

## **The October 23, 2011 Van, Turkey Earthquake ( $M_w=7.2$ )**

### **STRONG GROUND MOTION**

Distribution of estimated peak ground accelerations and peak ground velocities associated with the mainshock are shown in Figures 1 and 2. These figures are obtained by ELER and Google Earth and show site-dependent ground motion values obtained using the GMPE by Chiou and Youngs (2008). The figures suggest peak accelerations in the order of 0.6 g and peak velocities more than 50 cm/s may have been experienced in the epicentral region of the earthquake. It should be stated however that there is no evidence yet from the field, in terms of structural and utility damage and casualties, to support these levels of ground motion.

In Figure 3 we present the regional distribution of adjusted peak ground accelerations based on the ground motion data from the National Strong Ground Motion network and from the National Network of Iran. The comparison between the actual and estimated peak accelerations can be seen in Figure 4 on station basis.

The instrumental intensities due to the main shock and the main-aftershock are presented in Figures 5 and 6. Until empirical data become available, the estimations suggest that an epicentral intensity of VIII was experienced in the region.

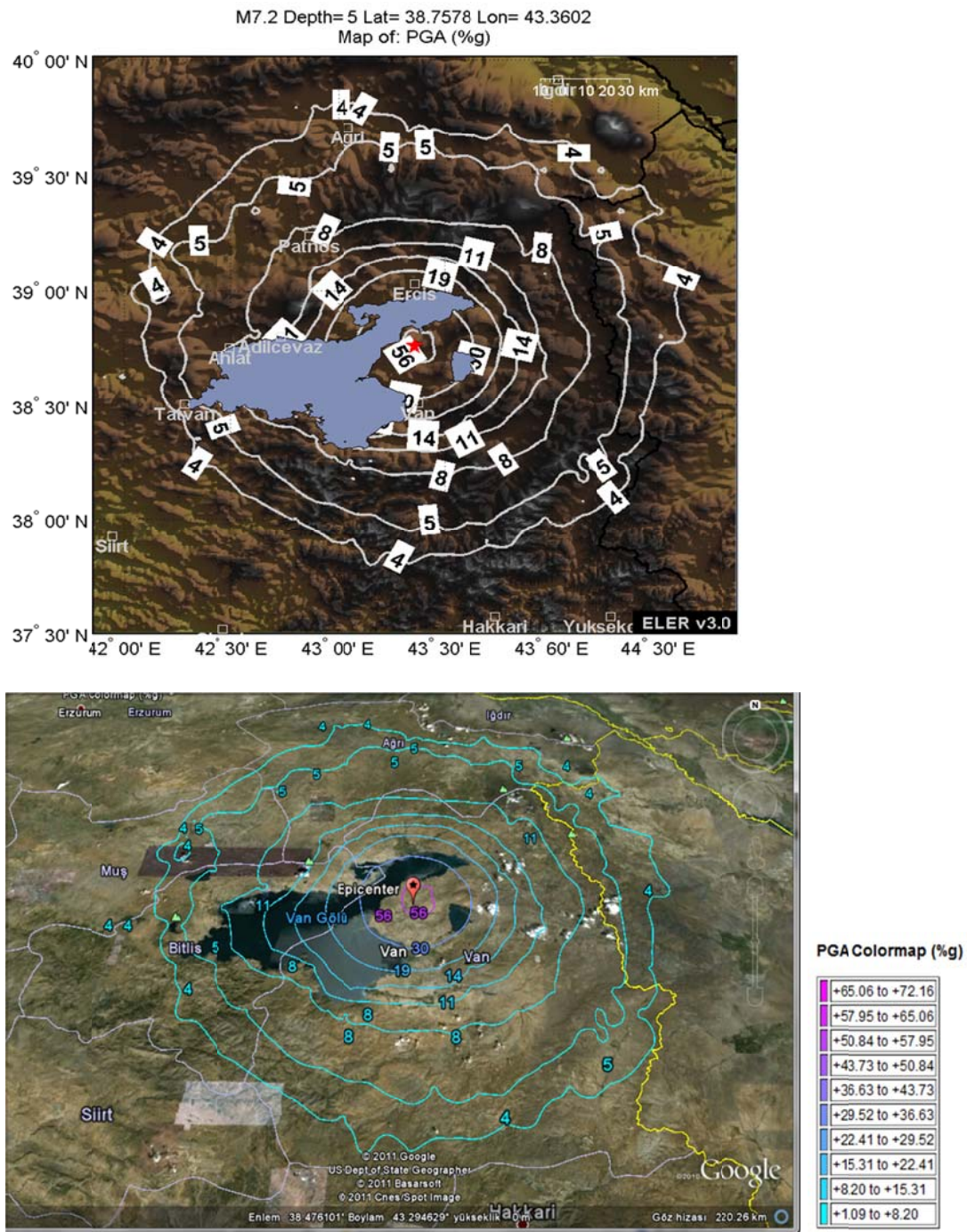


Figure 1. Distribution of peak ground accelerations associated with the mainshock.



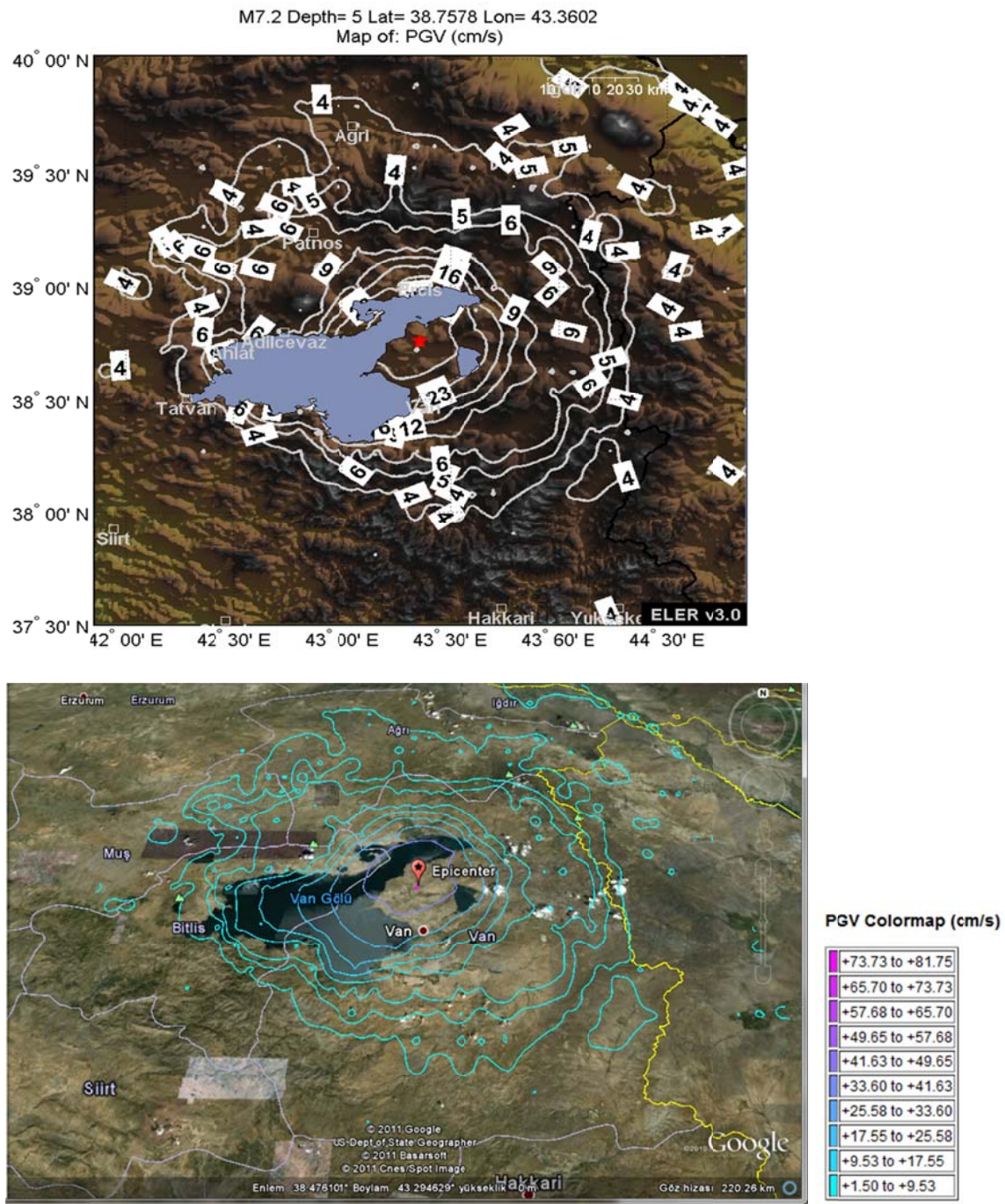


Figure 2. Distribution of peak ground velocities associated with the mainshock.

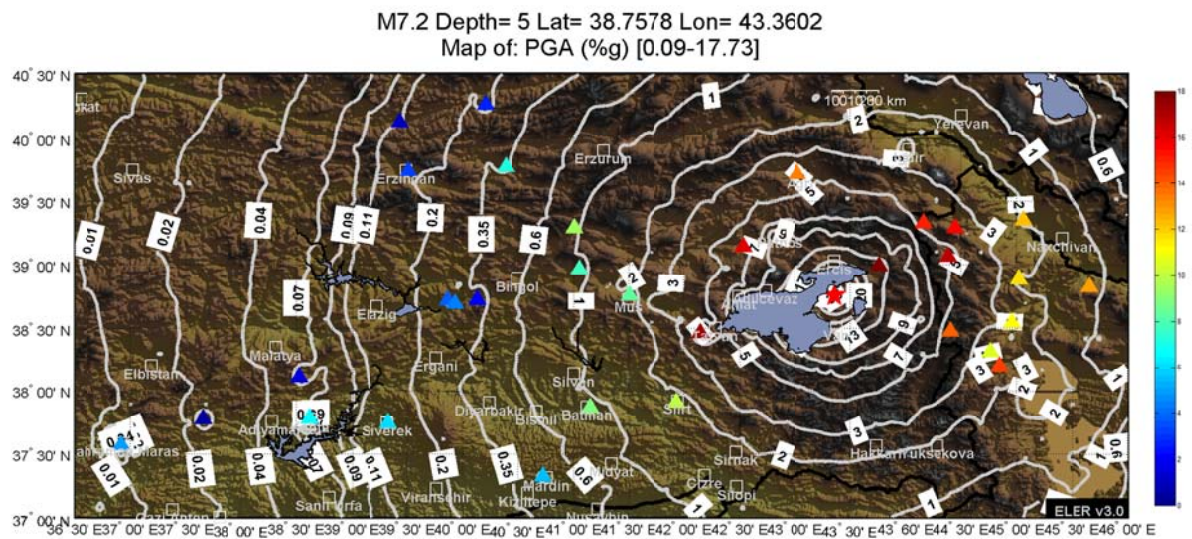


Figure 3. Distribution of peak ground accelerations bias-adjusted using strong ground motion data from regional networks.

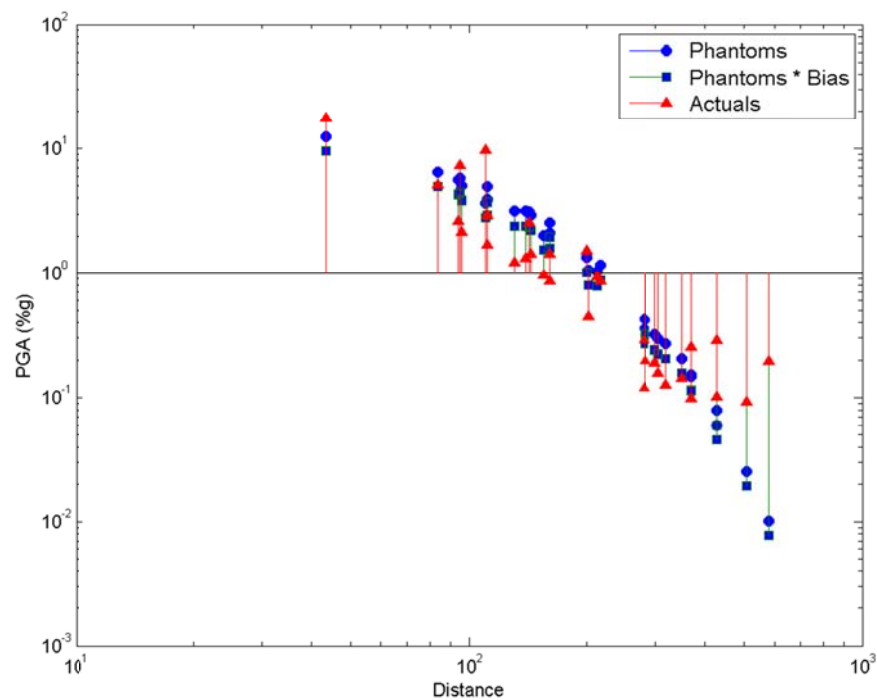


Figure 4. Comparison between the actual and estimated peak ground accelerations for individual stations used in the bias adjustment



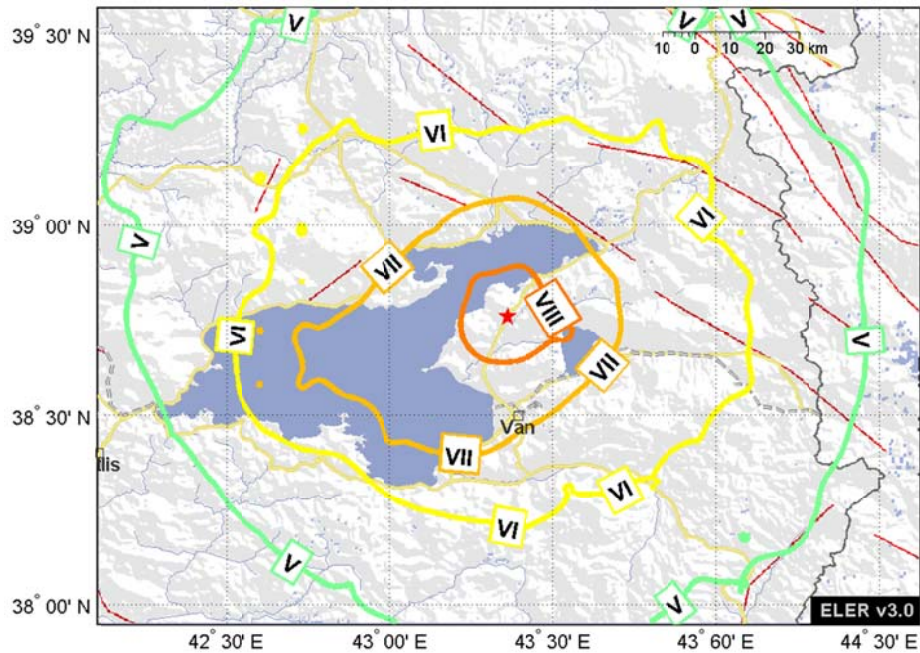


Figure 5. Instrumental intensities associated with the mainshock

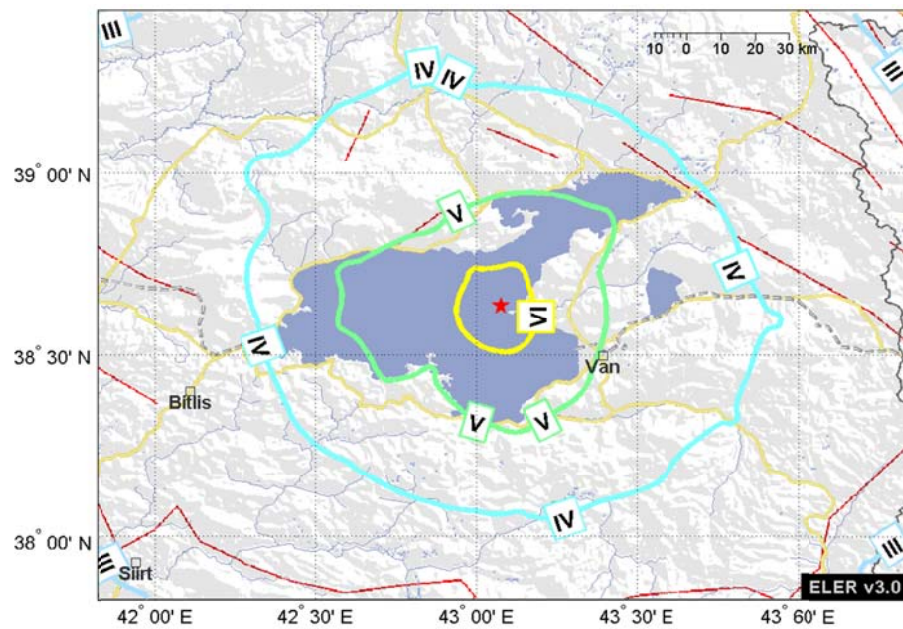


Figure 6. Instrumental intensities associated with the main aftershock (M 5.7)

### National Strong Ground Motion Network

The National Strong Ground Motion Network is operated by the Earthquake Department (<http://www.deprem.gov.tr/>) of the Disaster and Emergency Management Presidency –AFAD (<http://www.afetacil.gov.tr/>). The station layout as of June 2011 is given in Figure 7.

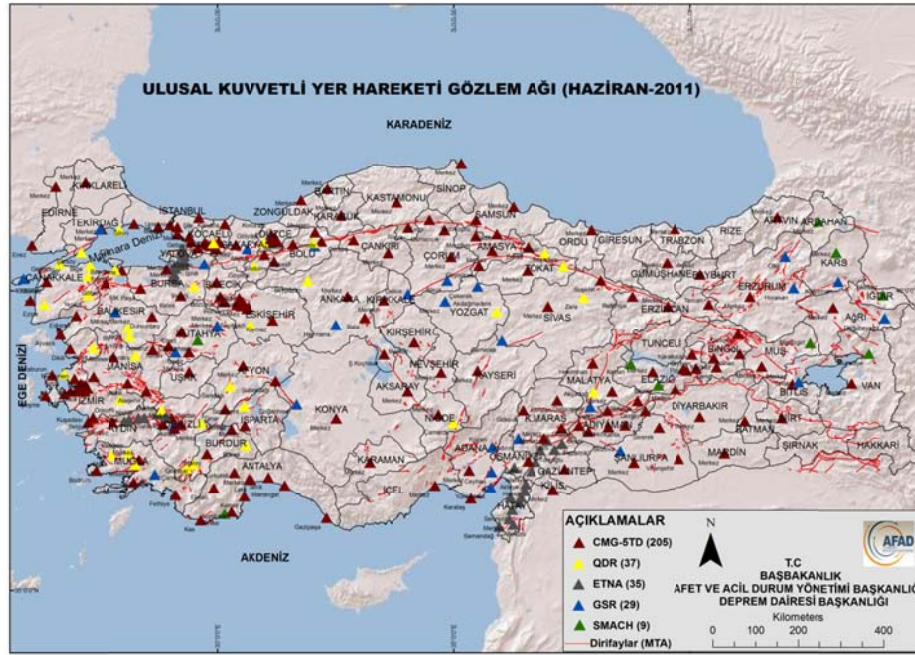


Figure 7. <http://kyh.deprem.gov.tr/>

7 stations of the national strong ground motion network, located in the provinces of Van, Mus, Bitlis and Agri, are within 120 kms of the epicenter. A raw peak ground acceleration of 0.18g is recorded at the station in Muradiye. The records obtained by the national network can be downloaded from <http://kyh.deprem.gov.tr/ftpe.htm>. For station information of the national network please see link <http://kyh.deprem.gov.tr/istbilgien.htm>. The processed records can be found at link [http://eerc.metu.edu.tr/Van\\_RawProc\\_Records](http://eerc.metu.edu.tr/Van_RawProc_Records). Comparison of the unprocessed PGA's with the NGA GMPE's, presented in Figure 8, indicates that the recorded ground motion levels are in agreement with the ground motion levels estimated by the GMPE's at distances larger than 30kms. There are no records obtained within 30 km's of the epicenter, where the damage is concentrated. In Figure 8, the distances are calculated according to the epicentral coordinates reported by KOERI.

The two nearest records to the epicenter were obtained in Muradiye and Bitlis. The acceleration record in the Muradiye station is 46 km away from the epicenter. The one recorded in Bitlis is at 116 km epicentral distance. The distance values are as reported by AFAD. In Figure 9 we present corrected accelerations, velocities, displacements, FAS, Arias Intensities and energy densities

associated with the Muradiye record. The records are uniformly corrected using baseline correction and a 4th order Butterworth bandpass filter between 0.1 and 25 Hz. The same information for the Bitlis station is in Figure 10. The peak accelerations in station Muradiye are  $195 \text{ cm/s}^2$  and  $167 \text{ cm/s}^2$  in the NS and EW directions respectively. In Bitlis stations the largest acceleration is  $101.5 \text{ cm/s}^2$  in the EW direction. The largest velocities in Muradiye station are obtained as  $27 \text{ cm/s}$  in the NS direction. Spectral accelerations associated with these two records are below the design levels of the Turkish rcode (Figure 11). Spectral velocities and displacements are shown in Figure 12. Based on bias-adjusted PGA's, the epicentral acceleration is estimated as 0.35 g (Figure 3).

Previous studies had varying views on the characteristics of the fault that this earthquake took place on (see sections on seismotectonics and hazard). Before detailed analysis of the aftershocks becomes available, regarding their hypocentral distribution, we can only hypothesize about the 3D geometry of the fault plane based on information from the field on ground deformations, damage distribution and strong motion data. The particle motions of the Muradiye record can be seen in the two subplots of Figure 13. If a wide frequency range is used in getting the particle motions the sense of dominant motion is not very clear. If we use a narrow frequency range, however, the NW-SE direction emerges as the dominant sense of ground displacements. Using special processing techniques it is possible to deduce permanent displacements from strong motion data. The results of such a preliminary exercise can be seen in Figure 14, which shows permanent displacements in the order of 3 cm in the NS direction. It should be noted that more information from INSAR and from the field are needed to further comment on permanent displacements.

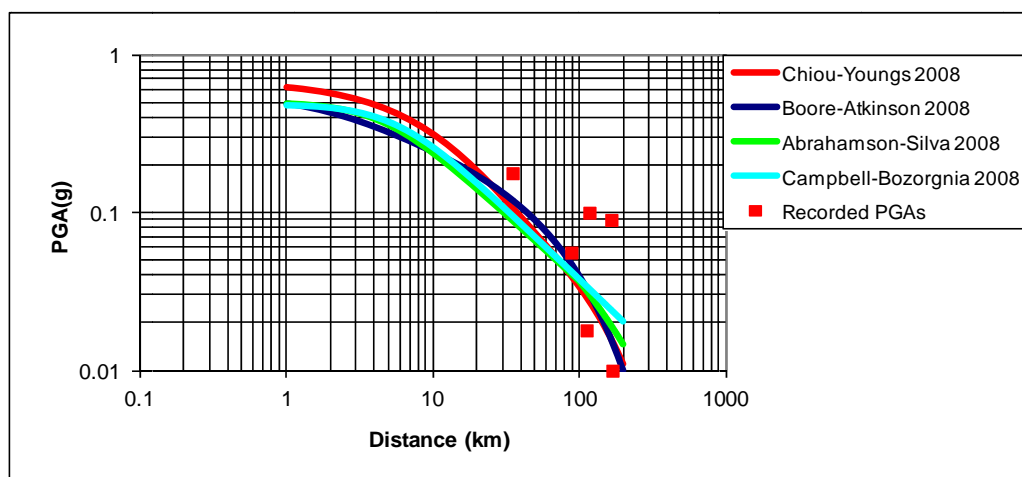


Figure 8. Comparison of recorded ground motion PGAs with NGA GMPEs



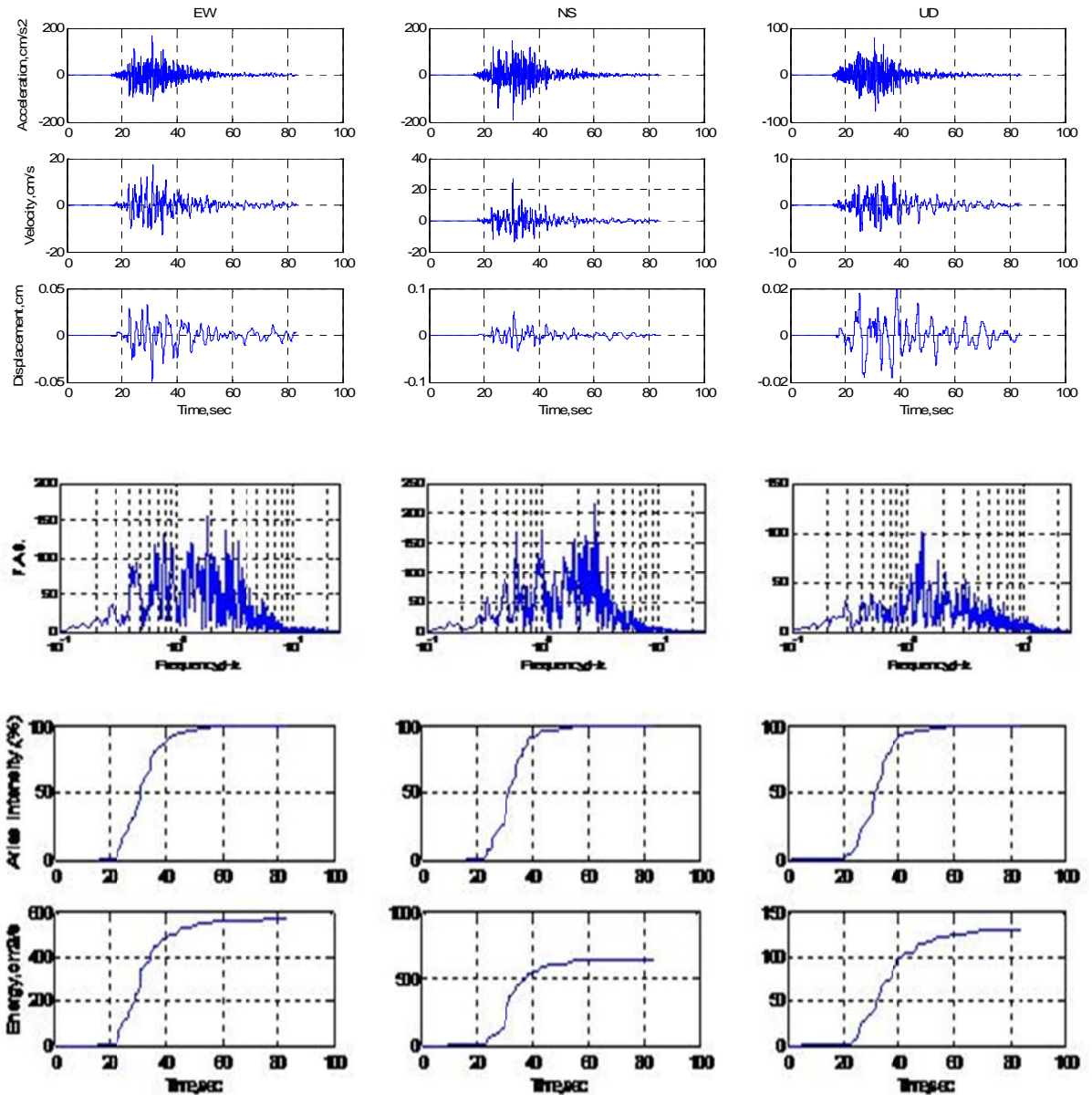


Figure 9. 6503 Muradiye Station. Corrected acceleration, velocity, displacement time histories, FAS, Arias intensities and energy densities in EW, NS and UD directions



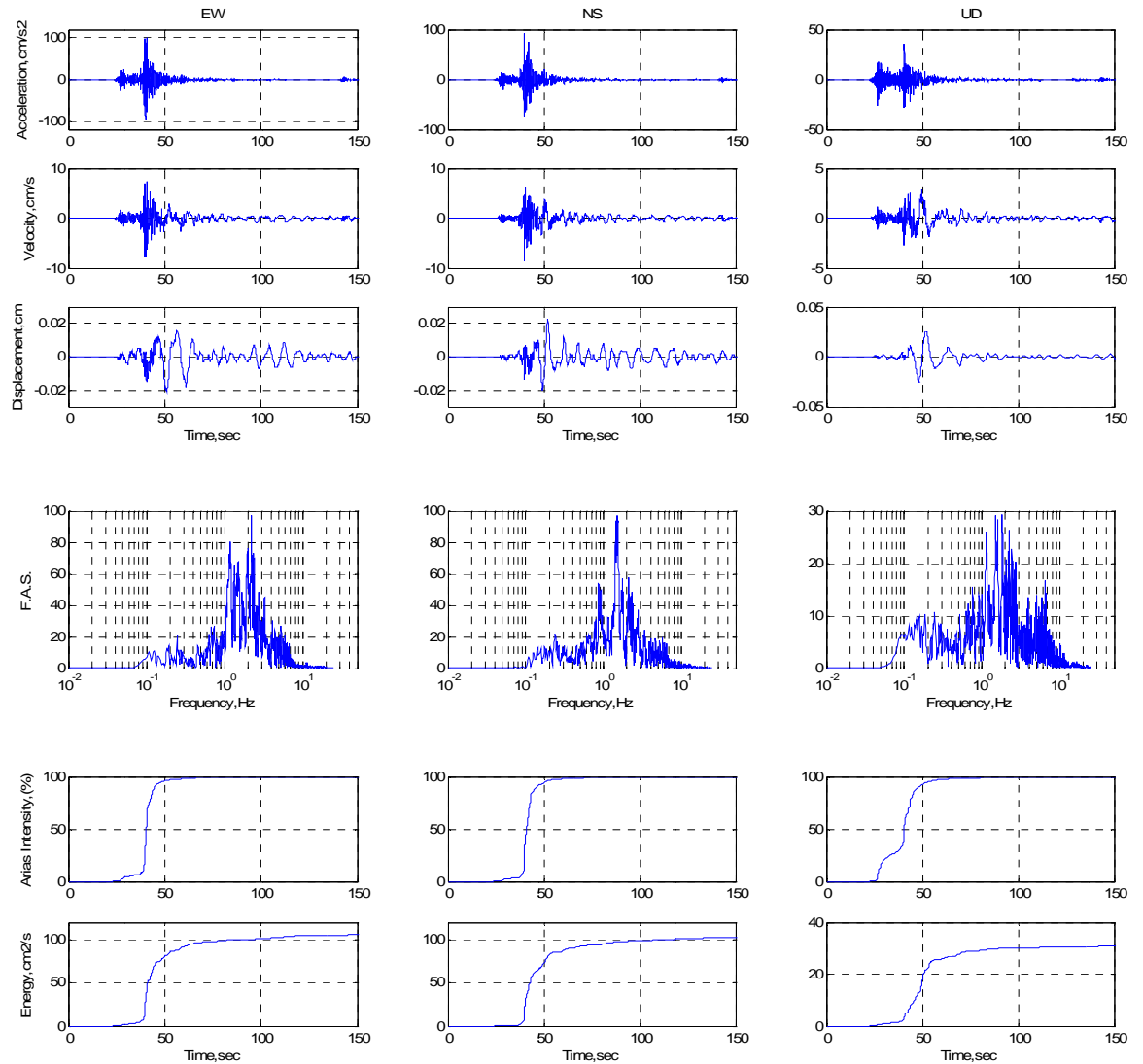


Figure 10. 1302 Bitlis Station. Corrected acceleration, velocity, displacement time histories, FAS, Arias intensities and energy densities in EW, NS and UD directions

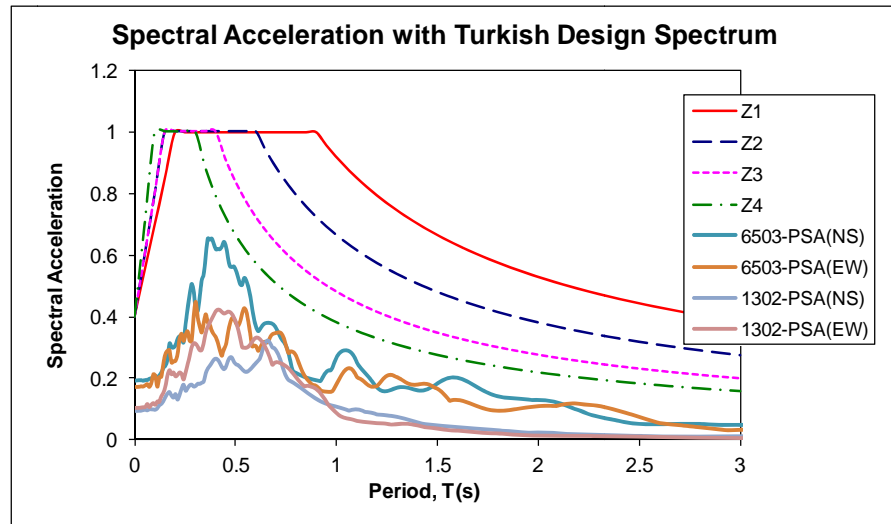


Figure 11. Spectral accelerations of two horizontal components of the 6503 Muradiye ve 1302 Bitlis stations shown with the Turkish Design Spectra for four types of soil conditions.

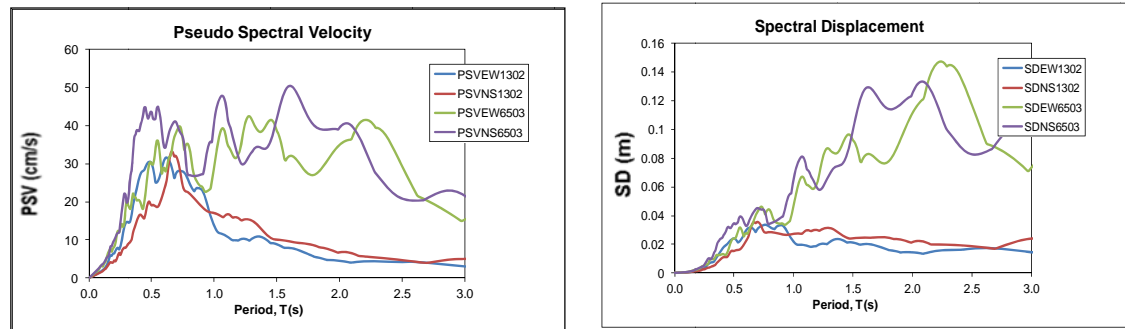


Figure 12. Spectral velocities and displacements of two horizontal components of the 6503 Muradiye and 1302 Bitlis records.

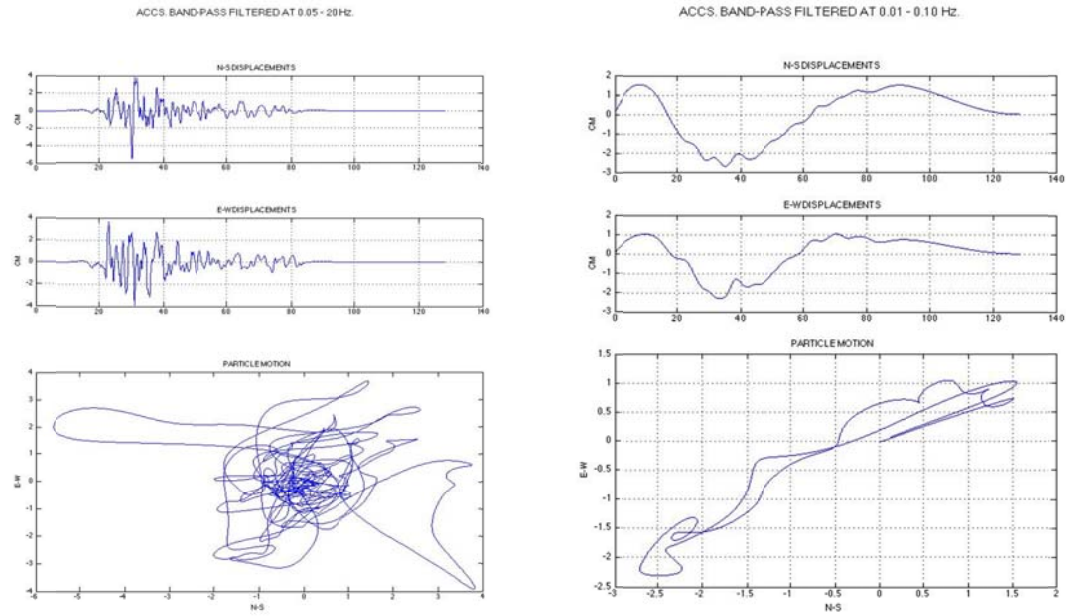


Figure 13. Particle motions, Muradiye record

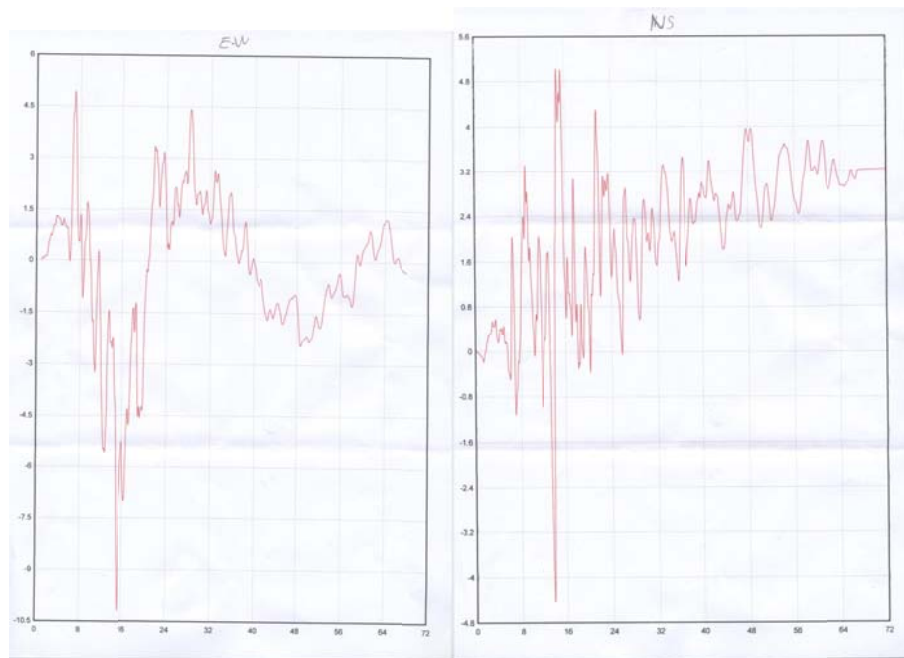


Figure 14. Muradiye record processed for permanent displacements





### Networks operated by the Department of Earthquake Engineering

The Department of Earthquake Engineering operates free-field and structural networks in the İstanbul region and in Antakya.

The Antakya Strong Motion Network in the province of Hatay in southeast Turkey consists of 6 stations. The Van earthquake is recorded by the five stations of the network. The network is about 685 km away from the epicenter. The accelerometric data can be seen in Figure 15.



Figure 15. Van earthquake as recorded by the stations of the Antakya network



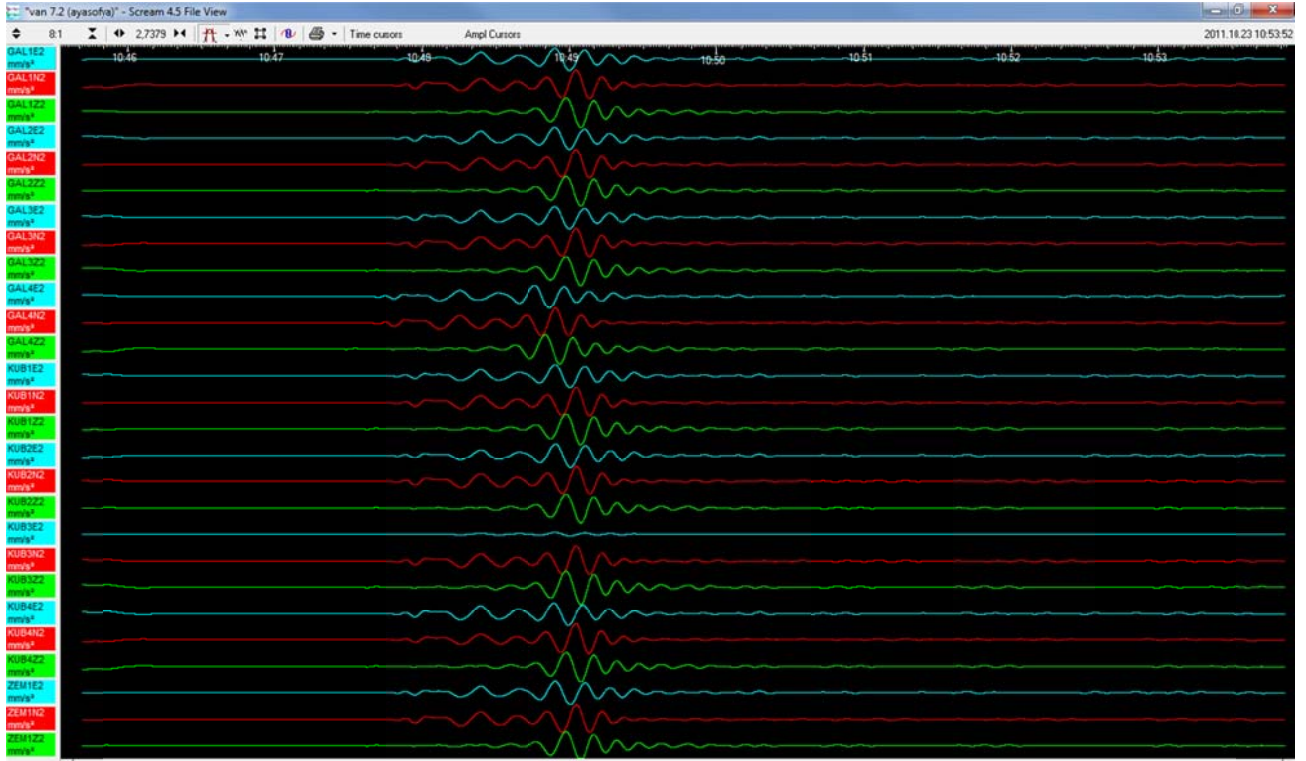


Figure 17. Van earthquake as recorded by the nine stations of the Hagia Sophia Structural Health Monitoring System in Istanbul.

### **Strong Motion Stations in Iran:**

The Iranian border is within 80 kms of the epicenter. We have informal information that the earthquake has been recorded by several stations of the Iranian network with a peak acceleration of 20 gals (Mehdi Zare, personal communication).

The IIEES , International Institute of Earthquake Engineering and Seismology, has compiled available data at link [http://www.iiees.ac.ir/index.php?option=com\\_content&view=article&id=862:van-turkey-earthquake-mw72-23-october-2011-iiees-observations&catid=71:2008-06-22-06-51-45&Itemid=918](http://www.iiees.ac.ir/index.php?option=com_content&view=article&id=862:van-turkey-earthquake-mw72-23-october-2011-iiees-observations&catid=71:2008-06-22-06-51-45&Itemid=918)

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