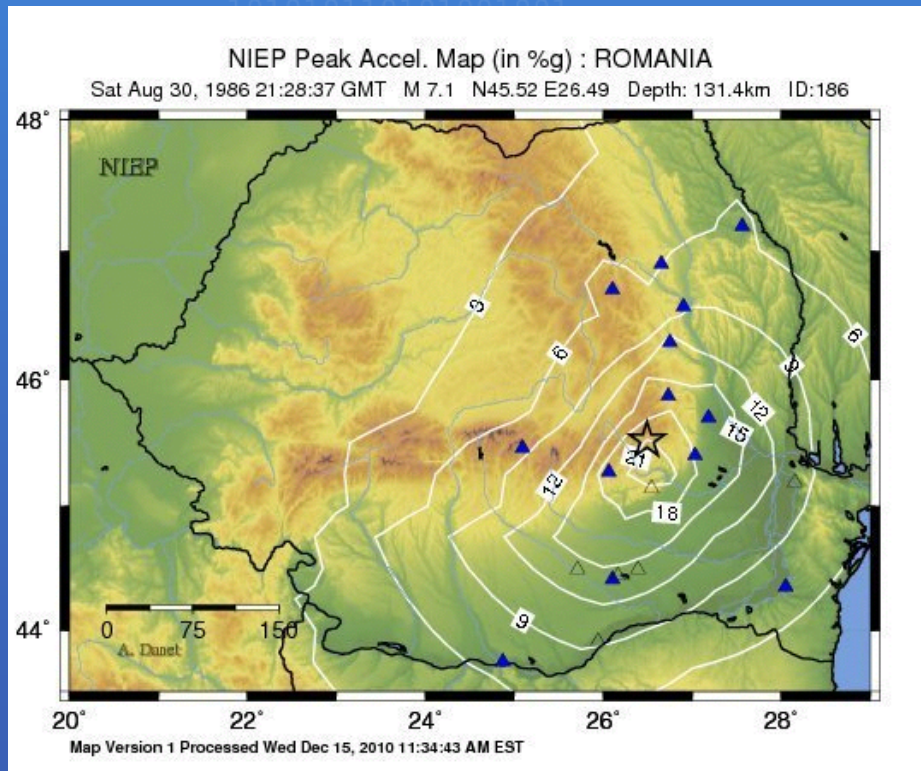


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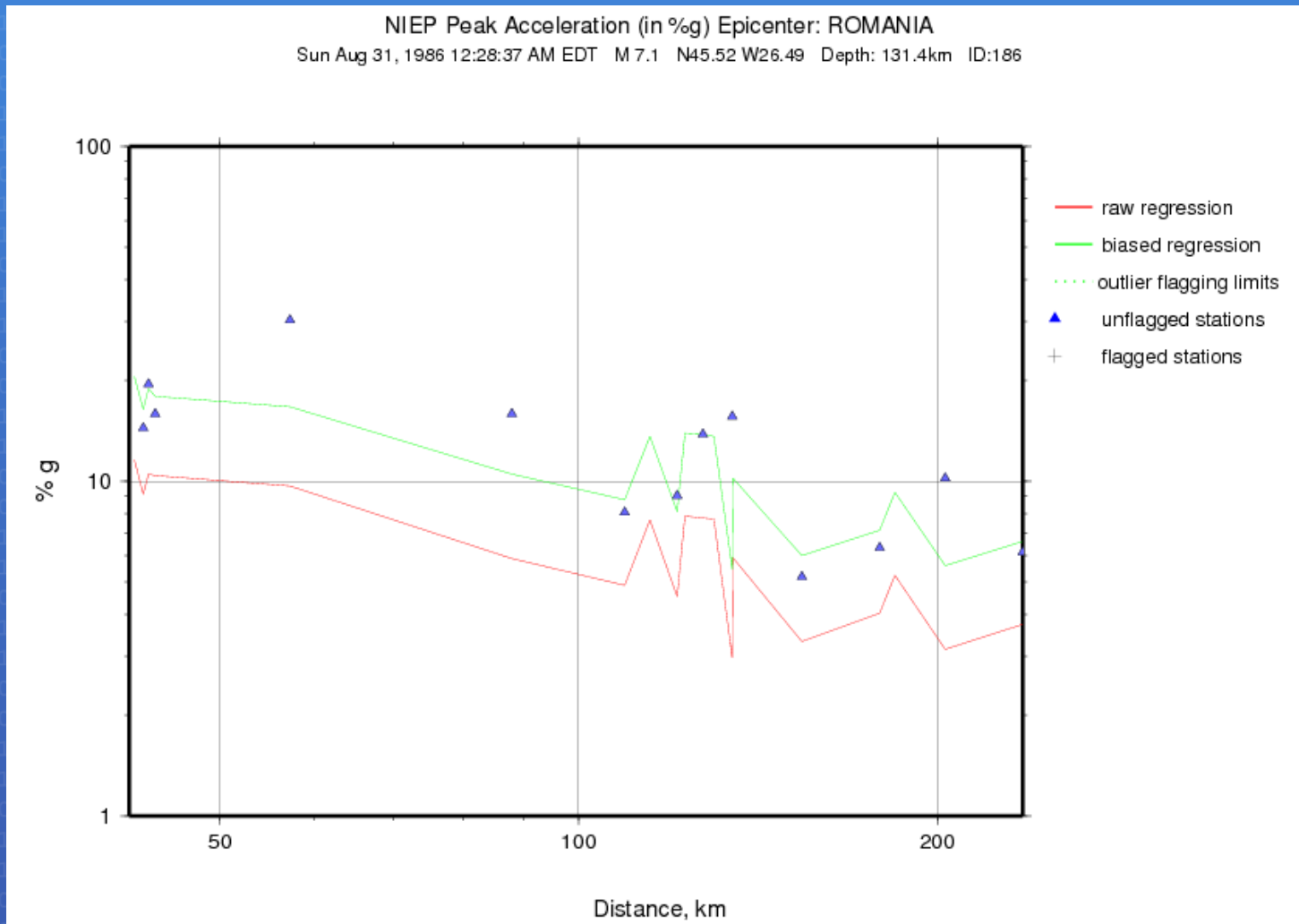
USGS

©2008 Google

Acceleration and velocity maps Aug 30, 1986 Mw 7.1



Acceleration regression Aug 30, 1986 Mw 7.1

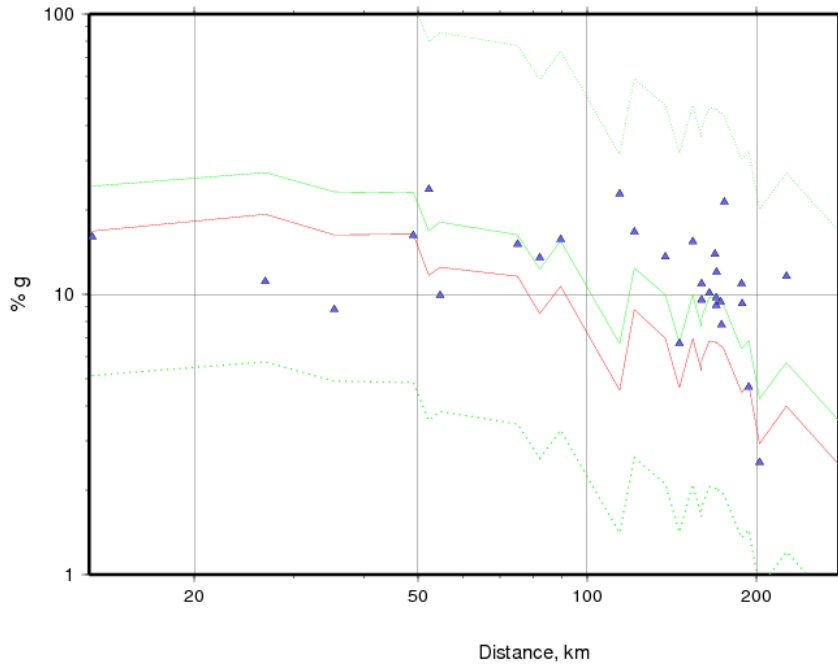


Acceleration regression May 30, 31 1990

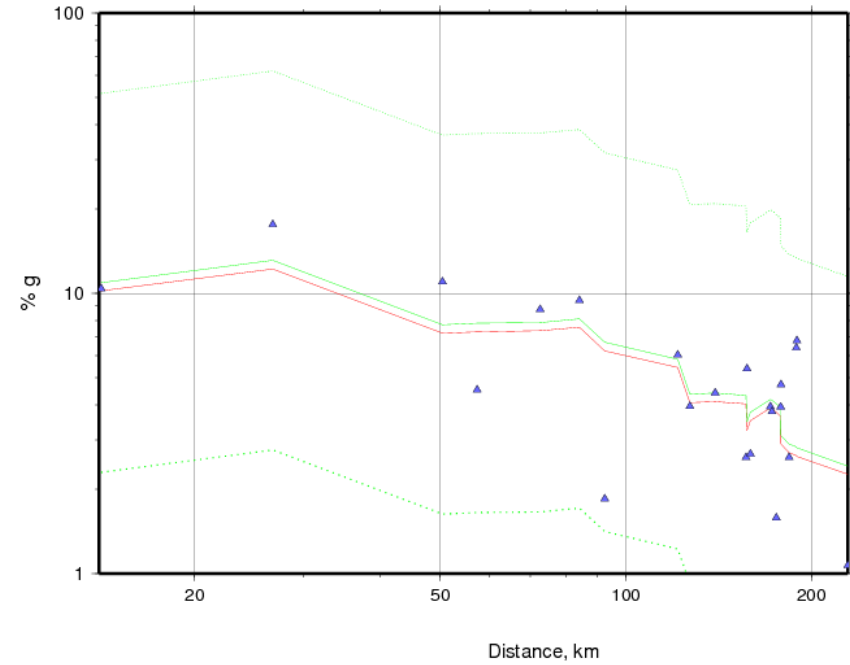
Mw 6.9

Mw 6.4

NIEP Peak Acceleration (in %g) Epicenter: ROMANIA
Wed May 30, 1990 01:40:06 PM EDT M 6.9 N45.83 W26.89 Depth: 91.0km ID:190

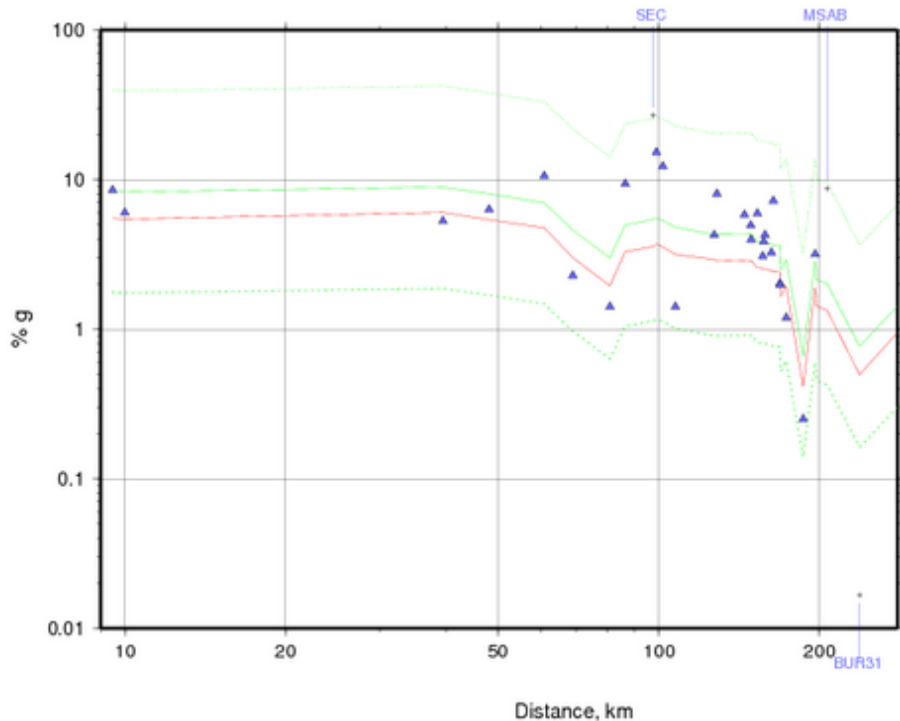


NIEP Peak Acceleration (in %g) Epicenter: ROMANIA
Thu May 31, 1990 03:17:47 AM EDT M 6.4 N45.85 W26.91 Depth: 87.0km ID:191

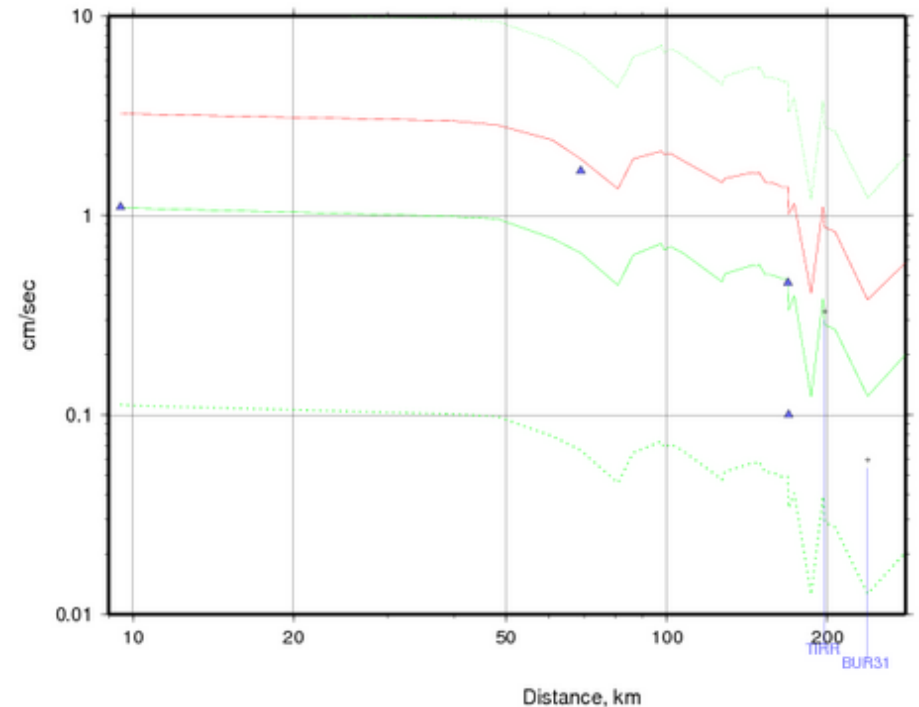


Acceleration and velocity regression Oct 27, 2004 Mw 6.0

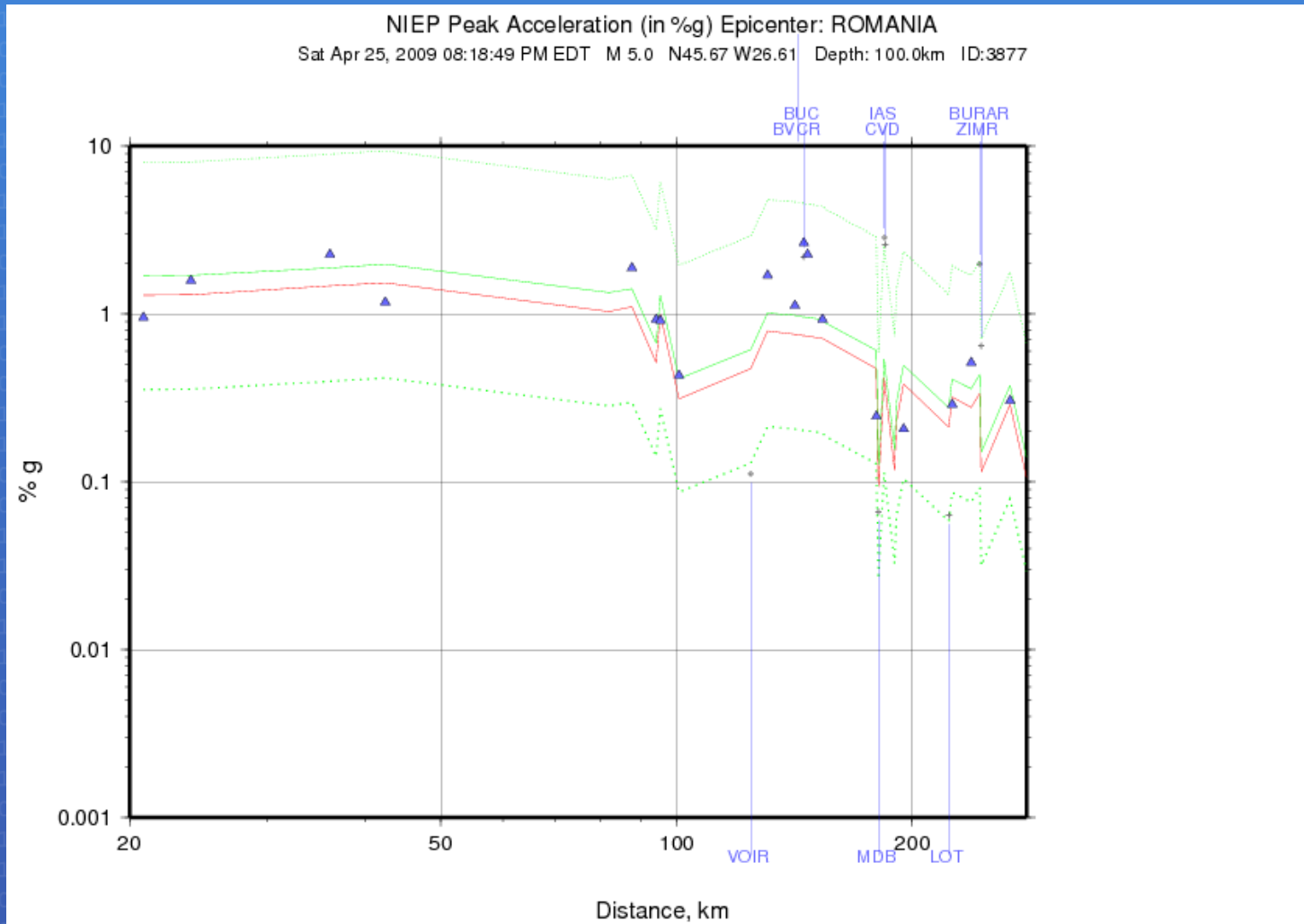
NIEP Peak Acceleration (in %g) Epicenter: ROMANIA
Wed Oct 27, 2004 11:34:36 PM EDT M 6.0 N45.78 W26.73 Depth: 98.6km ID:1356



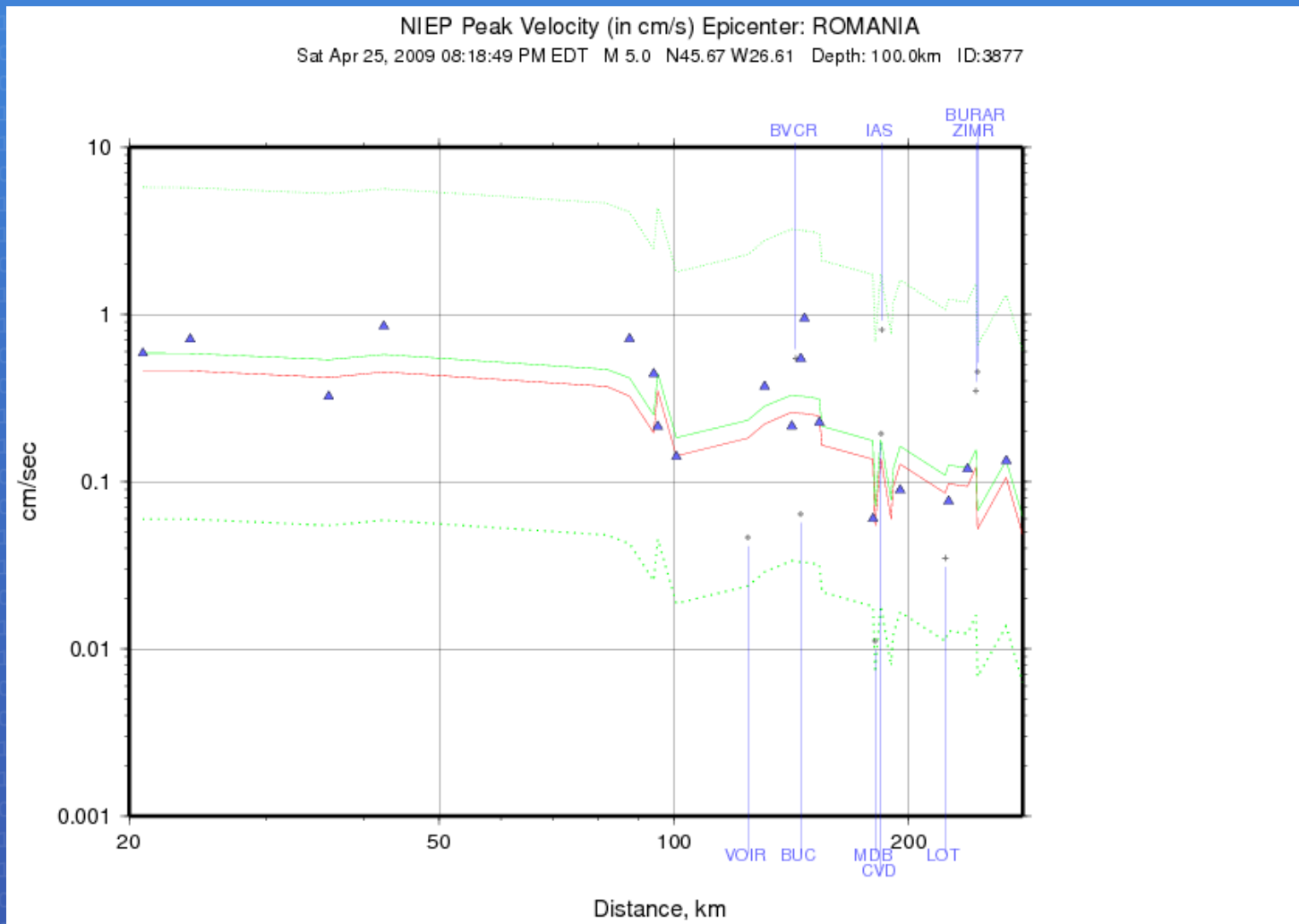
NIEP Peak Velocity (in cm/s) Epicenter: ROMANIA
Wed Oct 27, 2004 11:34:36 PM EDT M 6.0 N45.78 W26.73 Depth: 98.6km ID:1356



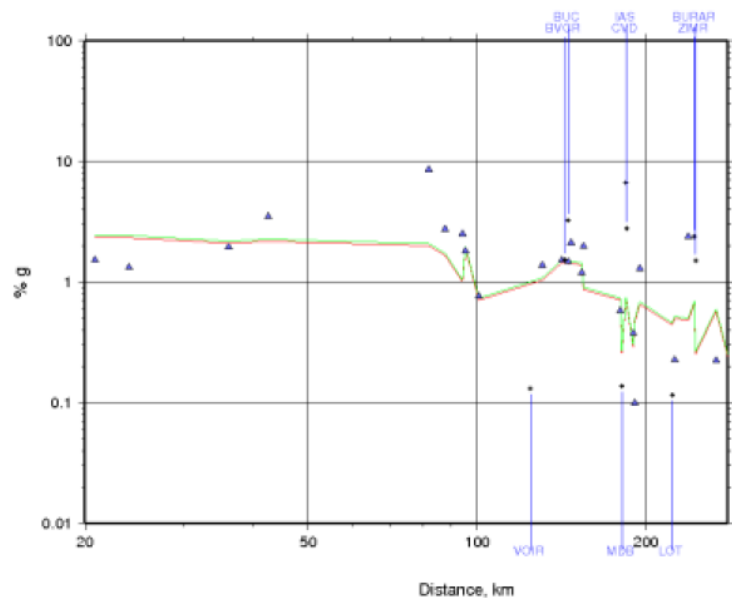
Acceleration regression Apr 25, 2009 Mw 5.0



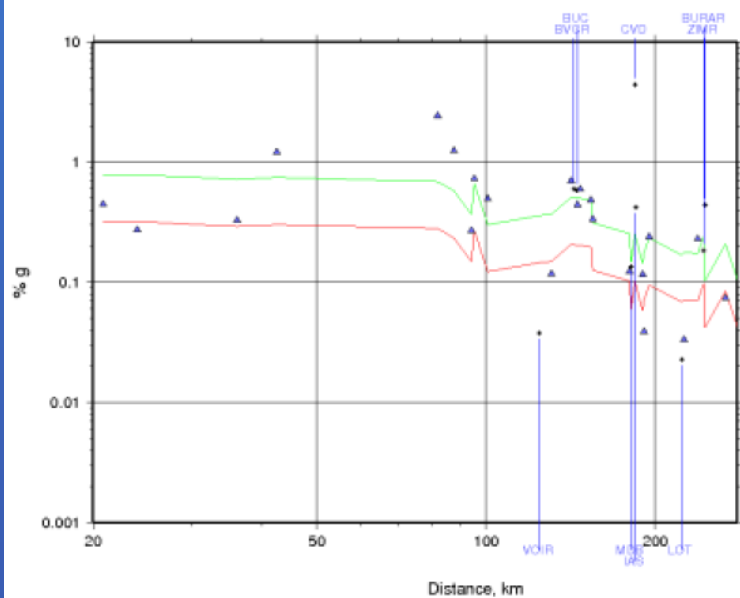
Velocity regression Apr 25, 2009, Mw 5.0



NIEP 0.3 s Pseudo-Acceleration Spectra (%g) Epicenter: ROMANIA
Sat Apr 25, 2009 08:18:49 PM EDT M 5.0 N45.67 W26.61 Depth: 100.0km ID:3877



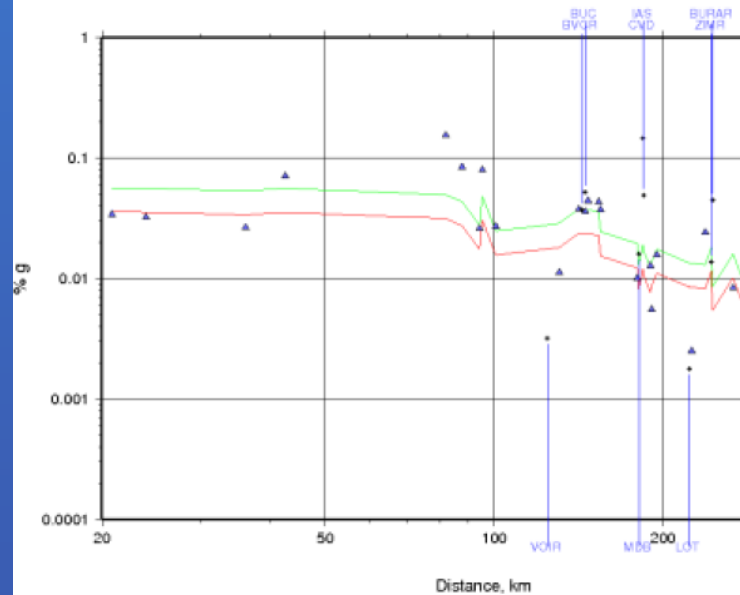
NIEP 1.0 s Pseudo-Acceleration Spectra (%g) Epicenter: ROMANIA
Sat Apr 25, 2009 08:18:49 PM EDT M 5.0 N45.67 W26.61 Depth: 100.0km ID:3877



Pseudo-Acceleration Spectra

Apr 25, 2009 Mw 5.0

NIEP 3.0 s Pseudo-Acceleration Spectra (%g) Epicenter: ROMANIA
Sat Apr 25, 2009 08:18:49 PM EDT M 5.0 N45.67 W26.61 Depth: 100.0km ID:3877



Earthquake

Event ID	Magnitude	Date	Time	Lat	Lon	Depth	Bpga	Bpgv
3877	5.0	4/25/2009	20:18:49 PDT	N45.6656	E26.6132	100.0000 km	0.18	0.12

Seismic Stations

BAPR: Bucurest - Parcul Copiilor Agency: RO

Lat: 44.4059 Lon: 26.1190 Distance: 145.4 km from epicenter

Station Comp	Max Vel (cm/s)	Max Acc (%g)	PSA: 0.3 sec (%g)	1.0 sec (%g)	3.0 sec (%g)
EHN	-0.2909				
HNN		1.6282	1.4736	0.4413	0.0357
SHN	-0.2426				
EHE	-0.5448				
SHE	-0.4066				
HNE		-2.6520			

BMR: Baia Mare Agency: RO

Lat: 47.6728 Lon: 23.4969 Distance: 326.1 km from epicenter

Station Comp	Max Vel (cm/s)	Max Acc (%g)	PSA: 0.3 sec (%g)	1.0 sec (%g)	3.0 sec (%g)
HHN	0.0282				
HHE	-0.0156				
HNN		0.0336	0.0633	0.0337	0.0046
BHN	-0.0278		0.0577	0.0332	0.0046
HNE		0.0188	0.0388	0.0264	0.0039
BHE	-0.0157		0.0250	0.0027	0.0000

PGA error statistics

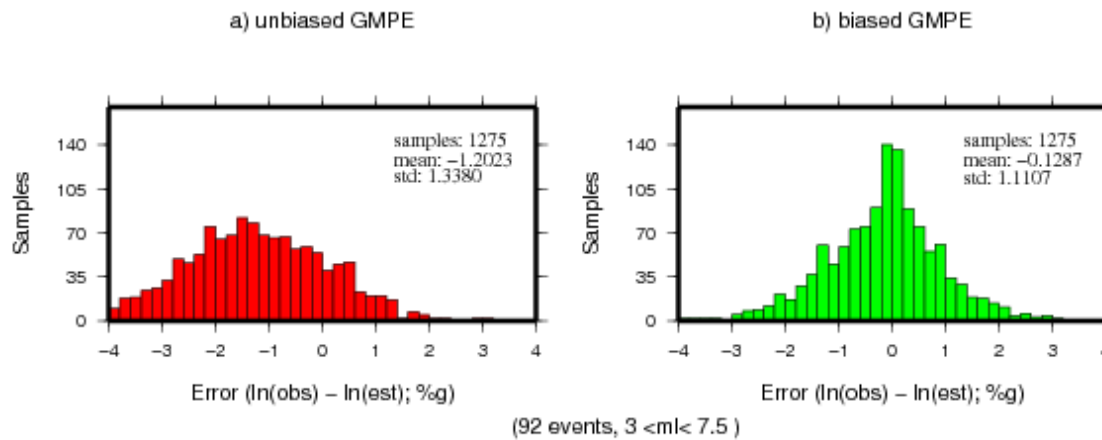


Figure 1. Histograms of log PGA error

PGV error statistics

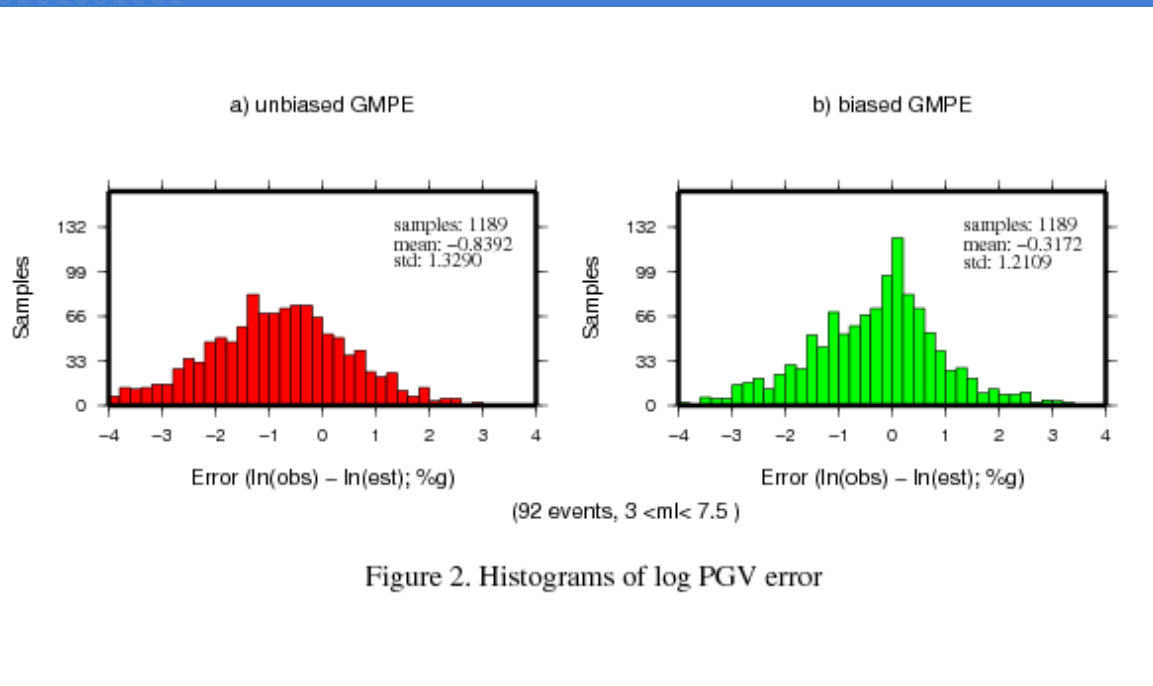


Figure 2. Histograms of log PGV error

PGA Residuals

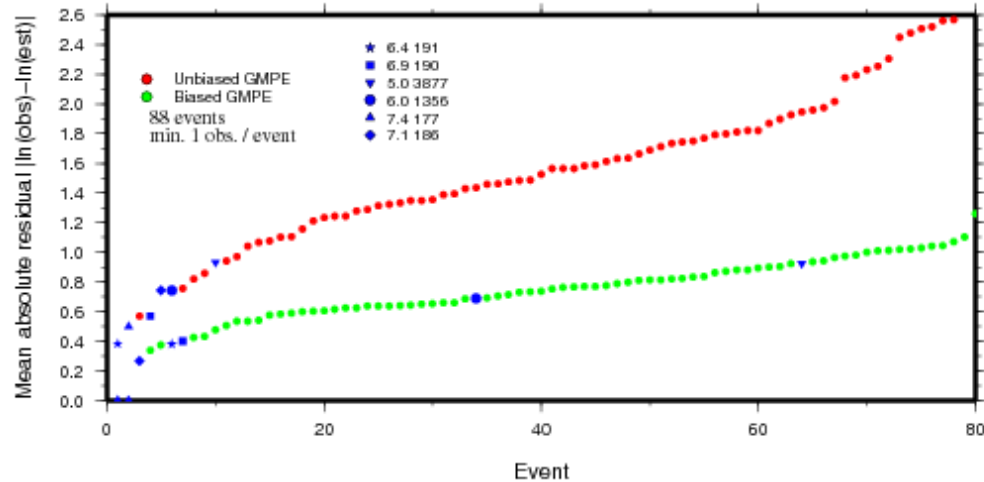


Figure 3. Mean PGA error sorted by increasing order of biased GMPE

PGV Residuals

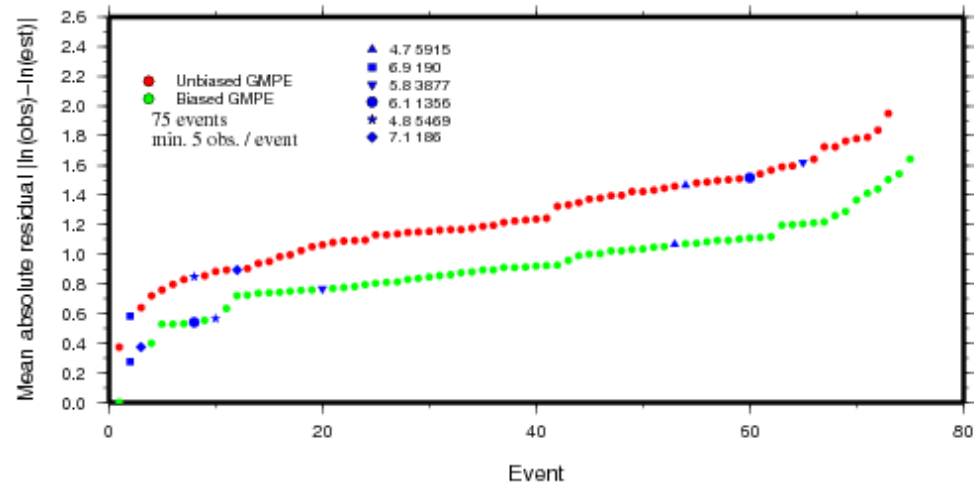


Figure 4. Mean PGV error sorted by increasing order of biased GMPE

PSA30 error statistics

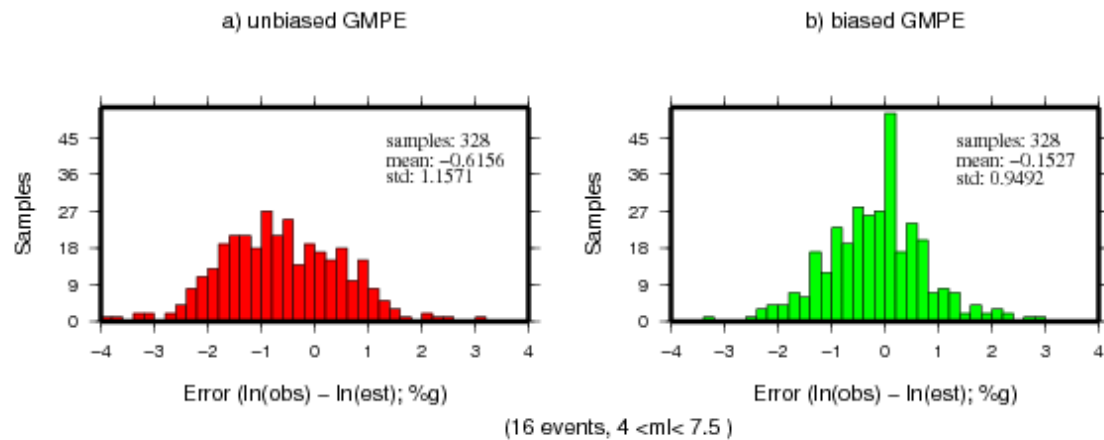


Figure 8. Histograms of log PSA30 error

PSA30 residuals

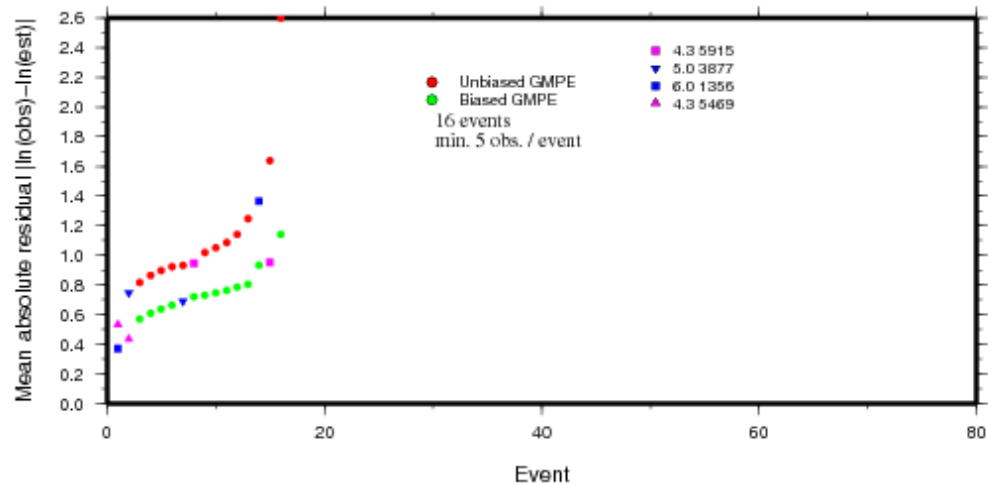
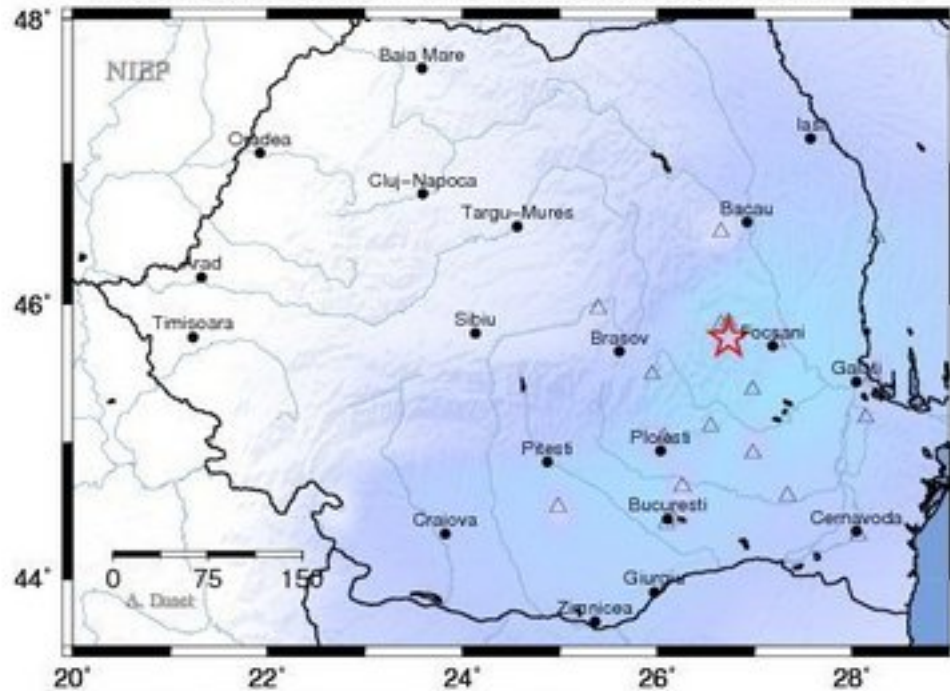


Figure 12. Mean PSA30 error sorted by increasing order of biased GMPE

100101000010111
010110011010010010
100101000101001110

NIEP ShakeMap : ROMANIA

Fri Feb 4, 2011 23:25:15 GMT M 4.2 N45.75 E26.73 Depth: 120.0km ID:6870



Map Version 1 Processed Sat Feb 5, 2011 01:34:27 AM EST

Event processing timeline

2011-035	23:26:16	perl *notify*: New origins: n1=2318 n2=2319 , 1 new origins	00:00
2011-035	23:26:16	perl *notify*: 7153 6870 - -999.00 -999.00 -999.00	
2011-035	23:28:05	perl *notify*: M -999.00 -999.00 4.20	
2011-035	23:28:05	perl *notify*: Start process_orid 7153 6870	01:49
2011-035	23:28:06	perl *notify*: mkwfm started, check mkwfm log	01:50
2011-035	23:28:06	perl *notify*: returned to main program	
2011-035	23:28:06	perl *notify*: 7153: mkwfm started, orid 7153	
2011-035	23:32:16	perl *notify*: db2shakemap_xml started	06:00
2011-035	23:32:17	perl *notify*: db2shakemap_xml ended	06:01
02/04/2011	23:34:01	event 6870: shake starts	07:45
02/04/2011	23:35:03	event 6870: processing ends	08:47

References

- Vladimir Yu Sokolov, Friedemann Wenzel, Rakesh Mohindra ,
Probabilistic seismic hazard assessment for Romania and sensitivity
analys: A case of joint consideration of intermediate-depth (Vrancea)
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Soil Dynamics and Earthquake Engineering, 29 (February 2009)
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- C. B. Worden, D. J. Wald, T. I. Allen, K. Lin, D. Garcia, and G. Cua,
A Revised Ground-Motion and Intensity Interpolation
Scheme for ShakeMap

Bulletin of the Seismological Society of America, Vol. 100, No. 6, pp.
3083–3096, December 2010, doi: 10.1785/0120100101