



International School and Workshop on Nonlinear Mathematical Physics and Natural Hazards



November 28 – December 02, 2013,
Bulgarian Academy of Sciences, Sofia

Seismic Monitoring and Data Processing in Seismological Observatory in Skopje – Republic of Macedonia – basis for a complex geophysical monitoring.

d-r Dragana Cernih, d-r Vera Čejkovska,
d-r Lazo Pekevski



Seismological Observatory
Faculty of Natural Sciences and Mathematics
University “Sts. Cyril and Methodius” – Skopje
Republic of Macedonia



Activities in the field of earthquake seismology in Republic of Macedonia are carried out by the Seismological Observatory at the Faculty of Natural Sciences and Mathematics, University "St. Cyril and Methodius" - Skopje, founded in 1957.

This is the only institution in Republic of Macedonia **authorized and obliged to perform **seismological service**. The Law for Participation of the Republic of Macedonia in Financing of Seismological and Engineering-Seismological Activities regulates the service.**

Seismological Observatory is a department of the Faculty of Natural Sciences and Mathematics in Skopje and is organized into five sections:

- telemetry,**
- microseismics,**
- macroseismics,**
- seismological instrumentation and**
- computer science laboratory.**

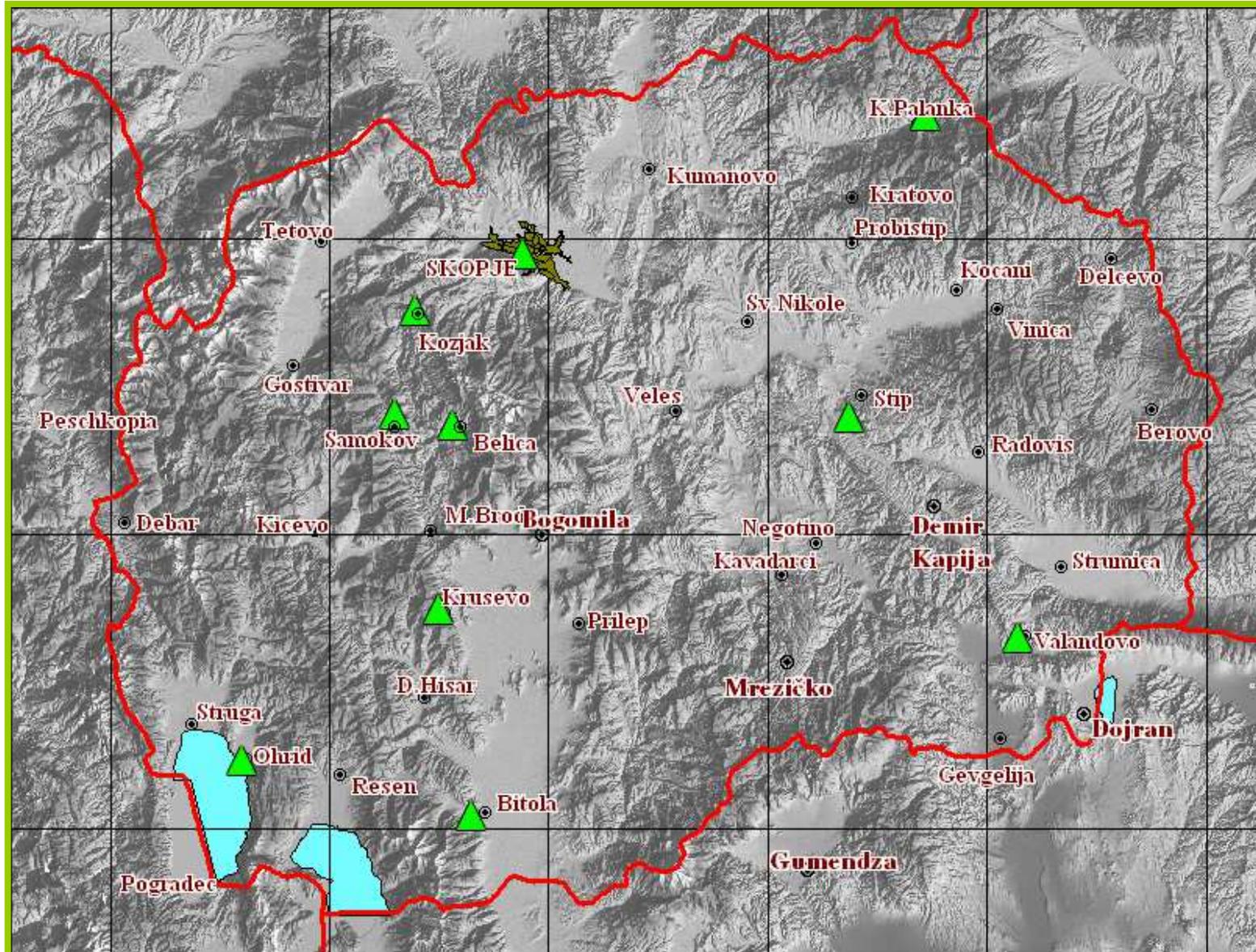
By using the network of digital seismological stations, this Observatory systematically monitors the seismic activity in the territory of Republic of Macedonia and the bordering areas and also records the regional and teleseismic earthquakes. In cases of felt earthquakes in the territory of Republic of Macedonia, the Observatory compiles and processes the data on the macroseismic effect of earthquakes.

The instrumental and macroseismic data are compiled, stored, analyzed and published in seismological bulletins and catalogues for the international exchange of seismological data and for scientific, teaching and civil engineering purposes. The Observatory also performs scientific research, education and applications in the field of seismology and geophysics.

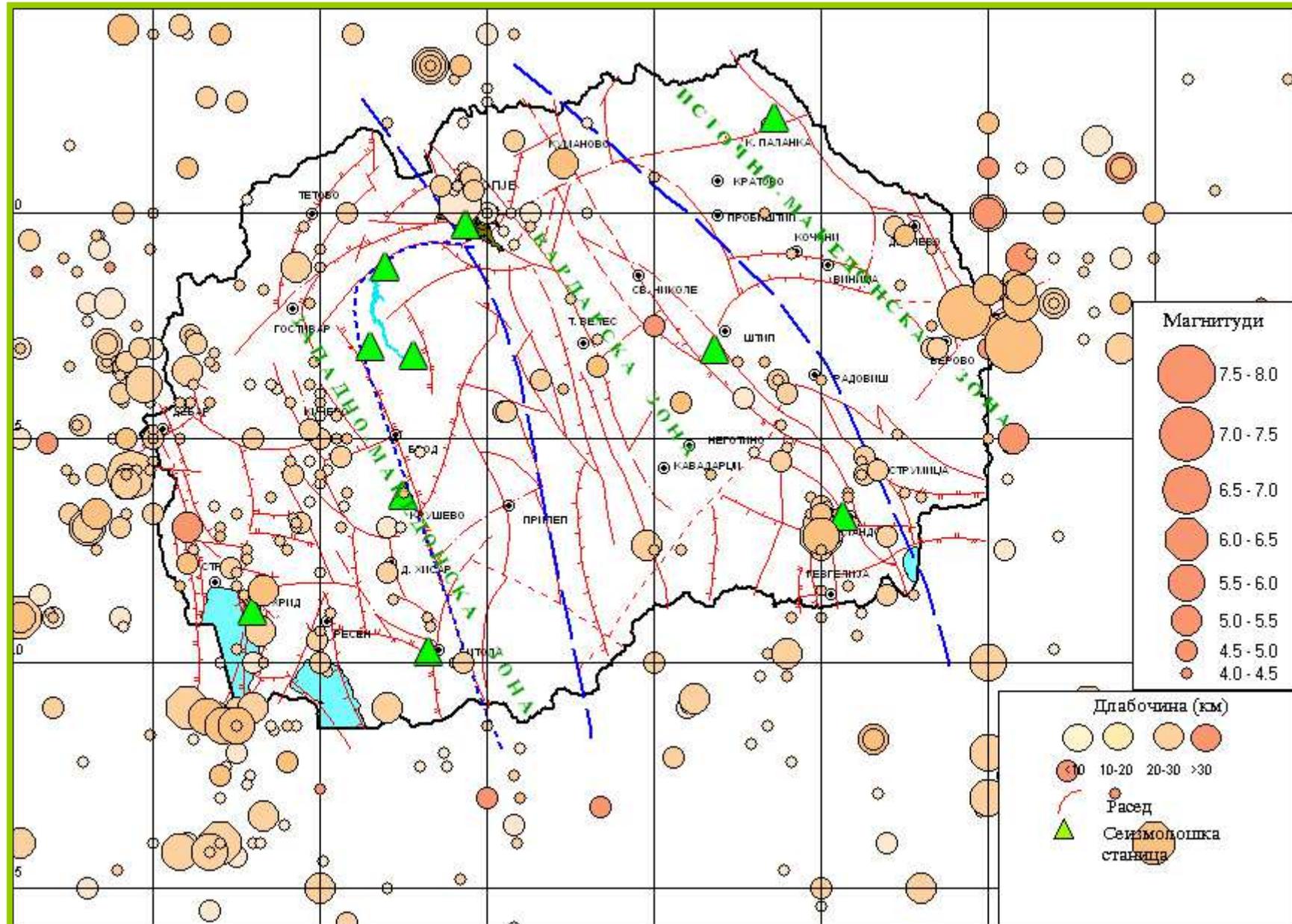
Strongest earthquakes on the territory of Republic of Macedonia and the bordering areas for the period 1900 - 2010

Time			Magnitude	Intensity	Region
1921	8	10	6.1	IX	Uroševac (Vitina)
1904	4	4	7.8	X	Pehčevo - Kresna
1931	3	8	6.6	IX	Valandovo
1963	7	26	6.1	IX	Skopje
1967	11	30	6.5	IX	Debar
1932	9	26	6.9	IX - X	Halkidiki
1995	5	13	6.1	IX - X	Kozani

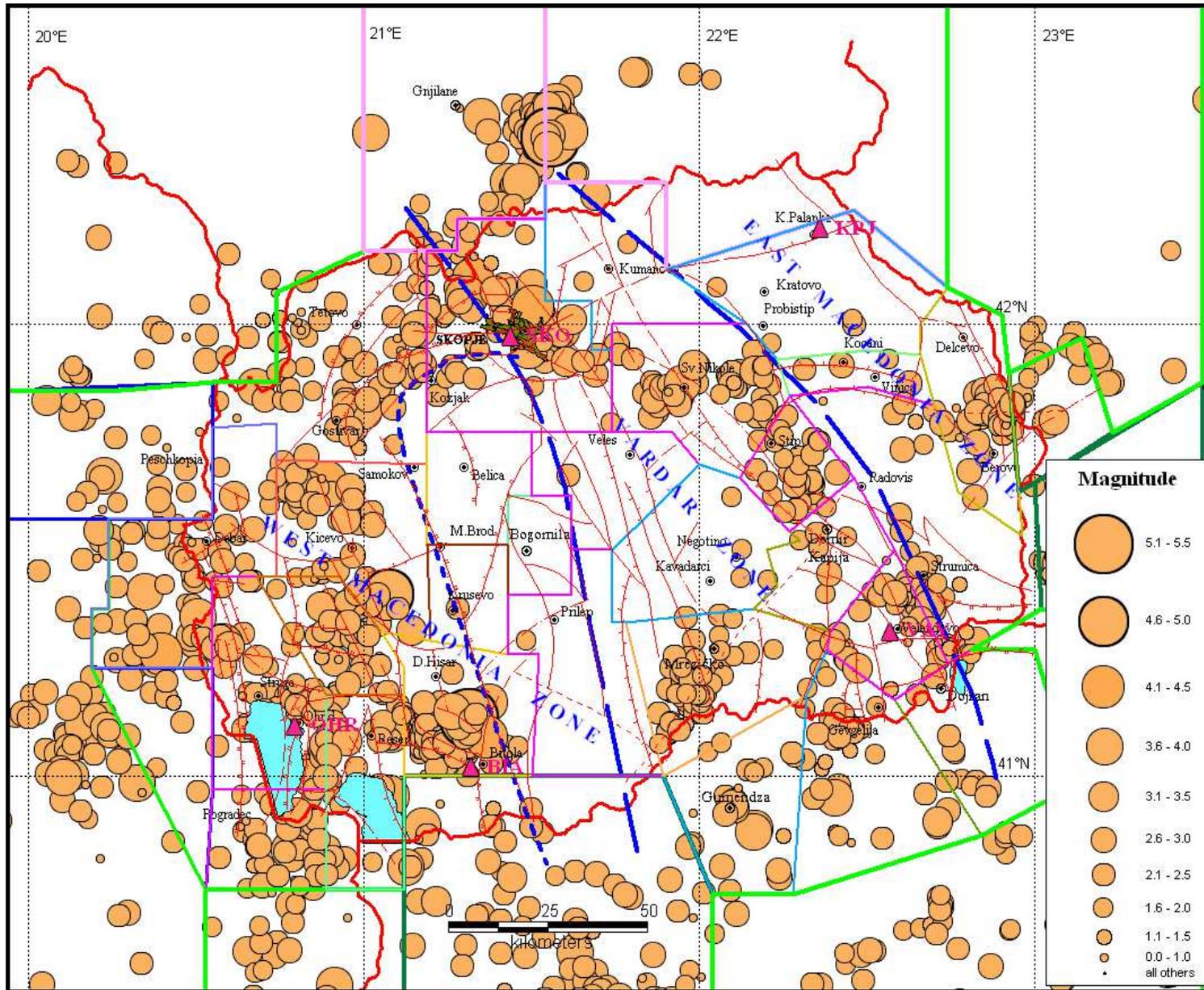
Seismological stations on the territory of the Republic of Macedonia



Distribution of the epicentres of the strong earthquakes on the territory of Republic of Macedonia, $M > 4.0$, 1900 - 2005



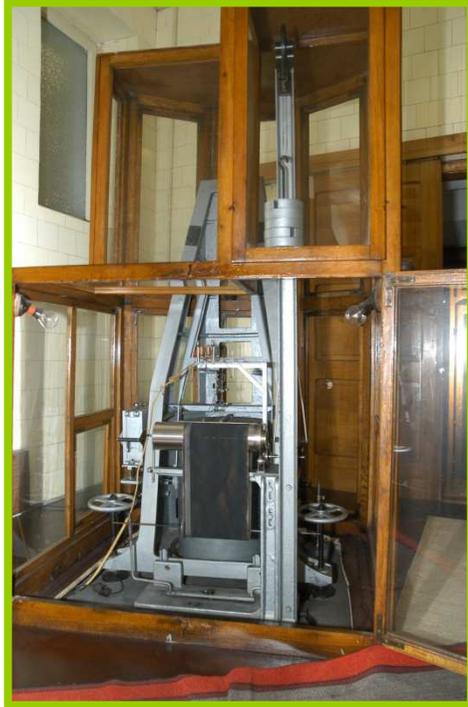
Distribution of the epicentres of the earthquakes in the epicentral areas on the territory of Republic of Macedonia for 1992–2005



Installed network in Republic of Macedonia

<i>Seismological station</i>	<i>Seismological equipment</i>
<p>Skopje (SKO) since 01.07.1957. (41.9721 N, 21.4396 E, h=346 m)</p>	<ul style="list-style-type: none"> - 2 MAINKA, mechanical seismographs, - 1 CONRAD mechanical seismograph, - 6 VEGIK, three components, short period electromagnetic seismographs, - 1 LEHNER-GRIFFITH, three components, short period electromagnetic seismograph, - 2 WILLMORE, three components, short period electromagnetic seismographs, - 2 VBP-3, single component , short period electromagnetic seismographs, - 1 SKD, three component, middle range period electromagnetic seismograph, - 1 PRESS-EWING, three components, long period electromagnetic seismograph, - 2 VR-1(SS-1) short period seismographs (Kinematics), - 2 SSR-1, digital seismographs (Kinematics), with three components short period SS-1 seismometers (Kinematics), three components wide-range WR-1 seismometers (Kinematics), - MSD-1, digital data storage device (Kinematics), - strong-motion recorder AR-240, - FBA-23 triaxial force balance accelerometer (Kinematics), - seismoscope WILLMOT, - GPS, chronometers and additional equipment (Kinematics).
<p>Valandovo (VAY) since 16.02.1966. (41.3211 N, 22.5701 E, h=168 m)</p>	<ul style="list-style-type: none"> - 1 LEHNER-GRIFFITH, three components, short period electromagnetic seismograph, - 1 VBP-3, single component, short period electromagnetic seismograph, - 1 SSR-1, digital seismograph, with three components wide-range WR-1 seismometers, - GPS, chronometers and additional equipment.
<p>Ohrid (OHR) since 09.09.1967. (41.1114 N, 20.5989 E, h=739 m)</p>	<ul style="list-style-type: none"> - 1 LEHNER-GRIFFITH, three components, short period electromagnetic seismograph, - 1 SSR-1, digital seismograph, with three components wide-range WR-1 seismometers, - GPS, chronometers and additional equipment.
<p>Bitola (BIT) since 17.09.1994. (41.0194 N, 21.3239 E, h=720 m)</p>	<ul style="list-style-type: none"> - 1 VR-1(SS-1) short period seismograph, - 1 SSR-1, digital seismograph, with three components short period SS-1 seismometers, - GPS and additional equipment
<p>Kriva Palanka (KRP) since 1995. (42.2092 N, 22.3617 E, h=700 m)</p>	<ul style="list-style-type: none"> - 1, SSR-1, digital seismograph, with three components short period SS-1 seismometers, - GPS and additional equipment

Instruments in seismological observatory



Mechanical seismograph



Electromagnet seismometer with galvanometric registration



Electromagnetic seismometer with digital registration with SSR-1

Equipment at the seismological stations

Seismometers

Kinometrics – SS1



Kinometrics – WR1

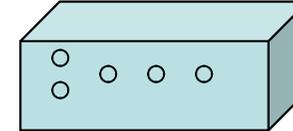


Kinometrics – ES-T



Digital Recorders

Kinometrics – SSR-1



MicroStep – Wave24



Kinometrics – Q330S



Kinometrics – Q330HRS





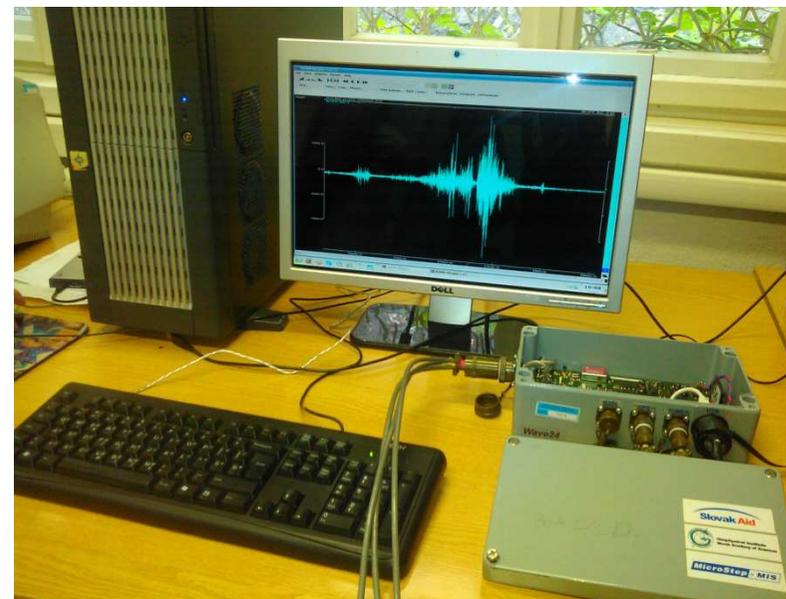
electromagnetic seismometers SS-1 (short-period) and WR-1 (wide-range period)



digital recorder SSR-1

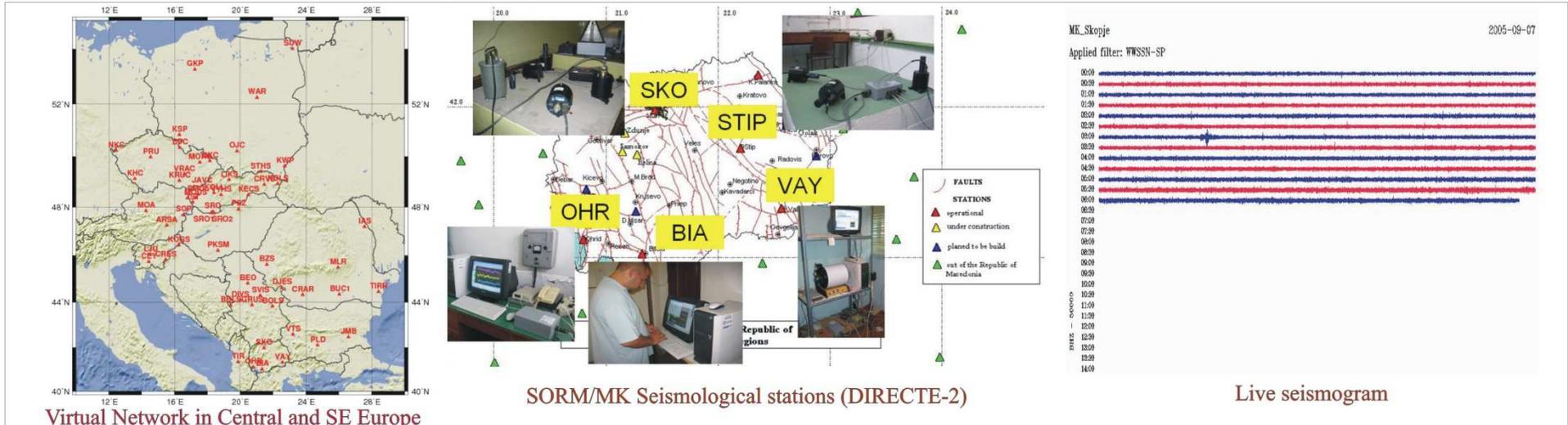


digital recorder Quantera-Q330HRS



digital recorder Wave-24

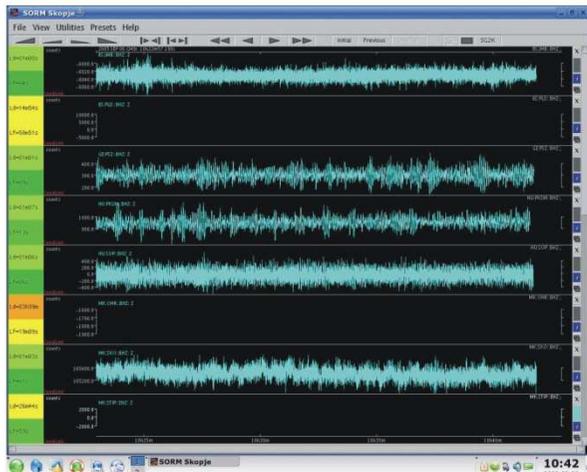
Seismological Network in Republic of Macedonia (2005 ==>)



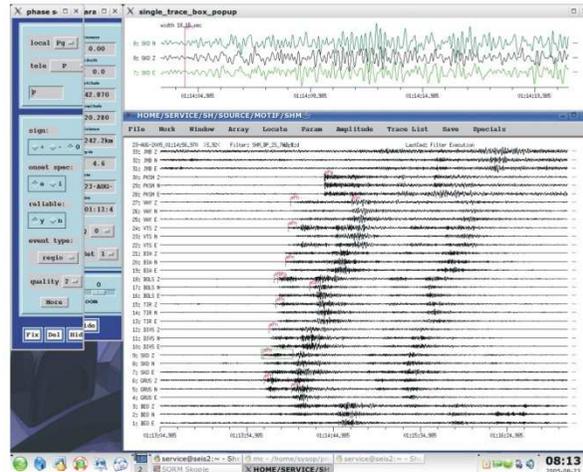
Virtual Network in Central and SE Europe

SORM/MK Seismological stations (DIRECTE-2)

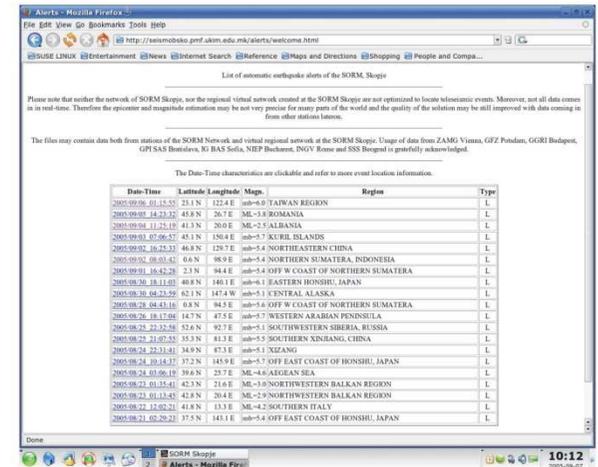
Live seismogram



Real-/near-real time acquisition of 18 stations from Central and SE Europe (BS, HU, MN, GE, SK, SJ)

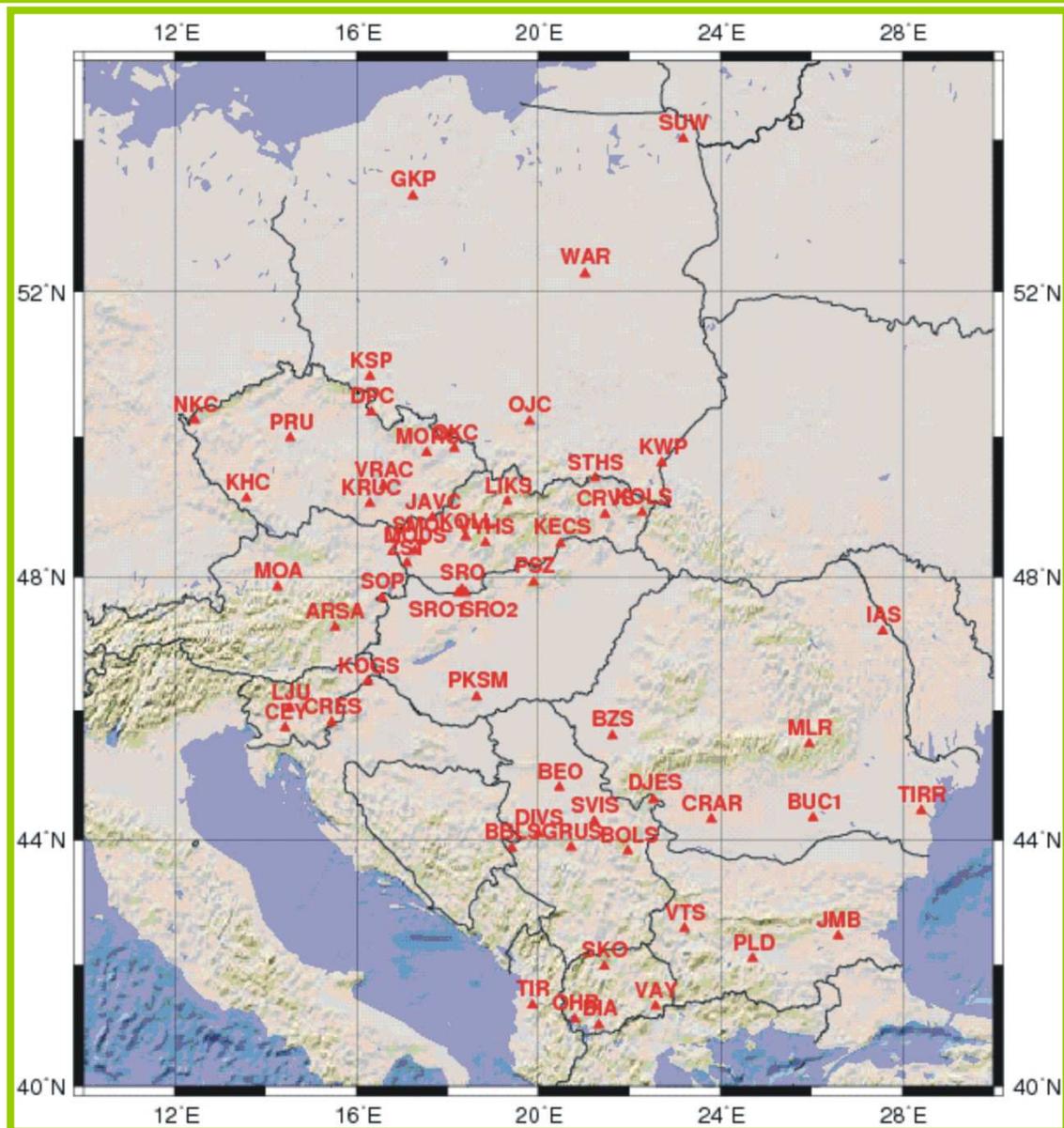


SeismicHandler Data Processing

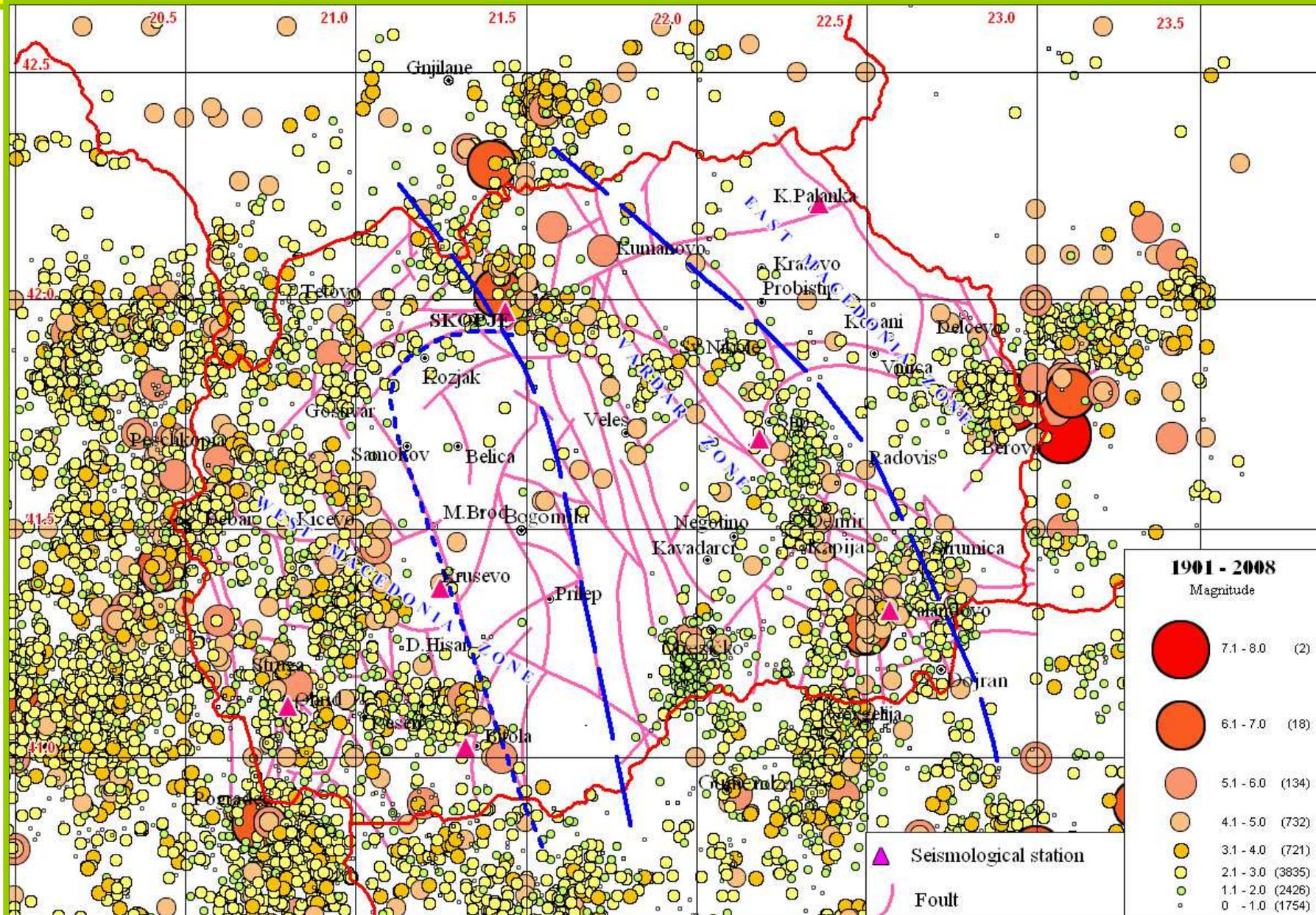


Seismic Alerts

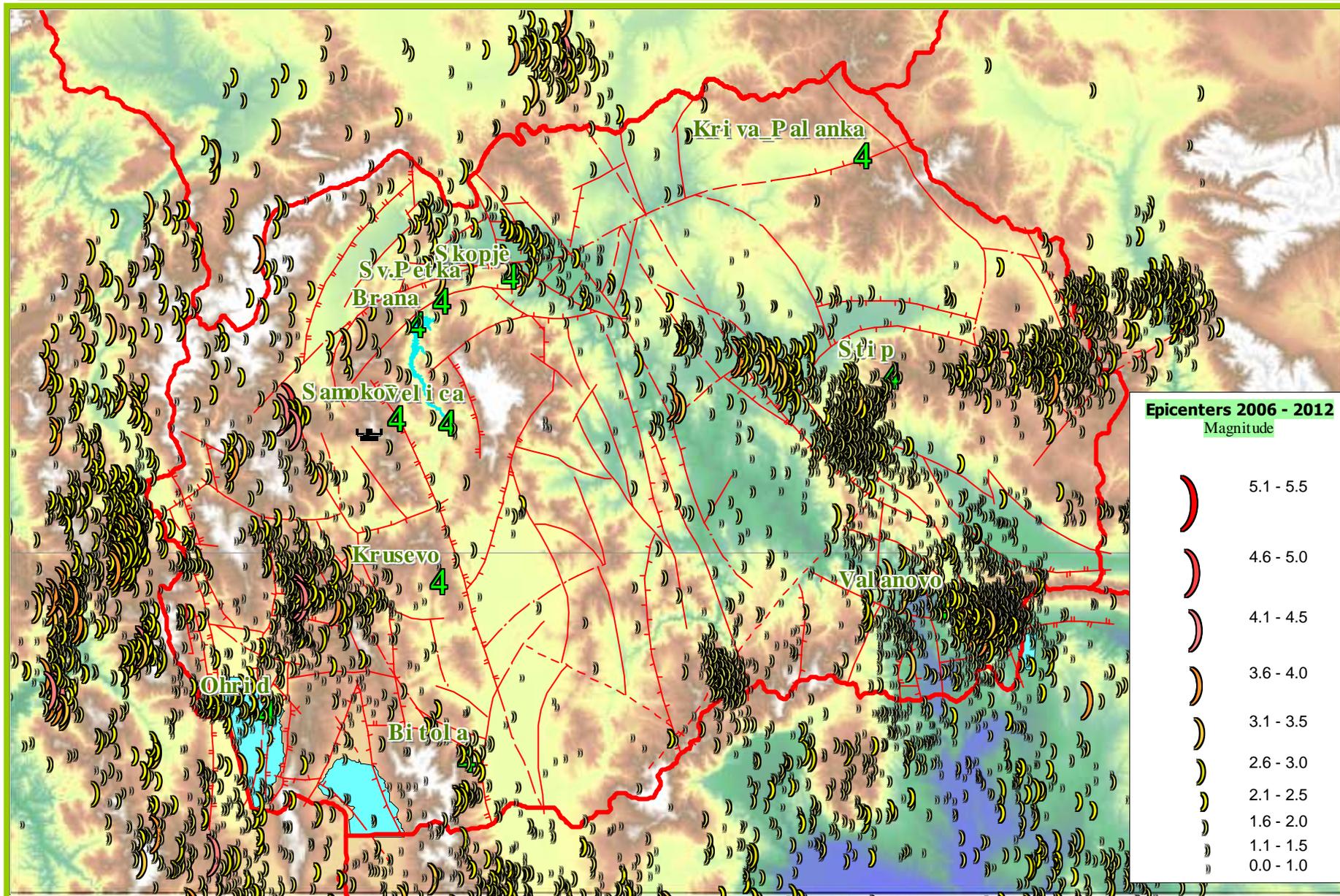
Virual Network in Central and SE Europe



Epicentral map of the earthquakes from the territory of RM and neighboring countries for period 1901 - 2008



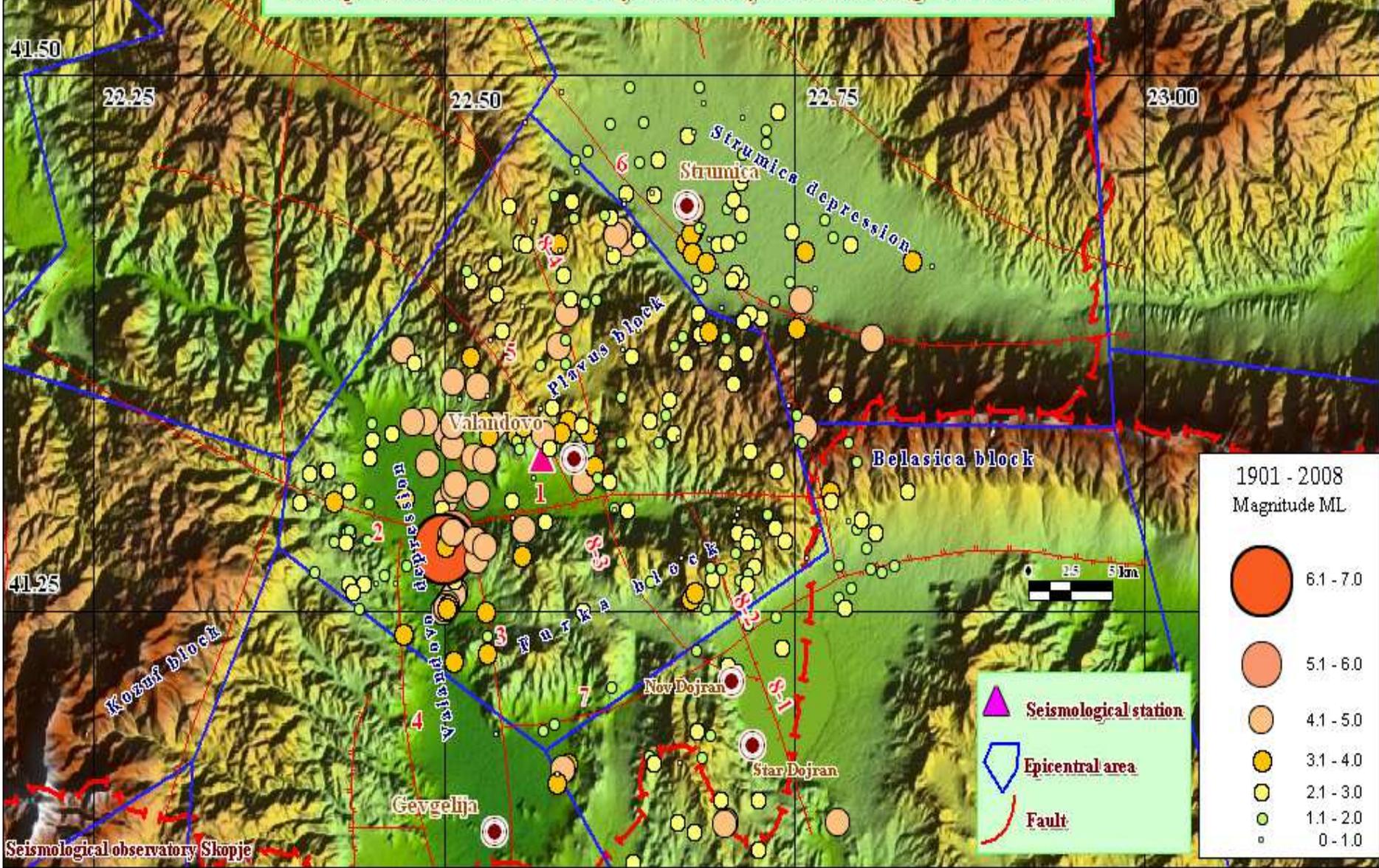
Epicentral map of the earthquakes from the territory of RM and neighboring countries for period 2006 - 2012

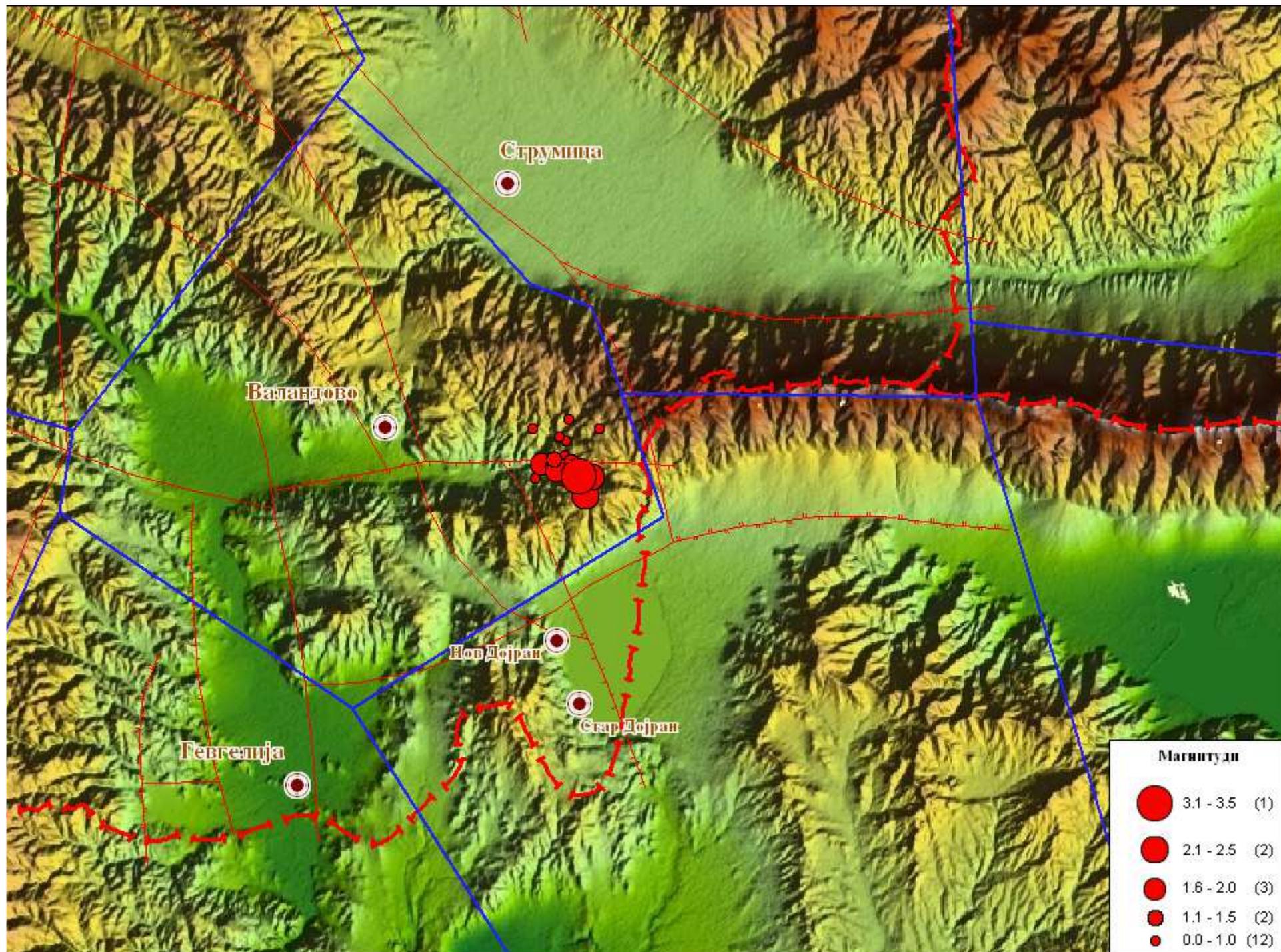


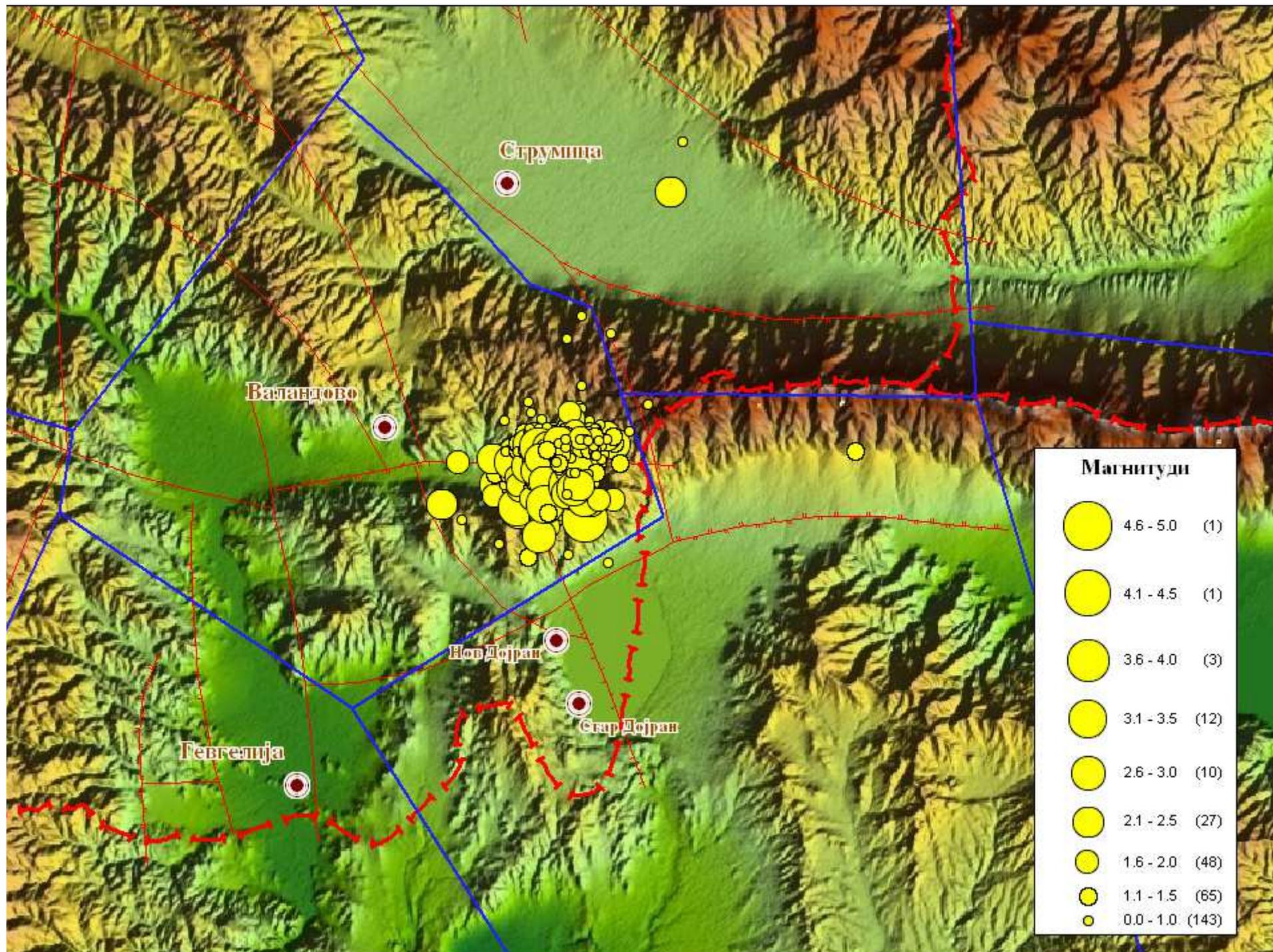
Number of epicenters with years

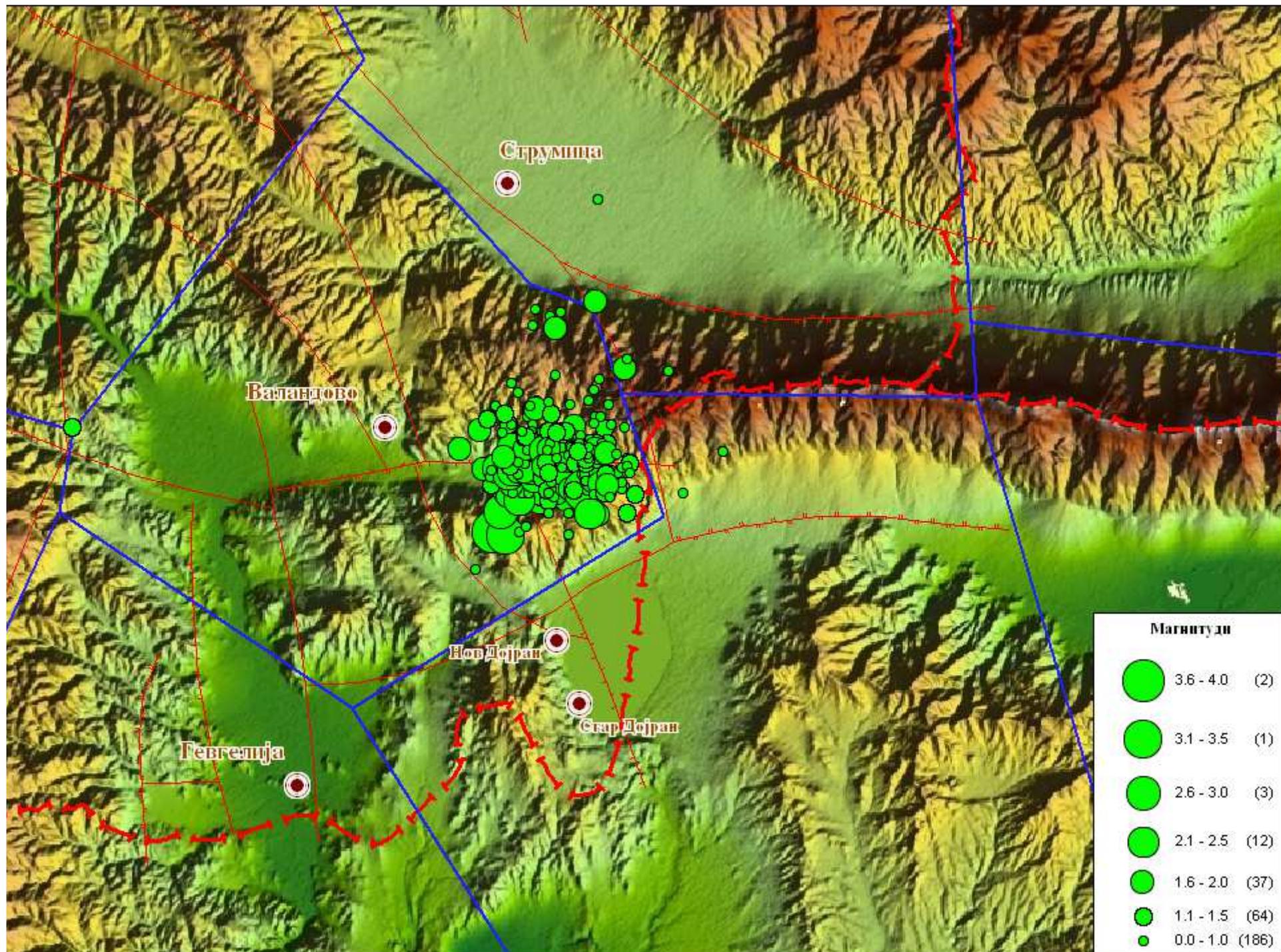
1900 – 1957	695
1957 – 1992	4000
1992 – 2005	3600
2006 – 2012	8300

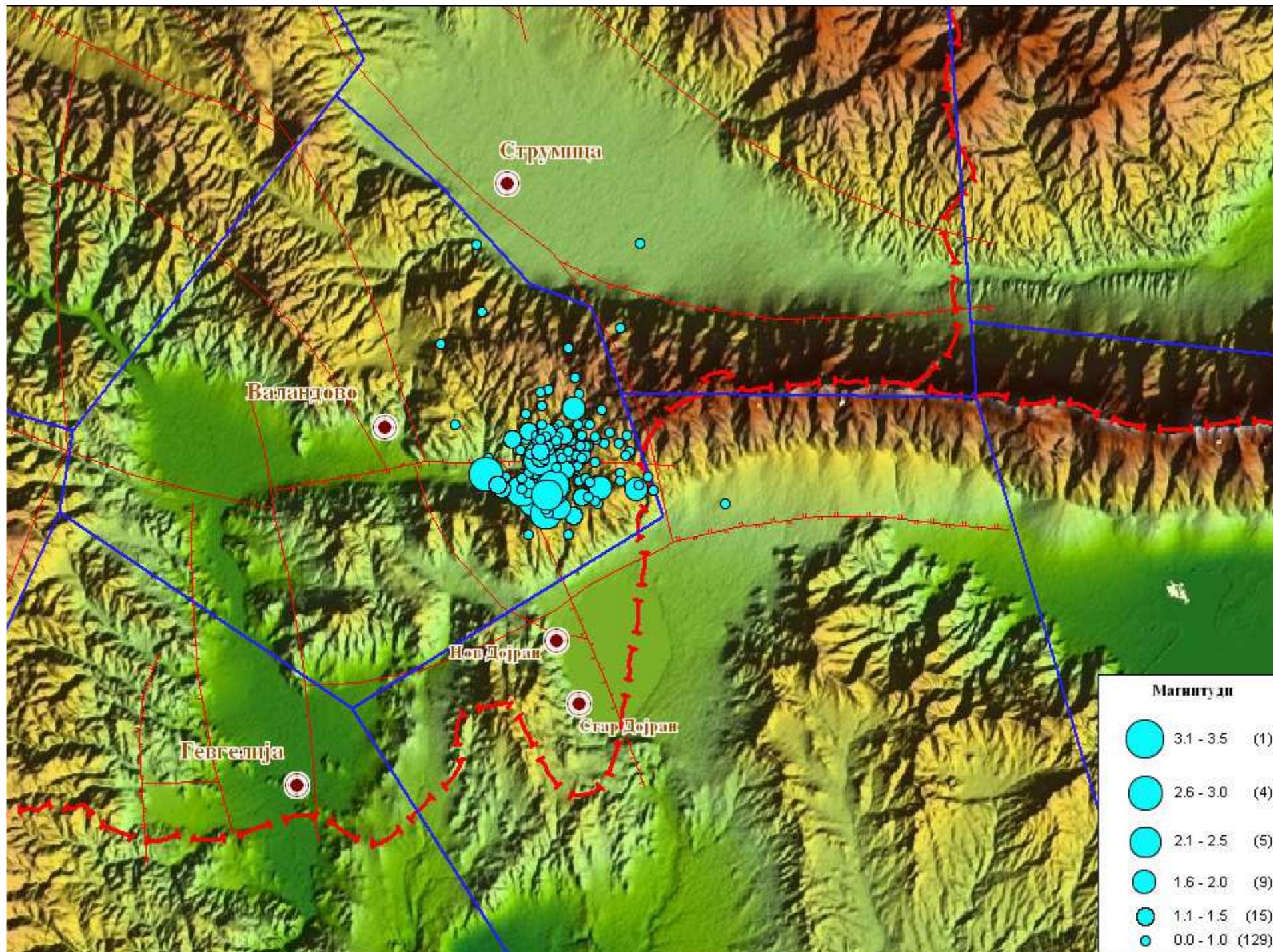
Earthquakes in Valandovo - Nov Dojran - Star Dojran - Strumica region in 1901 - 2008

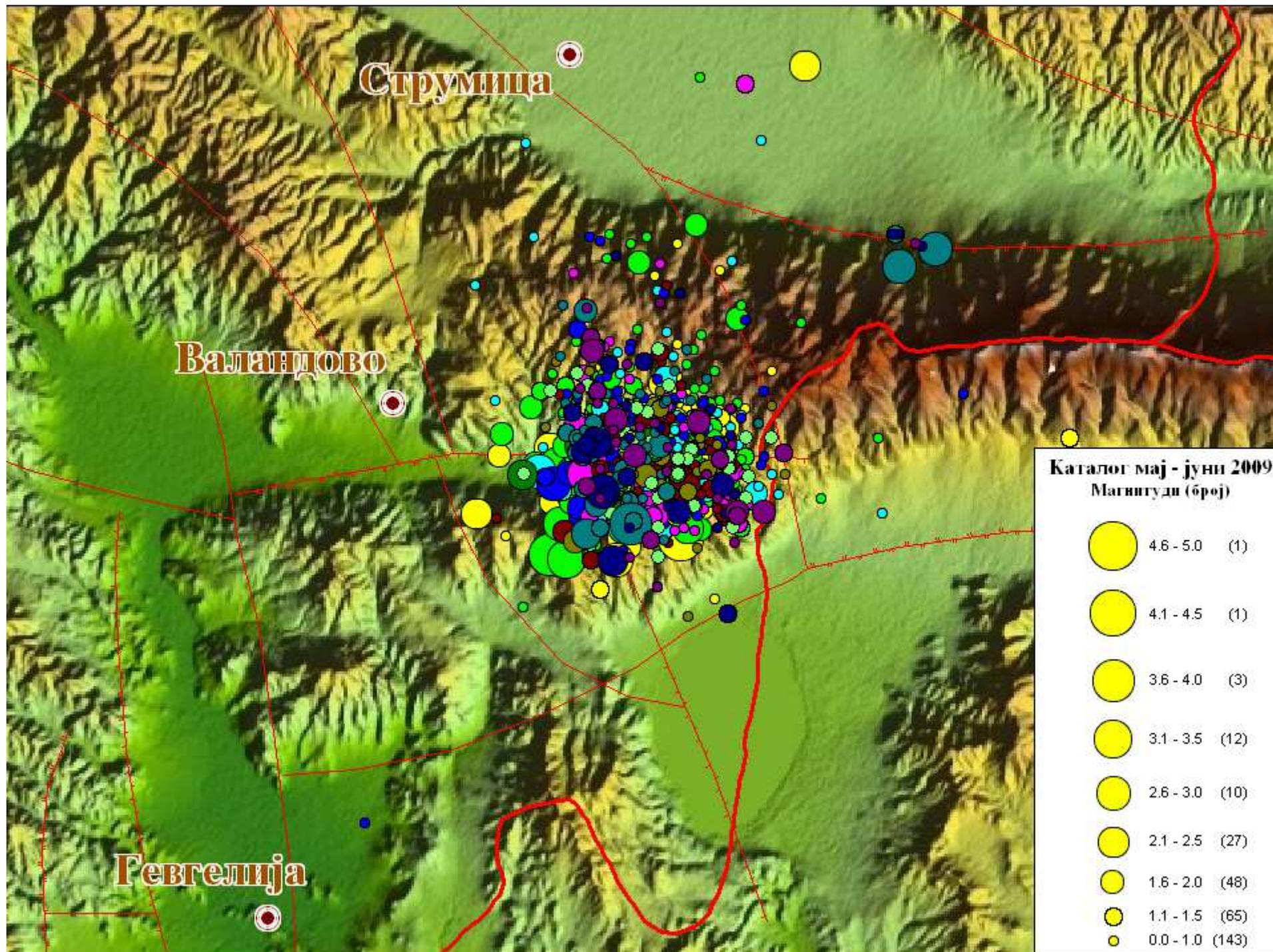












41.50

Earthquakes in Valandovo - Nov Dojran region, 23 May - 30 June 2009

22.50

22.75

23.00

Strumica

STRUMICA DEPRESSION

PLAVUS BLOCK

Valandovo

BELASICA BLOCK

FURKA BLOCK

Nov Dojran

Star Dojran

Magnitude ML

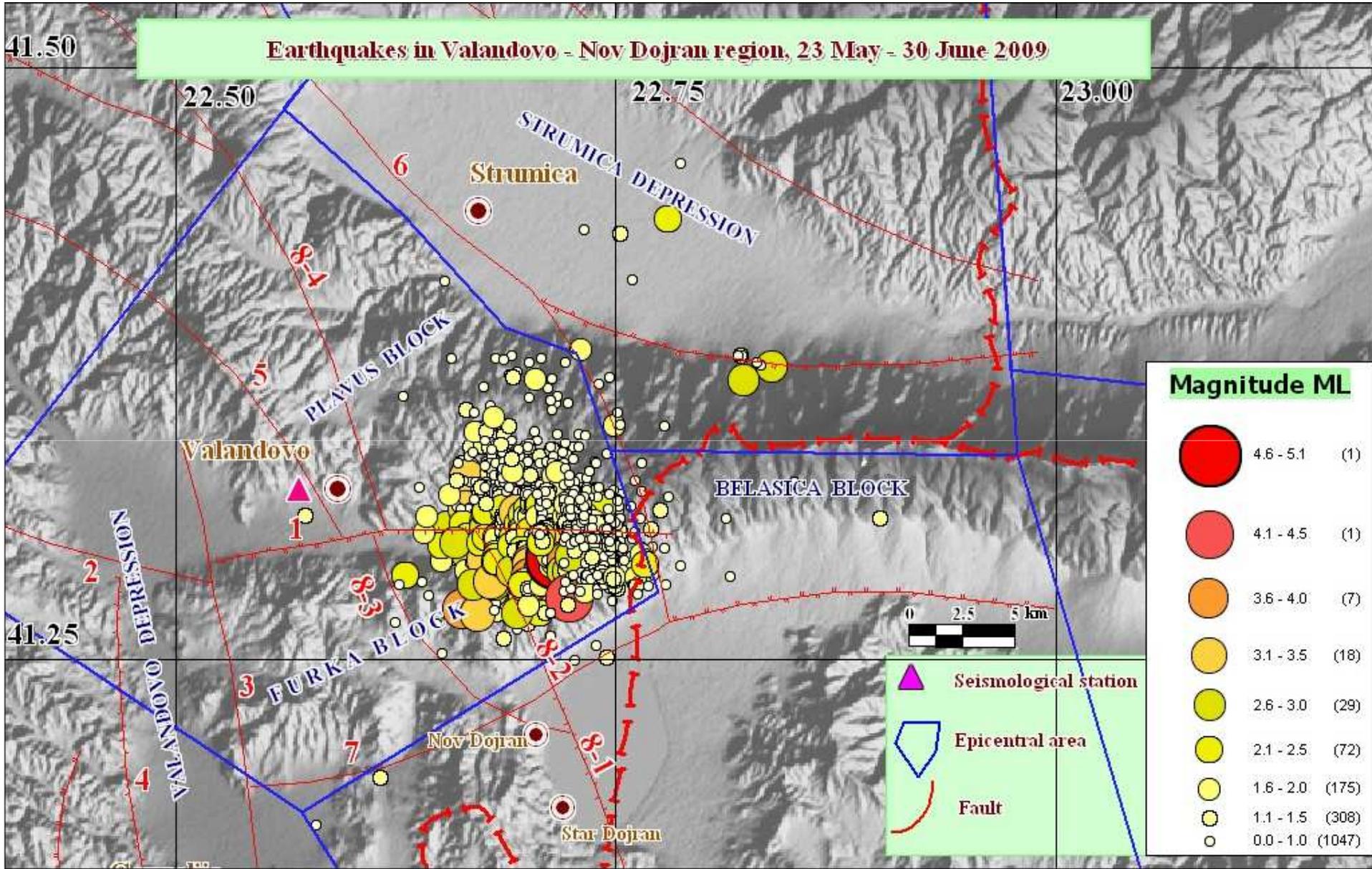
- 4.6 - 5.1 (1)
- 4.1 - 4.5 (1)
- 3.6 - 4.0 (7)
- 3.1 - 3.5 (18)
- 2.6 - 3.0 (29)
- 2.1 - 2.5 (72)
- 1.6 - 2.0 (175)
- 1.1 - 1.5 (308)
- 0.0 - 1.0 (1047)



- Seismological station
- Epicentral area
- Fault

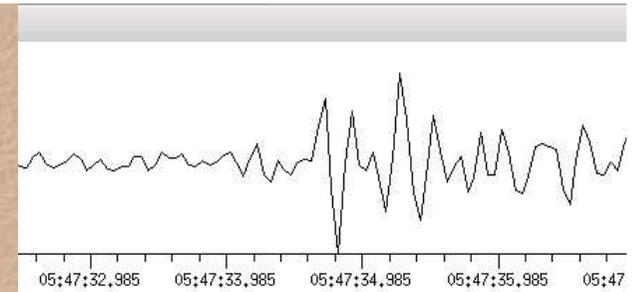
41.25

VALANDOVO DEPRESSION





Republic of Macedonia SEISMOLOGICAL OBSERVATORY



Republic of SEISMOLO

Present seismic

Live seismogr

[Skopje \(SKO\)](#)

[Stip RGF \(STIP\)](#)

[Bitola \(B\)](#)

[Home](#)

[Micro](#)

[Macro](#)

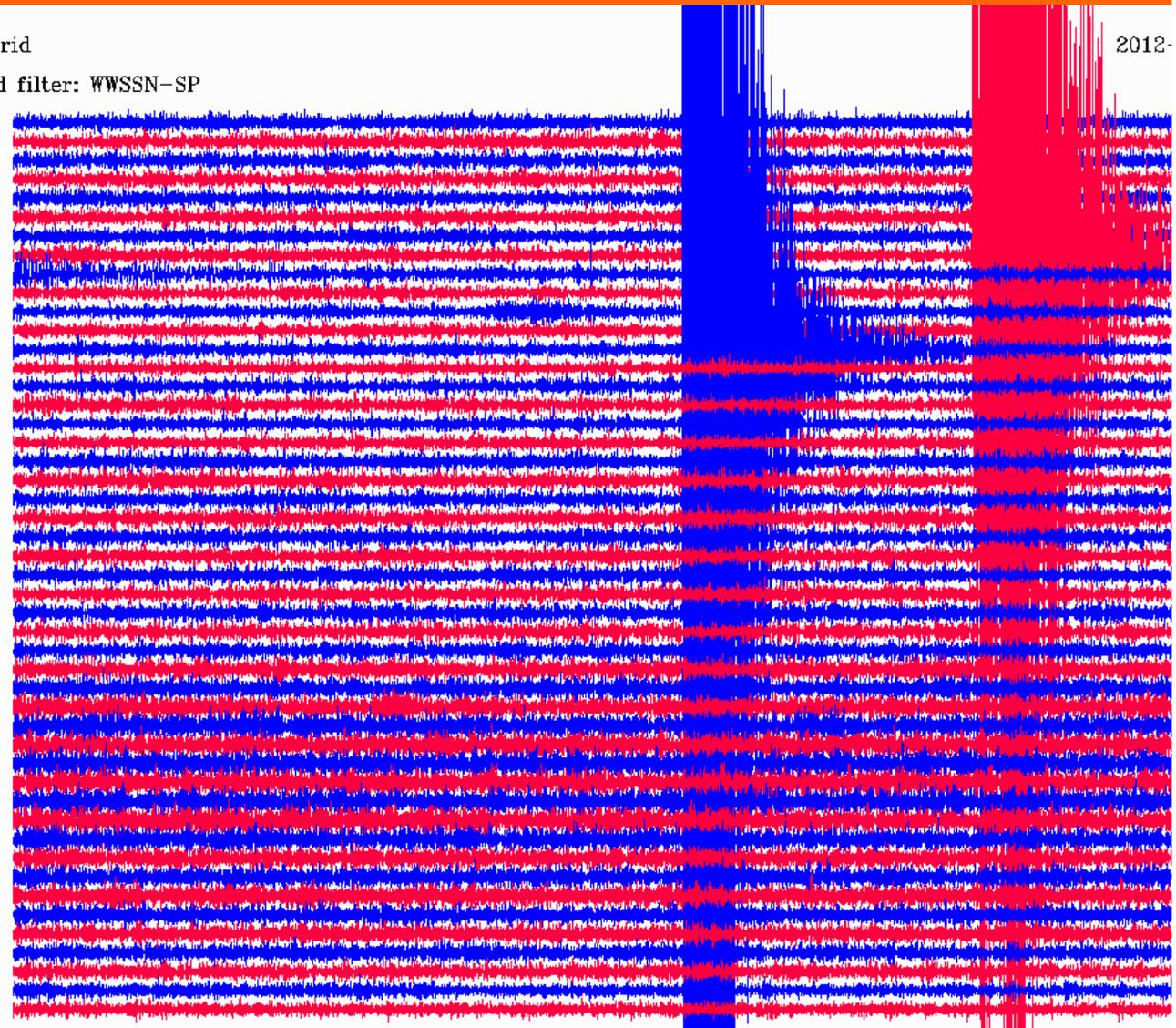
[Instrument](#)

MK_Ohrid

Applied filter: WWSSN-SP

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BHZ - 50000



2011-01-28 06:40:10.1	36.21 S	99.53 W	10	M	4.8	M	SOUTHEAST OF EASTER ISLAND	NEIR
2011-01-28 06:34:04.1	28.44 N	58.96 E	14	mb	4.3	M	SOUTHEASTERN IRAN	NEIR
2011-01-28 06:34:04.1	28.44 N	58.96 E	13	ML	4.3	M	SOUTHEASTERN IRAN	IGUT
2011-01-28 06:34:01.1	28.35 N	59.07 E	2	ML	4.2	M+	SOUTHEASTERN IRAN	INFO
2011-01-28 06:34:00.0	28.30 N	59.06 E	17	ML	4.2	M	SOUTHEASTERN IRAN	THR
2011-01-28 06:04						M		BUC
2011-01-28 06:03:29.4	41.54 N	20.10 E	10	ML	3.3	A	ALBANIA	NOA
2011-01-28 06:03:29.0	41.60 N	20.07 E	1	ML	3.3	A	ALBANIA	THE
2011-01-28 06:03:28.9	41.44 N	20.10 E	10	ML	3.4	A	ALBANIA	BEO
2011-01-28 06:03:28.1	41.54 N	20.21 E	2	ML	3.5	M+	ALBANIA	INFO
2011-01-28 06:03:28.1	41.50 N	20.20 E	14	ML	3.6	M	ALBANIA	SKO
2011-01-28 06:03:28.0	41.55 N	20.20 E	10	ML	3.5	M	ALBANIA	MSO
2011-01-28 06:03:28.0	41.54 N	20.14 E	7	ML	3.5	M	ALBANIA	MSO
2011-01-28 06:03:27.9	41.57 N	20.32 E	1	ML	3.4	M	ALBANIA	THE
2011-01-28 06:03:27.8	41.47 N	20.28 E	1	ML	3.4	A	ALBANIA	MSO
2011-01-28 06:03:27.5								MSO
2011-01-28 06:03:26.4								MSO

2011-01-28 05:31:27.5
2011-01-28 05:08:13.0
2011-01-28 05:07:06.8
2011-01-28 05:06:57.0
2011-01-28 05:06:49.6



Centre Sismologique Euro-Méditerranéen

Current time: 2011-01-30 14:07:52 UTC

Member access

Name:

Pwd:

ML 3.5 2011/01/28 - 06:03:28
 40 km NE Tirana (pop 374,801 ;
 6 km NW Bulqizë (pop 11,212 ; l

Earthquake information
Testimonies, photos
Information services
For seismologists
Projects
Publications & docs

You are here : EMSC > Earthquake > Alert

<< Back

Location provided by SKO

Date: Fri, 28 Jan 2011 08:36:04 +0000 UTC

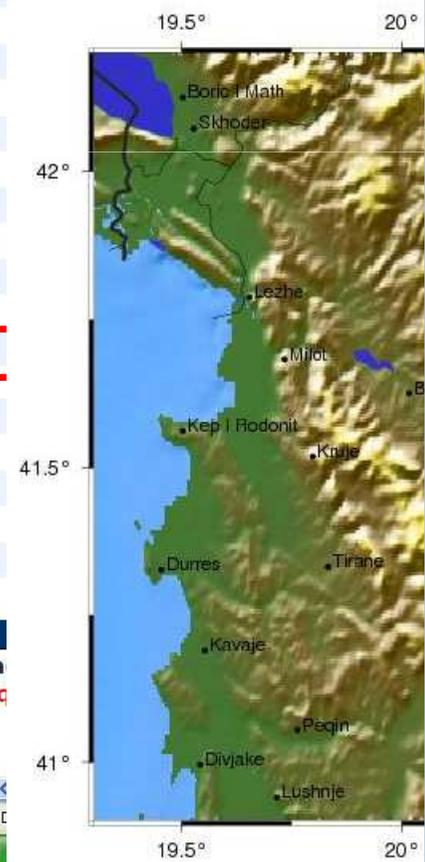
Date	Time	Latitude	Longitude	Depth	Ndef	Nsta	Gap	Mag1	N	Mag2	N	Mag3	N	Author	ID
	rms		Smajor Sminor Az	Err	mdist	Mdist		Err		Err		Err		Quality	
2011/01/28	06:03:28.153	41.5	20.2	14.0				ML3.6	10						

ALBANIA

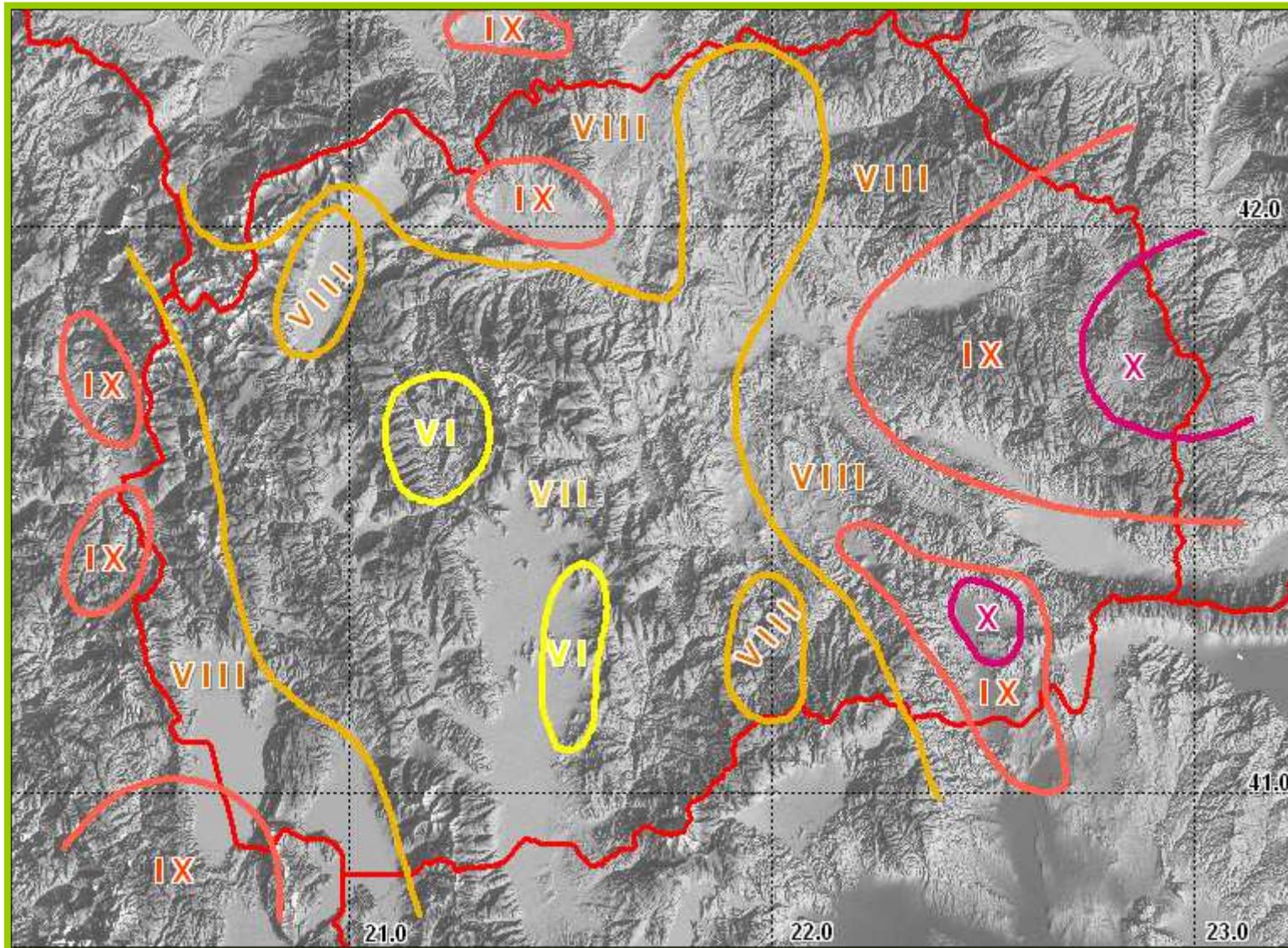
Sta	Dist	EvAz	Phase	Year/Mo/Day	Time	TRes	Azim	AzRes	Slow	SRes	Def	SNR	Amp	Per	Mag1	Mag2	ID
TIR	0.30		iPg	2011/01/28	06:03:33.9												SKO
OHR	0.60		iPg	2011/01/28	06:03:38.3										3.6		SKO
OHR	0.60		iSg	2011/01/28	06:03:48.1										3.6		SKO
OHR	0.60		eLg	2011/01/28	06:03:48.2					2249.0			0.5		3.6		SKO
OHR	0.60		eLg	2011/01/28	06:03:48.2					2100.5			0.3		3.6		SKO
ULC	0.90		ePg	2011/01/28	06:03:43.4												SKO
ZATK	1.00		ePg	2011/01/28	06:03:46.9												SKO
SKO	1.10		iPg	2011/01/28	06:03:47.3												SKO
SKO	1.10		iSg	2011/01/28	06:04:01.8												SKO
FNA	1.10		iPg	2011/01/28	06:03:48.4												SKO
PDG	1.20		ePg	2011/01/28	06:03:49.3												SKO
PEJK	1.20		ePg	2011/01/28	06:03:49.6												SKO
GJIK	1.40		ePg	2011/01/28	06:03:52.4												SKO
VAY	1.80		ePg	2011/01/28	06:03:59.5												SKO
VAY	1.80		iSg	2011/01/28	06:04:22.1												SKO

C Data from Seismological Observatory Skopje, Faculty of Natural Sciences and Mathematics,
 C University St.Cyril and Methodius , Republic of Macedonia (MK)
 C
 C

Usage of data from:
 C Aristotle University Thessaloniki Network (HT)
 C MEDNET INGW (MN), Seismological Survey of Serbia (SJ)
 C is gratefully acknowledged



Observed Maximum Intensity I_{max} (1900-2000)

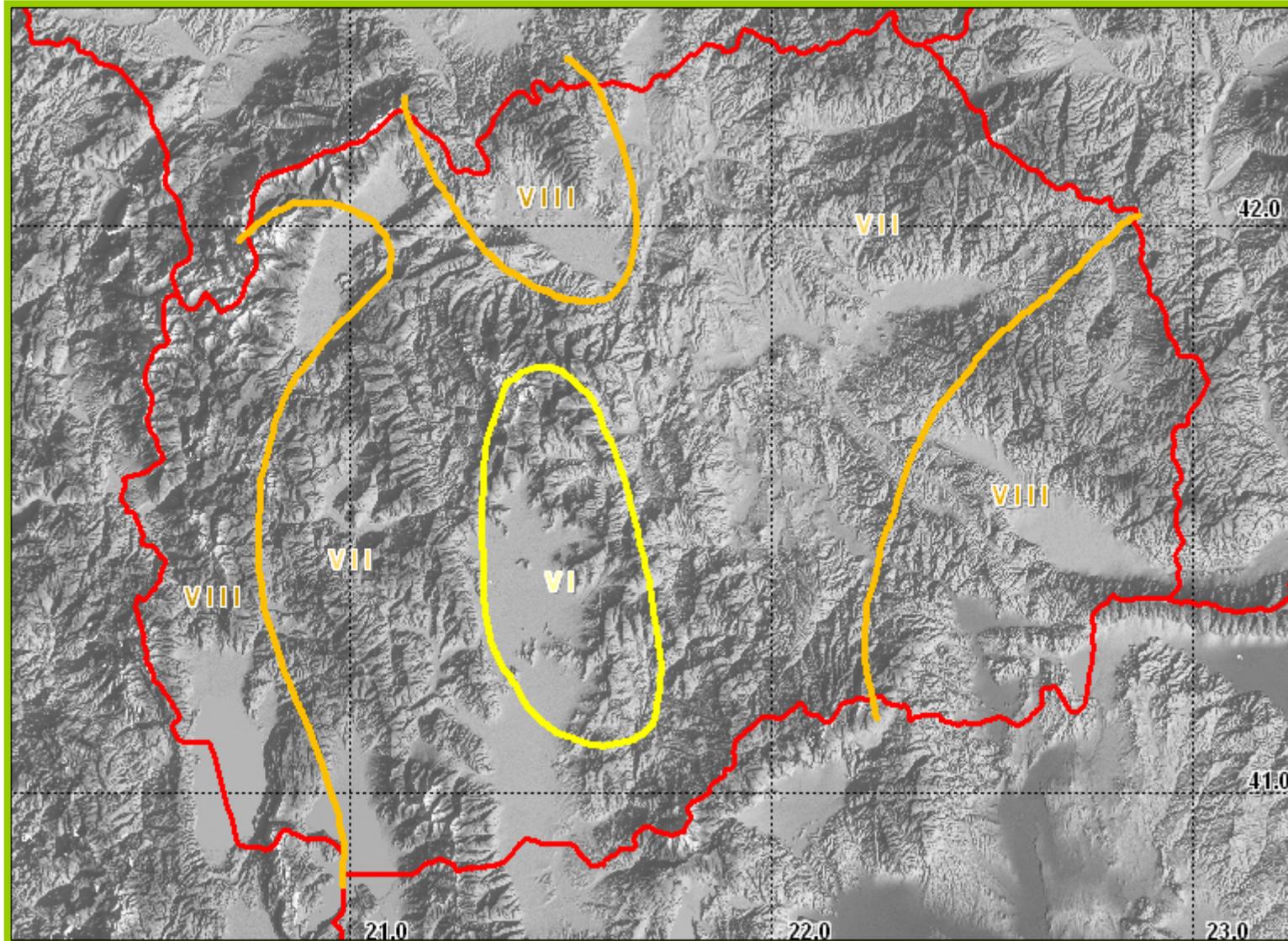


Standard procedures in case of felt earthquakes on the territory of Republic of Macedonia

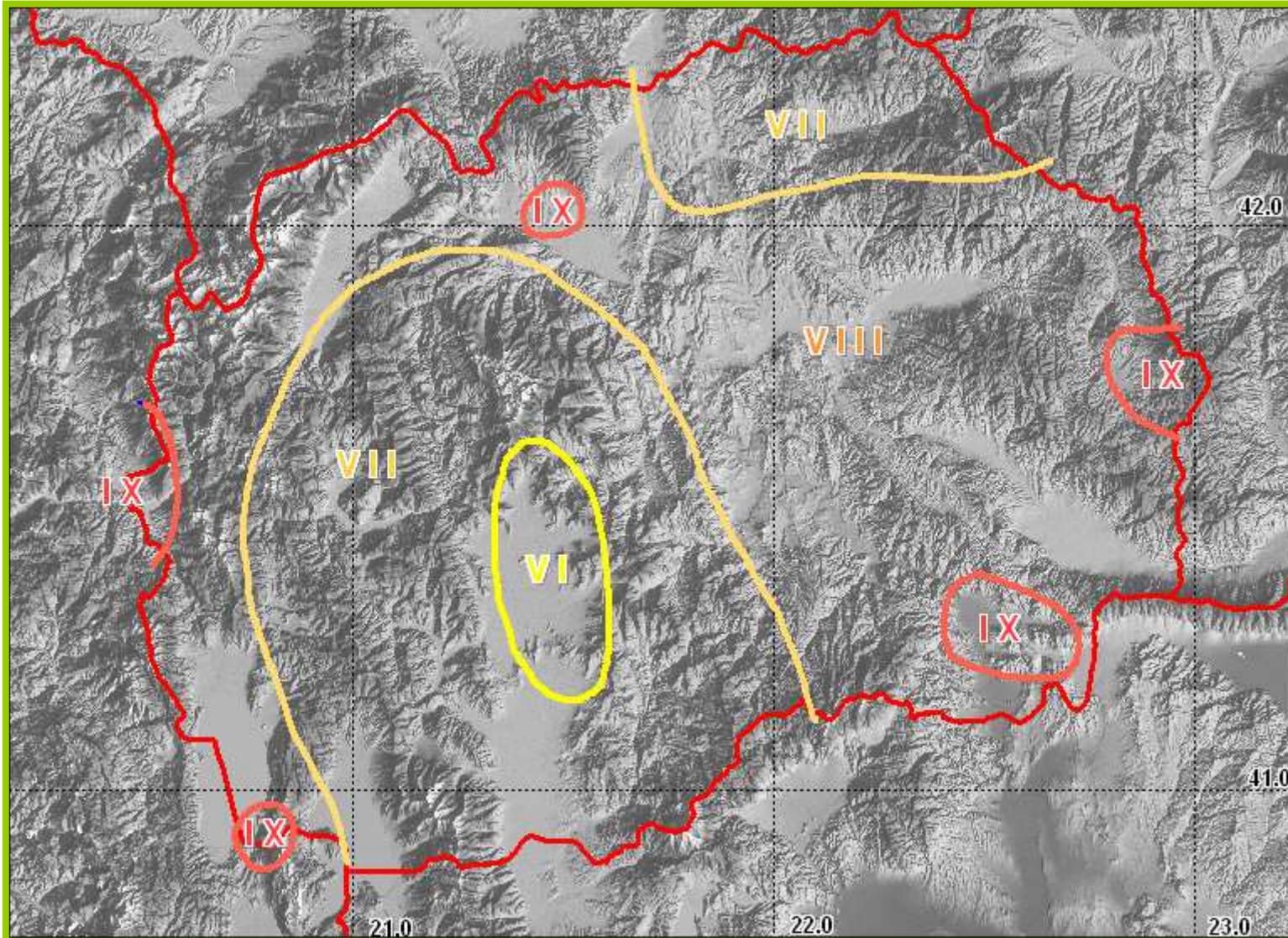
- Officers on duty at the Situation center at Crisis Management Center**
 - Providing information to the staff of the Seismological Observatory for the region and locations where and how the earthquake was felt. Those information are collected from the telephone calls to the Situation Center**

- Seismological Observatory**
 - Macroseismic analysis of the earthquake data**
 - Report is sent to Crisis Management Situation Center, other agencies and media**

Expected Intensity I_{max} in 100 years



Expected Intensity I_{max} in 200 years



Complex monitoring of particular geophysical parameters on the territory of Republic of Macedonia

In cooperation with d-r S. Mavrodiev senior researcher from the Institute for Nuclear Research and Nuclear Energy (INRNE), Bulgarian Academy of Sciences, from 2004 together with seismic activity the characteristics of the regional geomagnetic field are monitored.

From the bilateral cooperation between:

- Seismological Observatory, Faculty of Natural Sciences and Mathematics, Sts. Cyril and Methodius University, Skopje, Macedonia**
- INRNE, Bulgarian Academy of Sciences**

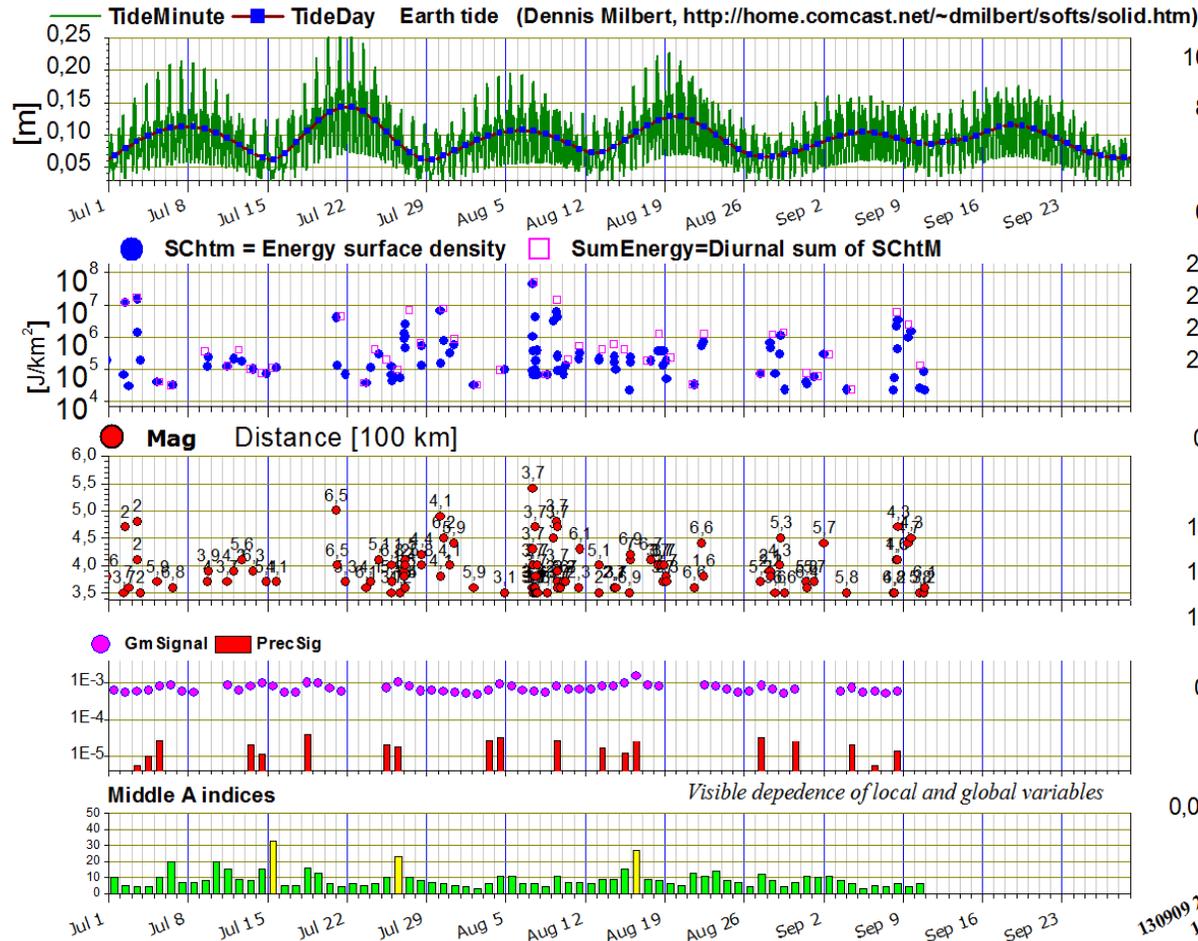
with EU FP7 IRSES the BlackSeaHazNet Project (*Balkan, Black Sea, Caucasus, Caspian NETWORK for Complex Research of Earthquake's Forecasting Possibilities, Seismicity and Climate Change Correlations*) ending this year. It was multilateral cooperation with 9 countries. More geomagnetic observatories like SKO, PAG, GCK, SUR, LVV, KIV, DSH are included in this monitoring.

A new FP7 european project is prepared, where this monitoring will include measuring of Radon concentration changes on particular locations in correlation with observed seismic activity.

Skopje, Macedonia

http://theo.inrne.bas.ba/~mavrodi/evervdav_monitoring.html

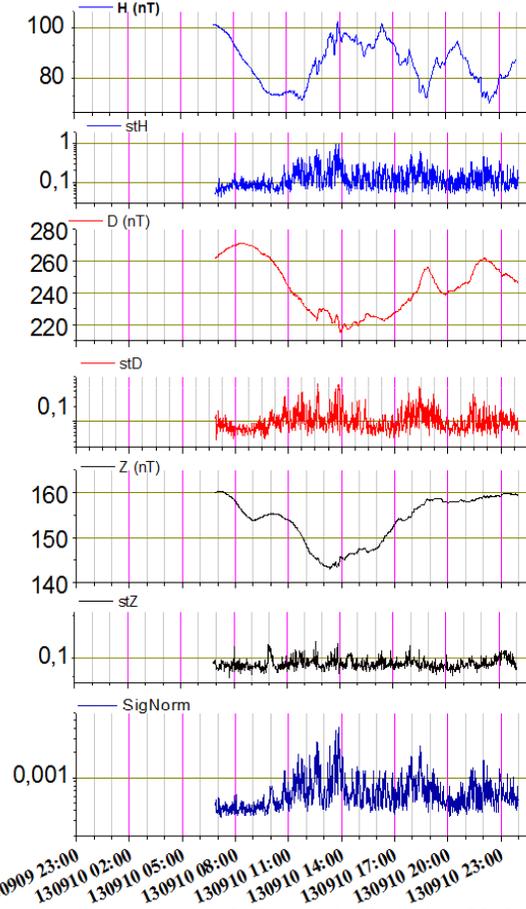
Skopje daily geomagnetic and earthquake monitoring



10 Sep 2013

Data by: Skopje (SORM), EMSC, NOAA

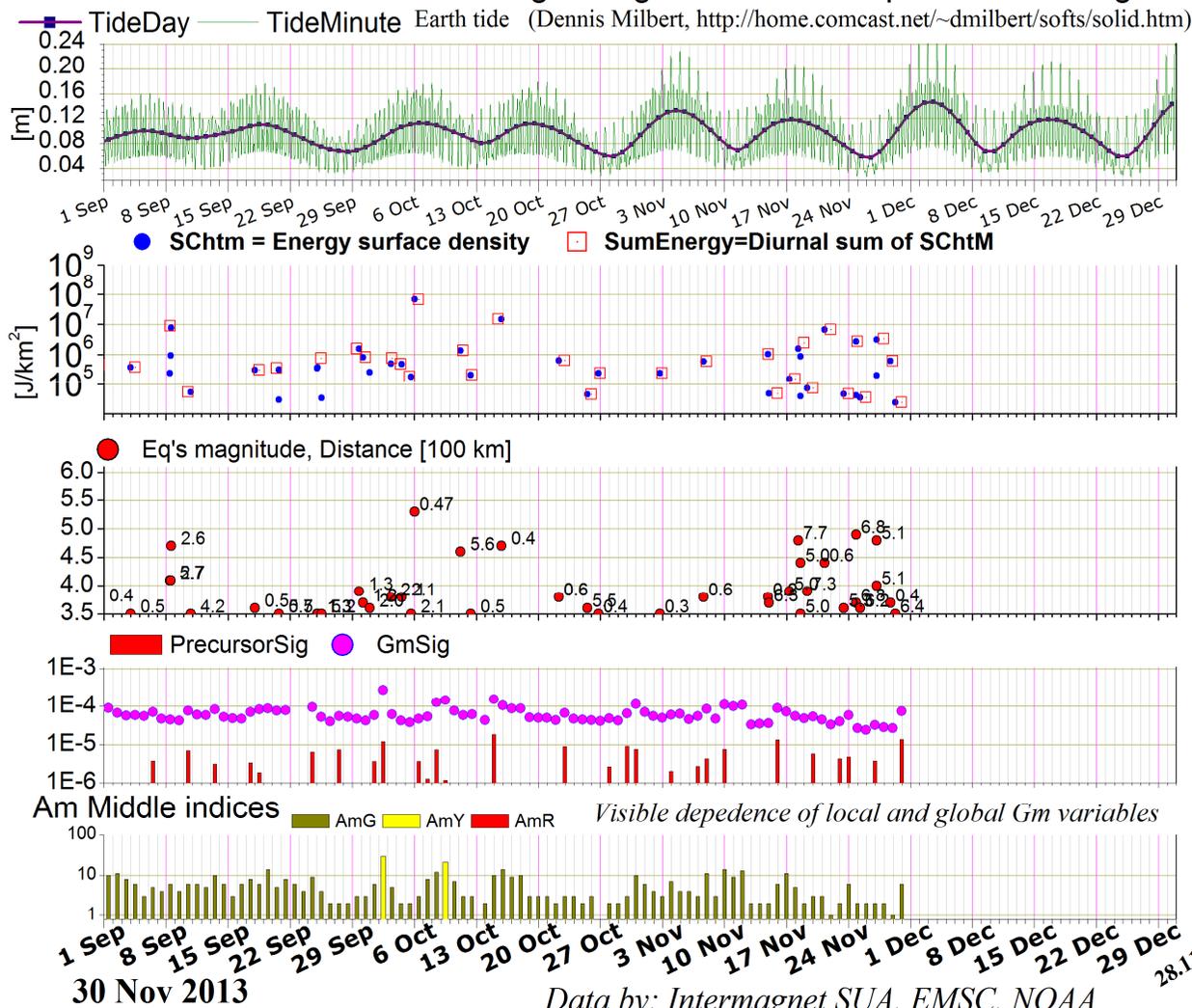
Seismological Observatory, Skopje (SORM)
 Lat 41,91 N, Lon21.44 E, Alt346 m, L. Pekevski
 Minute averaged variometer HDZ data



@ Pekevski, Mavrodiev 2013

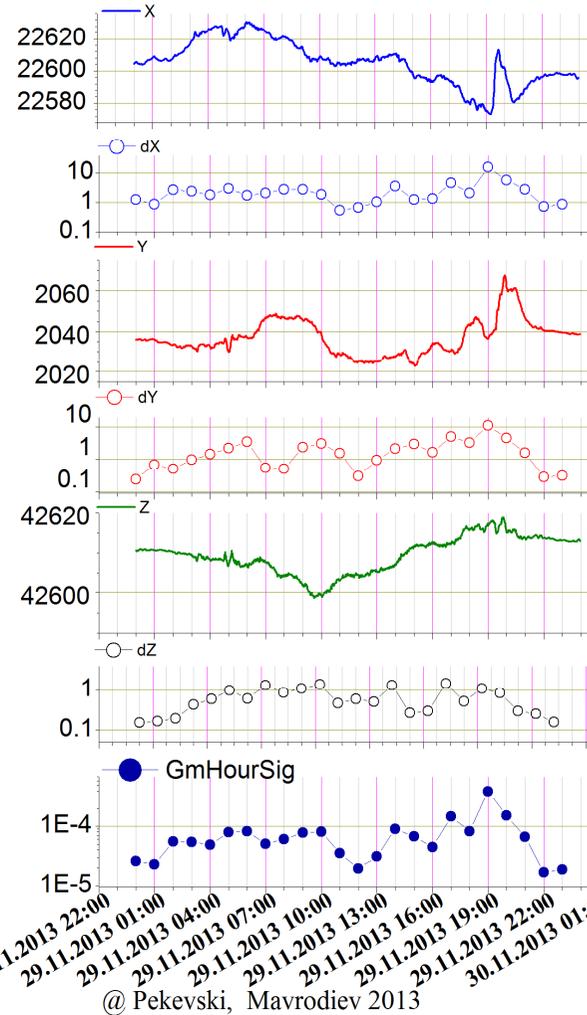
Surlari, Romania

SUA diurnal geomagnetic and earthquake monitoring



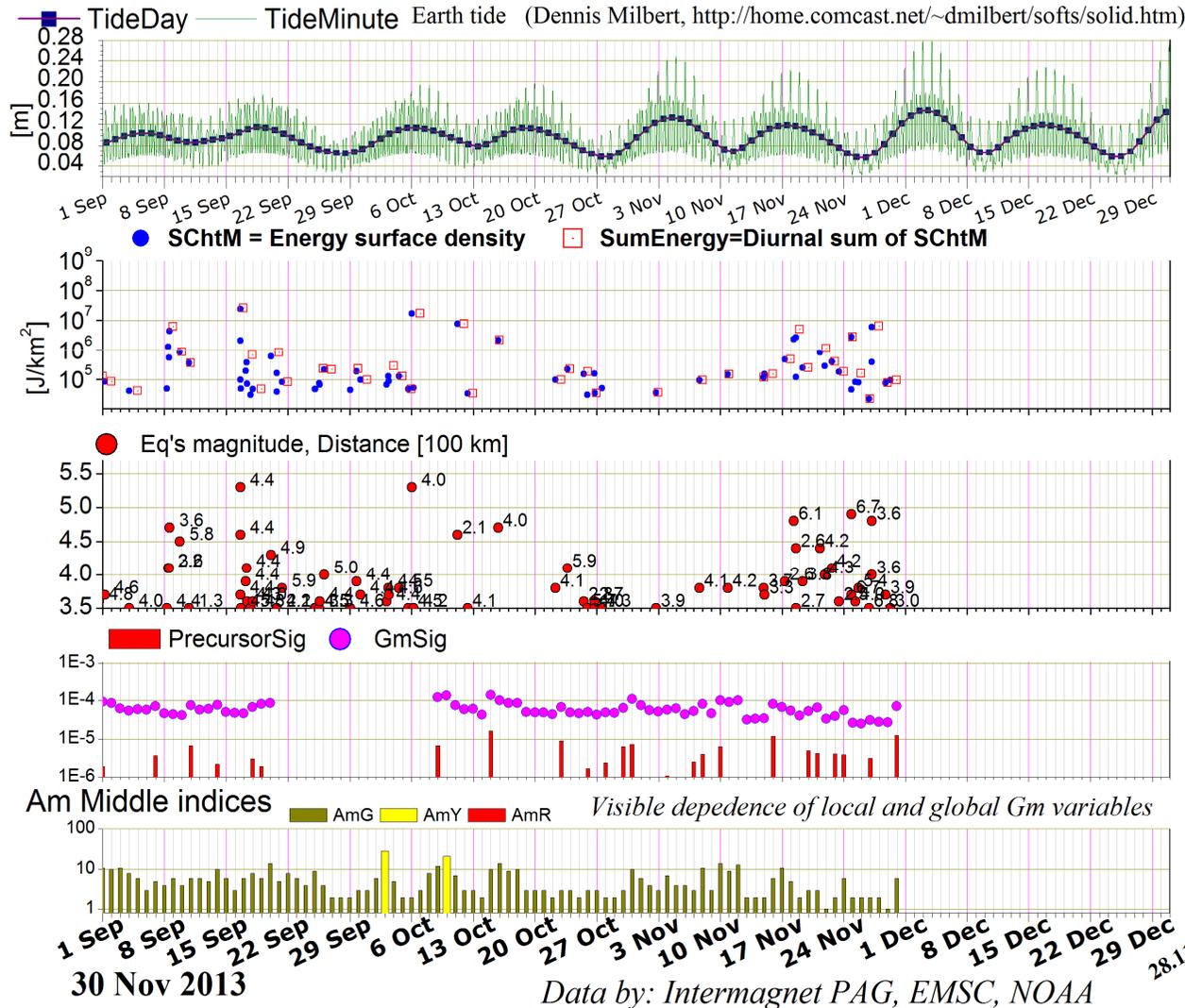
Data by: Intermagnet SUA, EMSC, NOAA

INTERMAGNET SUA Observatory, Surlari, Romania Lat 45.32 N, Lon 26.25E Hour averaged X Y Z variation end its SD data [nT]



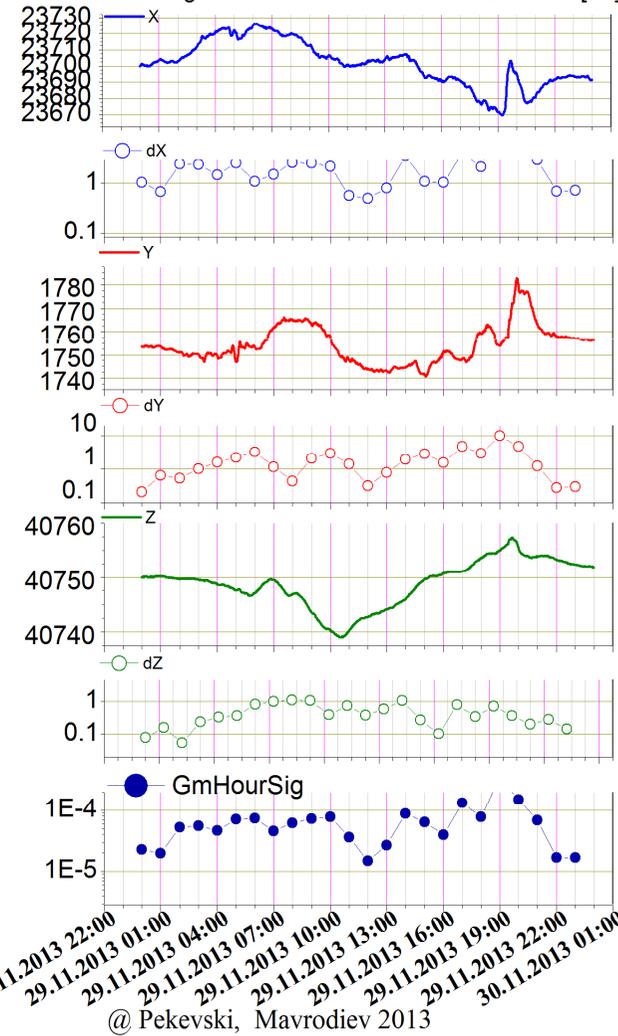
Panagurichte, Bulgaria

PAG diurnal geomagnetic and earthquake monitoring



INTERMAGNET PAG Observatory, Panagjurishte, GPhI, BAS, Sofia, Bg, Lat 42.515 N, Lon 24.177E, H=556 m

Hour averaged X Y Z variation end its SD data [nT]



Data by: Intermagnet PAG, EMSC, NOAA



Greetings from Macedonia