



SHARE-Project Experience: **The 2013 European Seismic Hazard Model**

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Swiss Seismological Service
ETH-Zurich

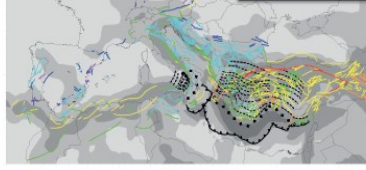


The EU-FP7 SHARE Project

Europe has a long history of destructive earthquakes, and seismic risk can severely affect our modern society, as recently shown by the 1999 Izmit (Turkey) and the 2009 L'Aquila (Italy) events. Seismic hazard defines the likelihood of ground shaking associated with the occurrence of future earthquakes, and is the first step to evaluate seismic risk, the likelihood of damage and loss depending on vulnerability factors (e.g. the type, age and value of buildings and infrastructures, population density and land-use). High hazard does not necessarily imply high risk. Frequent large earthquakes result in high hazard but pose limited risk if they occur in remote areas, while even moderate earthquakes may expose densely populated areas to high seismic risk.

The collaborative project "Seismic Hazard Harmonization in Europe (SHARE)" was supported by the EU-FP7 to deliver the first state-of-the-art reference hazard model for Europe, replacing older maps. The SHARE hazard contributes to the Global Earthquake Model (GEM) and serves as input for risk mitigation policies such as the design of earthquake-resistant multi-story buildings and critical infrastructures such as bridges or dams.

Active Faults in Euro-Mediterranean Region



Active faults and subducting plates in the Euro-Mediterranean region, differentiated by color from nearby sleeping (red to slowly slipping) (white). Over 1,200 active faults have been mapped, covering more than 64,000 km of fault length. The background depicts the estimated rate of deformation of the Earth's crust derived from geologic and geodesic data.

Map Content

The European Seismic Hazard Map displays the ground shaking (i.e. Peak Horizontal Ground Acceleration) to be reached or exceeded with a 10% probability in 50 years, corresponding to the average recurrence of such ground motion every 475 years, as prescribed by the national building codes in Europe for standard buildings. SHARE maps also the higher ground shaking occurring every 1,000-5,000 years, of importance for critical infrastructures such as dams or bridges.

The ground shaking values depicted in the map reach over 0.5g (g is the gravitational acceleration). Low hazard areas (PGA ≤ 0.1g) are colored in blue-green, moderate hazard areas in yellow-orange and high hazard areas (PGA > 0.25g) in red.

The SHARE seismic hazard is assessed with a time-independent, probabilistic approach. Models of future ground shaking are based on the history of earthquakes of the past 1,000 years, on the knowledge of active faults mapped in the field, on the knowledge of deformation of the Earth's crust from GPS measurements, and on the instrumental recordings of strong ground shaking generated by past earthquakes.

The SHARE results do not replace the existing national design regulations and seismic provisions, which must be obeyed for today's design and construction of buildings.

Acknowledgements

Supported by the EU FP7 Framework Program, the 4-year SHARE program brought together a core-team of over 50 leading scientists from 18 research institutions and 12 countries from Europe, North Africa and Turkey, and more than 250 additional European experts participating in workshops, providing their expertise and data.

SHARE was funded by the EU-FP7 (2007-2013) under grant agreement no. 226907.

SHARE hazard was computed using the ESH OpenQuake software. Maps were created using GMT (Wessens and Smith, 1992) and the poster was produced with Adobe Illustrator CS3.

See this map with:
D. Giardini, J. Woessner, L. Danciu, H. Crowley, F. Cotton, E. Grünthal, R. Fritzo and G. Valeriani and the SHARE consortium, SHARE European Seismic Hazard Map for Peak Ground Acceleration, 10% Exceedance Probabilities in 50 years, doi:10.2777/30343, ISBN-13, 978-92-79-25148-1.

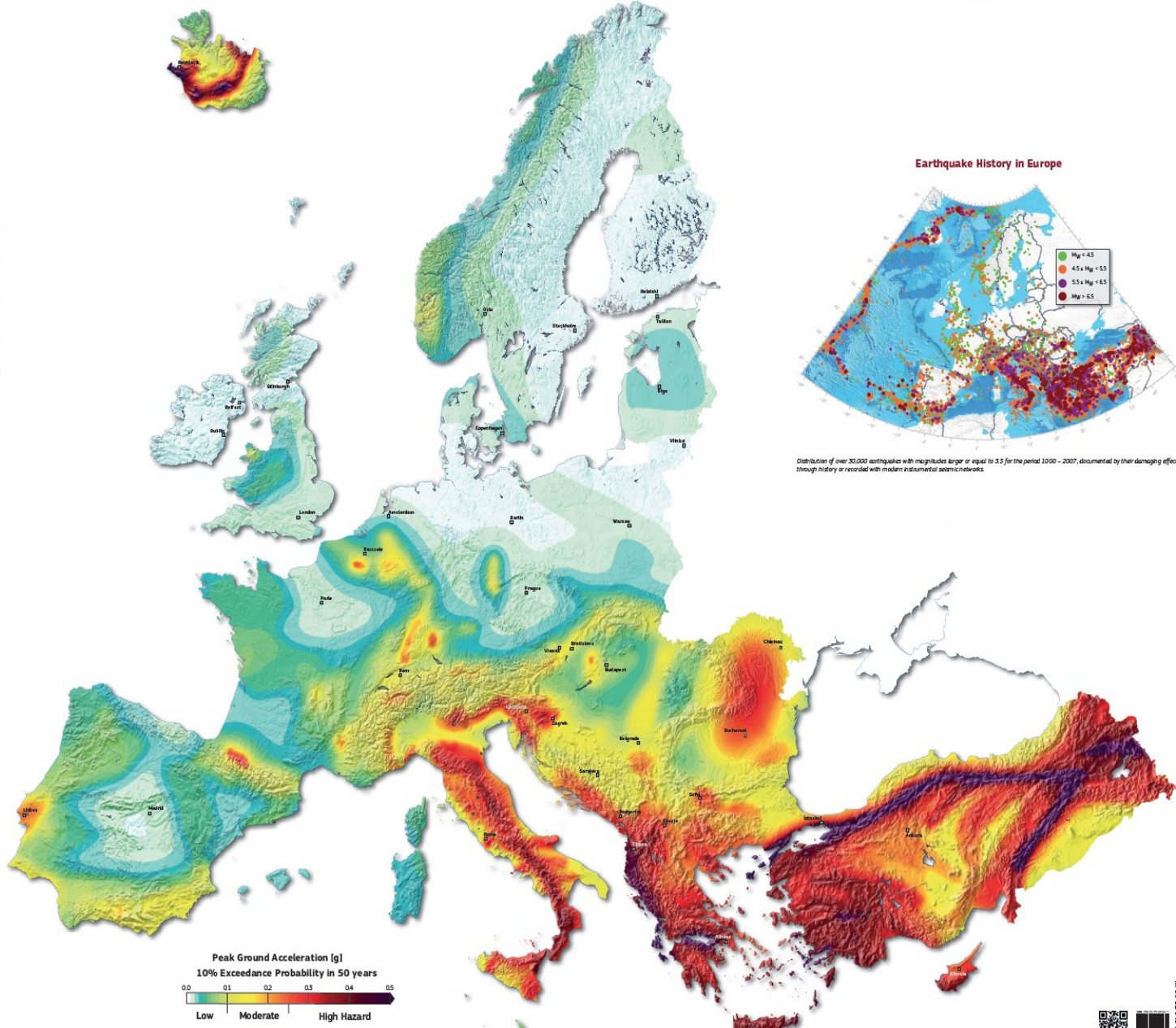
Online Access

All SHARE products, data and results, are provided through the project website at www.share-eu.org and the European Facility for Earthquake Hazard and Risk at www.efeh.org.

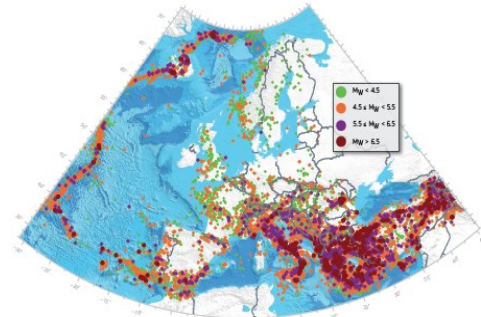
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SHARE Partners

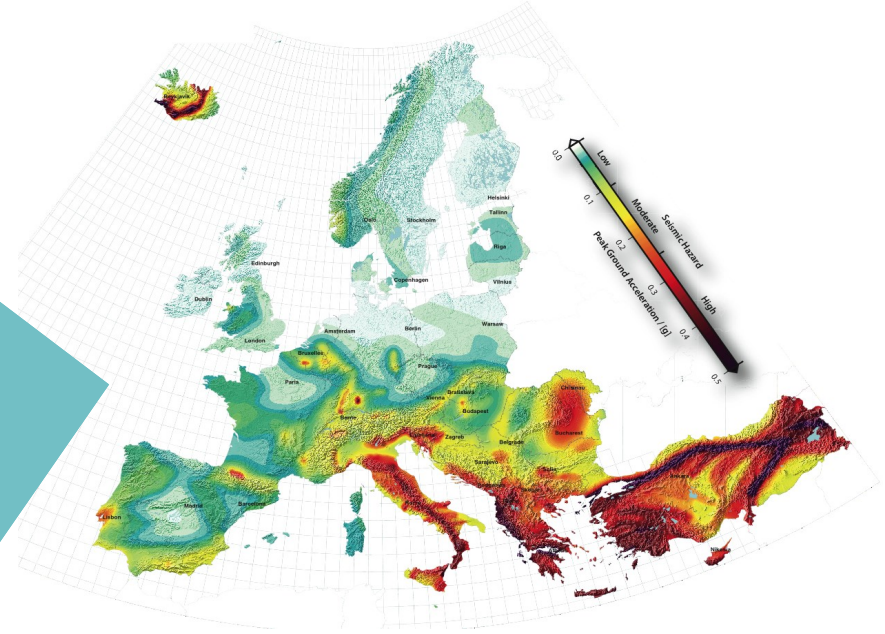
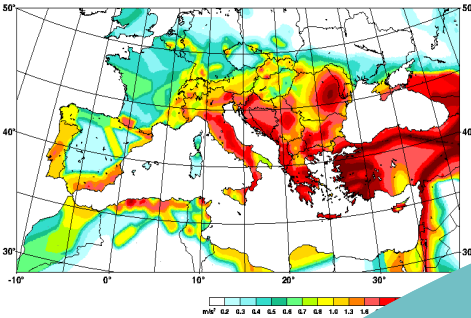
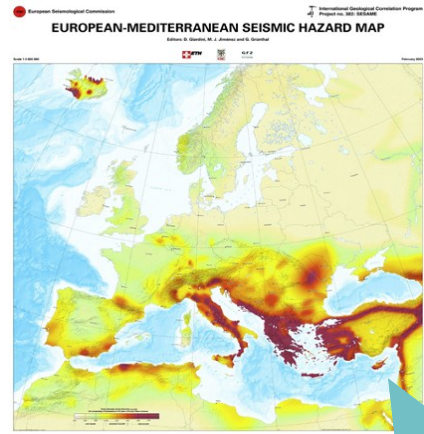


Earthquake History in Europe



Distribution of over 30,000 earthquakes with magnitudes larger or equal to 3.5 for the period 1000 - 2007, documented by their damaging effects through history or recorded with modern instrumental seismic networks.

European - Seismic Hazard Models - Evolution in Time



SESAME
[2003]

GSHAP
[1996]

SHARE
[2013]

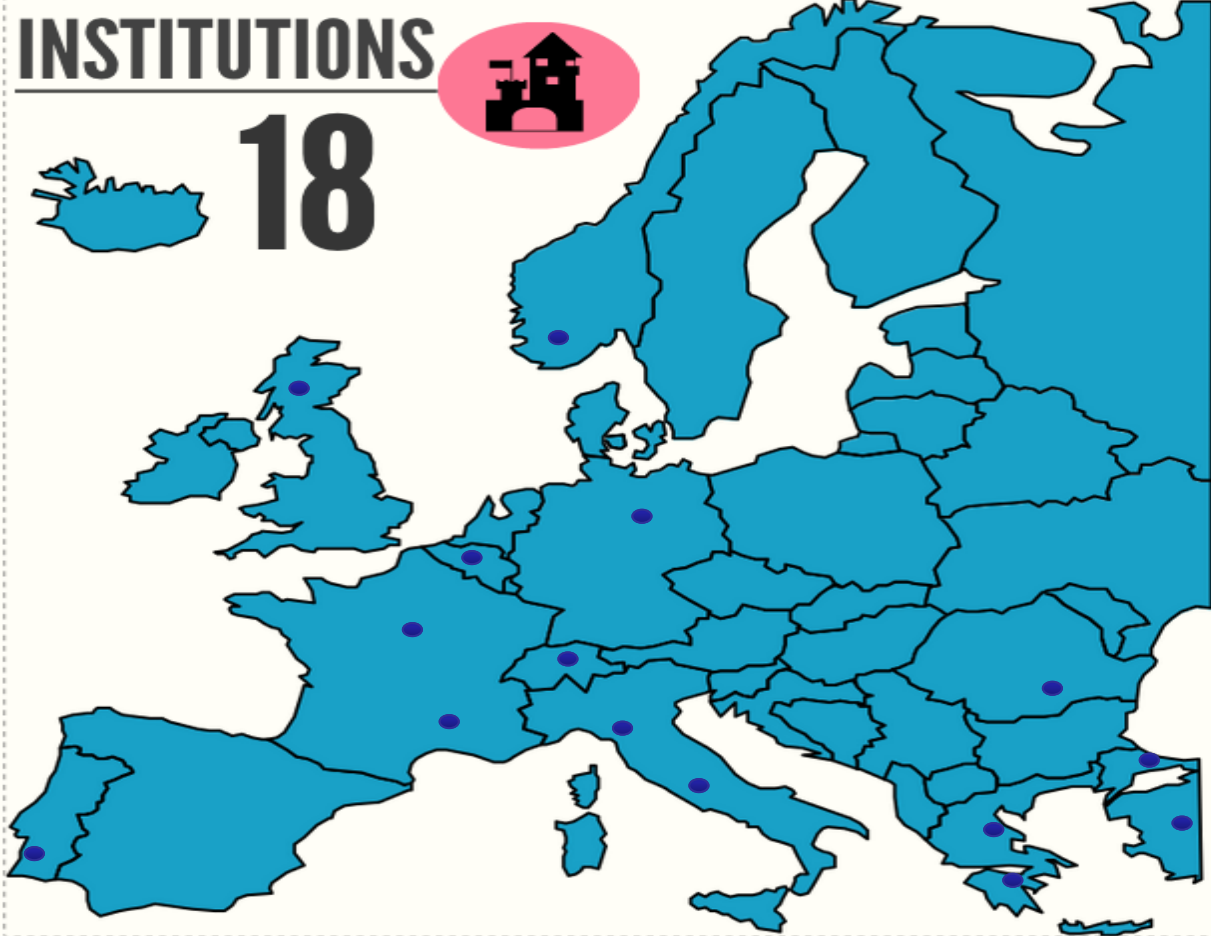
ELABORATION OF MAPS FOR CLIMATIC AND SEISMIC ACTIONS FOR STRUCTURAL DESIGN IN THE BALKAN REGION

27-28 October 2015, Zagreb

INSTITUTIONS



18



- Swiss Seismological Service, ETH Zurich
- GeoForschungsZentrum Potsdam
- Laboratoire de Géophysique Interne et Tectonophysique, Université Joseph Fourier
- Università degli Studi di Pavia
- Aristotle University of Thessaloniki
- Bureau de Recherches en Géologiques et Minières
- Centre de Recherche en Astronomie, Astrophysique et Géophysique
- Instituto Superior Técnico
- Kandili Observatory and Earthquake Research Institute Bogazici University
- Laboratório Nacional de Engenharia Civil
- Middle East Technical University
- Montenegro Seismological Observatory
- Natural Environment Research Council
- British Geological Survey
- National Institute for Earth Physics
- Seismological Laboratory, University of Athens
- NORSAR; International Centre for Geohazards
- Observatoire Royal de Belgique

Researchers

200



TURKEY

Included

2009-2013 SHARE Project



Objectives

HARMONIZE

Harmonization of the hazard assessment across national borders with focus on data, modeling and procedural level

AVAILABLE

Provides access to data, models, tools and expertise relevant for assessment of seismic hazard and risk in Europe.

REFERENCE

Generate a reference time-independent hazard model for European - Mediterranean region

**EC8
REQUIREMENTS**

Respect the engineering requirements to serve as reference for revision of European Building Code Ec8 and National Annexes

TRANSPARENT

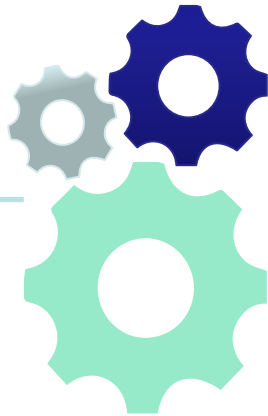
Focuses the efforts in generating a transparent hazard model, including datasets and procedures



**GMPE Workshop
Data and Source
Model Preparation
Workshop**

**Update Datasets
Review Source Models
Assign GMPEs weights**

**June
2009**



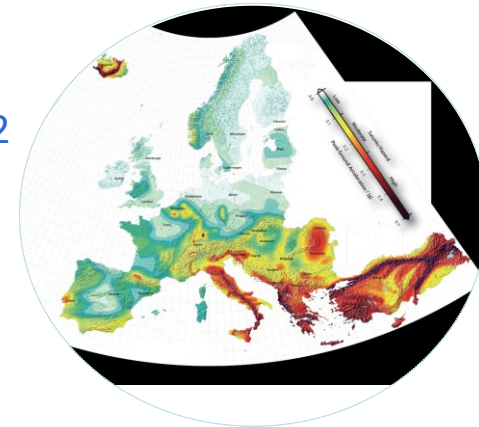
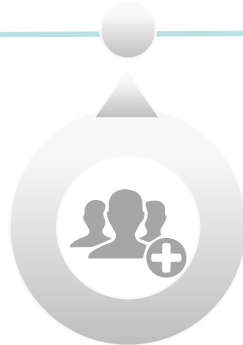
**External Data
Collection**

**1st Draft Model
March 2012**



**3rd Draft Model
November 2012**

**2nd Draft Model
Sept. 2012**



**Revise Source
Models
Assign final
weights**

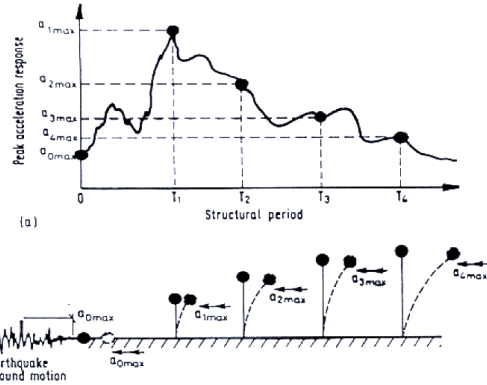
**External Experts Feedback
SHARE Participants**



**Model Development
Elicitation procedure**

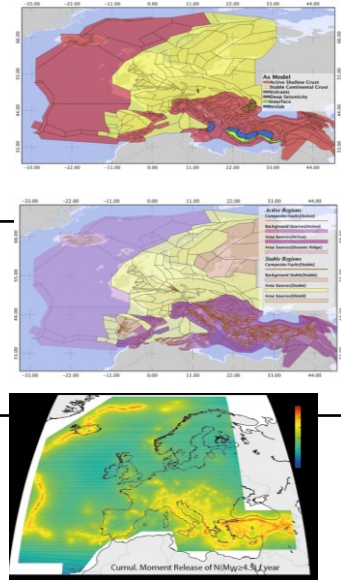
ESHM13 at a Glance

Seismic Source Models

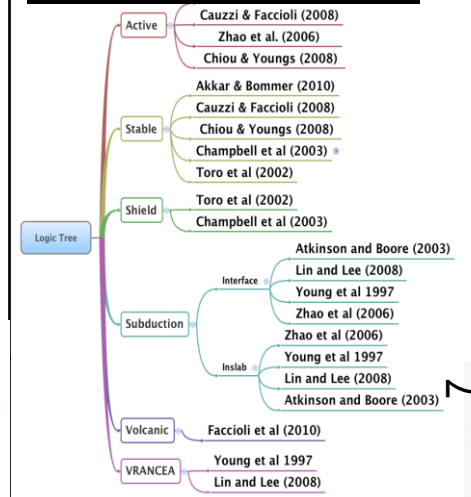
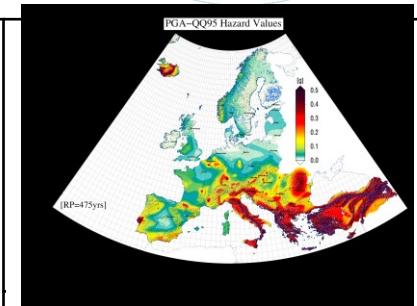
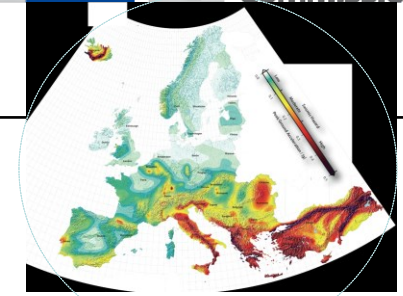
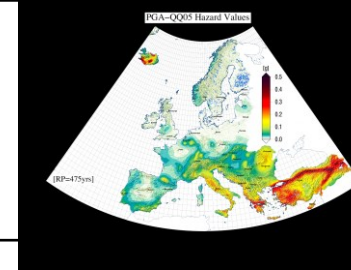


Twelve IMTs
PGA:SA(0.1s):SA(4s)

Mean Median Quantile



~ 130 000



The 2013 European Seismic Hazard Model: Milestones

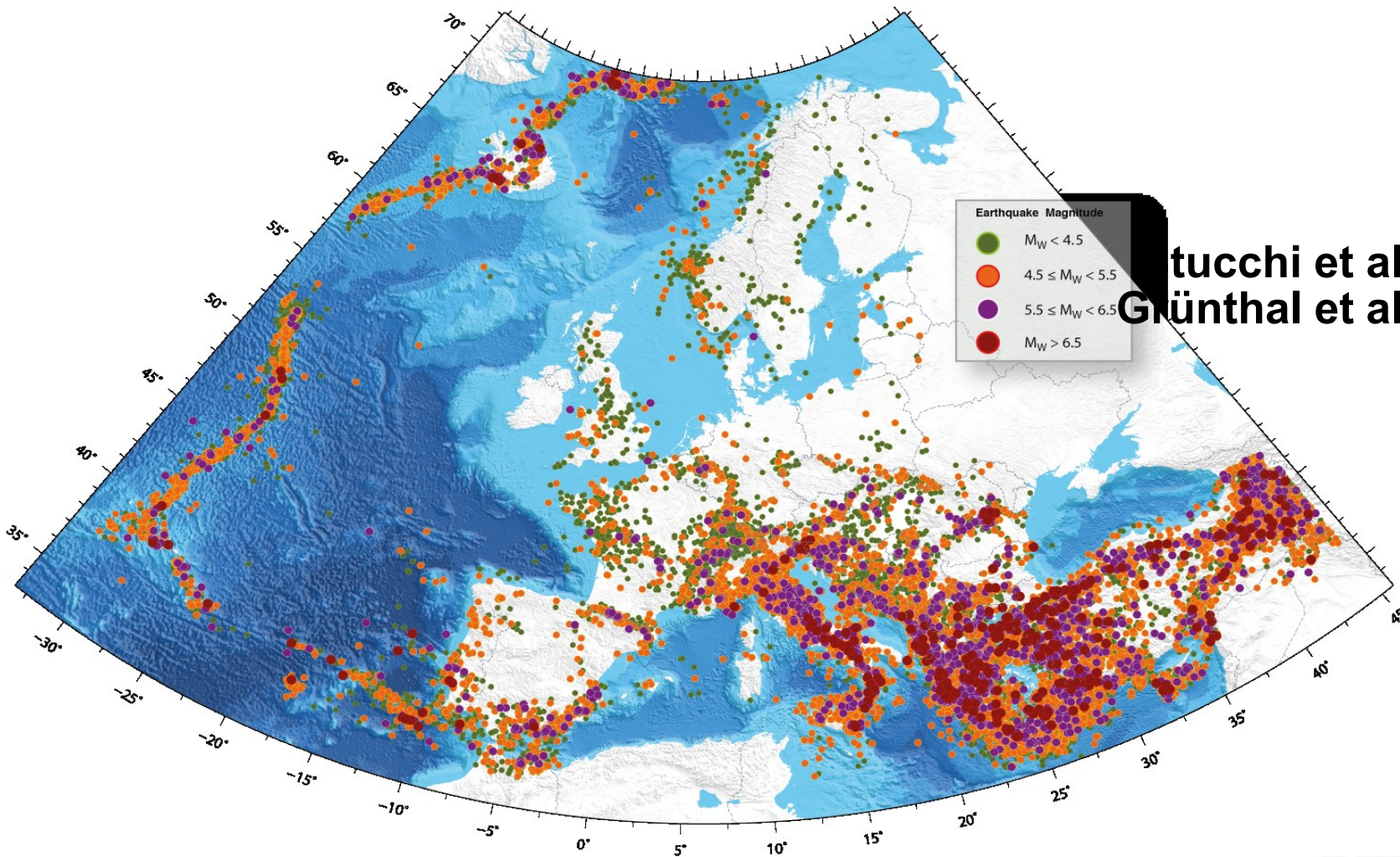


ELABORATION OF **MAPS** FOR **CLIMATIC** AND **SEISMIC** ACTIONS
FOR STRUCTURAL DESIGN IN THE **BALKAN REGION**

27-28 October 2015, Zagreb

Milestones

HARMONIZED DATASETS: AKE GUE



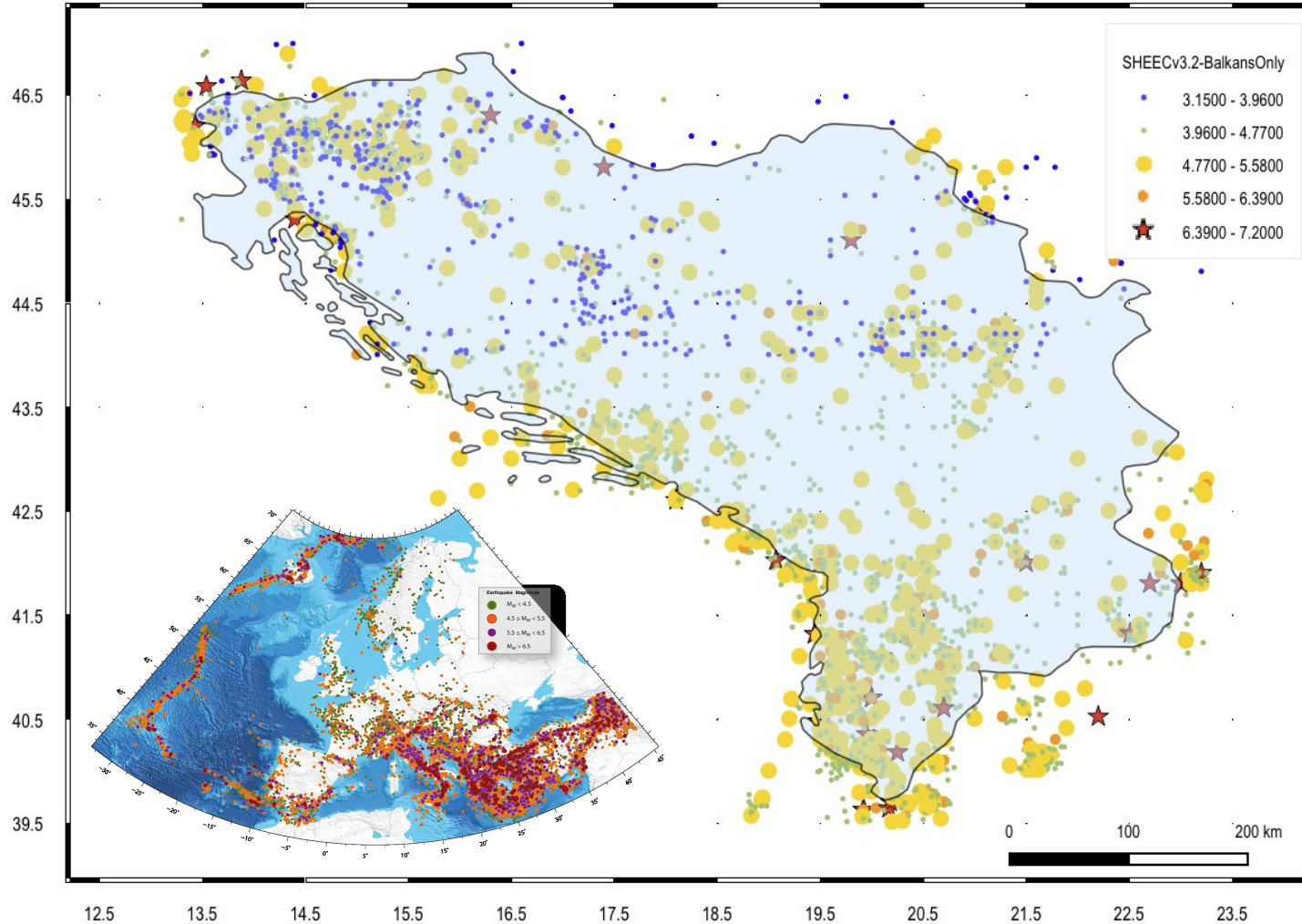
tucchi et al., 2012
Grünthal et al., 2012

ELABORATION OF MAPS FOR CLIMATIC AND SEISMIC ACTIONS
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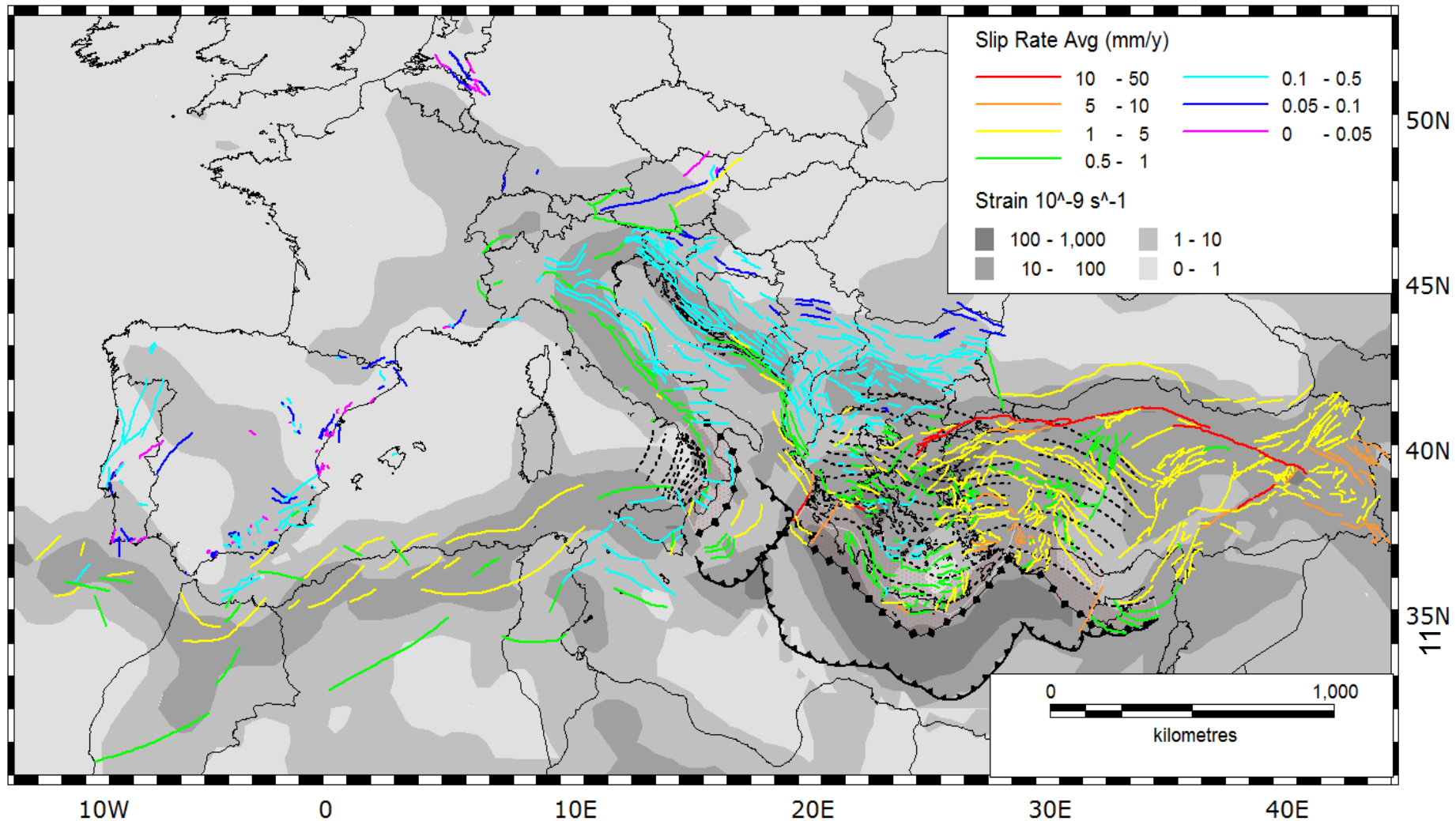
27-28 October 2015, Zagreb



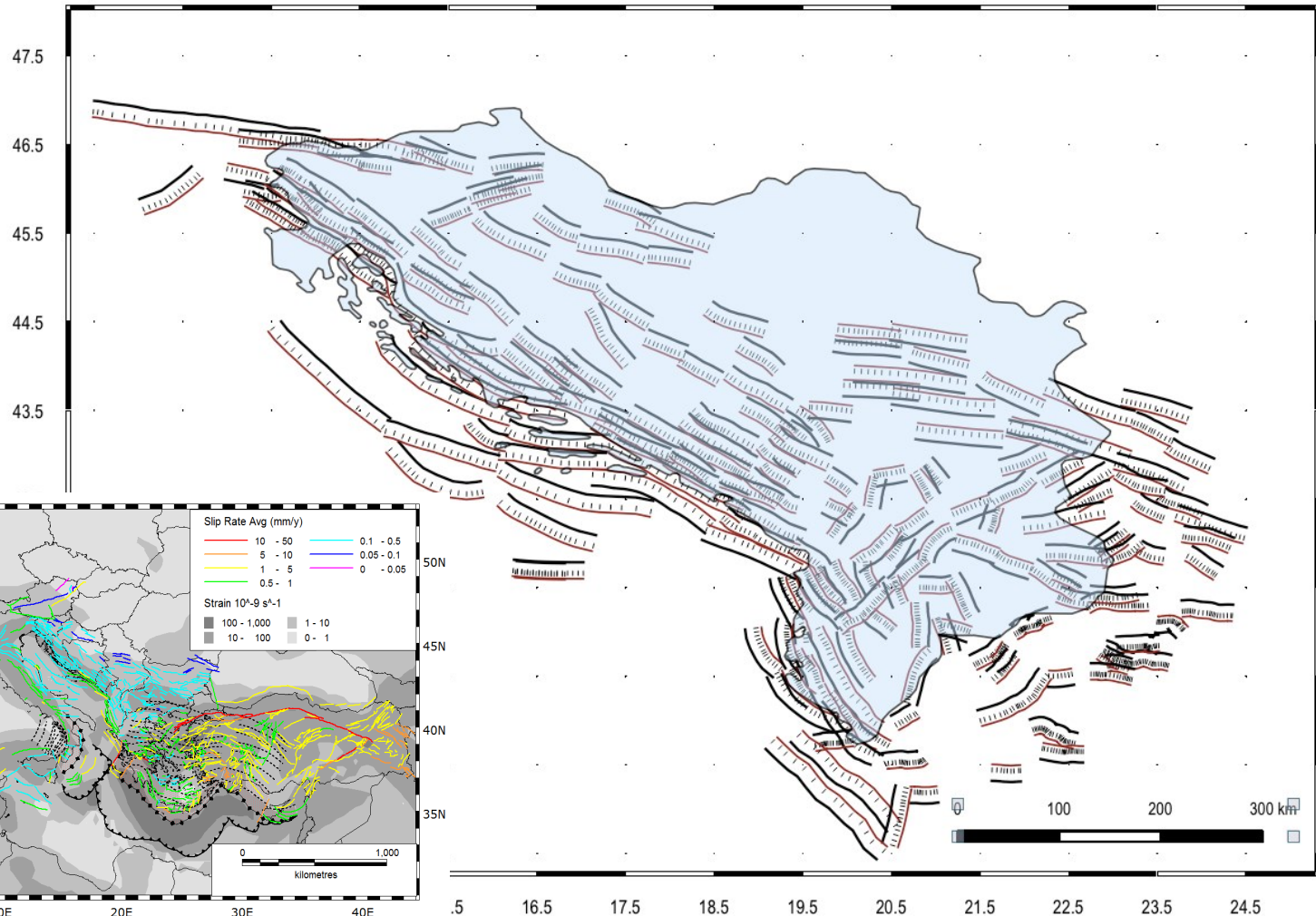
BALKAN REGION: EARTHQUAKE CATALOGUE



1ST EUROPEAN ACTIVE FAULTS DATABASE



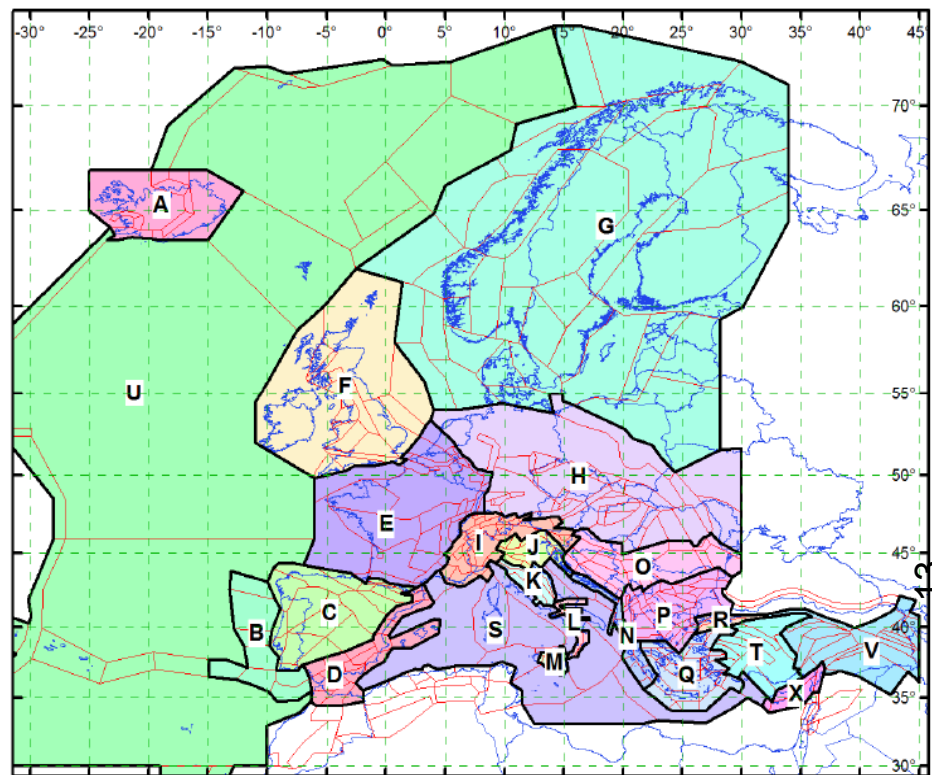
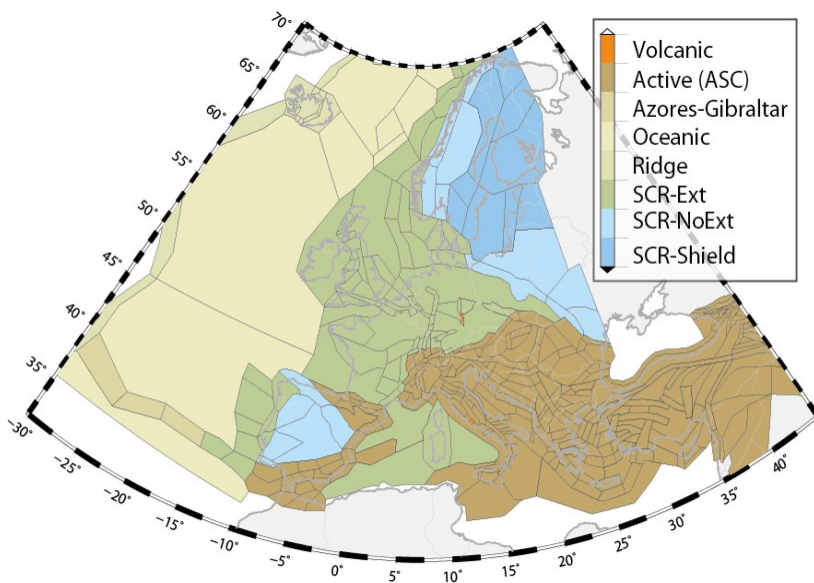
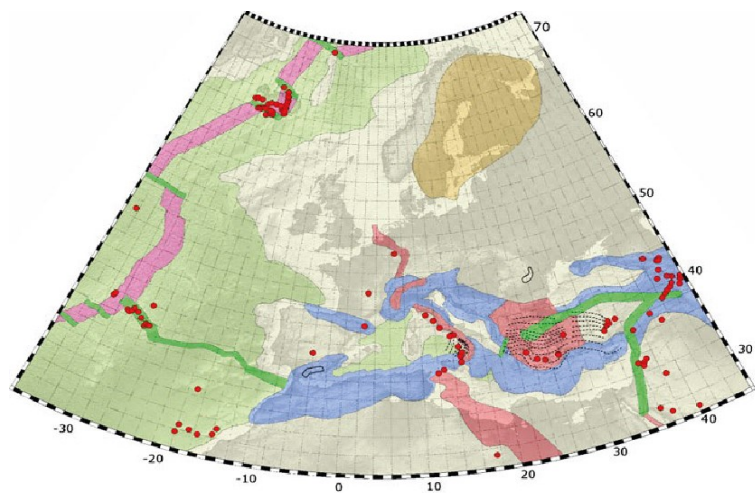
BALKAN REGION: ACTIVE FAULTS DATABASE



Milestones

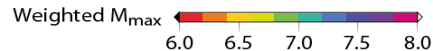
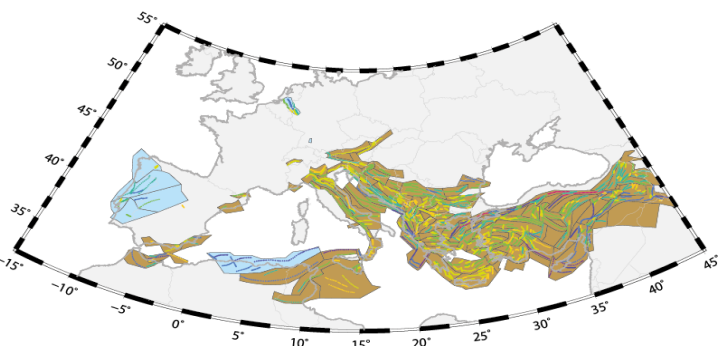
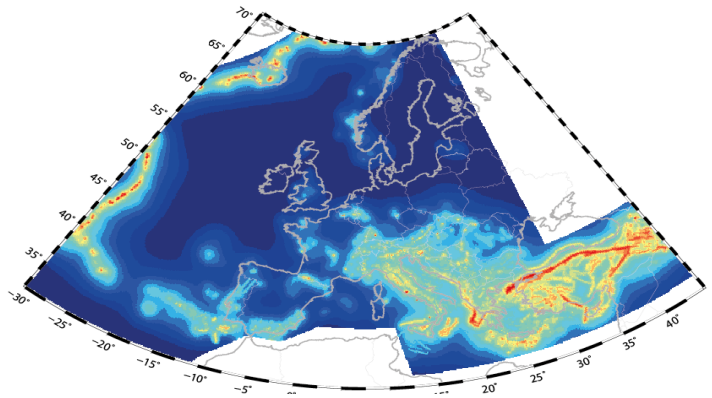
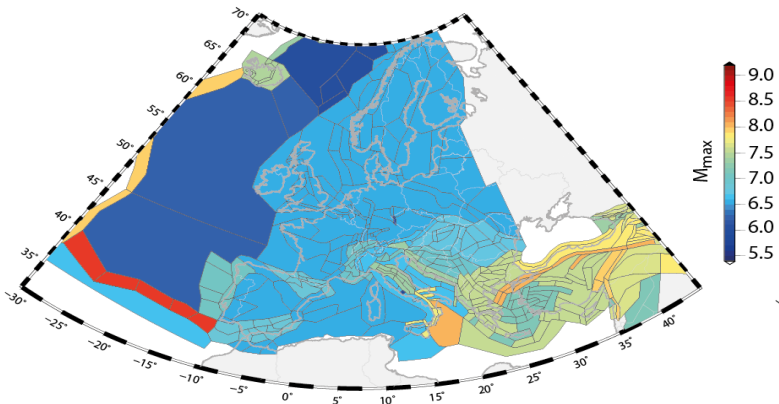
OTHER HARMONIZED DATABASE:

- TECTONICS
- COMPLETNESS



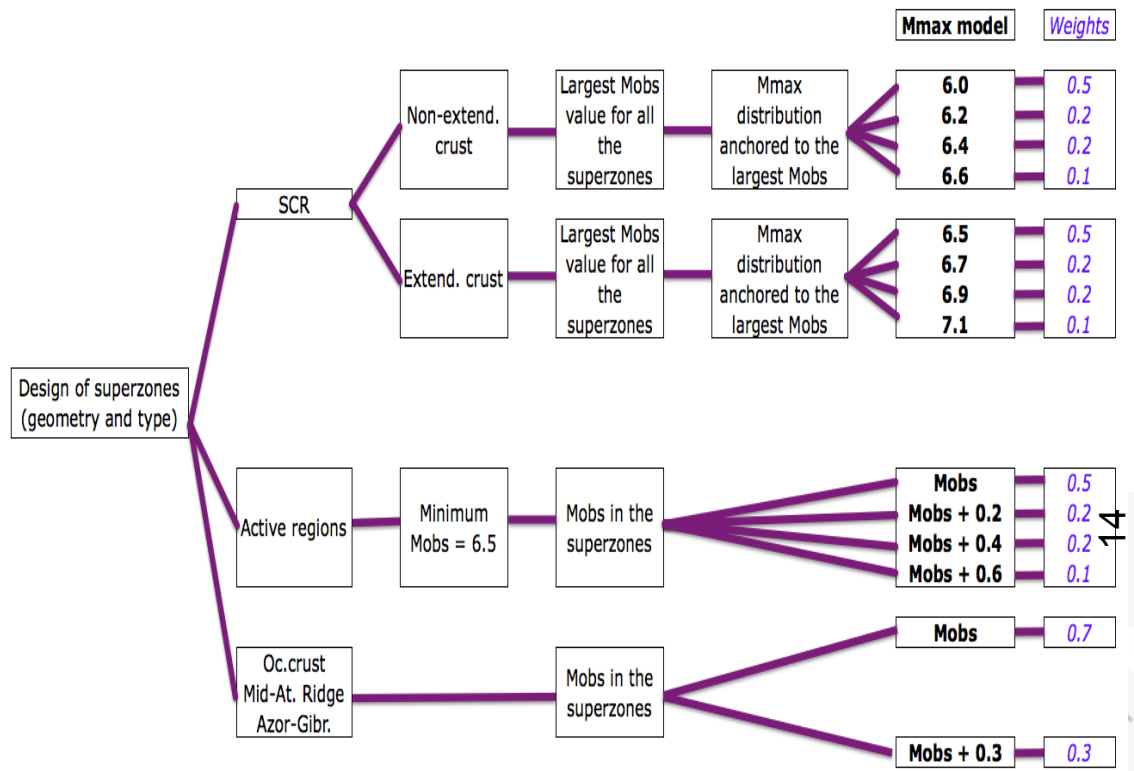
NS

Milestones



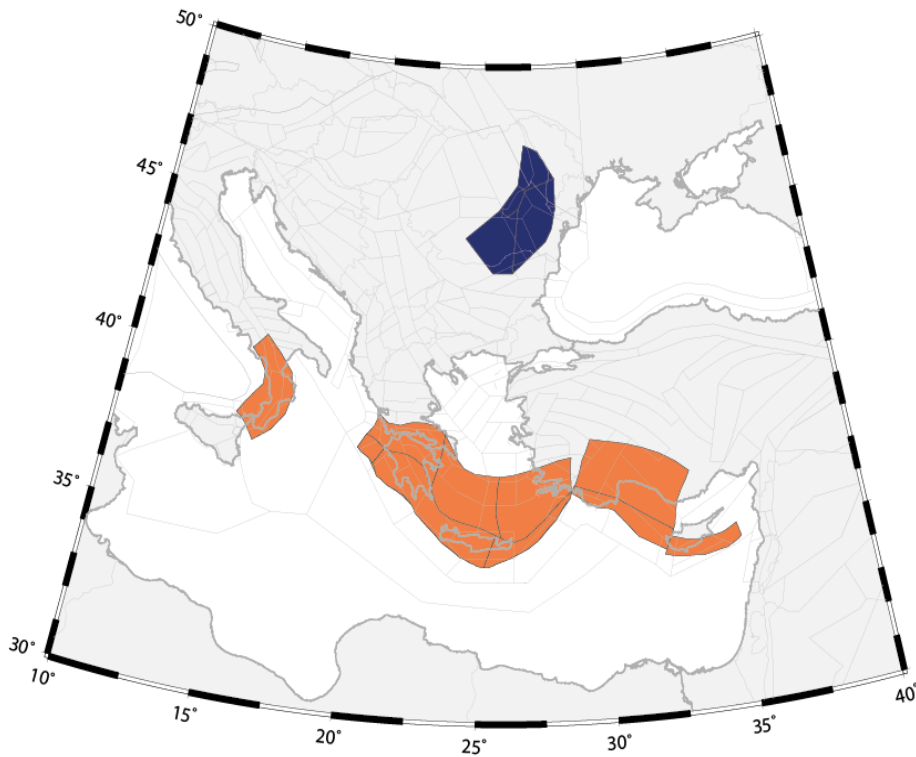
OTHER HARMONIZED DATABASE:

• MAXIMUM MAGNITUDE

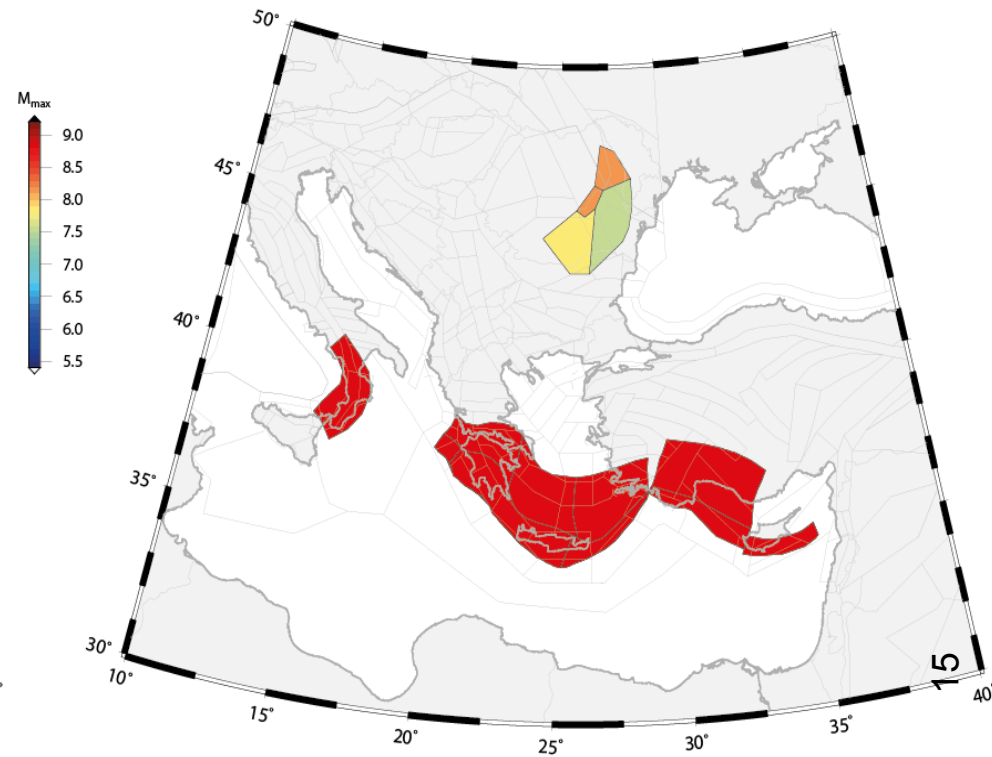


OTHER HARMONIZED DATABASE:

- SUBDUCTION
- VRANCEA DEEP SEISMICITY



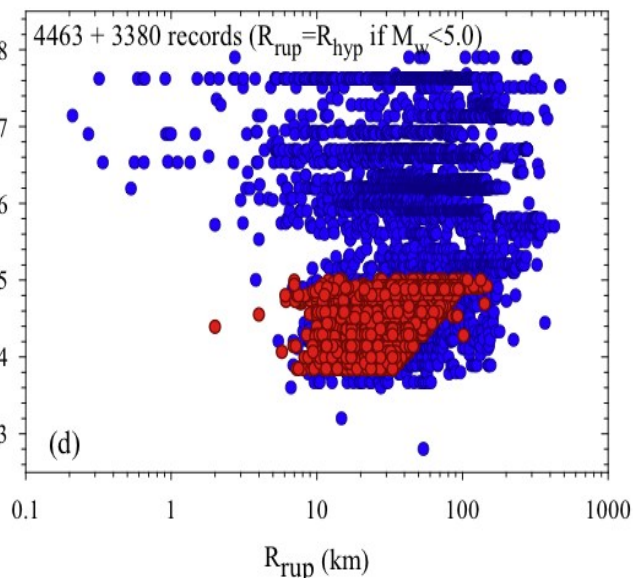
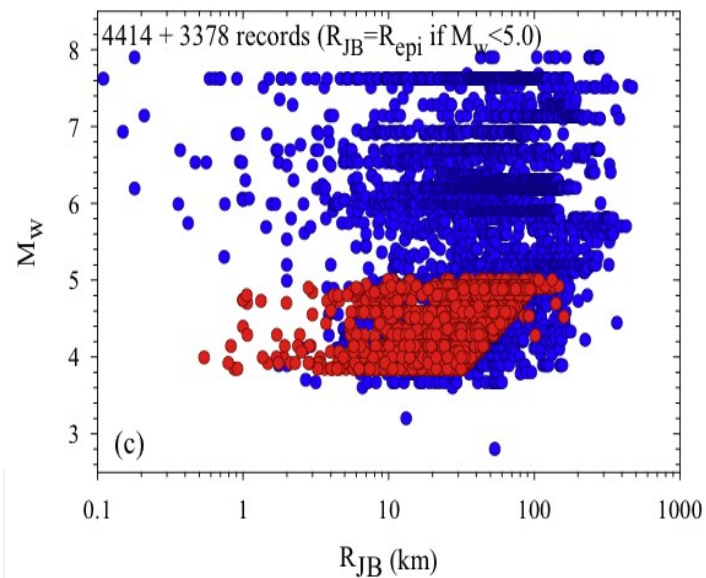
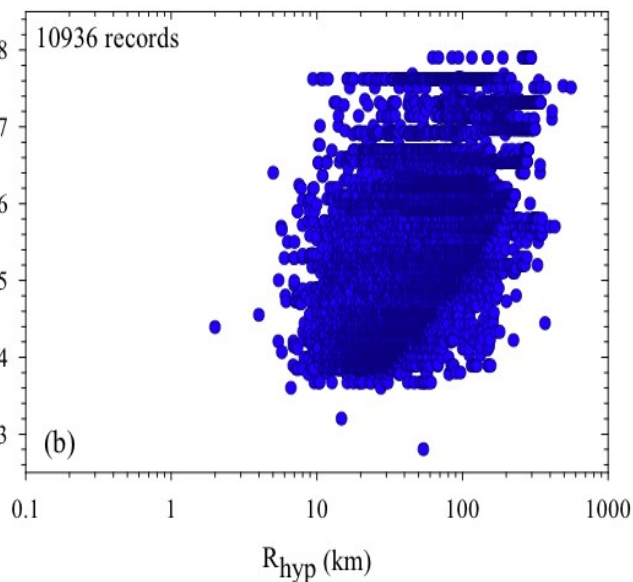
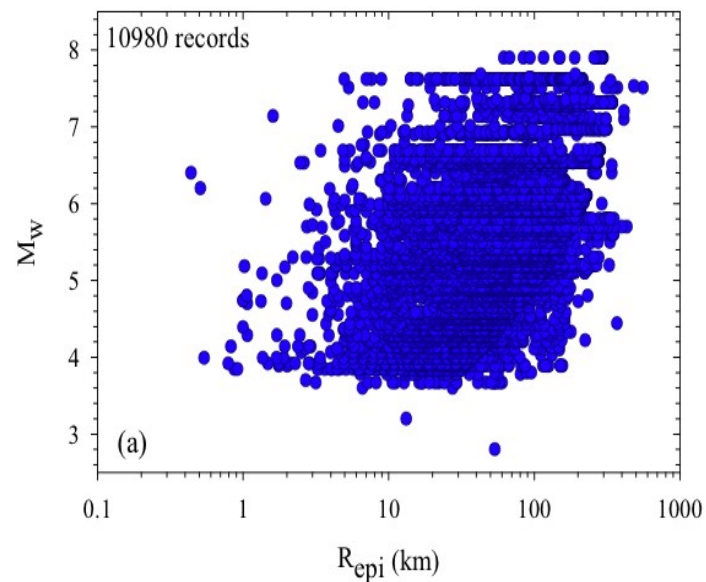
a) Smallest maximum magnitude



b) Largest maximum magnitude



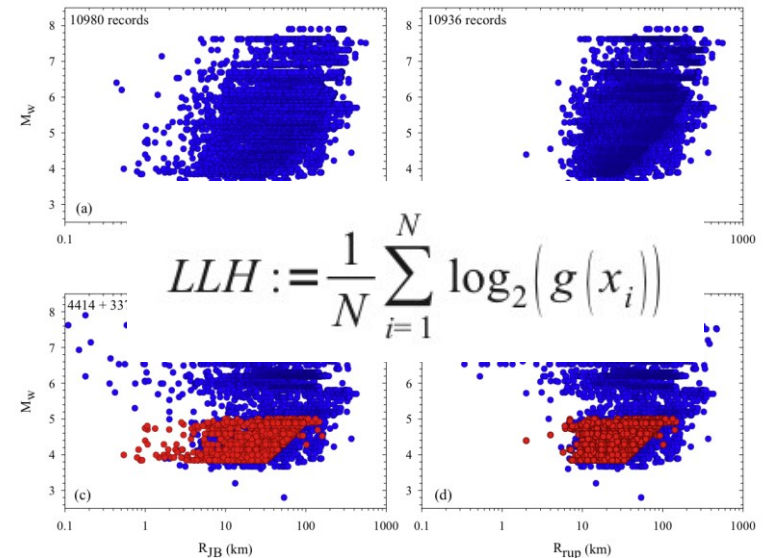
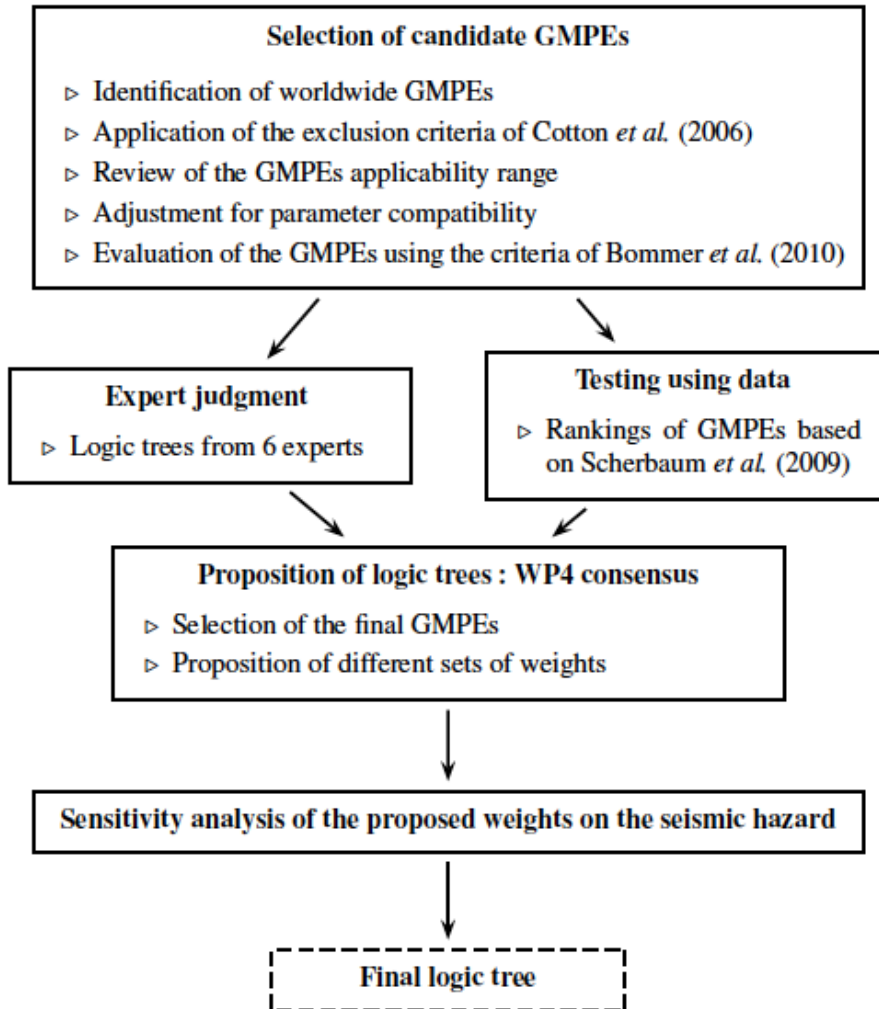
Milestones



PAN- EUROPEAN STRONG MOTION DATABASE



Ground Motion Models Selection



Active shallow crustal regions
 Ranking based on PSA at 5 periods (0.1s, 0.2s, 0.5s, 1s, 2s)
 For all magnitudes and distances → 6911 observations

rank	LLH	weight	ratio(*)	name
1	2.378	0.120	1.00	Bindi et al (2009)
2	2.396	0.119	1.01	Cauzzi and Faccioli (2008)
3	2.427	0.116	1.03	Cotton et al (2008)
4	2.588	0.104	1.16	Akkar and Bommer (2010)
5	2.680	0.097	1.23	Douglas et al (2006)
6	2.800	0.090	1.34	Zhao et al (2006)
7	2.938	0.082	1.47	Chiou and Youngs (2008)
8	3.158	0.070	1.72	Ambraseys et al. (2005)
9	3.271	0.065	1.86	Danciu and Tselentis (2007)
10	3.869	0.043	2.81	Abrahamson and Silva (2008)
11	4.121	0.036	3.30	Boore and Atkinson (2008)
12	4.785	0.023	5.30	Campbell and Bozorgnia (2008)
13	4.921	0.021	5.80	Kalkan and Gulkan (2004)
14	5.332	0.016	7.70	Massa et al (2008)

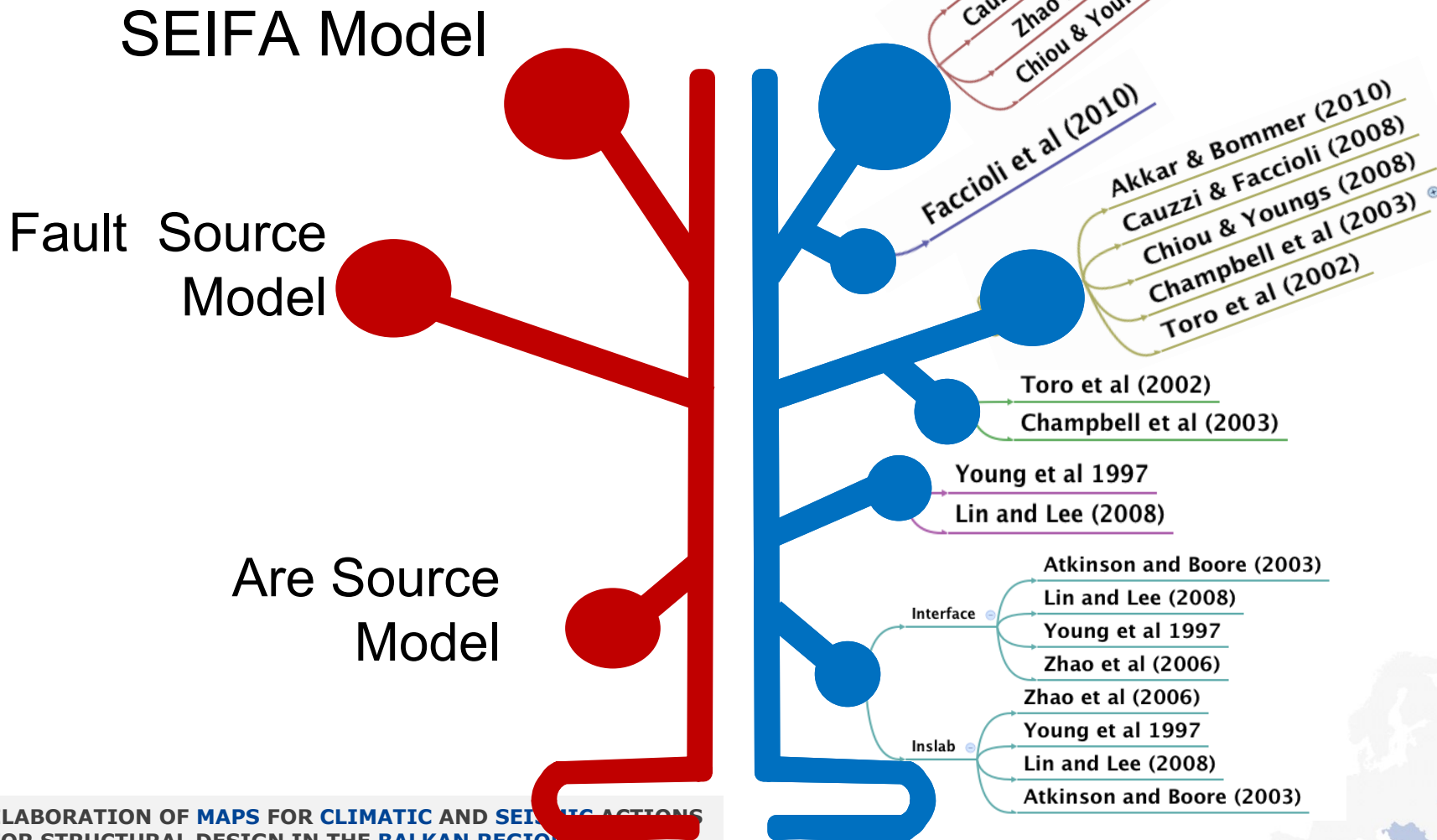
(*) ratio between the larger weight and the weight of each model



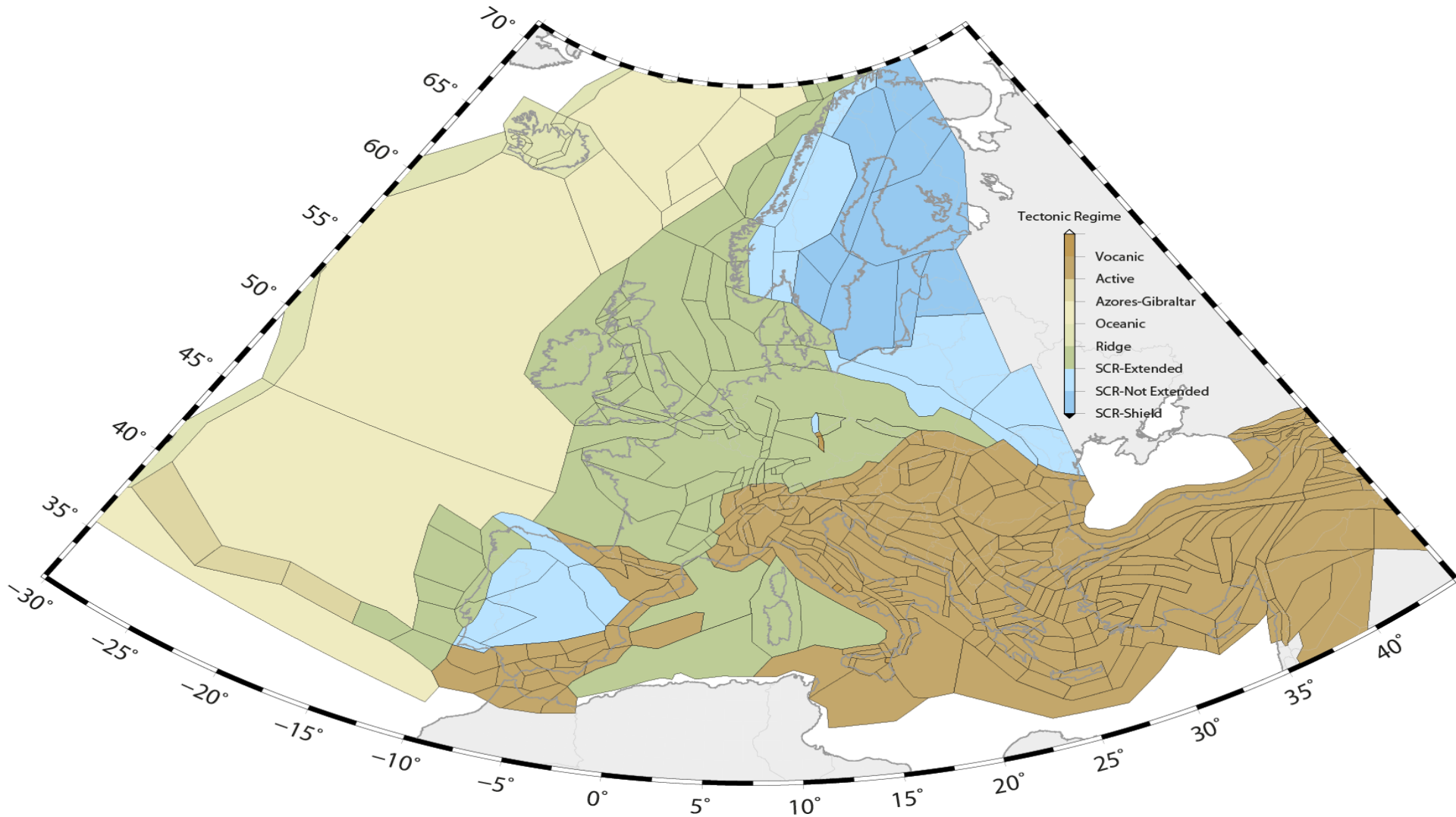
Handling Uncertainties



European Commission



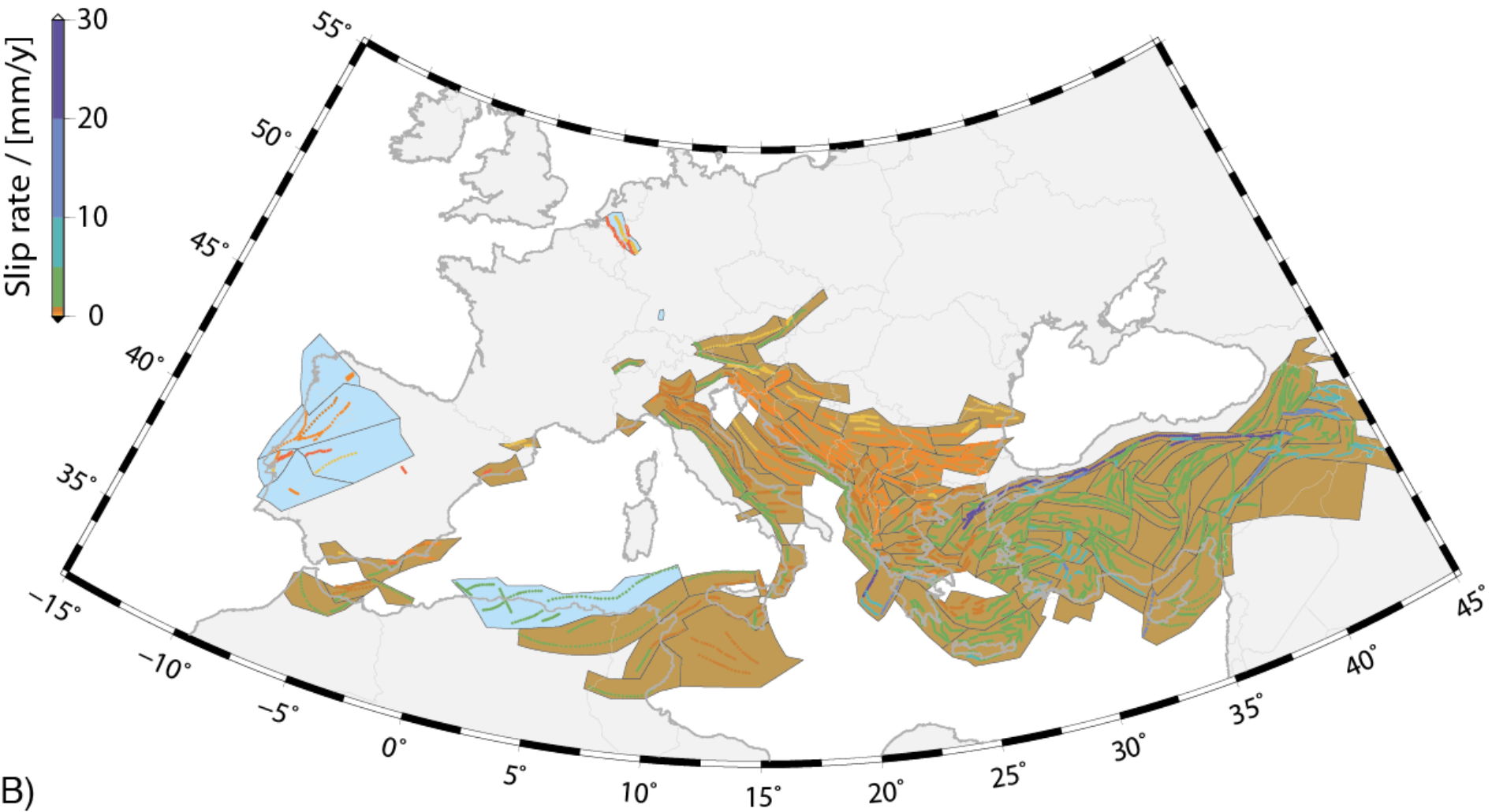
Seismic Area Sources



ELABORATION OF **MAPS** FOR **CLIMATIC** AND **SEISMIC** ACTIONS
FOR STRUCTURAL DESIGN IN THE **BALKAN** REGION

27-28 October 2015, Zagreb

Active Faults

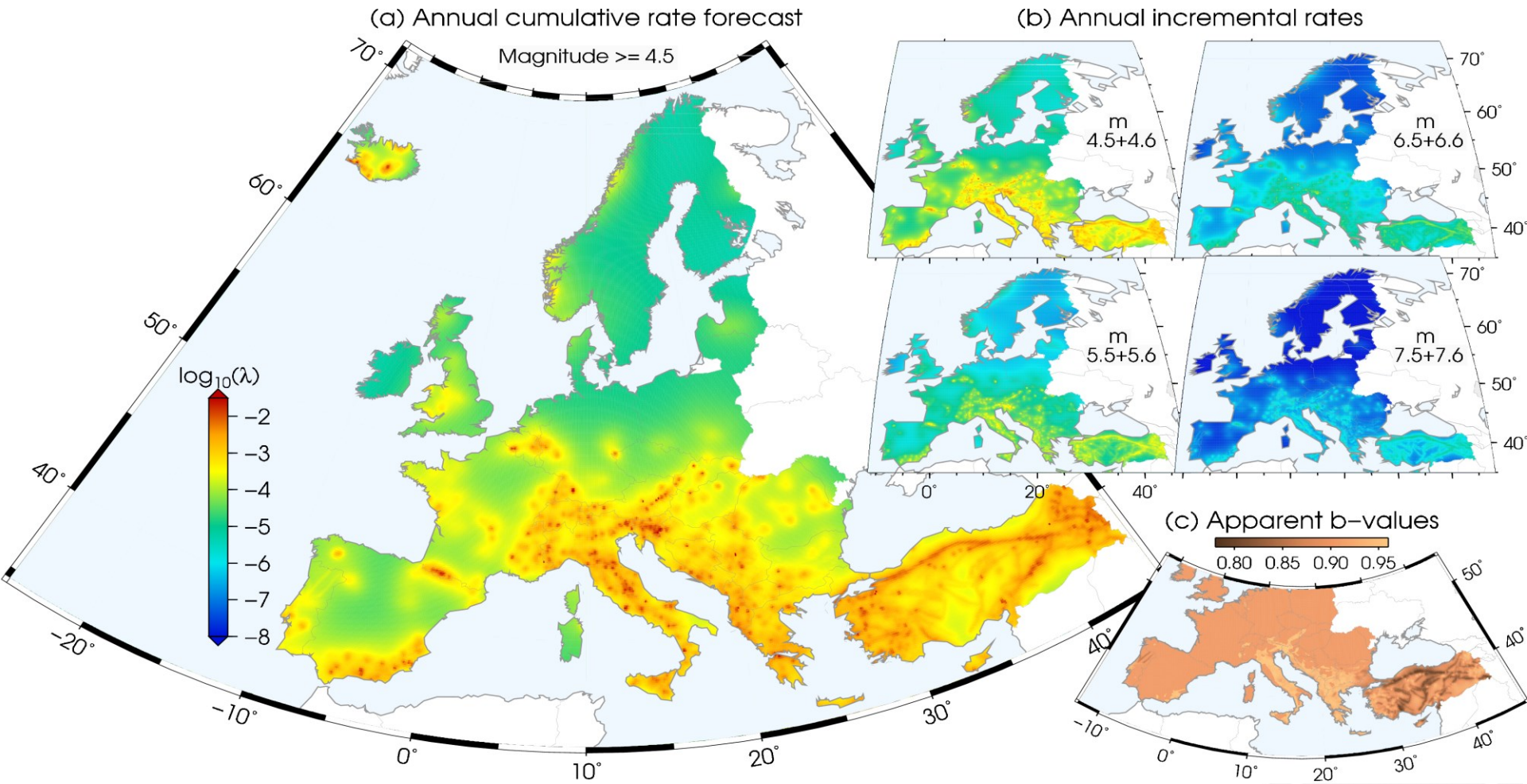


B)

ELABORATION OF **MAPS** FOR **CLIMATIC** AND **SEISMIC** ACTIONS FOR STRUCTURAL DESIGN IN THE **BALKAN REGION**
27-28 October 2015, Zagreb



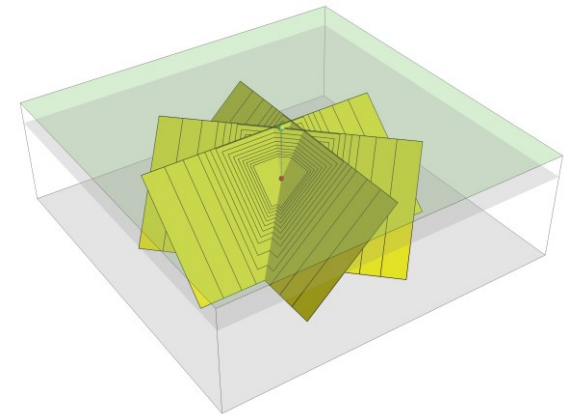
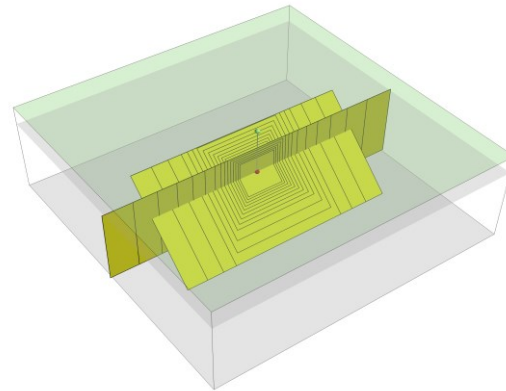
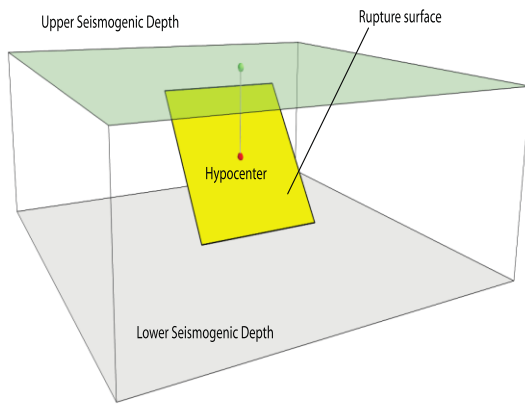
Smooth Seismicity (SEIFA Model)



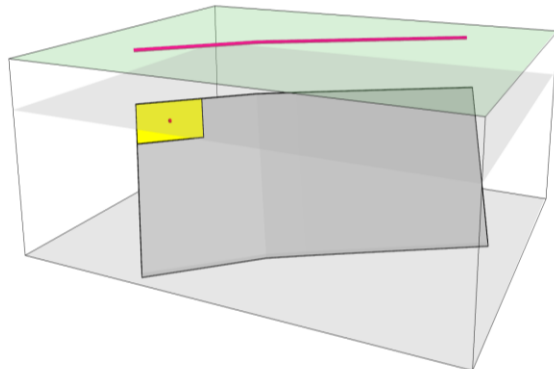
Milestones



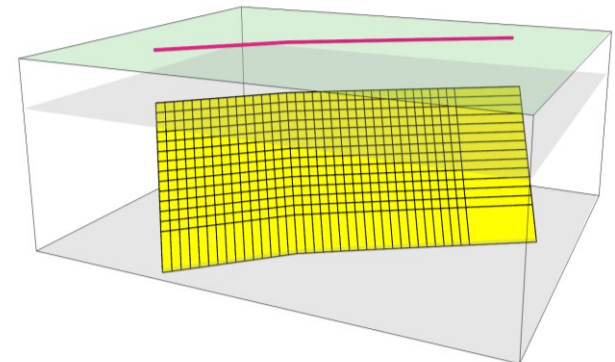
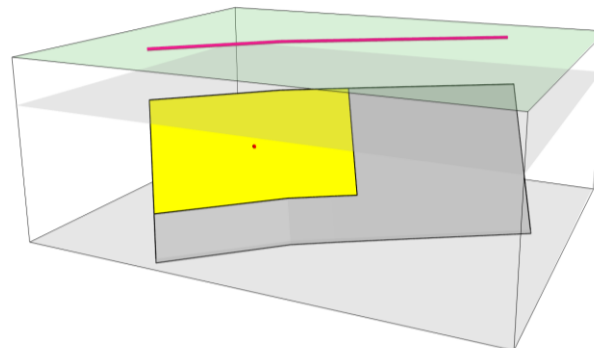
STATE-OF-THE-ART SEISMIC SOURCE REPRESENTATION



Magnitude: 5.5



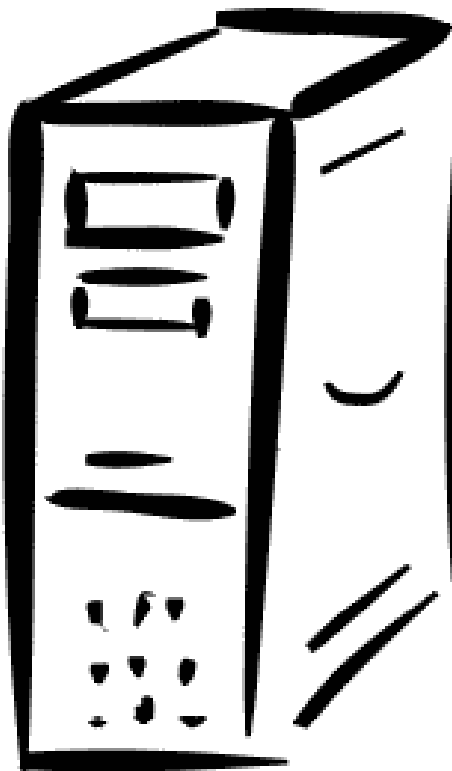
Magnitude: 6.5



Milestones



Standardized I/O Files

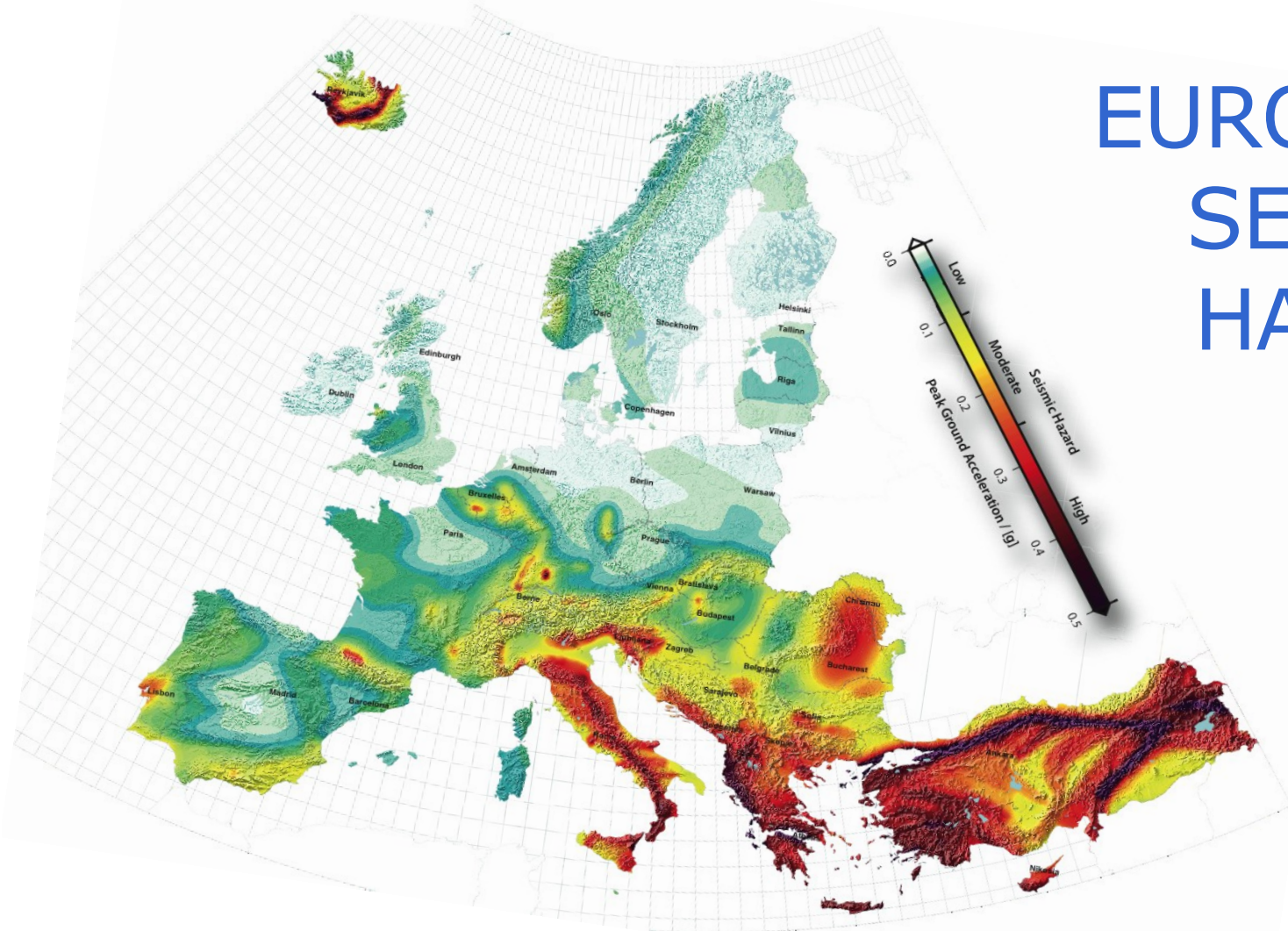


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Milestones

NEW EUROPEAN SEISMIC HAZARD MAP



The 2013 European Seismic Hazard Model: Output



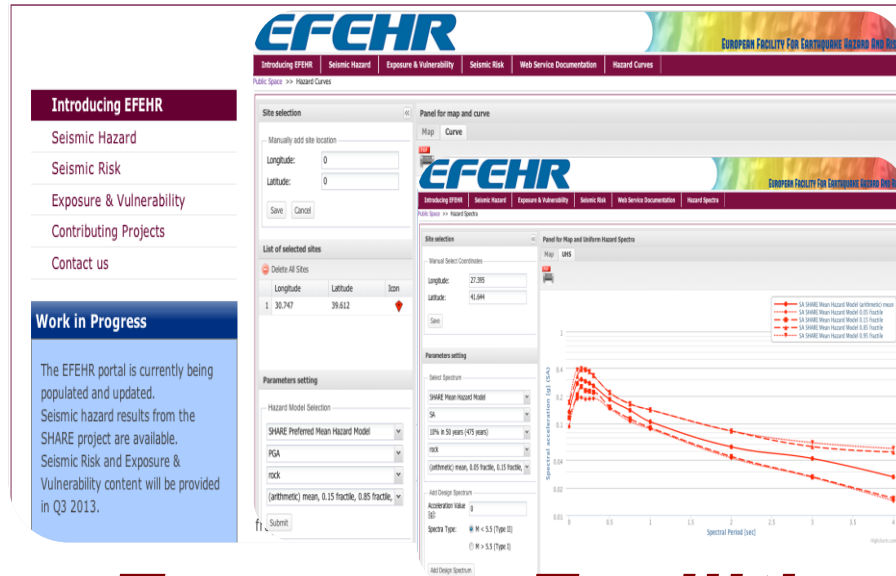
ELABORATION OF **MAPS** FOR **CLIMATIC** AND **SEISMIC** ACTIONS
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27-28 October 2015, Zagreb

Availability



Public Space >> Introducing EFEHR



Introducing EFEHR

- Seismic Hazard
- Seismic Risk
- Exposure & Vulnerability
- Contributing Projects
- Contact us

Work in Progress

The EFEHR portal is currently being populated and updated. Seismic hazard results from the SHARE project are available. Seismic Risk and Exposure & Vulnerability content will be provided in Q3 2013.

Site selection

Manually add site location

Longitude: 0
Latitude: 0

Save Cancel

List of selected sites

Longitude	Latitude	Icon
30.747	39.612	

Parameters setting

Hazard Model Selection

SHARE Preferred Mean Hazard Model: SA
PGA
rock
(arithmetic) mean, 0.15 fractile, 0.85 fractile
(arithmetic) mean, 0.15 fractile, 0.85 fractile

Site selection

Manual Select Coordinates

Longitude: 22.395
Latitude: 41.644

Save

Parameters setting

Seism Spectron

SHARE Mean-Hazard Model: SA
(2% in 50 years (475 years))
rock
(arithmetic) mean, 0.85 fractile, 0.15 fractile

All Design Spectra

Acceleration value: g

Spectra Type: M < 5.5 (Type I) M > 5.5 (Type II)

All Design Spectra

Panel for map and curve

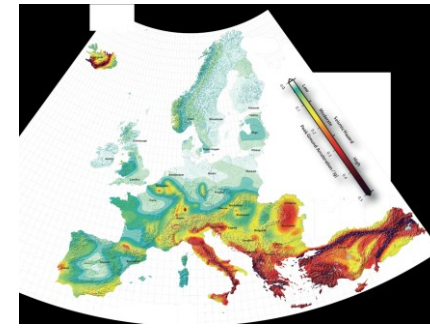
Map Curve

Panel for map and Uniform Hazard Spectra

Map UHS

Selected mean hazard curves (g)

Spectral Period (sec)



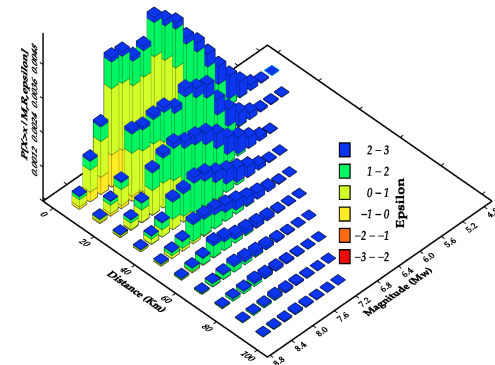
Hazard Maps
504

Hazard Curves
9.36 Mil

UHS
5.46Mil

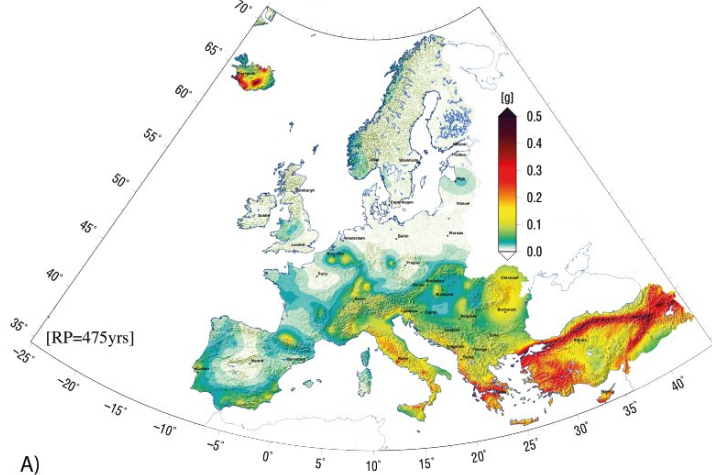
Disaggregation
10

European Facilities for Earthquake Hazard and Risk



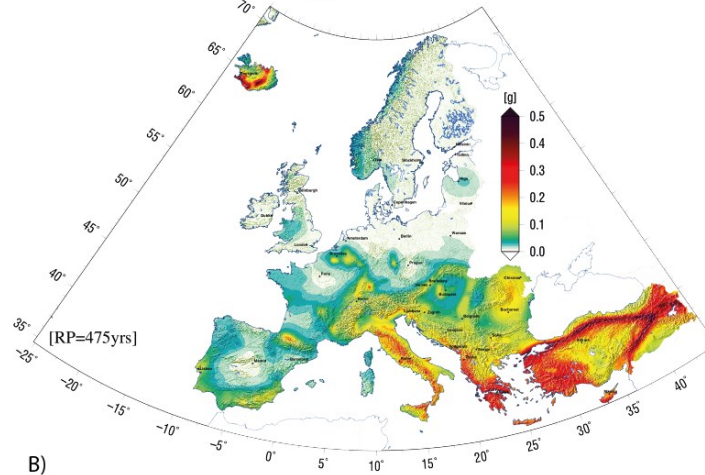
Quantiles PGA Maps RP 475yrs

PGA-QQ05 Hazard Values



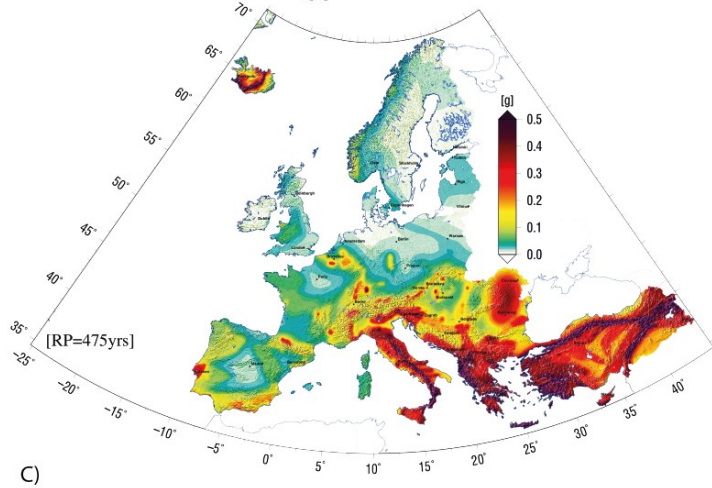
A)

PGA-QQ15 Hazard Values



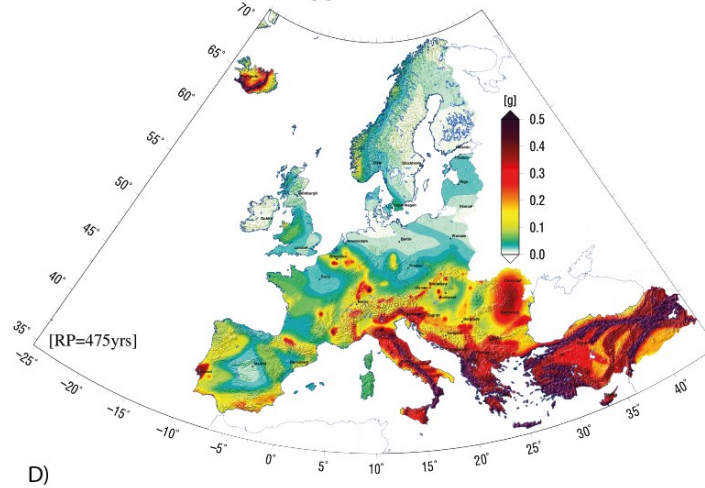
B)

PGA-QQ85 Hazard Values



C)

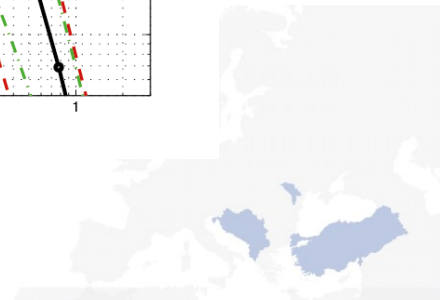
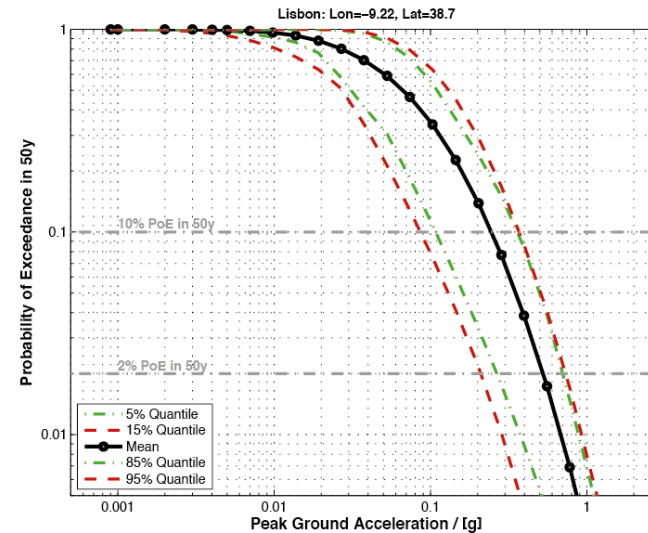
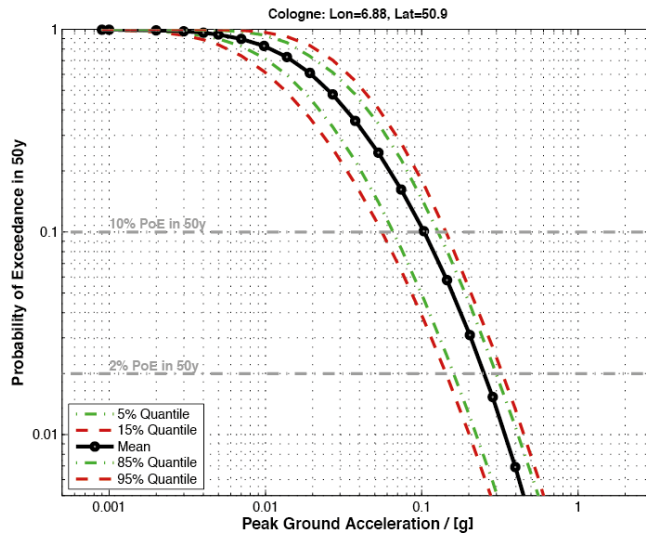
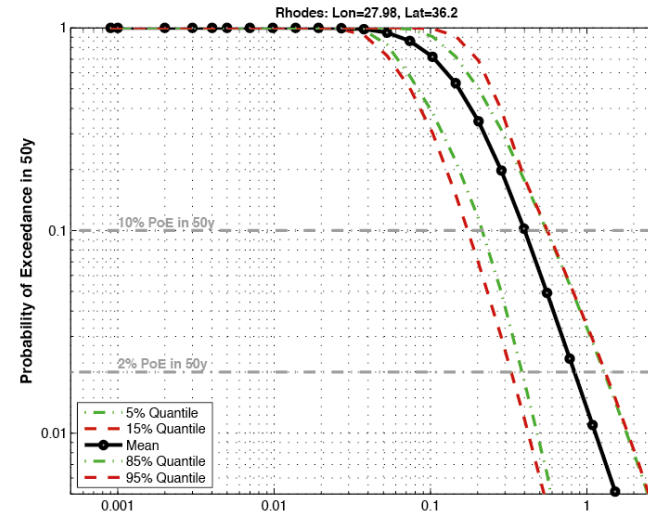
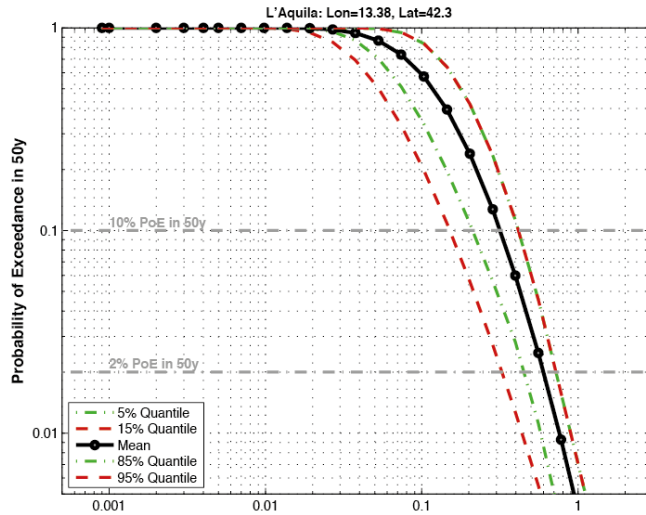
PGA-QQ95 Hazard Values



D)

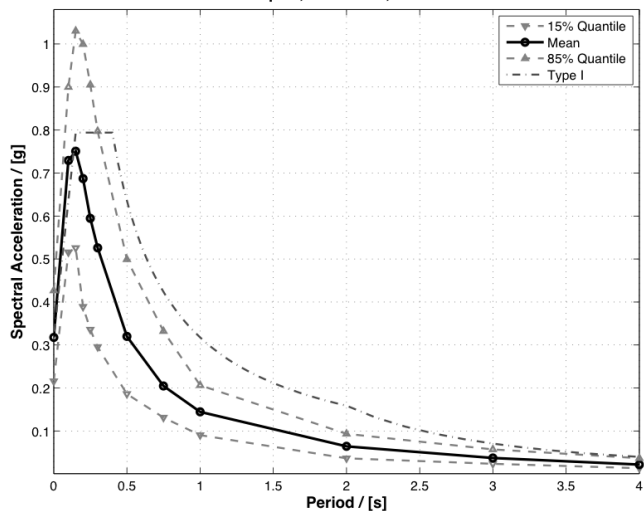


Hazard Curves

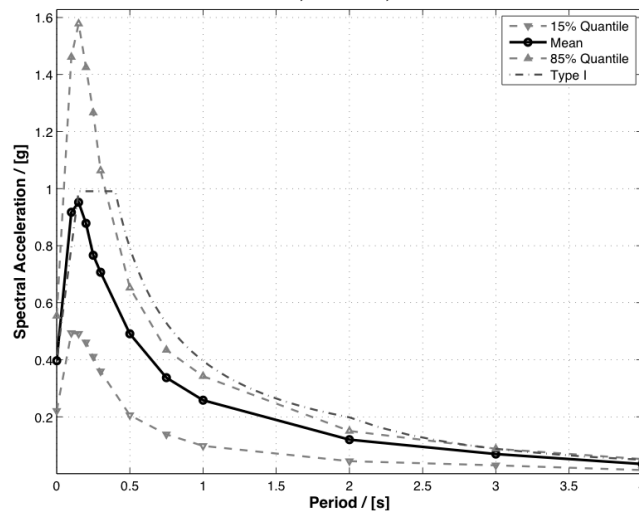


Uniform Hazard Spectra

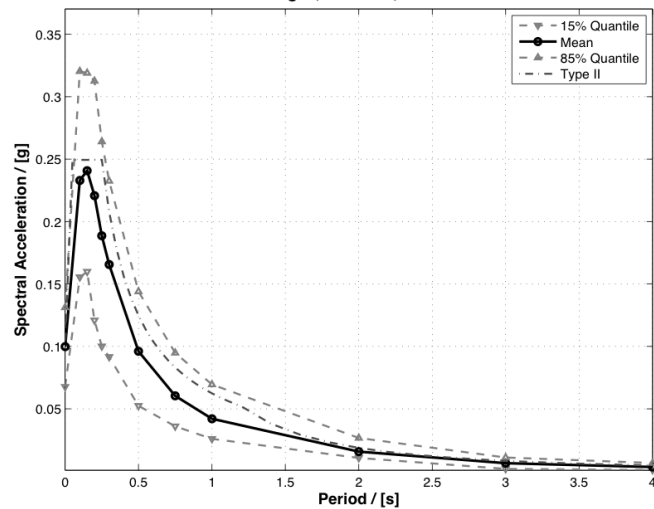
L'Aquila, Lon=13.38, Lat=42.3



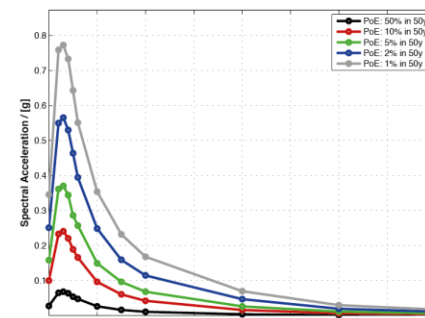
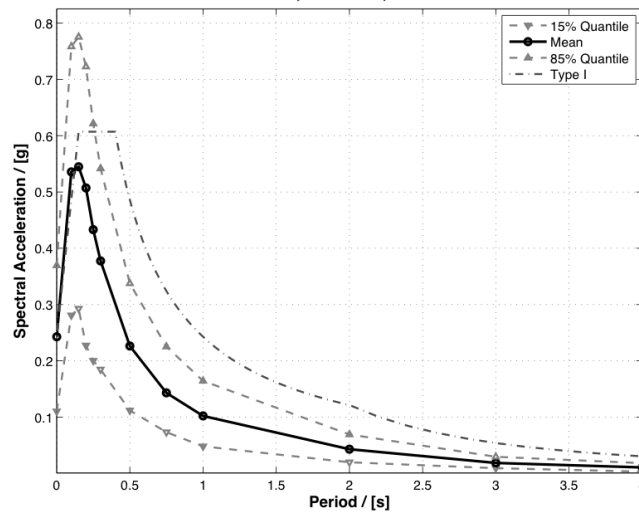
Rhodes, Lon=27.98, Lat=36.2



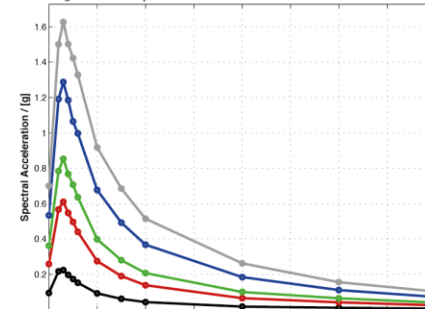
Cologne, Lon=6.88, Lat=50.9



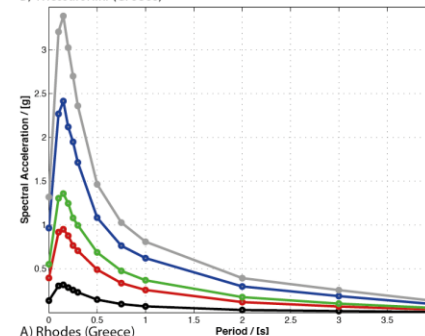
Lisbon, Lon=-9.22, Lat=38.7



C) Cologne (Germany)



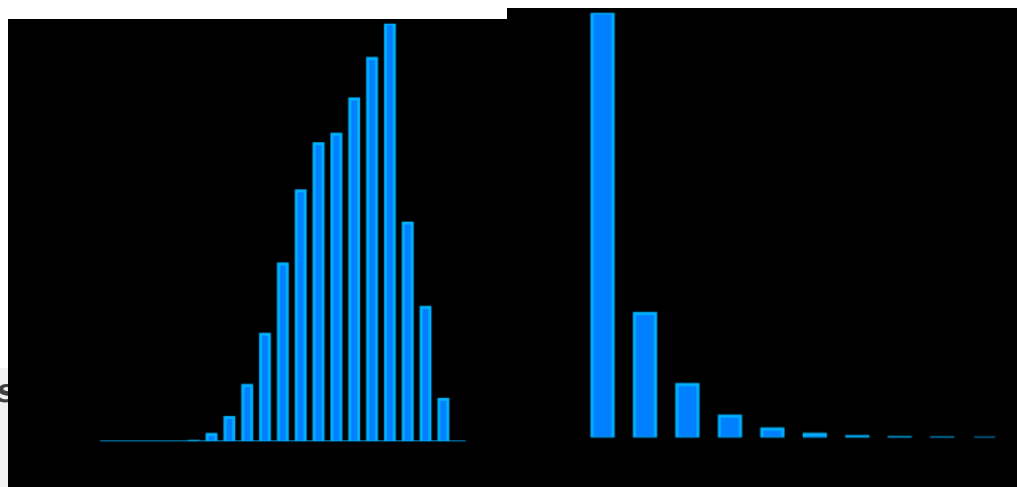
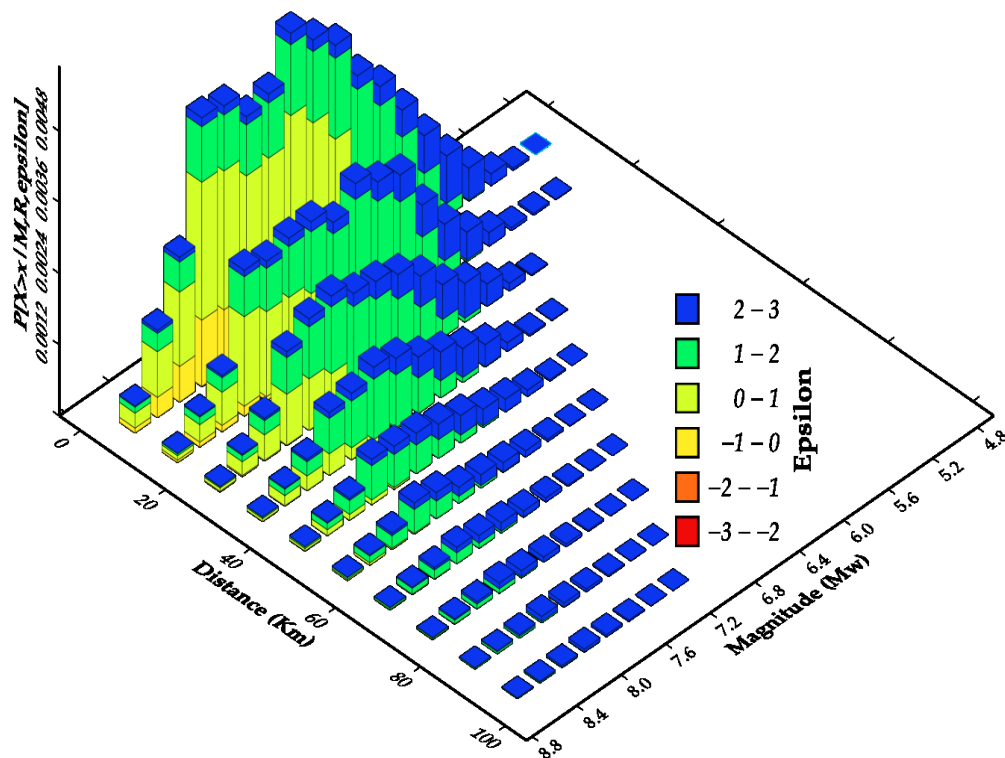
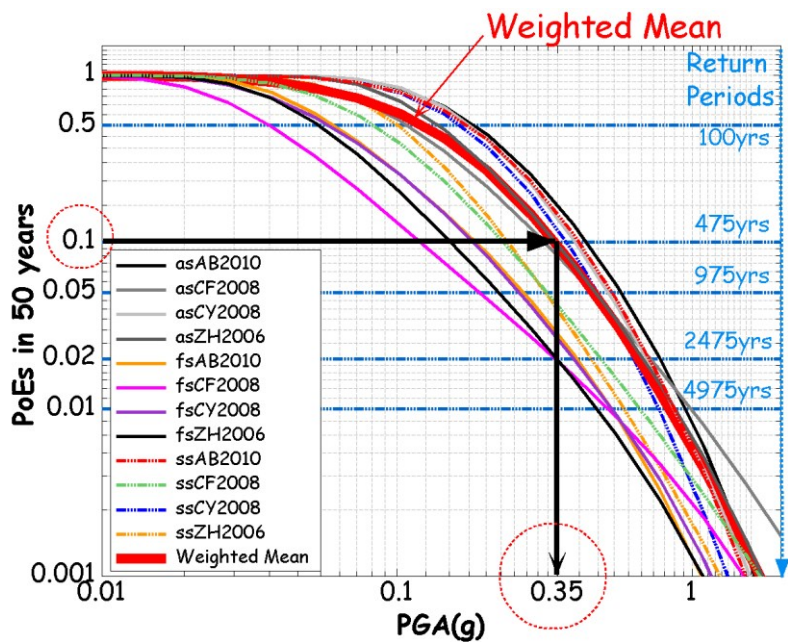
B) Thessaloniki (Greece)



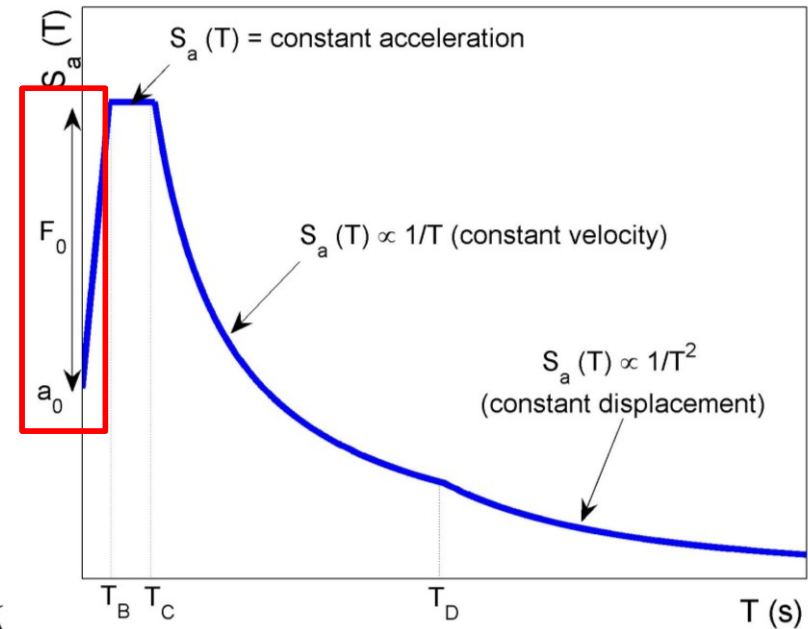
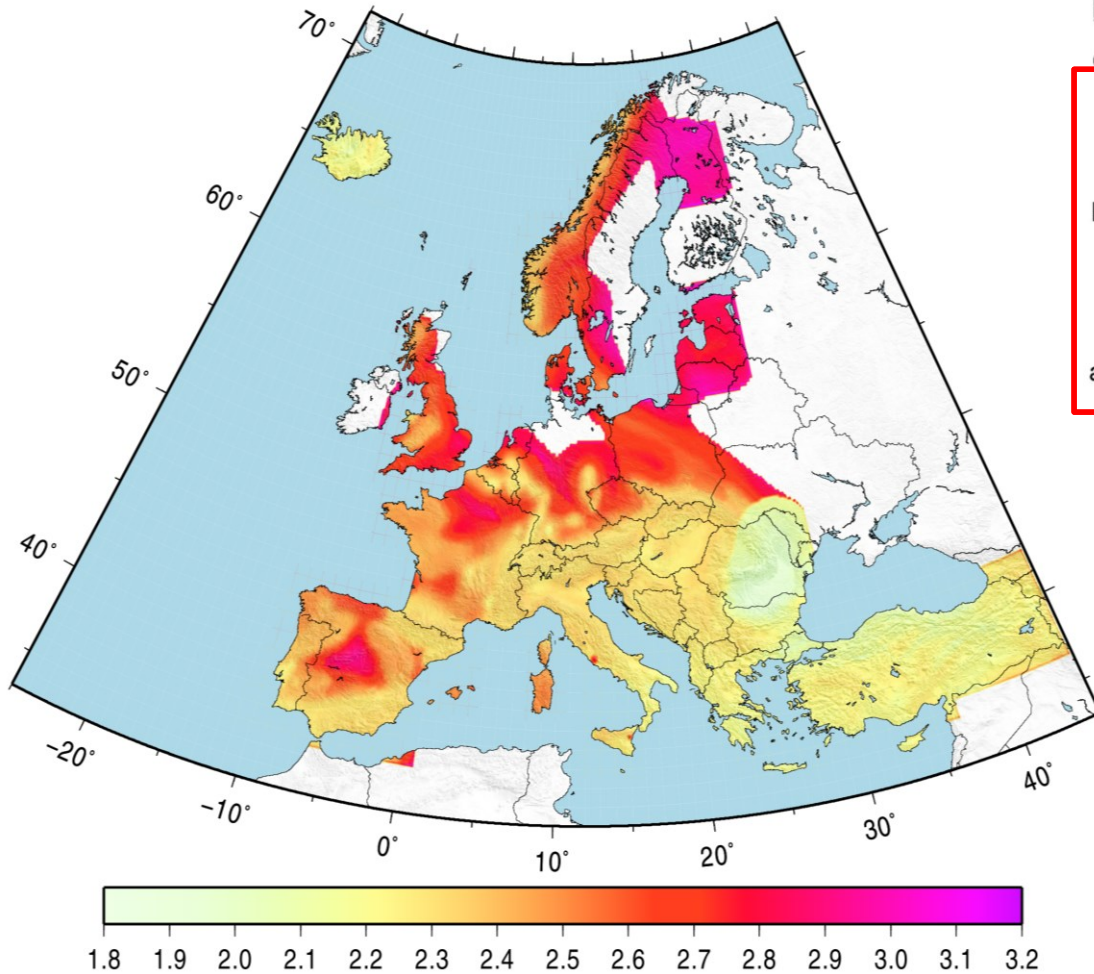
A) Rhodes (Greece)



Disaggregation

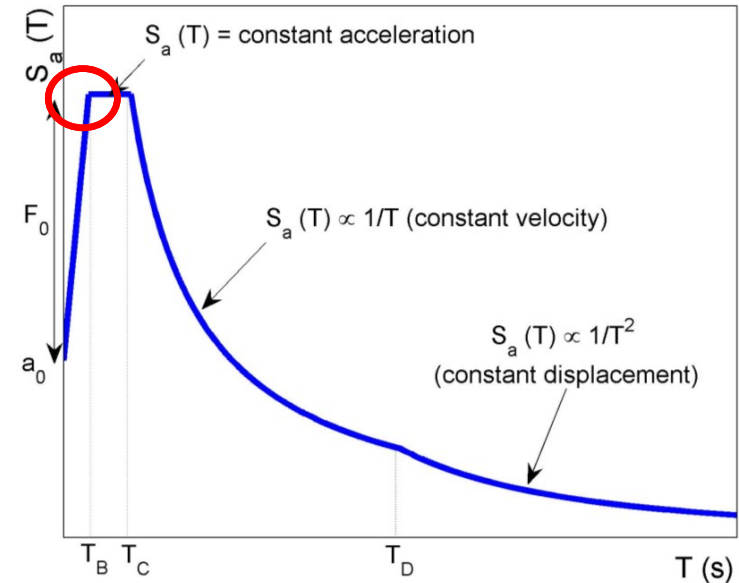
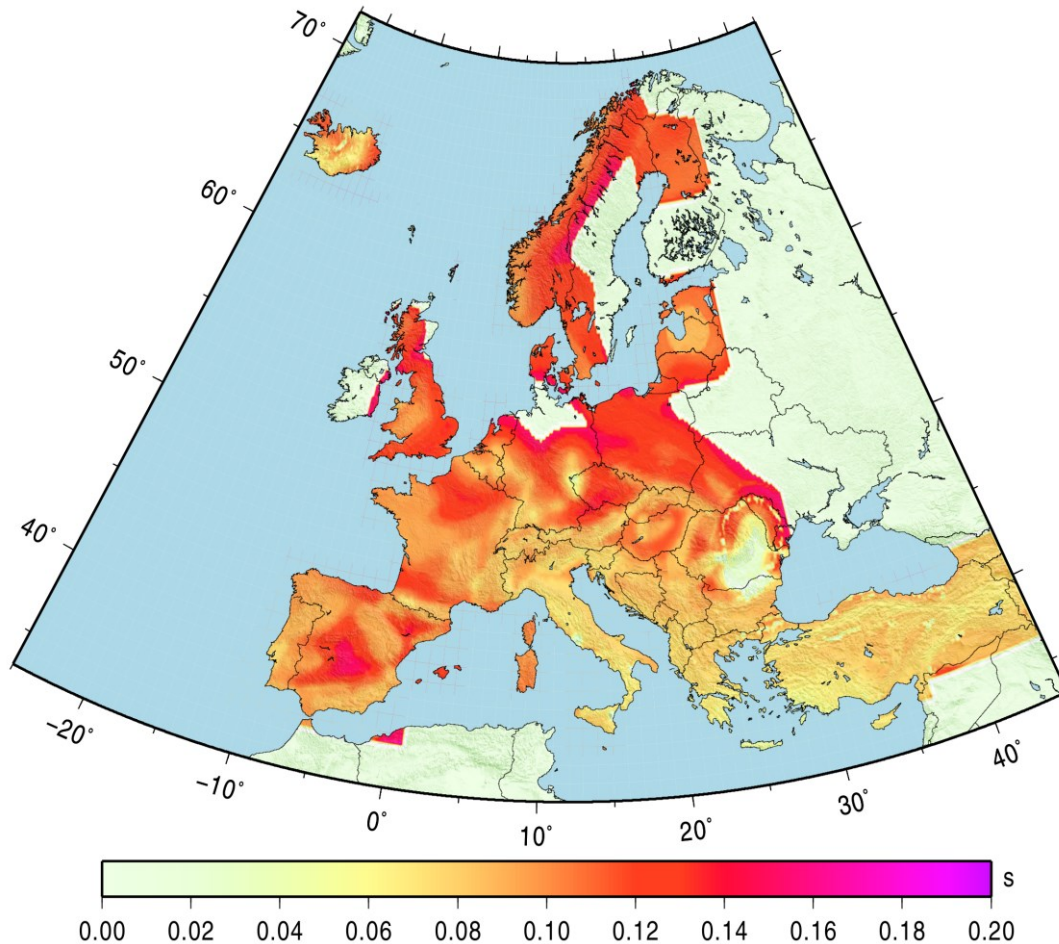


Regional Variation in Spectral Shape



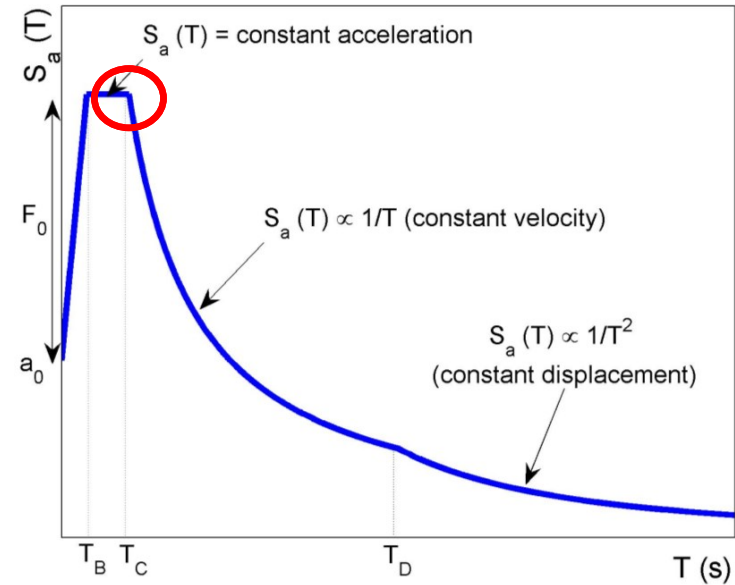
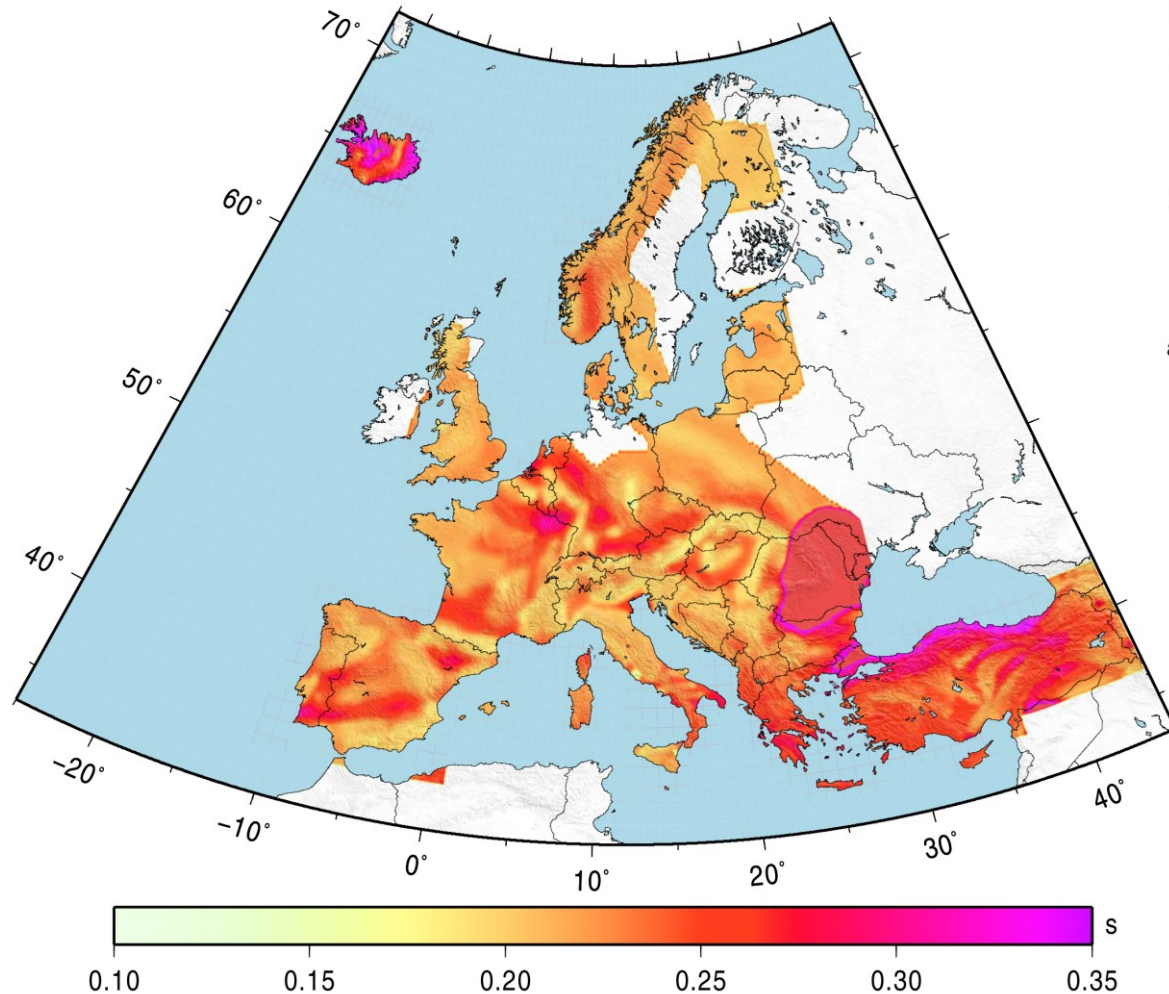
Amplification Factor F_0
(Current EC8 = 2.5)

Regional Variation in Spectral Shape



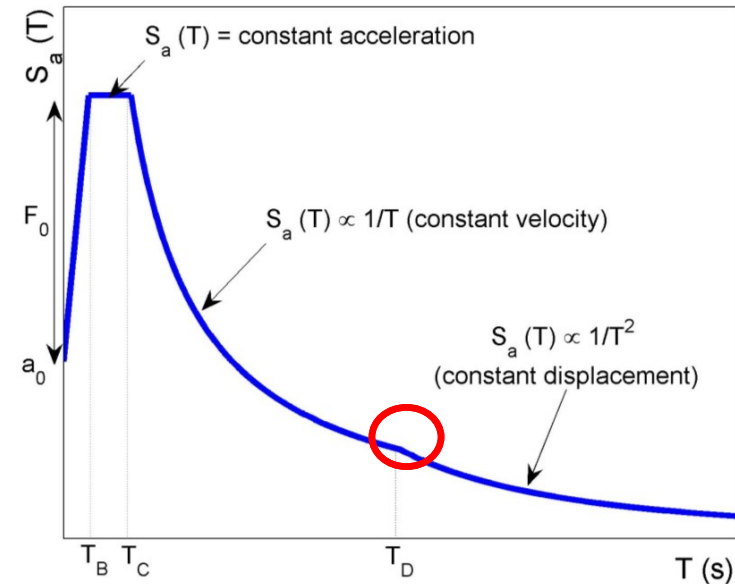
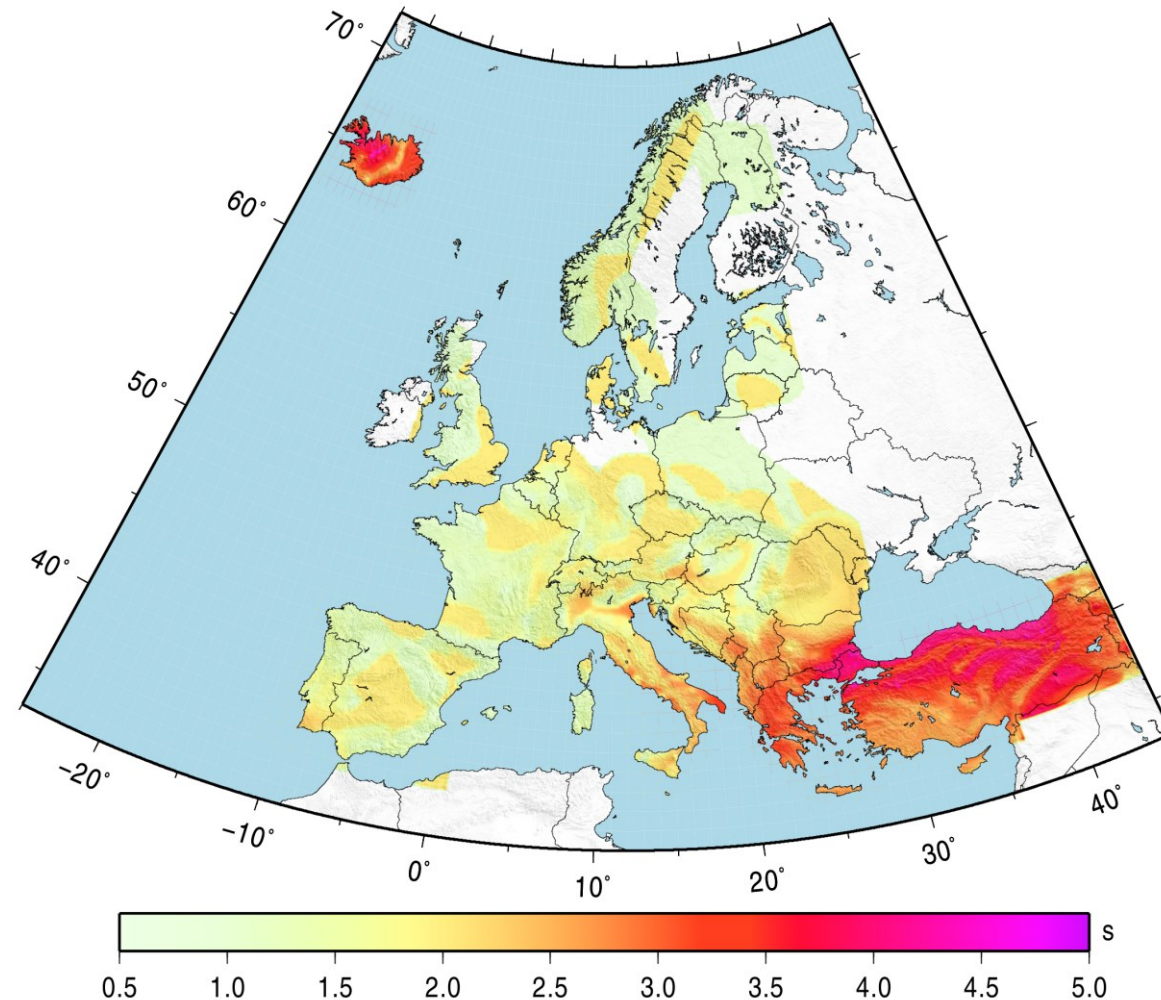
**Constant
Acceleration
Corner Period (T_B)
(Current EC8:
0.15s – Type 1
0.05 – Type 2)**

Regional Variation in Spectral Shape



**Constant
Velocity Corner
Period (T_C)
(Current EC8 =
0.4 s – Type 1
0.25 – Type 2)**

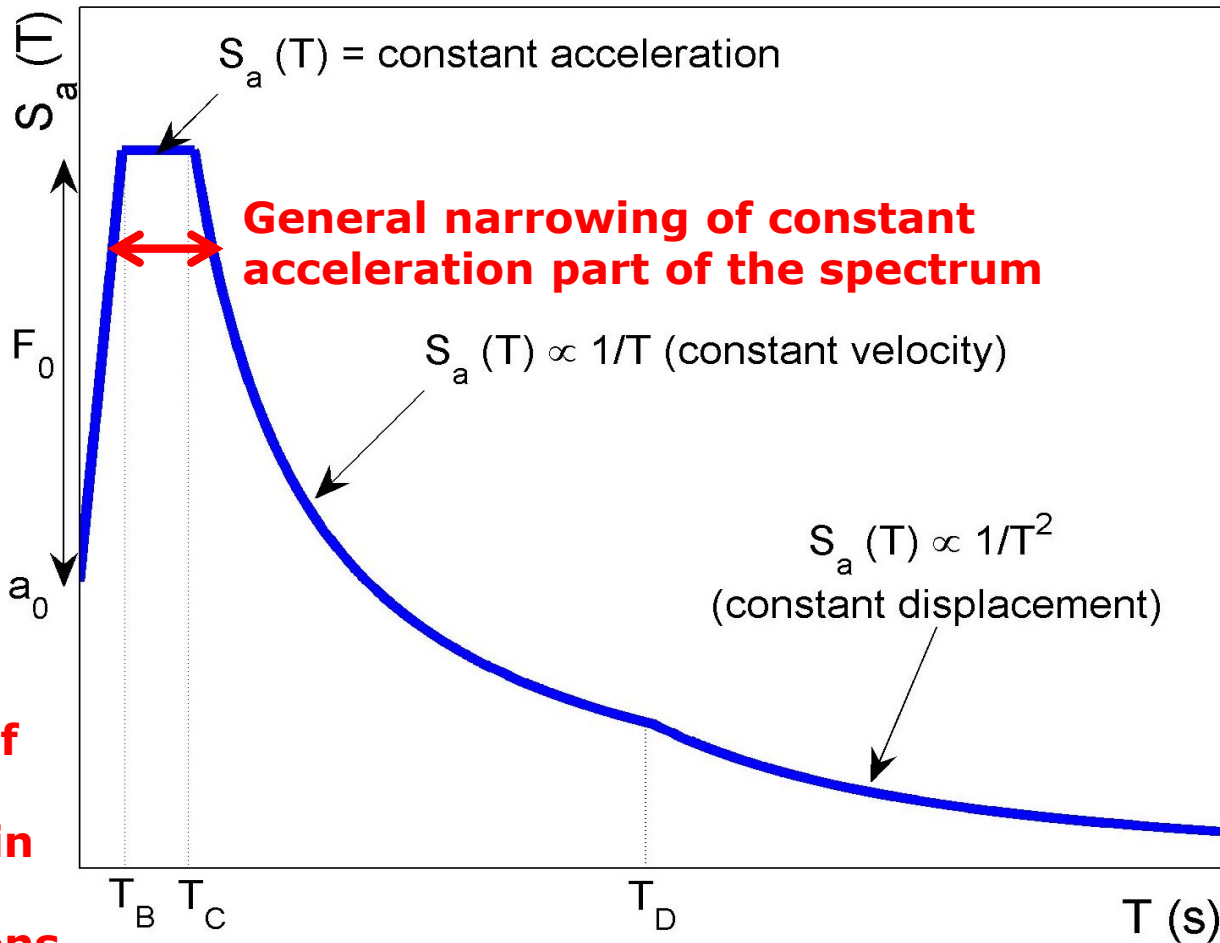
Regional Variation in Spectral Shape



**Constant
Displacement
Corner Period
(T_D)
(Currently EC8:
2.0 s – Type 1
1.2 s – Type 2)**

ESHM13 Design Spectra

General Trends



Slight flattening of spectrum (reduction in F_0) in more active regions

T_D shifting toward longer periods



"*k-value*": Usage and Implications

"At most sites the annual rate of exceedance, $H(a_{gR})$, of the reference peak ground acceleration a_{gR} may be taken to vary with a_{gR} as:

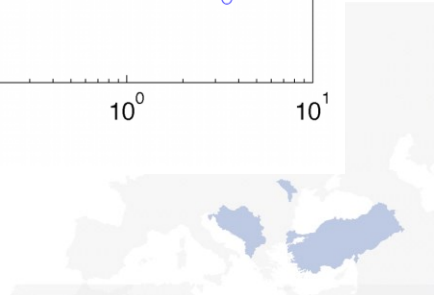
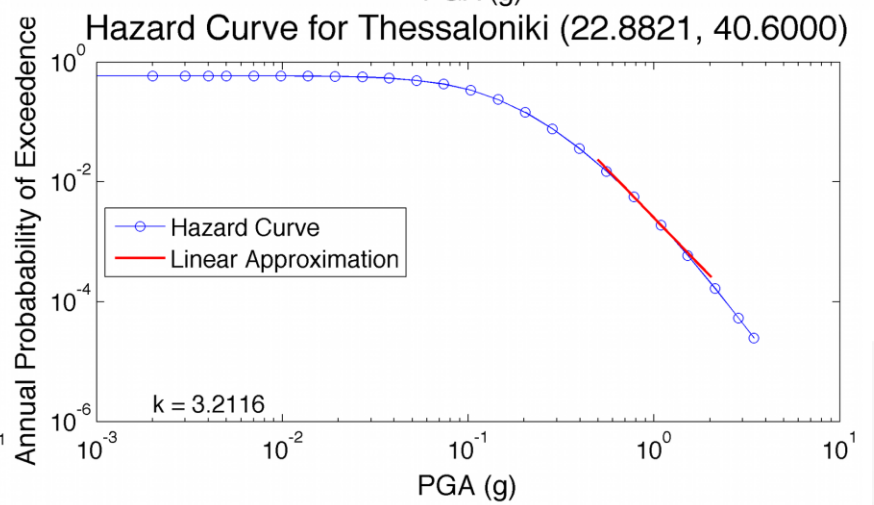
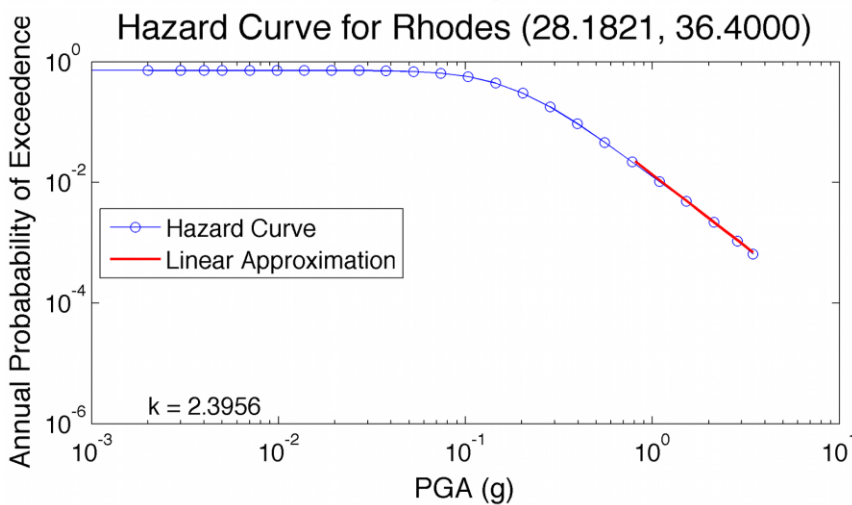
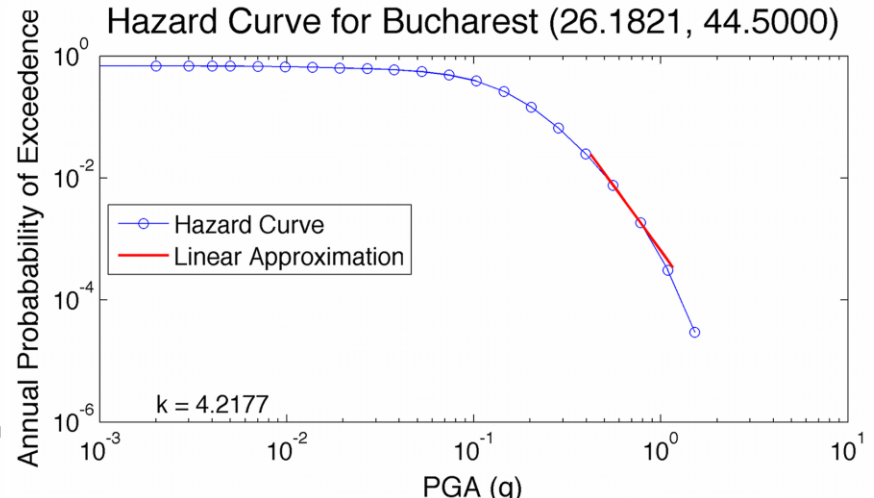
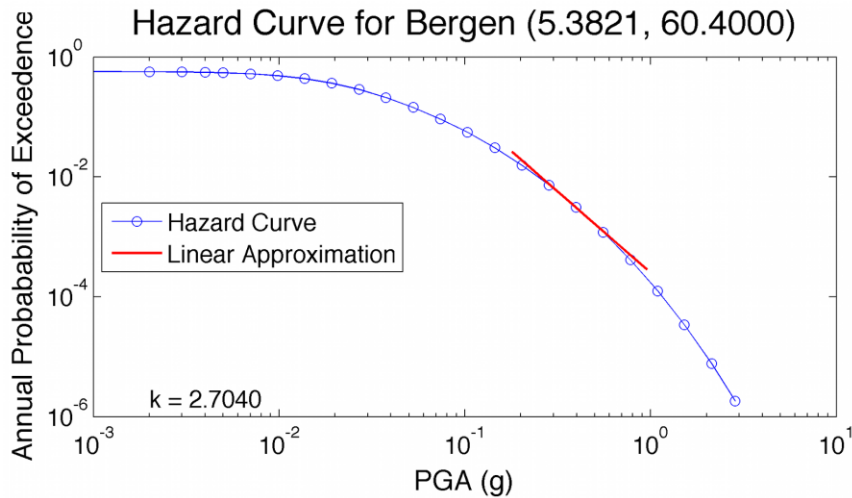
$$H(a_{gR}) \sim k_0 a_{gR}^{-k},$$

with the value of the exponent k depending on seismicity, but being generally of the order of 3"

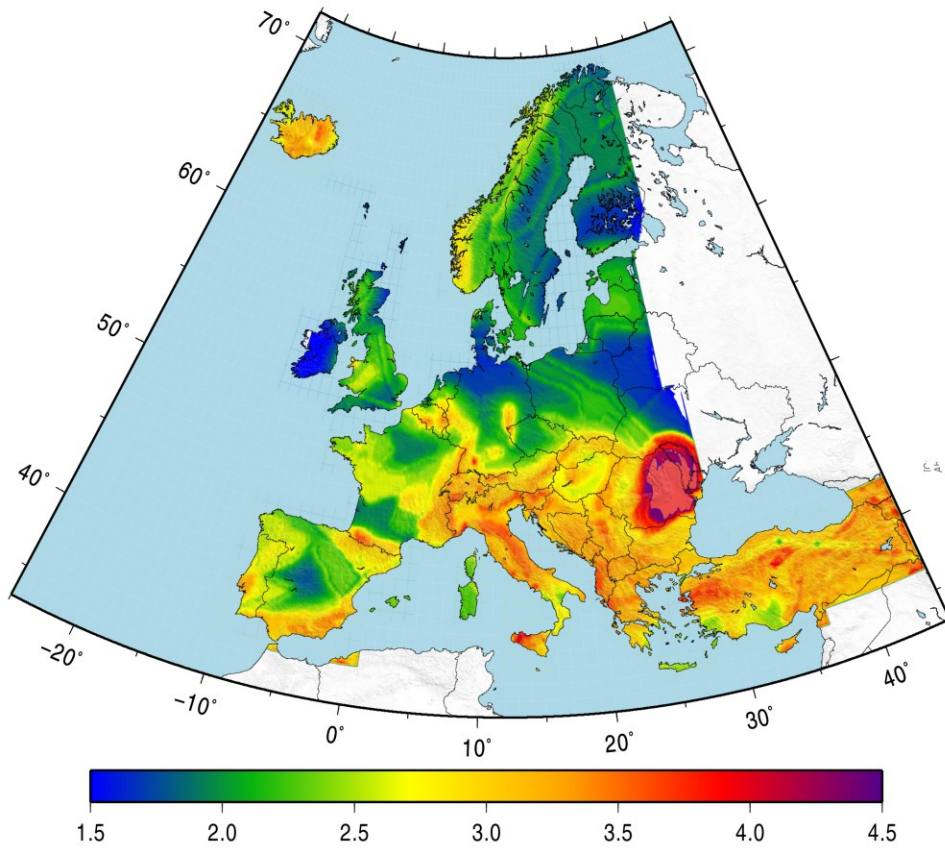
- *Allows for scaling to different performance levels and adjustment of the importance factor*
- *Fixed to 3!*
- *Over what return periods is this approximation valid?*



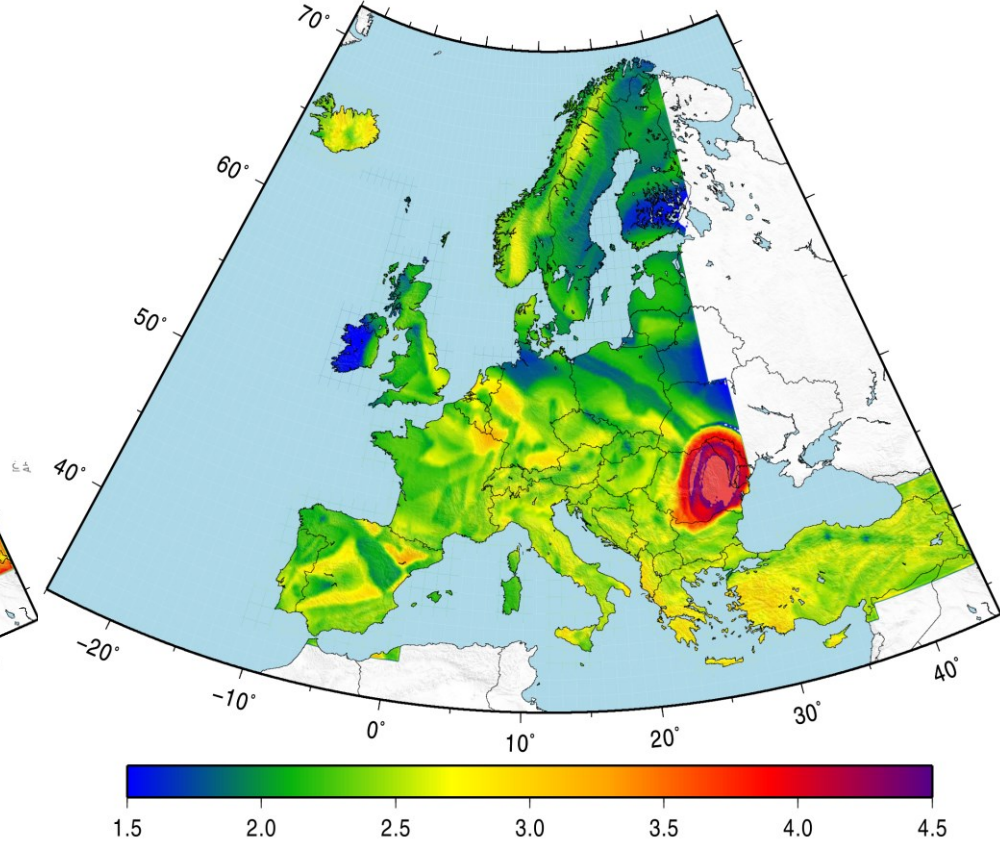
"k-value": Usage and Implications



k-value Across Europe



K-value fit to Peak Ground Acceleration (PGA)



K-value fit to 1-second Spectral Acceleration

Summary

- *SHARE Project **successfully delivered** a pan-European Model*
- ***Compilation of harmonized databases** of all parameters required for PSHA*
- *Adoption of **rigorous, standardized** procedures in all steps of the process*
- ***Full accounting** of epistemic uncertainties for model components and hazard results*
- *Full **transparency** and **open availability** of all data, results, and methods*
- ***Multidisciplinary approach**, relying on input from all branches of earthquake science and engineering*
- *Ensured the definition of **proper output specifications** relevant for **Ec 8***

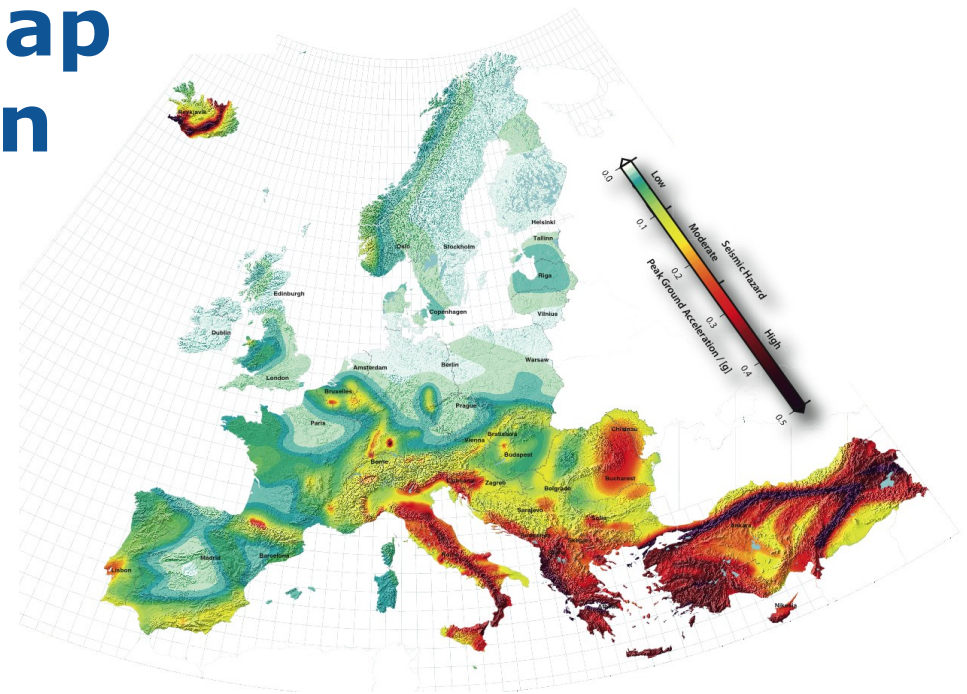
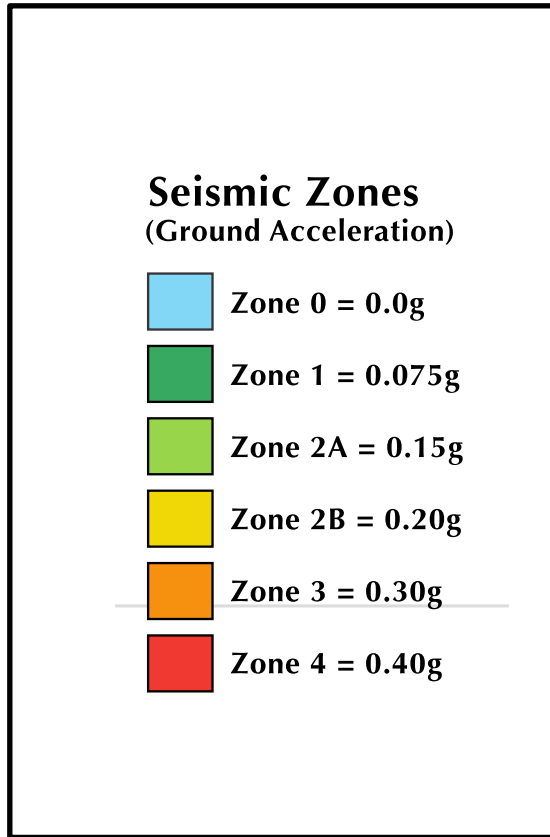


ESHM13 – Pathway to Eurocode

- *Improvement and Acceptance of ESHM13*
 - **Investigation of factors causing differences between ESHM13 and existing models**
 - **Updates and improvements at local level – further contribution from local scientists**
- *Revision and Version Control*
- *Application in local/regional risk studies*
 - **Comparison with losses from previous models**



The 2013 European Seismic Hazard Map *is not* an European Seismic Zonation



- *Seismic Zones have to be defined at the country level by: legislators , engineers, practitioners*
- *National Annexes*
- *Zonation is country specific*



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 D. Slejko V. Poggi J. D. Fonseca D. G. Moreno J. Wössner M. Stucchi S. Hiemer B. Wyss
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Thank you!

ELABORATION OF MAPS FOR CLIMATIC AND SEISMIC ACTIONS FOR STRUCTURAL DESIGN IN THE BALKAN REGION

27-28 October 2015, Zagreb

