Project funded by the EUROPEAN UNION

A Scientific Network
for Earthquake, Landslide & Flood Hazard Prevention

SciNetNatHazPrev – STAKEHOLDERS MEETING

NOVEMBER 12-13, 2015, ISTANBUL, TURKEY

VENUE: MAÇKA SOCIAL CENTER, ISTANBUL TECHNICAL UNIVERSITY FOUNDATION

An OVERVIEW
OF
SEISMIC HAZARD of TURKEY

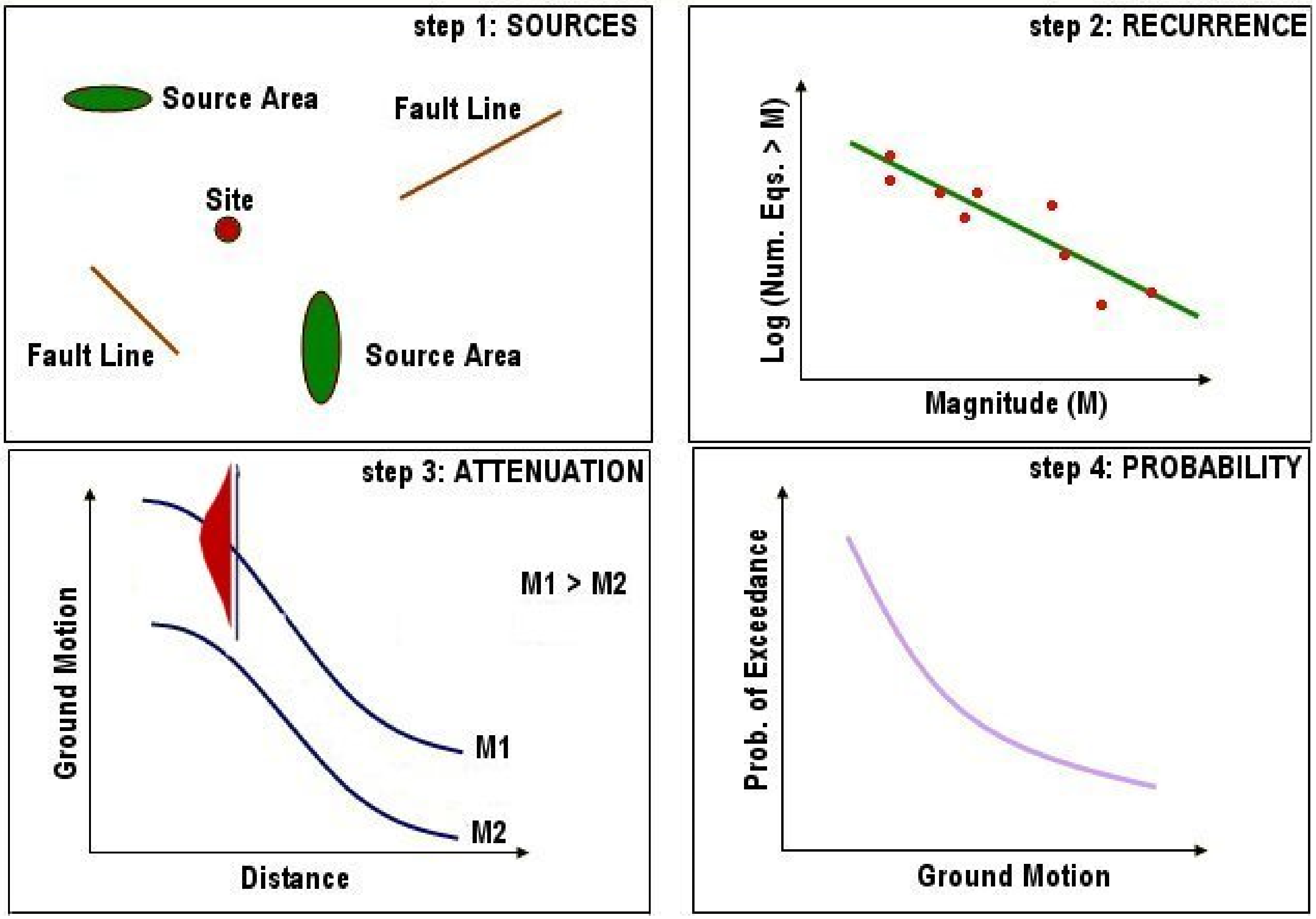
Seismic Hazard Analysis

- Probabilistic accounts for
  - ✓ all possible senarios that could affect the site and results in hazard represented by ground motions parameters at reference ground conditions, such as peak ground acceleration and spectral accelerations.

- Deterministic SHA involves
  - ✓ the determination of the scenario earthquake,
  - ✓ identification of proper attenuation relationships and
  - ✓ appropriate site response quantification.

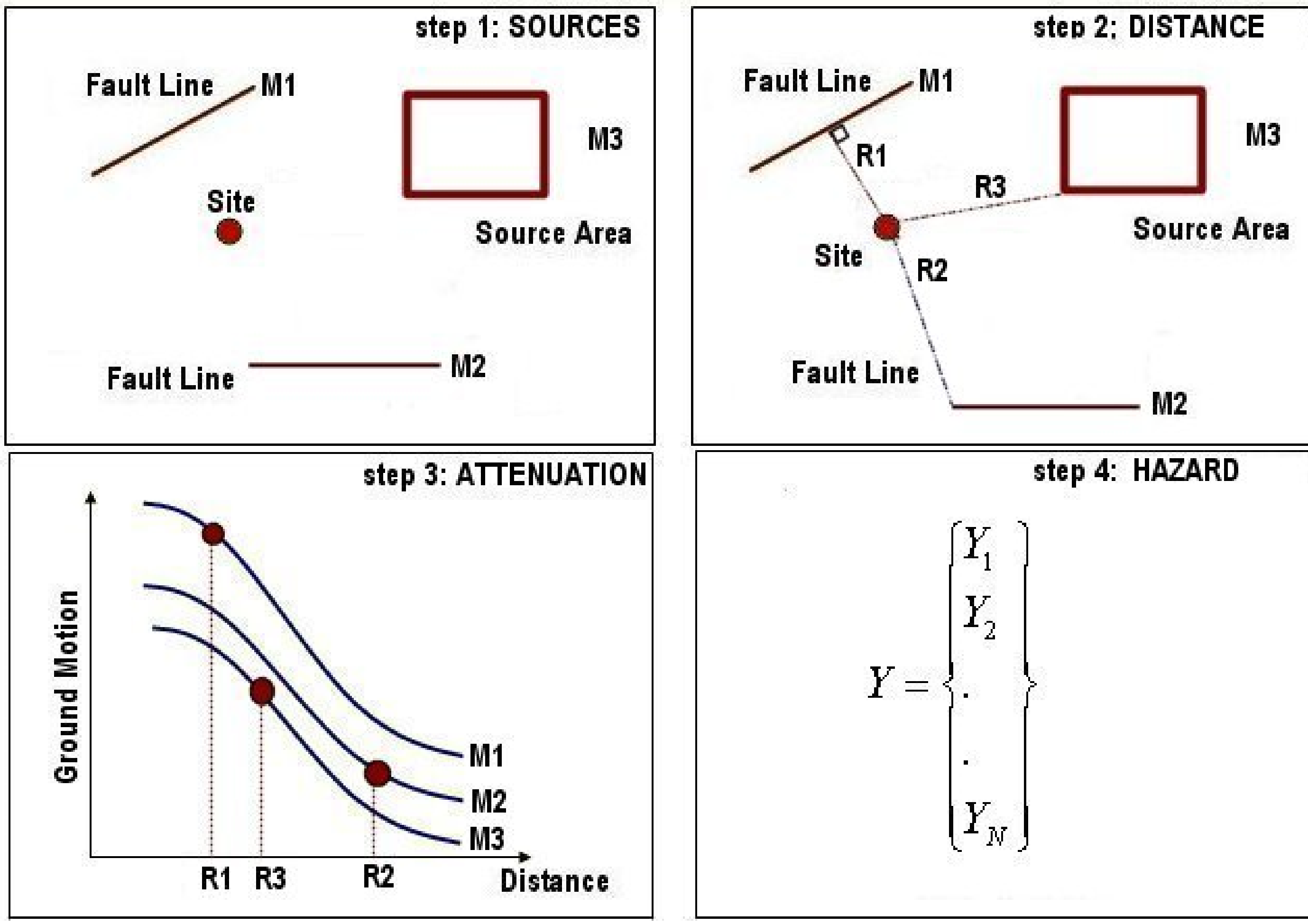
Basic steps in probabilistic seismic hazard analysis

(1) Definiton of the seismic sources (2) earthquake recurrence characteristics for each source, (3) GMPEs with magnitude and distance, and (4) ground motions for specified probability of exceedance levels (calculated by summing probabilities ovel all the sources, magnitude and distances)



Basic steps in deterministic seismic hazard analysis

(1) Definiton of the seismic sources (2) selection of a source to site distance parameter for each source zone, (3) Selection of the controlling earthquake (GMPEs with magnitude and distance), and (4) Definition of the hazard at site in terms of the ground motions produced at the site by the controlling earthquake.



Olasılıksal yaklaşımla deprem tehlikesini verilen bir konumda belirli bir yer hareketi parametresinin (*Y)* verilen bir "*y*" düzeyini aşmasının yıllık frekansı γ olarak tanımlayabiliriz. Yıllık aşılma frekansının tersi "*y*" düzeyi için ortalama dönüş periyodudur.

$$\lambda[Y > y] = \sum_{k=1}^{N_S} \nu_k \left\{ \int_{m_{\min}}^{m_{\max}} \int_{r_{\min}}^{r_{\max}} \int_{\varepsilon_{\min}}^{\varepsilon_{\max}} f_M(m) \times f_R(r|m) \times f_E(\varepsilon) \times P[Y > y|m, r, \varepsilon] \times dm \times dr \times d\varepsilon \right\}_k$$

f_M (*m*) k kaynağındaki deprem büyüklüğü olasılık yoğunluk fonksiyonu

Probability Density function for k source model

f_R(r/m) k kaynağındaki verilen bir deprem büyüklüğü için mesafenin olasılık yoğunluk fonksiyonu

Probability Density Function that earthquake occur at a distance R from the site

f_E (ε) belirsizlik teriminin olasılık yoğunluk fonksiyonu

PDF for uncertainity

$P[Y > y|m, r, \varepsilon]$ verilen bir deprem büyüklüğü, mesafe ve belirsizlik terimi için belirli bir yer hareketi parametresinin (*Y*) verilen bir "*y*" düzeyini

Probability of exceedence of acceleration, due to an earthquake of magnitude m, originated in a source at a distance r

Burada N_s toplam deprem kaynağı adedini. υ_k k kaynağında büyüklüğü mmin değerinin üzerinde olan depremlerin yıllık oluşum frekansını. r_{min}, r_{max} ve m_{min}, m_{max} : *R* mesafesinin ve *M* deprem büyüklüğünü sınırlandırmaktadır. Log-normal bir dağılımı olan *Y* yer hareketi parametresinin belirsizliğini niteleyen terim ε ile gösterilmiştir.

SOFTWARES FOR SEISMIC HAZARD ASSESSMENT

Name	References	statue	language
CRISIS	M. Ordaz	Free	Visual Basic
EQRM	Robinson	Open Source	Python
FRISK88M	R. McGuire	Private	Fortran
MoCaHAZ	S. Wiemer	Free	Matlab
MRS	R. Laforge	Free	C
NSHM	Frankel et al	Free	Fortran, C
OHAZ	B. Zabikovic	Free	Java
OpenSHA	E. Field	Open Source	Java
SeisRisk IIIM	Bender, Perkins R. LaForge	Free	Fortran
SeisHaz	M. Stirling	Private	Fortran

Application Problems

To determine;

- the maximum Crediable Earthquakes
- Earthquake recurrence period
- Distance Parameters (epicenter, hypocenter, etc)

- **Epistemic Uncertainity (logic tree application)**, and
- **Aleatory Uncertainity due to unpredictable nature of the physical process**

In order to reduce the epistemic uncertainty associated with the prediction of strong ground motion for given source properties, the current seismic hazard assessment practice in the world involves the use of a logic tree structure composed of a suitable number of GMPEs with weights

the aleatory uncertainty is considered by the incorporation of the standard deviation of the log-normally distributed ground motion attenuation relationships. This serves to increase the median hazard

MAGNITUDE FREQUENCY DISTRIBUTIONS

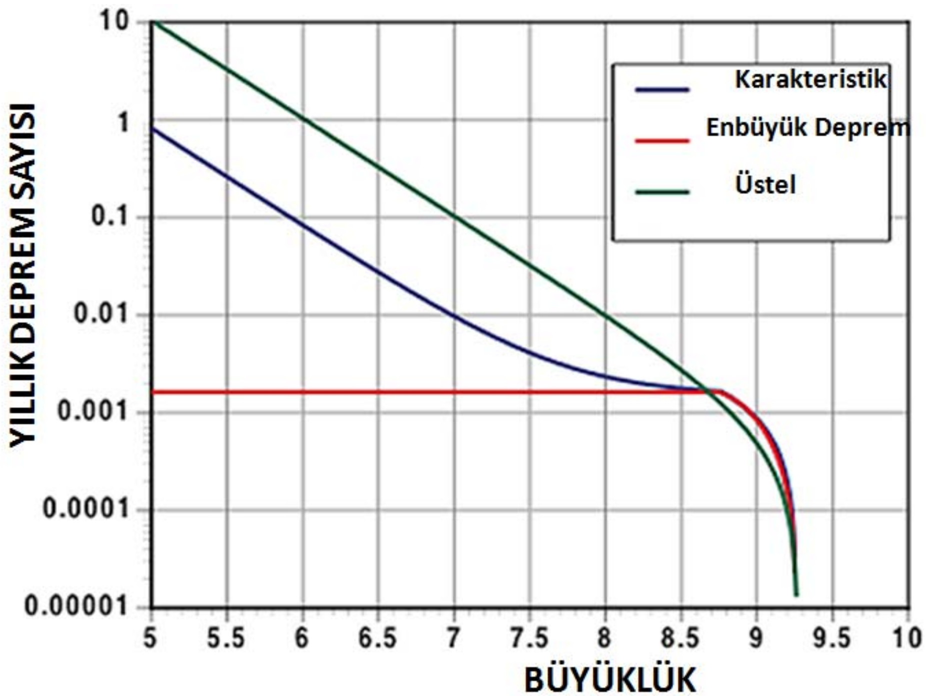
1. Characteristic

a. Assess magnitude of potential earthquakes (segmentation, floating)

b. Calculate recurrence of earthquake=
moment of char earthquake/moment rate of fault
= rigidity*area*displacement/rigidity*area*slip rate
rigidity modulus (resistance to shearing motion we use in U.S. is 3.0 X 10exp11 gm/cm*s*s(dynes/cm*cm)

2. Truncated Gutenberg-Richter distribution

- a. logN=a-bM



ESTIMATION OF THE SOURCE SEISMICITY PARAMETERS AND PROBABILISTIC MODEL

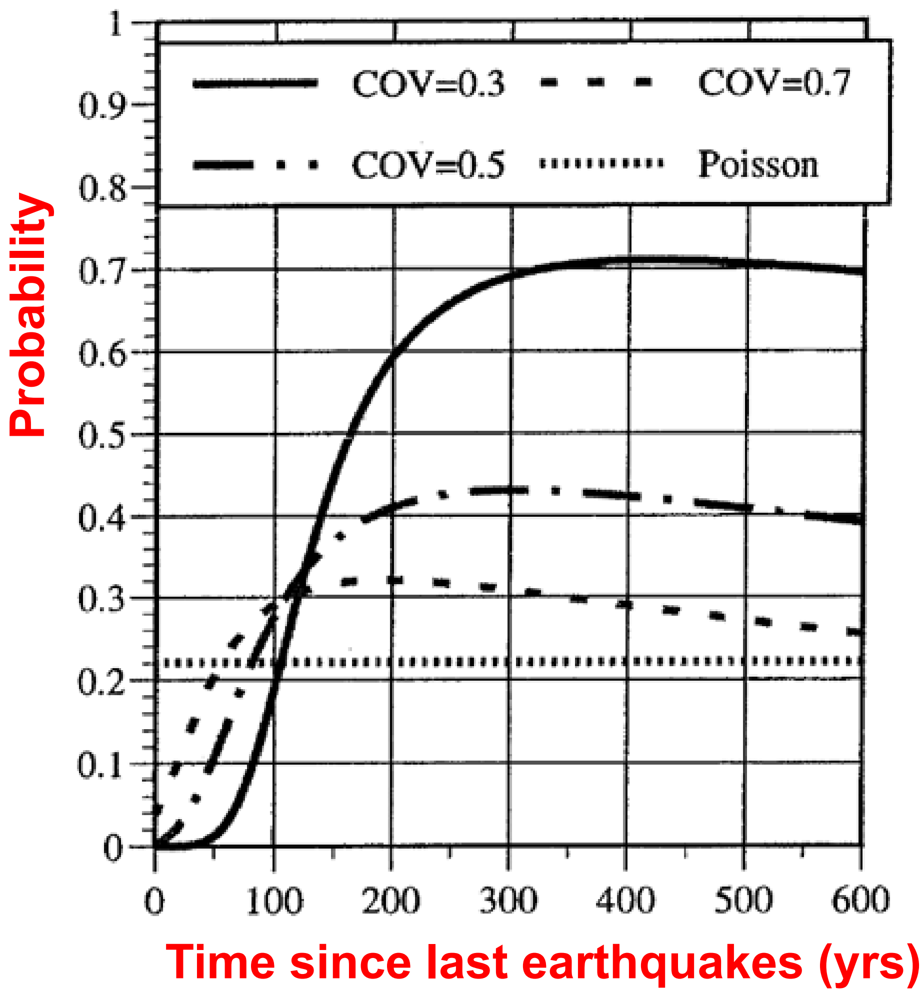
The earthquake recurrence model for the fault segments

- **Poisson Model**
  - ✓ characteristic earthquake recurrence is assumed,
  - ✓ probability of occurrence of the characteristic event does not change in time
  - ✓ The annual rate is calculated as:

    R=1/ mean recurrence interval

- **Time Dependent (Renewal model)**
  - ✓ the probability of occurrence of the characteristic event increase s as a function of the time elapsed since the last characteristic event,
  - ✓ A lognormal distribution with a coefficient of variation of 0.5 is assumed to represent the earthquake probability density distribution.
  - ✓ The annual rate is calculated as:

    Reff=-In(1-Pcond) / T



TIME DEPENDENT AND **TIME INDEPENDENT** MODELS

The figure shows that the probability remains constant for the Poisson model and that as the covariance becomes larger, the conditional probability approaches the Poisson probability

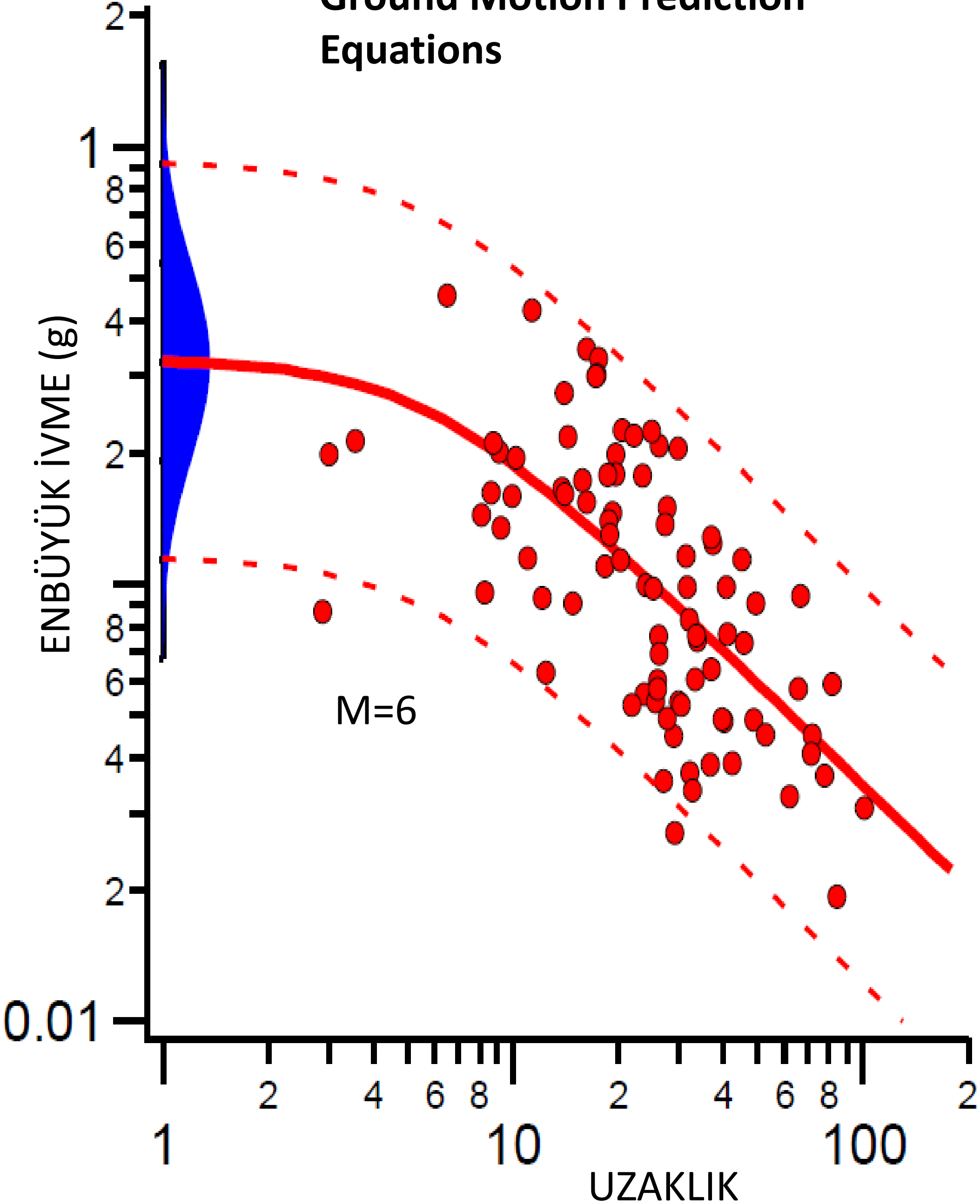
GROUND MOTION PREDICTION EQUATIONS (GMPE)

Ground motion prediction models (GMPEs) used in earthquake hazard assessments estimate ground motion parameters (in this case peak ground acceleration –PGA and spectral accelerations -SA) as a function of source parameters (magnitude and mechanism), propagation path (fault distance) and site effects (site class), and uncertainity

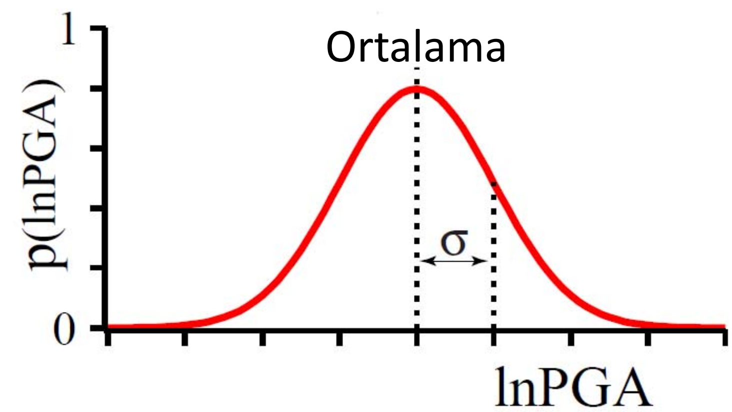
$$\ln SA(T) = f(M, R, \alpha) + \varepsilon\sigma$$

f(M,R,α) defines as the median value of spectral acceleration (μ), and σ is a total standart deviation.

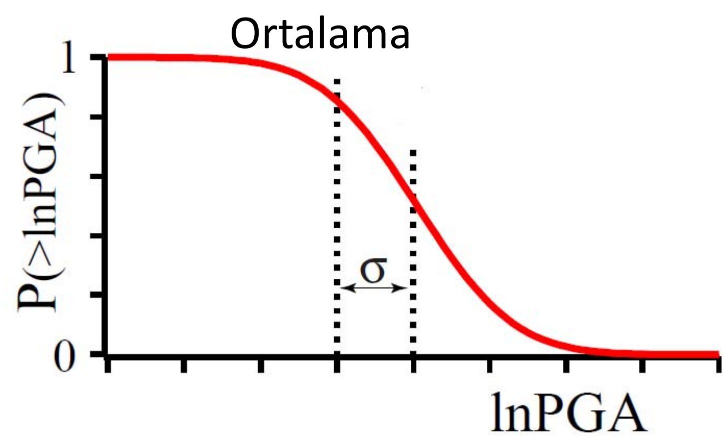
Ground Motion Prediction Equations



NORMAL Distribution



Cumulative Distribution

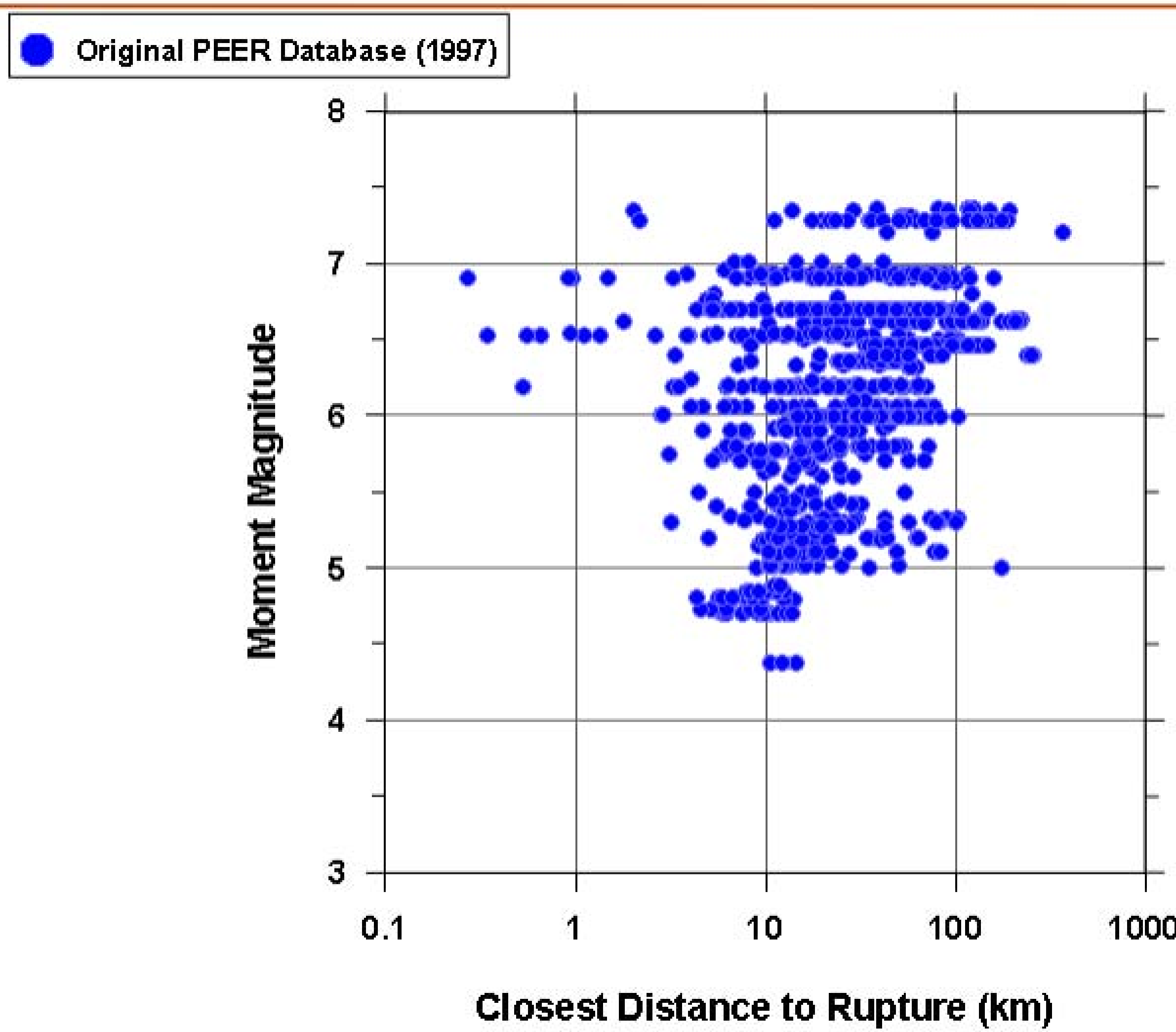


The current understanding on the GMPEs is that the differentiation in the models is related to the major geo-tectonic regimes (such as shallow crustal, extensional and subduction) rather than with country boundaries.

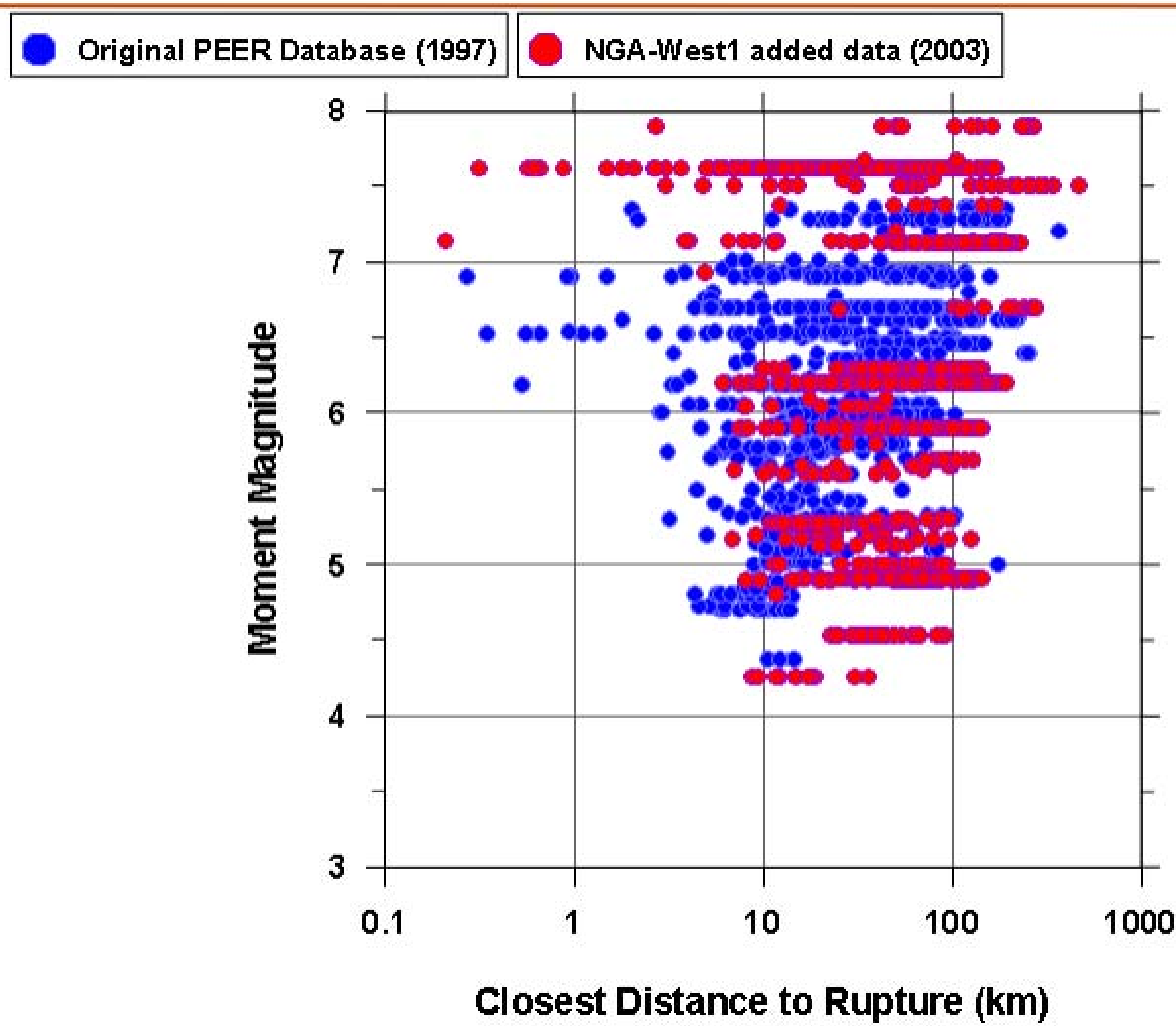
Ground Motion "Mega" Research Projects at PEER

- **NGA-West2**
  - Ground motion hazard in active tectonic regions
- **NGA-East**
  - Ground motion hazard in low seismicity regions
- **NGA-Sub**
  - Ground motion hazard in Subduction regions
- **GEM**
  - Global Earthquake Model

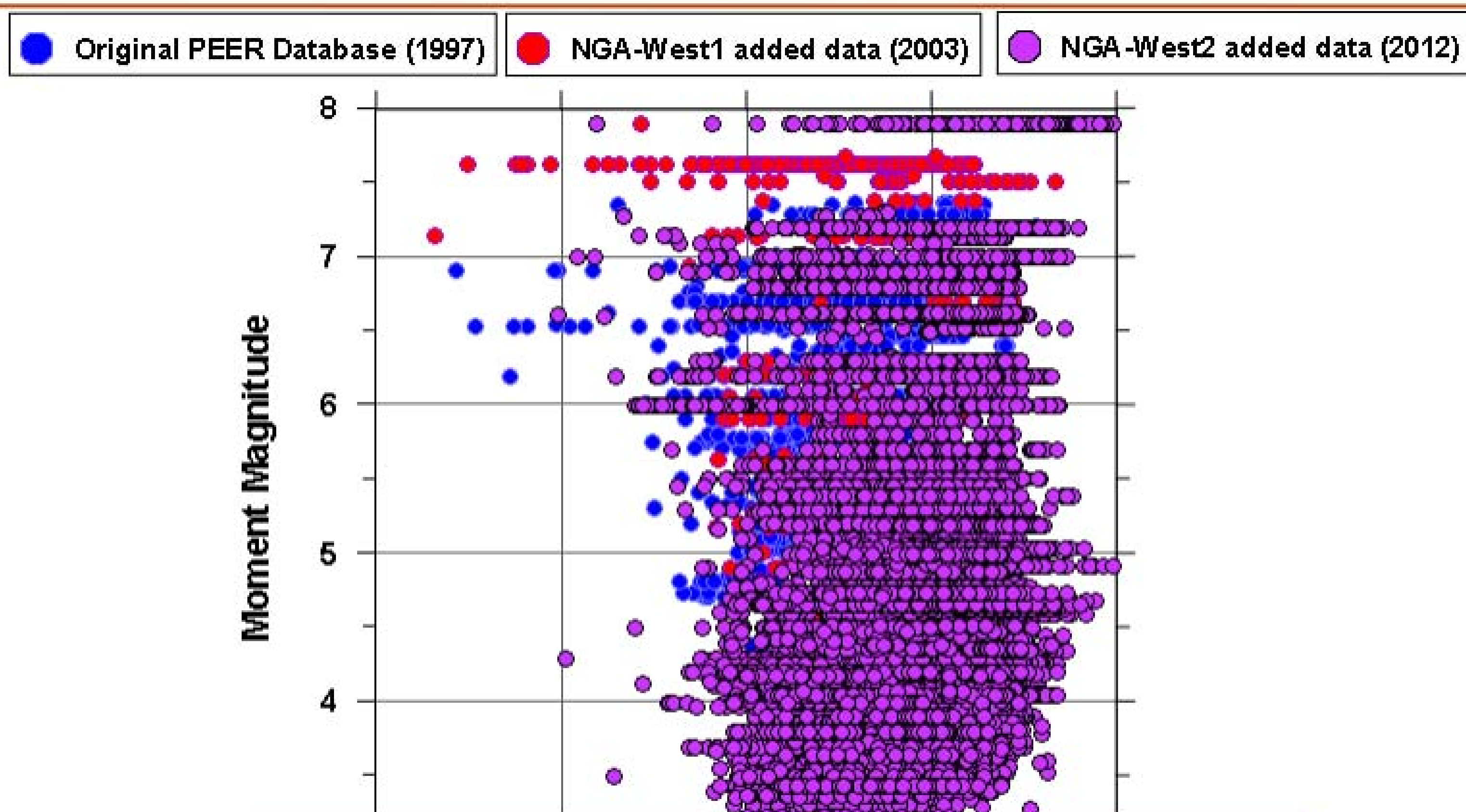
Update worldwide database



Update worldwide database

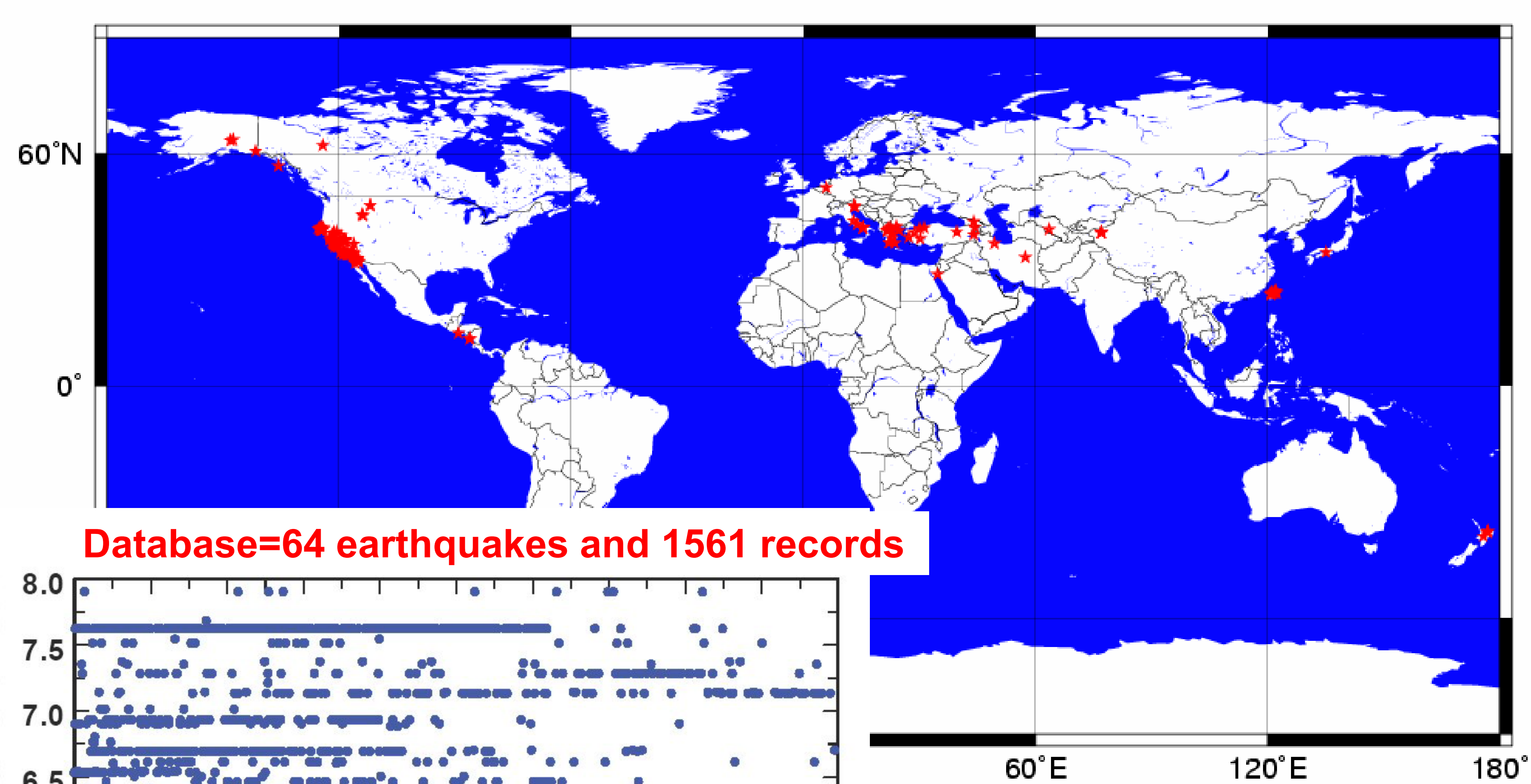


Update worldwide database

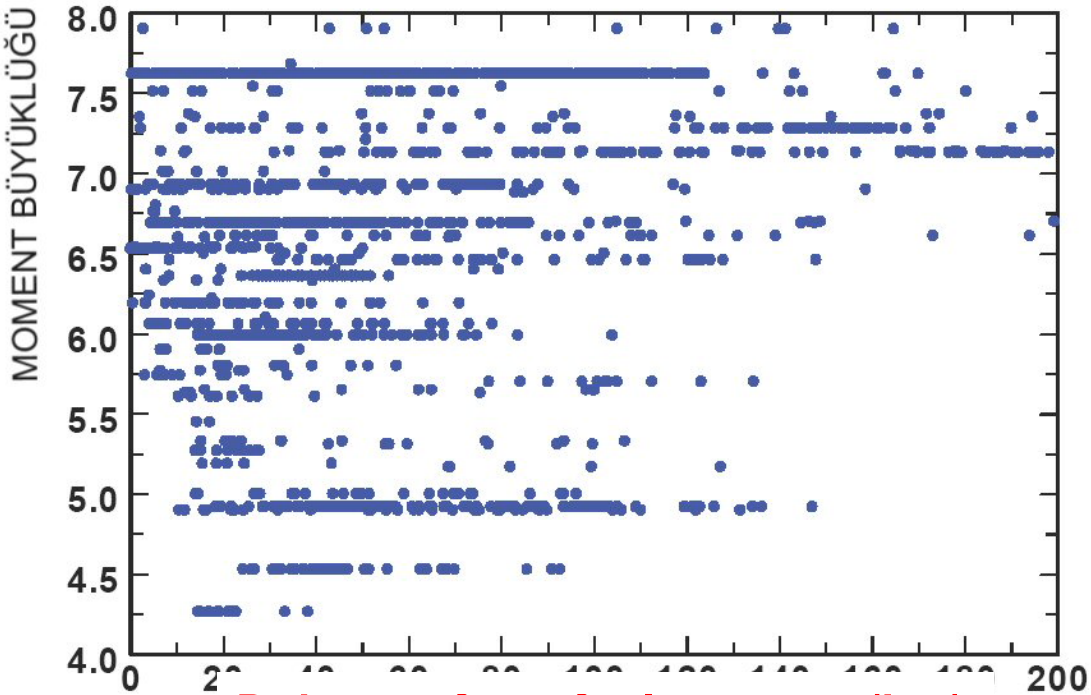


NGA-West2 database includes over 21,000 three-component recordings… over 63,000 records

From NGA-West1 to NGA-West2 the size of database was increased by a factor of 5.5



Database=64 earthquakes and 1561 records



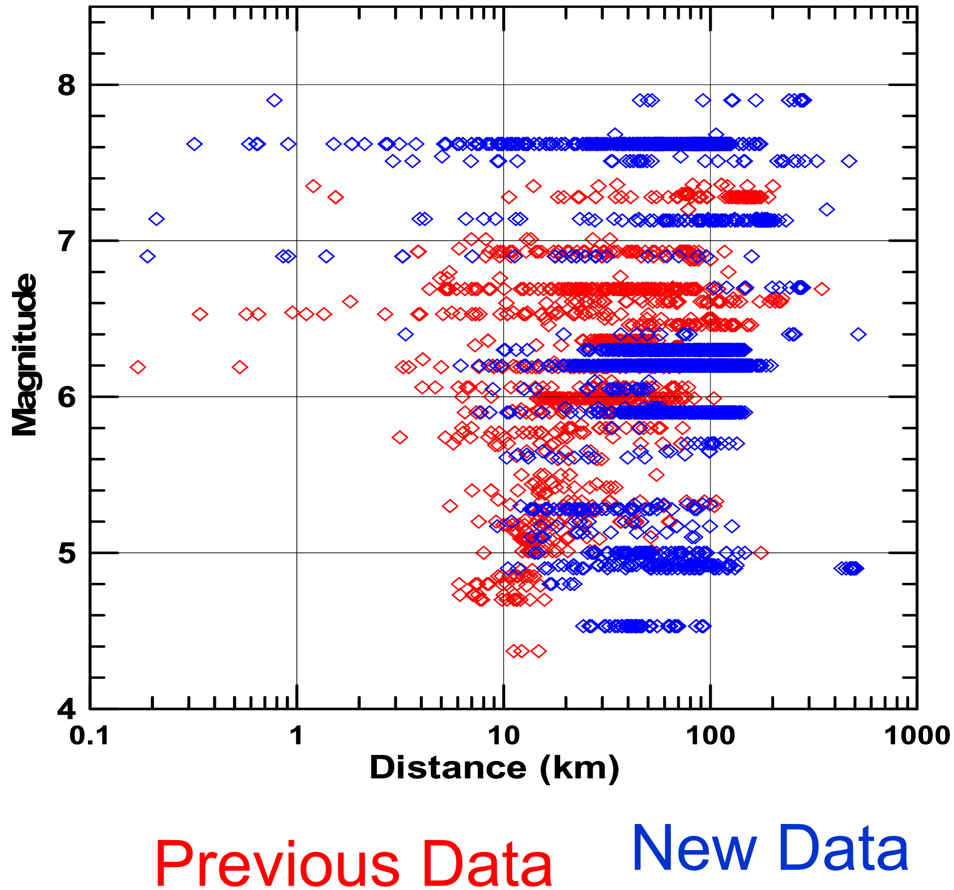
Dsitance from fault rupture (km)

NGA 2008

Ground Motion Prediction Equations

NGA (2008) Next Generation Ground Motion Prediction Equations

- More than 172 global earthquake records including Turkey
- 1,400 stations
- 3,500 record of strong ground motion
- 100 parameters for definition of source, attenuation path, and site condition
- PGA,PGV, PGD, 5% SA(T)
- 0-10s period range
- M5-M8.5
- 0-200km
- Earthquakes with Strike slip, reverse and normal focal mechanism



The Next Generation Attenuation (NGA) project has yielded in the year 2008 a set of ground motion prediction equations based on a comprehensive worldwide strong ground motion data set, Among the models developed in this project Abrahamson and Silva (2008), Boore and Atkinson (2008), Campbell and Bozorgnia (2008) and Chiou and Youngs (2008) can be cited.

Stafford et al. (2008) have indicated that the NGA models were perfectly applicable to ground-motion prediction in the Euro-Mediterranean region. Akkar and Bommer (2010) is a recently developed prediction model, based on Euro-Mediterranean and Middle East data, suitable to be used for the hazard assessment studies in the region

Based on the these considerations, there were also used in the SHARE (www.share-eu.org) and EMME EMME (www.emme-gem.org) projects,

Most of the active shallww earthquakes were occurred in Turkey .Thus, Ground Motion Prediction Equations for active shallow crustal region are recommended as follows: (NGA GMPE, 2008-2014) and Akkar and Bommer (2010) GMPEs

GROUND MOTION PREDICTION EQUATIONS STRUCTURES used İn SHARE and EMME projects

GMPES CHARACTERIZATIONS

- **ACTIVE SHALLOW CRUSTAL**
- **SUBDUCTION INTERFACE AND INSLAB**

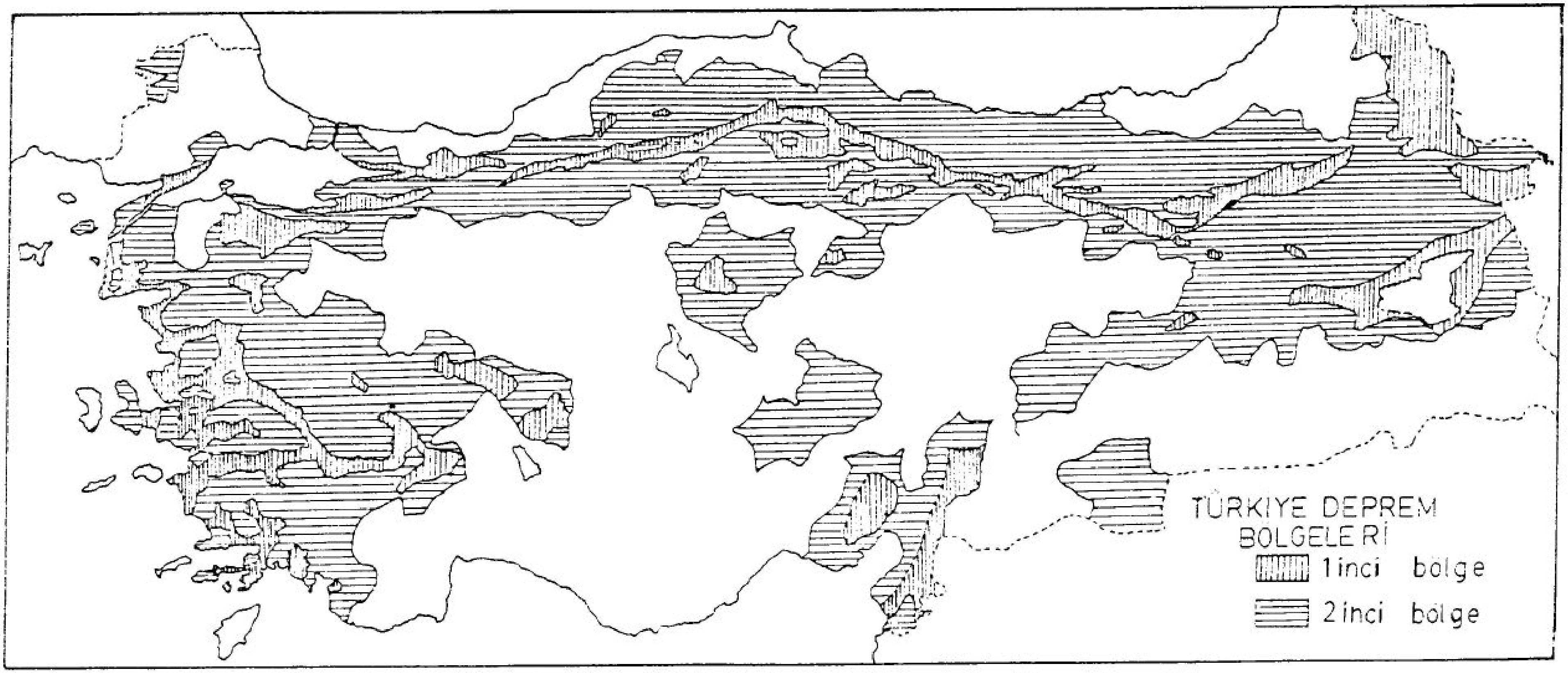
Akkar vd. (2014)
Akkar ve Çağnan (2014)
Chiou ve Youngs (2008)
Zhao vd. (2006)

Zhao vd. (2006)
Lin ve Lee (2008)
Atkinson ve Boore (2003)
Youngs vd. (1997)

SOME STUDIES FOR SEISMIC HAZARD ASSESSMENT for TURKEY

- **ARTICLES**
  - **Pamir , 1948**
  - **Ipek vd, 1965**
  - **Tabban, 1969**
  - **Ergin ve Güçlü, 1971**
  - **Yarar vd.,1980**
  - **Ketin, 1982**
  - **Erdik vd., 1985**
  - **Eyidoğan ve Güçlü, 1993**
  - **Gülkan vd., 1993**
  - **..........**
- **PROJECTS**
  - **GSHAP,1999**
  - **TEFER,2000**
  - **SESAME,2003**
  - **DLH,2008**
  - **SHARE, (2009-2012)**
  - **EMME (2008-2014)**
  - **GEM (2009-2013)**
  - **Revision of Turkish Seismic Hazard Map -Türkiye Sismik Tehlike Haritasının Güncellenmesi Projesi (2014-2015)**

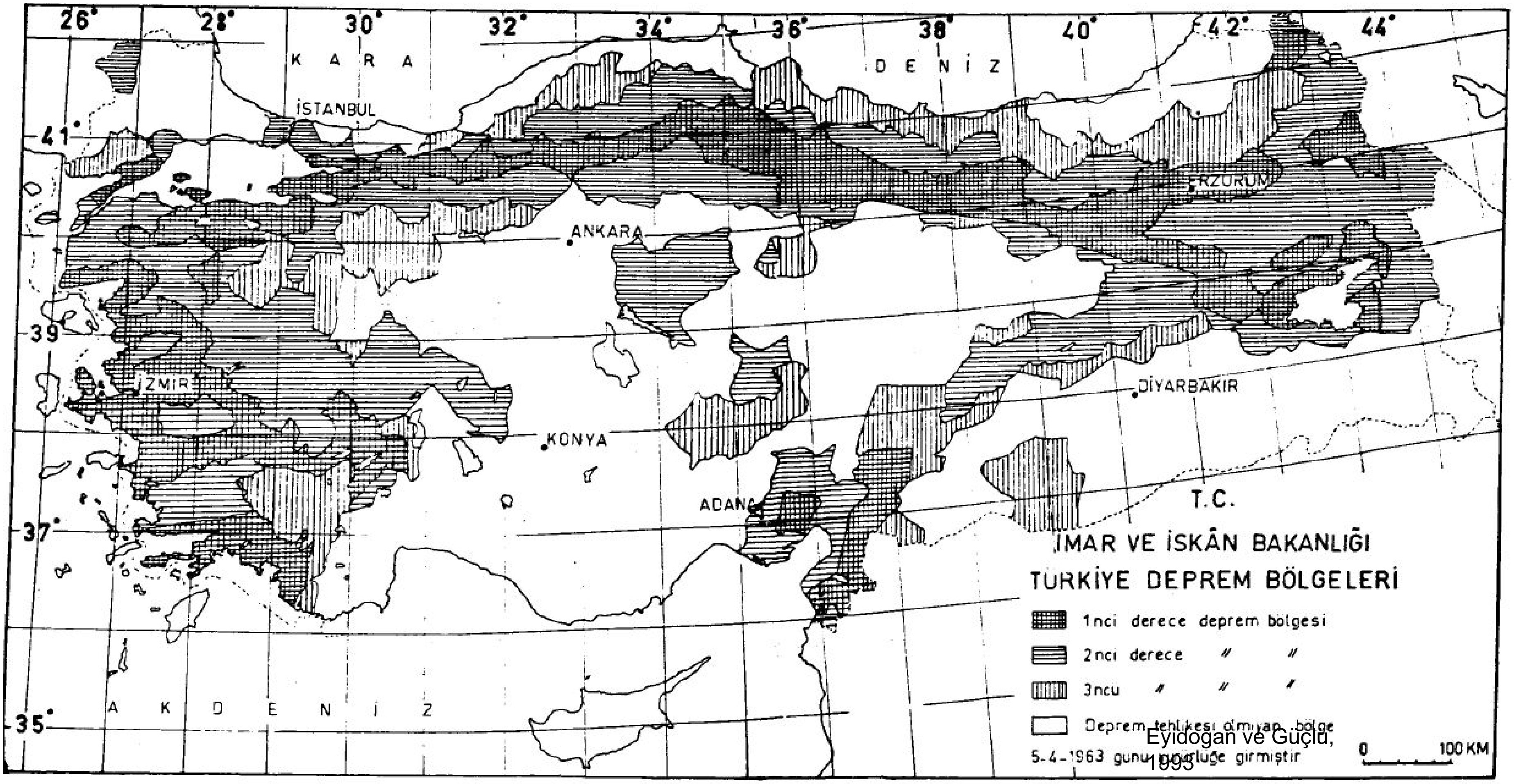
1948 Seismic Zoning Map of Turkey



Eyidoğan ve Güçlü, 1993

- First in- official seismic zoning map of Turkey (Pamir, 1948)
- Three regions (First degree zone, Second Degree zone, and Safe Zone)

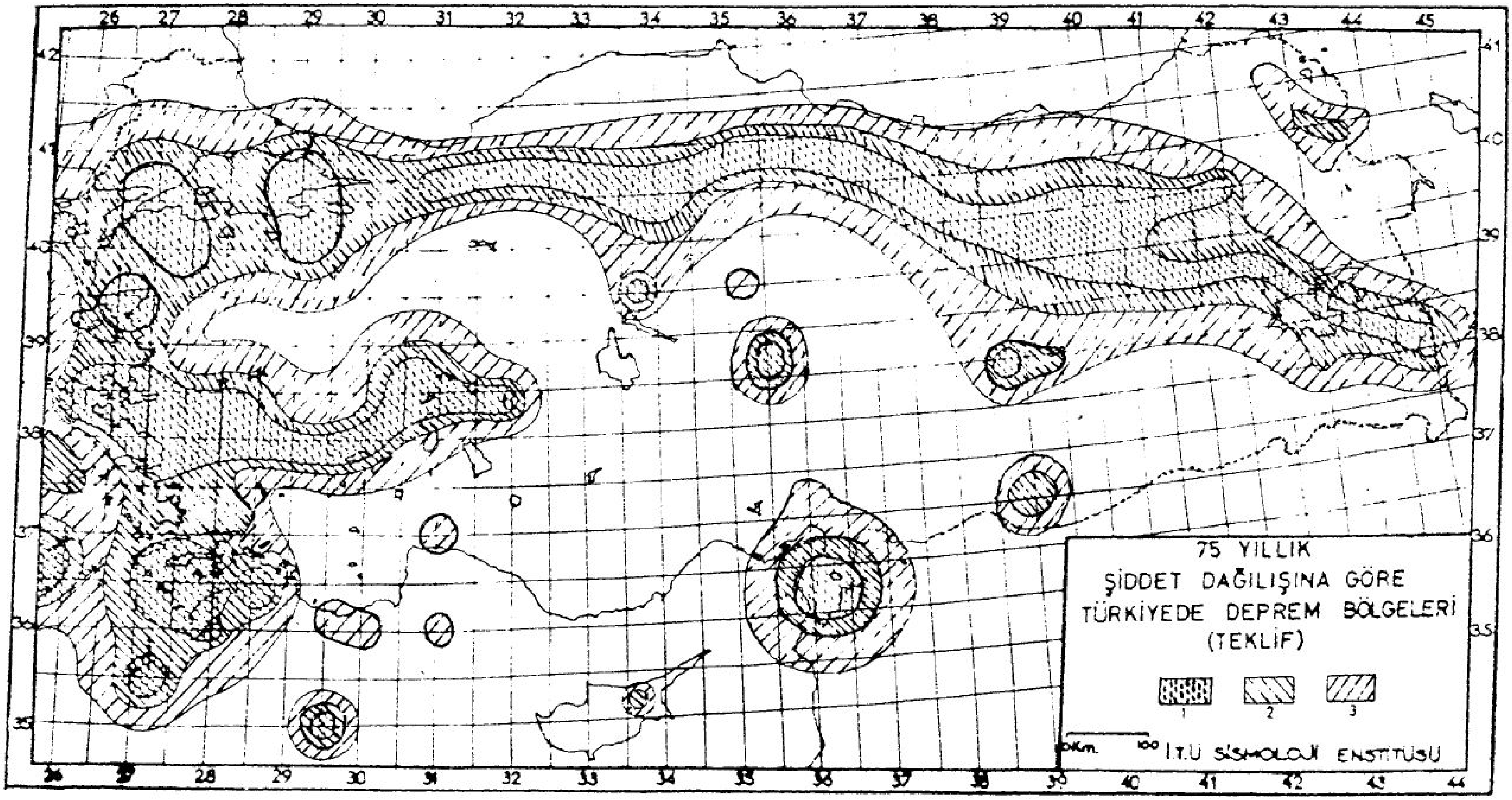
1963 Seismic Zoning Map of Turkey



Eyidoğan ve Güçlü, 1993

- First official seismic zoning map of Turkey
- 4 regions (First zone, Second Zone, Third Zone and No hazard Zone)

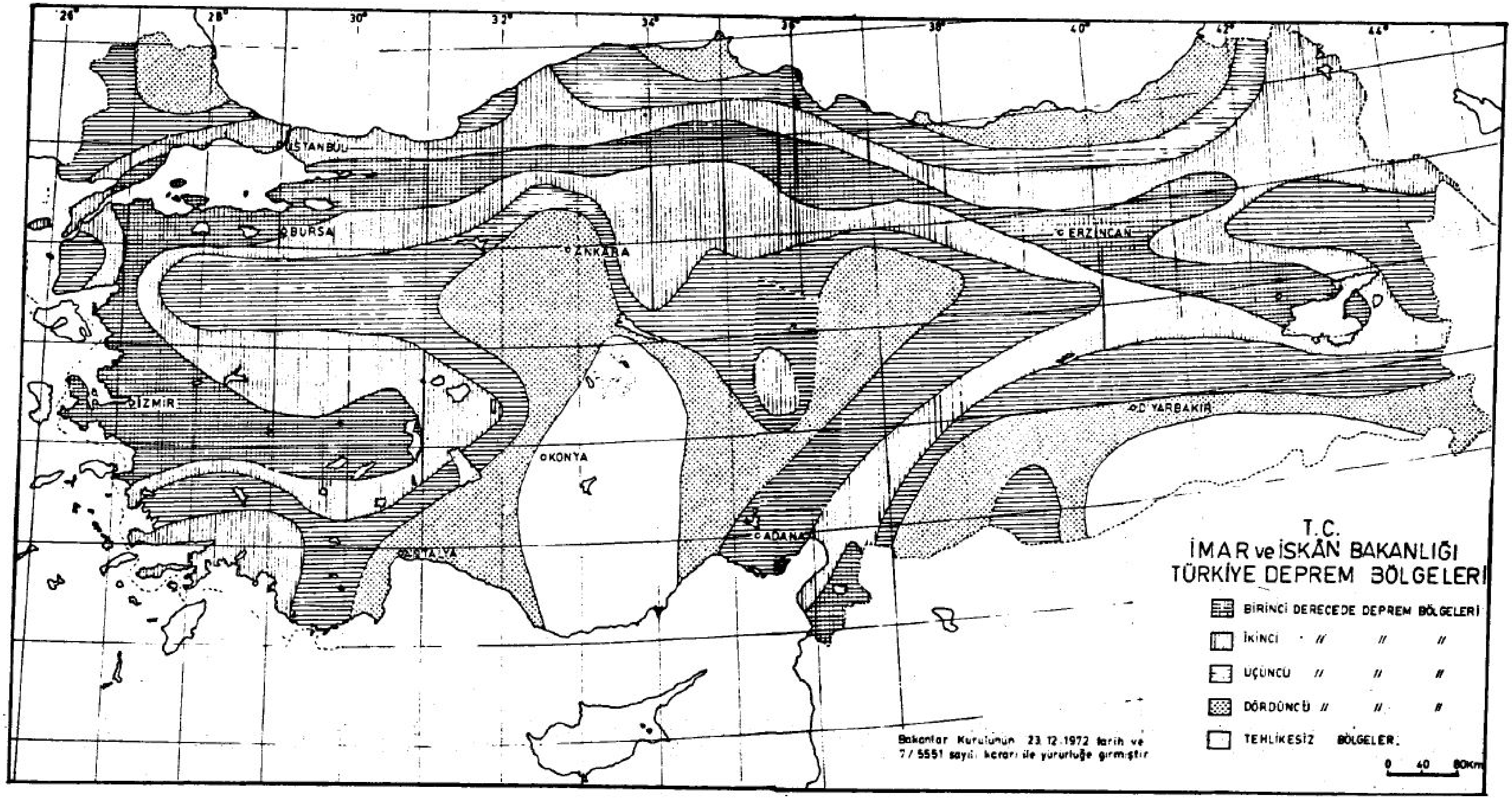
1965 Seismic Zoning Map of Turkey



Eyidoğan ve Güçlü, 1993

- **$I = I_0 + 3.58 - 3.33\log_{10}R$ Macrosismic attenuation relationships were used.**

1972 Seismic Zoning Map of Turkey



Eyidoğan ve Güçlü, 1993

- **Figure shows that the delineation in the five zones of earthquake hazard. In the 1st degree hazard zone the maximum intensity (MSK) is higher than or equal to IX, in the 2nd equal to VIII, in the 3rd equal to VII, in the 4th equal to VI, and in the 5th no hazard zone equal to V.**

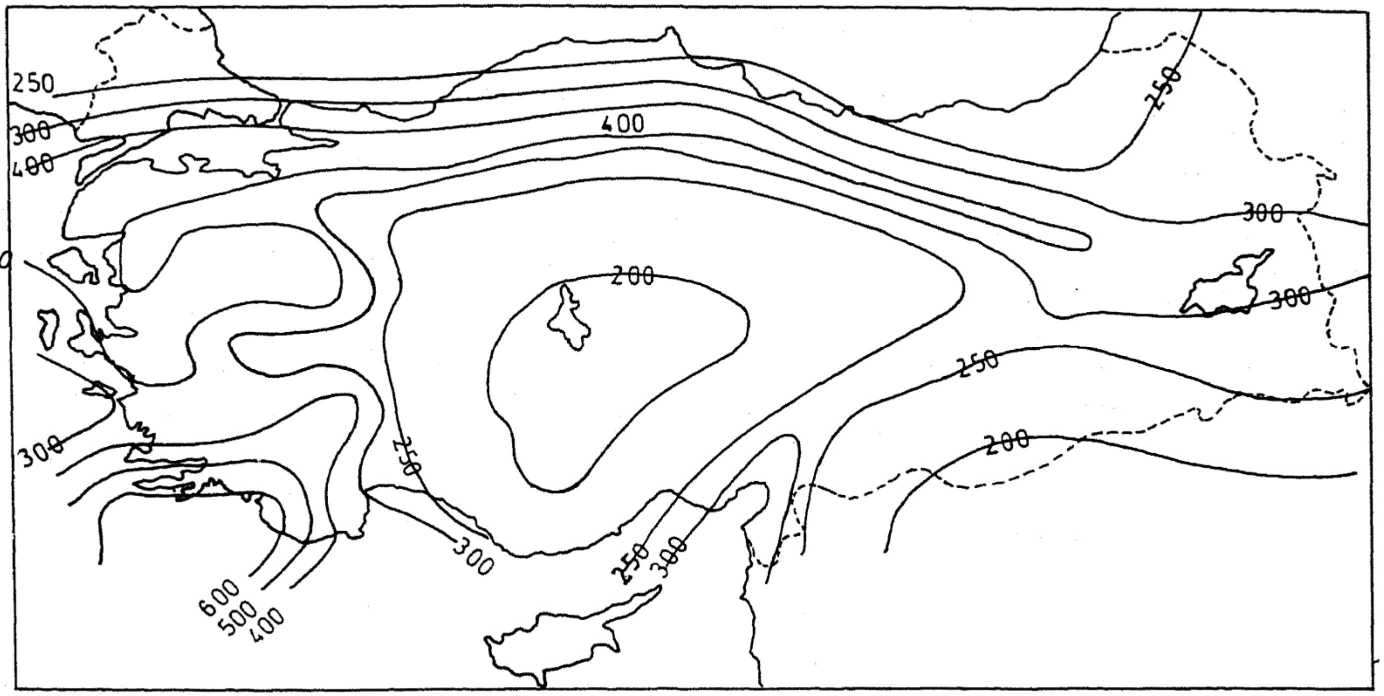
35 years before (just after the 5 years from USA) ; Prof. Mustafa Erdik and Prof Rifat Yarar have published the first article

A Preliminary Probabilistic Assessment of the Seismic Hazard in Turkey. ***Proc. 7th World Conf. Earthquake Eng., Istanbul, pp. 309 316, 12 Eylül 1980***

McGuire, R.K. (1976), FORTRAN Computer Program for Seismic Risk Analysis, USGS Open File Report, No. 76-67.

McGuire, R.K. (1978), "Seismic Ground Motion Parameter Relations", Proc. ASCE, GT4, p. 481, 490.

S. T. Algermissen and D. M. Perkins, A Probabilistic Estimate of Maximum Acceleration in Rock in the Contiguous United States, U.S. Geol. Surv. Open-File Rep. 76–416, 1976

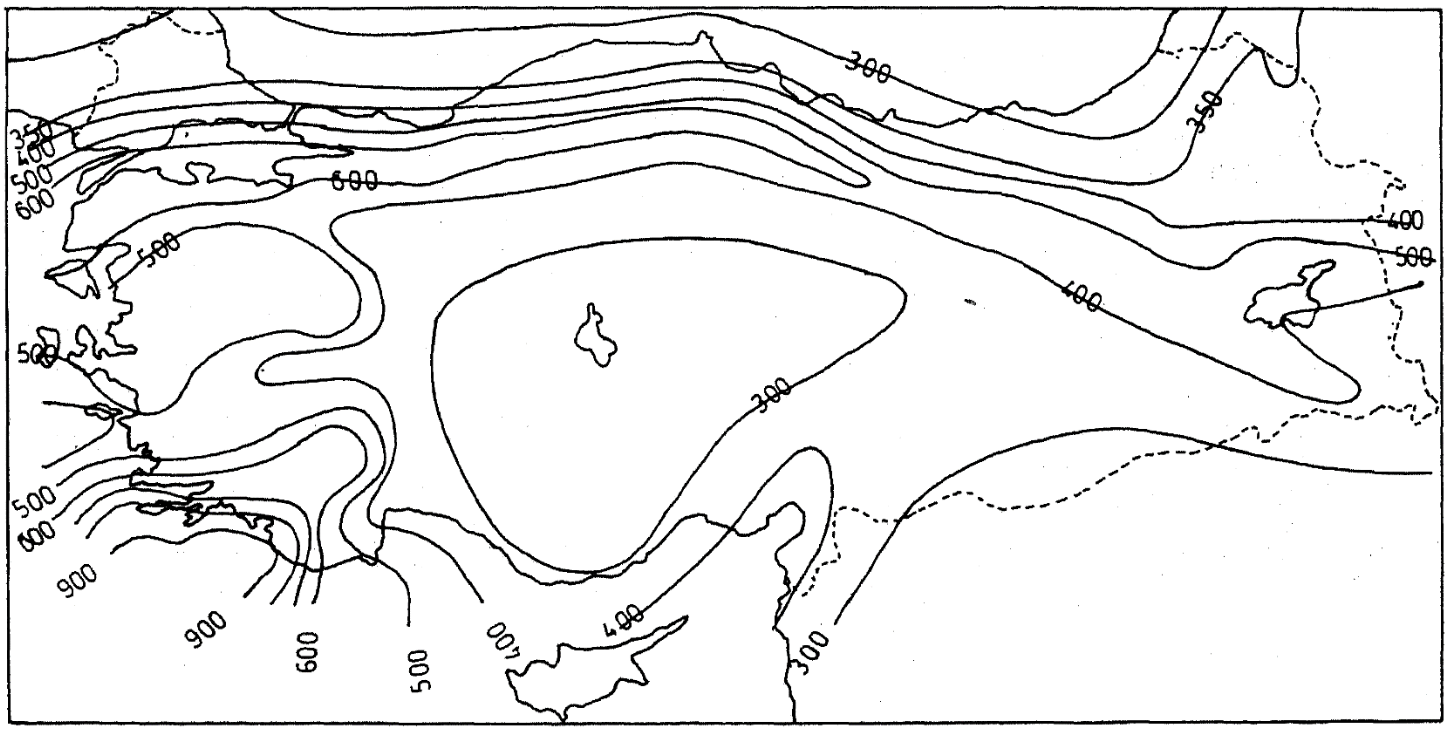


The return period of 200 yrs for PGA (cm/sn2)

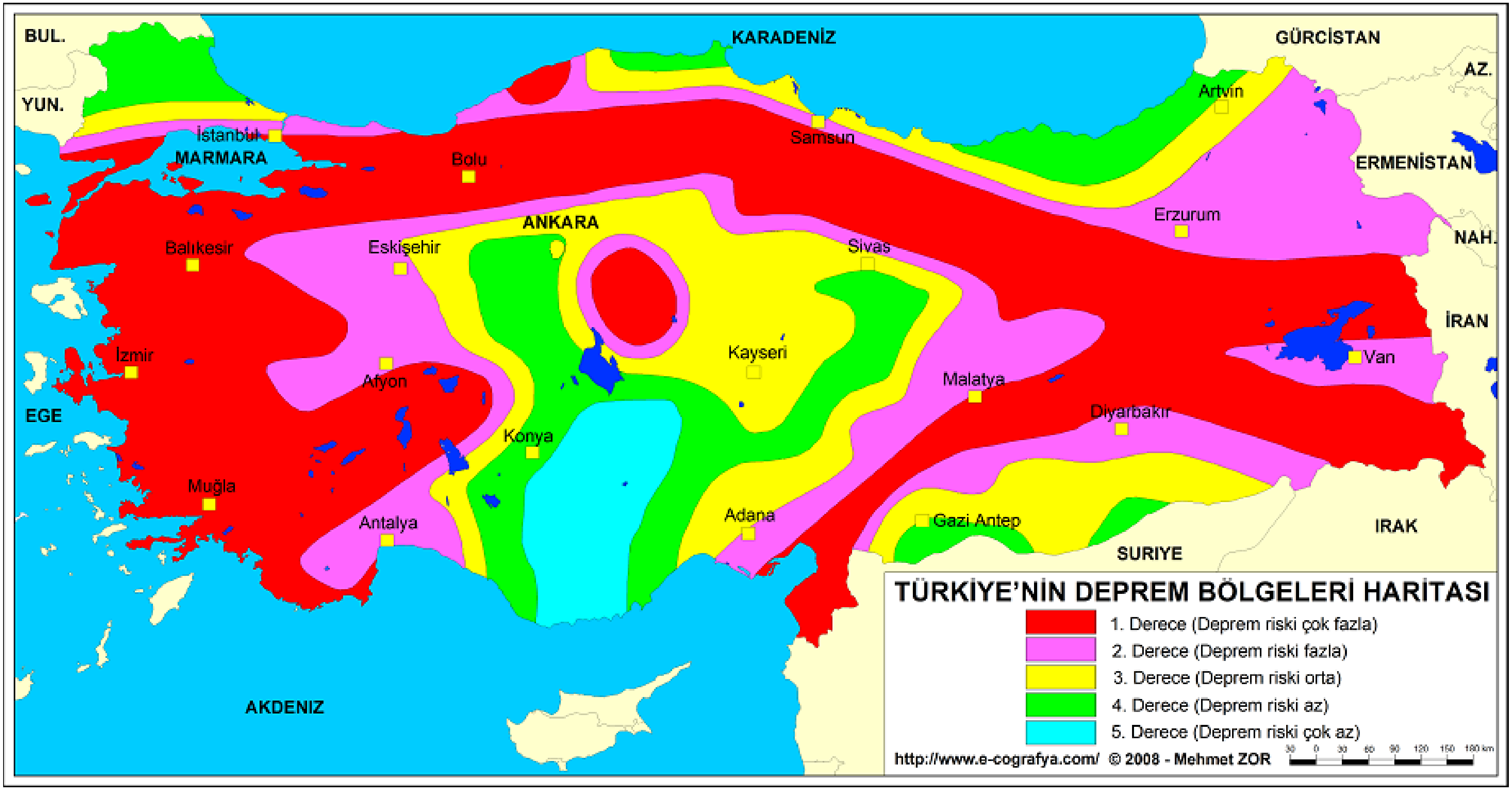
200 YIL YİNELENME SÜRESİ ENBÜYÜK İVME cm/sn2

The return period of 500 yrs for PGA (cm/sn2)

500 YIL YİNELENME SÜRESİ ENBÜYÜK İVME cm/sn2

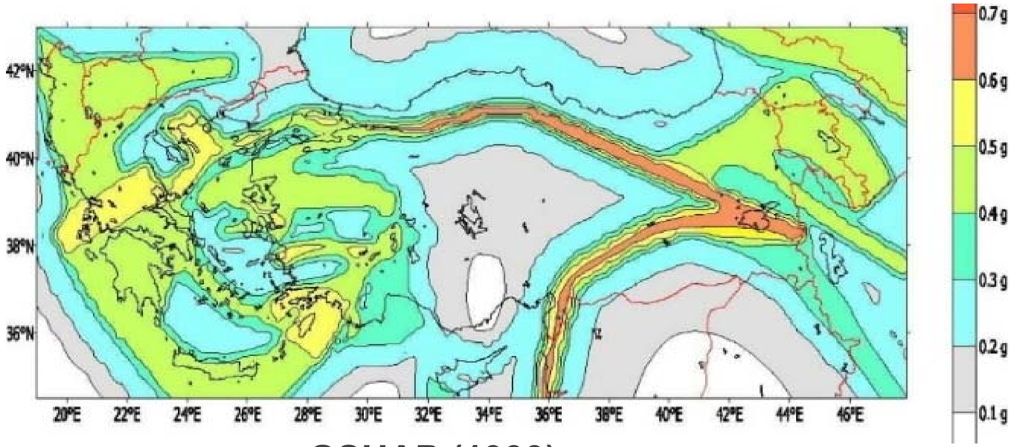


1996 Seismic Zoning Map of Turkey

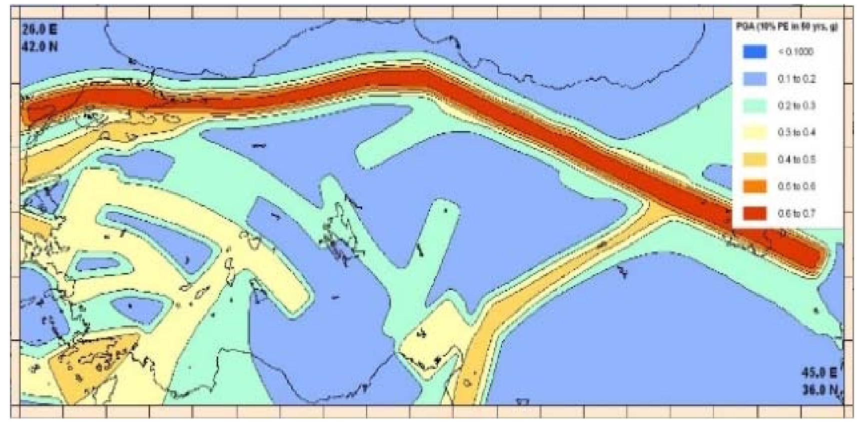


- Based on the PSH for PGA distribution for return period of 475 yrs.
- 5 regions

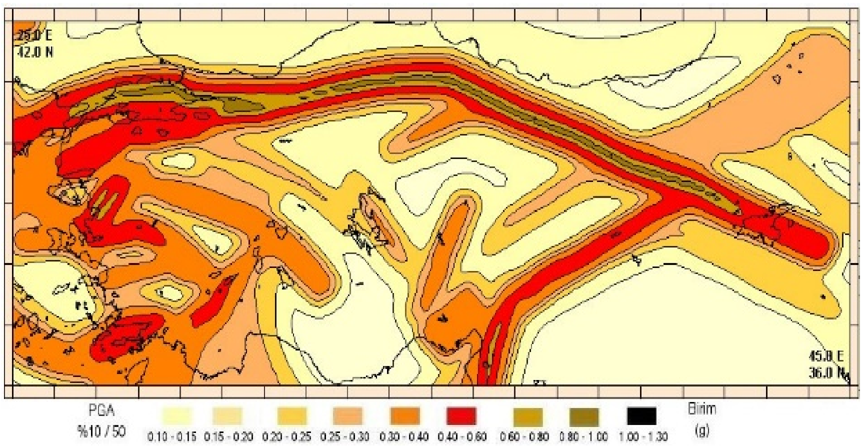
After 1996, PGA Distribution Maps



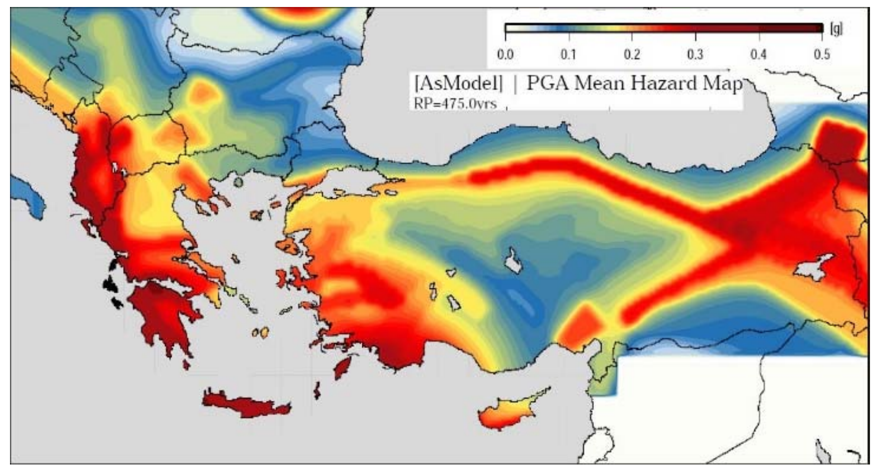
GSHAP (1999)



TEFER (2000)



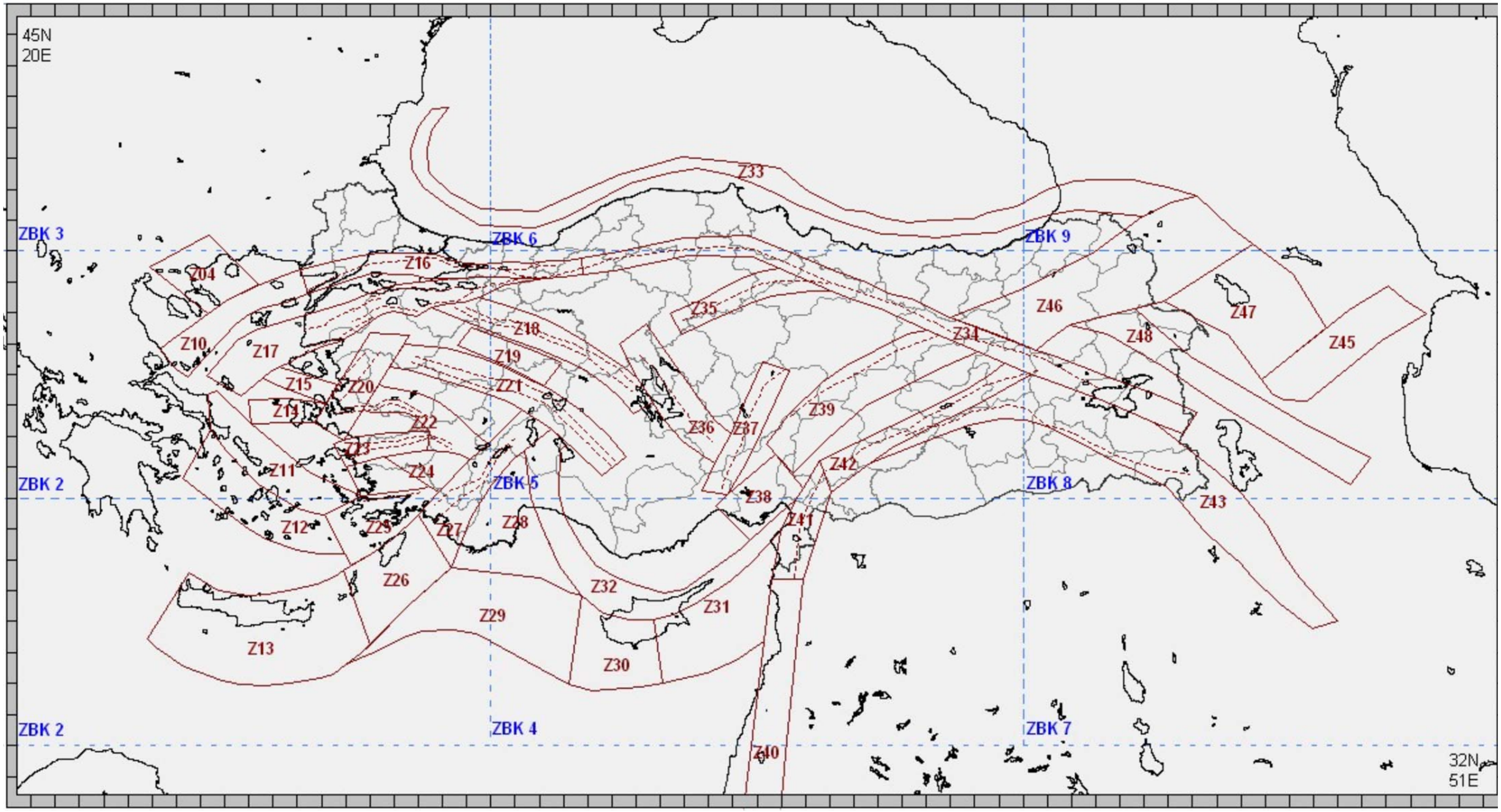
DLH (2008)



SHARE (2013)

- **After 1996, Seismic hazard assessment for Turkey were provided using the reevaluated earthquake catalog, seismic source model and GMPEs**

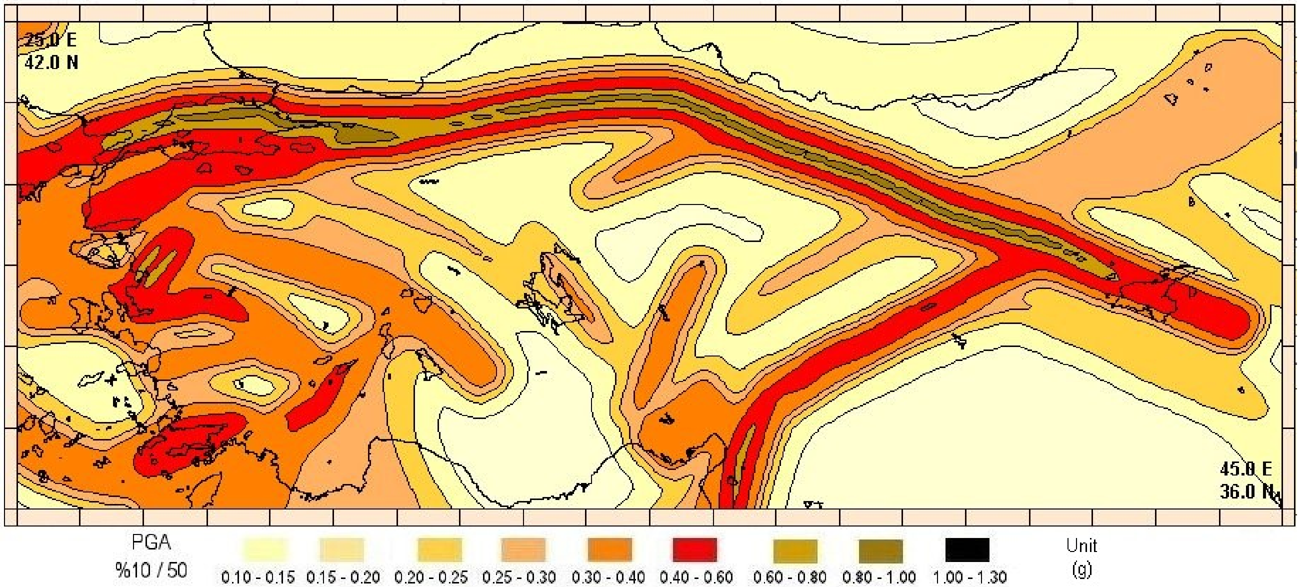
The seismic source zonation model of Turkey developed within the context of a project conducted for the Ministry of Transportation Turkey, aiming the preparation of an earthquake resistant design code for the construction of railways, seaport and airport.



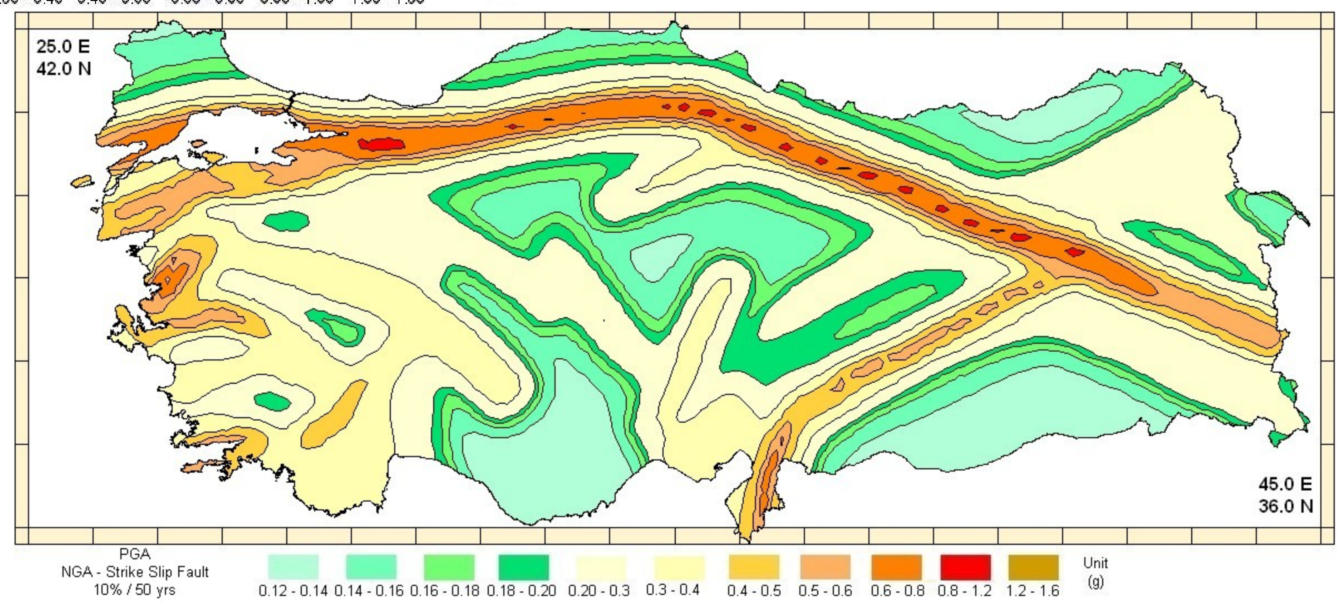
SEISMIC SOURCE MODEL USED IN DLH 2008

DLH 2008 SEISMIC HAZARD MAPS

%10 PROBABILITY OF EXCEEDENCE IN 50 YRS



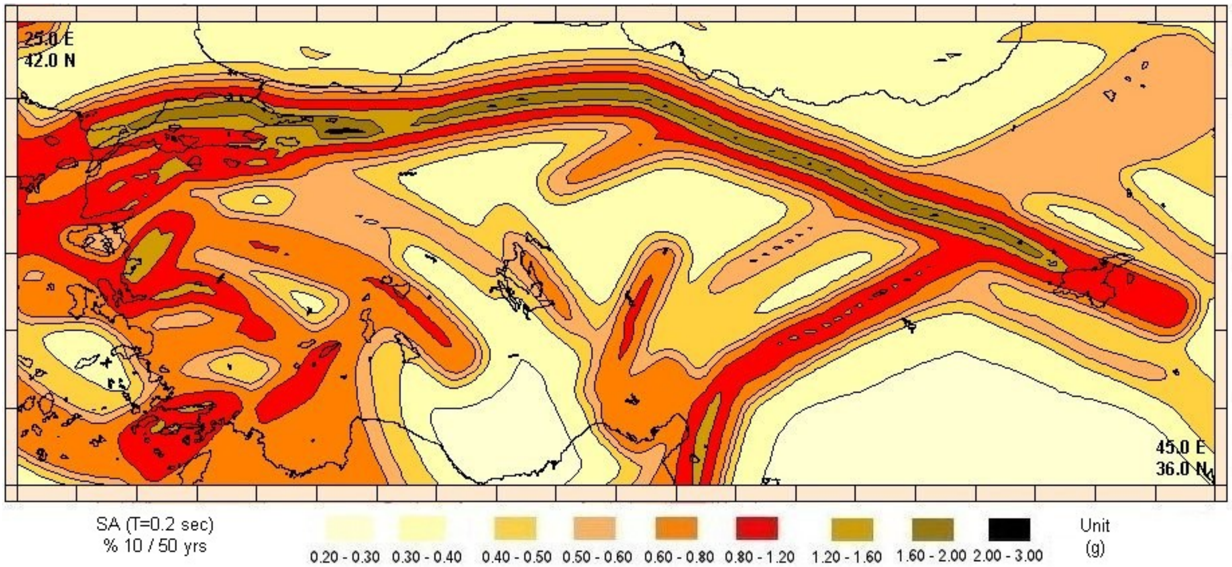
PGA Distribution using the pre NGA (1997) GMPEs



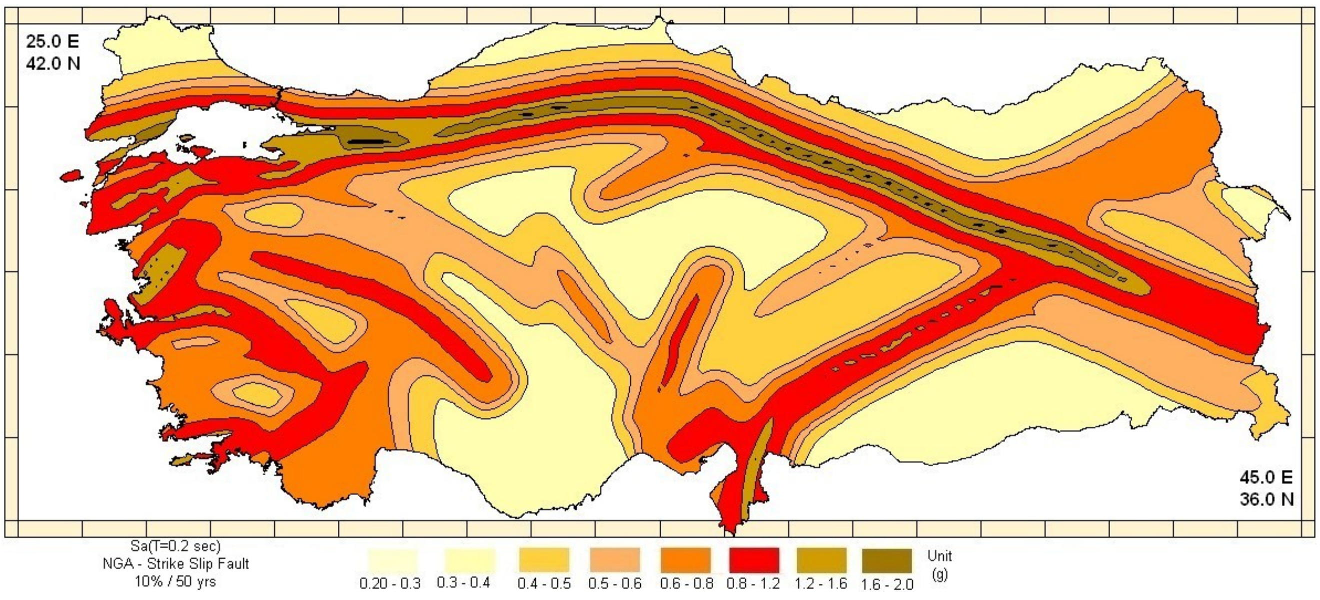
PGA Distribution Using the NGA GMPEs

DLH 2008 SEISMIC HAZARD MAPS

%10 PROBABILITY OF EXCEEDENCE IN 50 YRS



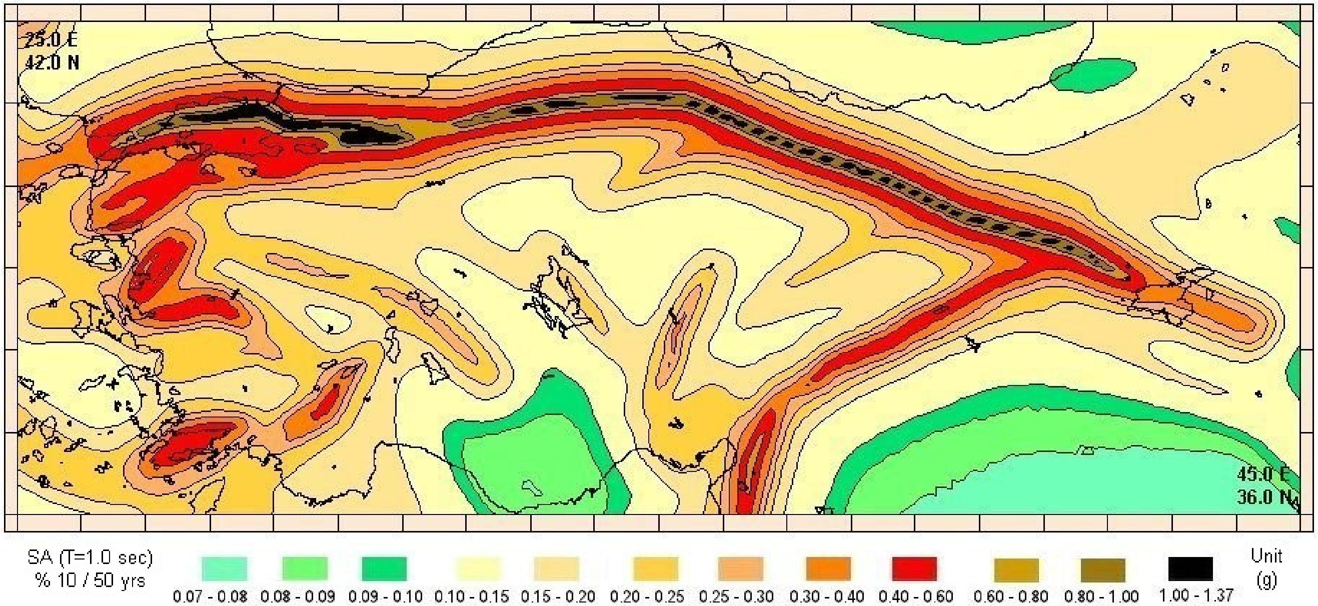
Sa (T=0.2s),Distribution using the pre NGA (1997) GMPEs



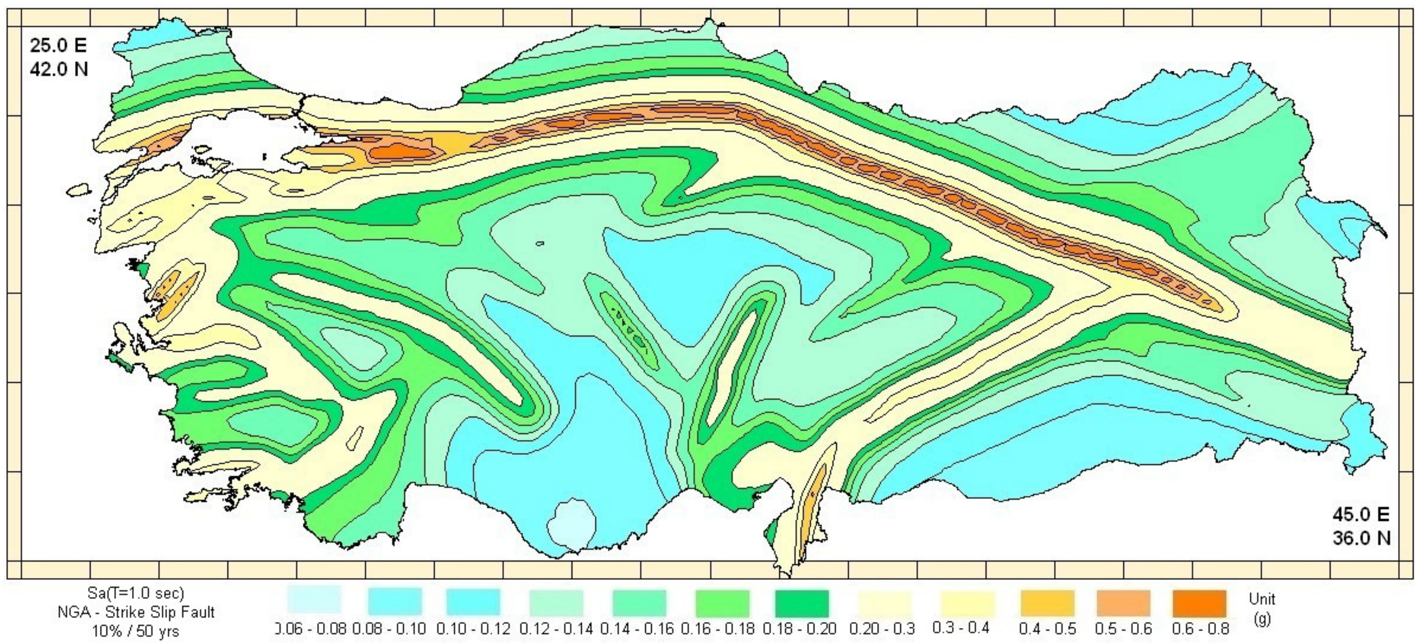
Sa (T=0.2s),Distribution using the NGA GMPEs

DLH 2008 SEISMIC HAZARD MAPS

%10 PROBABILITY OF EXCEEDENCE IN 50 YRS



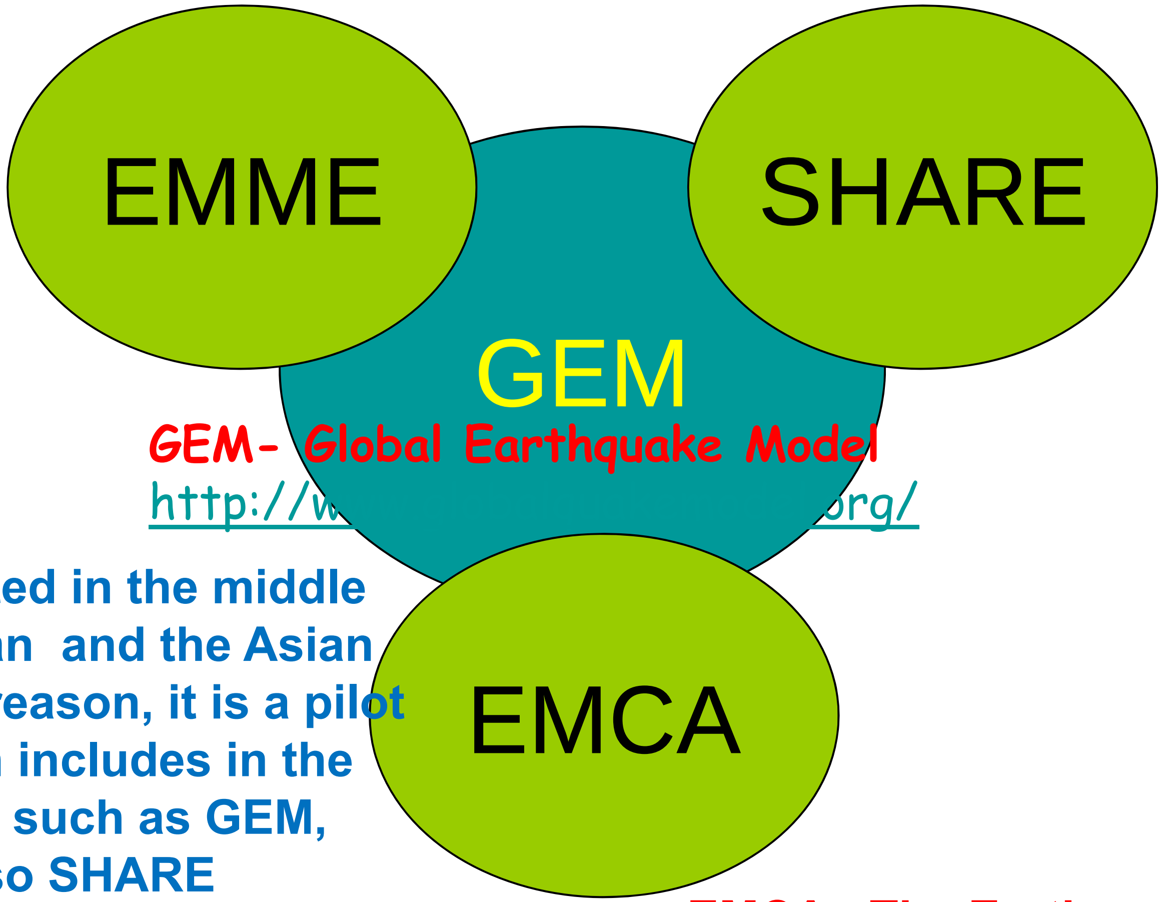
Sa (T=1.0s),Distribution using the pre NGA (1997) GMPEs



Sa (T=1.0s),Distribution using the NGA GMPEs

EMME - Earthquake Model of the Middle East region:
Hazard, Risk Assessment, Economics & Mitigation
http://www.emme-gem.org/

Seventh Framework Programme
Theme 6: Environment
Seismic Hazard Harmonization in Europe (SHARE)
http://www.share-eu.org/



GEM- Global Earthquake Model
http://w ... org/

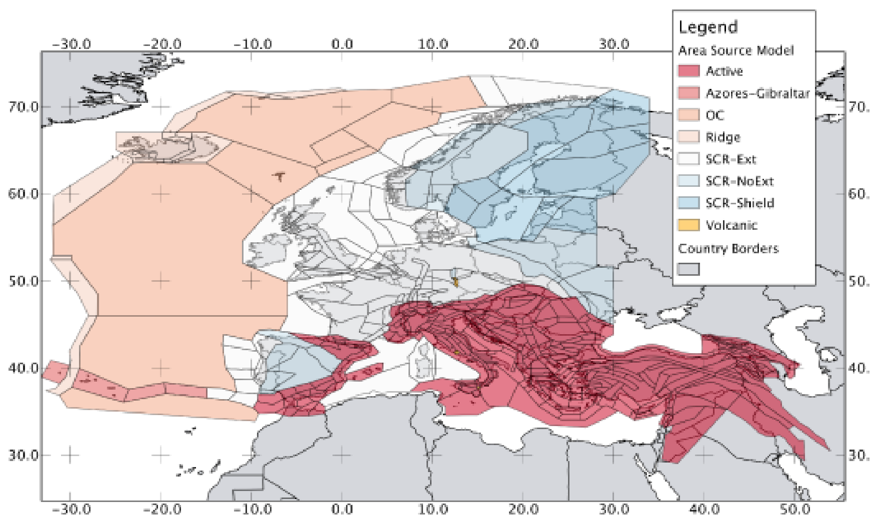
Turkey is located in the middle of the European and the Asian side. For that reason, it is a pilot country, which includes in the major projects such as GEM, EMME, and also SHARE projects.

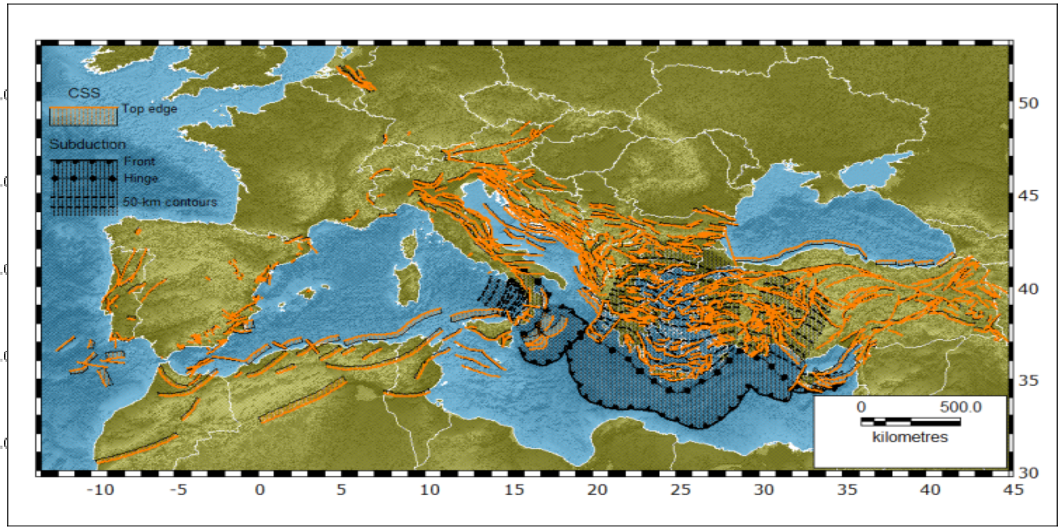
EMCA - The Earthquake Model Central
http://www.emca-gem.org/

Seismic Hazard Assessment: SHARE PROJECT

SHARE - Seismic Hazard Harmonization in Europe" (www.share-eu.org) is a Collaborative Project in the Cooperation programme of the Seventh Framework Program of the European Commission.
SHARE's main objective is to provide a community-based seismic hazard model for the Euro-Mediterranean region with update mechanisms. The project aims to establish new standards in Probabilistic Seismic Hazard Assessment (PSHA) practice by a close cooperation of leading European geologists, seismologists and engineers:

For the first time, a Euro-Mediterranean wide model considers three approaches to assess the occurrence of earthquake activity:
- **a classic Area Source (AS) Model,**
- **a model that combines activity rates based on fully parameterized faults imbedded in large background seismicity zones, the Fault-Source & Background (FSBG) Model, and**
- **a kernel-smoothed model that generates earthquake rate forecasts based on fault slip and smoothed seismicity (SEIFA).**





European Seismic Hazard Map

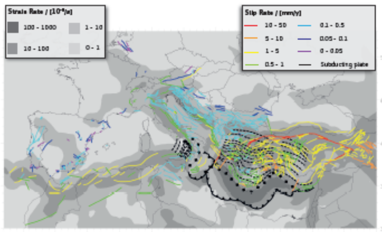
edited by D. Giardini, J. Woessner, and L. Danciu, Swiss Seismological Service, ETH Zurich, August 2013

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-storey buildings and critical infrastuctures such as bridges or dams.

Active Faults in Euro-Mediterranean Region



Active faults and subucting plates in the Euro-Mediterranean region, differentiated by color from rapidly slipping (red) to slowly slipping (violet). Over 1,100 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 geodetic 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 motions every 475 years, as prescribed by the national building codes in Europe for standard buildings. SHARE maps also the higher ground shaking recurring only 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 style and rate 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 constuction of buildings.

Acknowledgements

Supported by the EU 7th 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. 226967.

SHARE hazard was computed using the GEM OpenQuake software. Maps were created using GMT (Wessels and Smith, 1991) and the poster was produced with Adobe Illustrator CS5.

Cite this map with:

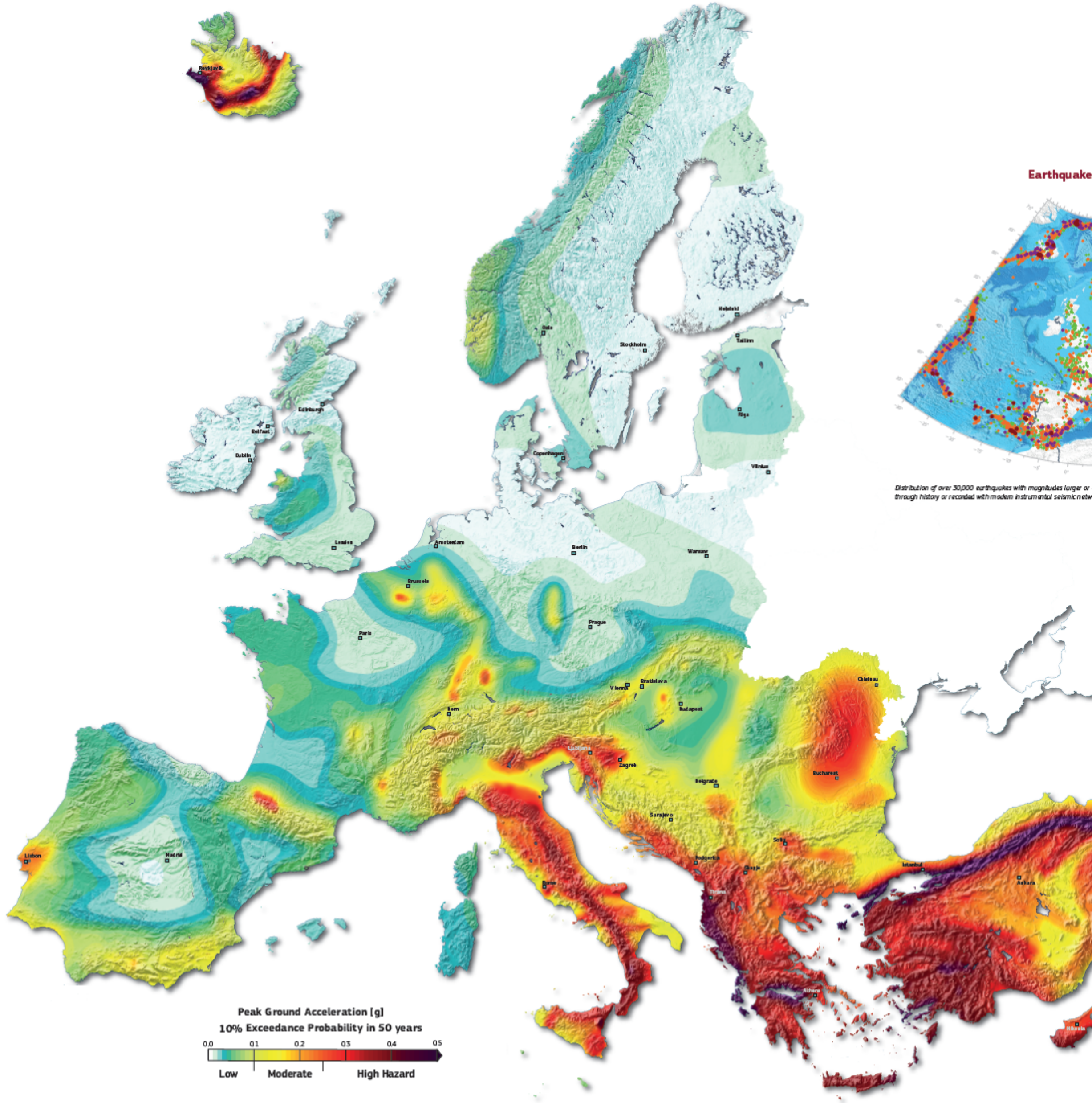
D. Giardini, J. Woessner, L. Danciu, H. Crowley, F. Cotton, G. Grünthal, R. Pinho and G. Valensise and the SHARE consortium, SHARE European Seismic Hazard Map for Peak Ground Acceleration, 10% Exceedance Probabilities in 50 years, doi: 10.2777/30345, ISBN-13, 978-92-79-25148-1.

Online Access

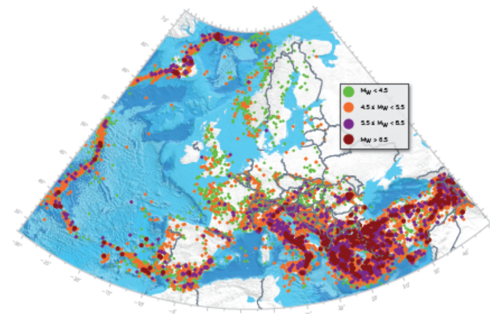
All SHARE products, data and results, are provided through the project website at www.*share-eu.org* and the European Facility for Earthquake Hazard and Risk at www.*efehr.org*.

Legal Notice

SHARE Partners



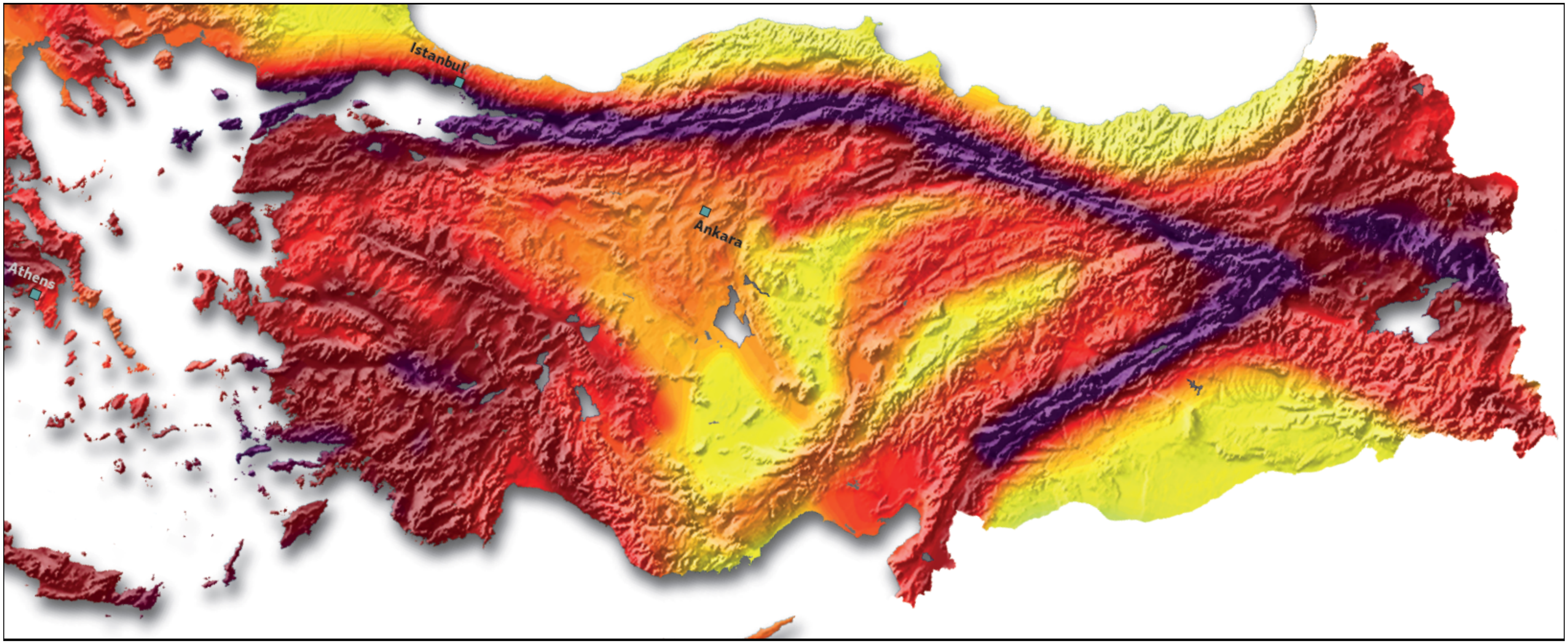
Earthquake History in Europe



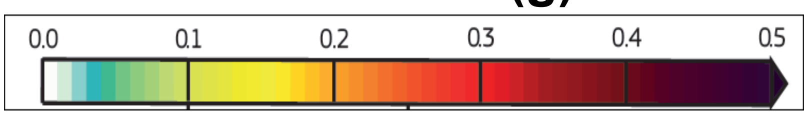
Distribution of over 30,000 earthquakes with magnitudes larger or equal to 3.5 for the period 1000 – 2007, documented by their damaging effects through history or recorded with modern instrumental seismic networks.

European Seismic Hazard Map

European Commission



10%/50 PGA(g)



Schweizerischer Erdbebendienst
Service Sismologique Suisse
Servizio Sismico Svizzero
Servizi da Terratrembels Svizzer

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

GFZ
Helmholtz Centre
Potsdam

Istituto Nazionale di Geofisica e Vulcanologia

GEM
Global Earthquake Model
working together to assess risk

LNEC
Laboratório Nacional de Engenharia Civil

ISTerre

brgm

Boğaziçi Üniversitesi
1863

BGS
British Geological Survey
Natural Environment Research Council

EERC
Earthquake Engineering Research Center
Middle East Technical University

NORSAR

Royal Observatory of Belgium

National and Kapodistrian University of Athens
Faculty of Geology & Geoenvironment
Department of Geophysics - Geothermics
Seismological Laboratory

INFP

Montenegro Seismological Observatory

Técnico Lisboa

Aristotle University of Thessaloniki

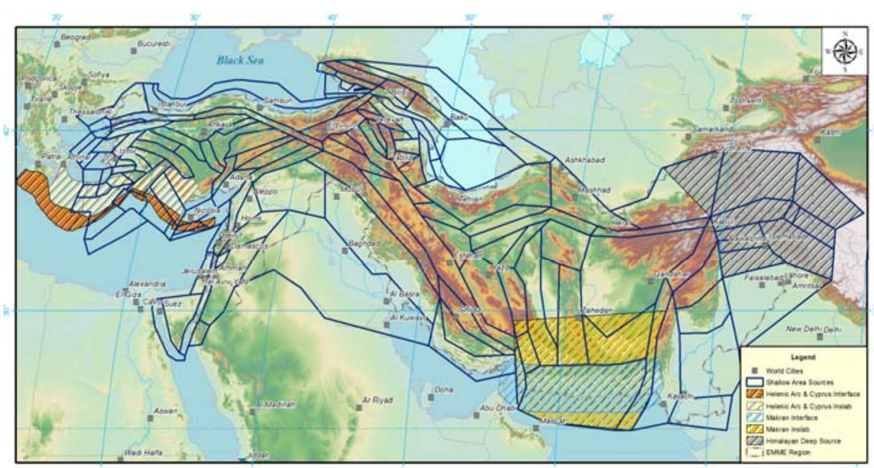
CRAAG

Seismic Hazard Assessment: EMME PROJECT

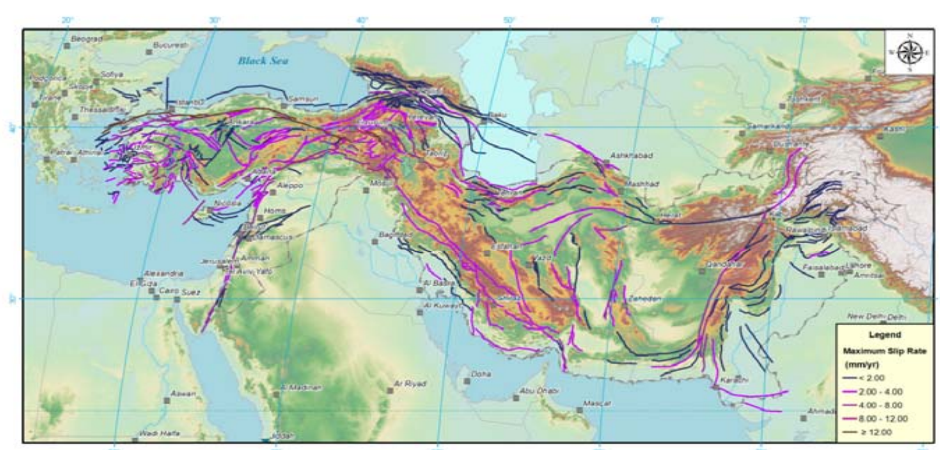
Another regional project is EMME "Earthquake Model of Middle East" (www.emme-gem.org) , which aims at the assessment of earthquake hazard, the associated risk in terms of structural damages, casualties and economic losses and also at the evaluation of the effects of relevant mitigation measures in the Middle East region in concert with the aims and tools of GEM (Global Earthquake Model). The Project started on April 2009 and will end on September 2013.

A Middle East wide model considers three approaches to assess the occurrence of earthquake activity:

- **a classic Area Source (AS) Model**
- **a model that combines activity rates based on fully parameterized faults imbedded in large background seismicity zones, the Fault-Source and various kernel smoothed model and**
- **a fix kernel-smoothed**



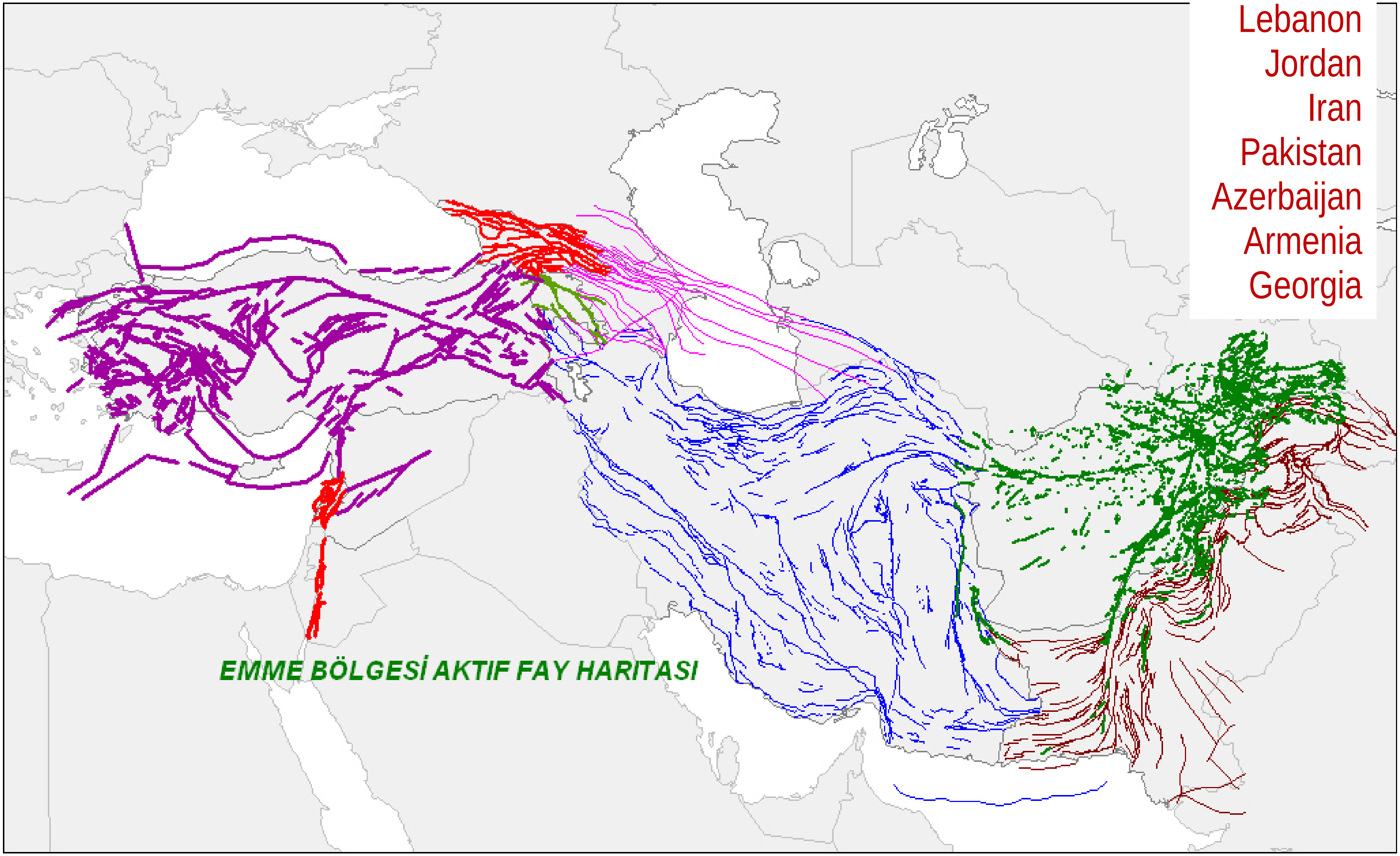
EMME Area Source Model

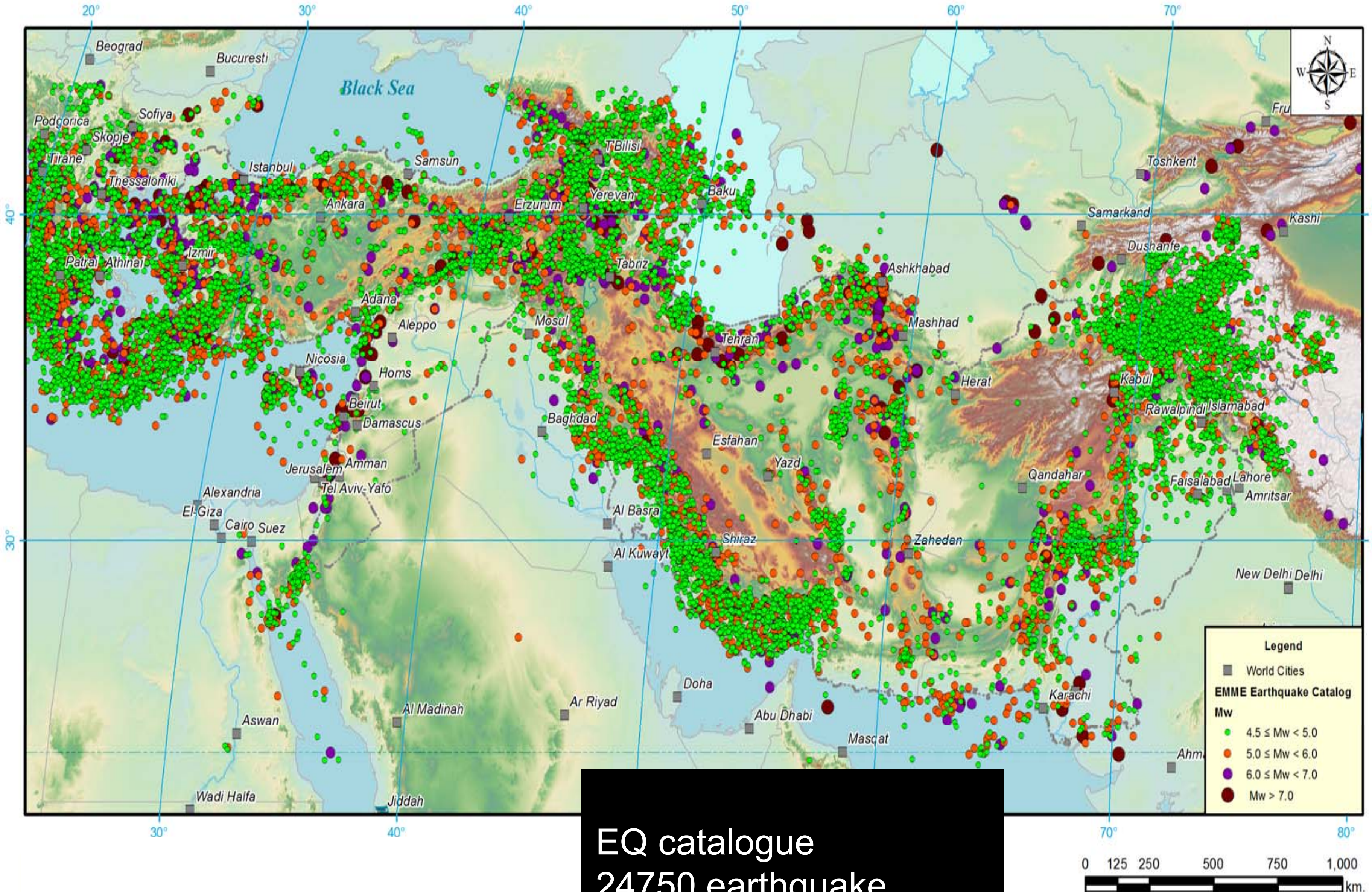


EMME Fault Sources

ACTIVE FAULT MAPS

Turkey
Cyprus
Lebanon
Jordan
Iran
Pakistan
Azerbaijan
Armenia
Georgia





(Zare et al 2013)

EQ Catalog

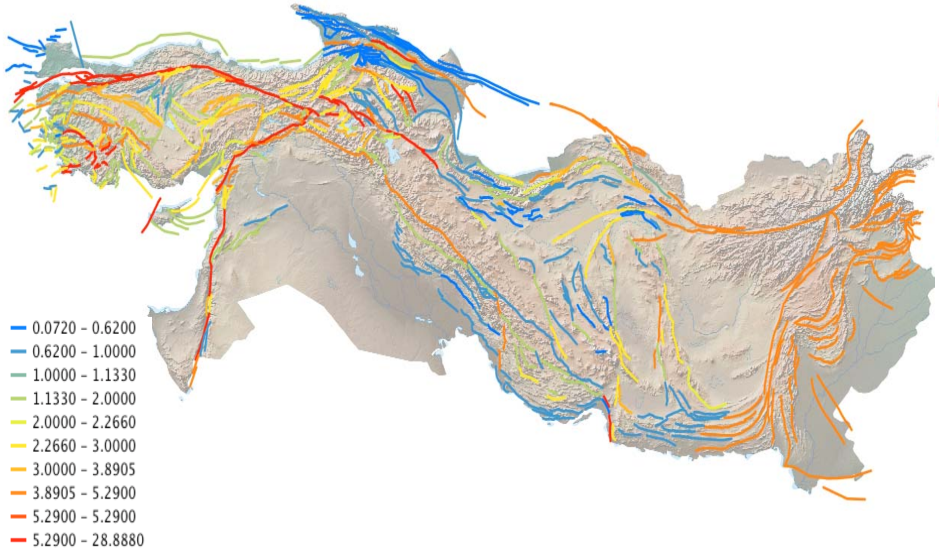
EQ catalogue
24750 earthquake
Historical
Instrumental (2424)
Total number 27174

Active-Fault Source Model

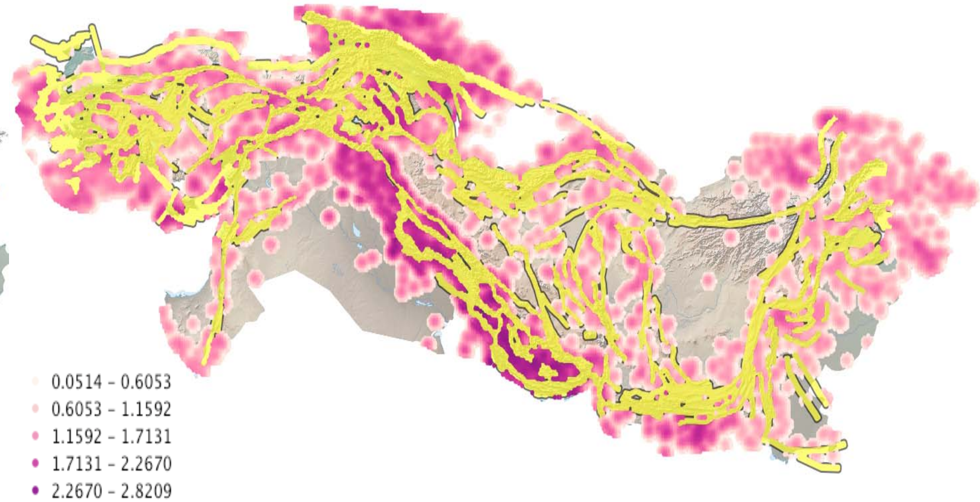
Simplified procedure to avoid double counting:

1) TOP-LEFT: Subset of seismically active faults (slip rates color from blue to red)
2) BOTTOM-LEFT: Asymmetrical Buffer
3) TOP RIGHT: Smoothed Seismicity **outside** buffer
4) BOTTOM-RIGHT: Smoothed Seismicity **inside buffer**

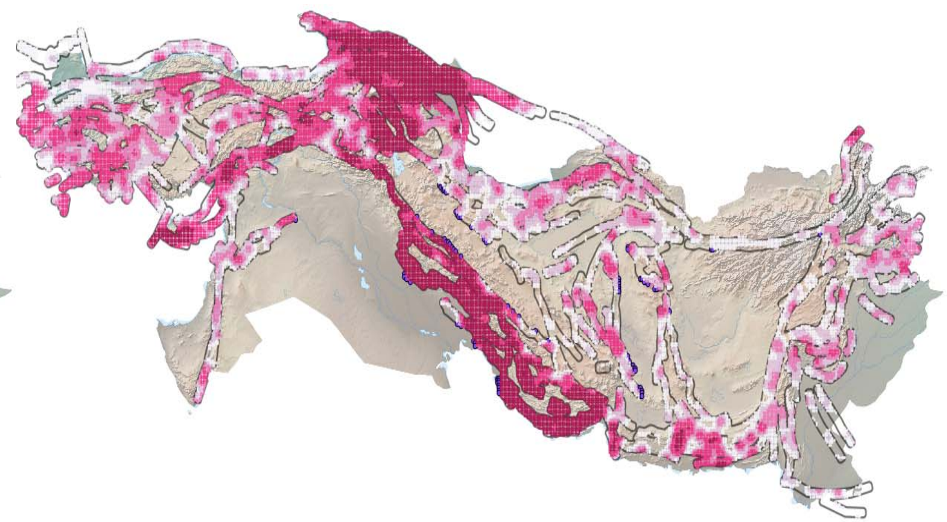
Active Faults



Background Smoothed Seismicity Outside Buffer



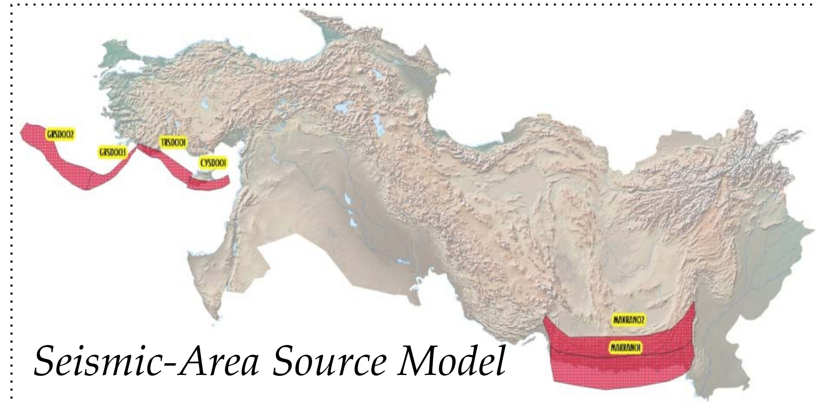
Background Buffer Regions

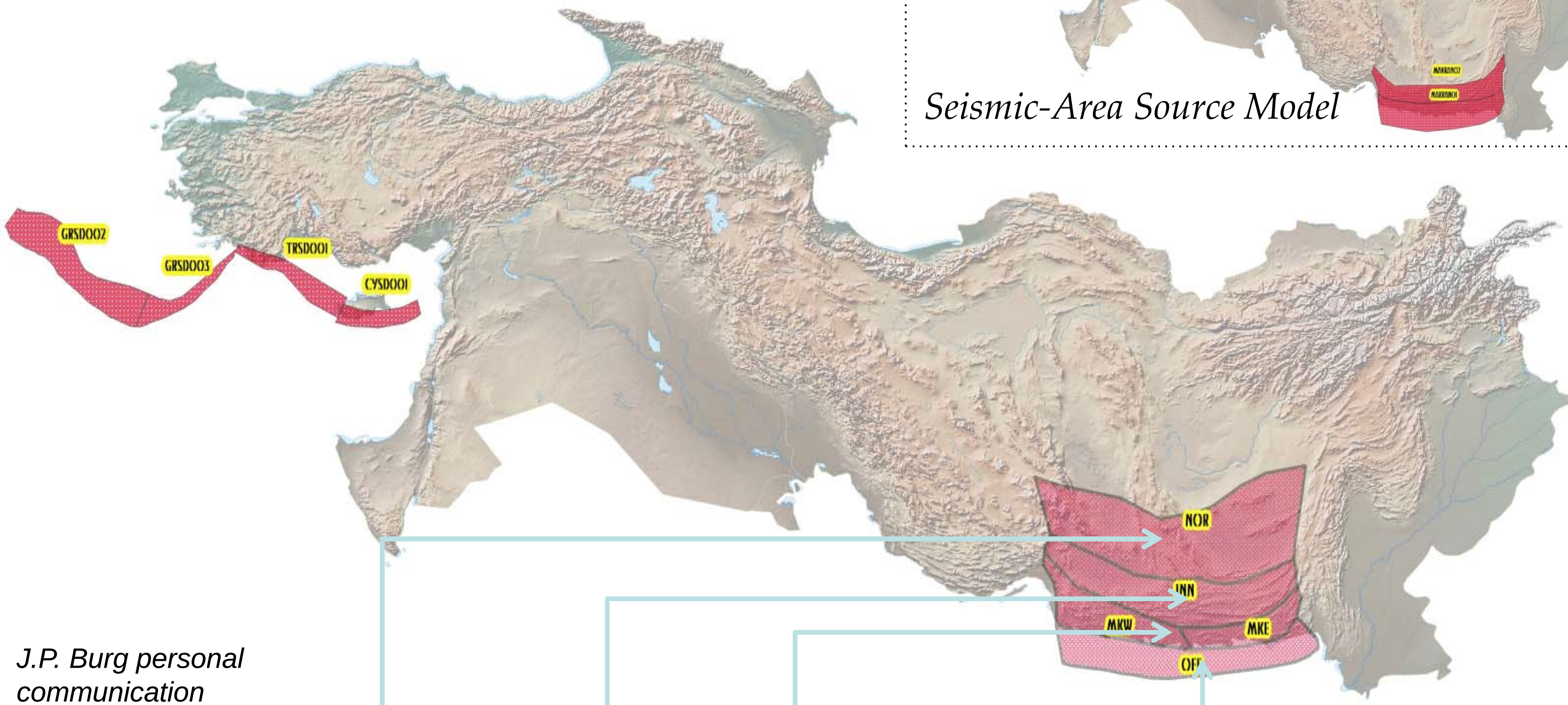


Background Smoothed Seismicity Inside Buffer

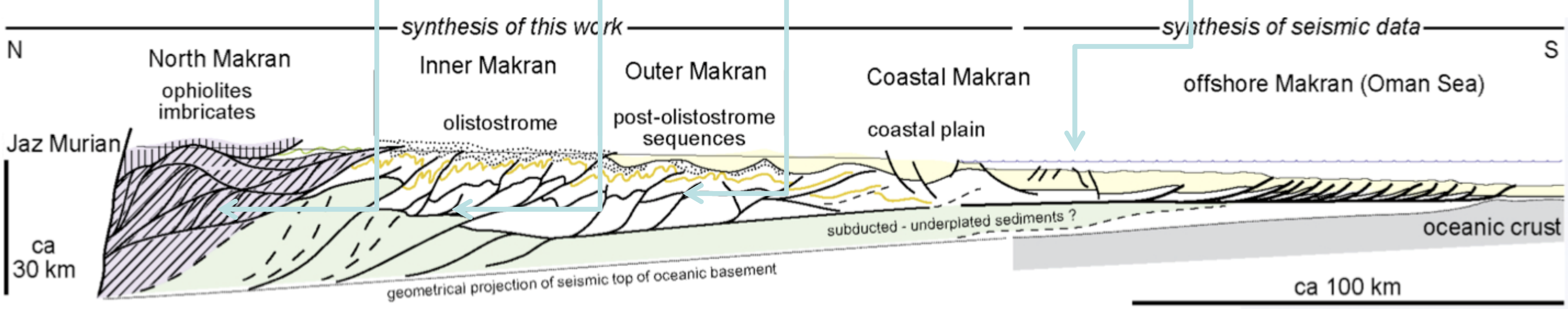
Subduction Interface

Seismic activity from slip-rate (mm/year)

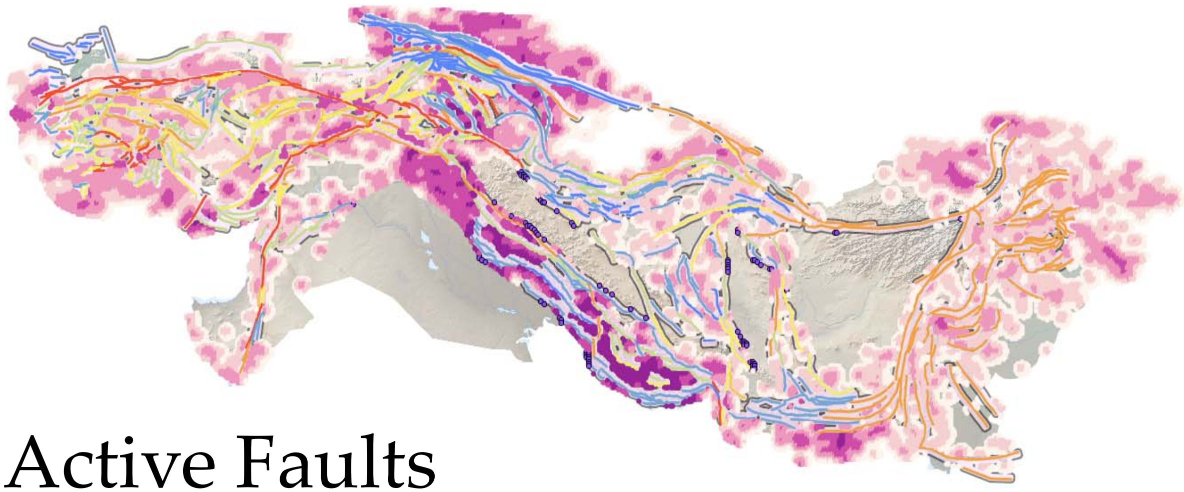




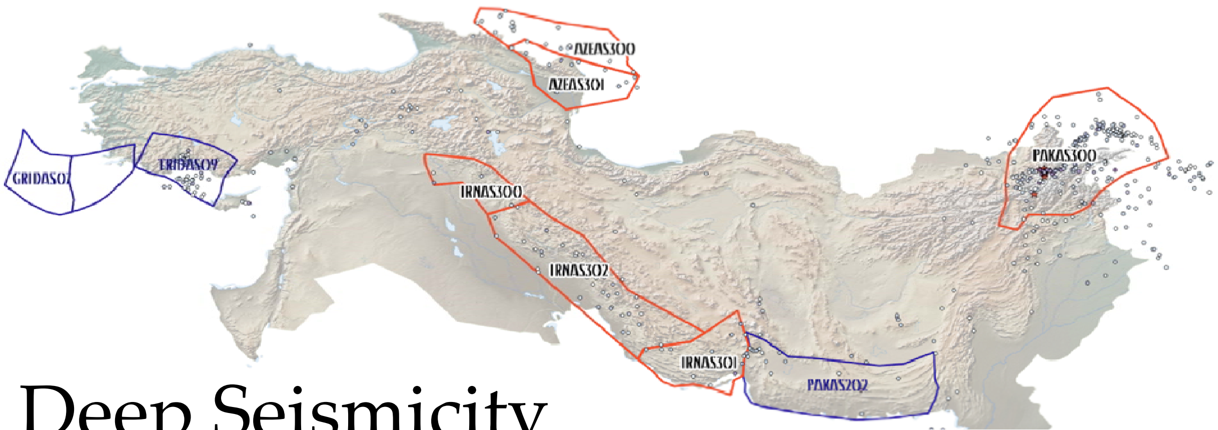
J.P. Burg personal communication



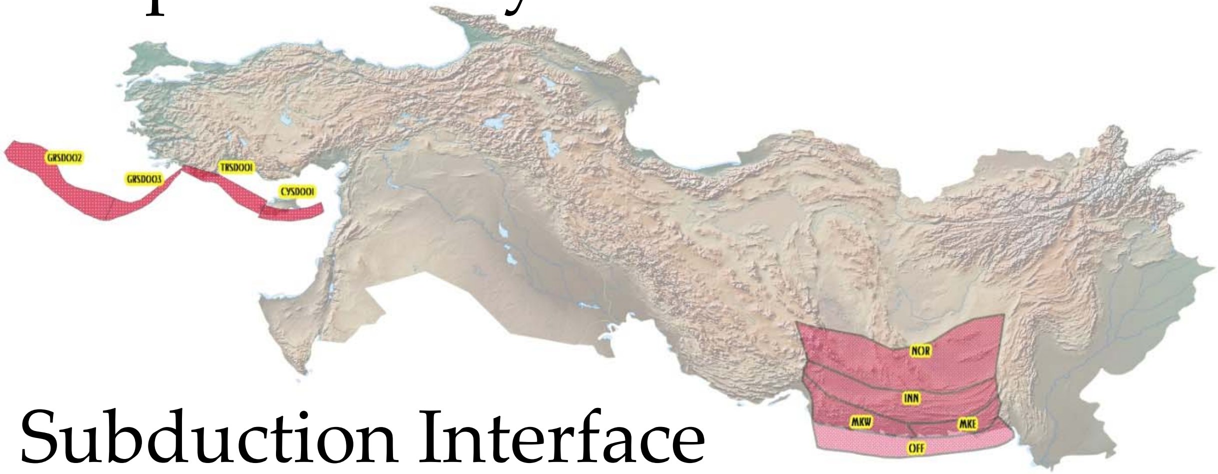
Fault Source Model



Active Faults



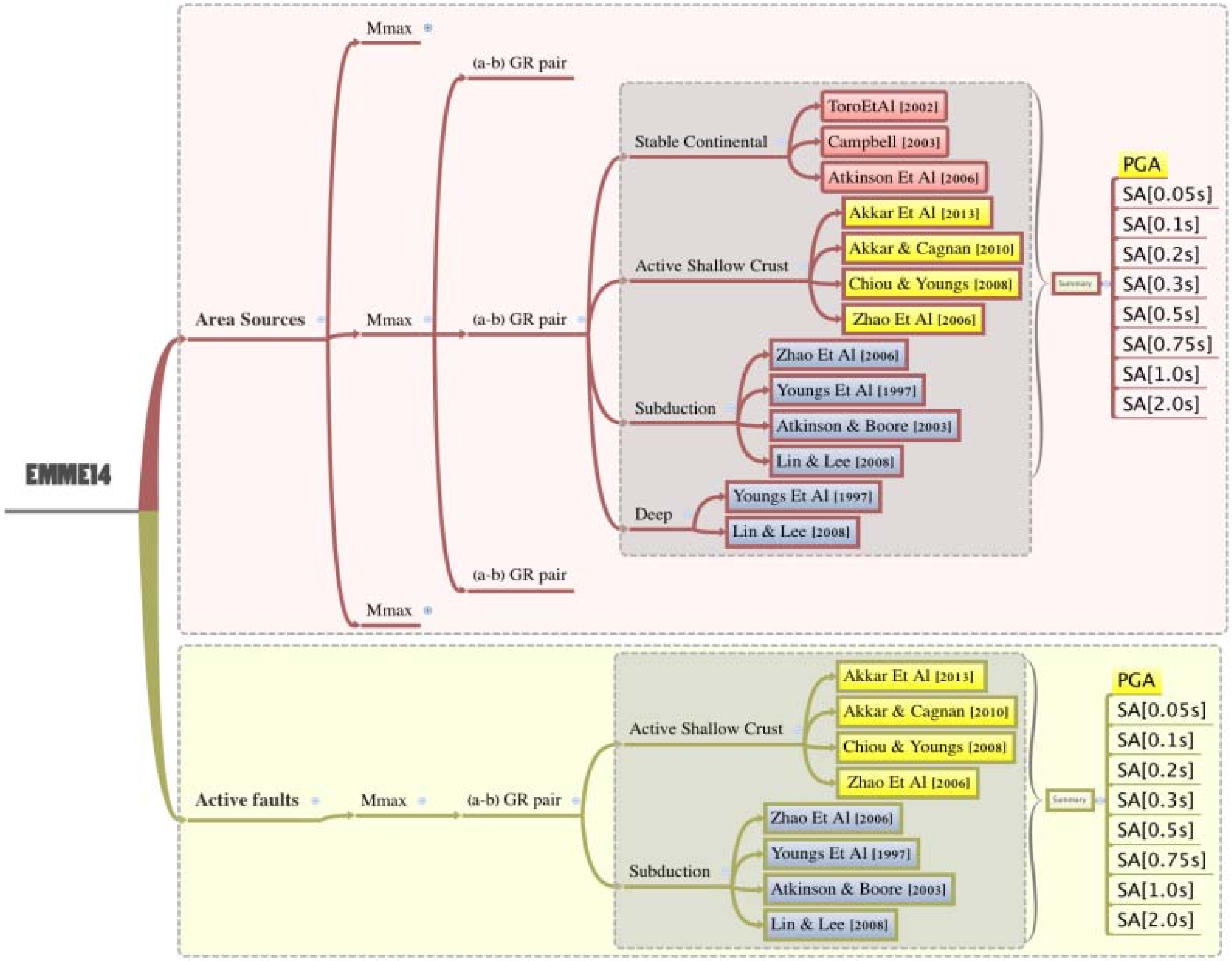
Deep Seismicity



Subduction Interface

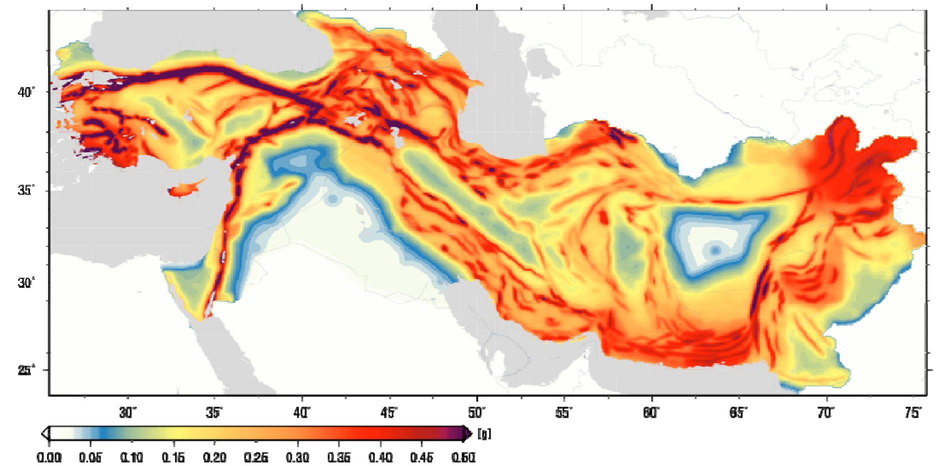
Four Source Layers
778 Active Faults
10 Deep Area-Sources
9 Interface Complex Faults
Background Seismicity

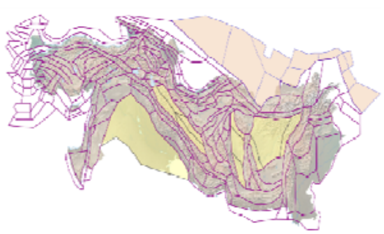
EMME Full Logic Tree

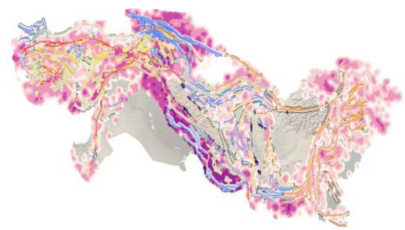


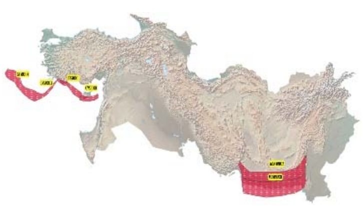
EMME14 at a Glance

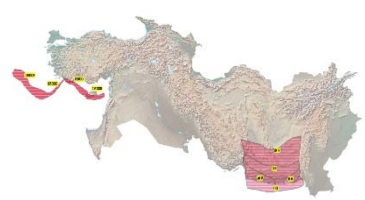
Earthqua
Source
Models





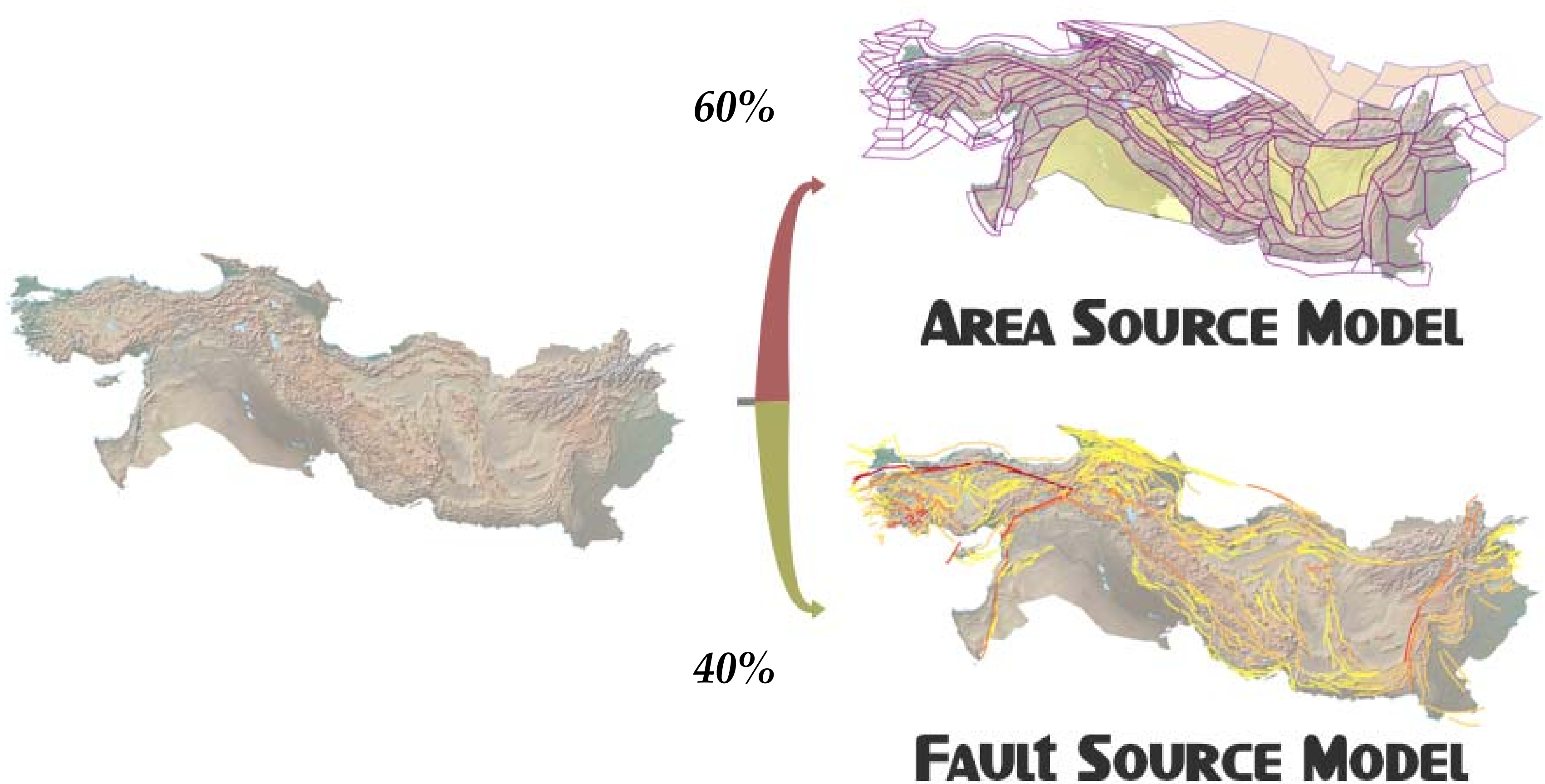




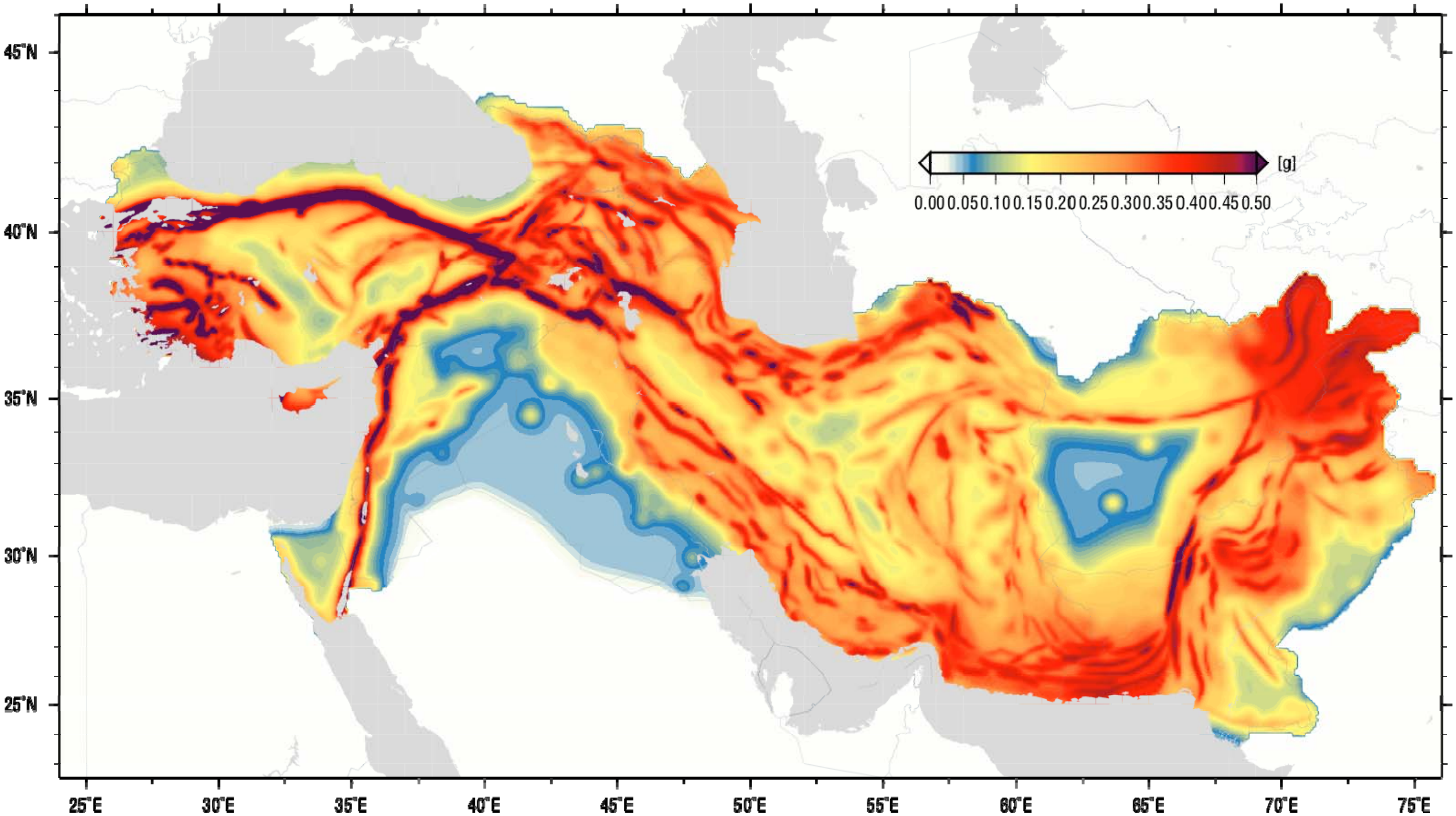


Active Shallow		Subduction		Stable		Deep	
GMPE	Weight	GMPE	Weight	GMPE	Weight	GMPE	Weight
ASB13	0.35	ZH06	0.40	AB06	0.40	YO07	0.50
CY08	0.35	AB03	0.20	TO02	0.25	LL08	0.50
AC10	0.20	YO97	0.20	CB03	0.35		
ZH06	0.10	LL08	0.20				

Source Model Logic Tree



PGA FOR 475YRS RETURN PERIOD
AS60FS40 MODEL



Revision of Turkish Seismic Hazard Map (UDAP-Ç-13-06)

S. Akkar, T. Eroğlu Azak, T. Çan, U. Çeken, M.B. Demircioğlu, T. Duman, S. Ergintav, T.F. Kadirioğlu, D. Kalafat, Ö. Kale, R.F. Kartal, T. Kılıç, S. Özalp, K. Şeşetyan, S. Tekin, A. Yakut, M.T. Yılmaz, M. Utkucu, Ö. Zülfikar

The project group consists of researchers and faculty members of

This project were supported by Republic of Turkey Prime Ministry Disaster and Emergency Management Authority (AFAD) and Turkish Natural Catastophe Insurance Pool (DASK)

Revision of Turkish Seismic Hazard Map (UDAP-Ç-13-06)

The scope of the project is confined to the revision of current national seismic hazard map.

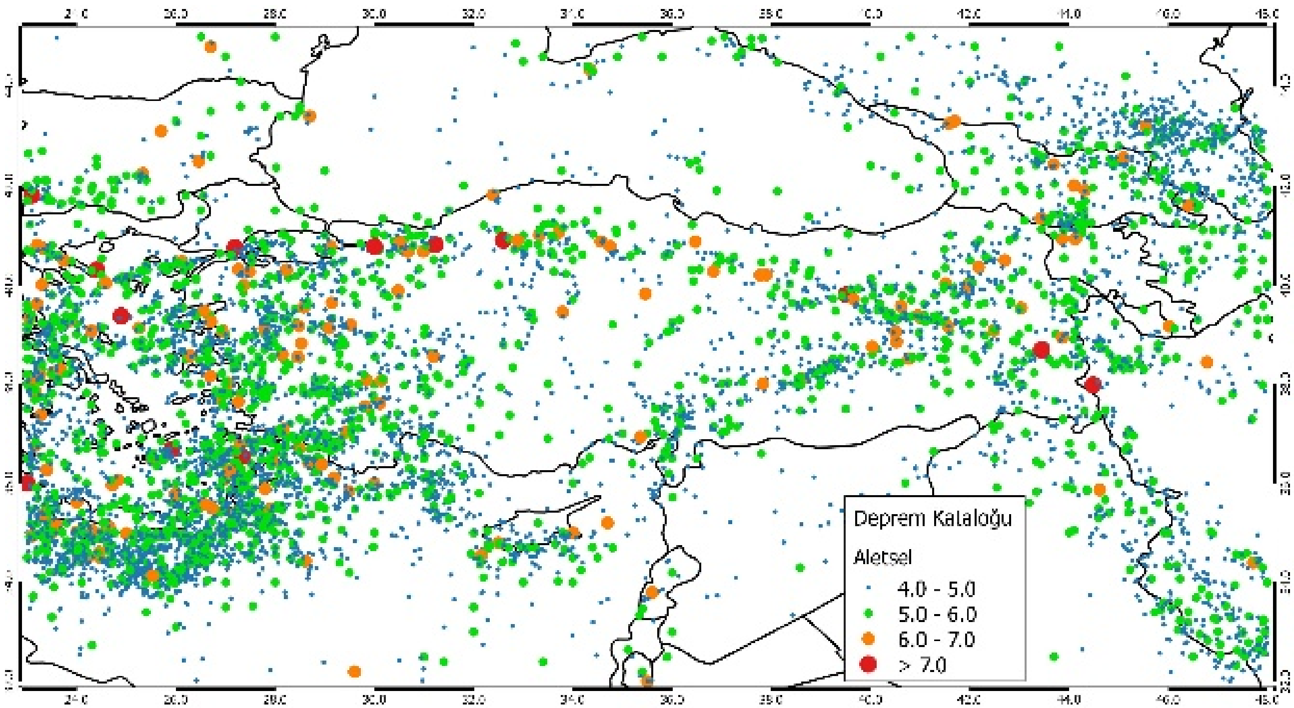
The key deliverable of the project is the elastic spectral ordinates at different exceedence probabilities for a range of structural periods of engineering interest.

The chosen exceedance probabilities are consistent with those of the Turkish Earthquake Code that are used in the design and seismic performance assessment of structural systems.

The return periods: 43 years (%69/50 yrs), 72 years(%50/50 yrs), 475 (%10/50 yrs) years, 2475 years(%2/50 yrs)

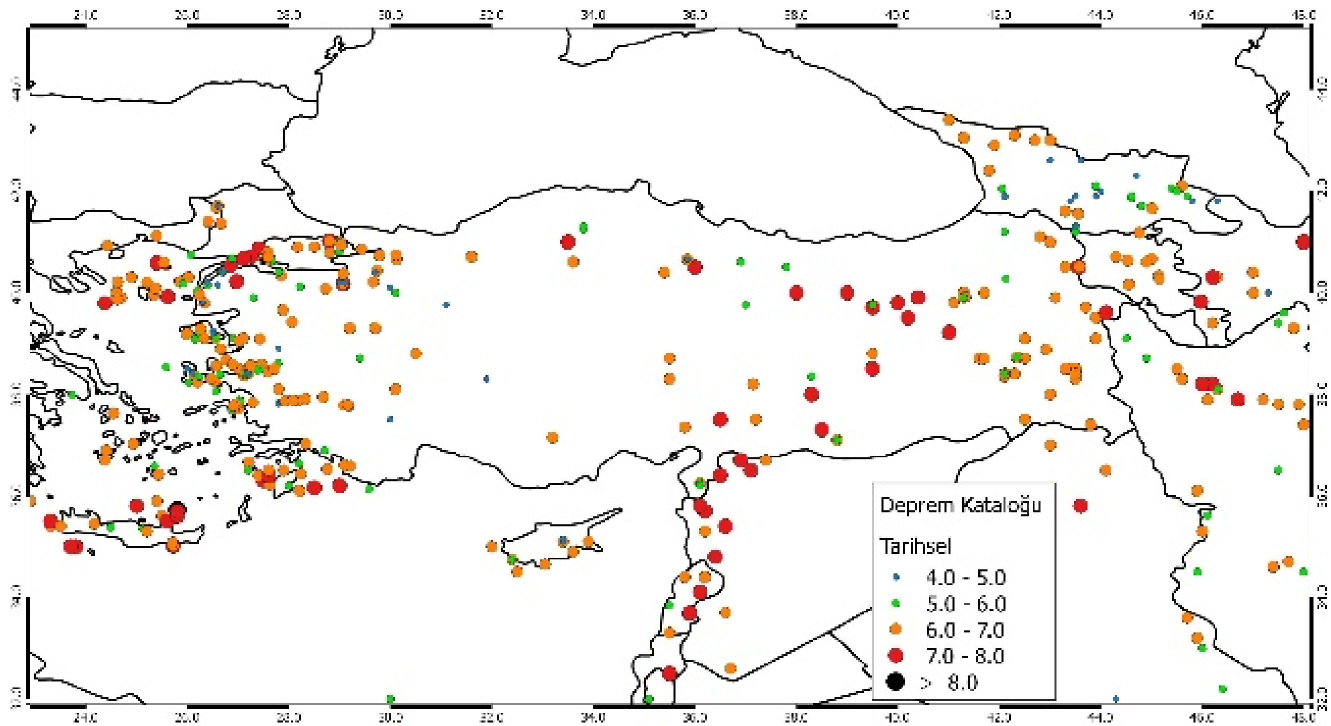
For a given exceedence level, the computed spectral values will be presented as counter maps for a generic rock site that can be modified for different site conditions through empirical scaling factors.

Ground Motions: PGA, Sa(T=0.2s) and Sa(T=1.0s)



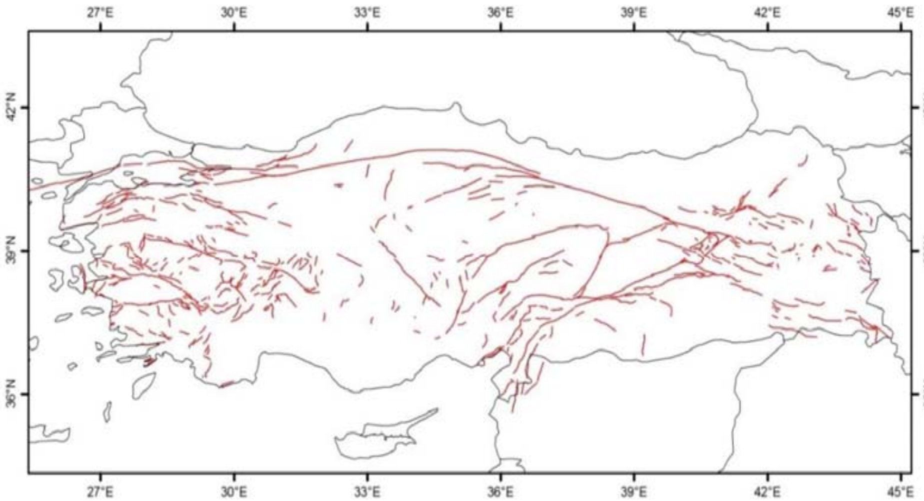
INSTRUMENTAL EARTHQUAKE CATALOG

HISTORICAL EARTHQUAKE CATALOG

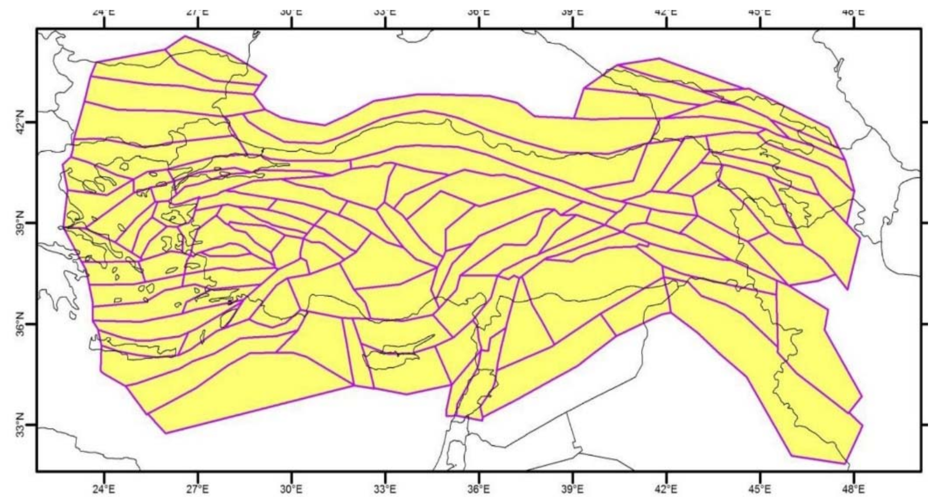


SEISMIC SOURCES

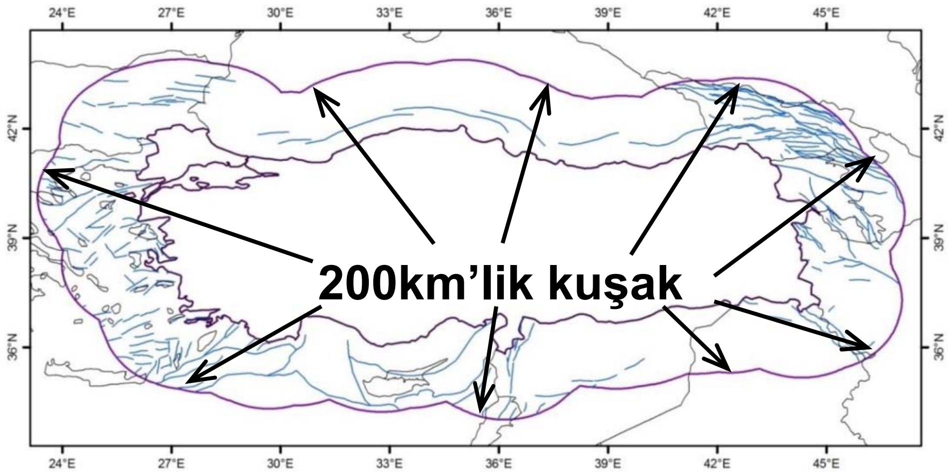
Kara sınırları içindeki diri faylar



Kara sınırları ve 200km'lik kuşak içinde alan kaynaklar

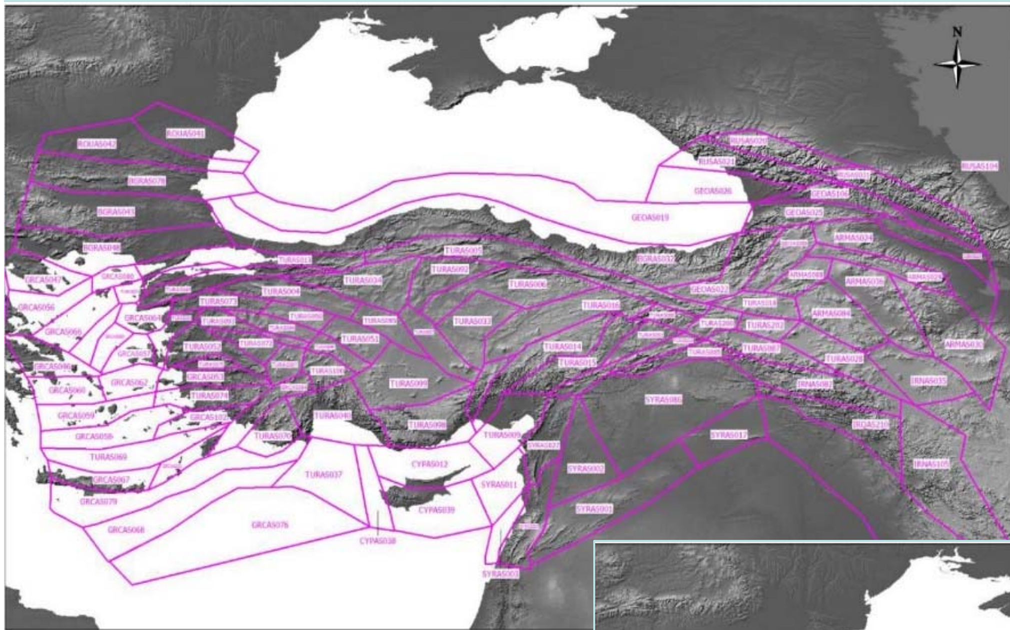


ACTIVE FAULTS WITHIN 200 KM BUFFER ZONE

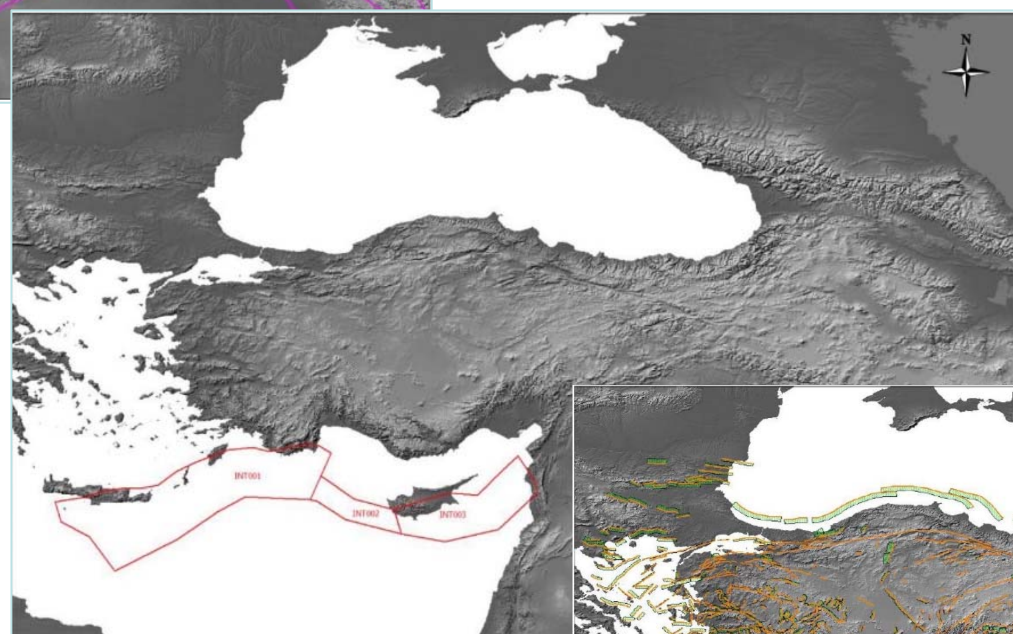


Aktif fay segmentlerini, alan kaynakları, maksimum deprem büyüklüklerini, fay tiplerini, derinlik dağılımlarını bulabilmek için literatür taraması, ulusal ve uluslararası proje sonuçları, deprem katalogları ve CBS tabanlı haritalar kullanıldı

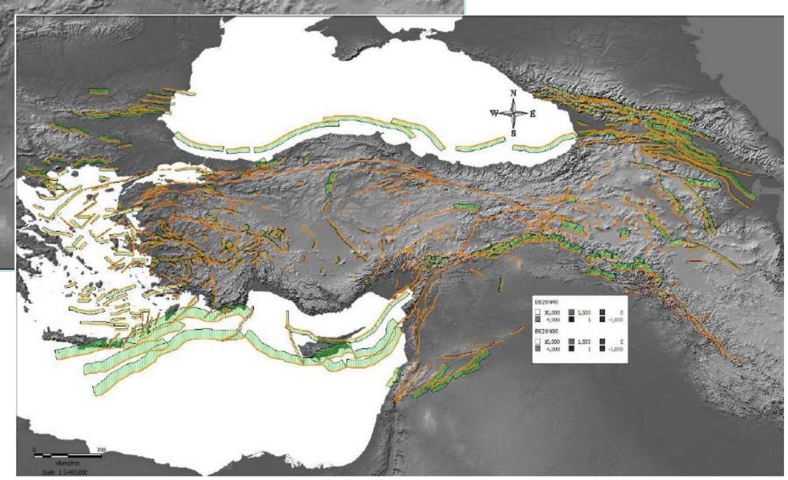
SEISMIC SOURCE MODELS



AREA SOURCE MODEL
FOR ACTIVE SHALLOW EVENTS
DEPTH <50KM)

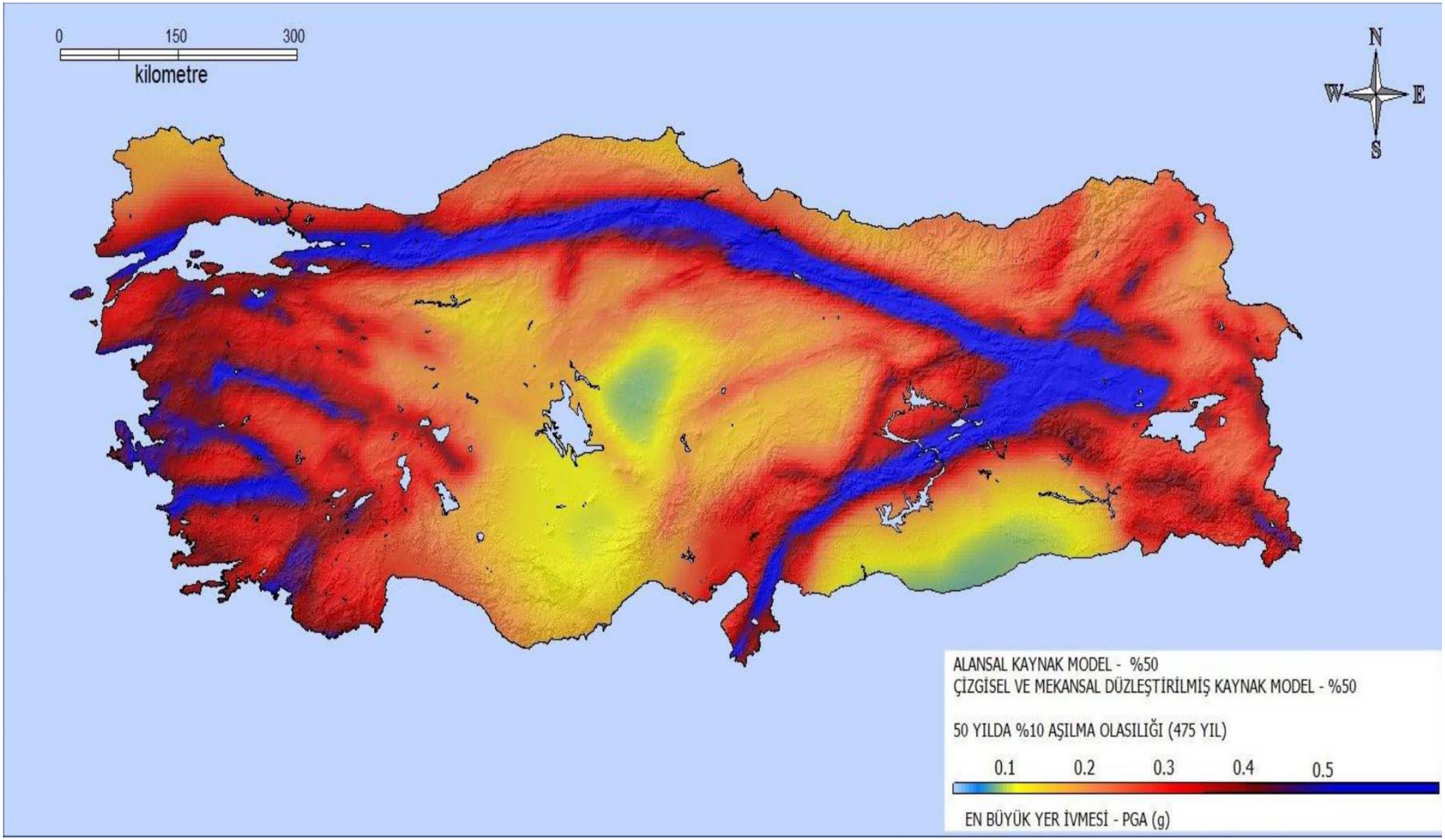


AREA SOURCE MODEL
FOR DEEP EVENTS
(DEPTH > 50 KM

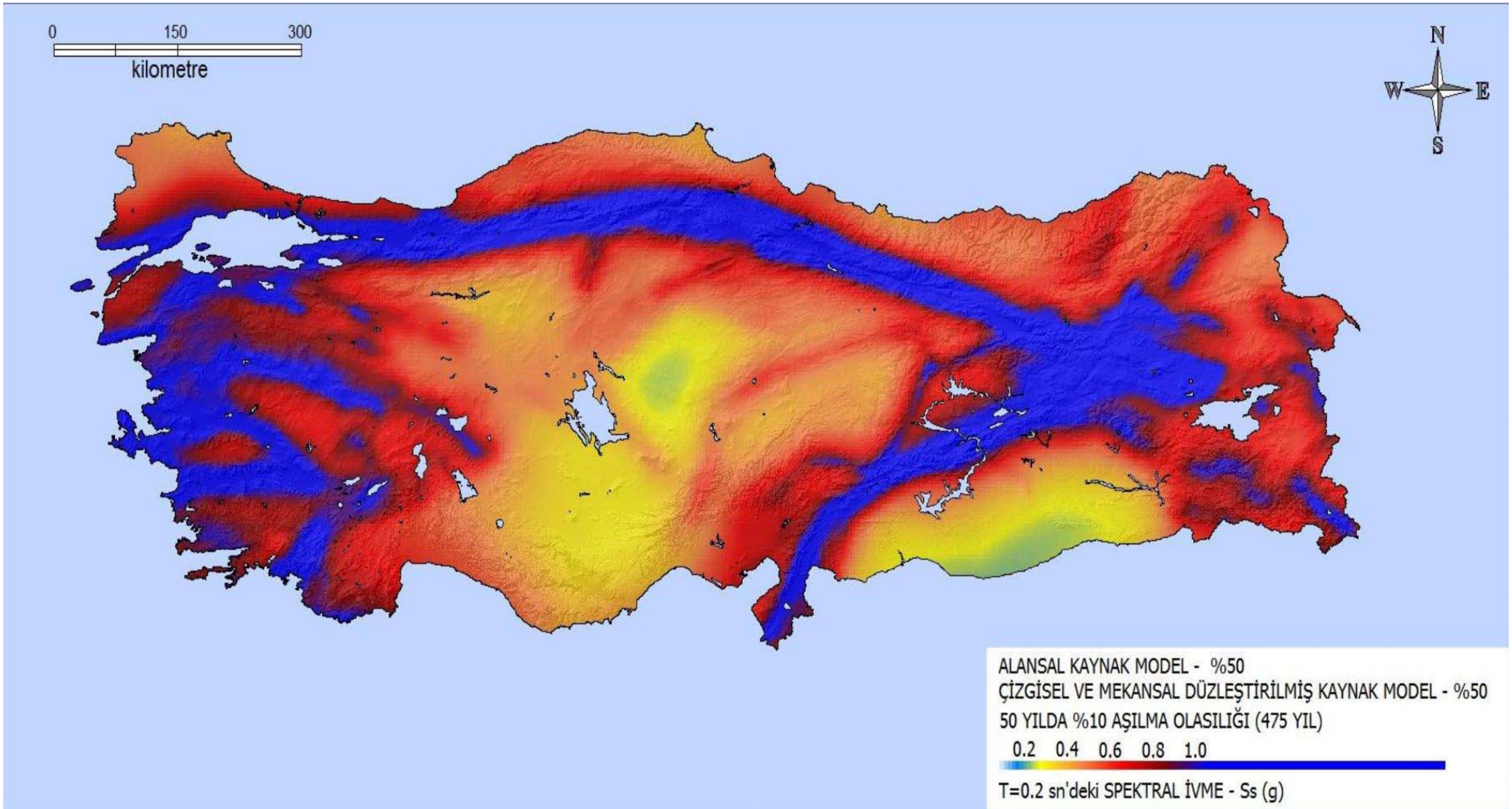


FAULT SOURCE MODEL

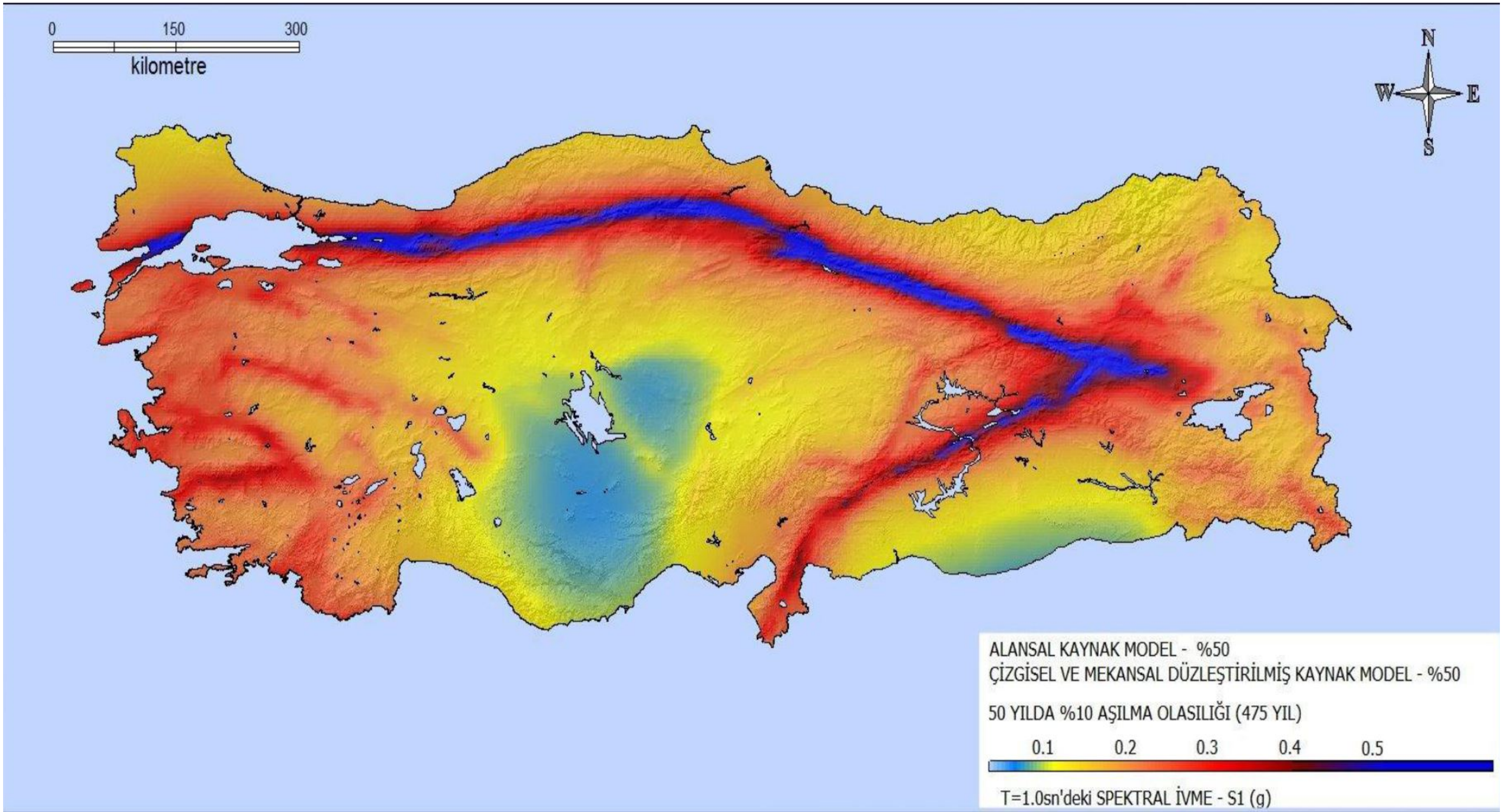
PGA – 475 yıl (%10/50 yıl)



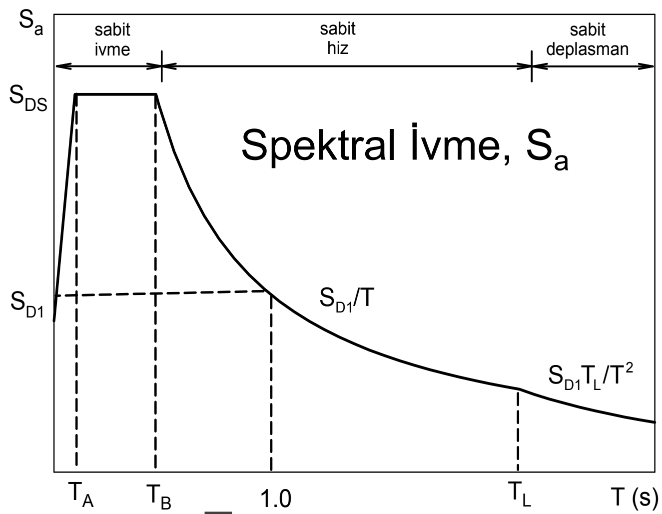
Spektral ivme T = 0.2s – 475 yıl (%10/50 yıl)



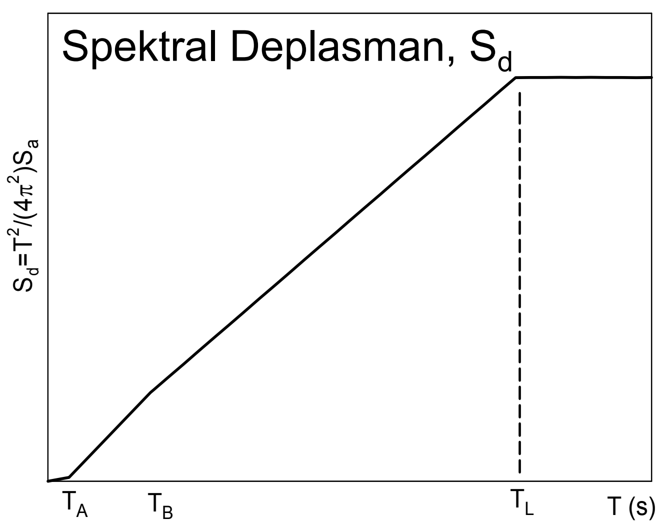
Spektral ivme T = 1.0s – 475 yıl (%10/50 yıl)



New Earthquake resistance Design Code Spectrum



$$S_d = T^2/(4\pi^2)S_a$$



Site Coeffients

T = 0.2s and T = 1.0s coming from directly contour maps

$$S_{DS} = F_a S_S; \quad S_{D1} = F_v S_1; \quad T_B = S_{D1}/S_{DS}; \quad T_A = 0.2T_B$$

$$S_a = S_{DS}(0.4 + 0.6\,T/T_A); \quad 0 \leq T < T_A$$

$$S_a = S_{DS}; \quad T_A \leq T < T_B$$

$$S_a = S_{D1}/T; \quad T_B \leq T < T_L$$

$$S_a = S_{D1}T_L/T^2; \quad T \geq T_L$$

Tasarım: 475 yıl (%10/50 yıl) tekrar süresini temsil eden spektrum
Farklı performans seviyeleri: 43 yıl (%69/50 yıl) ile 2475 yıl (%2/50 yıl) tekrar sürelerini temsil eden spektrumlar

MARMARA REGION AND ISTANBUL

Isoseismic map of 1894 Istanbul earthquake
(Cooperation with Kandilli and Athen Observatories)

1875 İTALYA – First Modern seismometer installed in Roma

1881 JAPONYA – First Seimometer installed in Tokyo

1895 OTTOMAN EMPIRE – First seismometer instaled in Pera and Yıldız Palaces

1897 ABD- First Seimometer installed in San Jose

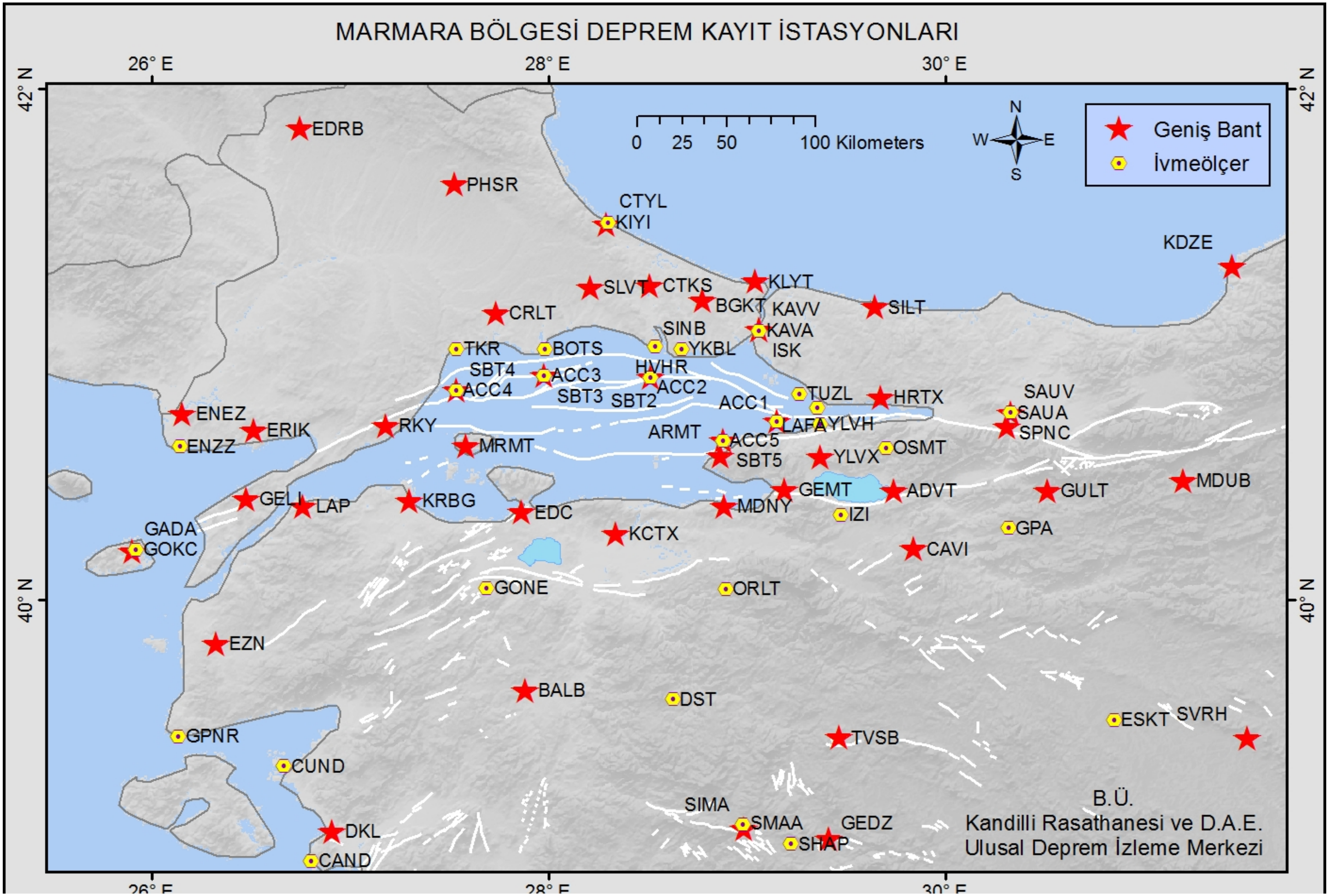
Istanbul Early Warning and Rapid Response System

- The initiatives on the establishment of the Istanbul Earthquake Rapid Response and Early Warning System proposed by Boğaziçi University in 1998 (before the 1999 Kocaeli earthquake) became valid after the decree of Council of Minister on 2001 Fiscal Year following the 1999 Kocaeli and Duzce earthquakes.

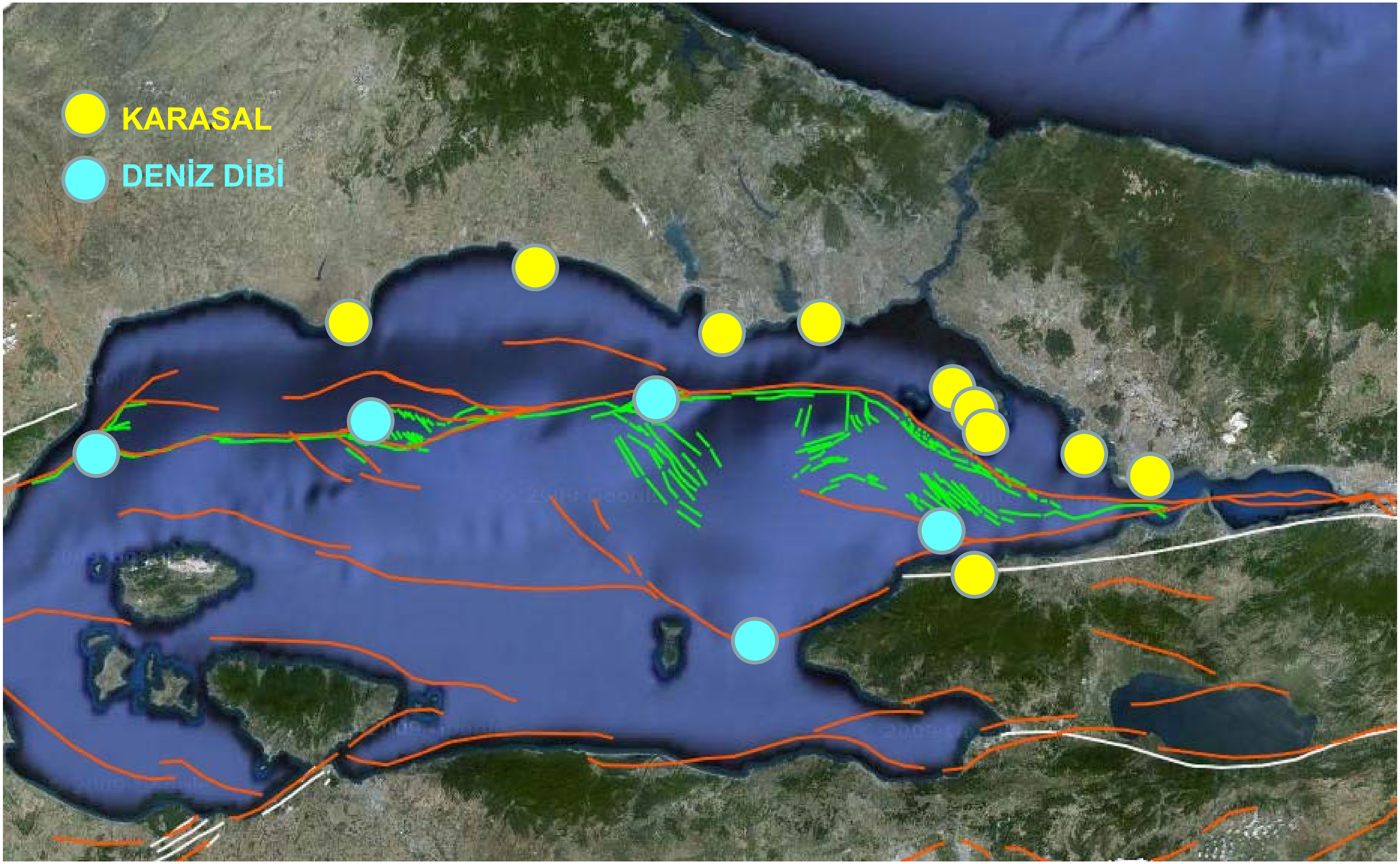
- The establishment of the Istanbul Earthquake Early Warning and Rapid Response System commenced on May 10th, 2001 by Boğaziçi University Kandilli Observatory and Earthquake Research Institute (KOERI) and was logistically supported by Istanbul Governorate, Istanbul Metropolitan Municipality and First Army Headquarters.
- The whole design and technical specifications were prepared by the Department of Earthquake Engineering at KOERI. The system consisted of 100 stations for rapid response and 10 stations for early warning .

- In December 2012, with support of Istanbul Governorate, 20 new instruments were added and other strong motions instruments operating in the Early Warning and Rapid Response network were maintained. 120 rapid response and 10 early warning stations are operating currently.

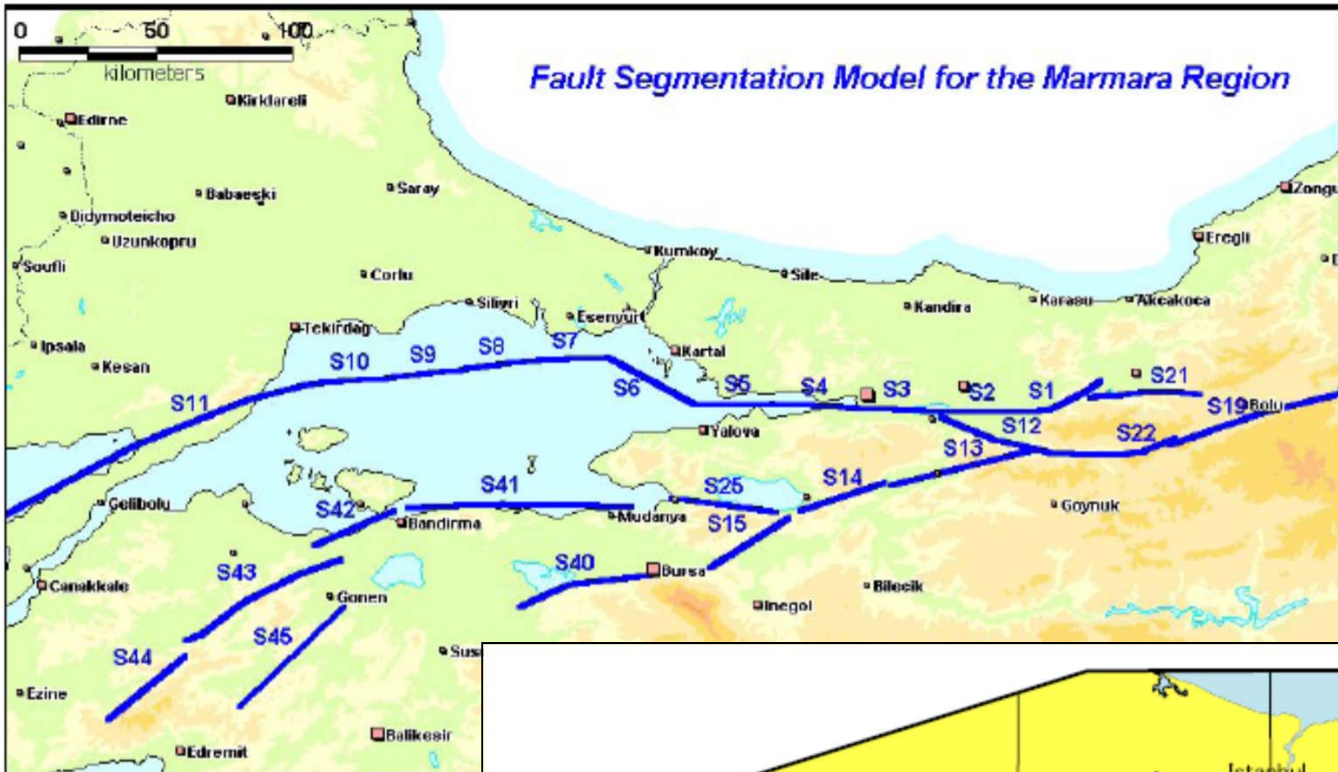
Distribution of earthquake stations in Marmara Region



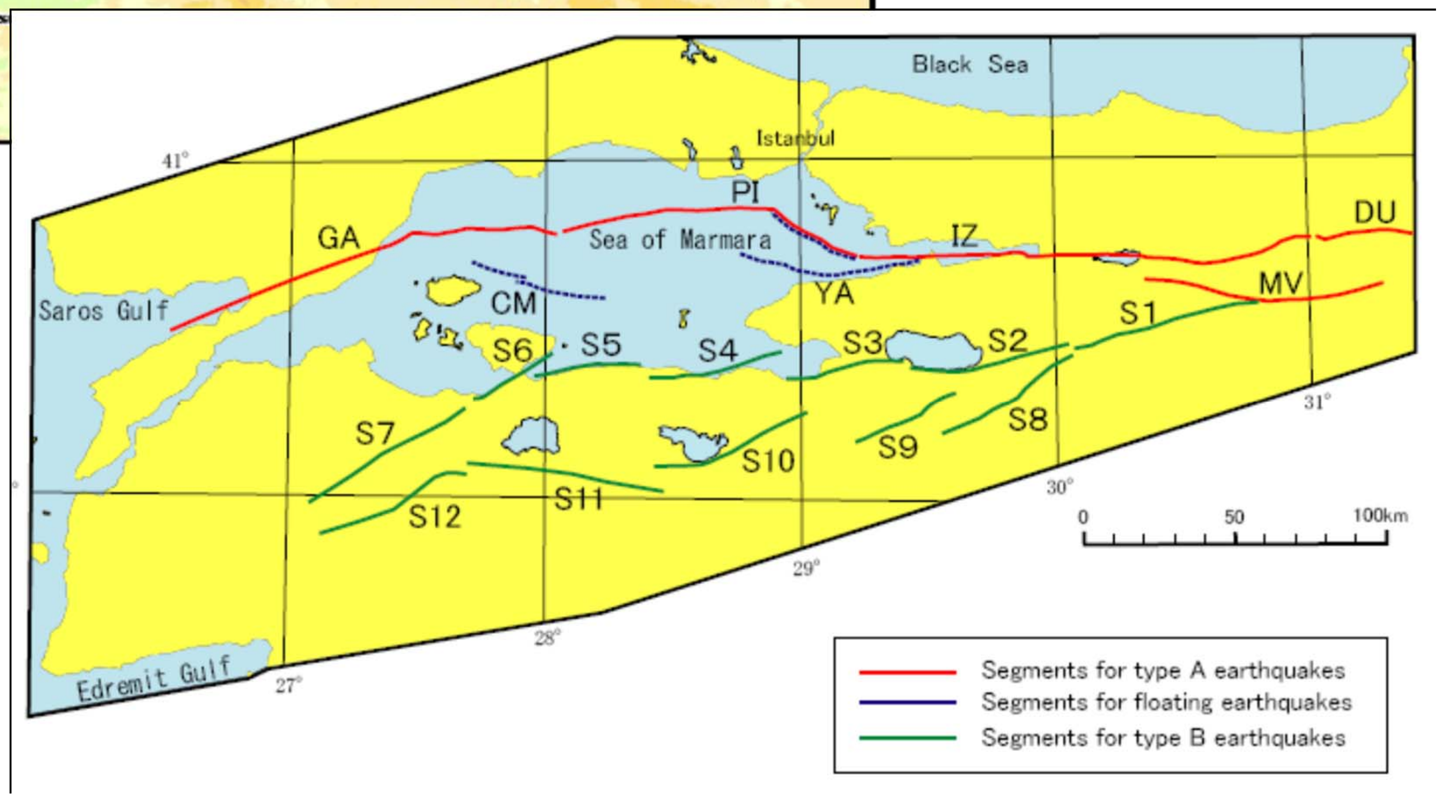
ISTANBUL EARLY WARNING SYSTEMS



EARTHQUAKE HAZARD in MARMARA REGION
2% Annual Probability for an Mw>7 Earthquake

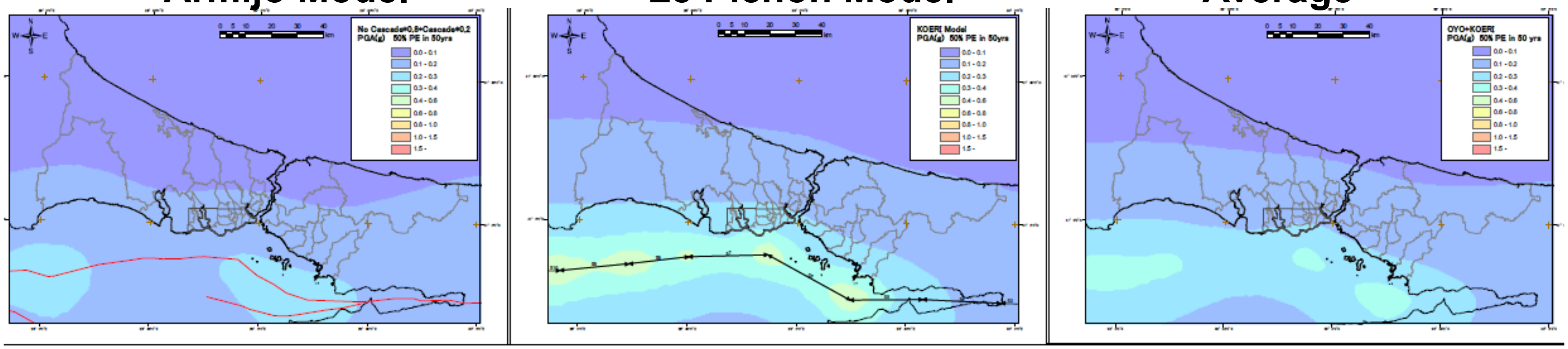


FAULT MODELS

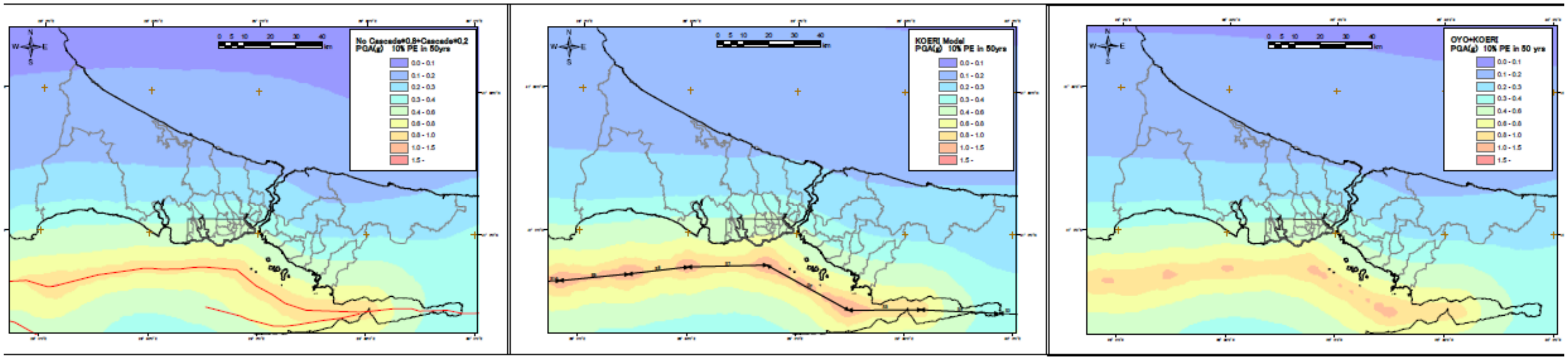


Time dependent PSHA

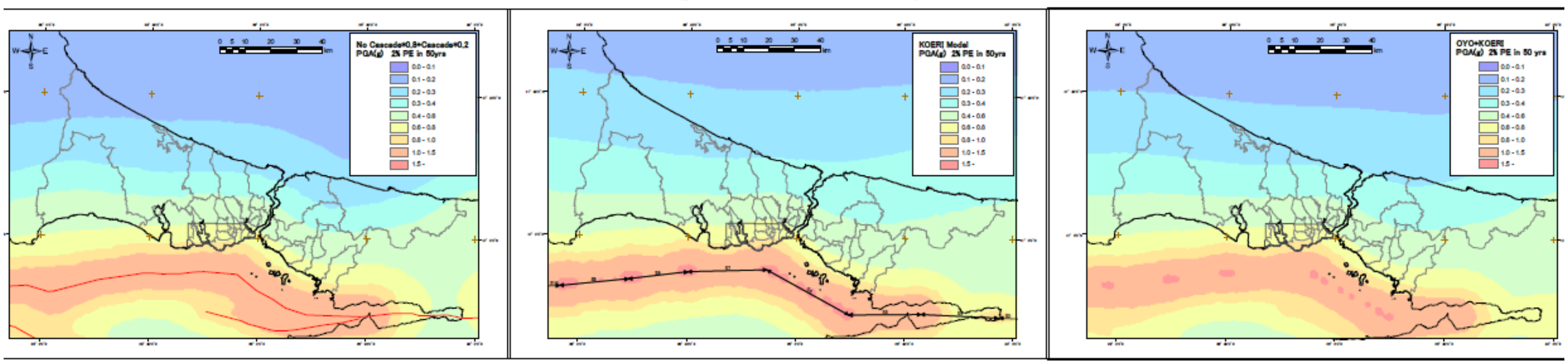
Armijo Model | Le Pichon Model | Average



PGA map for 50% PE in 50 years



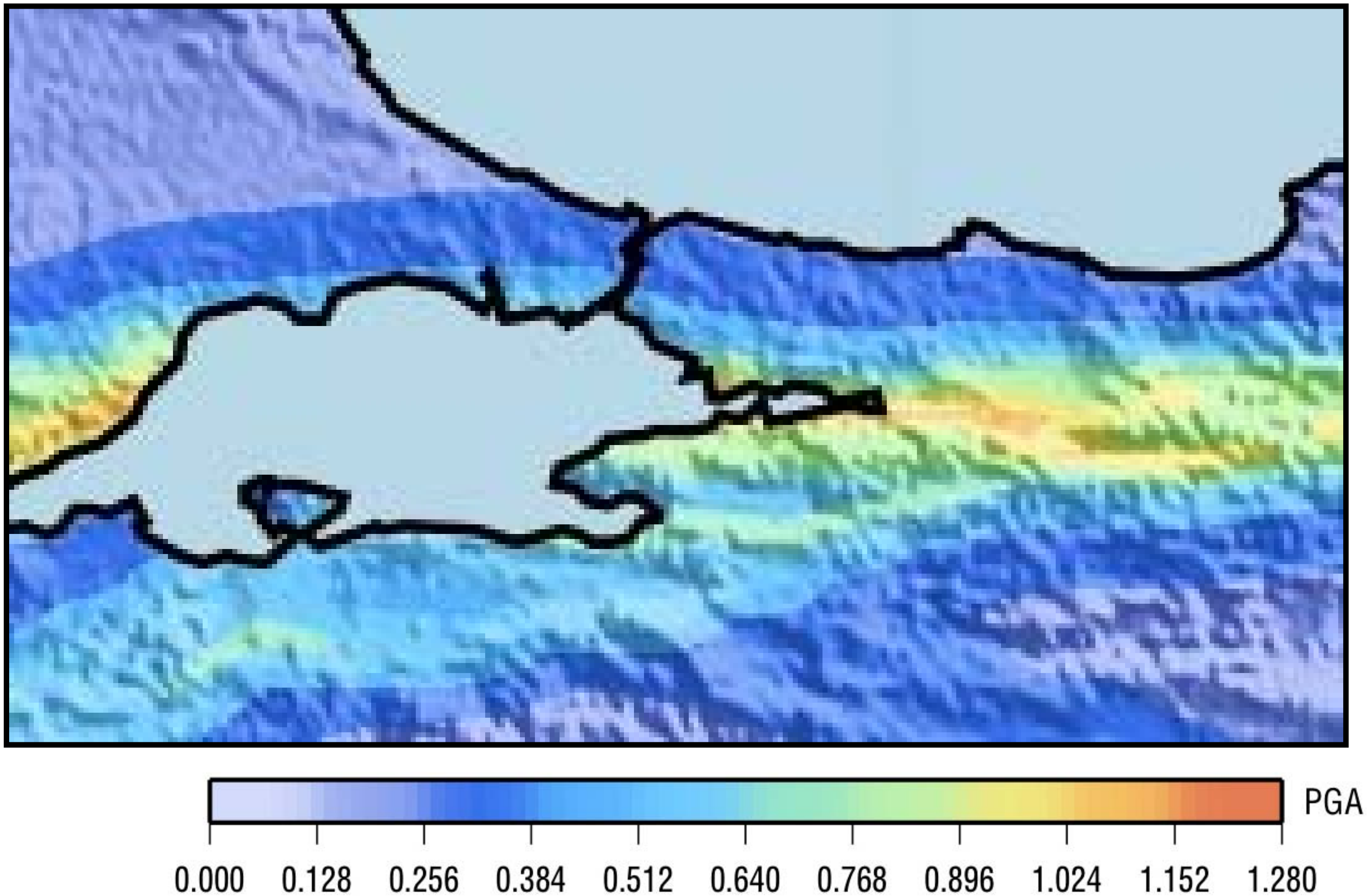
PGA map for 10% PE in 50 years



PGA map for 2% PE in 50 years

PROBABILISTIC ASSESSMENT OF THE MARMARA REGION

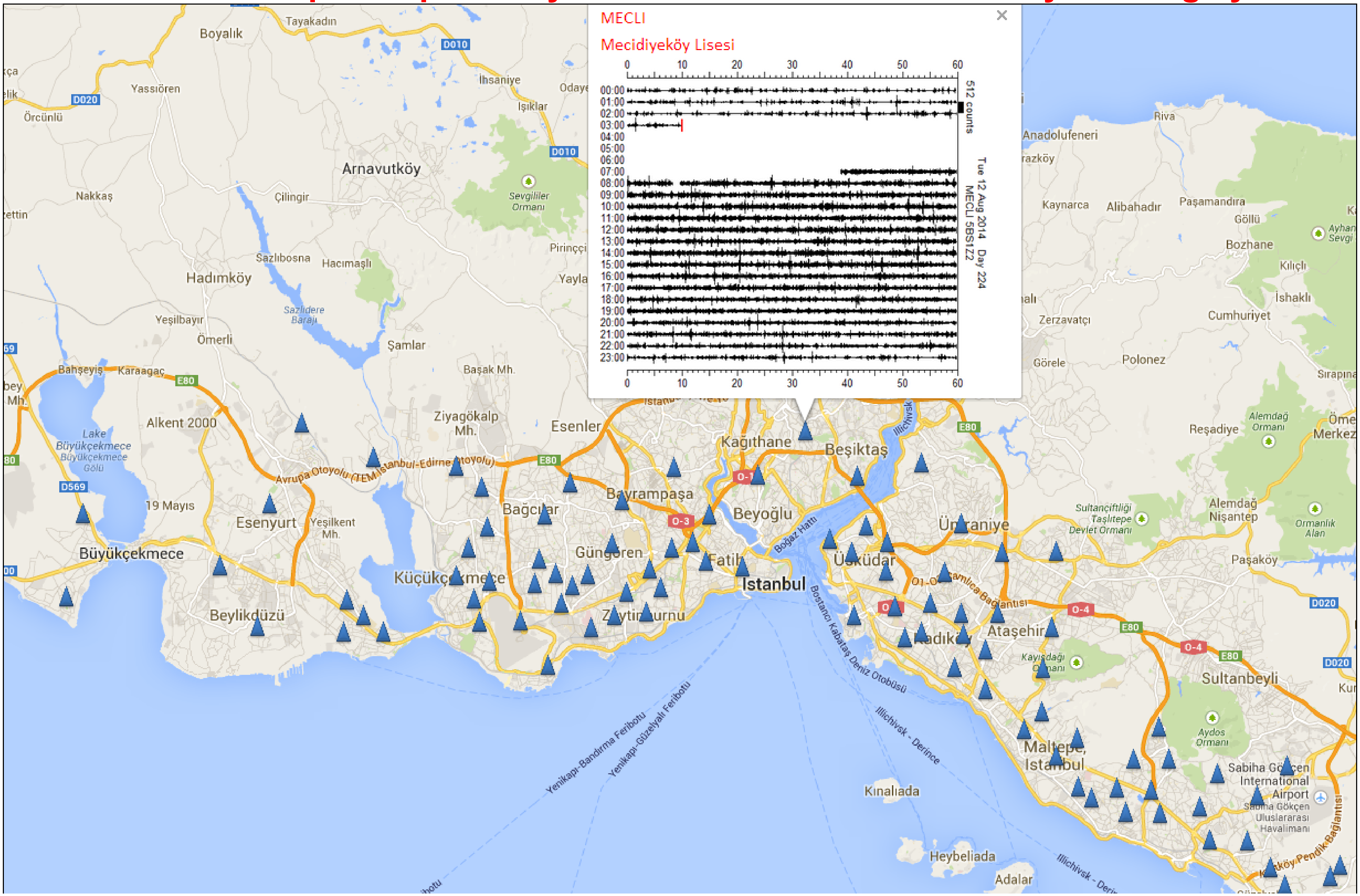
%10/50 PGA

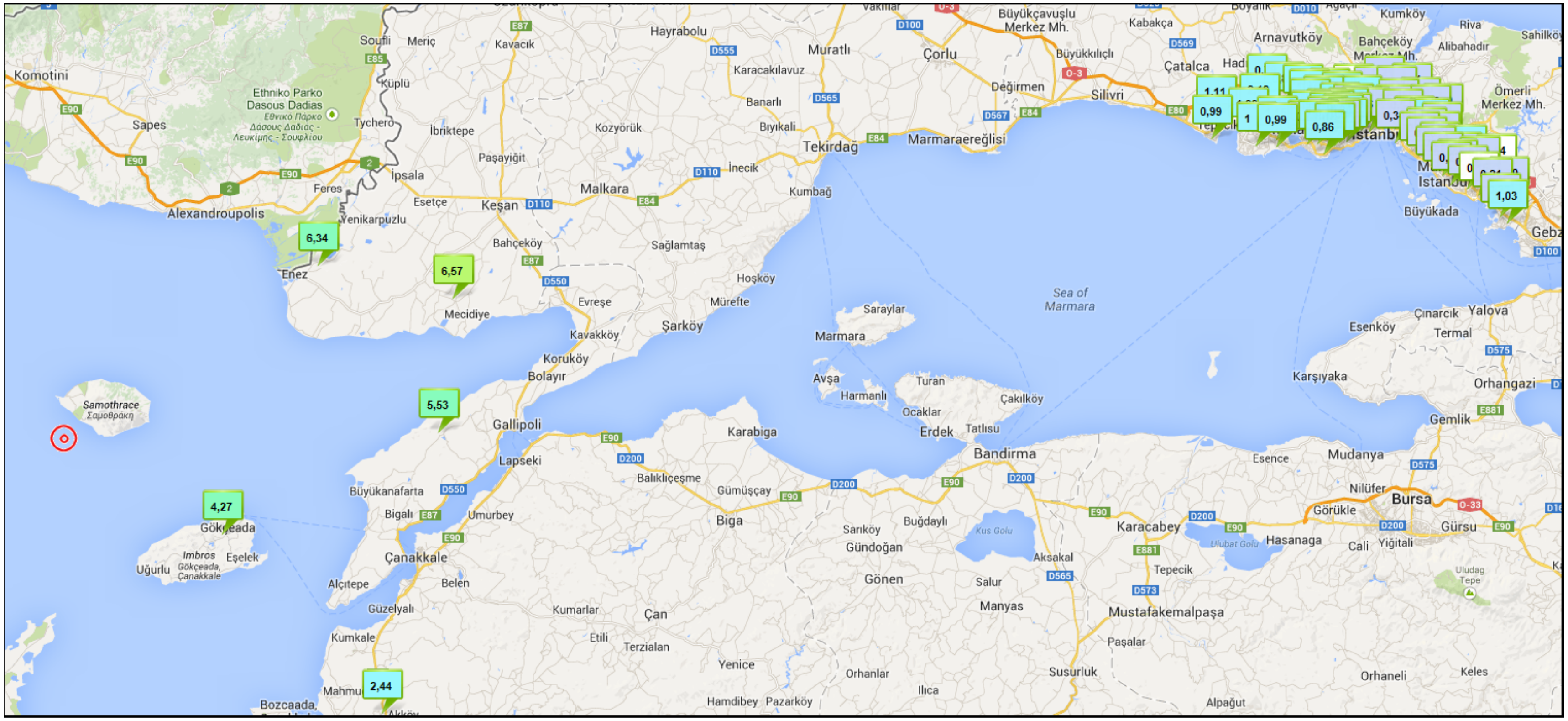


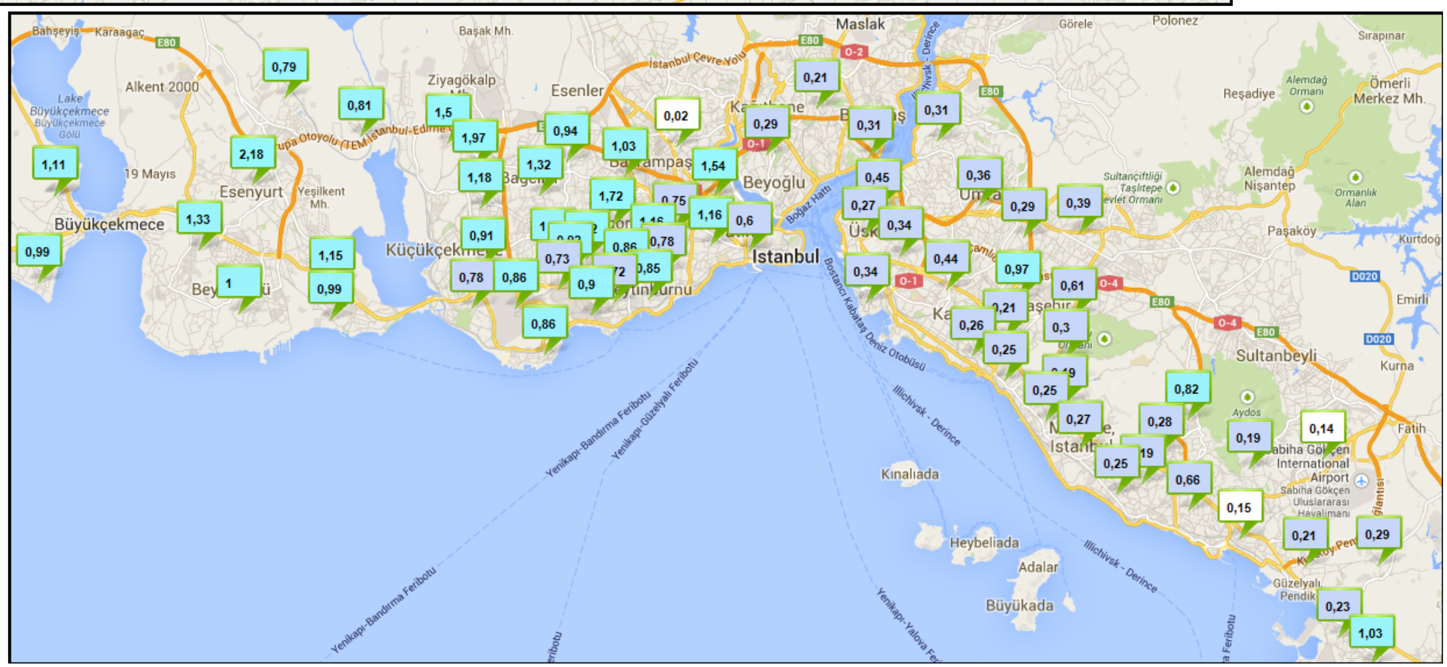
About 11.000 ground motion fields were produced for the risk calculations, using the fault source model. Above, a hazard map for a 10% probability of exceedance in 50 years is presented.

İSTANBUL EARTHQUAKE RAPID RESPONSE SYSTEM

120 stations for rapid response systems and 10 stations for early warning systems







PGA DISTRIBUTION FOR 24.05.2014 M6.5 AEGEAN EARTHQUAKE

http://kandilli.info/

Kandilli.info

Tarih	Saat	Enlem	Boylam	Derinlik	MD	ML	Mw	Siddet	Yer
2014.03.04	17:15:46	38.8623	43.6422	5	-.-	3.3	-.-	III	KELLE-(VAN)
2014.03.04	16:11:17	38.8502	43.6558	6	-.-	3.5	3.6	III	KELLE-(VAN)
2014.03.03	16:14:49	38.4362	45.136	5	-.-	3.0	-.-	II	IRAN
2014.03.02	23:15:16	41.7402	43.1098	5.3	-.-	3.4	-.-	III	GURCISTAN
2014.03.02	07:33:16	36.786	35.1547	9.4	-.-	3.0	-.-	III	YASSIOREN-KARATAS (ADANA)
2014.03.02	06:29:09	36.7735	35.1567	13	-.-	3.5	-.-	III	DAMLAPINAR-KARATAS (ADANA)
2014.03.02	06:25:57	36.7853	35.1752	6.7	-.-	4.0	-.-	IV	KEFELI-TARSUS (MERSIN)
2014.03.02	05:34:27	44.4127	34.3493	63.1	-.-	4.1	-.-	IV	KARADENIZ
2014.03.01	17:38:27	35.142	27.413	11.2	-.-	3.2	-.-	III	MEDITERRANEAN SEA
2014.03.01	12:54:50	39.3765	44.4453	8.4	-.-	3.0	-.-	III	SARICAVUS-DOGUBAYAZIT (AGRI)
2014.03.01	02:09:25	34.1795	26.1847	97	-.-	3.4	-.-	III	GIRIT ADASI ACIKLARI (MEDITERRANEAN SEA)
2014.03.01	00:13:53	38.258	22.4632	12.7	-.-	3.6	-.-	III	YUNANISTAN
2014.02.28	17:35:15	41.1922	25.482	11.7	-.-	3.3	-.-	III	YUNANISTAN
2014.02.28	15:16:57	39.2738	29.2982	5	-.-	3.6	-.-	III	KIRGIL-EMET (KUTAHYA)
2014.02.28	05:51:48	36.0488	25.0797	8.3	-.-	4.0	-.-	III	GIRIT ADASI (MEDITERRANEAN SEA)
2014.02.27	21:16:55	35.5582	23.4047	30.9	-.-	3.8	-.-	III	GIRIT ADASI (MEDITERRANEAN SEA)
2014.02.27	10:09:22	39.0262	30.0553	5	-.-	3.9	-.-	IV	KARAAGAC-ALTINTAS (KUTAHYA)
2014.02.27	10:03:58	39.006	30.0305	5	-.-	3.0	-.-	III	KARAAGAC-ALTINTAS (KUTAHYA)
2014.02.27	09:59:54	39.0097	30.0587	6	-.-	3.9	3.8	III	KARAAGAC-ALTINTAS (KUTAHYA)
2014.02.26	14:10:42	38.884	42.3702	5	-.-	3.0	-.-	II	GOLGOREN-AHLAT (BITLIS)
2014.02.26	09:34:17	41.0367	39.0897	11.5	-.-	3.0	-.-	II	KEKIKTEPE-EYNESIL (GIRESUN)

Project funded by the EUROPEAN UNION

SciNet NatHaz Prevention

Black Sea CROSS BORDER COOPERATION

A Scientific Network
for Earthquake, Landslide & Flood Hazard Prevention

SciNetNatHazPrev – STAKEHOLDERS MEETING

NOVEMBER 12-13, 2015, ISTANBUL, TURKEY

VENUE: MAÇKA SOCIAL CENTER, ISTANBUL TECHNICAL UNIVERSITY FOUNDATION

THANK YOU
FOR YOUR ATTENTION