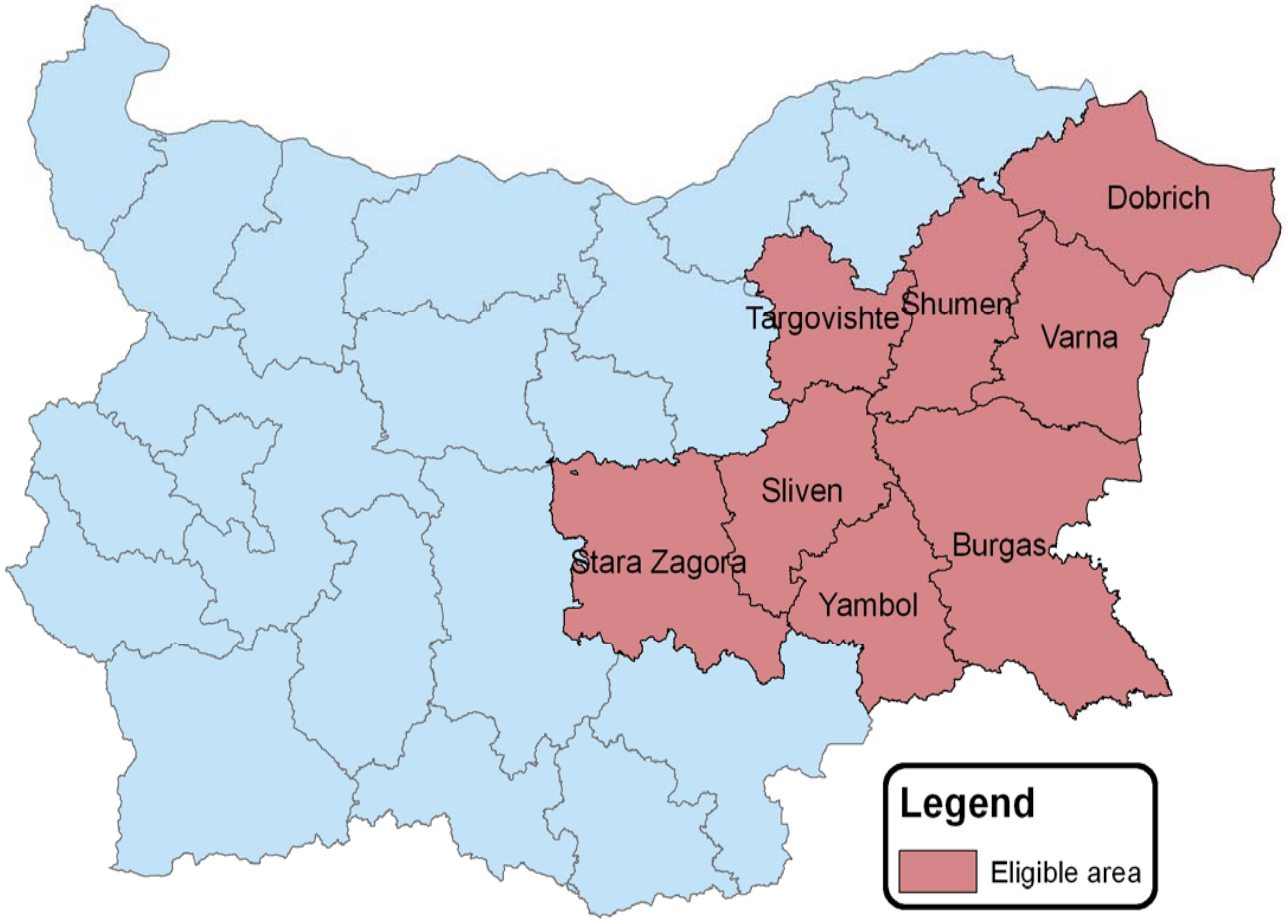
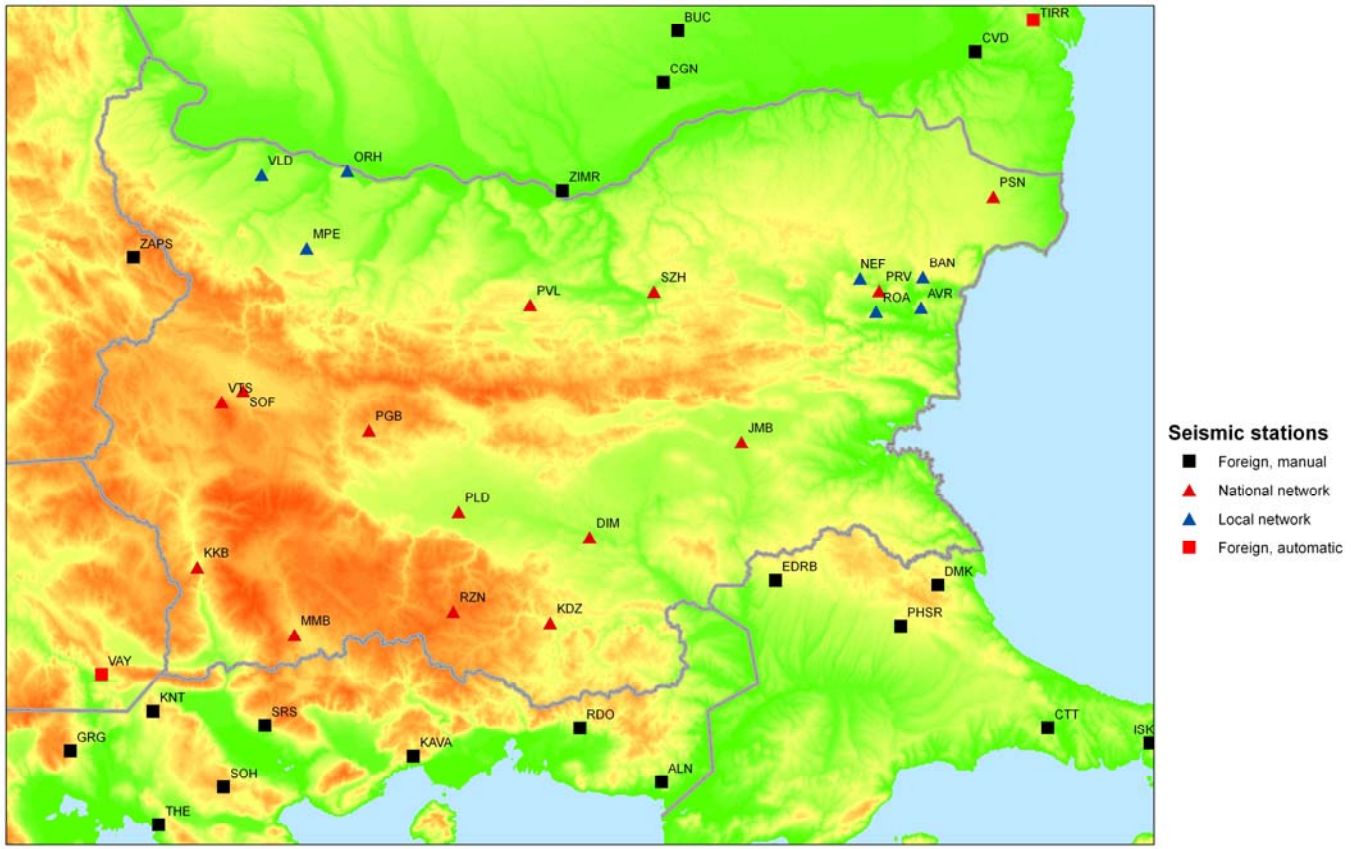
Seismic hazard modeling for Bulgaria

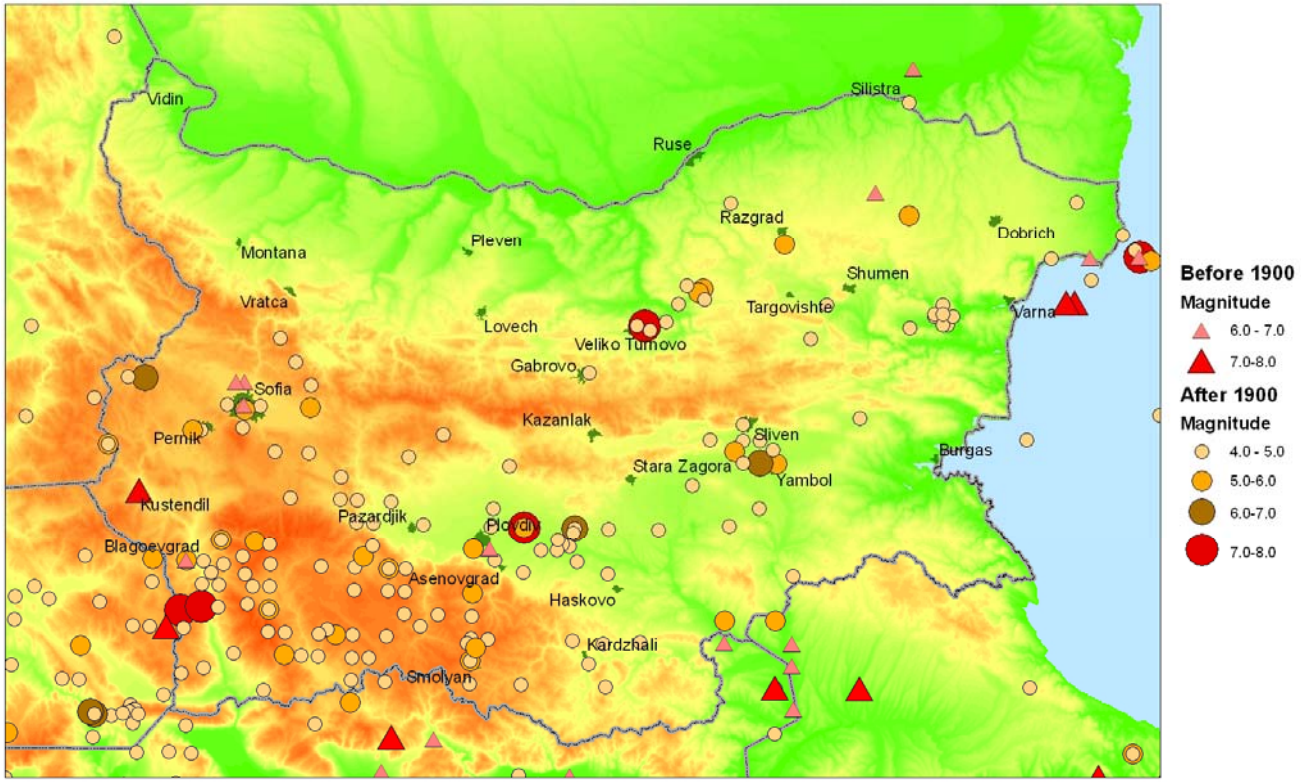
D. Solakov, S. Simeonova


Dobrich
Targovishte
Shumen
Varna
Sliven
Stara Zagora
Burgas
Yambol
Legend
Eligible area

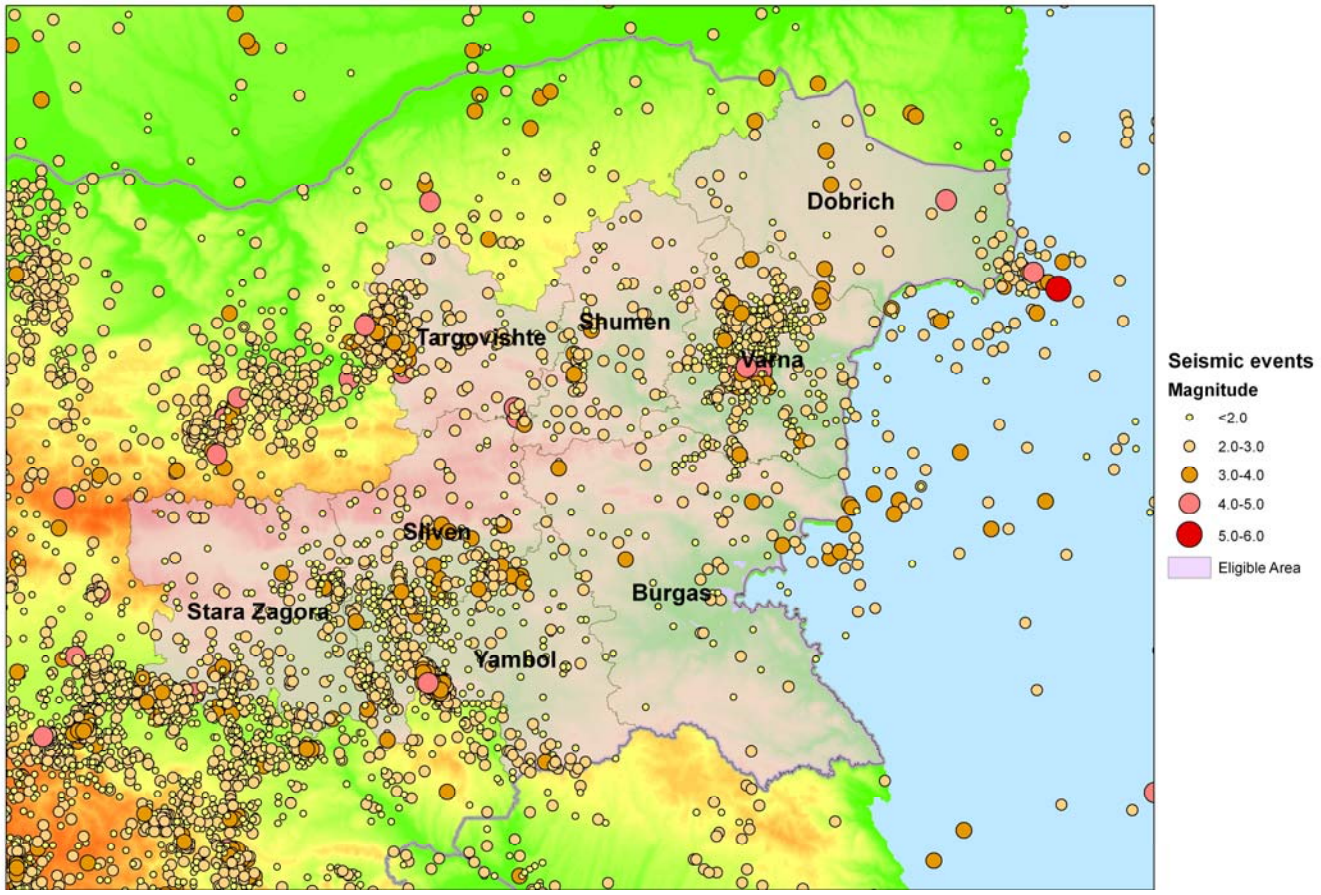
Bulgarian seismic network and foreign stations used in epicenter location



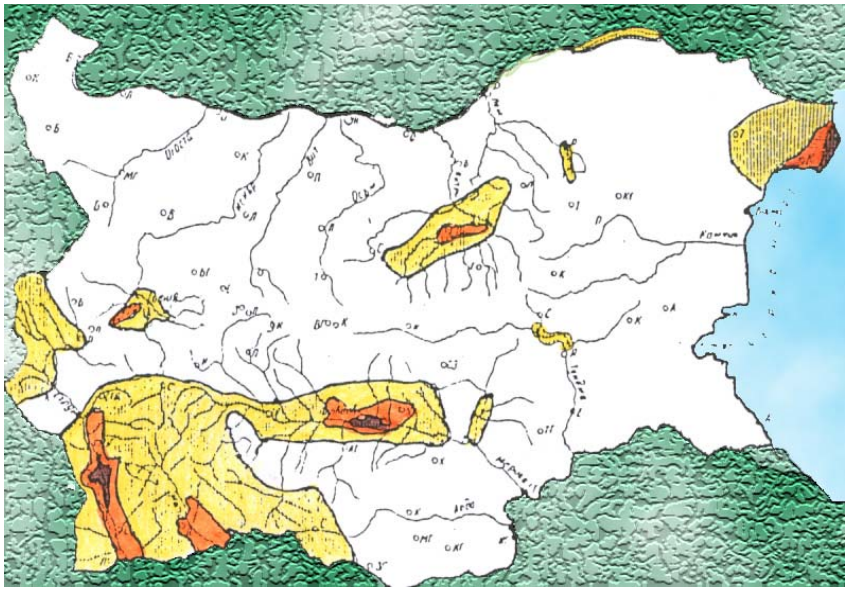
Sismicity in Bulgaria and surroundings (M≥4.0)



Epicentral map for Bulgaria and surroundings (after 1980, all recorded quakes)

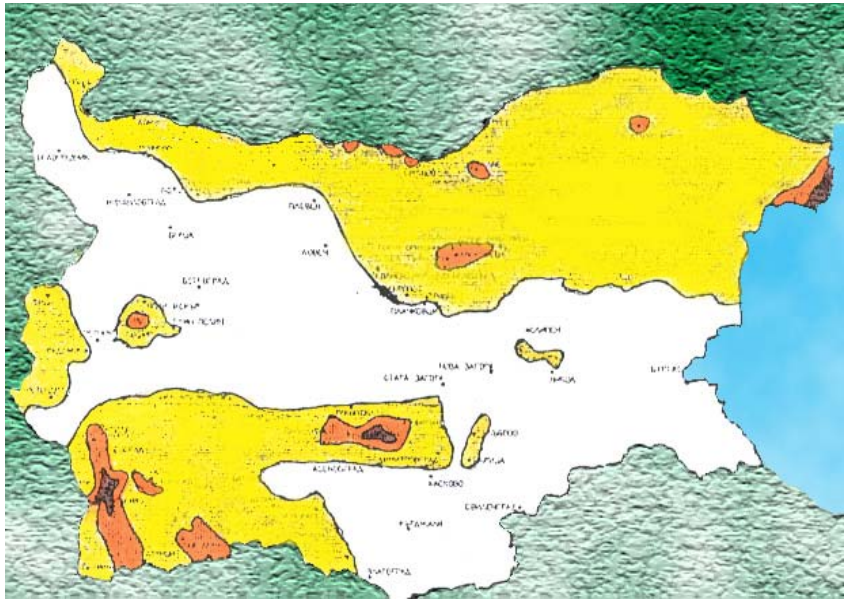


SEISMIC ZONING MAP 1961-1964

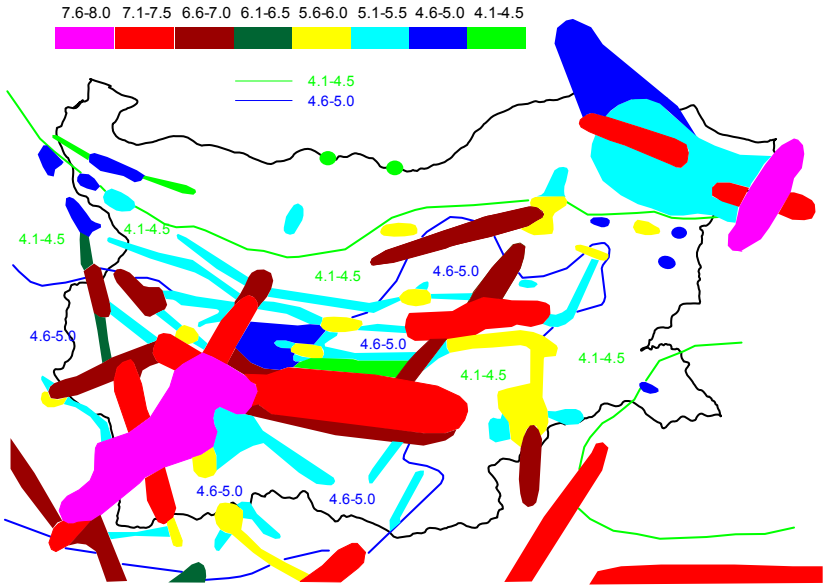


First building code - 1957

SEISMIC ZONING MAP 1977



SEISMIC SOURCES



SEISMIC ZONING MAP – 1987, return period 1000 years

PROBABILISTIC SEISMIC HZARD ASSESSMENT

The probability that a ground motion parameter, **Z**, at a given site, will exceed a specified level, **z**, during a given time period, **t**, is given by the expression:

$$P(Z \geq z \mid t) = 1 - e^{-\nu(z)t} \leq \nu(z)t$$

where ν**(z)** is the average frequency during time period **t** at which the level of ground motion parameter **Z** exceeds **z** at the site, resulting from earthquakes in all sources in the region.
The frequency of exceedance, ν**(z)** is calculated by**:**

$$\nu(z) = \sum_n \alpha_n(m^0) \int_{m^0}^{m^u} \int_0^{\infty} f(m)\, f(r \mid m) P(Z \geq z \mid m, r)\, dr\, dm$$

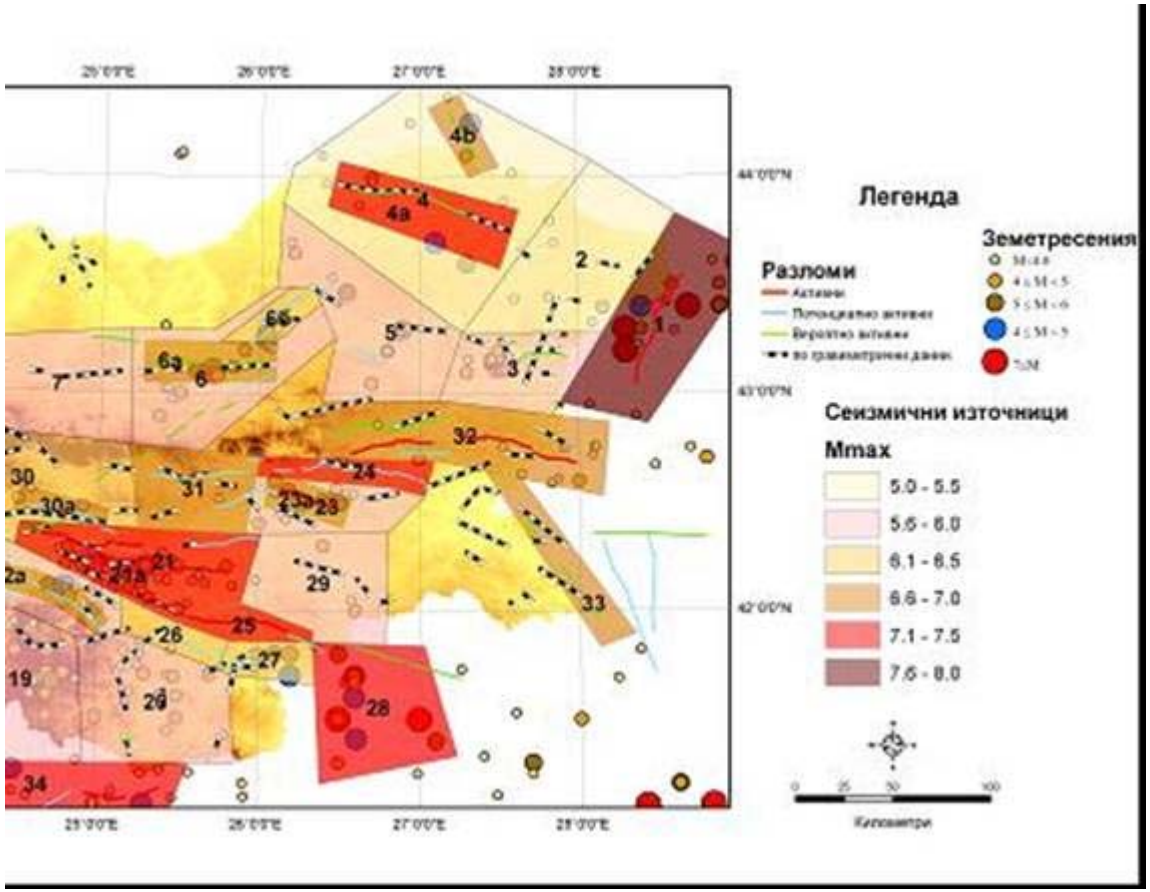
$\alpha^{\mathbf{n}}$**(m$^{\mathbf{o}}$)** is the frequency of earthquakes on source **n** above a **m$^{\mathbf{o}}$** (min. mag. of ing. Importance);
f(m) is the PDF for events between **m$^{\mathbf{o}}$** and maximal event for the source **m$^{\mathbf{u}}$**;
f(r|m) is the PDF for distance to the earthquake rupture;
P(Z≥z | m,r) is the probability that for a given magnitude **m** earthquake at a distance **r** from the site, the ground motion exceeds level **z**.

A seismic source model is developed for PSHA for the territory of Bulgaria. The model is based on complex geodetic, geological, geophysical and seismological data and is presented in Fig. For each source are defined the all parameters describing the seismicity in the source. Two cases are considered:

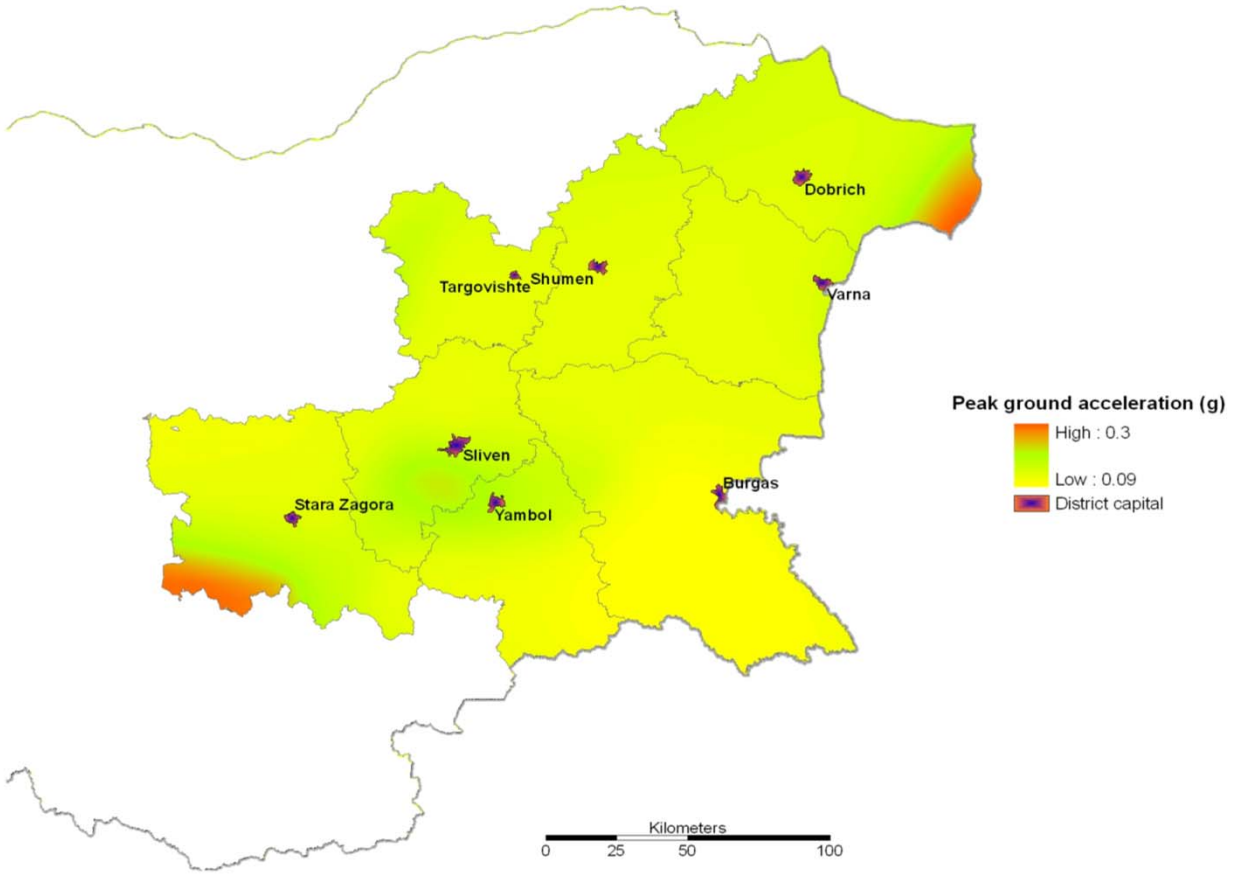
1.All sources are areal sources – earthquakes are randomly distributed in the corresponding source
2.Smaller earthquakes are randomly distributed in the source while stronger earthquakes are happened only on the faults defined in the source.

The final result is a mean of the two considered cases.
The hazard was evaluated for a grid with cell size 0.05°x0.05°.

COMPLEX GEOLOGO-GEOPHYSICAL AND SEISMOLOGICAL MAP



Seismic hazard (475 years return period)



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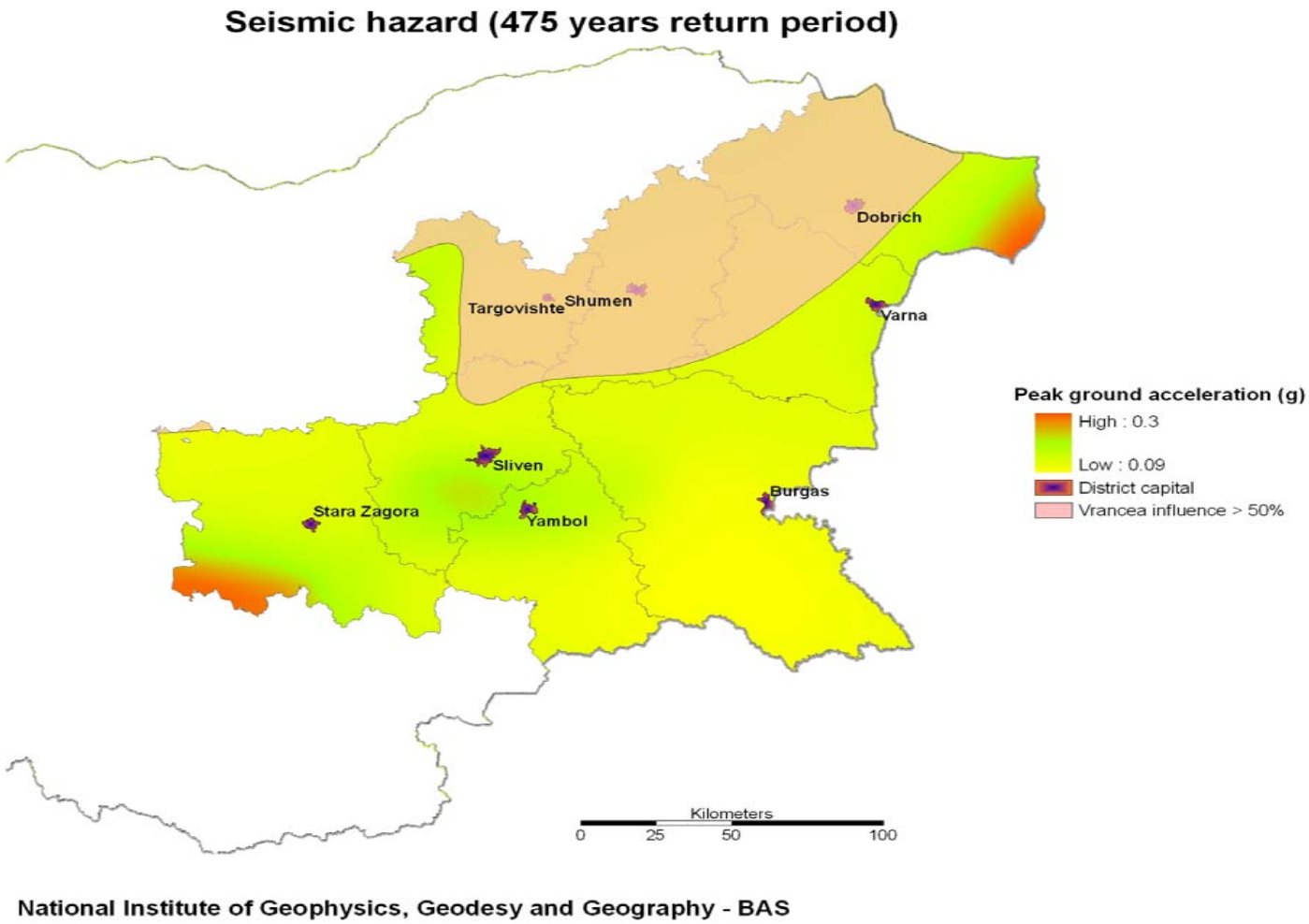
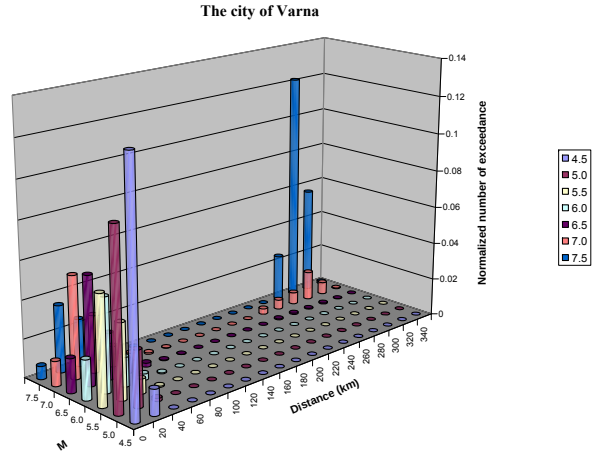
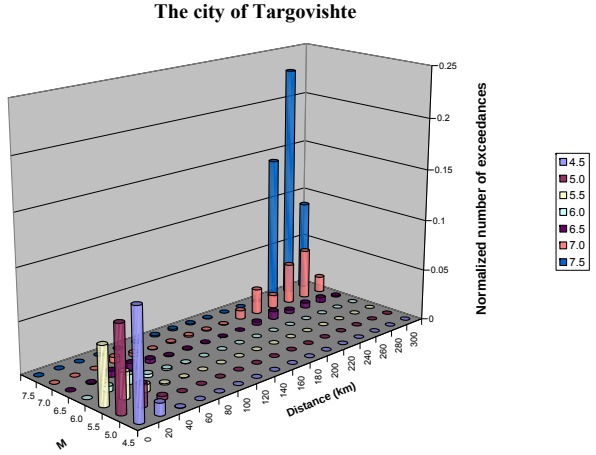
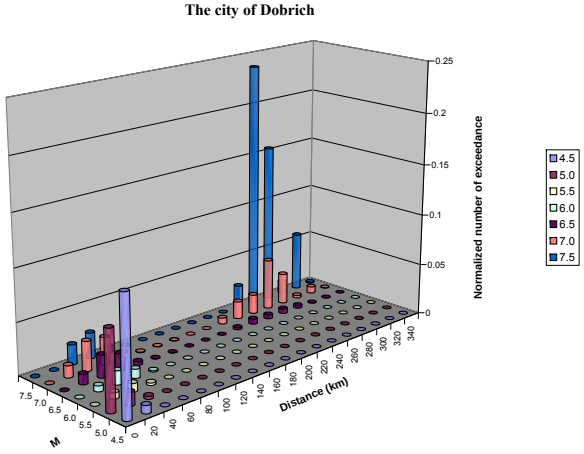
Influence of intermediate Vrancea earthquakes

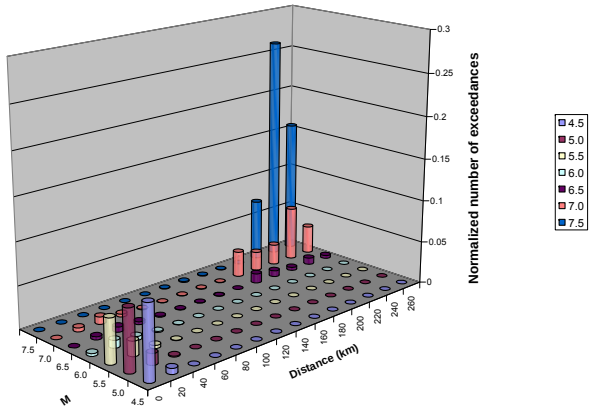


DEAGGREGATION OF THE 475 YEARS HAZARD – Northern cities

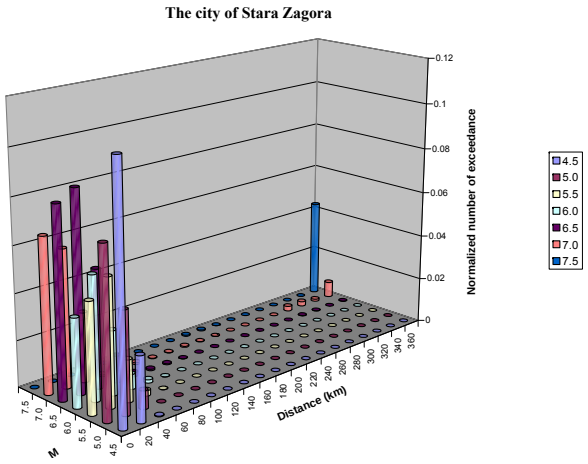


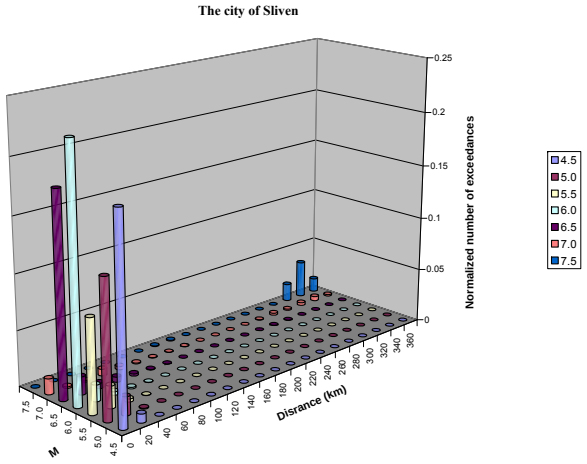


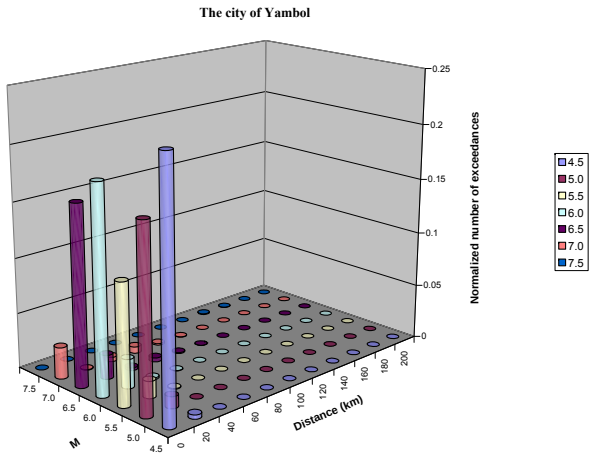


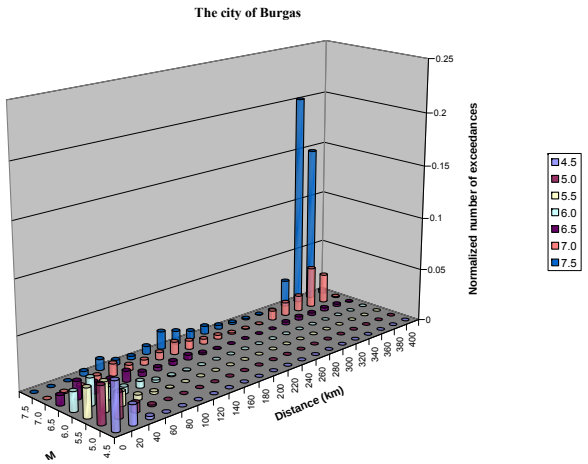


DEAGGREGATION OF THE 475 YEARS HAZARD – Southern cities

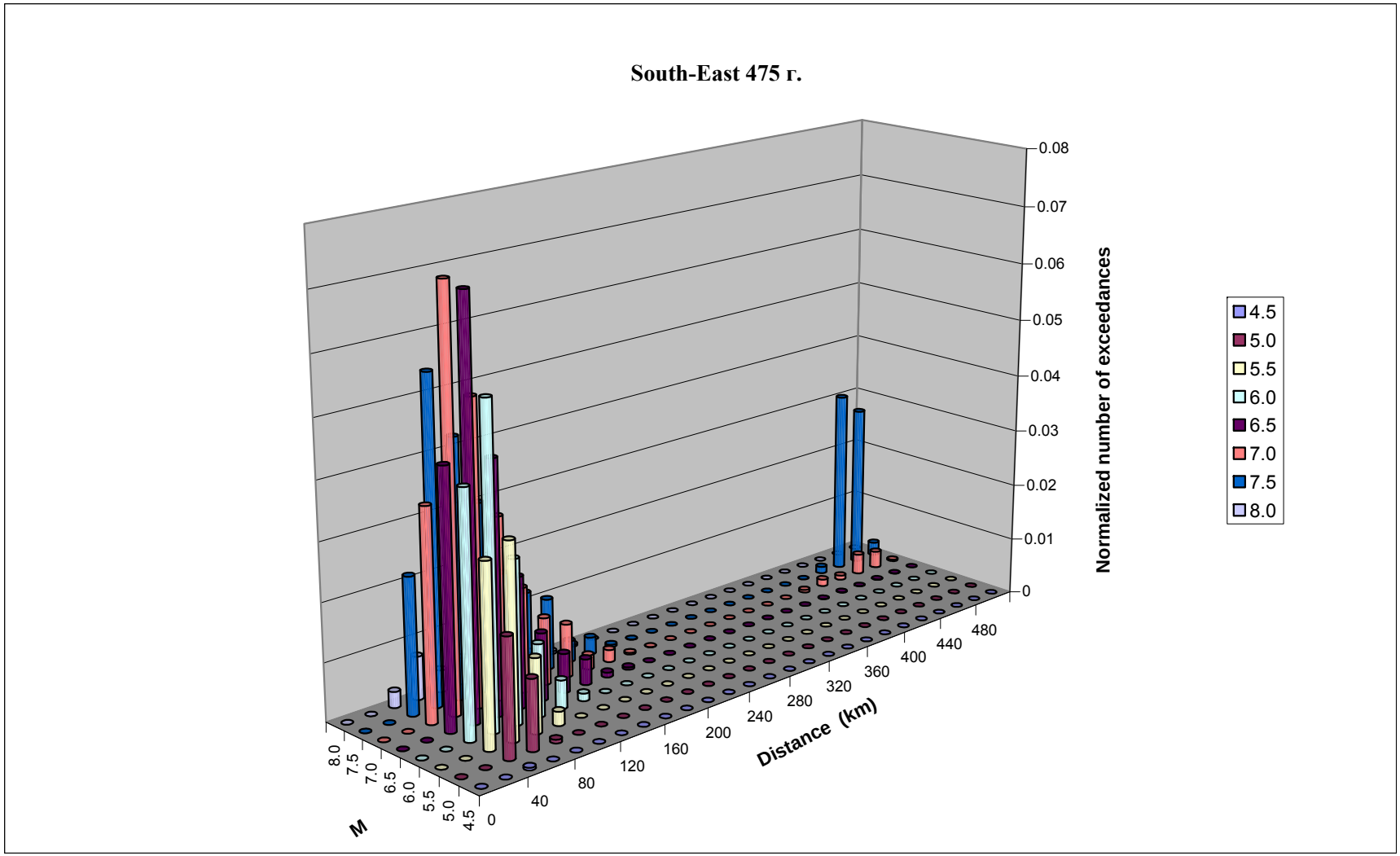








DEAGGREGATION OF THE 475 YEARS HAZARD – South-Eastern part



DETERMINISTIC HAZARD ASSESSMENT

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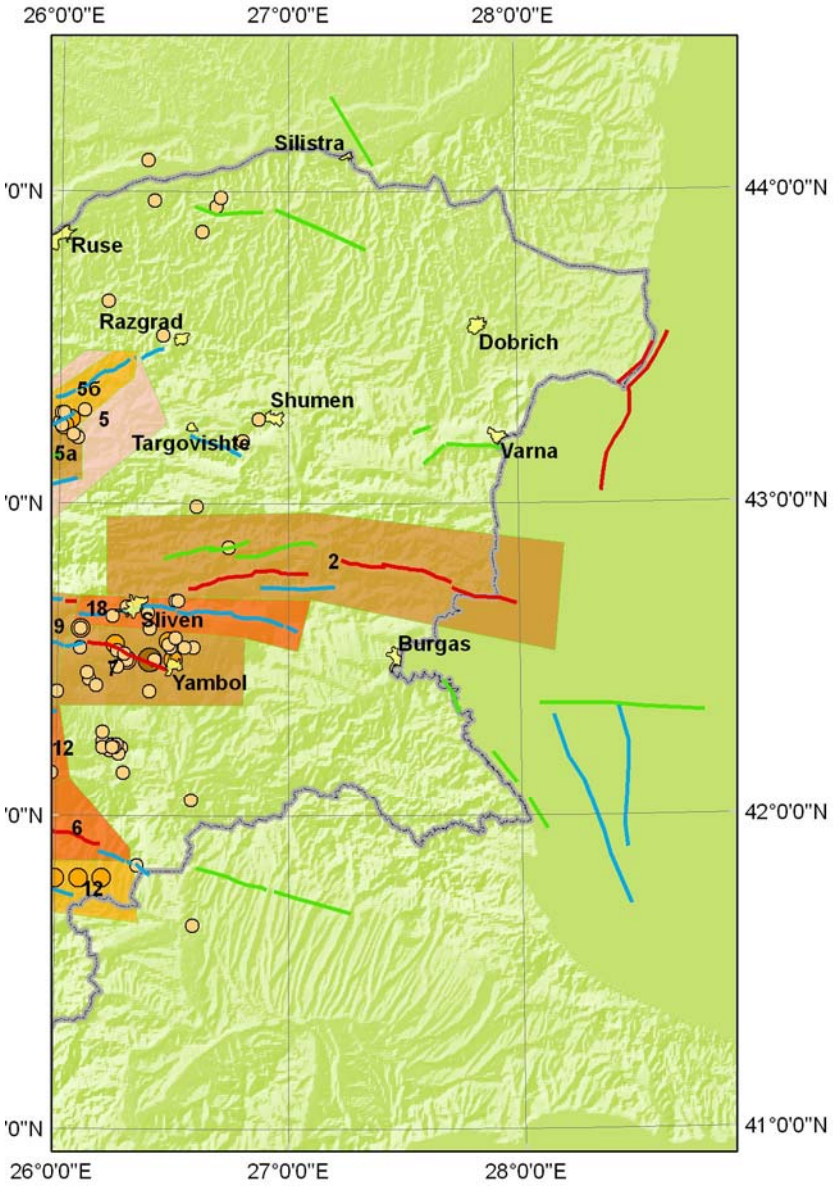
Boore and Atkinson (2008) - Boore, D.M. and Atkinson G. M. (2008), "Ground-Motion Prediction Equations for the Average Horizontal Component of PGA, PGV, and 5%-Damped PSA at Spectral Periods between 0.01 s and 10.0 s" Earthquake Spectra, Vol. 24, No. 1, pp: 99–138

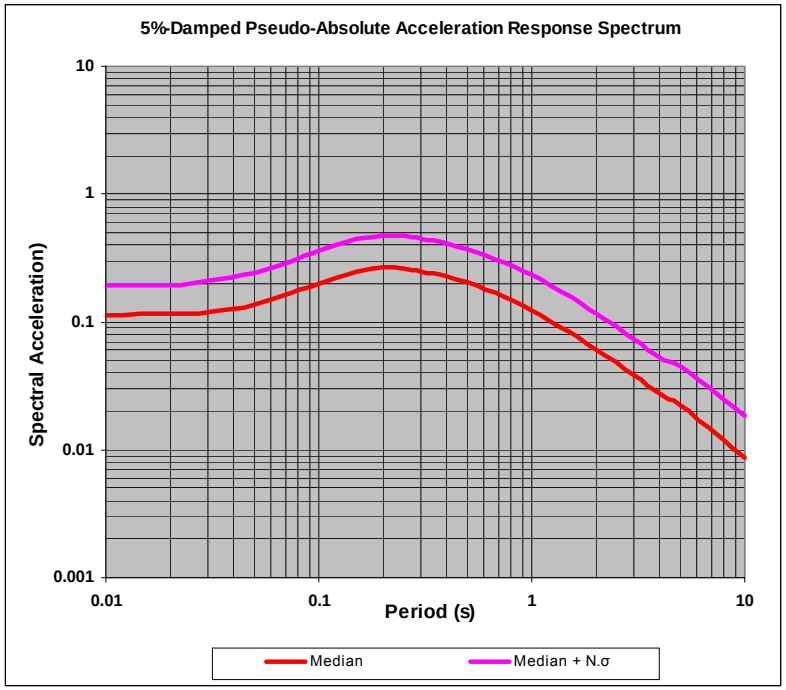
Chiou and Youngs (2008) - Chiou, B.S:J. and R.R. Youngs (2008) "An NGA Model for the Average Horizontal Component of Peak Ground Motion and Response Spectra" Earthquake Spectra, Vol. 24, No. 1, pp: 173–215

Campbell and Bozorgnia (2008) - Campbell, K. W. and Y. Bozorgnia (2008) "NGA Ground Motion Model for the Geometric Mean Horizontal Component of PGA, PGV, PGD and 5% Damped Linear Elastic Response Spectra for Periods Ranging from 0.01 to 10 s" Earthquake Spectra, Vol. 24, No. 1, pp: 139–171

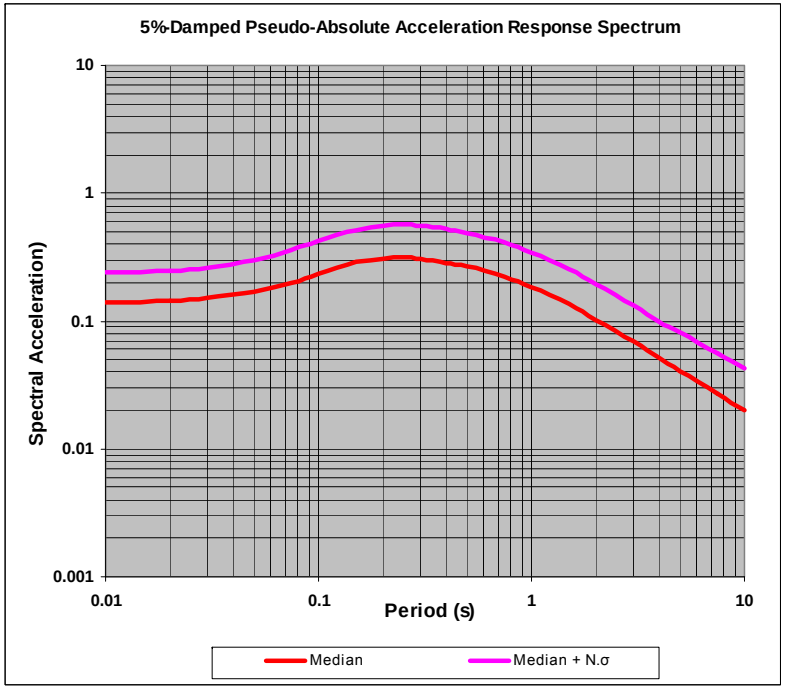
Abrahamson and Silva (2008) - Abrahamson, N. and W. Silva (2008) "Summary of the Abrahamson & Silva NGA Ground-Motion Relations" Earthquake Spectra, Volume 24, No. 1, pp. 67–97



Active faults



Bourgas,
Fault length=64 km, M=7.2, distance=31km



Varna,
M=8, distance=39km

THANK YOU FOR ATTENTION