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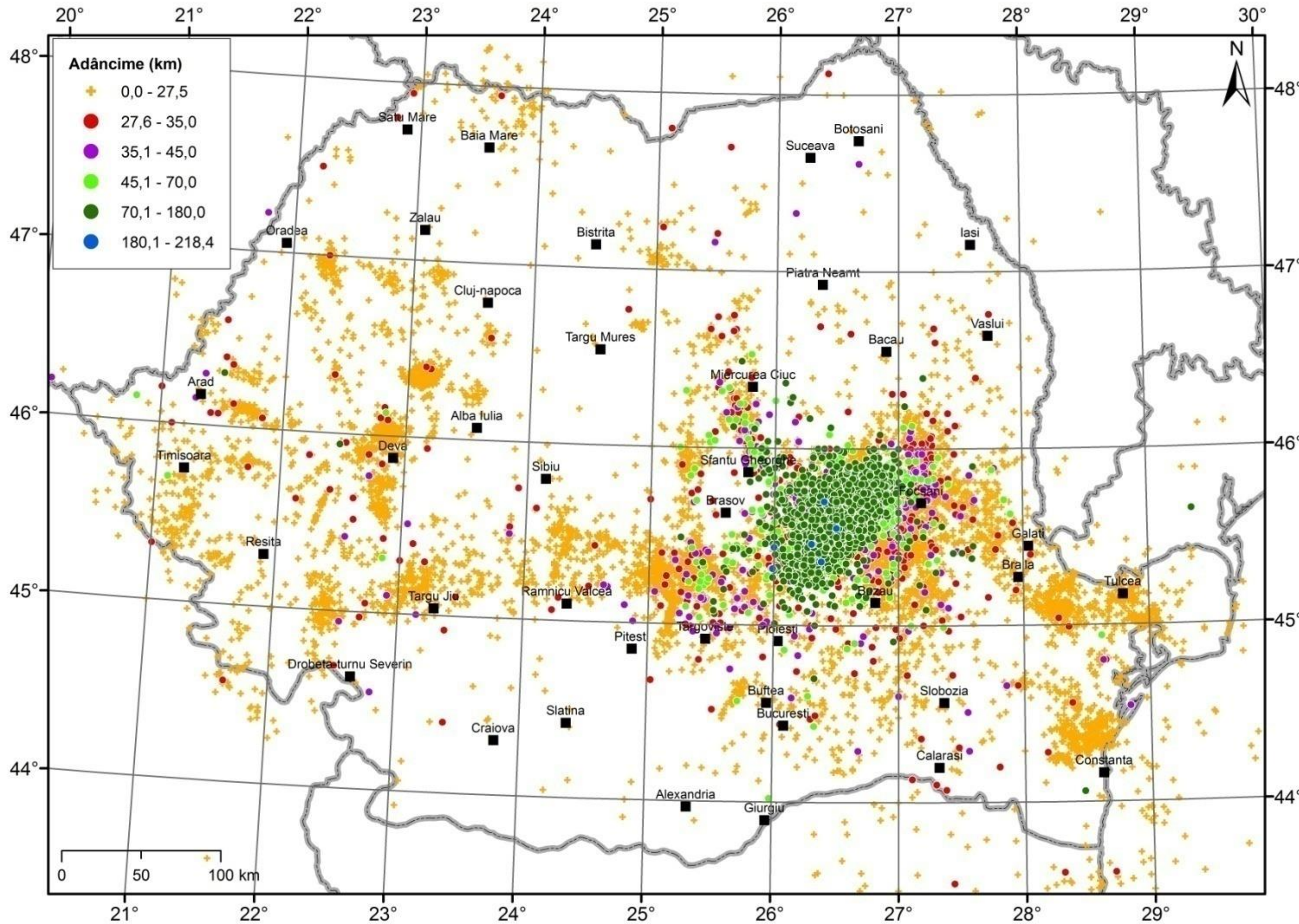
SEISMIC HAZARD ASSESSMENT IN ROMANIA

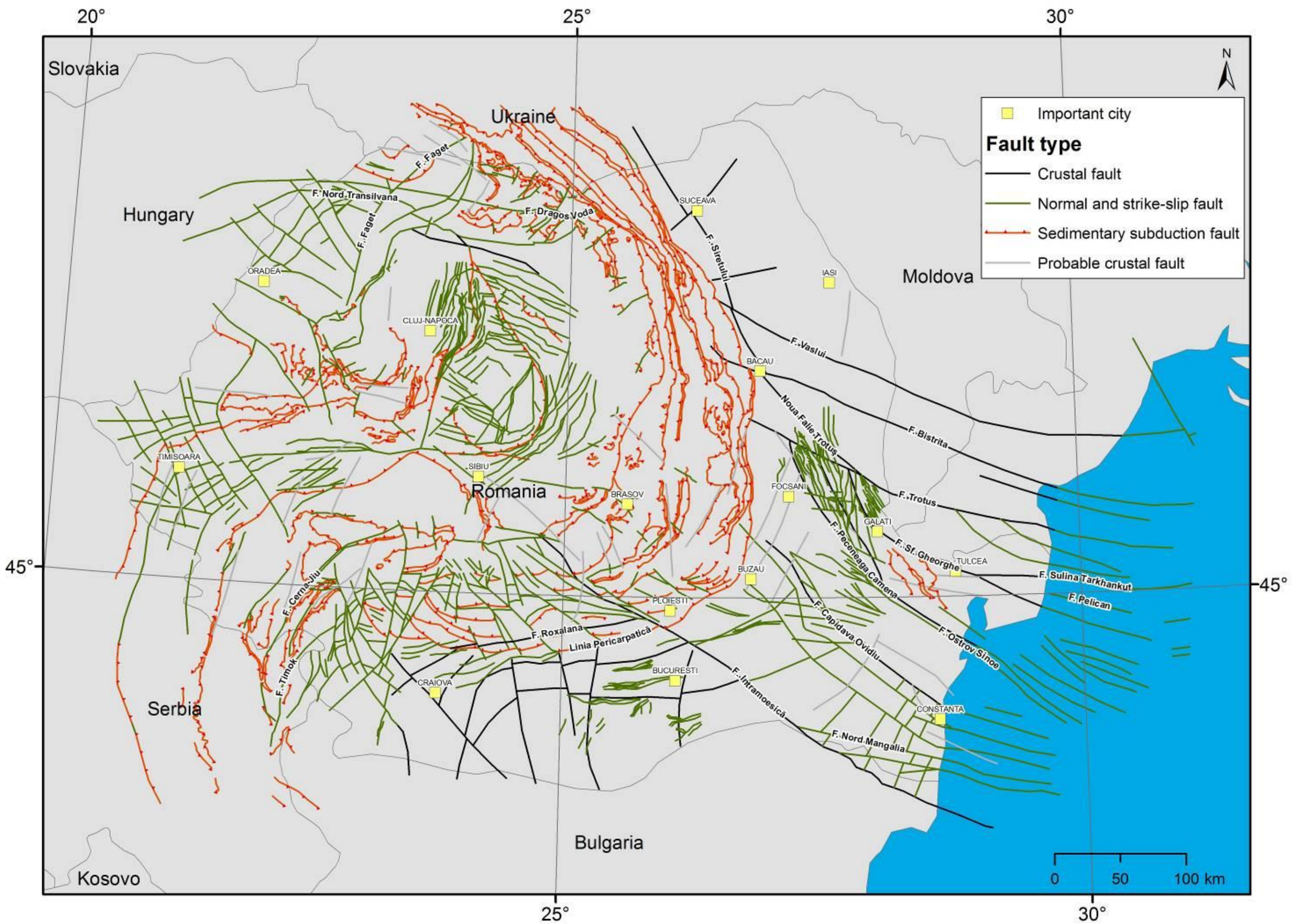
Summary

- Seismic activity in Romania
- Input data
- A few significant results
- Final discussions

Seismicity in Romania



Active faults

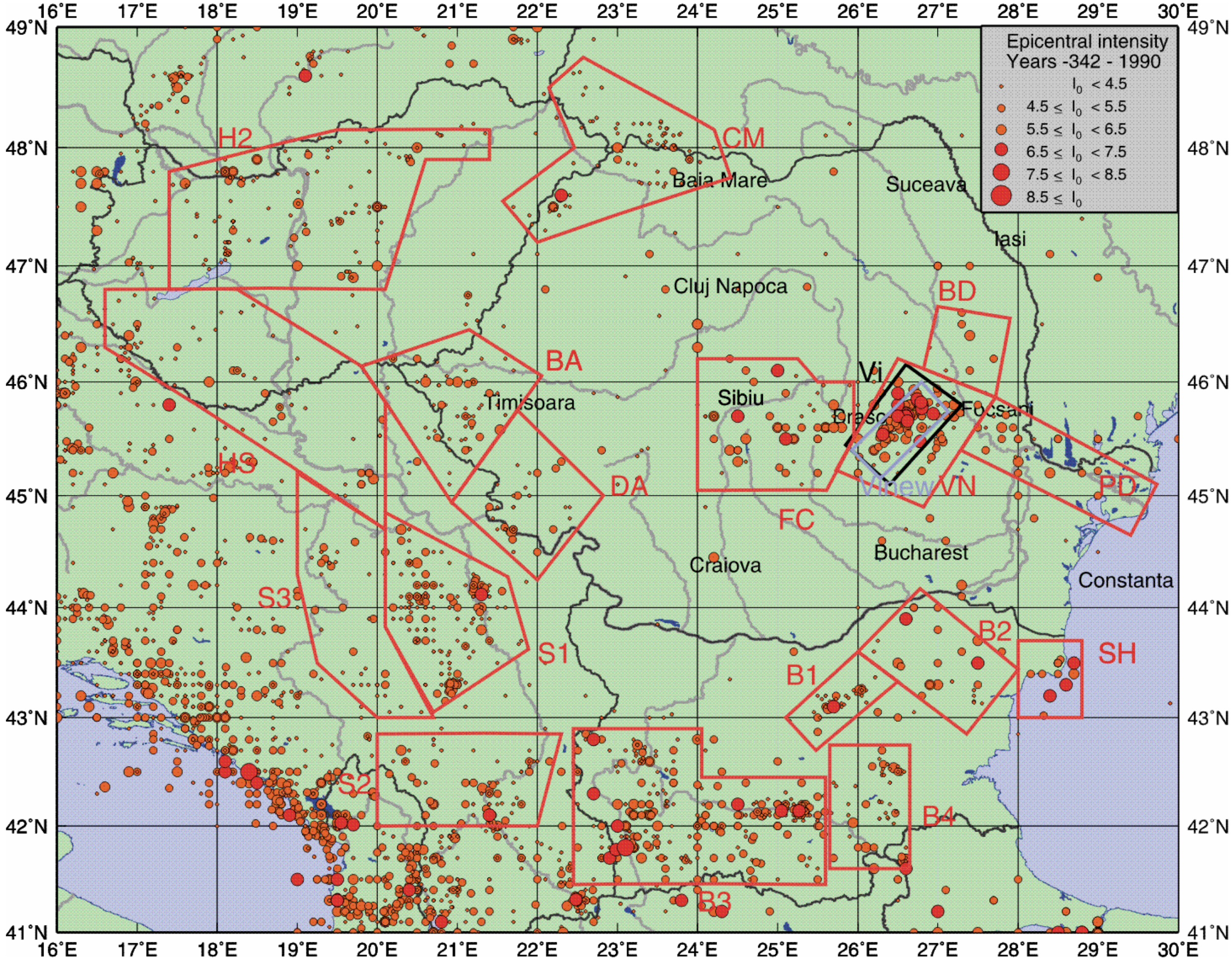


after Raileanu et al. (2009)

Seismogenic zones

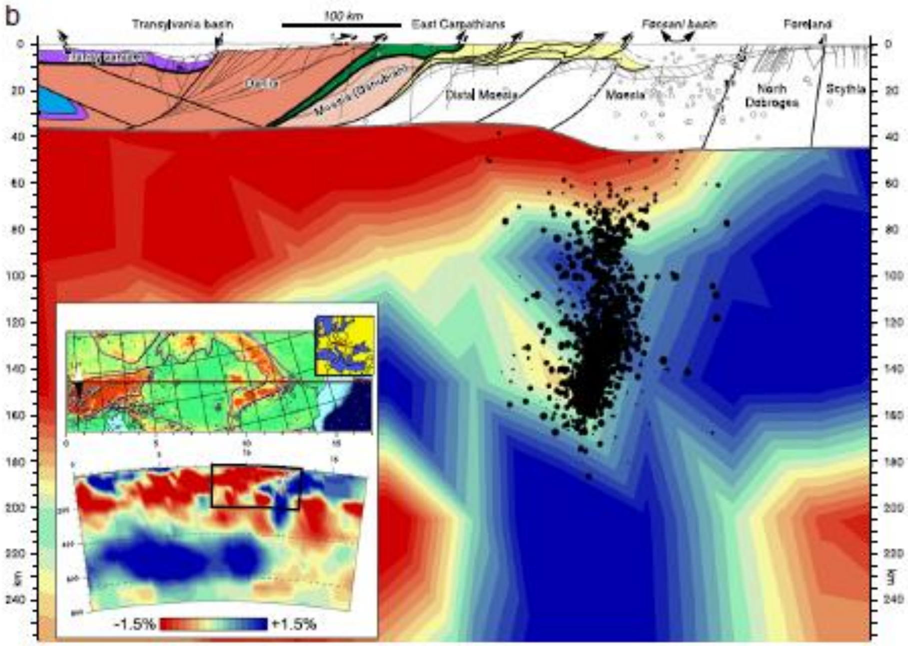
28 crustal source zones
1 intermediate-depth zone (Vrancea)

(after Leydecker et al., 2008)



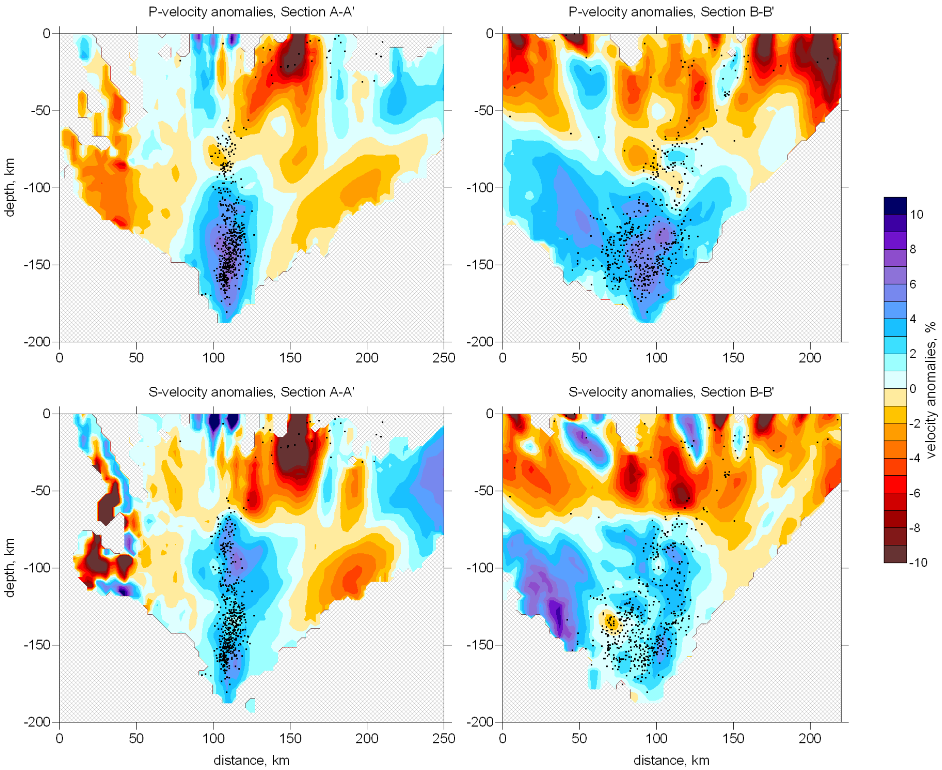
Seismicity in Vrancea

Teleseismic tomography



after *Matenco et al., 2007; Bijwaard and Spakman, 2000*; *Wortel and Spakman, 2000*

Local tomography



after *Koulakov et al., 2009*

Vrancea source

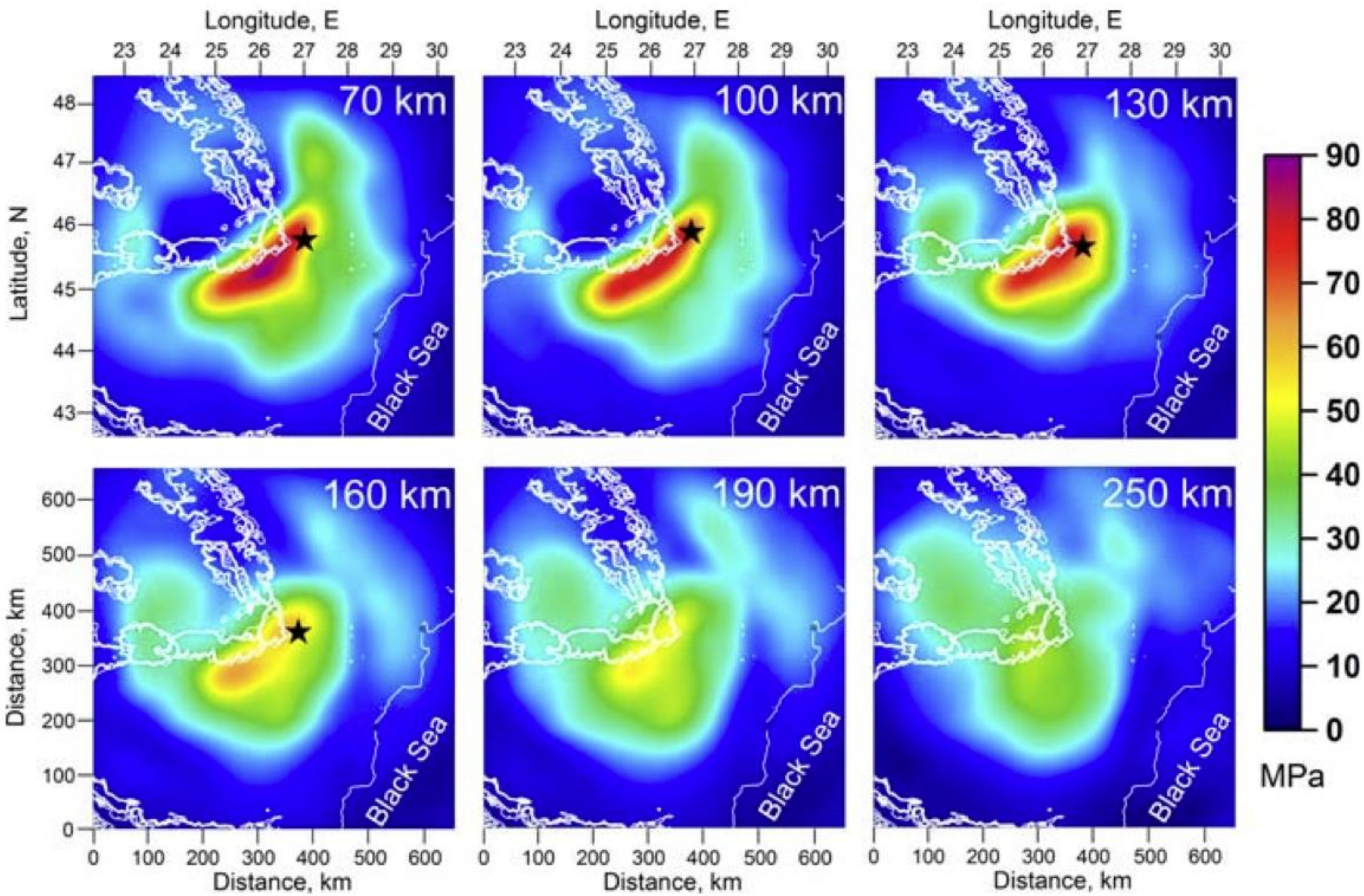
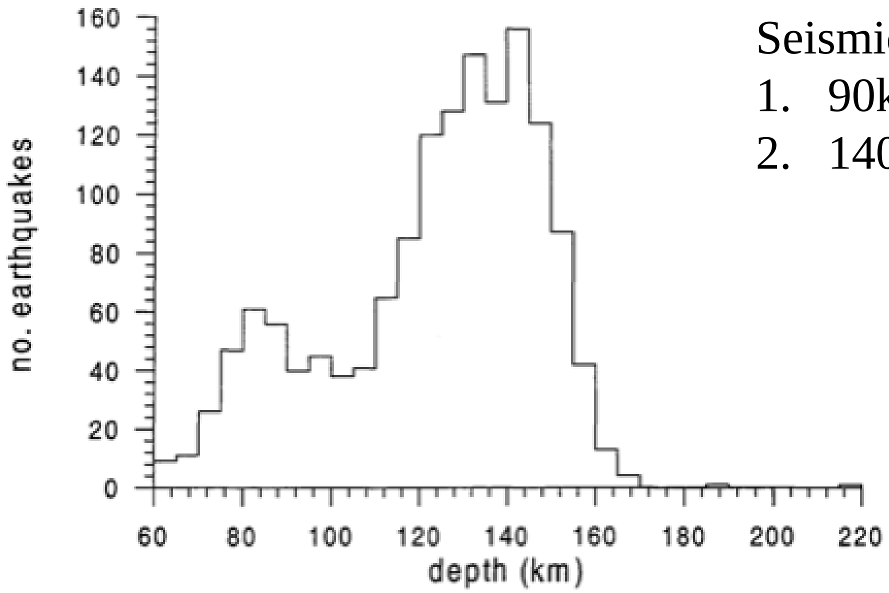


Fig. 3 Maximum shear stress beneath the SE-Carpathians at different depths. Isolines present the surface topography. Star marks the location of the Vrancea intermediate-depth earthquakes

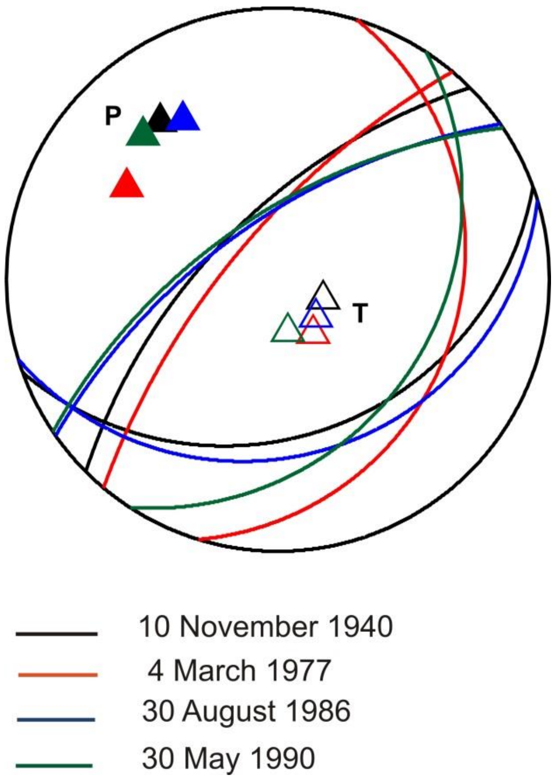
Ismail-Zadeh et al. (2007)

Vrancea source



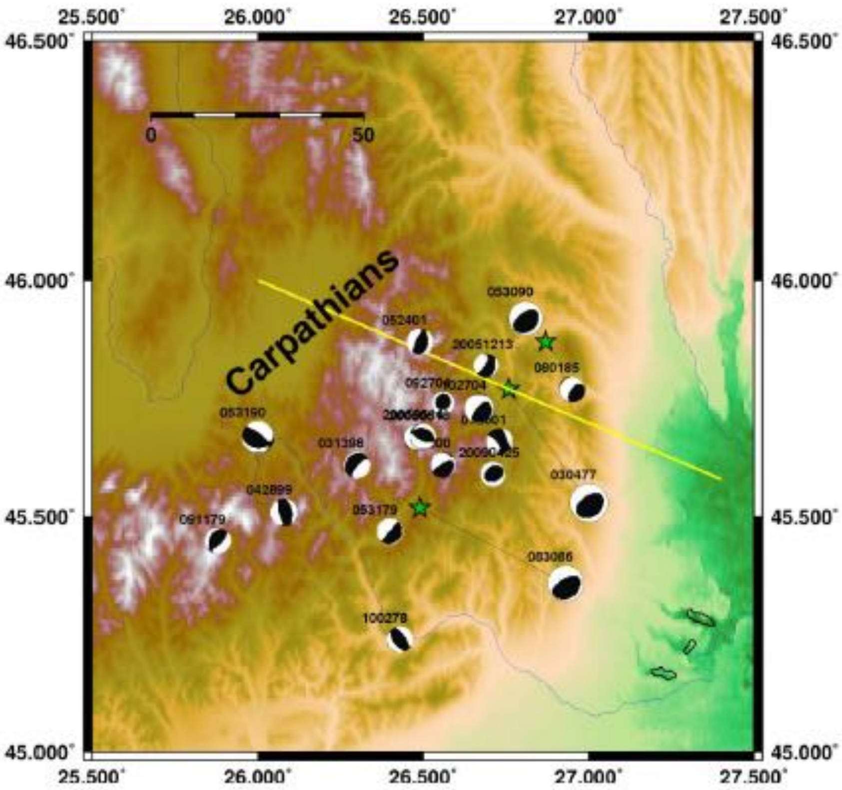
Seismicity concentrates at two depths:

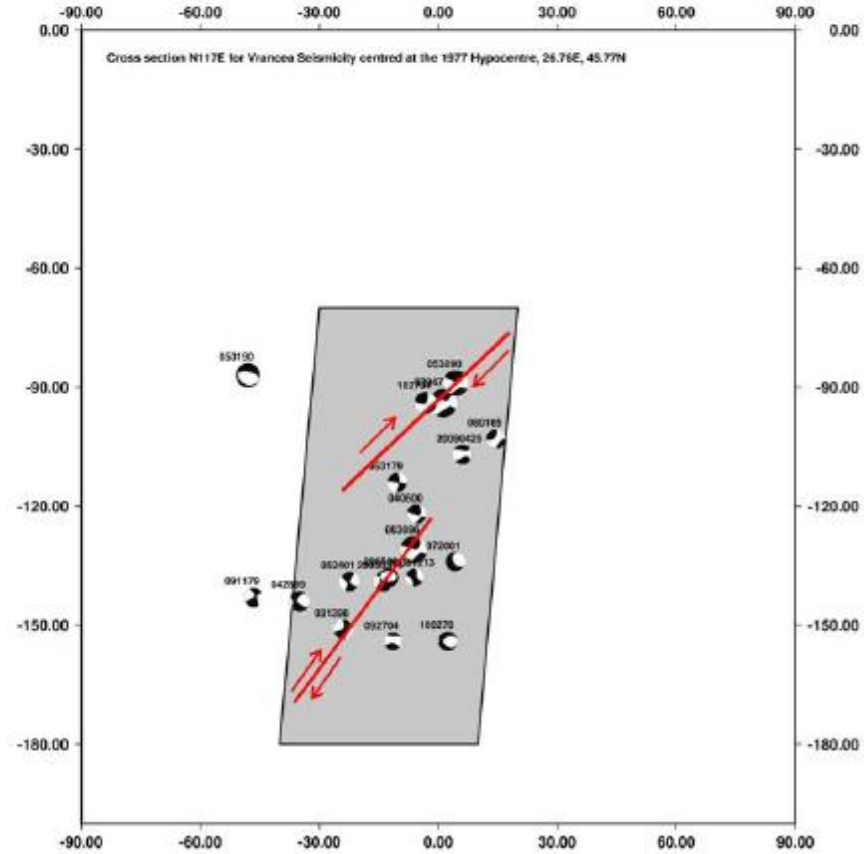
1. 90km
2. 140km



all the major earthquakes (M > 7 are characterized by a reverse faulting mechanism with the T-axis almost vertical and the P-axis almost horizontal

Vrancea source





CMT solutions for Vrancea earthquakes Mw > 4.8
http://www.globalcmt.org/

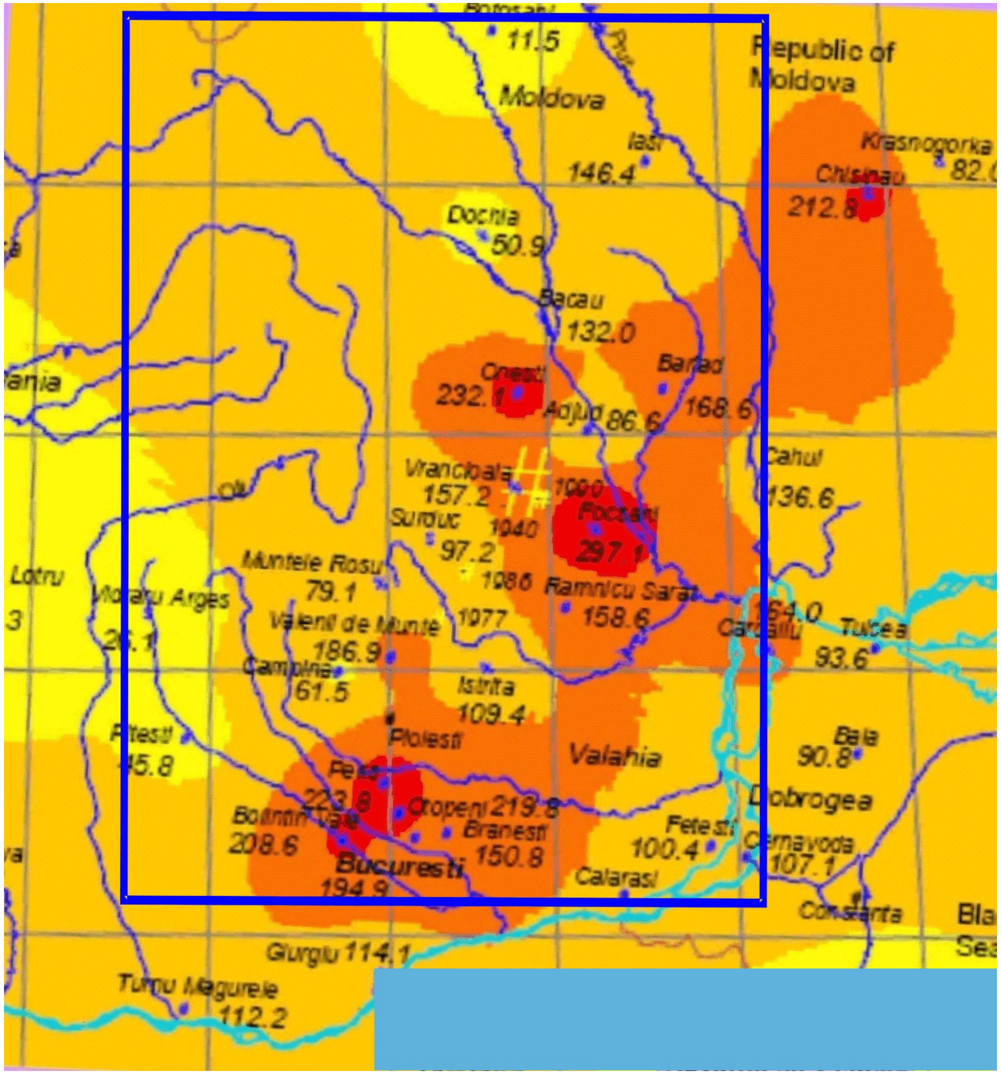
Ganas et al., 2010

Projected mechanisms indicate down-dip extension along west dipping planes. Possible two major planes of weakness in the slab.

Vrancea earthquakes impact

Recorded PGA : 1977, 1986, 1990

after *Lungu and Aldea (1999)*



Central European Initiative project "Unified Seismic Hazard Mapping for the Territory of Romania, Bulgaria, Serbia and Macedonia"

Unified and integrated macroseismic field for the main Vrancea earthquakes that occurred since 1940

Participants: Bulgaria, Hungary, Italy, Republic of Moldavia, Montenegro, Romania, Serbia, and Russia.

Discrete macroseismic IDP maps are generalized to the continuous macroseismic fields using the formalized procedures proposed by Molchan et al. (2002)

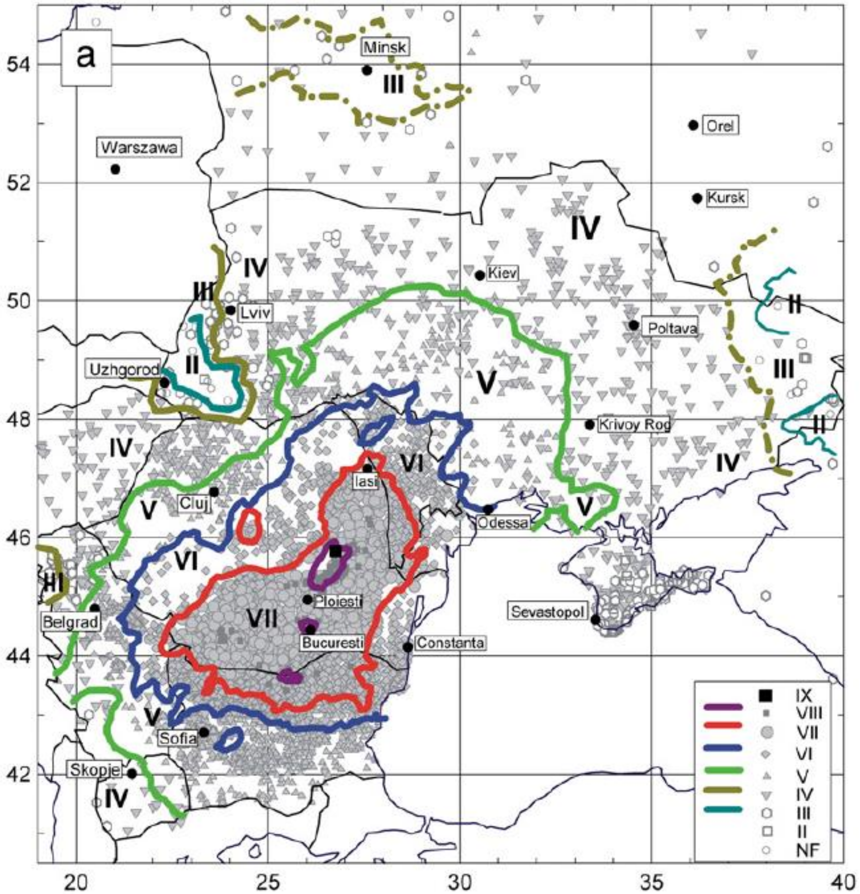
Discrete data available on line http://dx.doi.org/10.1016/j.tecto.2013.01.019

Summary of the macroseismic database

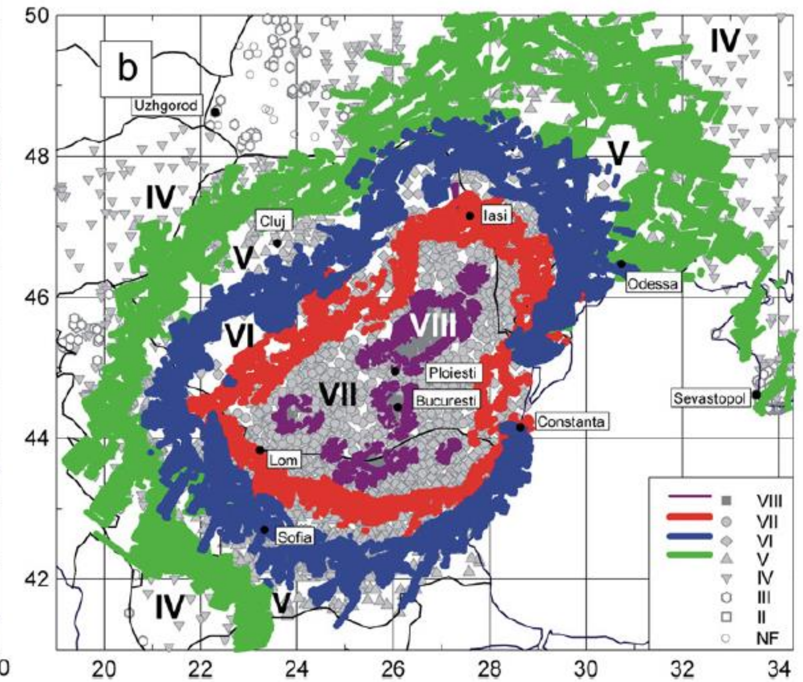
Country	Earthquake						Summary	Sites number
	1940	1977	1986	1990main	1990aft	2004		
Byelorussia	–	46	60	–	–	–	106	76
Bulgaria	200	1196	276	90	–	11	1773	1346
Hungary	1	63	42	95	–	–	201	136
Macedonia	1	23	12	6	–	–	42	24
Moldova	25	264	214	76	62	33	674	392
Romania	217	1314	1046	946	392	22	3937	2122
Russia	3	30	31	–	–	–	64	55
Serbia	326	302	39	20	–	2	689	612
Ukraine[1)]	33	842	472	431	348	162	2288	1313
Other[2)]	3	7	7	–	–	4	21	18
Summary	809	4087	2199	1664	802	234	9795	6110

Maps of the trans-frontier macroseismic field for the Vrancea 1940 event

Kronrod et al. (2013)



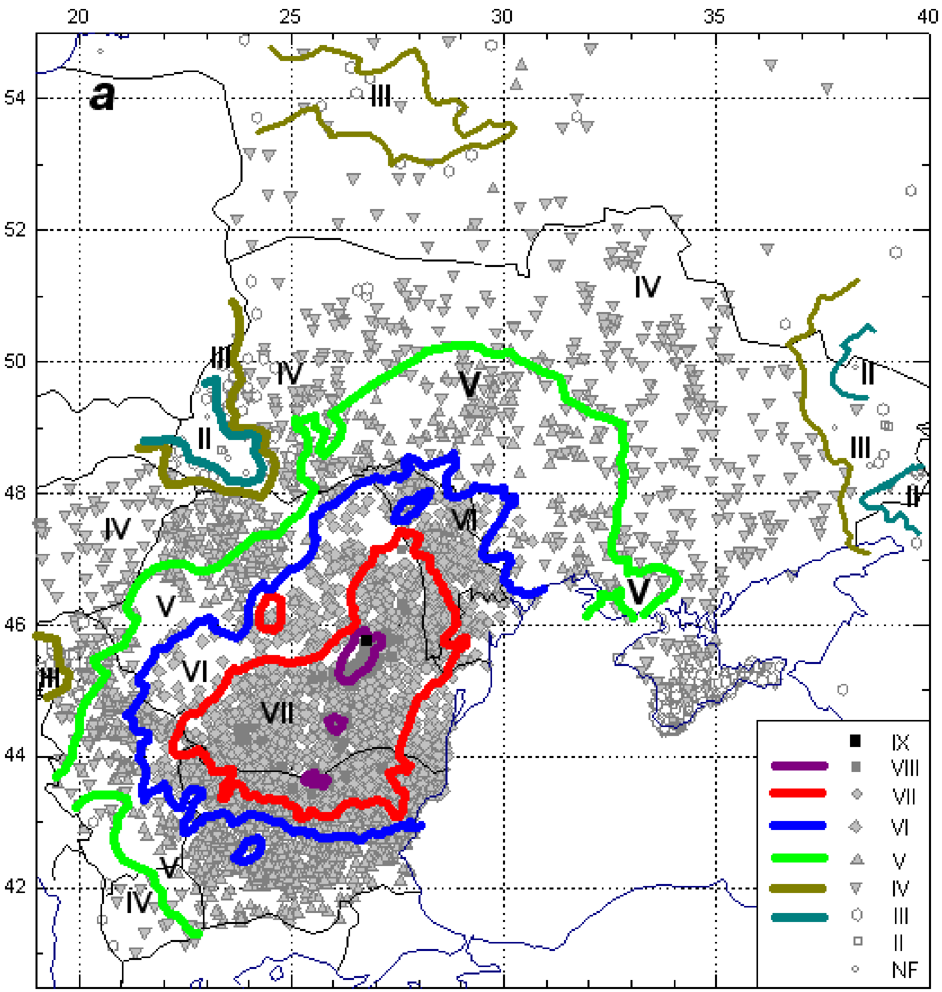
Modified polynomial filtering method



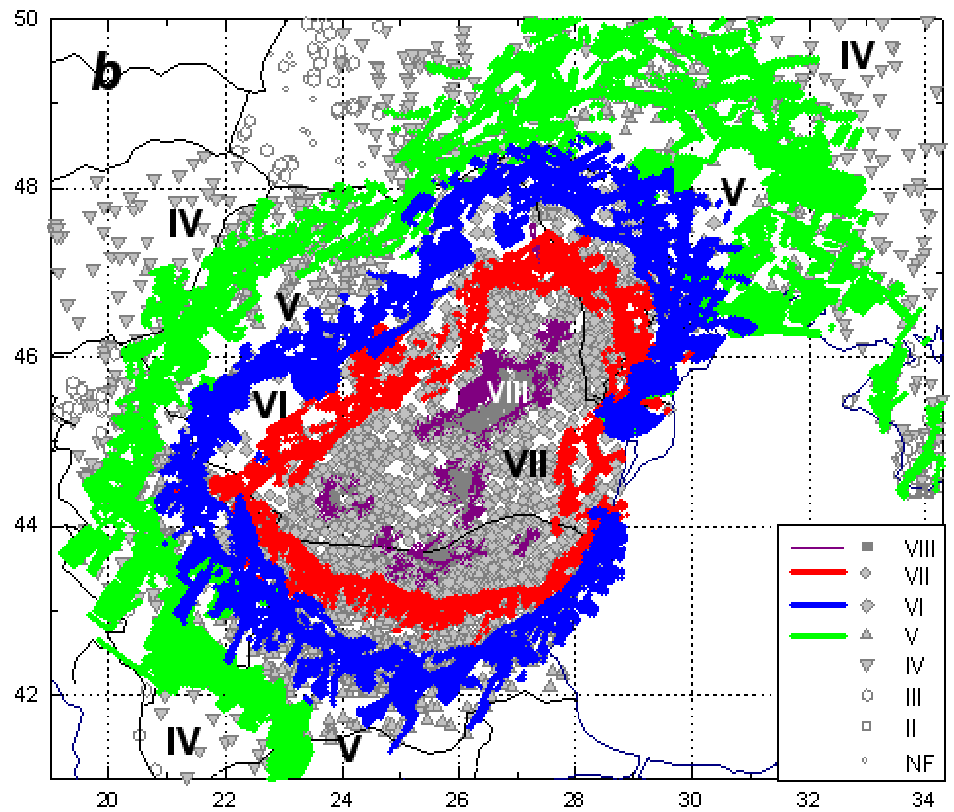
Diffuse boundary method

Maps of the trans-frontier macroseismic field for the Vrancea 1977 event

Kronrod et al. (2013)

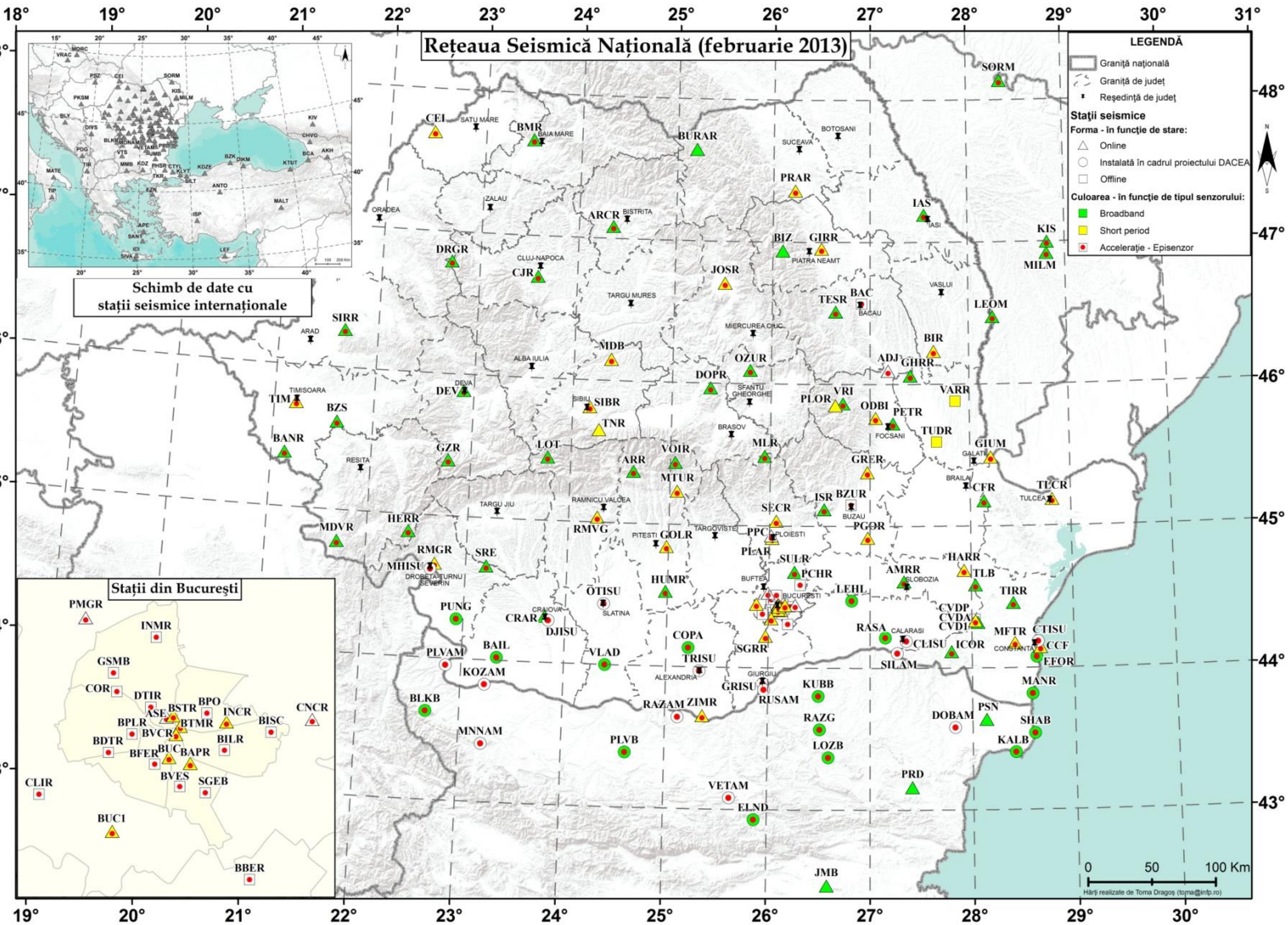


Modified polynomial filtering method

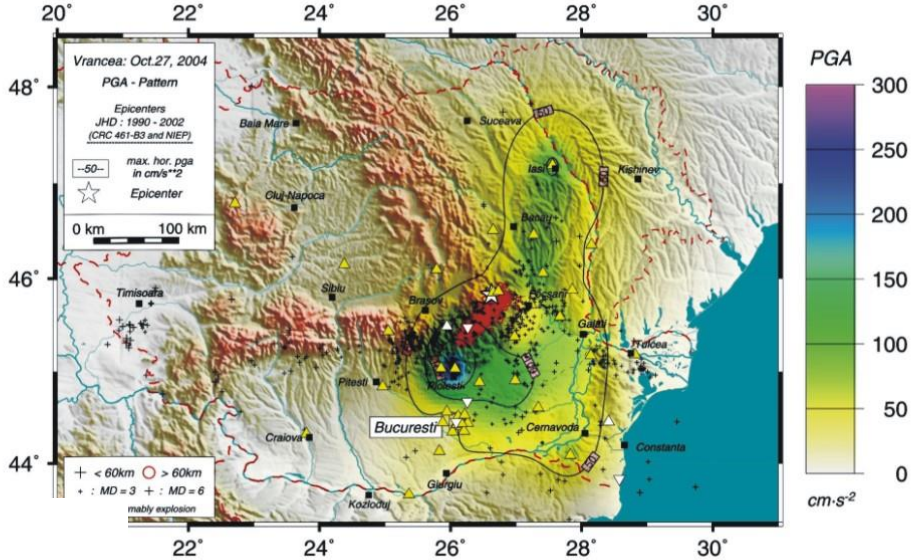


Diffuse boundary method

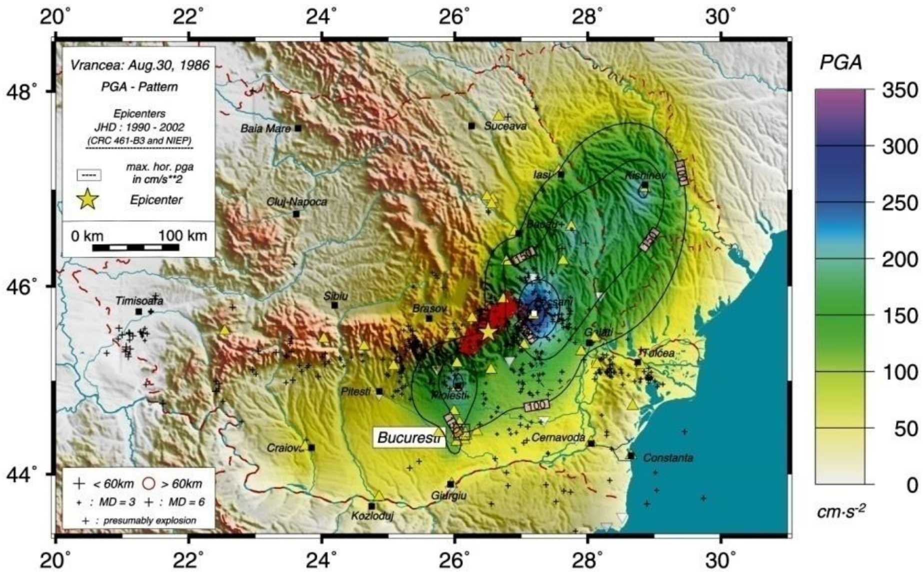
Real-time seismic network



Shakemaps



Peak ground acceleration distribution for the Vrancea earthquake of August 30, 1986 (M 7.1)

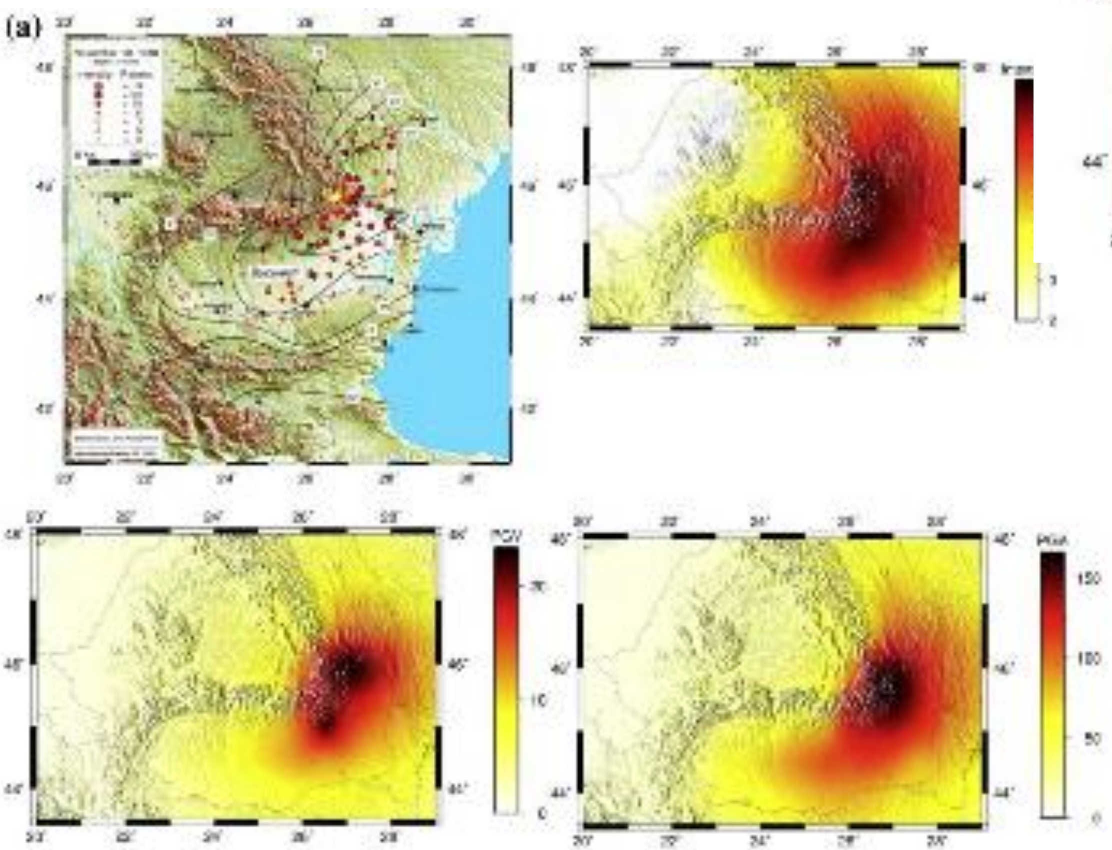


Peak ground acceleration distribution for the Vrancea earthquake of October 27, 2004 (M 6.0)

Vrancea earthquakes impact

Azimuth-dependent GMPE
Sokolov et al. (2005)

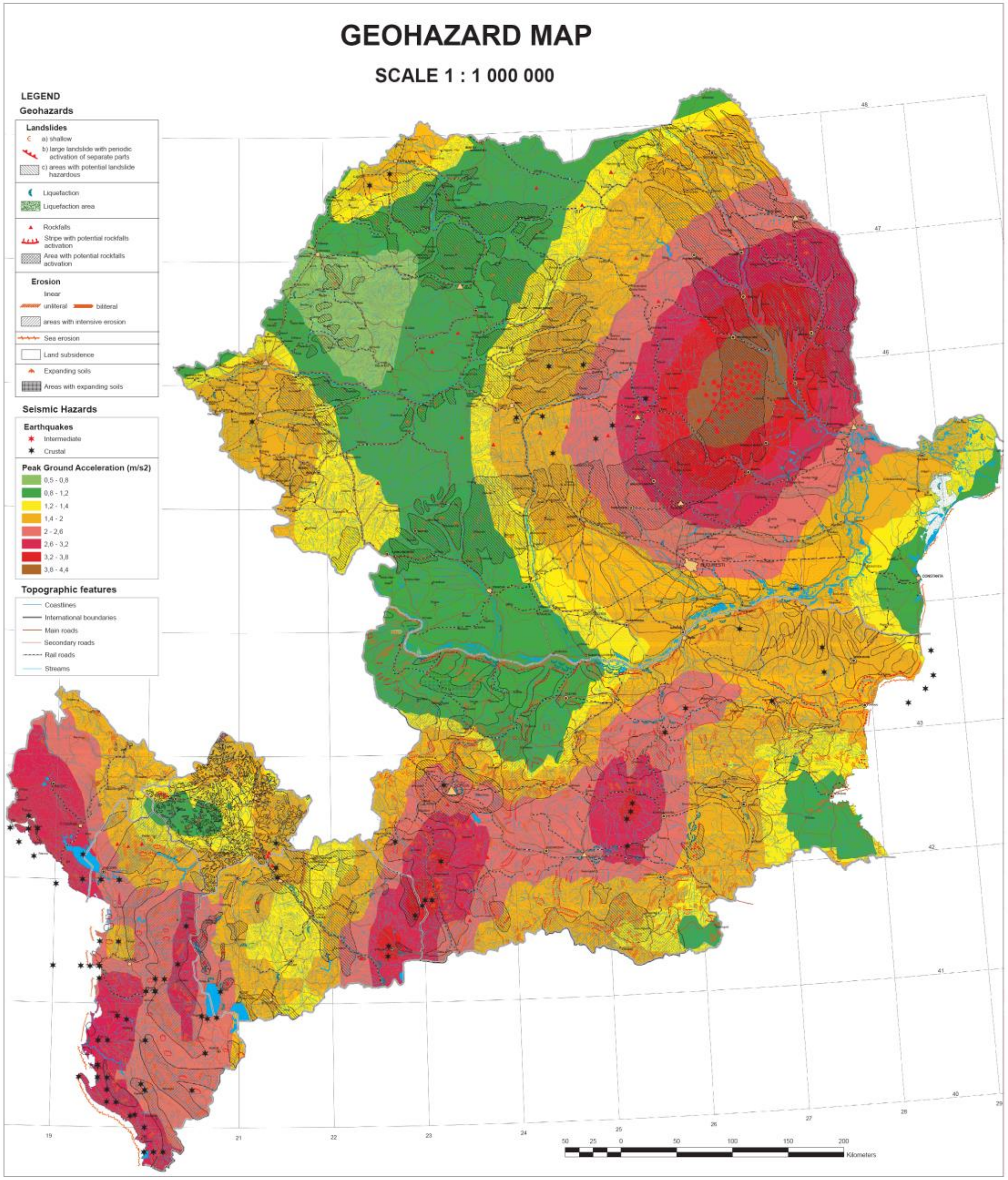
Vrancea 1940 event



Project "Balkan Geohazard Assessment and Map" (OPP-024) - 2007

awarded under the Grant program of US Civilian Research and Development Foundation (CRDF);

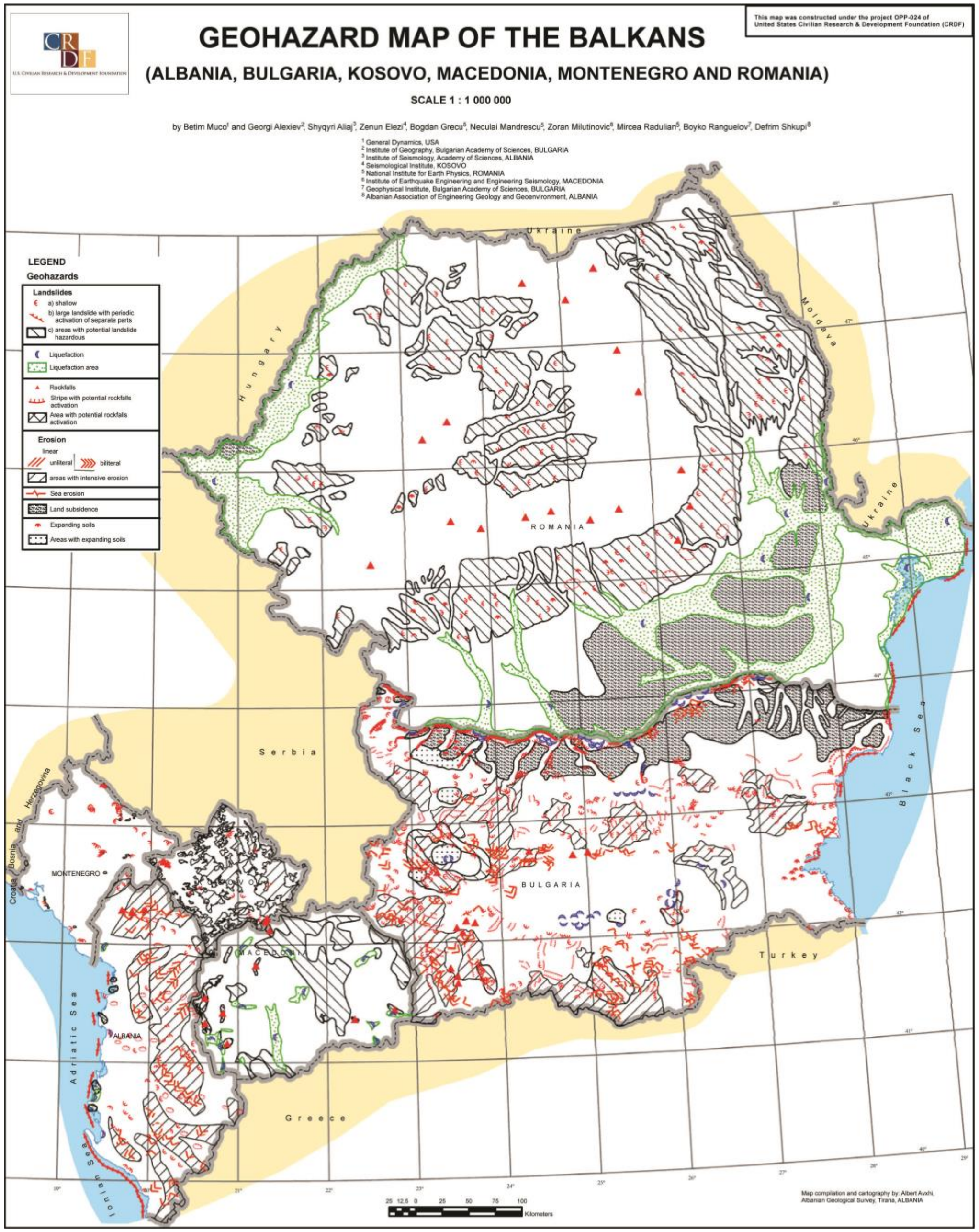
Albania, Bulgaria, Montenegro, Romania



Integration of different potentially dangerous geohazard factors

Legend

- 1_Landslides point
- 2_landslide_area
- 3_Large_lendslide
- 4_Liquefaction
- 5_liquefaction_area
- 6_Rockfalls
- 7_stripe
- 8_rockfalls_area
- 9_Erosion_area
- 10_Erosion linear
  - 1 unliteral
  - 2 biliteral
- 11_Sea erosion
- 12_Land_Subsidence
- 13_Expanding Soils
- 14_Expanding_soils



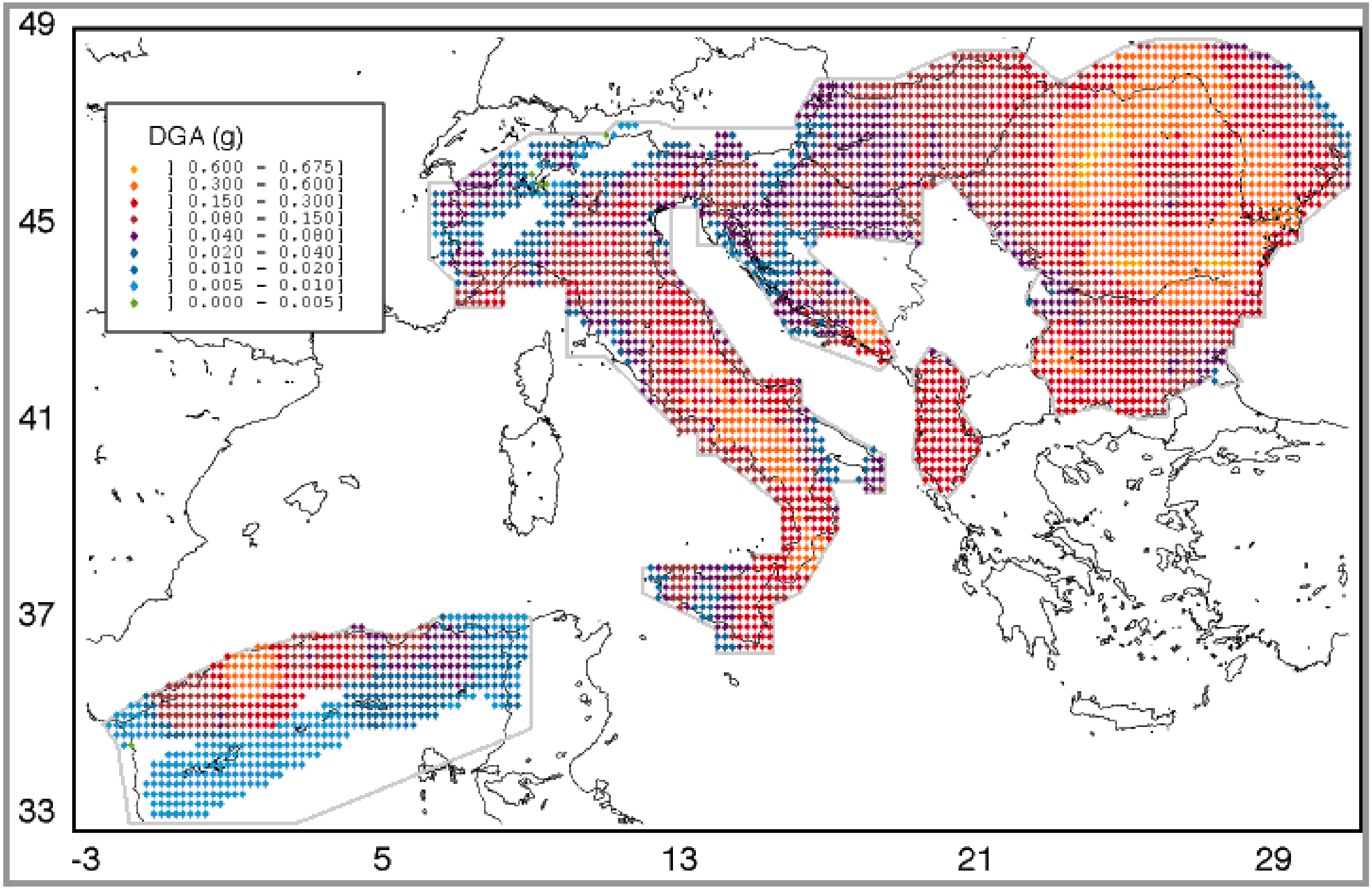
Deterministic approach

Computation of complete synthetic seismograms for scenario earthquakes (Panza et al., 2009)

For local and regional seismic hazard assessment (see for example, the Pageoph topical volume “Seismic hazard of the Circum-Panonnian region”, Editors Panza, Radulian, Trifu, 2000)

Successfully applied to numerous metropolitan areas (Panza et al., 2005), including Bucharest, Sofia, Russe, Zagreb.

Deterministic hazard map



Radulian et al. (2000)

Seismic Hazard Harmonization in Europe

Unified procedure for seismic hazard assessment on a pan-European scale. The data bases and maps developed within the project exhibit the highest quality presently possible in the field.

Unified, continent-wide dataset of earthquake data achieved by blending existing historical datasets and reassessing calibrated magnitudes with support from several institutions and national catalogues.

Coordination of strategy with GEM Programme

SHARE

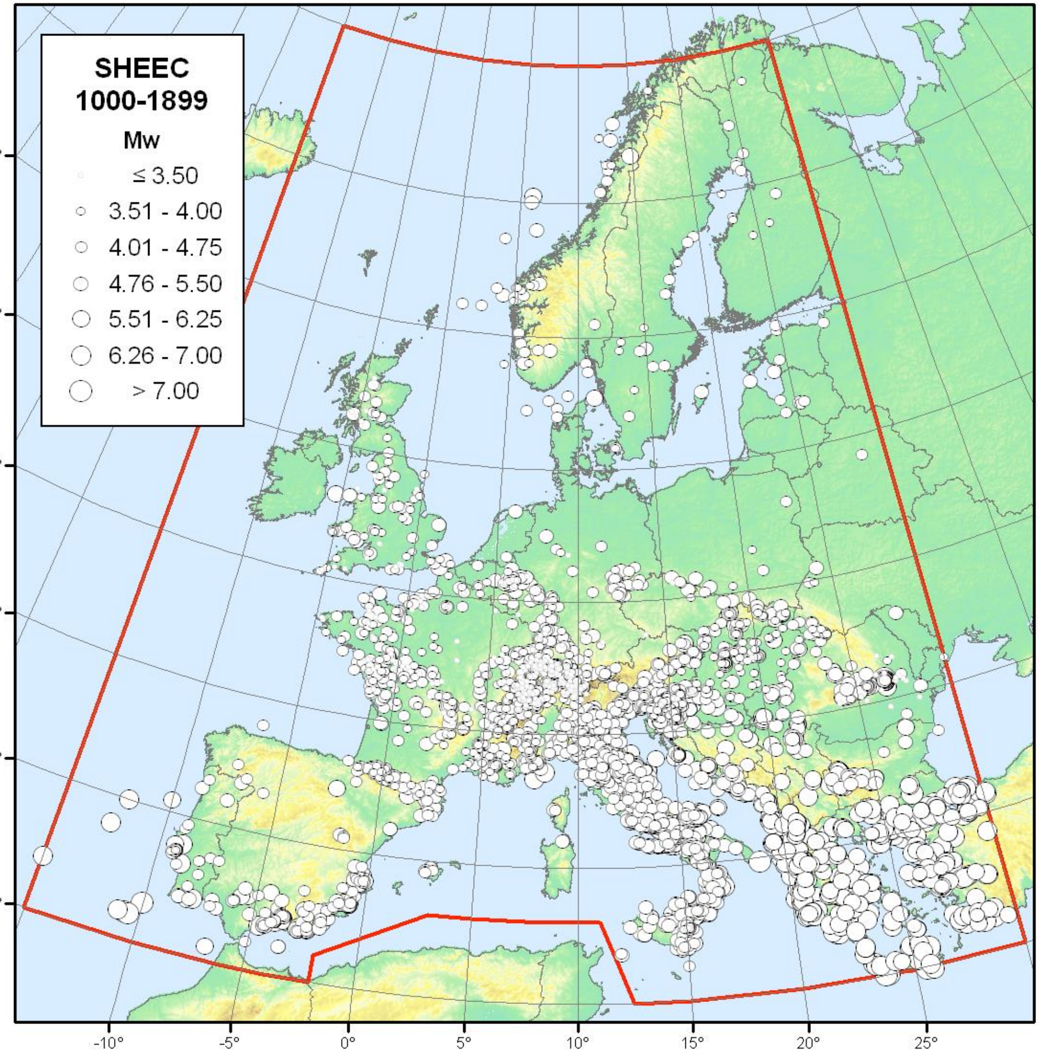
SHEEC catalog and working area

SHEEC contains 24210 events

1000-2006 time interval

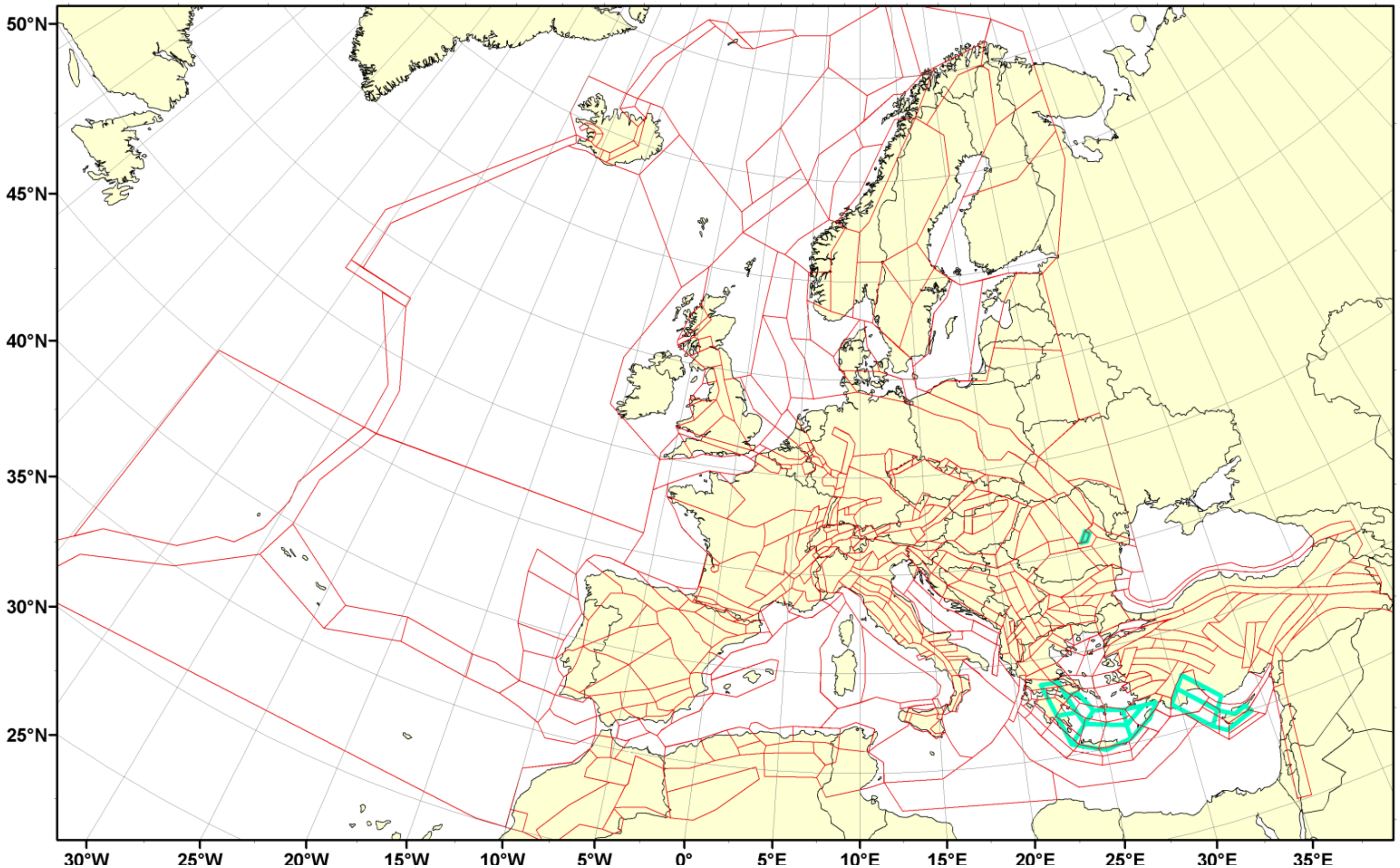
$1.7 \leq M_W \leq 8.5$ moment magnitude range

224 events with no magnitude (all before 1900)



SHARE

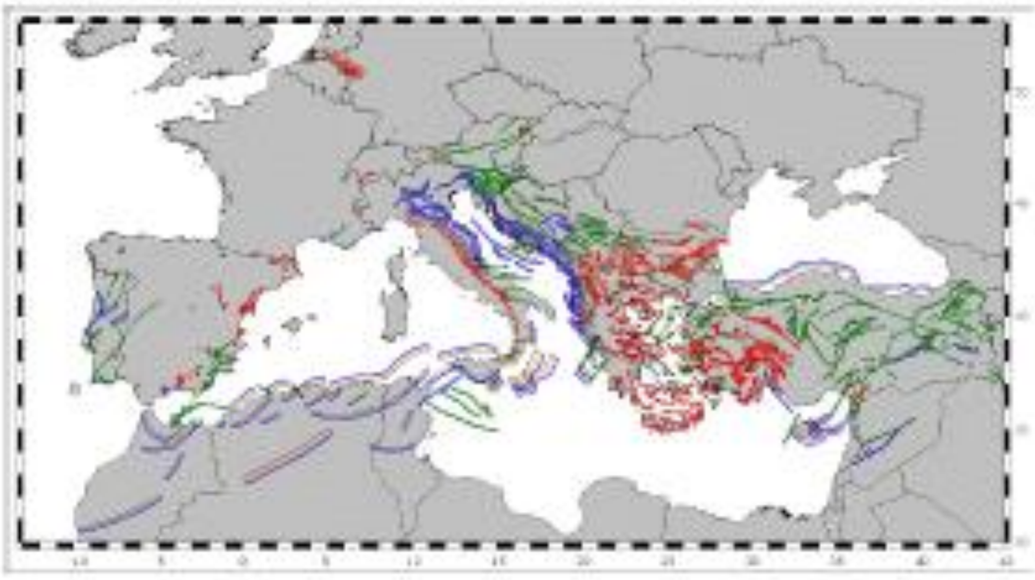
Area Source Model



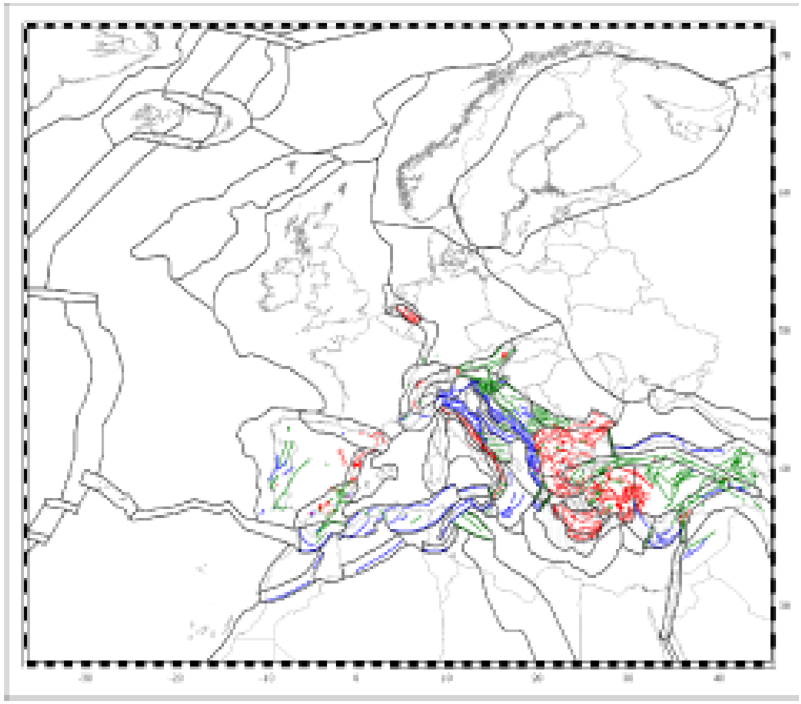
The SHARE seismic source zone model. Intermediate-depth sources are highlighted in green.

SHARE

Fault-Source and Background Model



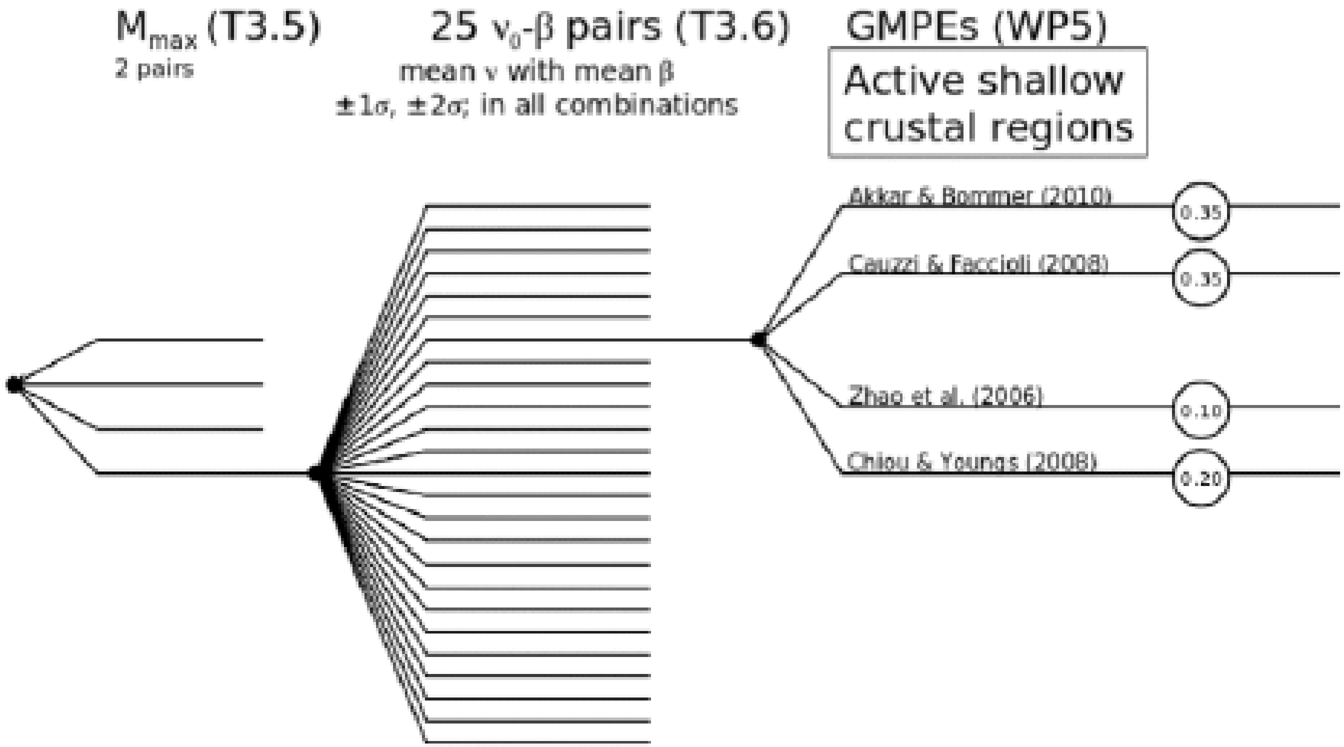
Fault sources. Red – normal faulting; blue – reverse faulting; green – strike-slip faulting.



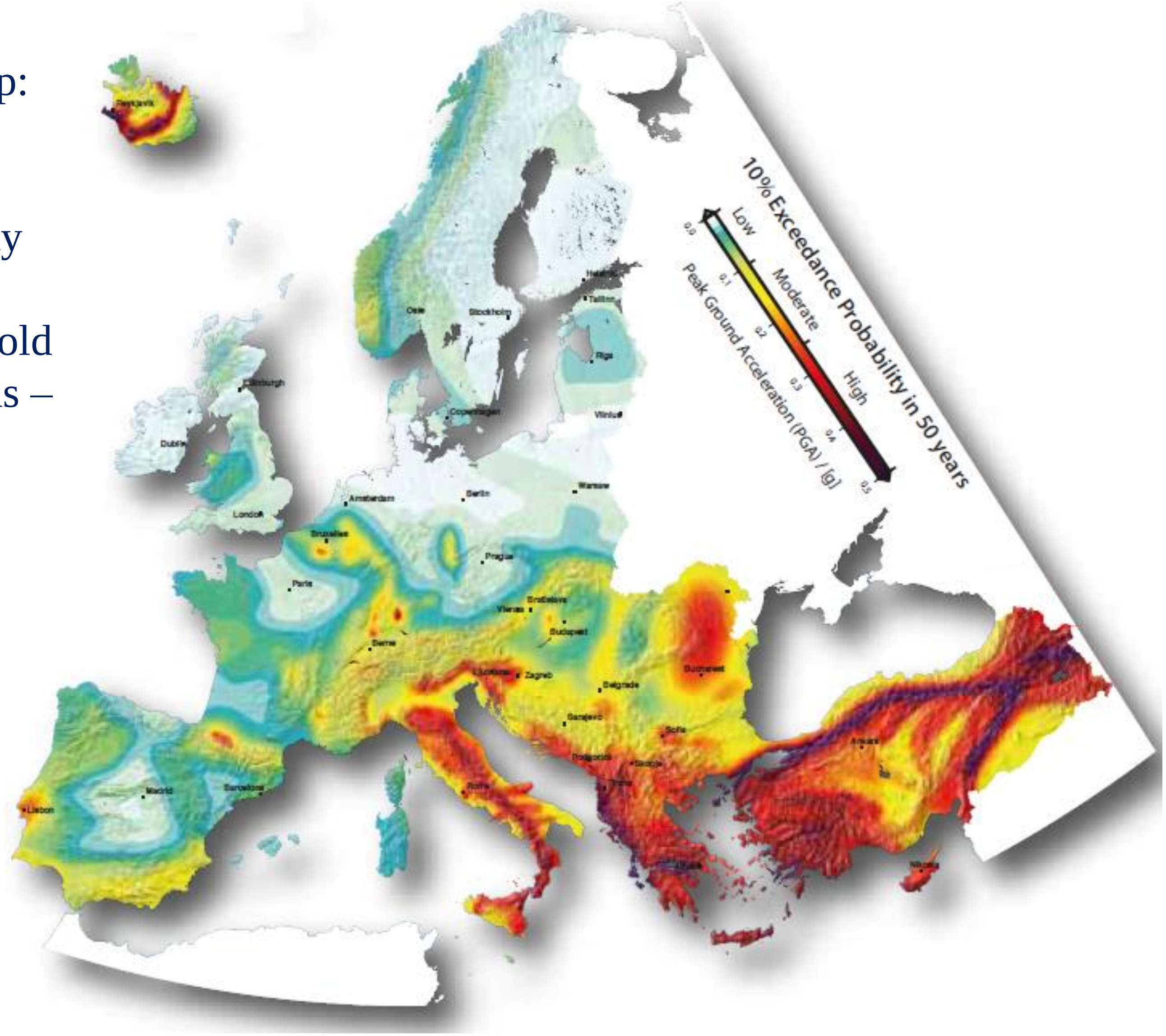
Background zones for fault sources

SHARE

Logic tree structure



European Seismic Hazard map: peak ground acceleration expected to be reached or exceeded with 10% probability in 50 years (475 years return period). Low hazard areas – cold colours; moderate hazard areas – yellow to orange; high hazard areas – red colours (***SHARE project***, ***www.share-eu.org***)



Conclusions

- It is very important to illustrate epistemic uncertainty somehow since most (non-specialized) structural engineers are not aware of these uncertainties.
- Expert judgment cannot be eliminated and has to be included in the logic tree structure, expressing epistemic uncertainty.
- It is important to consider the influence of deeper geology on the site effect
- It is encouraged the idea of merging source zones in order to attenuate singular hazard spots if there are plausible geological arguments to do so.
- Zonation is based on PGA, but may also take into account spectral shape and controlling earthquake scenario.

Conclusions

- Standard procedures for seismic hazard assessment are not suitable for Vrancea
- A few obviously unrealistic features are noticed in the SHARE results, such as the high hazard values in Vrancea, or the hazard values in Italy that go drastically down and at the North Anatolian Fault Zone up, both in case of the fault source model compared to the area source one.
- Deterministic computation provides good results for crustal sources; for Vrancea source the hazard values reproduce well the observations for the extra-Carpathians area, but are unrealistic high for the intra-Carpathians area