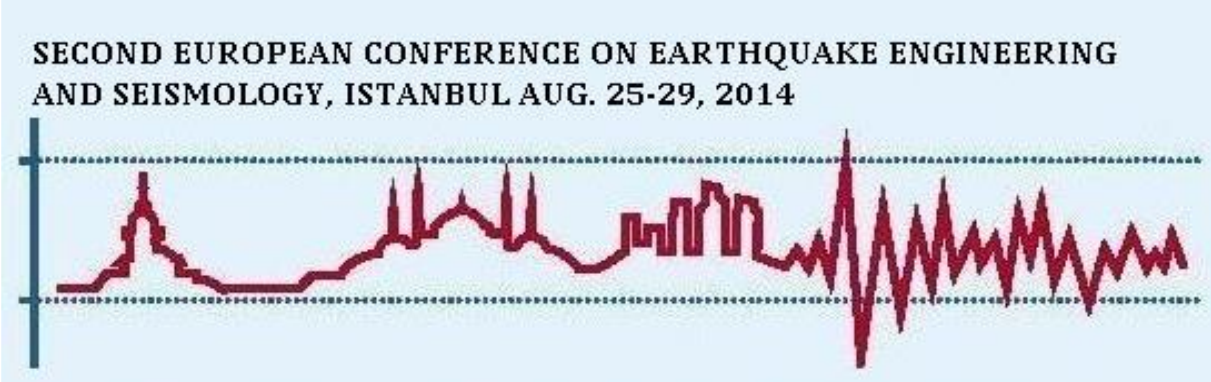

RAPID ESTIMATION OF EARTHQUAKE LOSSES IN TURKEY USING AFAD-RED SYSTEM

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ABSTRACT

In order to enhance the rapid response and emergency operation after the earthquake, valuable information can be achieved by utilizing the modern technology of the seismic instrumentation and loss estimation methodologies.
In this paper, shaking maps generation and rapid estimation of earthquake losses system in Turkey is introduced. Advanced algorithms are implemented to integrate the earthquake source information with the strong ground motion stations records to produce reliable shaking maps. Then, rapid loss estimation algorithm is developed to generate earthquake losses maps.
The system, which is called AFAD-RED (AFAD Rapid Earthquake Damage and Loss Estimation Software), utilize the earthquake parameters obtained from earthquake observation stations that operated by AFAD Department of Earthquake to estimate the ground shaking maps for the earthquake area. Currently, AFAD-RED utilizes the available building and population database in Turkey to estimate the building and fatality loses due to a specified earthquake.

INTRODUCTION

The technological advances in seismic instrumentation and telecommunication permit the development of rapid estimation of earthquake losses in order to enhance the rapid response and emergency operation after the earthquake.

Current earthquake rapid loss estimation methodologies have different approaches to measure and estimate the ground shaking of earthquake area, in order to estimate the intensity and damage maps.

The first approach uses the seismic source parameters (hypocenter, magnitude, intensity) in order to compute the ground shaking and potential damage.

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The second approach use the direct engineering parameters such as peak ground acceleration (PGA), peak ground velocity (PGV), spectra displacements (SD) and Intensity maps to compute the potential damage. The second approach requires a large number of seismic stations (strong motion instruments), which are distributed uniformly over an urban area.

AFAD-RED system are planned to estimate the earthquake risk loses all over Turkey. Therefore, combination of the above two methodologies are adopted (Figure 1). The existing online accelerometers operated by AFAD are integrated into the system. Therefore AFAD-RED system is designed to utilize both weak and strong earthquake monitoring systems that operated by AFAD. The two monitoring system are called National Seismological Monitoring Network and National Strong Motion Network of Turkey.

It is worth to say that, KOERI is operating an earthquake rapid response and early warning system for Istanbul area. The rapid response part constitutes of extensive array of strong motion accelerometers that placed in populated areas of Istanbul, within an area of approximately 50x30km, to constitute a network that will enable rapid shake map and damage assessment after a damaging earthquake (Erdik, et al. 2003).

AFAD-RED system can also be utilized to run earthquake scenarios for the risk assessment due to a scenario earthquake. The output of risk assessment analysis is used for planning and execution of the management and mitigation of the seismic disaster and damage within the study area. Knowing the seismic risk and potential losses allows for proper budgetary planning, raising public awareness, assessment and allocation of the necessary manpower for mitigation and disaster management operations, educating the public and professionals on preparedness and mitigation, and prioritization of retrofit applications (EERI, 1997).

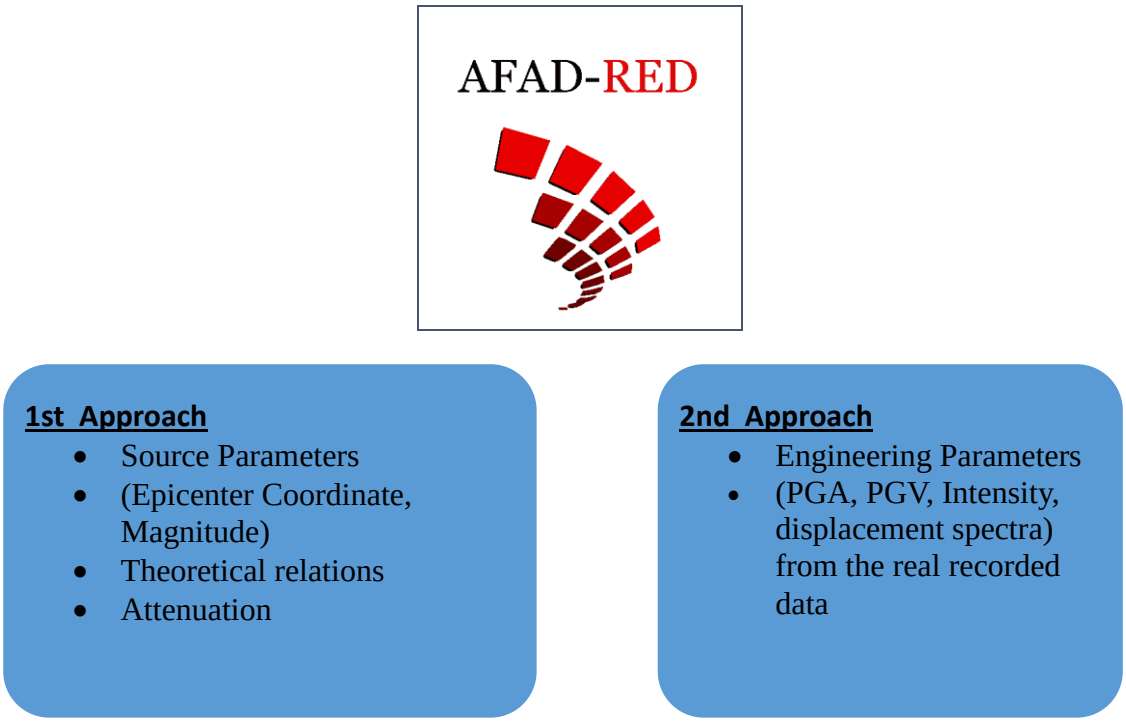

Figure 1. Integration of Shaking maps approaches (Estimated and Real Recorded parameters)

National Seismological Monitoring Network of Turkey

In 1989, "Telemetric Earthquake Monitoring Network System" was established in nationwide under a National Earthquake Monitoring Network System with 12 stations for earthquake monitoring, recording, evaluation, archiving and announcement. Then with the "National Seismic Network Development (USAG) Project" "Telemetric Earthquake Monitoring Network System" was transformed into "Turkey's National Earthquake Monitoring Network System" which is in the world-class, have high-quality data and can receive real-time data.

By December 2013 the number of National Earthquake Monitoring Network System stations reached to 422 and after that earthquake activities have been simultaneously monitoring, evaluating, archiving and offering public service via web pages. According to Earthquake Administration Strategic Plan (2011- 2014), the number of the stations will increase 20 pieces per year and it is expected to reach 265 by the end of 2014. So, the earthquakes which have 2.0 and bigger magnitude should be recorded and evaluated in any part of our country and the earthquake activity in our country will be closely monitored (Figure 2).

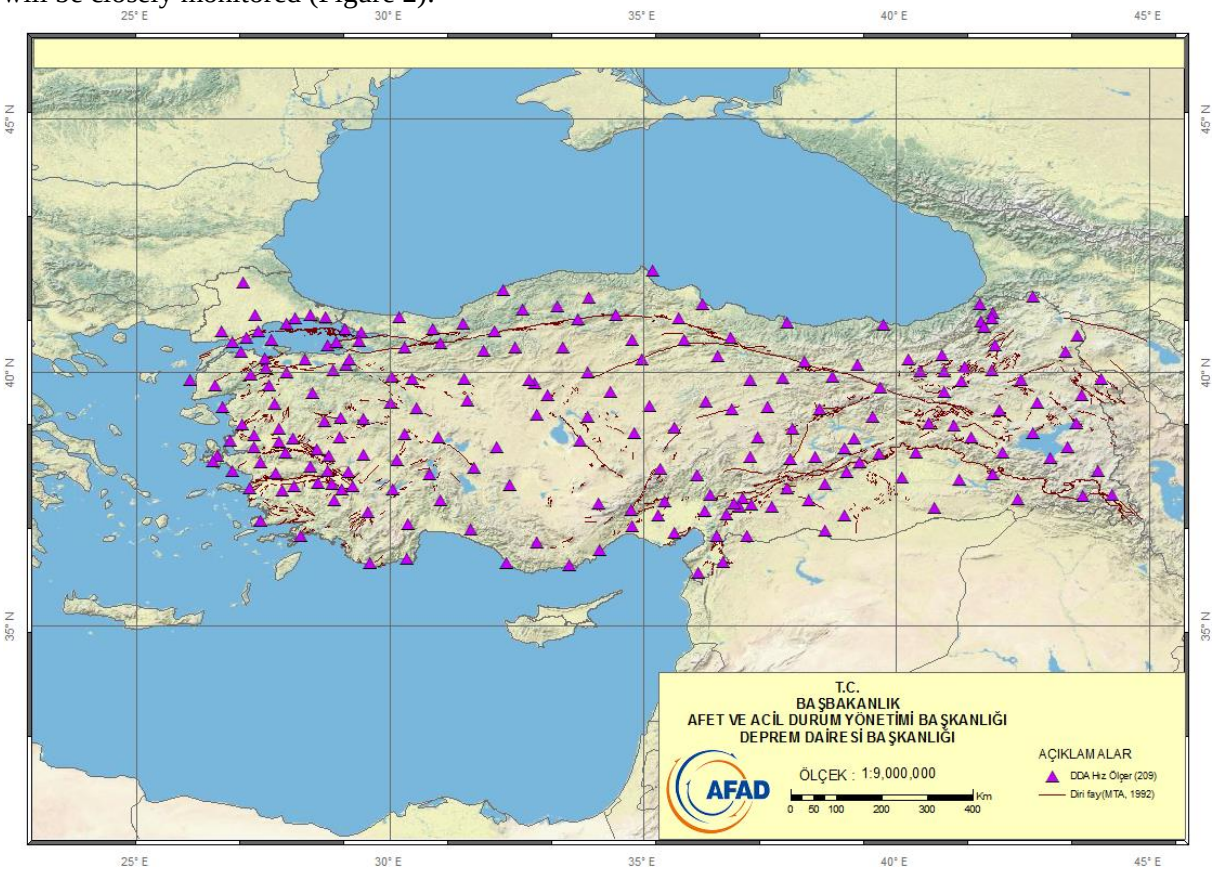

Figure 2. National Seismological Network of Turkey

National Strong Motion Network of Turkey

Turkey's National Strong Ground motion Monitoring Network (TR-SGM), is operated in the country since 1973, and from 17 December 2009 the network continues its works under Earthquake Administration. As of November 2011, Turkey's National Strong Ground motion Monitoring Network (TR-SGM), has 372 pieces of accelerometer stations.

According to Earthquake Administration Strategic Plan (2011- 2023), the number of the stations will increase 50 pieces per year and it is expected to reach 1000 by the year 2023. Since (TR-SGM)'s

establishment, acceleration records archive is created by compiling the past earthquake acceleration records and this archive is being constantly updated (Figure 3).

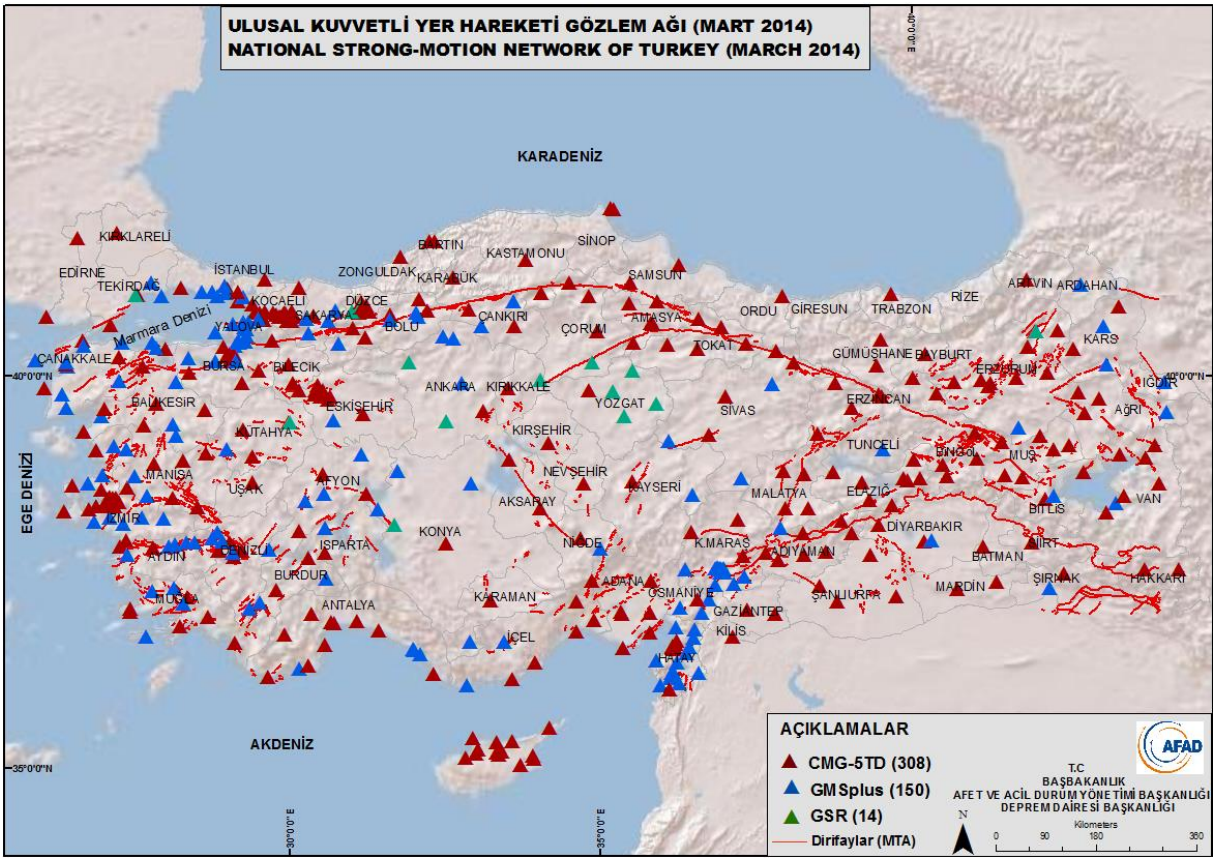

Figure 3. National Seismological Network of Turkey

AFAD-RED Rapid Estimation of Earthquake Loses System

The main objective of AFAD-RED project is to develop a methodology and a software for “Rapid Loss Estimation” after an earthquake in Turkey. With realizing “Rapid Loss Estimation System” it is expected to minimize chaos and information pollution and enable effective emergency response to disaster area.

The system is designed for nearly real time estimation of losses after a major earthquake in disaster area by the integration of the online data provided by the two existing monitoring systems National Seismological Monitoring Network and National Strong Motion Network of Turkey. “Rapid Loss Estimation System” combines the estimated and recorded strong ground parameters to produce the shaking maps for the earthquake. Then, a procedure to estimate the building losses is performed. The procedure utilizes the seismic hazard information, local soil conditions, and building inventory data within the geographic information systems (GIS) platform to compute the losses maps.

Estimation of Shake Map Parameters

To ensure fast and reliable Shake maps generations, three approaches are considered. The schematic algorithm of the three approaches is given in Figure 4.

The first approach is performed automatically as soon as the earthquake epicenter and magnitude are announced on the AFAD-Earthquake Department server. The approach use the attenuation relationship to estimate the shake map parameters then the soil amplification effects are

considered to produce the PGA, PGV, spectral Acceleration (SD) and Intensity parameters for all the area in the vicinity of the earthquake epicenter.

The second approach can be used whenever further information about focal mechanism of the earthquake is available. The fault geometry with any number of points can be introduced. The closest distance to the fault is computed based on provided fault information.

The third approach is performed automatically by checking the avialiabity of the strong ground motion records on the data server. The recorded accelerograms are processed automatically and the recorded PGA, PGV, SA are computed for the location of the corresponding accelerometers. In order to combine with the shake map generated by the first approach, the following procedure is used:

- Processing of strong ground motion records to compute shaking map parameters PGA, PGV and SA for the accelerometers locations.
- Removing the soil effects of the computed parameters to have the shaking parameters for B/C soil level.
- Estimating the shaking parameters for all the area of the vicinity of the earthquake epicenter at B/C Soil Level
- Integrating the recorded parameters with the estimated shaking map parameters PGA, PGV, SD for the B/C soil level using Fuzzy logic approach based on the radial distances between the records locations and earthquake epicenter/fault locations.
- Applying soil amplification and compute the earthquake intensity maps.

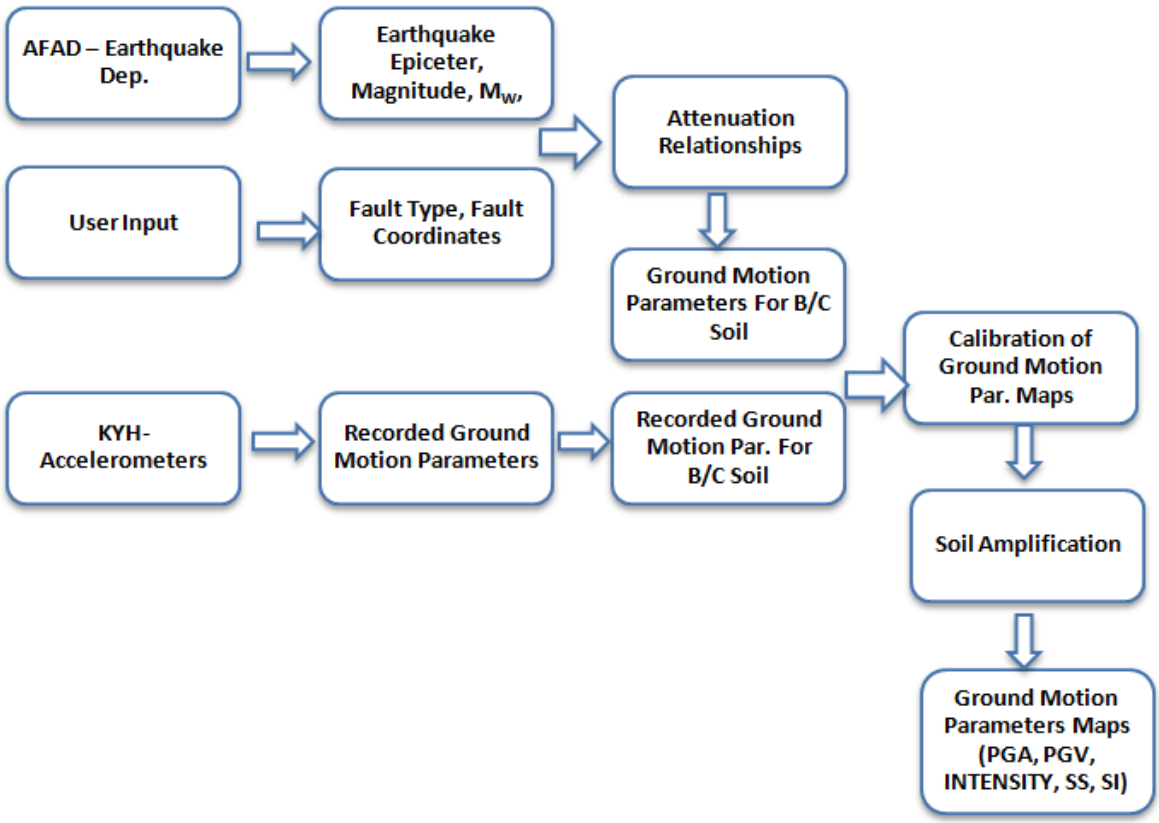

Figure 4 Estimation of shake map parameters

Rapid Post-Earthquake Damage Assessment Methodology

The shake maps are used as the basis for the automatic preparation of building damage and fatality loses maps.

The generation of rapid loss information is based on both spectral displacements and instrumental intensities are used. These methodologies are coded into online computer programs similar to HAZUS-MH MR3 (2003). Both of spectral displacements and instrumental intensities essentially rely on the building inventory database, fragility curves and the methodology developments.

Using the estimated shake maps of response spectra and the instrumental intensities the building damage and the casualties are computed separately by using the spectral-displacement based and intensity based fragility curves.

The computations are conducted at the centers of user defined grid system comprised of geo-cells. The building inventories for each geocell together with their spectral displacement and intensity based fragility curves are incorporated in the software. The casualties are estimated on the basis of the number of collapsed buildings and degree of damage.

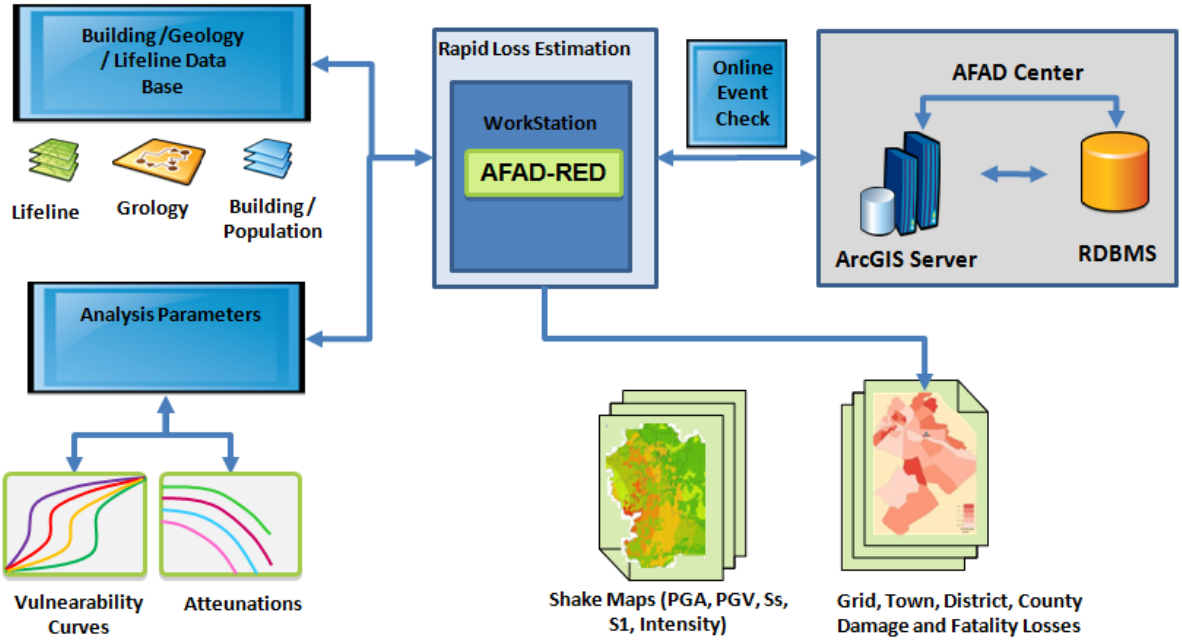

Figure 5 AFAD-RED System for shake maps and earthquake damage estimation

Features of Software and Superiorities to Current Rapid Loss Estimation Systems

AFAD RED system is developed for all Turkey where the country districts have different population density, life culture, tectonics and earthquake potential to estimate the losses in disaster area as nearly in real time after a major earthquake.

AFAD RED is user friendly software that has simple interface and online monitoring for the weak motion and strong motion systems in AFAD (Figure 6). The software is working in both online and offline modes and can be able to automatically generated shake and risk maps. AFAD RED system is developed under VB-Net and C# environments for the system design and the Arc-Object is used for mapping and geographic information system. Different attenuation relationships can be used as a weighted average and the calculation of structural damage for different building types, the

fragility curves can be used simultaneously for both intensity and spectral-based. The casualties loss can be estimated based on both intensity and damage level of buildings.

Example of intensity map that results for earthquake combing the estimated and recorded strong motion parameters data is provided in Figure 7.

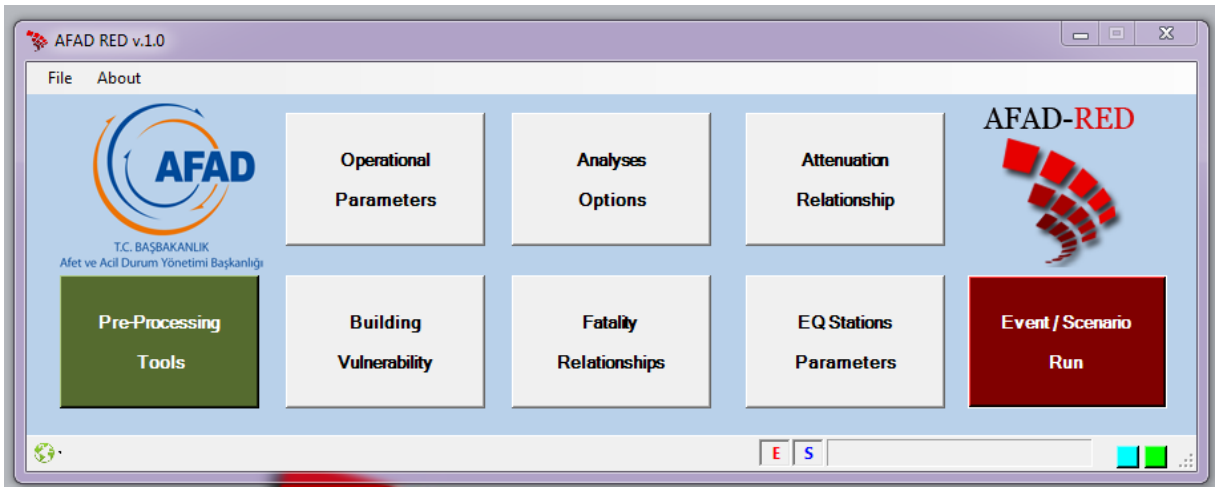

Figure 6. User Interface of AFAD-RED System

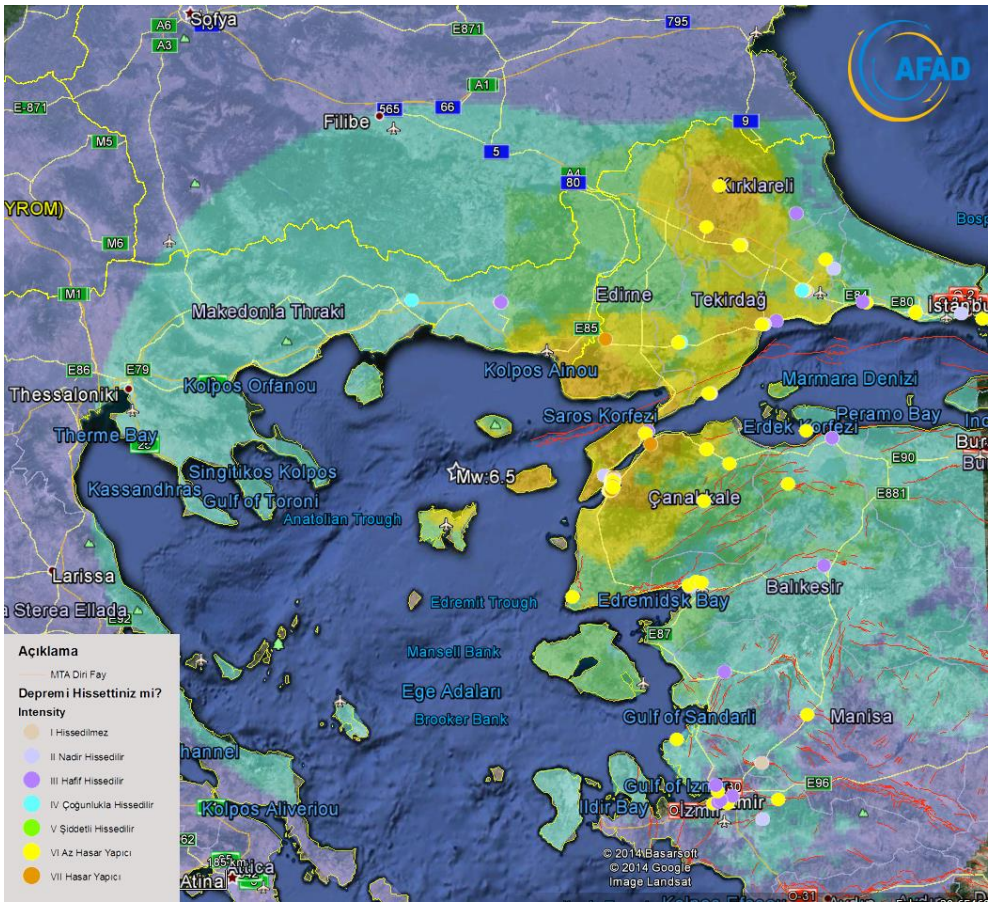

Figure 7. Simulated intensity map of real earthquake

CONCLUSION

AFAD-RED (AFAD Rapid Earthquake Damage and Loss Estimation Software) is designed and developed for nearly real time estimation of losses after a major earthquake in disaster area by the integration of the online data provided by the two existing monitoring systems National Seismological Monitoring Network and National Strong Motion Network of Turkey.

The procedure utilizes the seismic hazard information, local soil conditions, and building inventory data within the geographic information systems (GIS) platform to compute the losses maps. The generation of rapid loss information is based on both spectral displacements and instrumental intensities are used. The computations are conducted at the centers of user defined grid system comprised of geo-cells. The building inventories for each geocell together with their spectral displacement and intensity based fragility curves are incorporated in the software. The casualties are estimated on the basis of the number of collapsed buildings and degree of damage.

AFAD-RED is under development to include direct economical loss, direct damage for lifeline, critical facilities and direct damage for transportation systems of Turkey.

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