THE EFFECTS OF THE DIFFERENT SOURCE MODELS ON PSHA FOR THE TURKISH TERRITORY

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Abstract: Turkey is located in one of the most seismically active regions in the world and consequently has been an important contributor to several international projects related to regional scale seismic hazard assessment (SHA). Among these four major projects towards the unified assessment and mapping of seismic hazard in the European-Mediterranean region, Middle East region, and at aglobal scale. These were in chronological order::

The Global Seismic Hazard Assessment Program (GSHAP), a UN/IDNDR demonstration project, produced the first seismic hazard map for the European-Mediterranean region as part of the Global Seismic Hazard Map, based on the compilation and assemblage of hazard results obtained independently in different test areas and multinational programs (Adria, Ibero-Maghreb, Central-Northern Europe, Fennoscandia, Turkey and Greece, Caucasus, Near East, the Balkans). We (as BU-KOERI) were in charge of the external project area which provided the opportunity of interaction with other European institutions.

The **ESC-SESAME** project (European Seismological Commission -IUGS Program Project no. 382) produced a unified model for Probabilistic Seismic Hazard Assessment for Europe and the Mediterranean. We (as KOERI) have jointly worked and furthered our cooperation with European institutions involved in the project

SHARE project (Seismic Hazard Harmonization in Europe) was a Collaborative Project in the Cooperation programme of the Seventh Framework Program of the European Commission. SHARE's main objective was to provide a community-based seismic hazard model for the Euro-Mediterranean region with update mechanisms. We (as BU_KOERI) have jointly implemented our knowledge through a multidisciplinary work, and furthered our cooperation with European institutions involved in the project

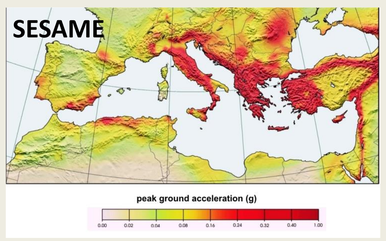
EMME project (the Earthquake Model of the Middle East) aimed to contribute and facilitate the seismic risk reduction in the Middle East region through the realization of the following specific tasks: 1) Calculate seismic hazard uniformly and with highest standards, 2) Rigorously validate earthquake and shaking probabilities using regional and global data, 3) Communicate seismic risk clearly, accurately and transparently, 4) Integrate local expertise in a regional and global context. Several institutions from Turkey have contributed to EMME and BU-KOERI has also acted as one of the project coordinators.

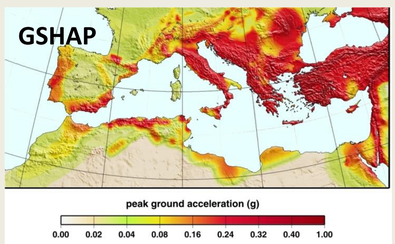
There have been two recent national projects towards the assessment and mapping of seismic hazard for the Turkish Territory. **DLH** project aimed at the preparation of an earthquake resistant design code for the construction of railways, seaports and airports (DLH, 2007;Demircioglu et al.2004). Secondly, a national earthquake strategy and action plan were conceived and accordingly with the collaboration of the several institutions and expert researchers, the Revision of Turkish Seismic Hazard Map Project (**UDAP-Ç -13-06**) was initiated. Due to the necessity to review the national active fault database and the compiled earthquake catalogue for the development of a national earthquake hazard map, developed techniques, increased knowledge and improved databases were used for the revision of Turkish Seismic Hazard Map. SHARE (Woessner et al, 2013); EMME (Danciu et al, 2017, Sesetyan et al., 2017), and UDAP-Ç -13-06 models use multiple source modelling approaches combined in a logic tree structure. In the present study, we compare PSHA results obtained from the above-mentioned national and international studies, in terms of hazard curves for major city locations in Turkey, and the contribution of the different source models to the results.

INTERNATIONAL SCALE

DEFINITION: Global Seismic Hazard Map (GSHAP, Giardini et al., 1999; Giardini et al.,2003). The primary goal of GSHAP was to create a global seismic hazard map in a harmonized and regionally coordinated fashion, based on advanced methods in probabilistic seismic hazard assessments (PSHA). The Global Seismic Hazard Map depicts the seismic hazard as peak ground acceleration (PGA) with 10% probability of exceedence in 50 years, corresponding to a return period of 475 years.

DEFINITION: Seismotectonic and Seismic Hazard Assessment of the Mediterranean Basin (SESAME). The IGCP project SESAME was focused on the extension of the uniform seismic source zone model derived within GSHAP for Europe north of the Mediterranean (GSHAP Regions 3 at the GFZ) to the south.





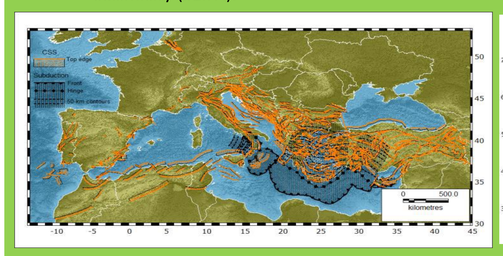
DEFINITION:
Seventh Framework Programme Theme 6: Environment Seismic Hazard Harmonization in Europe (SHARE)
http://www.share-eu.org/

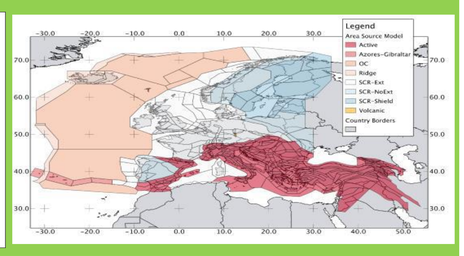
SHARE - Seismic Hazard Harmonization in Europe" (www.share-eu.org) is a Collaborative Project in the Cooperation programme of the Seventh Framework Program of the European Commission. SHARE's main objective is to provide a community-based seismic hazard model for the Euro-Mediterranean region with update 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:

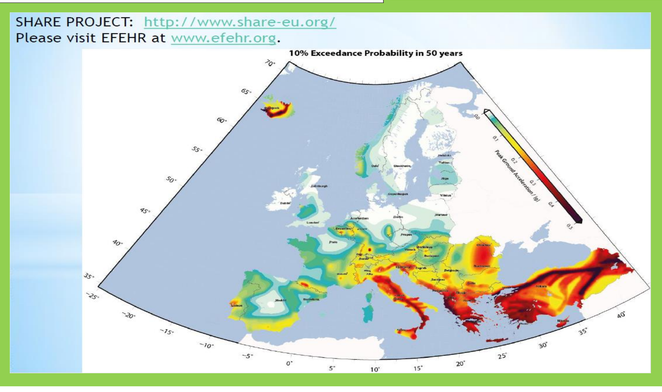
SOURCE MODEL:

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).







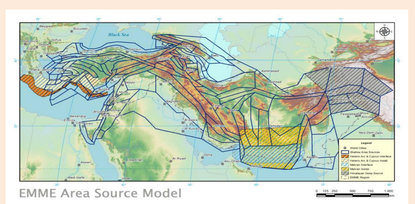
DEFINITION:
EMME - Earthquake Model of the Middle East region: Hazard, Risk Assessment, Economics & Mitigation
http://www.emme-gem.org/ S (Danciu et al. 2016)

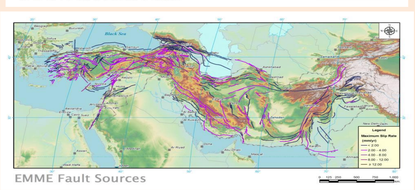
Another regional project is EMME "Earthquake Model of Middle East" (www.emme-gem.org) , which aims at the assessment of earthquake hazard, the associated risk in terms of structural damages, casualties and economic losses and also at the evaluation of the effects of relevant mitigation measures in the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

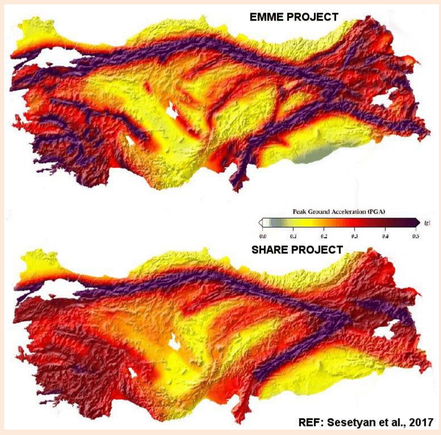
SOURCE MODEL:

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

- ✓ a classic Area Source (AS) Model
- ✓ a model that activity rates based on fully parameterized faults imbedded in large background seismicity zones, with the combination of the smoothed seismicty model.







CONCLUSION

- ➢ The inputs to the probabilistic seismic-hazard analysis (PSHA) have large uncertainties regarding the seismic source model parameters; therefore, results may vary significantly due to subjective judgment and interpretation of the limited data.
- ➢ The variances in the hazard results obtained by different seismic source models are closely correlated with the source-to-site distance and the acceptable hazard level.
- ➢ While building the fault source models, several assumptions and/or simplifications have to be made to define the fault parameters and the associated uncertainty. The hazard analysts should be absolutely familiar with all aspects of the PSHA framework to develop a common sense on the sensitivity of the hazard outcome to different source models and model parameters. The factors affecting the b-value such as the source zone boundaries, catalogue completeness intervals, catalogue declustering, and regression methodology should be properly considered and the involved uncertainty should be included in the logic tree

The first unofficial seismic hazard map of Turkey by Sieberg (1932)

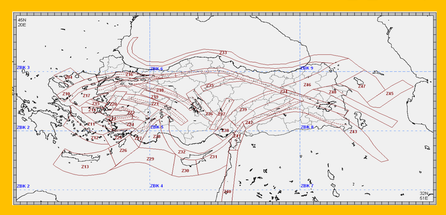
DEFINITION:
The seismic source zonation model of Turkey developed within the context of a project conducted for the Ministry of Transportation Turkey, aiming the preparation of an earthquake resistant design code for the construction of railways, seaport and airport. (DLH, 2007)

SOURCE MODEL:

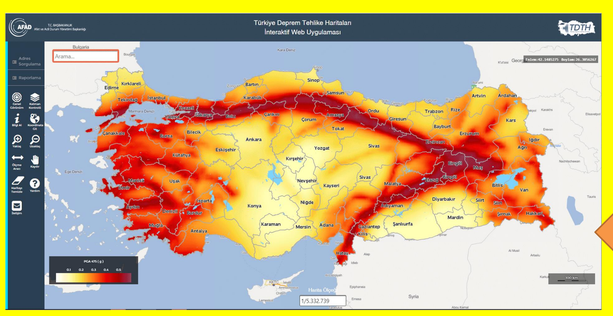
The earthquakes with magnitude > 6.5 are assumed to take place on the linear zones (Purple line), whereas the smaller magnitude events associated with the same fault are allowed to take place in the surrounding larger areal zone(Green Line).

In addition to linear and areal source zones, background seismicity zones are defined to model the floating earthquakes that are located outside these distinctly defined source zones and to delineate zones where no significant earthquake has taken place.

Web Address for hazard maps. :
http://www.koeri.boun.edu.tr/YayInlar/YonetmelIkler_4_12.depmuh



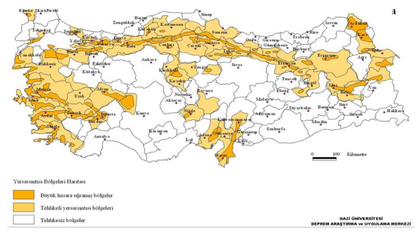
DEFINITION: INTERACTİVE WEB BASED EARTHQUAKAE HAZARD MAP PREPARED BY AFAD:
https://testtdth.afad.gov.tr/



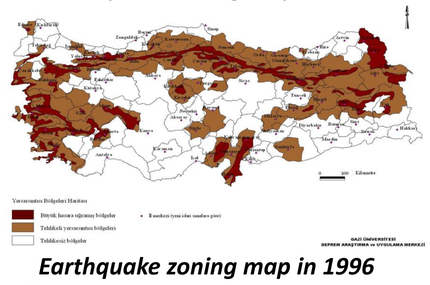
NATIONAL SCALE

As the first article of the act stated, Ministry of PublicWorks and Settlement and Ministry of National Education, with all the data in hand, prepared the first official earthquake zoning map in 1945. "Earthquake Zoning Map" came into force on July 12, 1945 with the Council of Ministers' 3/2854 numbered decision. The map was scaled 1/2,000,000. According to the map, our country was divided into 3 regions as: Regions of High Damage, Dangerous Earthquake Regions and Regions without Danger. The map was updated by the decision of the Council of Ministers and put into force respectively in 1947, 1963, 1972and 1996 because of the developments in engineering seismology, the increase in tectonic and seismo tectonic data as well as the increase in earthquake records. The first unofficial earthquake zoning map was prepared by A. Sieberg in 1932. The reference of all figures is Pampal, and Özmen, 2009.

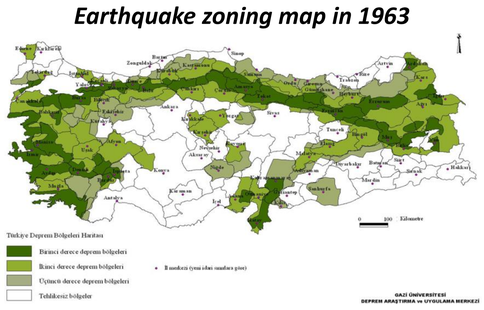
The first official earthquake zoning map in 1945



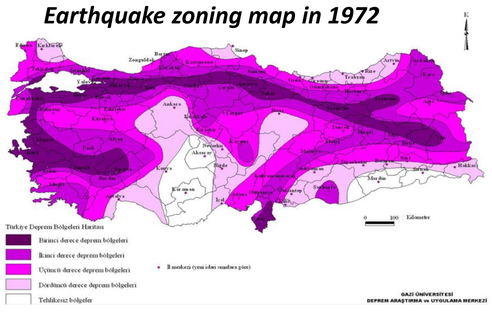
Earthquake zoning map in 1947



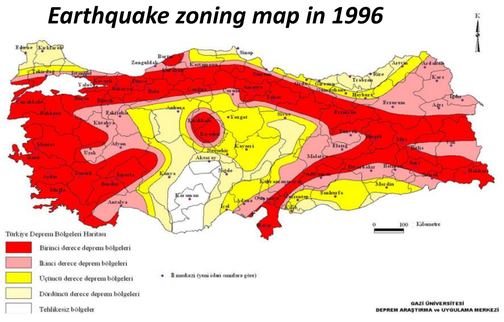
Earthquake zoning map in 1963



Earthquake zoning map in 1972



Earthquake zoning map in 1996

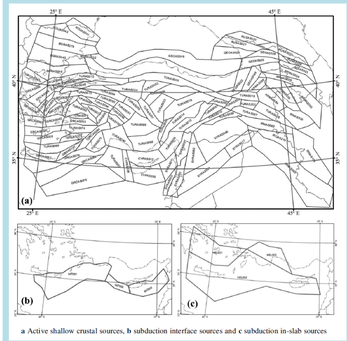


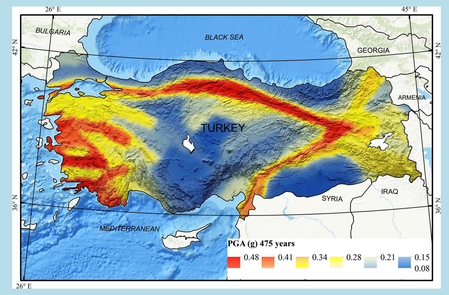
DEFINITION: Revision of Turkish Seismic Hazard Map (**UDAP-Ç-13-06**). This project were supported by Republic of Turkey Prime Ministry Disaster and Emergency Management Authority (AFAD) and Turkish Natural Catastophe Insurance Pool (DASK). The project group consists of researchers and faculty members of AFAD, BU, Cukurova University, TCIP, MTA, METU and Sakarya University.

- 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)

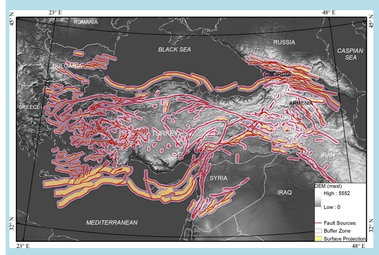
SOURCE MODEL:

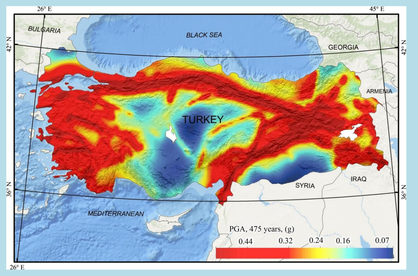
THE AREA SOURCE MODEL: Şeşetyan et al., 2016: DOI: 10.1007/s10518-016-0005-6





THE FAULT AND BACKGROUND SOURCE MODEL: Demircioglu et al, 2017, DOI: 10.1007/s10518-017-0130-x





In Revision of Turkish Seismic Hazard Map (**UDAP-Ç-13-06**) Project (Akkar et al., 2016), equal weights were assigned to the area source and fault source & background models (i.e 0.5 and 0.5each). The hazard maps for different ground motion parameters (i.e., PGA, Sa(T=0.2s) and Sa(T=1.0s)) corresponding to 43, 72, 475 and 2475 years return period are published by AFAD on an interactive web portal. Currently, the web site is still at a test stage. However, it will be published as soon as the recent national building code comes into force.

	LAN	LOT	1945	1947	1963	1972	1996
ISTANBUL	28.964	41.020	HIGH DAMAGE ZONE	HIGH DAMAGE ZONE	2ND DEGREE HAZARD ZONE	2ND DEGREE HAZARD ZONE	1ST DEGREE HAZARD ZONE
ANKARA	32.849	39.929	UNDAMAGED ZONE	UNDAMAGED ZONE	UNDAMAGED REGION	4TH DEGREE HAZARD ZONE	4TH DEGREE HAZARD ZONE
IZMIR	27.136	38.423	HIGH DAMAGE ZONE	HIGH DAMAGE ZONE	1ST DEGREE HAZARD ZONE	1ST DEGREE HAZARD ZONE	1ST DEGREE HAZARD ZONE
ERZURUM	41.287	39.913	HIGH DAMAGE ZONE	HIGH DAMAGE ZONE	1ST DEGREE HAZARD ZONE	1ST DEGREE HAZARD ZONE	1ST DEGREE HAZARD ZONE

PGA_475	LAN	LOT	DLH	SHARE	EMME	UDAP
ISTANBUL	28.964	41.020	0.52	0.446	0.380	**0.374**
ANKARA	32.849	39.929	0.153	0.215	0.191	**0.149**
IZMIR	27.136	38.423	0.504	0.357	0.296	**0.459**
ERZURUM	41.287	39.913	0.269	0.351	0.404	**0.462**