Bogazici University
Kandilli Observatory and Earthquake Research Institute
Department of Earthquake Engineering

THE OCTOBER 23, 2011 VAN, TURKEY EARTHQUAKE (MW=7.2)

The Mw=7.2 earthquake took place on October 23, 2011 at 10:41 GMT in the province of Van, located in Eastern Turkey near Lake Van. The epicenter is about 30 km to the north of the Van city center. The province of Van has a population of 1,035,418. The population of the city center is 367.419. Although figures on damage and casualties are just emerging, given its size and location the earthquake is expected to cause significant losses. The earthquake parameters reported by various institutions are presented in Table 1. The moment tensor solutions of USGS and GFZ are given in Table 2 and shown in Figure 1.

Table 1.

Date / Time	2011 / 10/ 23 13:41:21(Local) (KOERI*)	2011 / 10/ 23 10:41:21 UTC (USGS*)	2011 / 10/ 23 10:41:22.7 UTC (EMSC*)	2011 / 10/ 23 10:41:00 (UTC) (INGV*)
Latitude	38.7578N (KOERI)	38.628N (USGS)	38.86N(EMSC)	38.86N(INGV)
Longitude	43.3602E (KOERI -)	43.486E (USGS)	43.48E(EMSC)	43.48E(INGV)
Depth	5 km (KOERI)	20 km (USGS)	10 km (EMSC)	10 KM (INGV)
Magnitude	6.6 (ML), 7.2 (Mw)- KOERI	7.2 (USGS)	7.3 (Mw) (EMSC)	7.3 (Mw) (INGV)
Location	Tabanlı- VAN	Eastern Turkey	Eastern Turkey	Eastern Turkey

*KOERI- Kandilli Observatory and Earthquake Research Institute
(http://www.koeri.boun.edu.tr/scripts/lst9.asp)
*USGS- United State Geological Survey
(http://earthquake.usgs.gov/earthquakes/recenteqsww/Quakes/usb0006bqc.php#details)
*INGV- Instituto Nazionale di Geofisica e Vulcanologia
(http://cnt.rm.ingv.it/data_id/8219894410/event.html#maggiori_informazioni_sismiche)
EMSC- Centre- Mediterrananean Seismological – Mediterraneen
(http://www.emsc-csem.org/Earthquake/earthquake.php?id=239856#summary)

Table 2.

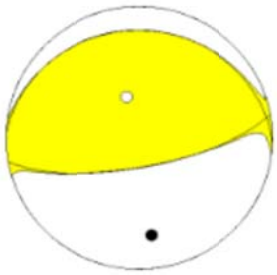
USGS

http://earthquake.usgs.gov/earthquakes/eqinthenews/2011/usb0006bqc/neic_b0006bqc_cmt.php
1/10/23 10:41:21.73

Epicenter: 38.710 43.446
MW 7.3

USGS CENTROID MOMENT TENSOR
11/10/23 10:41:44.50
Centroid: 39.451 43.354
Depth 16 No. of sta: 159
Moment Tensor; Scale 10**19 Nm
Mrr= 5.89 Mtt=-6.13
Mpp= 0.24 Mrt= 7.73
Mrp= 1.60 Mtp=-0.51
Principal axes:
T Val= 9.83 Plg=63 Azm=344
N 0.22 4 81
P -10.05 26 173

Best Double Couple:Mo=9.9*10**19
NP1:Strike= 80 Dip=71 Slip= 86
NP2: 272 19 101



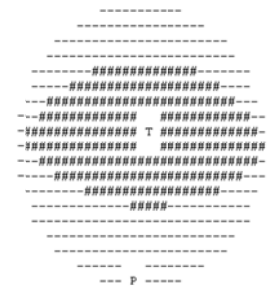
GFZ

(http://geofon.gfz-potsdam.de/geofon/alerts/gfz2011utuo/mt.txt)

GFZ Event gfz2011utuo
11/10/23 10:41:22.22
Turkey
Epicenter: 38.674 43.581
MW 7.1

GFZ MOMENT TENSOR SOLUTION
Depth 15 No. of sta: 114
Moment Tensor; Scale 10**19 Nm
Mrr= 4.43 Mtt=-4.61
Mpp= 0.18 Mrt= 1.40
Mrp=-0.28 Mtp=-4.61
Principal axes:
T Val= 4.66 Plg=81 Azm= 22
N 0.17 3 272
P -4.83 9 182

Best Double Couple:Mo=4.7*10**19
NP1:Strike= 94 Dip=54 Slip= 94
NP2: 268 36 85



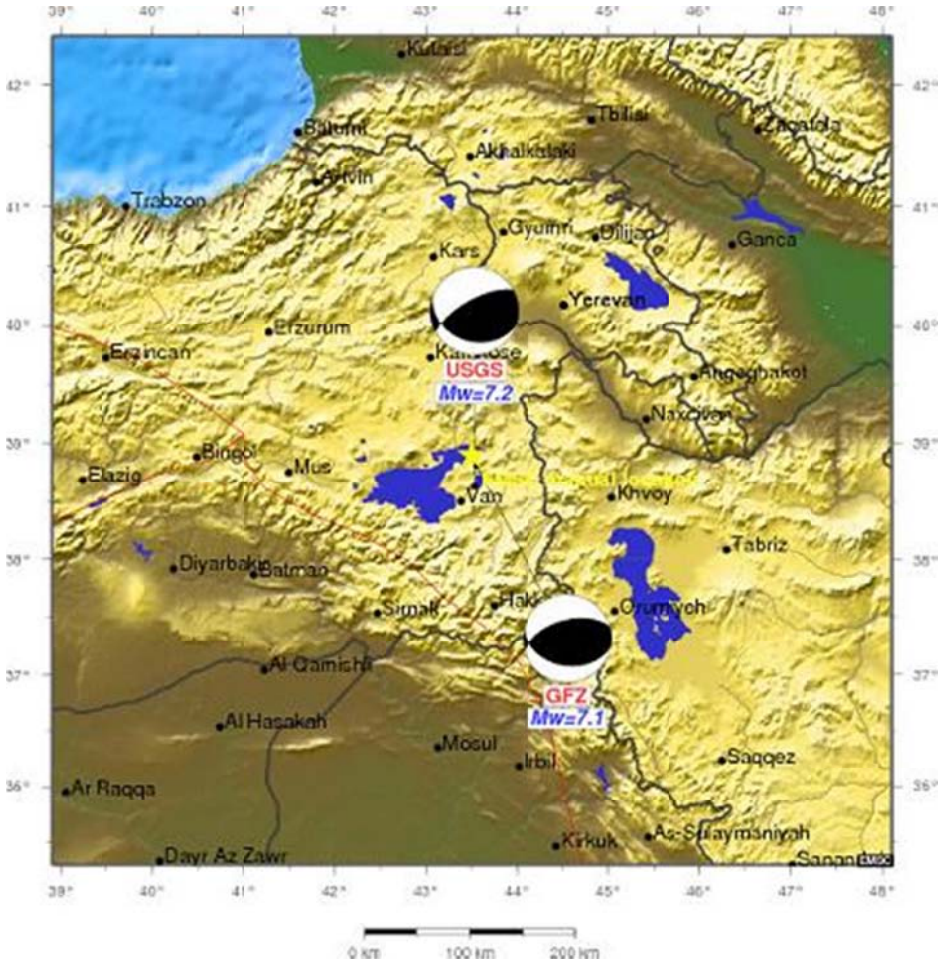


Figure 1. Source KOERI

Aftershock Activity

A significant aftershock activity is underway in the earthquake region. Figures 2 and 3 show the aftershock activity in 2D and 3D respectively as of 28 October 12:00 local time. The figures include events with Ml> 2.4 There was practically no seismic activity in the region prior to the main shock.

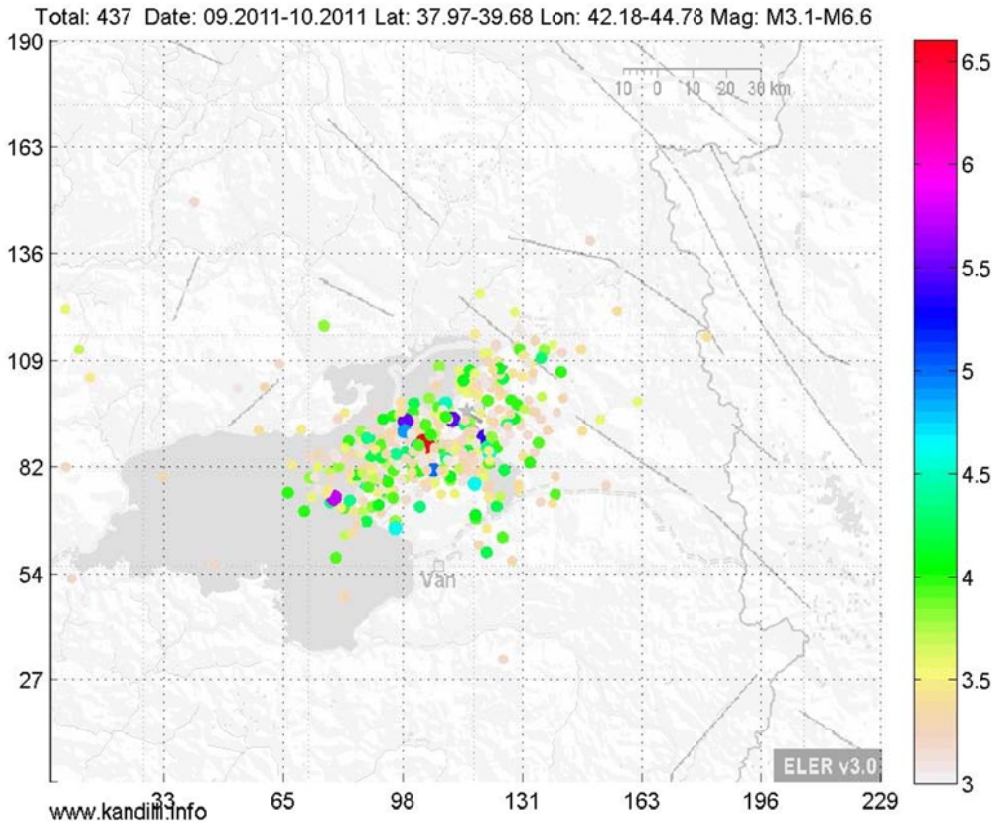


Figure 2. The aftershock activity in the earthquake region within 5 days of the mainshock.

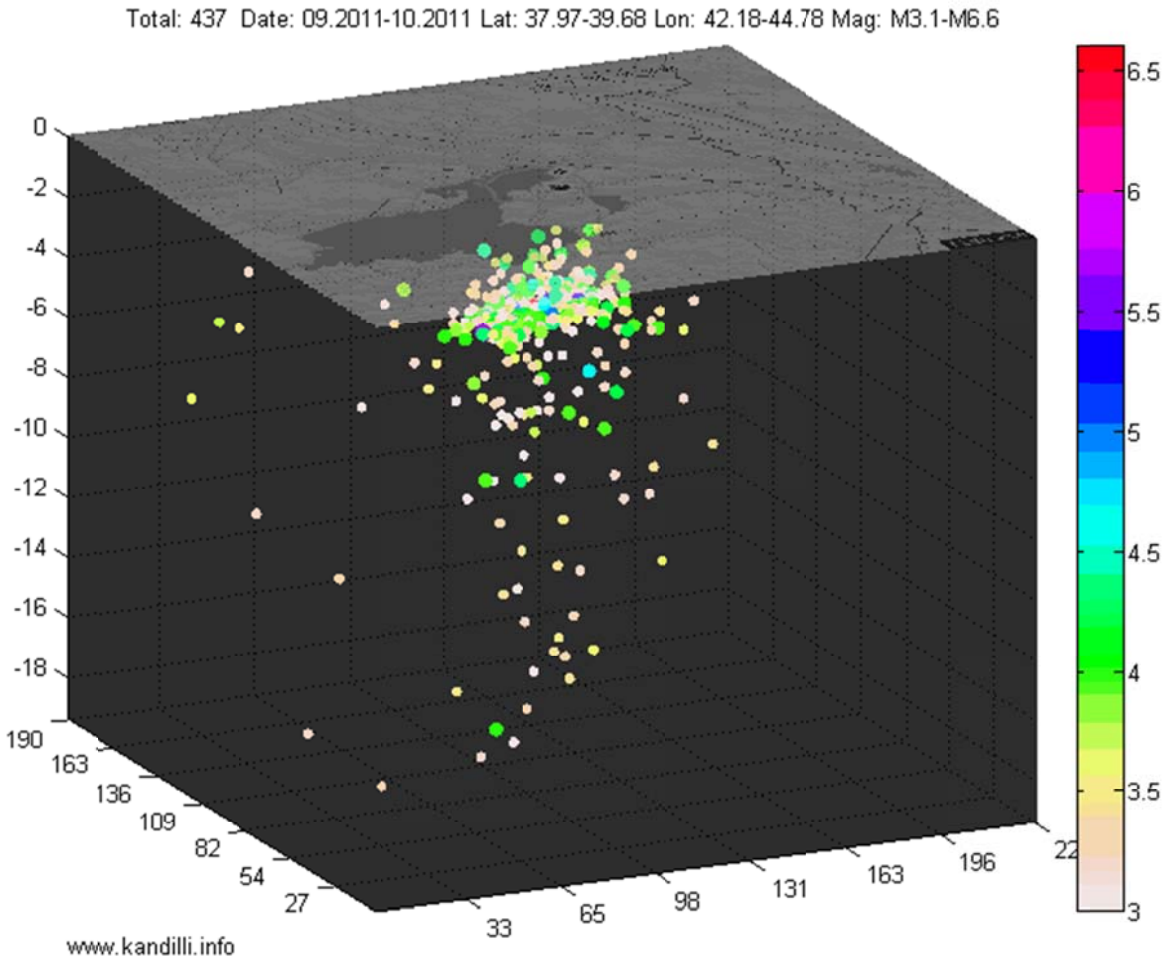


Figure 3. The aftershock activity in the earthquake region within 5 days of the mainshock, shown in 3D.

Contributed by: E. Çaktı, M.B. Demircioğlu, M. Erdik, Y. Kamer, B. Sungay, E. Şafak, K. Şeşetyan, E. Uçkan, E. Vuran, C. Yenidoğan, C. Zulfikar (in alphabetical order)

The October 23, 2011 Van, Turkey Earthquake (Mw=7.2)

SEISMOTECTONICS OF VAN REGION

Active Tectonics of Van Region

Turkey is a tectonically active region that experiences frequent destructive earthquakes, and, is surrounded by three major plates: African, Eurasian, and Arabian, and is located on two generally acknowledged minor plates: Aegean and Anatolian, as shown in Figure 1 (McKenzie, 1970). The relative motion between Eurasian, Arabian Plates and the westward motion of the Anatolian-Aegean Block is also illustrated in Figure 2 and Figure 3 (Armijo *et* al., 1999 and Armijo et al., 2005).

According to McKenzie (1972), the drift of the Arabian Plate towards the north-northeast against Eurasia results in a collision in the region of Lake Van. The other smaller plates of the region - the Turkish, Iranian, Black Sea and South Caspian plates - move symmetrically away from the Lake Van region to the east and to the west, as if pushed aside by the advancing Arabian plate. The northward motion of the Arabian plate is also taken up by the thrust faults associated with the Caucasus. The result of the geometry is the thickening of the continent throughout the region and the continuous elevation of the Caucasus.

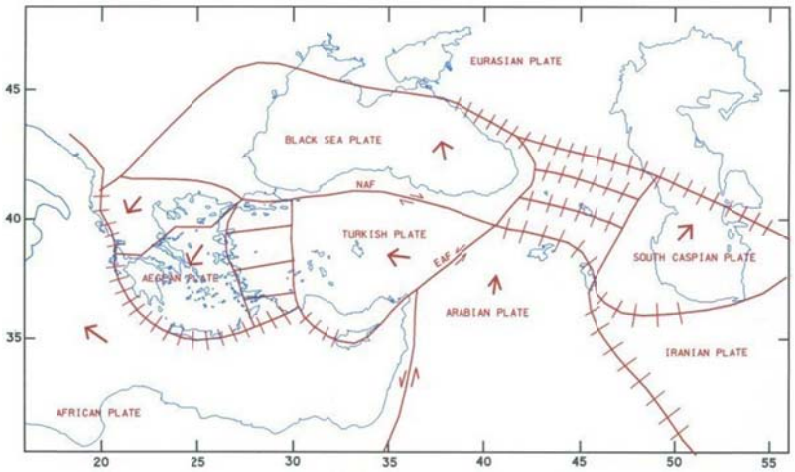


Figure 1. Plate tectonics of the Eastern Mediterranean and Caucasus regions (after McKenzie, 1970)

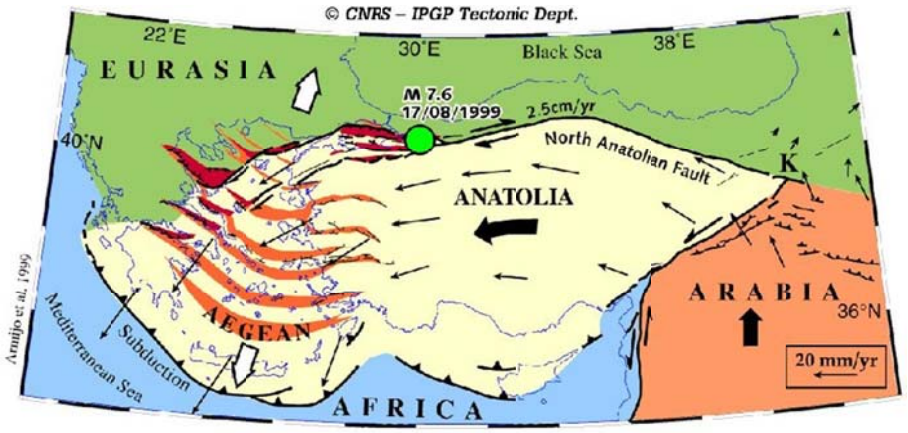


Figure 2. The relative motion between Eurasian and Arabian Plates and the westward motion of the Anatolian and Aegean Blocks (Armijo *et al*., 1999)

Figure 3. The relative motion between Eurasian and Arabian Plates and the westward motion of the Anatolian and Aegean Blocks (Armijo *et al*., 2005)

Lake Van is the largest lake (3600 km2) in Turkey and the fourth largest one in the World. It is located in the very intensely deformed Eastern Anatolian region (Figure 4), which is the product of young continent–continent collision zone of Arabian and Eurasian plates (Sandvol et al., 2003). Eastern Anatolia was initially formed as a result of the collision of Arabian and Eurasian plates in Early Miocene, 12–20Ma age (Dewey et al., 1986; Yılmaz, 1993). During the initial collision, the Neo-Tethys oceanic slab was detached from the Arabian continental lithosphere and allowed the asthenospheric magma to flow into the area between the detached slab and the overriding plate (Innocenti et al., 1982; Sengor et al., 2003). In Early Miocene, the eastern Anatolia was below a shallow sea. At the end of Miocene, most of the lakes disappeared and erosion and widespread volcanism started. The chain of continental-collision-related volcanoes (Nemrut, Suphan, Tendurek and Agri) in 11 Ma – present age (Keskin, 2003) were formed along the NE-SW direction. The lavas covered the region. In the period following Late Miocene, the uplifting reached a certain level and deformation started. The observed region-wide tectonic structures in the present day; NE and NW trending conjugate strike-slip faults, E-W trending thrust faults, N-S trending tensional cracks, and

volcanoes (Figure 4) were created as a result of crustal shortening and thickening caused by the post-collisional convergence (Sengor et al., 1985; Yılmaz, 1987, 2005). Lake Van was formed about 100,000 years ago when the lavas of the Nemrut volcano blocked the outward drainage of water in the Mus Basin (Barka and Saroglu, 1995).

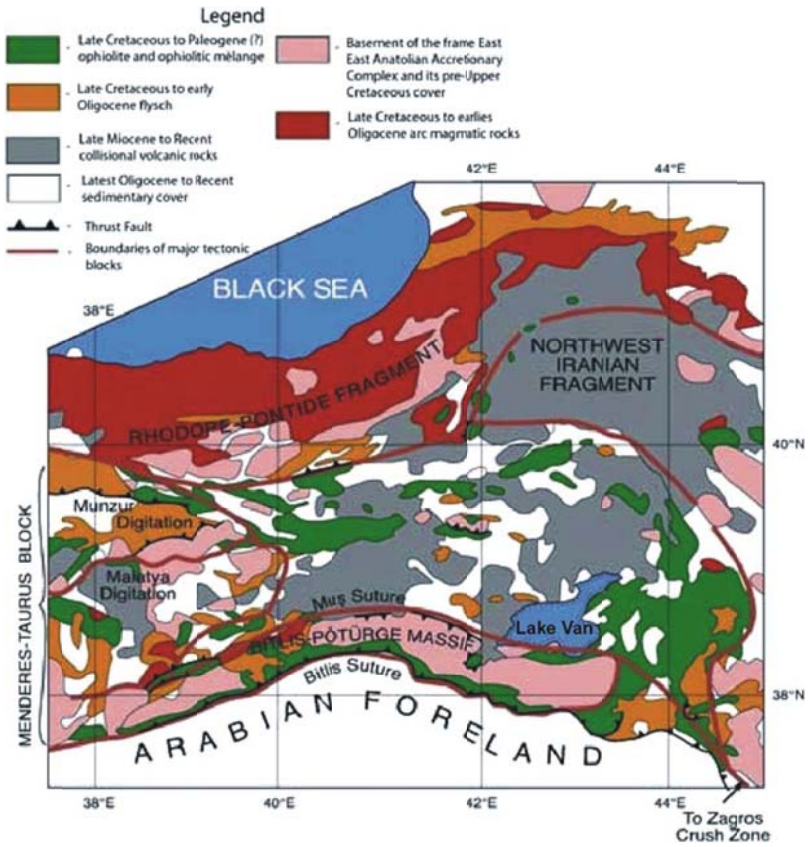


Figure 4. Geological map and tectonic units of Eastern Anatolia modified by Sengor et al. (2003) from numerous sources (Horasan and Boztepe, 2007)

According to recent GPS studies (Barka and Reilinger, 1997, McClusky et al., 2000) The Arabian Plate is moving in a north-northwest direction relative to Eurasia at a rate of about 25 mm/yr, 10 mm/yr of this rate is taken up by shortening in the Caucasus. Resulting in a continental collision along the Bitlis –Zagros fold and thrust belt, this motion is thought to cause intense seismic activity. Figure 5 presents the major tectonic elements of the region with fault ruptures associated with the major events (Barka and Reilinger, 1997).

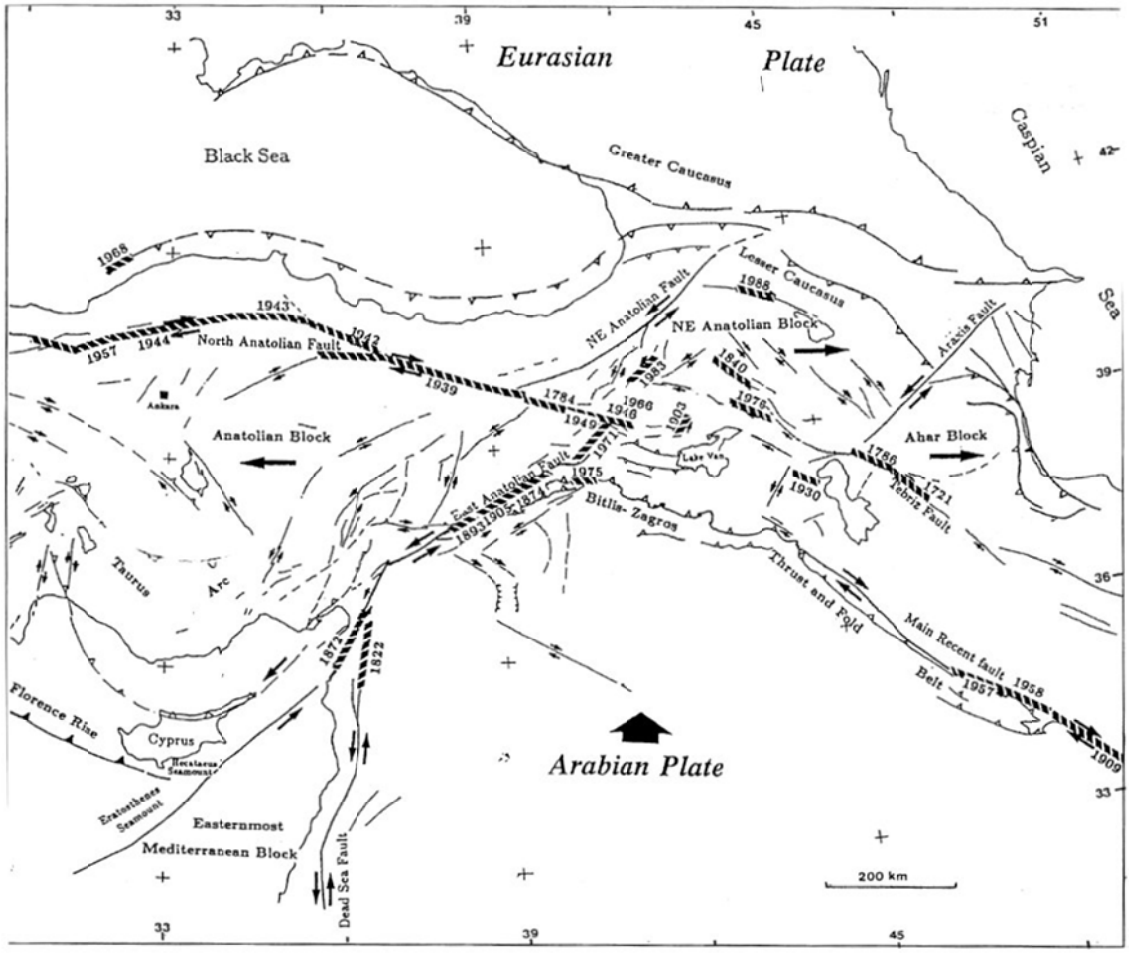


Figure 5. The Active tectonic features of the Eastern Mediterranean region (Barka and Reilinger, 1997)

The active fault map of the region recently compiled within the context of SHARE "Seismic Hazard Harmonization in Europe" (www.share-eu.org) and EMME "Earthquake Model of Middle East" (www.emme-gem.org) projects is presented in Figure 6.

Figure 6. The active faults in the vicinity of Van Lake.

The seismicity and tectonics of Lake Van region were first studied by Tchalenko (1977) in connection with the plate tectonics model of the region suggested by McKenzie (1972), with the symmetrical escape of the Turkish, Iranian, Black Sea and South Caspian plates from the Lake Van region to the east and to the west (Figure 1). Tchalenko (1977) argued that the four major faults of the region, namely North Anatolian (NAF), East Anatolian (EAF), Main Recent (MRF) and Tabriz (TF) faults died out as they approached Lake Van. Based on the fact that no major aftershocks of the 1939 Erzincan earthquake have continued east of Karlıova, it was deduced that the North Anatolian Fault lost its character of major transcurrent fault east of Erzincan. Although the faulting associated with the 1966 Varto earthquakes have proved that the faults continued at least 75 km east of Karlıova, Wallace (1968) concluded that the NAF at this region had a structure of not a single trace but as a few kilometers wide zone, formed of several parallel strands. The 1966 displacement, though on average right lateral with a slip of a few tens of centimeters had also a distinctive extensional component. On the other hand the fault plane solution of the 1966 Varto earthquake by McKenzie (1972) suggested equal amount of right lateral strike slip and thrust (Figure 7).

The East Anatolian Fault (EAF) is a left-lateral strike slip transform fault marking the boundary of the Arabian and Anatolian Plates (Arpat and Şaroğlu, 1972). It extends 600 km from Karlıova basin, where it meets NAF, to the city of Maraş in the southwest, where it joins the Dead Sea Fault Zone (DSFZ). A relatively small number of large earthquakes occurred along the EAF during the last century, and faulting mechanisms associated with these events have supported the left-lateral transform motion with reverse component *(Jackson and McKenzie,* 1984; Taymaz et al., 1991). The Ms 6.7 Bingol earthquake of May 22, 1971 which occurred at the northeastern end of the fault near Karlıova junction was associated with a maximum 25 cm of left lateral displacement also with tensional features. Based on the fault breaks associated with the 1966 Varto on NAF, the 1971 Bingöl on EAF as well as their aftershocks and the locations of other smaller events in the region Tchalenko (1977) concluded that the junction region is characterized by a number of small active faults parallel to either NAF or to EAF to the south and northeast of Erzincan, with a mosaic structure of small parallel faults which distribute the tectonic movements along these two main faults in the region. This suggestion was further confirmed with more recent studies, (e.g. Saroglu et al., 1992) as seen in Figure 6.

The Main Recent Fault (MRF) is a 1500 km long fault bordering the Arabian Plate in the northeast. The fault enters Turkey at the meeting point of Iran, Iraq and Turkish borders and continues in the Yuksekova valley to the vicinity of the Great Zab River. No further northeast extension of the fault is observed beyond the Great Zab River. The Tabriz Fault (TF) starts near Bostanabad in the southeast, continues to the northwest passing north of the town of Tabriz and near Marand the fault is divided to two different directions, to Derik Fault and to the Northwest fault system. The Derik fault as well as the Salmas Fault which is parallel to the TF were most recently activated by the May 6, Mw 7.2 1930 Salmas earthquake. The so-called Northwest Fault System by Tchalenko (1977) was defined as system of little-known NW-SE trending faults. The fault is also named as Balıkgölü Fault in its part in the Turkish territory where it extends at least 90 km (Barka and Kadinsky-Cade, 1988). The Turkish section has been mapped in detail by Arpat et al. (1977). July 2, 1840 Mw7.5 Ararat earthquake occurred on the Turkish section rupturing about 60 km of the of the fault between Doğu Beyazit and Balık Lake.

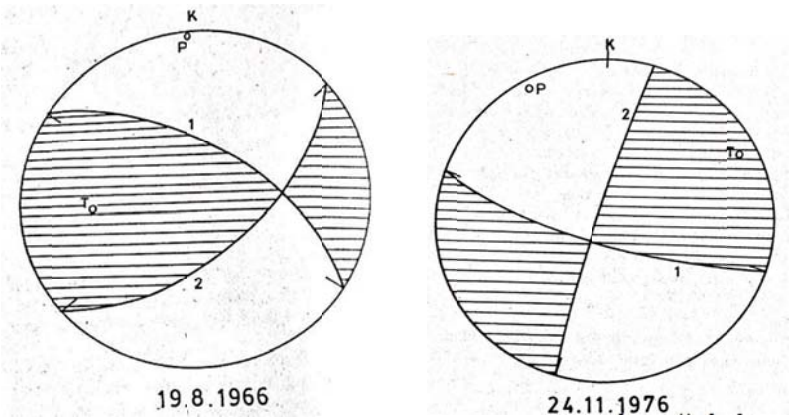


Figure 7. Fault plane solutions of 1966 Varto and 1976 Çaldıran earthquakes

The Caldıran Fault is separated from the Northwest Fault System near the Turkish frontier and is directed toward ENE and extends about 60 km in this direction. The April 14, 1696 and the November 24, 1976 Çaldıran earthquakes are associated with this fault. The 1976 M7.3 Çaldıran earthquake had a right lateral strike-slip mechanism (Figure 7) and the maximum displacements along the fault reached 4 m close to the eastern end of the rupture, whereas the average slip was in the order of 2m (Saroglu and Erdoğan, 1983). The earthquake produced an 55 km long zone of surface breaks. The zone of surface breaks includes numerous and well-developed open tension cracks, right stopovers, outcrop-scale depression (pull-apart basins) and intervening pressure ridges and reverse faults (Kocyigit et al., 2001). The earthquake caused damage in a broad area of 2000 km^2 around Caldiran, causing 3,840 fatalities and demolishing about 10,000 buildings. The intensity distribution of the 1976 Çaldıran earthquake is given in Figure 8. A detailed location map of Balıkgölü and Çaldıran faults in the Turkish terrioty is provided in Figure 9.

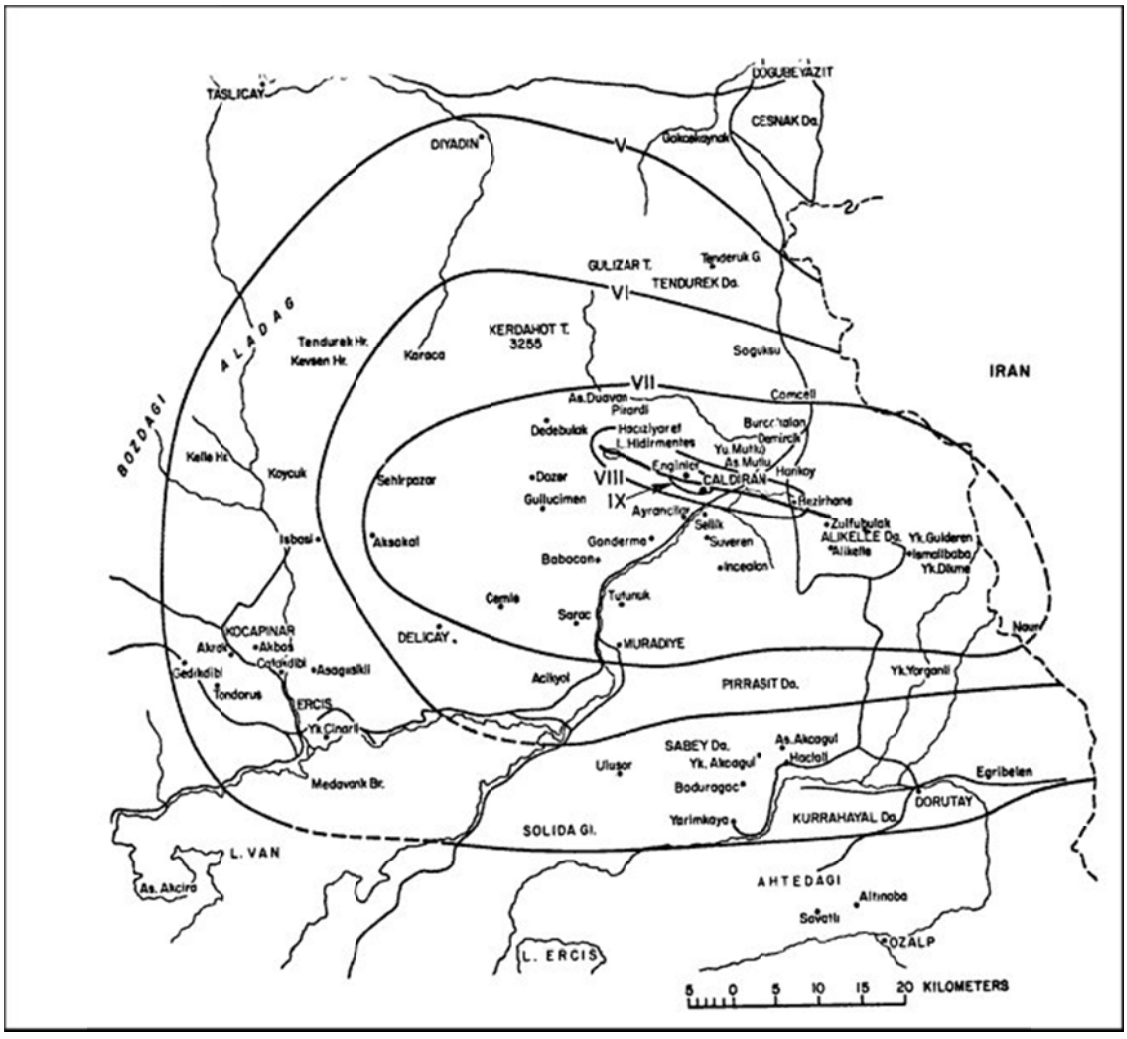


Figure 8. Isoseismal map of the Muradiye-Caldiran earthquake (Gulkan et al., 1978)

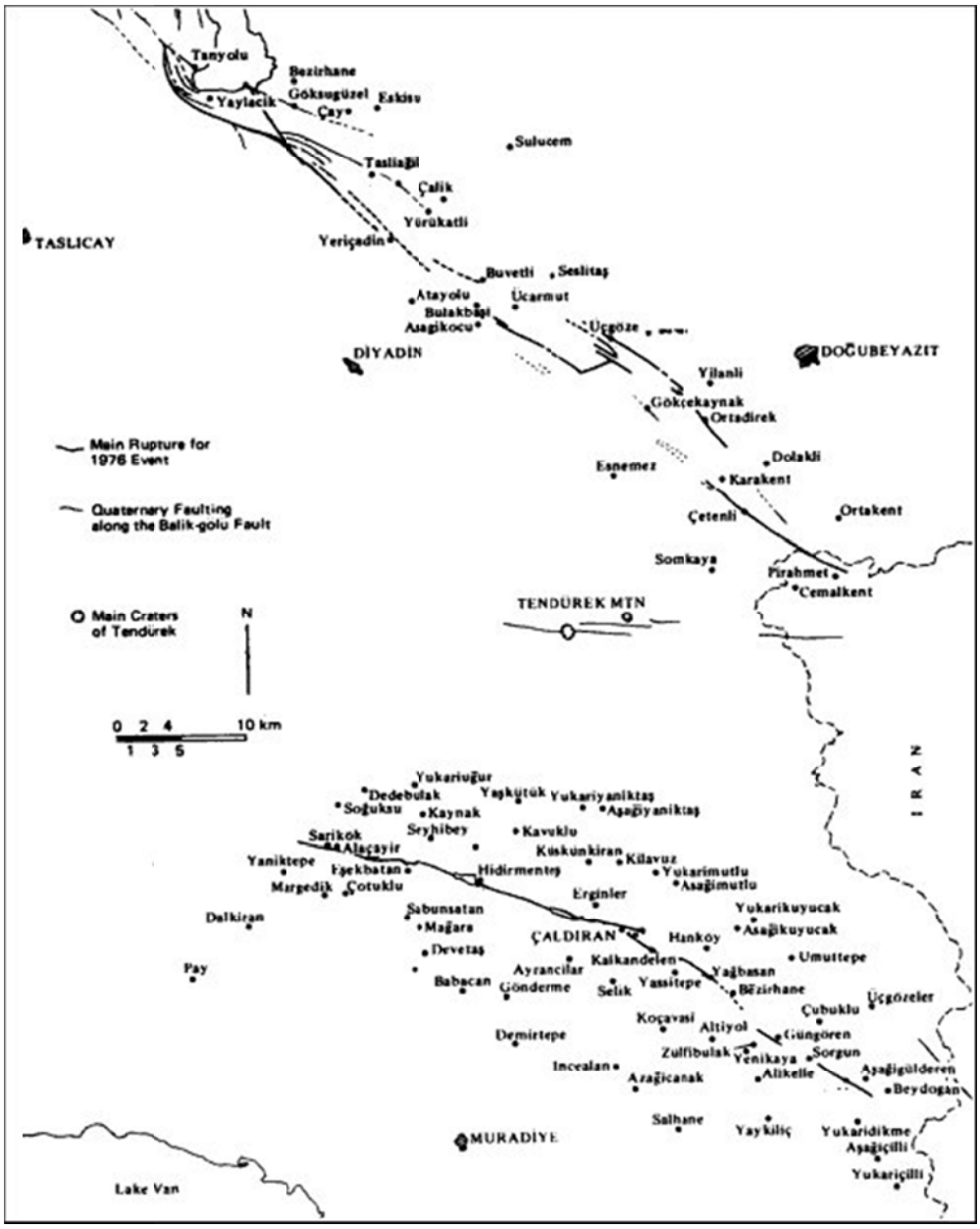


Figure 9. Caldıran and Balikgolu Faults (Gulkan et al., 1978)

In addition to the major faults described above, conjugate strike-slip faults of dextral and sinistral character paralleling to North and East Anatolian fault zones are the general dominant structural elements of the region. Some of these structures include Agrı Fault, Bulanık Fault, Ercis¸ Fault, Horasan Fault, Igdır Fault, Malazgirt Fault, Süphan Fault, Baskale Fault, Çobandede Fault Zone, Dumlu Fault Zone, Hasan Timur Fault Zone, Kavakbası Fault, Kagızman Fault Zone, Dogubayazıt Fault Zone, Karayazı Fault, Tutak Fault Zone, Yüksekova–Şemdinli Fault Zone and the Northeast Anatolian Fault Zone (Bozkurt, 2001, Figure 10).

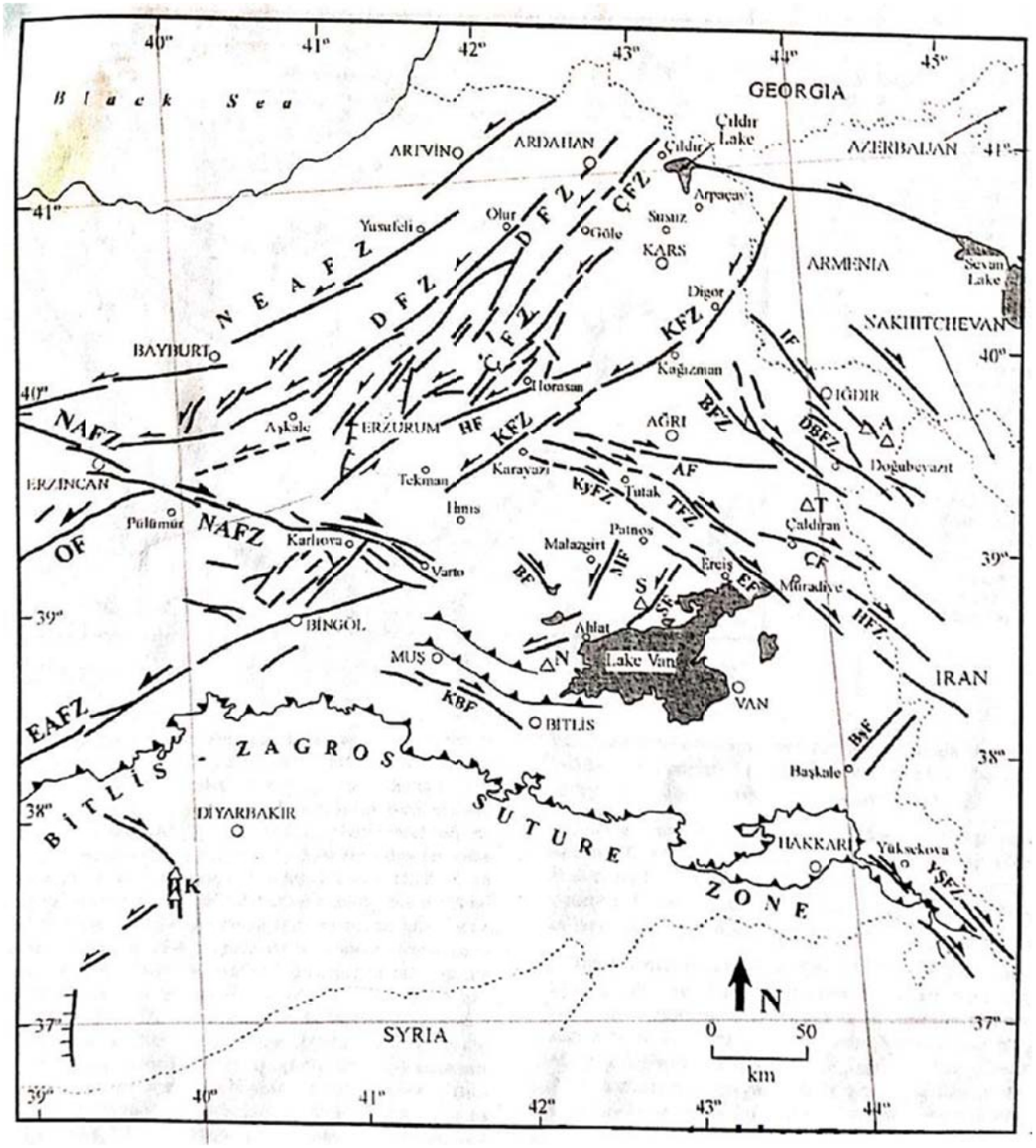


Figure 10. Active faults of East Anatolian Province (Bozkurt, 2001)

Tchalenko (1977) argued that the major Anatolian and Persian faults decreased in importance and disappeared altogether as they approached the central Lake Van region. However he identified a close-spaced system of lineaments oriented on average ENE-WSW and NW-SE, producing a mosaic pattern based on satellite images. This structure is compatible with NNE-SSW compression and WNW-ESE extension in the region, as well as the reverse mechanism associated with the recent Van earthquake.

It should be noted that, although a large number of studies elaborate on the active faults in the East Anatolina Tectonic province, according to the current knowledge of the authors of this report, the only active or probably active tectonic element in the epicentral region of the 23 October, 2011 Van earthquake is mapped by Kocyigit et al., (2002) as shown in Figure 11. On the other hand, the pure reverse character of the recent Van earthquake is not in accordance with the strike-slip character of the fault mapped by Kocyigit et al., (2002).

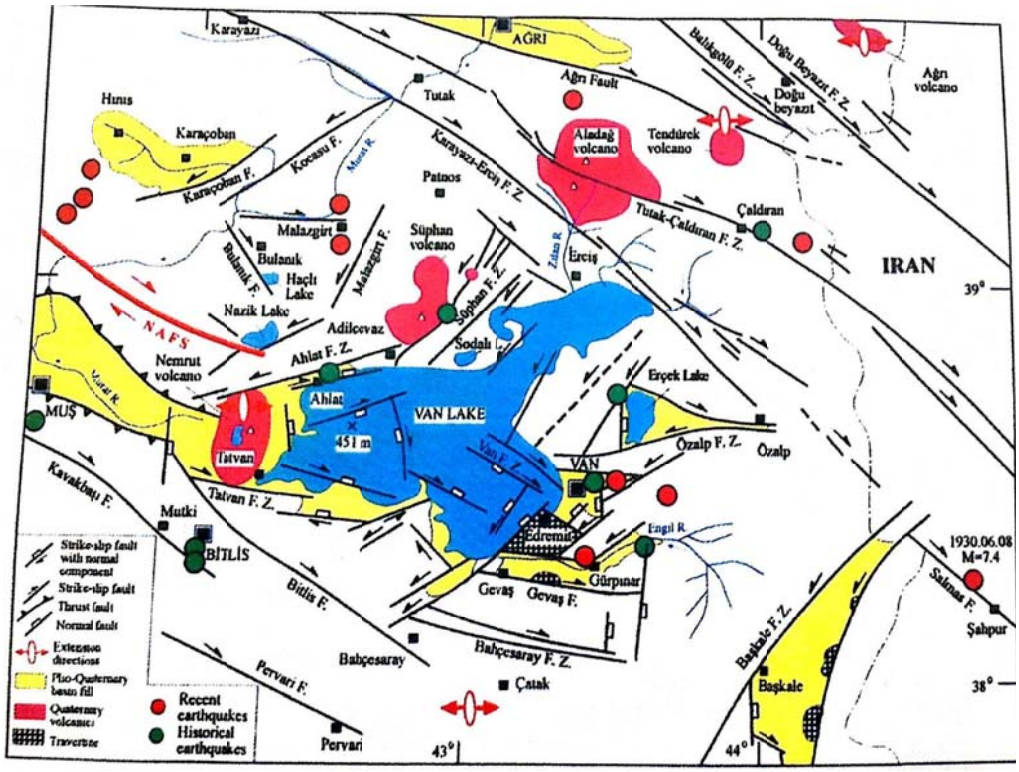


Figure 11. Active fault map prepared by Kocyigit et al, 2002

Uner et al. (2010) evaluate the formation of earthquake induced soft sediment deformation structures (seismites) in the Van Lake basin, and suggest that the existence of seismites in different levels of lacustrine sediments in the Van Lake basin is an indicator of a Quaternary tectonic activity in the region as well as an indicator of frequent occurrences of earthquakes with magnitudes of 5 or greater. Figure 12 reveals three such locations in the epicentral region of the recent Van earthquake.

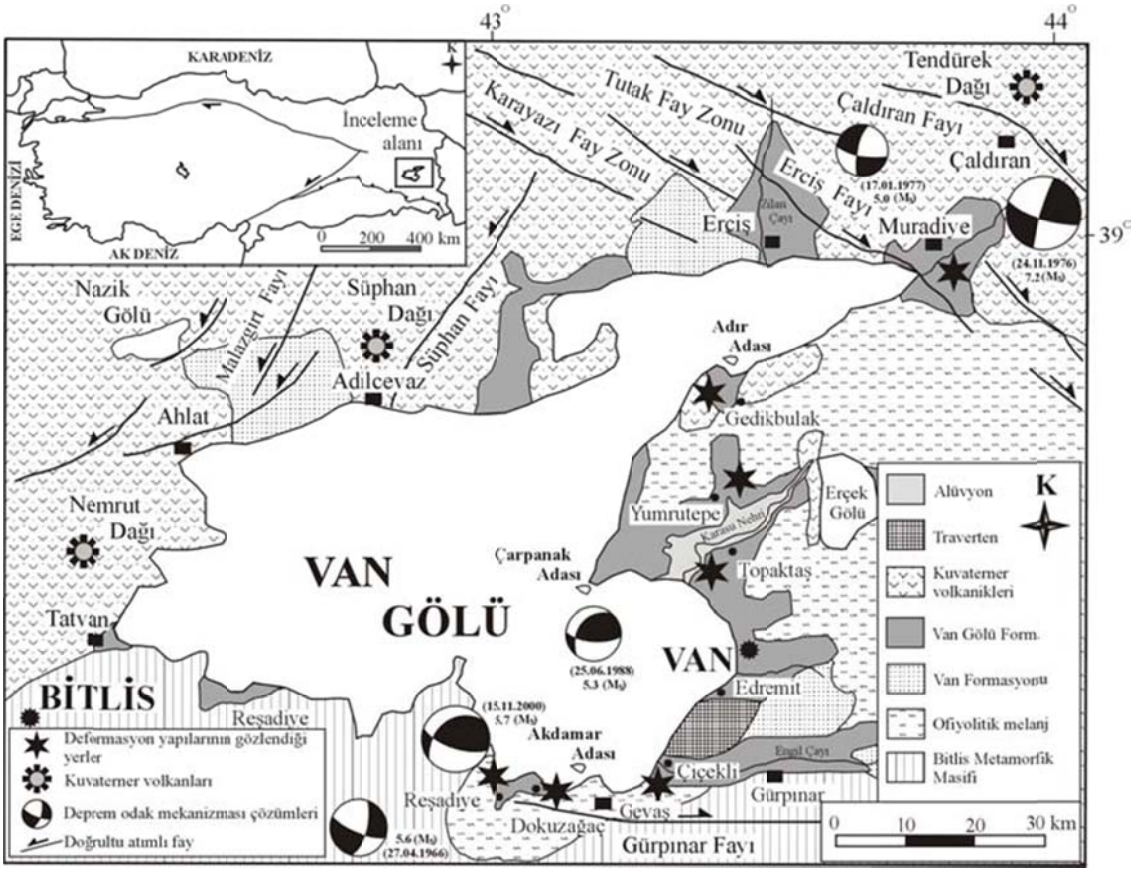


Figure 12. Simplified geological map (Uner et al., 2010)

Seısmıcıty of The Region

The East Anatolian tectonic province is associated with a number of large historical and early instrumantal period earthquakes as well as a large number of recent moderate events.

One of the major historical destructive events is the Oct 3, 1275 event in the region north of Lake Van (Guidoboni and Comastri, 2005, Albini 2011). Ambraseys (2009) dates this event to Oct 3, 1276. The earthquake destroyed Arces/Arkestia/Argish/Arges (Erciş) and Xlat (Ahlat). Walls and buildings fell down, and many people perished. The earthquake aslo caused great fear in the city of Ani. Guidoboni and Comastri (2005) assigns an epicentral intensity IX and magnitude 6 to this event.

A major historical event that is known to damage the city of Van is the 1648 March 31 (Mw about 6.6) event. Berberian (1997) associates this earthquake with an east-west trending fault in the south of Van. Ozkaymak et al., (2004) identify the eastwest trending Gurpınar thrust at this location (Figure 6) which can be associated with this event. The damage distribution pictured by Tchalenko (1977) is presented in Figure 14. The only known large scale destruction by earthquake in the Van region after 1648 occurred in 1945. A swarm type series of earthquakes with a maximum magnitude of about 5.2 started on June 28 and continued until December.

The earthquake of March 8, 1715 is associated with an estimated epicentral location between the eastern termination of Derik fault and Van (Tchalenko, 1977 and Berberian, 1997).

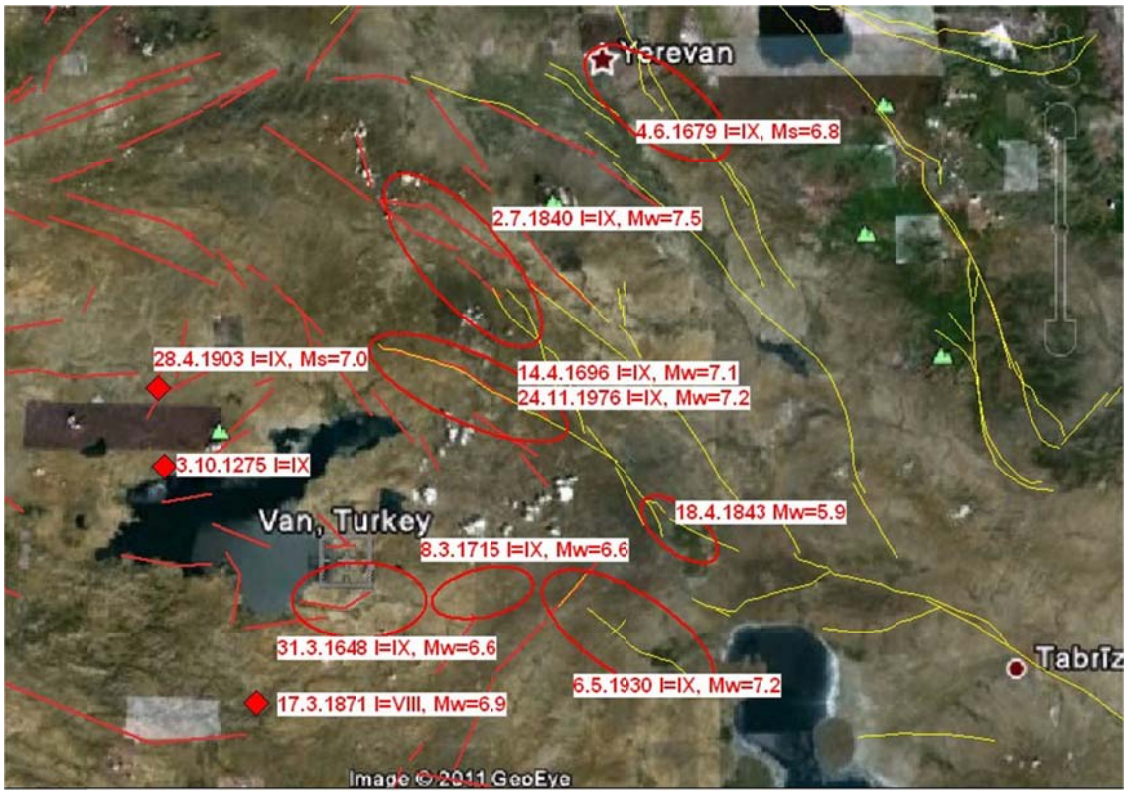


Figure 13. The historical and early instrumental earthquakes in the region

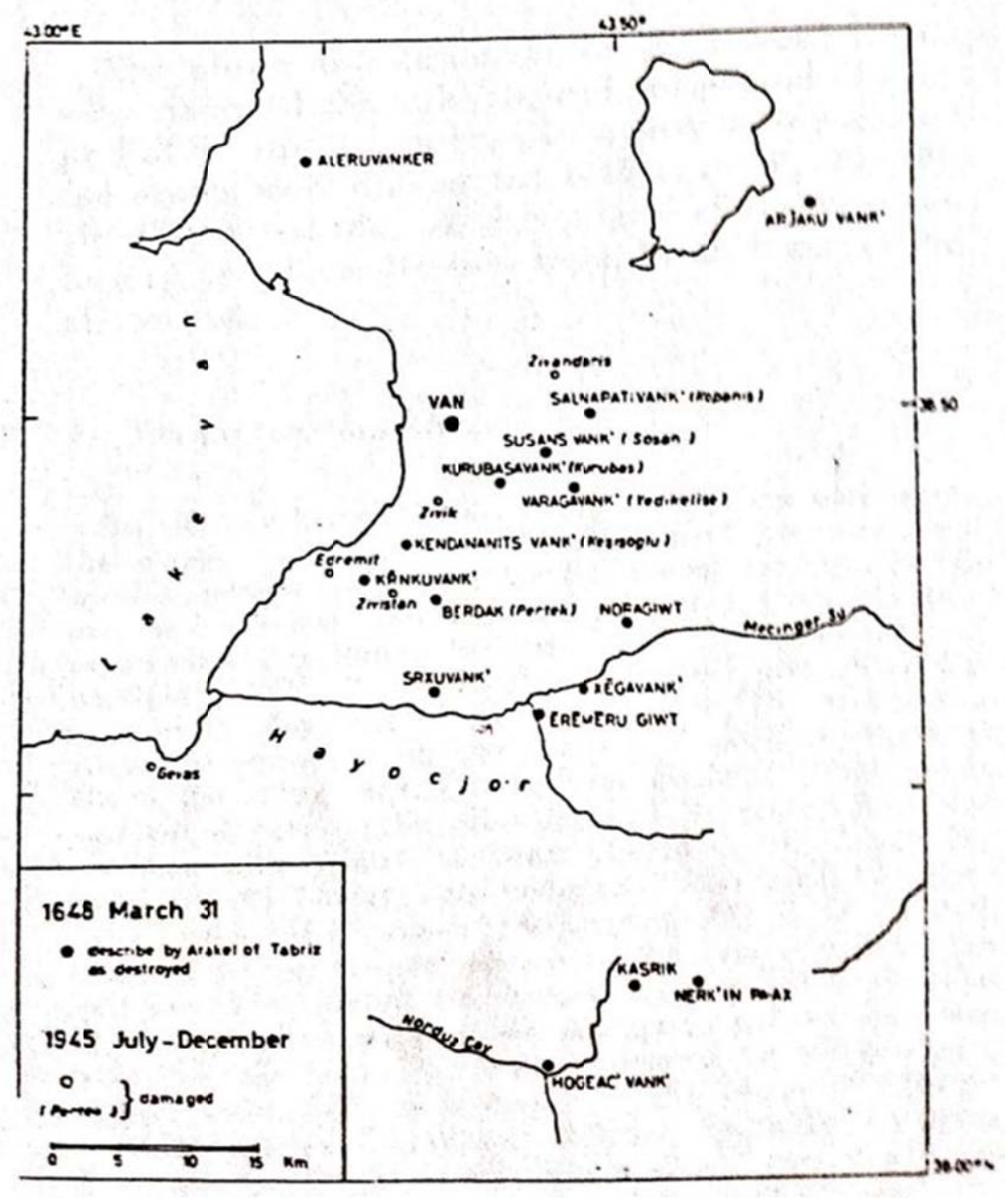


Figure 14. Van earthquakes of 1648 and 1945. Localities destroyed and damaged (Tchalenko, 1977)

The May 30, 1881 Tergut and February 6, 1891 Adilcevas earthquakes are two earthquakes that caused in the western and northern parts of Lake Van, close to the region of Nemrut Volcano. A more recent damaging earthquake in the same region is the Malazgirt earthquake of April 28, 1903. Karnik (1969) gives the magnitude of this event as 6.3, however more recent macroseismic interpretations point out a magnitude around 7. The damage distribution

of the 1903 Malazgirt event as given by Tchalenko (1977) is shown in Figure 15. Again the distribution of damaged villages suggests a NNE-SSW trending in the rupture.

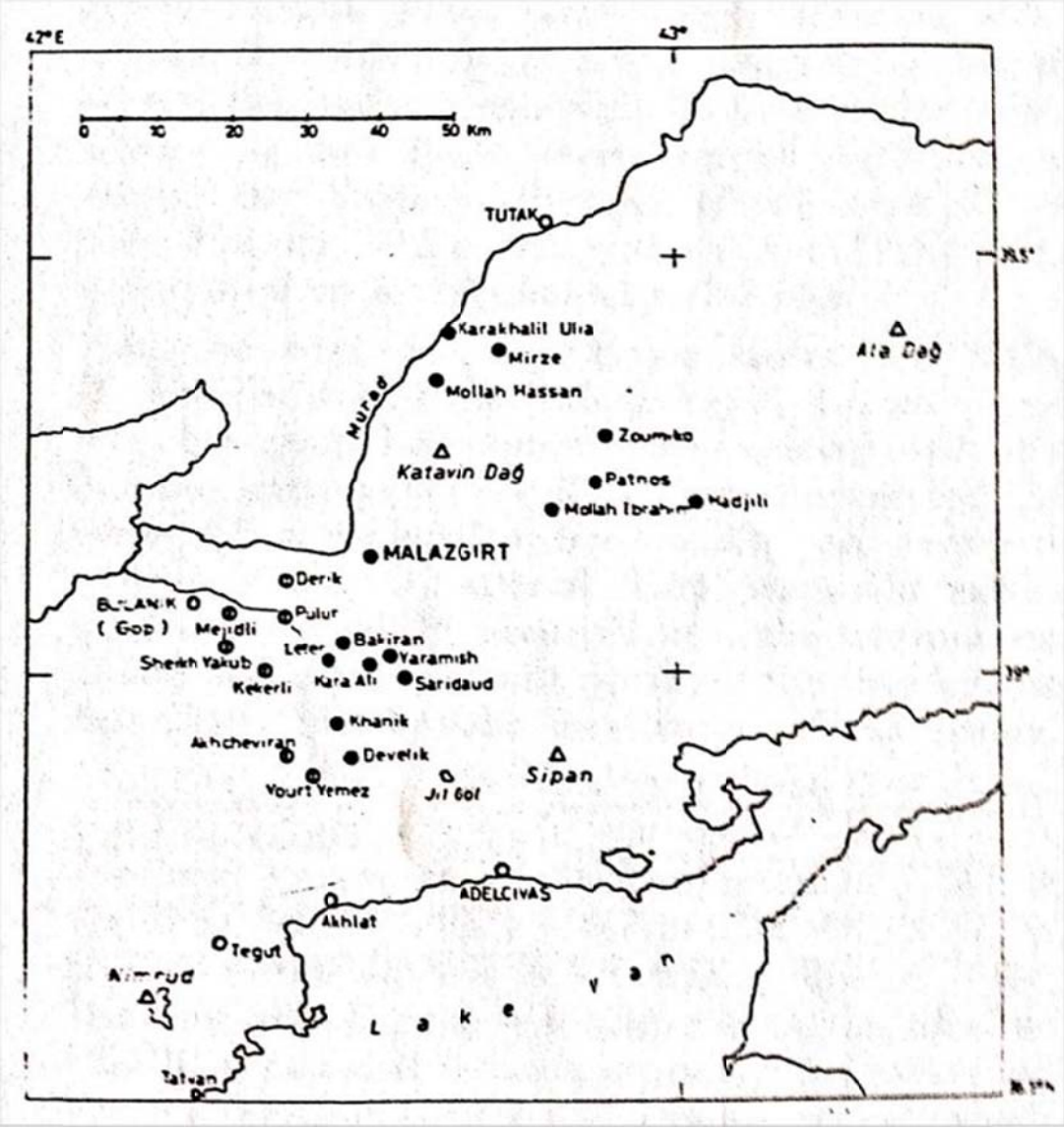


Figure 15. Villages damaged during the 1903 Malazgirt earthquake (Tchalenko, 1977).

A number of large destructive earthquakes and active faults have been used to characterize the deformation of the the East Anatolian Plateau (EAP) (Jackson and McKenzie, 1984). Most of this deformation is taken up by pure shear, along conjugate strike-slip faults trending NE and NW. Orgulu et al., 2003 located many events in the central part of the EAP and presented that the seismic deformation is distributed throughout the EAP (Figure 16). There are two events that have strike slip character and give evidence for the shearing process. They are located on the Balık Gölü Fault (BGF) and Tutak Fault (TF) respectively that have a dextral strike slip motion clearly seen from morphological evidence (Bozkurt, 2001; Koçyiğit et al., 2001).

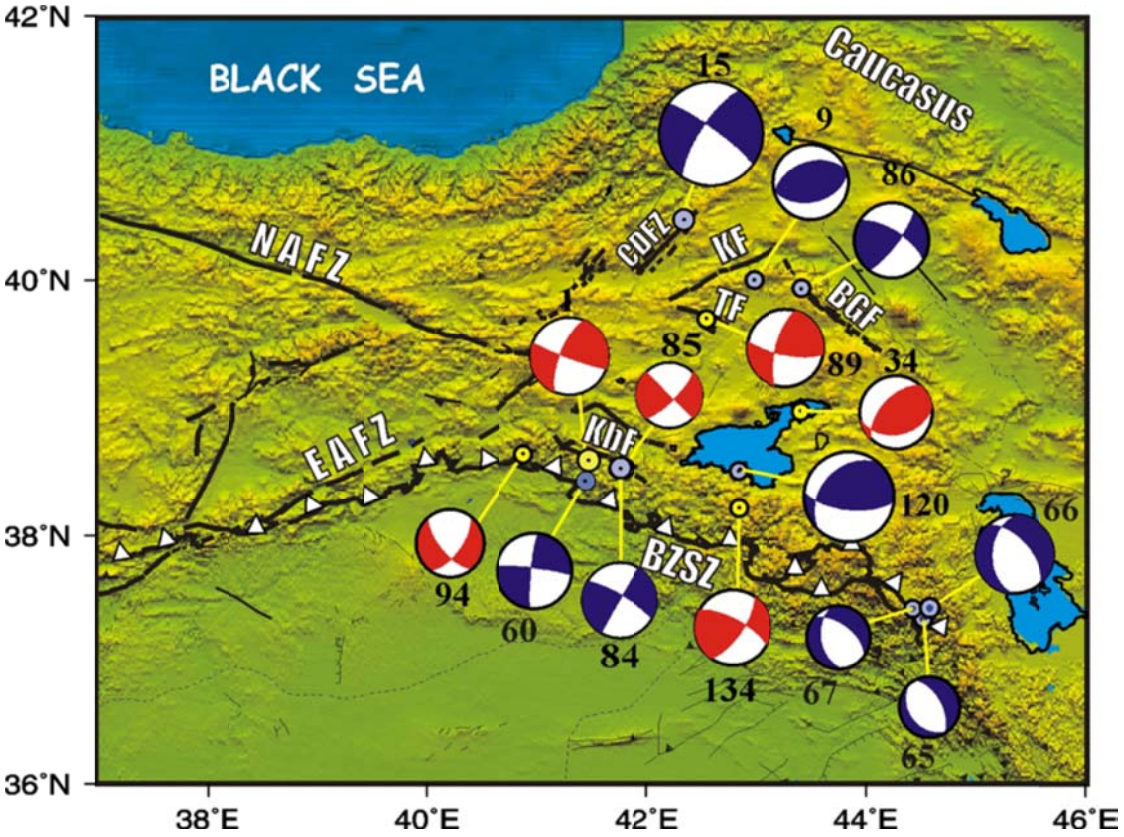


Figure 16.Fault plane solutions obtained from the moment tensor inversion for selected events distributed in Eastern Anatolian Plateau (east of Karlıova. Çobandede Fault Zone (ÇDFZ), Kağızman Fault (KF), Tutak Fault (TF), Balık Gölü Fault (BGF), Kavakbaşı Fault (KbF) (Orgulu etal, 2003)

Figure 17 presents the epicentral locations of the earthquakes occurred in the Van Lake region since 1980 with some moment tensor solutions from Harward CMT catalog.

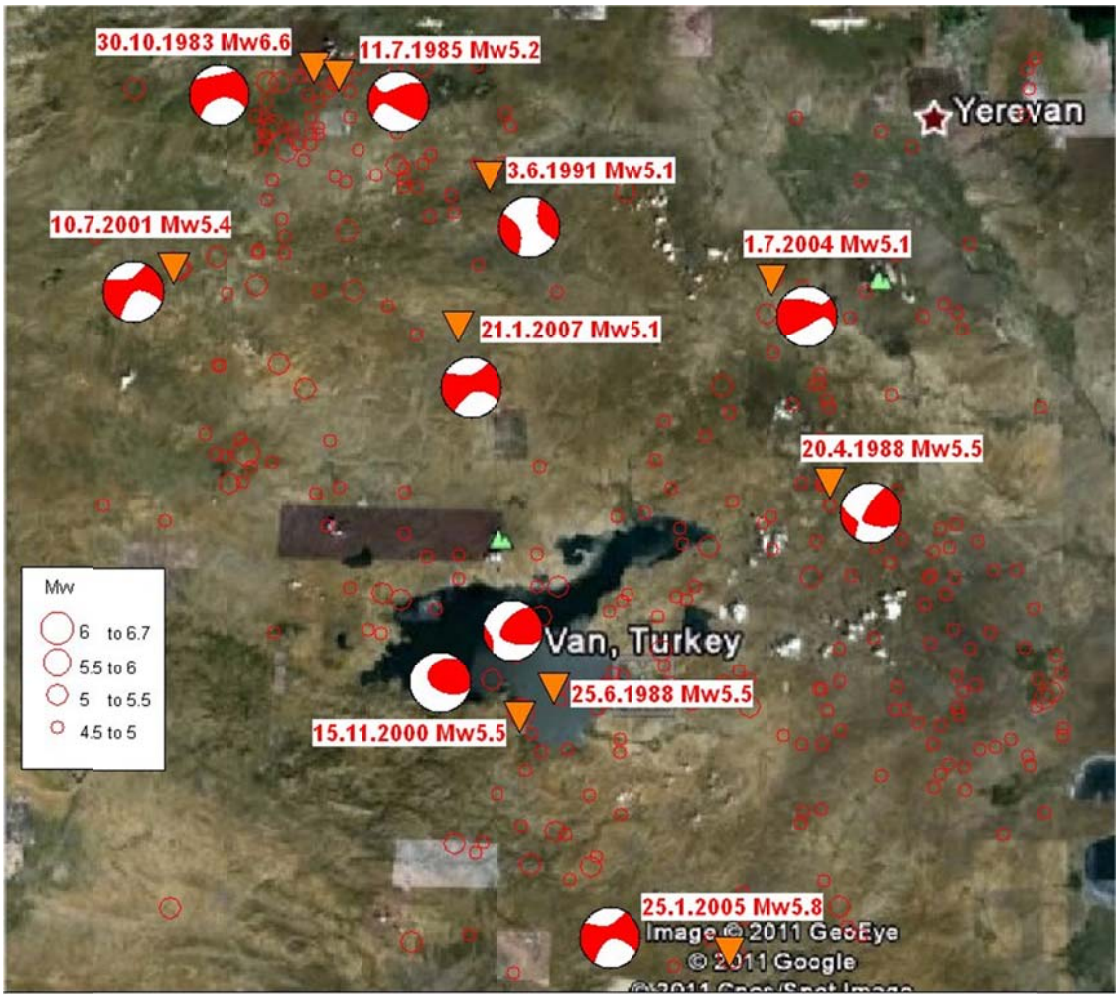


Figure 17. Recent earthquakes (after 1980) with moment tensor solutions taken from Harward CMT catalog

Preliminary Assessments of Faulting Plane ABD Slip Distributions

Preliminary assessments for co-seismic ground displacement and preliminary source models for the 23 OCT, 2011 Van earthquake have been conducted by Atzori et al. (2011), who generated the first co-seismic COSMO-SkyMed differential interferogram for the earthquake was generated 4 days after the mainshock. The InSAR displacements have been modeled by linear and non-linear inversion using the Okada dislocation model in an elastic half-space. The preliminary source models developed by Atzori et al. (2011) for both south dipping and north dipping faulting planes are presented in Figure 18 and Figure 19respectively.

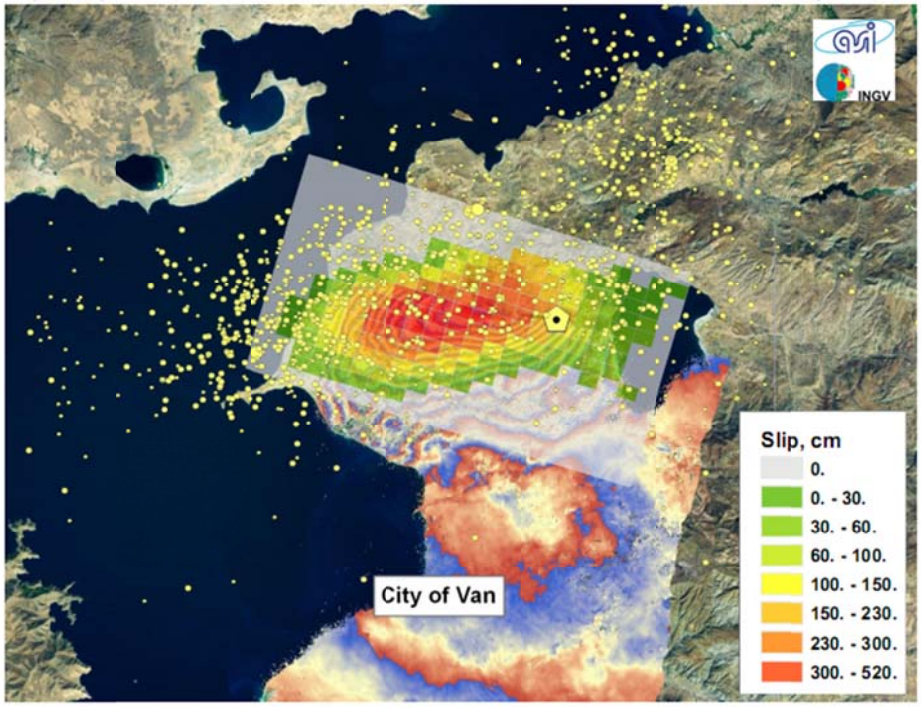


Figure 18. Surface projection of the South-dipping source modeled from the COSMO InSAR ground displacements. Also shown: seismicity and wrapped interferogram (Atzori et al., 2011)

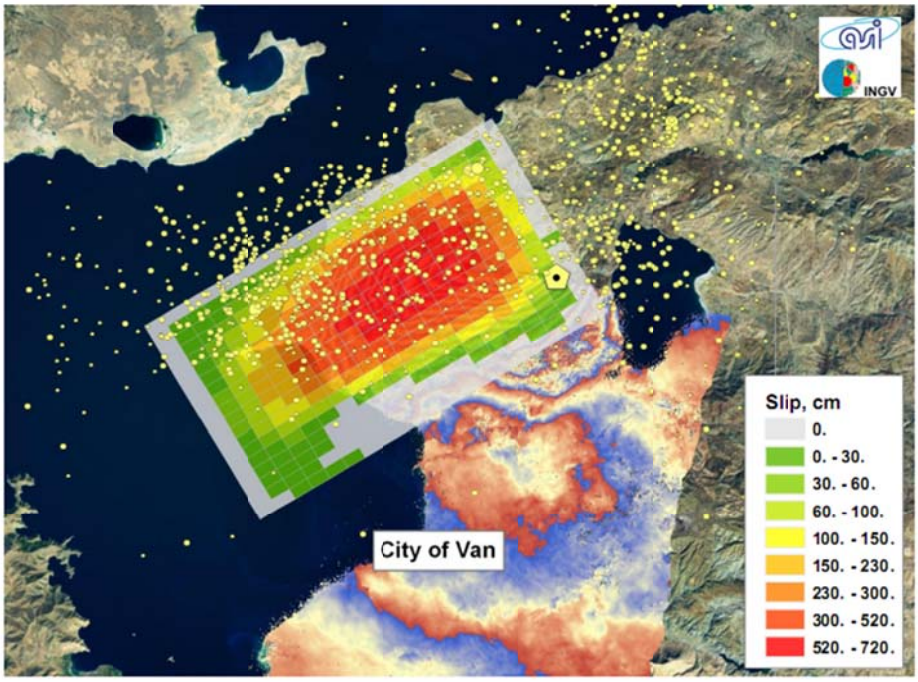


Figure 19. Surface projection of the North-dipping source modeled from the COSMO InSAR ground displacements. Also shown: seismicity and wrapped interferogram (Atzori et al., 2011)

The finite fault model of the event as developed by G. Hayes (USGS, NEIC) (http://earthquake.usgs.gov/earthquakes/eqinthenews/2011/usb0006bqc/finite_fault.php) is as follows:

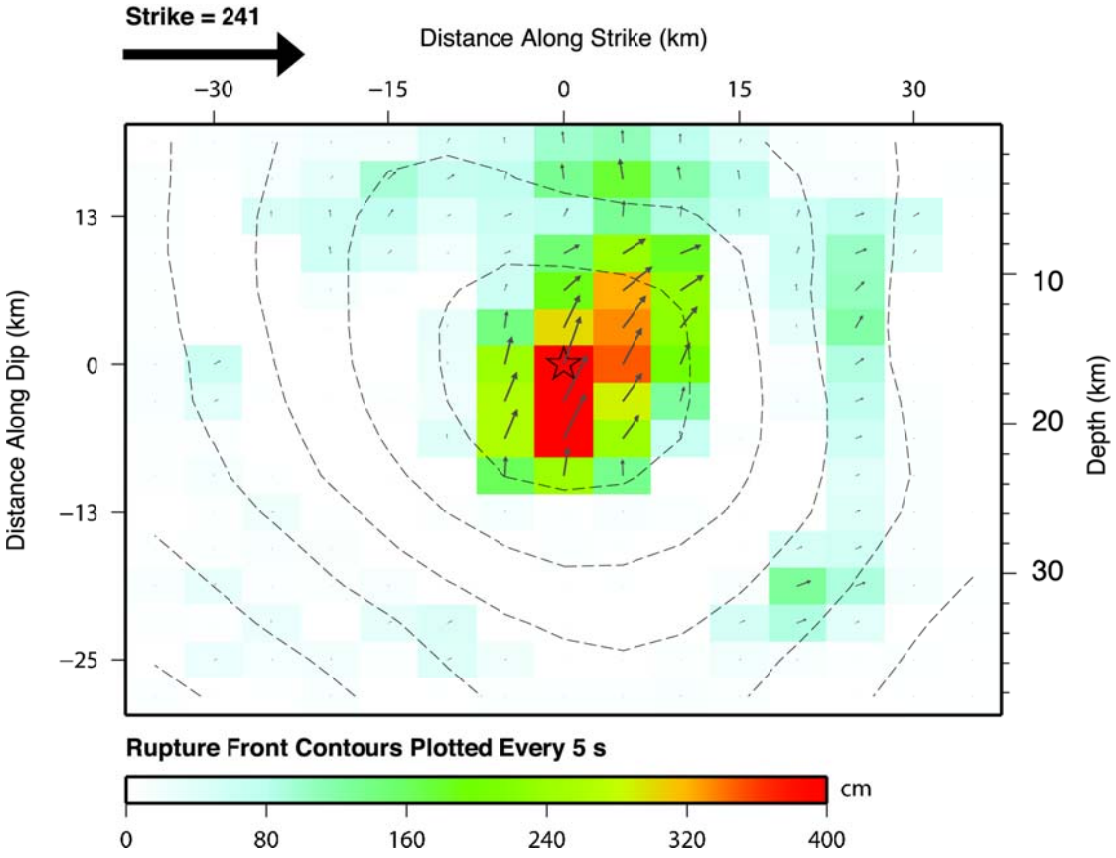


Figure 20. Cross-section of slip distribution (Hayes, 2011).

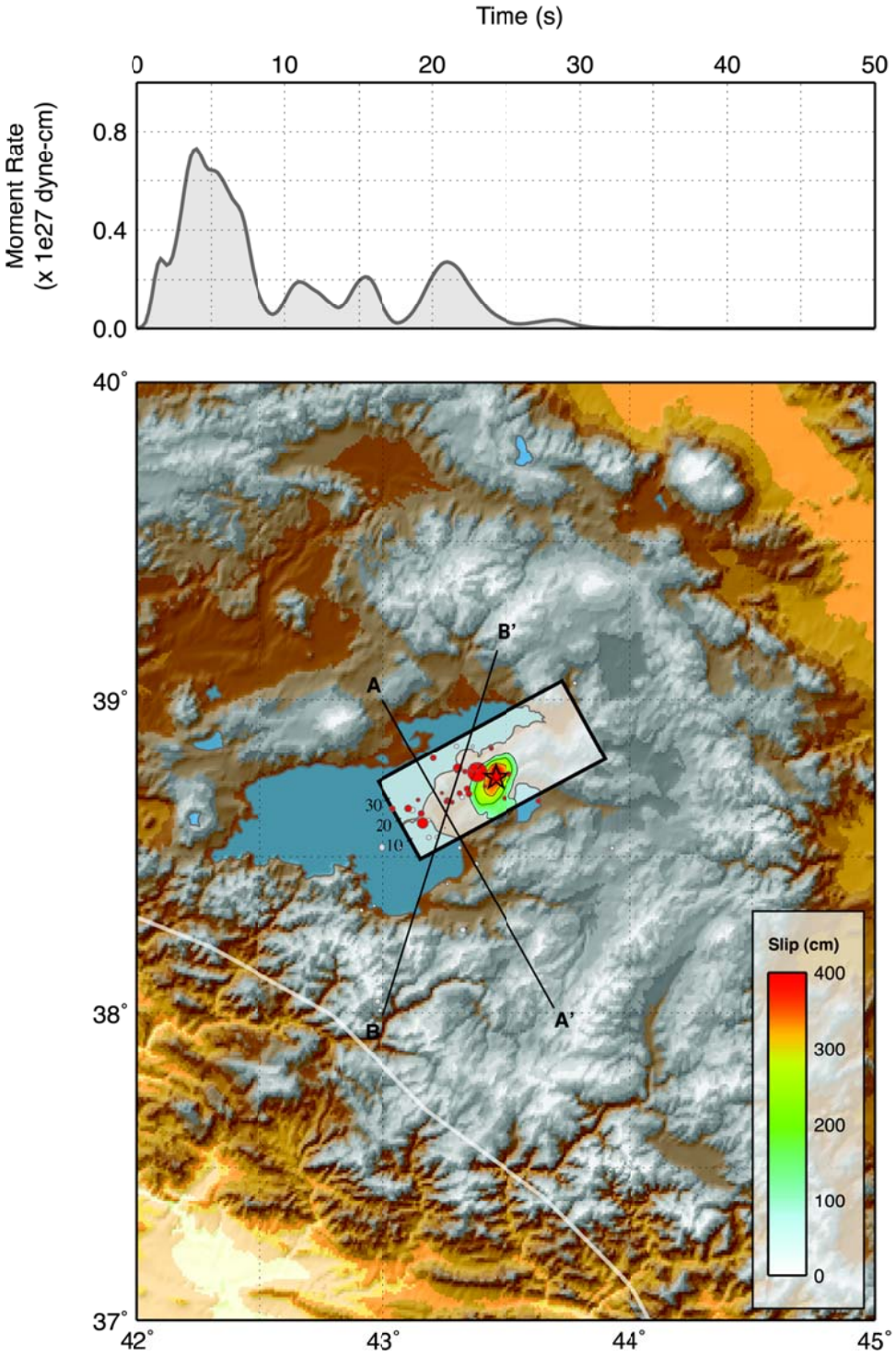


Figure 21. Basemap of slip distribution overlain on topography data from GEBCO. Red circles show main and aftershock relocations from Eric Bergman. Grey circles are foreshocks, also from Bergman. The panel above the map shows the moment rate function (Hayes, 2011).

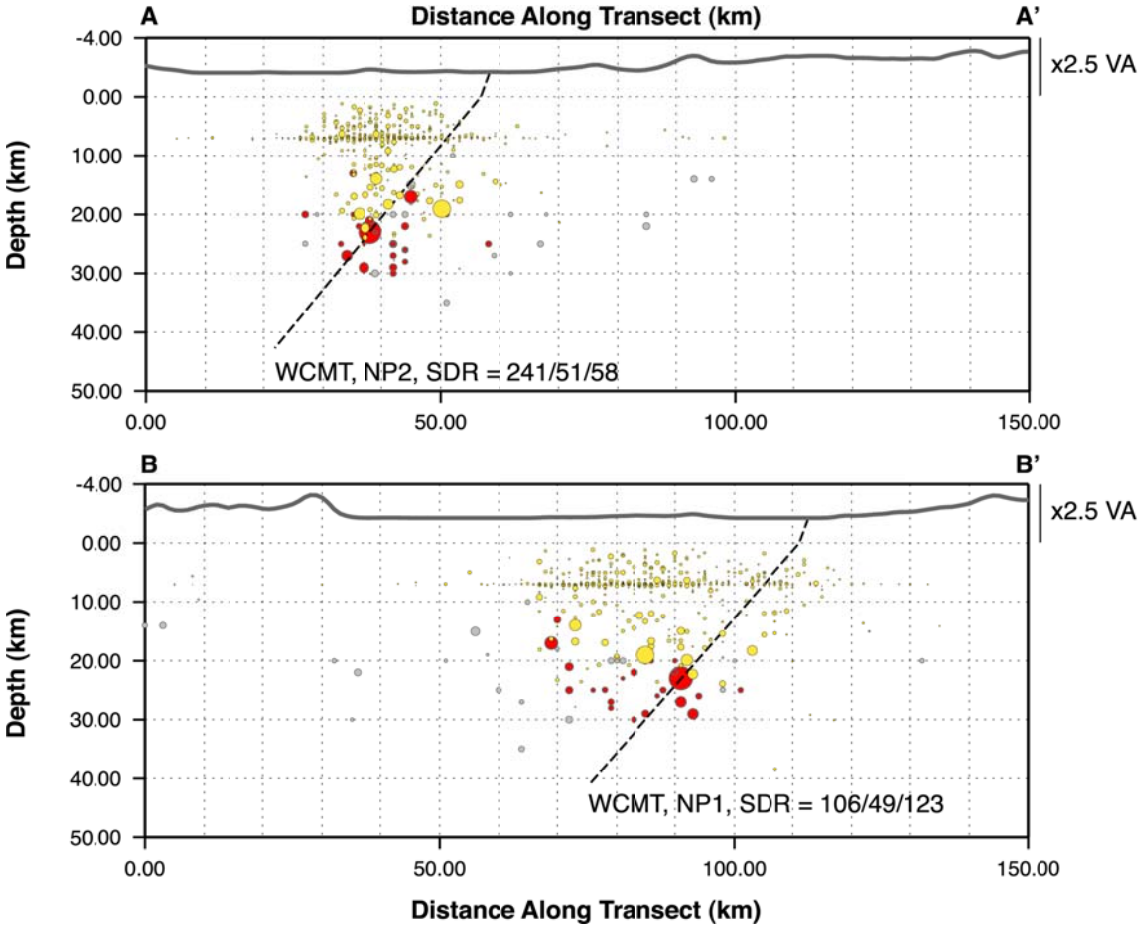
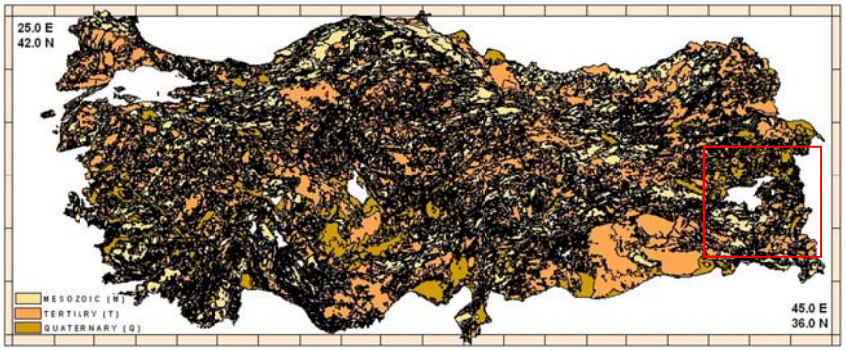


Figure 22. Cross-sections A and B through hypocenteral data plotted above. Lines are perpendicular to WCMT nodal planes (shown dashed in cross-sections) (Hayes, 2011).

QTM-Based Local Site Conditions

The 1/500,00 scale geologic map of Turkey produced by General Directorate of Mineral Research and Exploration (MTA) has been digitized and classified in terms of geological age as Quaternary, Tertiary and Mesozoic (QTM) by KOERI. The resulting QTM map given in Figure 23 has been utilized to reflect the effect of local sites. The approach used for the inclusion of site effects involves using QTM classification for the assigment of Vs30 (the average shear wave velocity of the upper 30 m) values. For southern California, Park and Elrick (1998) assigned V_{s30} values of 589 m/s, 406 m/s and 333 m/s to Mesozoic, Tertiary and Quaternary sediments respectively. Site correction according to these values is applied by Wald et al. *(*1999) in the TriNet ShakeMap alghoritm. The average shear-wave velocity in the upper 30 meters (V_{S30}) is mostly used to classify the local site conditions. The same QTM vs. V_{s30} values, together with the site correction methodology of Borcherdt (1978) were used to obtain site corrected ground motion distributions from the assigned Vs30 values for Turkey.



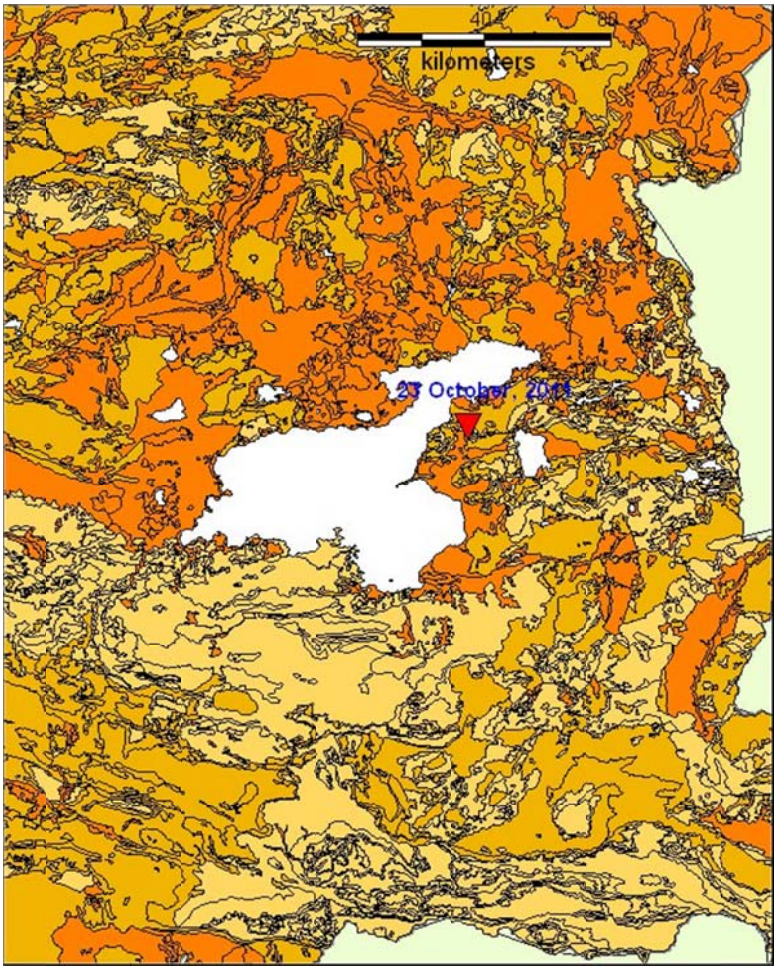


Figure 23. QTM based geologic age classification for Turkey

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Campbell, K. W. And Bozorgnia Y., "Updated Near-Source Ground- Motion (Attenuation) Relationships for the Horizontal and Vertical Components of Peak Ground Acceleration and Acceleration Response Spectra", Bulletin of the Seismological Society of Ameraica, Vol. 93, No,1, pp:314-331, 2003

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The October 23, 2011 Van, Turkey Earthquake (Mw=7.2)

PROBABILISTIC ASSESSMENT OF THE SEISMIC HAZARD FOR THE LAKE VAN BASIN

Introduction

The seismic hazard in Van Lake region is retrieved from the study of probabilistic assessment of seismic hazard in Turkey conducted for the Ministry of Transportion Turkey, aiming the preparation of an earthquake resistant design code for the construction of railways, seaports and airports (DLH, 2007).

Methodology of PSHA

The general methodology of calculating probabilistic seismic hazard is well established in literature (Cornell 1968). The method involves two separate models: a seismicity model describing a geographical distribution event sources and the distribution of magnitudes, and an attenuation model describing the effect at any site given as a function of magnitude and source-to-site-distance. The seismicity model may comprise a number of source regions, the seismicity of which should be expressed in terms of a recurrence relationship of events with magnitudes greater or equal to a certain value. The attenuation model relates the earthquake intensity (i.e. the effect of it, as a general term) at a site to magnitude, distance, source parameters and site conditions.

For forecasting seismic occurrences numerous models have been developed. The simplest stochastic model for earthquake occurrences is the Homogeneous Poisson Model, which is used in this study. For the earthquake events to follow that model, the following assumptions are in order:

1. Earthquakes are spatially independent;
2. Earthquakes are temporally independent;
3. Probability that two seismic events will take place at the same time and at the same place approaches zero.

Obviously for the above assumptions to be applicable to a data set, it should be free of fore- and aftershocks. This has been achieved in our study by removing all the dependent events from the earthquake catalogue.

The recurrence relationship of the events is expressed with the help of the empirical relationship first defined by Gutenberg - Richter: $\log N = A - bM$ where N is the number of shocks with magnitude greater or equal to M per unit time and unit area, and A and b are seismic constants for any given region. The source regions may be described as lines representing the known faults or areas of diffuse seismicity, so that M may be related to unit

length or unit area. The value of N will also generally be found assuming that M has upper and lower bounds M1 and Mo.

Using an application of the total probability theorem the probability per unit time that that ground motion amplitude a* is exceeded can be expressed as follows (McGuire, 1993):

$$P[A > a^* \text{ in time t}]/t = \sum_i v_i \int\int G_A\big|_{m,r}(a^*) f_m(m) f_r(r|m) dm dr$$

where $P[I \le i|m,r]$ is the probability that the maximum effect I is less than i. Given m and r, $f_m(m)$ is the probability density function for magnitude, and $f_r(r|m)$ is the probability distribution function for distance. $f_r(r|m)$ is dependent on the geometric nature of the source.

Seismic Source Zonation

A seismic source zone is defined as a seismically homogenous area, in which every point within the source zone is assumed to have the same probability of being the epicenter of a future earthquake. An ideal delineation of seismic source zones requires a complete comprehension of the geology, tectonics, paleoseismology, historical and instrumental seismicity, and other neotectonic features of the region under study. However, it is not always possible to compile detailed information in all these fields for the majority of the world. Thus, frequently, seismic source zones are determined with two fundamental tools; a seismicity profile and the tectonic regime of the region under consideration. Although seismic source zonation is a widely used methodology to determine earthquake hazard, it is not the only approach. Since delineation of the seismic source zones still remains rather subjective, researchers (e.g. Frankel, 1995) are suggesting other methods for evaluating seismic hazard, in order to eliminate the subjectivity of this procedure. This is particularly important in areas where the tectonic structure is very fragmented and the seismicity is diffuse. Whereas in most regions of Turkey, the seismicity is relatively well documented, major faults are often well defined and the source zones are fairly obvious. Hence it is considered adequate to use the conventional method of seismic source zonation for Turkey in this study.

The seismic source zonation used in this study is essentially based on the seismic source zonation model of Turkey developed within the context of a project conducted for the Ministry of Transportion Turkey, aiming the preparation of an earthquake resistant design code for the construction of railways, seaports and airports (DLH, 2007), which was an updated version of the GSHAP (1999, Erdik et al. 1999) and TEFER (2000) models. The main improvement of the DLH model when compared to the previous two models (the GSHAP and TEFER models) was the representation of main fault traces (such as the North Anatolian and the East Anatolian Faults) with linear sources. In order to account for the spatially more diffuse moderate size seismicity around these faults, widths of at least several kilometers were assigned to the zones even if the associated faults were well expressed on the surface. In the new model however, earthquakes with magnitude > 6.5 have been assumed to

take place on the linear zones, whereas the smaller magnitude events associated with the same fault have been allowed to take place in the surrounding larger areal zone. In addition to these zones, background zones have also been used in this model.

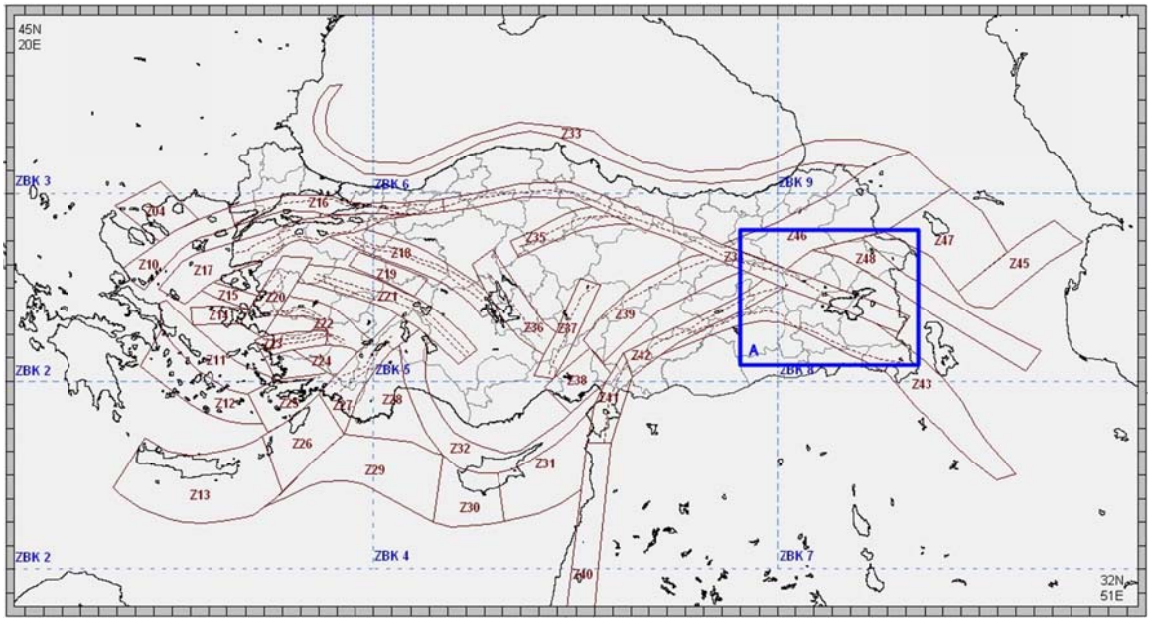


Figure 1. Source Zonation model used in the study of DLH (2007)

Earthquake Recurrence Relationships

The empirical recurrence relationship for earthquakes (Gutenberg and Richter Model. Richter, 1954) is as follows:

$\log N = a + b M$

where N is the number of the earthquakes above the magnitude M in a given region and within a given period and a and b are regression constants. The Gutenberg-Richter recurrence model has been extensively used in many seismicity studies and has also been confirmed to hold for micro-earthquakes. The coefficient a is a constant that is dependent on the location and time of the sample used and b represents a constant thought to be characteristic of the region.

The earthquake catalogues are often biased due to incomplete reporting for smaller magnitude earthquakes in earlier periods. Thus to fit the recurrence relationship to a region, one should choose among using

(1) a short sample that is complete in small events or

(2) a longer sample that is complete in larger events or

(3) a combination of the two data sets to complete the deficient data thereby obtaining a homogeneous data set.

A direct attempt to fit these data to a regression relationship may result in quadratic or higher order expressions to accommodate the inherent bias and inhomogeneity of the data. In the method used in this study, an artificially homogeneous data set is simulated through the determination of the period over which the data in a given magnitude group are completely reported (Stepp, 1973).

The computed recurrence parameters as well as the maximum magnitudes associated with the source zones are presented in Table 1.

Table 1. Source Zone Information

Source Zone No	Fault Name	Mechanism	a	b	M_{min} - M_{maks}
Z34 Outside Zone	North Anatolian Fault Zone (NAF)	Right Lateral Strike Slip	5.0	0.8	5.0 – 6.7
Z34 Inside Zone					6.8 – 7.9
Z39 Outside Zone	Goksun Fault ı	Left Lateral Strike Slip	2.7	0.7	5.0 -6.9
Z39 Outside Zone					7.0 – 7 .5
Z42 Outside Zone	East Anatolian Fault Zone(EAF)	Left Lateral Strike Slip	4.6	0.9	5.0 – 6.7
Z42 Inside Zone					6.8 – 7.9
Z43 Outside Zone	Bitlis_Zagros Fault Zone	Thrust	4.7	1.0	5.0 – 6.6
Z43 Inside Zone					6.7 – 7.0
Z46	North East Anatolian Fault Zone	Left and Right Lateral Strike Slip	5.6	1.1	5.0 - 7.7
Z47	PambaSevan Fault Zone	Right Lateral Strike Slip + Thrust	3.9	0.9	5.0 - 7.3
Z48	Tebriz Fault Zone	Right Lateral Strike Slip	4.4	1.0	5.0 - 7.3

Ground Motion Prediction Equations

Owing to the geological and geo-tectonic similarity of Anatolia to the California (strike slip faults similar to North, Northeast and East Anatolian Faults), the following ground motion

prediction equations currently being used for the assessment of earthquake hazard for the Western US was utilized:

1. Average of Boore, Joyner and Fumal (1997), Sadigh et al.(1997), and Campbell (2003) for Peak Ground Acceleration (PGA)

- Average of Boore et al. (1997), Sadigh et.al. (1997) and Campbell (1997) for Spectral Acceleration (Ss and S1)

Hazard Results

The present analysis has been conducted for return periods of 475 and 2,475 years corresponding to 90% and 98 % probabilities of non-exceedence in 50 years respectively. The selected ground motion parameters of analysis were the Peak Ground Acceleration (PGA), the Spectral Accelerations (SA) at periods of 0.2 sec and 1 sec. A grid size of 0.05° by 0.05° was used. The earthquake location uncertainty was taken as 10 km. The standard deviations in the attenuation functions were taken as given in the associated papers. The results are presented in Figure 2 through Figure 7 in form of the mean of the log normally distributed results obtained from computations with the above attenuation relationships in bedrock conditions.

The sub-province based hazard result is also presented in Table 2.

Table 2. Hazard results for Tabanlı, Erciş, Muradiye and Van-Merkez districts

		72	475	2475
Epicentral Location (Tabanlı)	PGA	0.23	0.43	0.64
	SA(T=0.2s)	0.51	0.94	1.42
	SA(T=1.0s)	0.14	0.28	0.46
Erciş	PGA	0.12	0.22	0.34
	SA(T=0.2s)	0.27	0.49	0.76
	SA(T=1.0s)	0.09	0.16	0.26
Muradiye	PGA	0.1	0.18	0.29
	SA(T=0.2s)	0.26	0.41	0.65
	SA(T=1.0s)	0.075	0.14	0.22
Van - Merkez	PGA	0.27	0.47	0.7
	SA(T=0.2s)	0.59	1.04	1.56
	SA(T=1.0s)	0.15	0.31	0.51

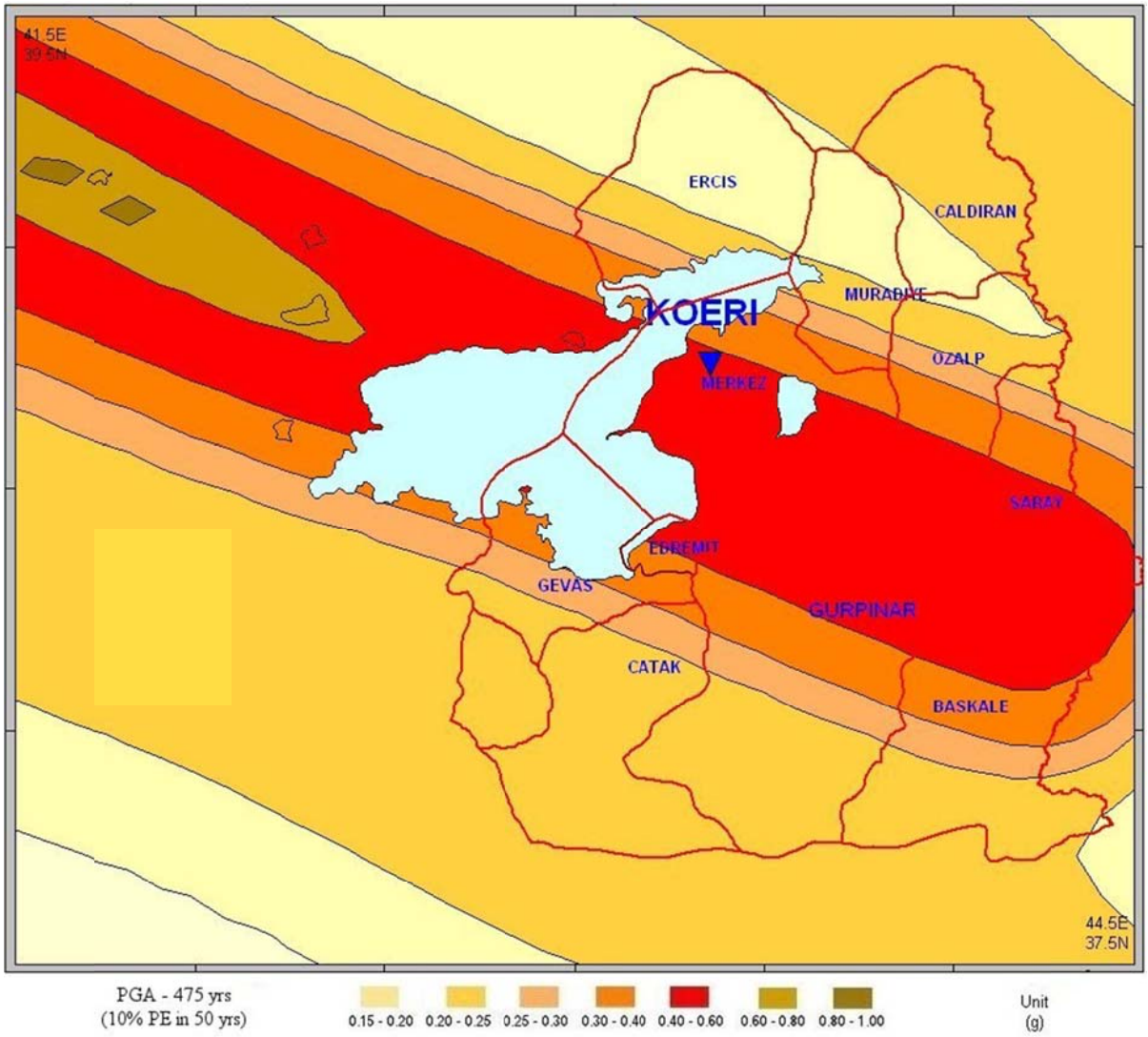


Figure 2. PGA for 10% probability of exceedence in 50 years (blue triangle shows the epicenter of the Van earthquake given by KOERI).

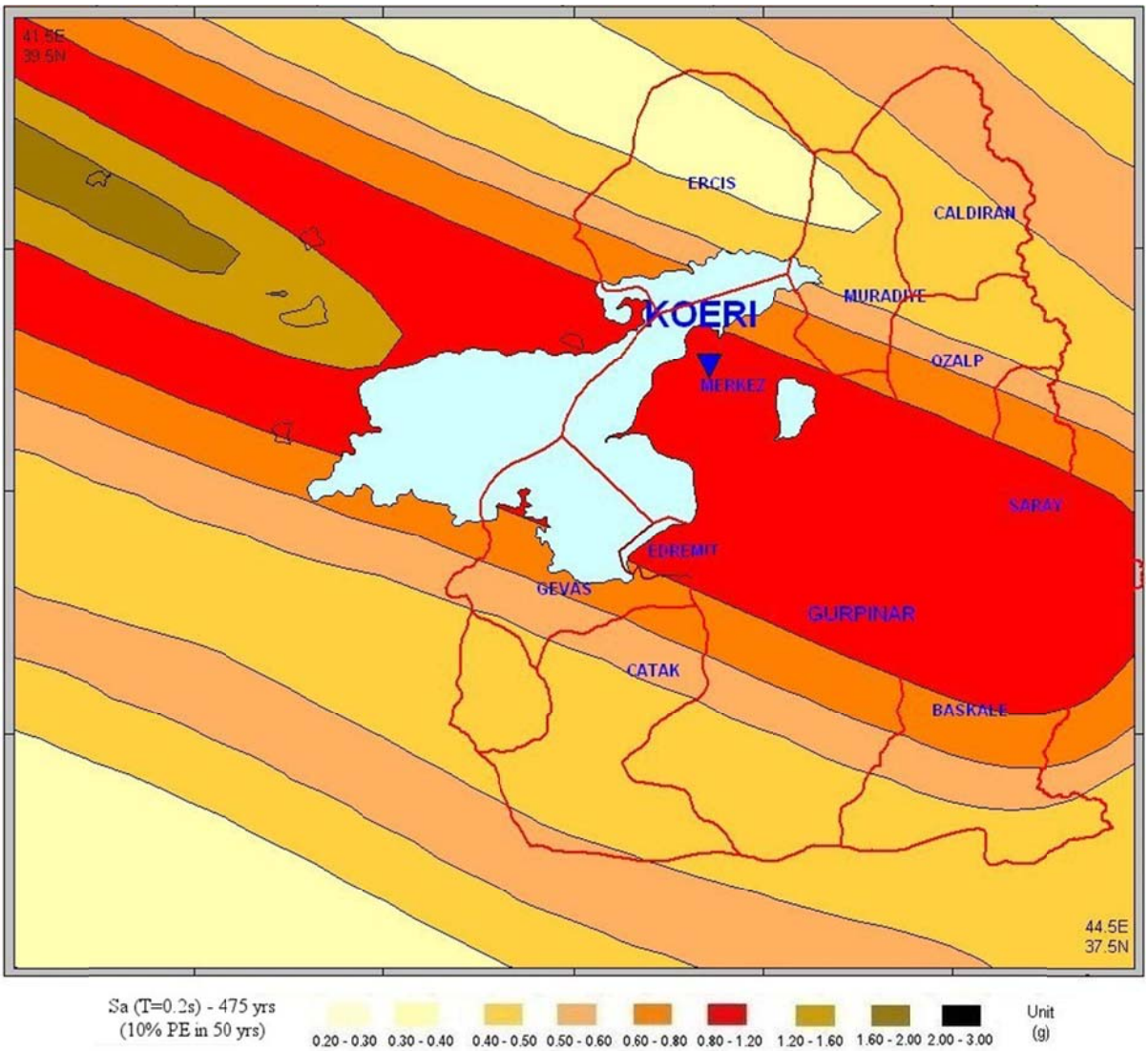


Figure 3. SA (T=0.2s) for 10% probability of exceedence in 50 years (blue triangle shows the epicenter of the Van earthquake given by KOERI).

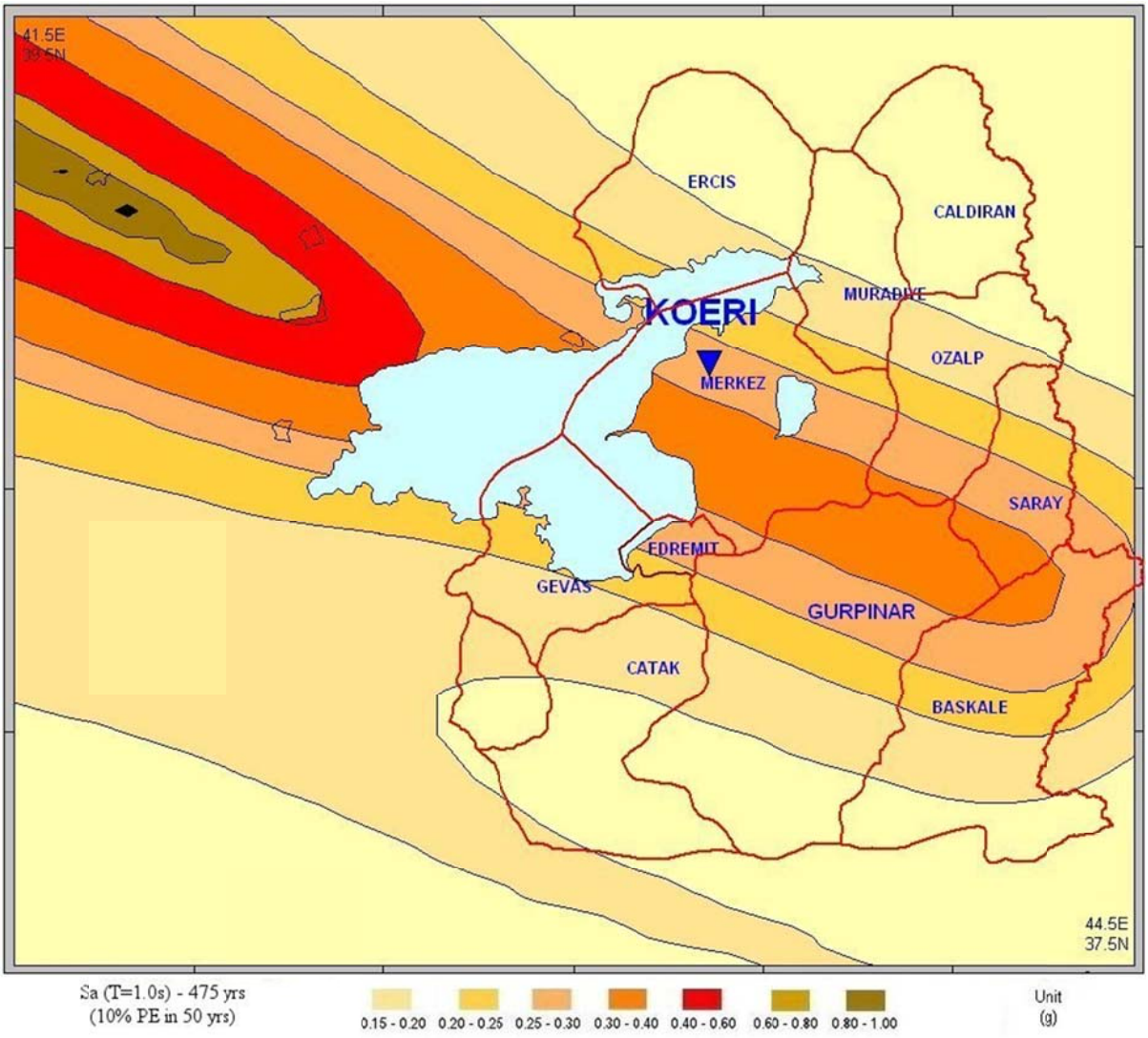


Figure 4. SA (T=1.0s) for 10% probability of exceedence in 50 years (b**l**ue triangle shows the epicenter of the Van earthquake given by KOERI).

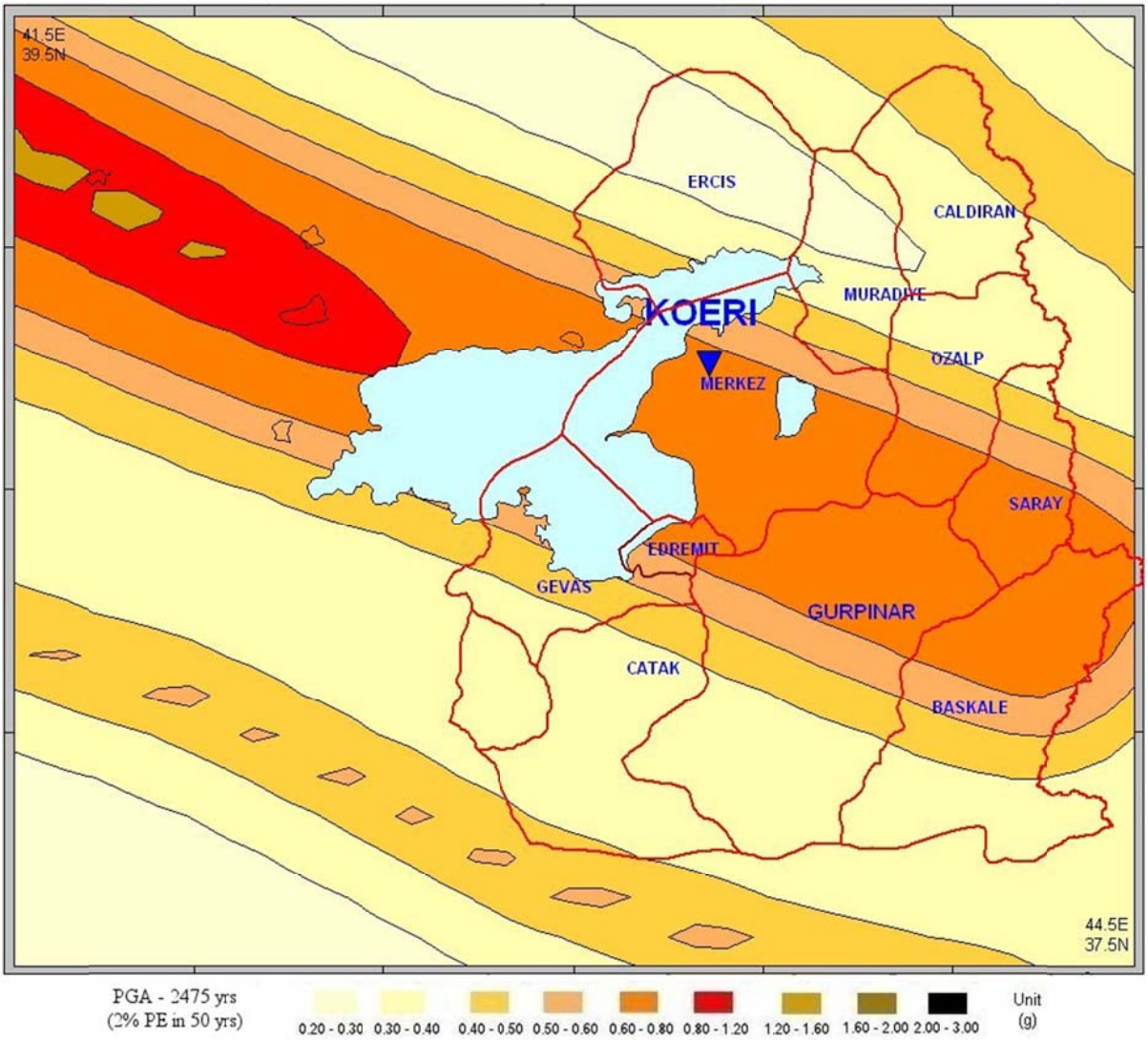


Figure 5. PGA for 2% probability of exceedence in 50 years (blue triangle shows the epicenter of the Van earthquake given by KOERI).

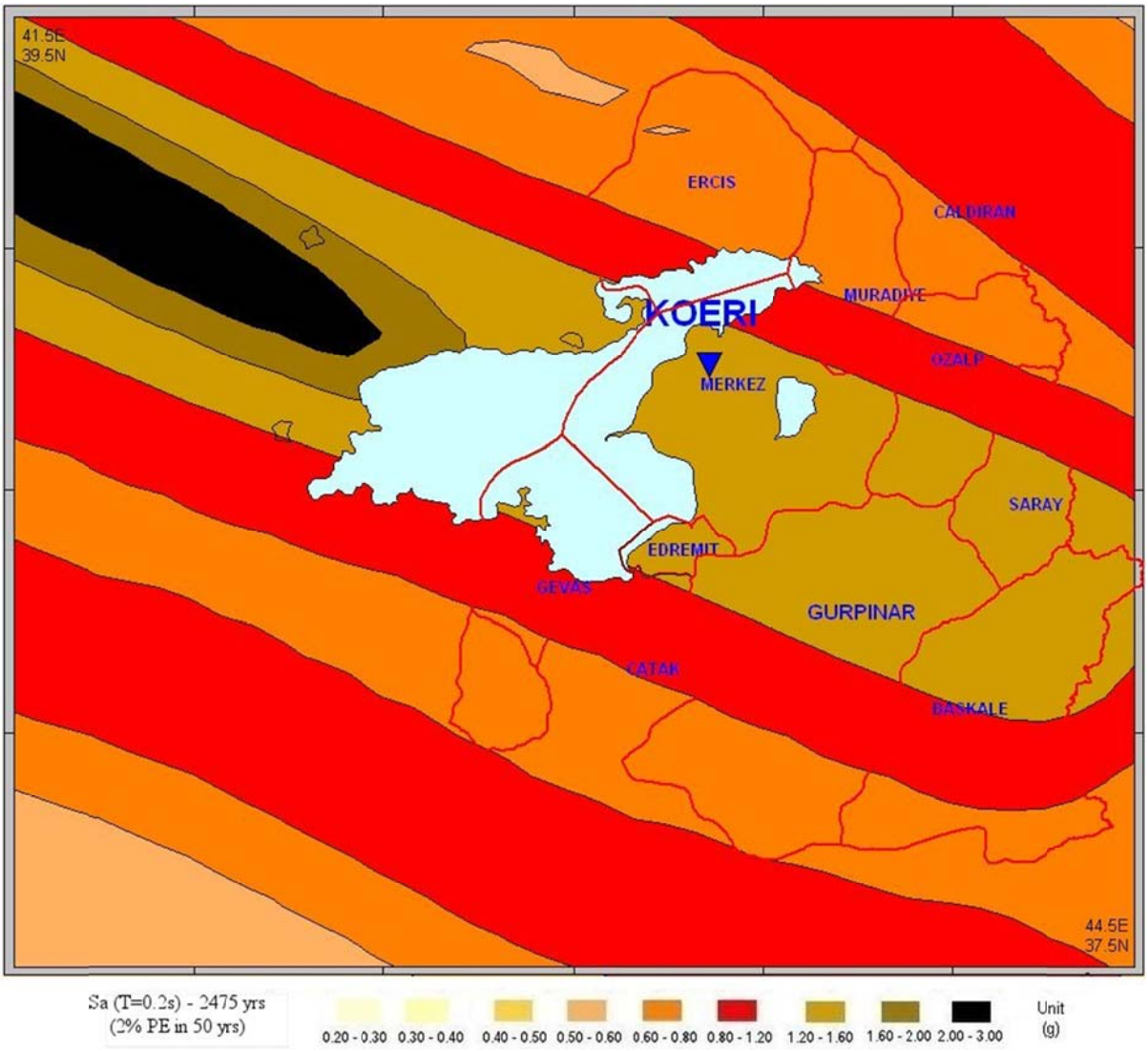


Figure 6. SA (T=0.2s) for 2% probability of exceedence in 50 years (blue triangle shows the epicenter of the Van earthquake given by KOERI).

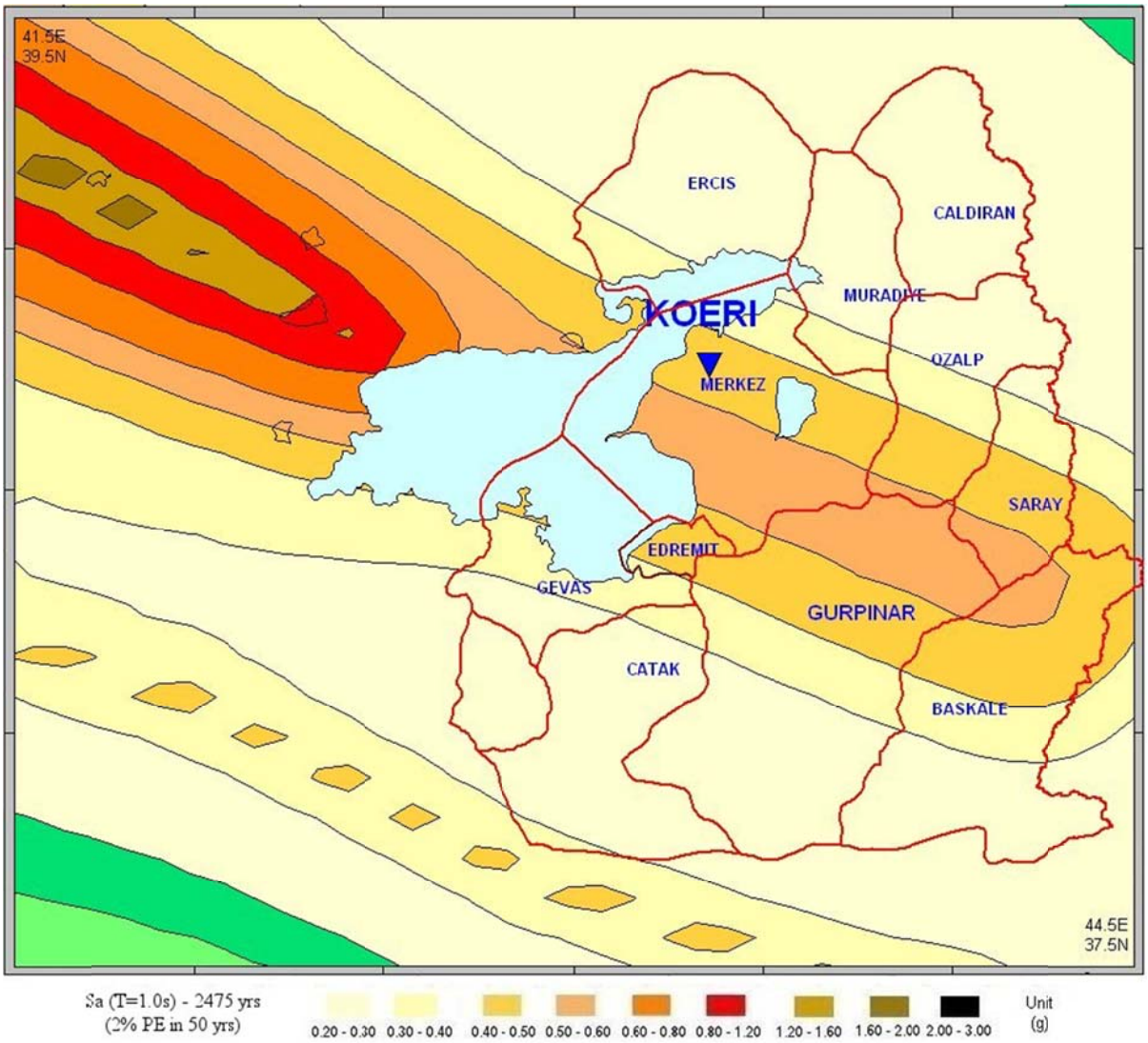


Figure 7. SA (T=1.0s) for 2% probability of exceedence in 50 years (blue triangle shows the epicenter of the Van earthquake given by KOERI).

Site Specific Modification of Design Basis Ground Motion

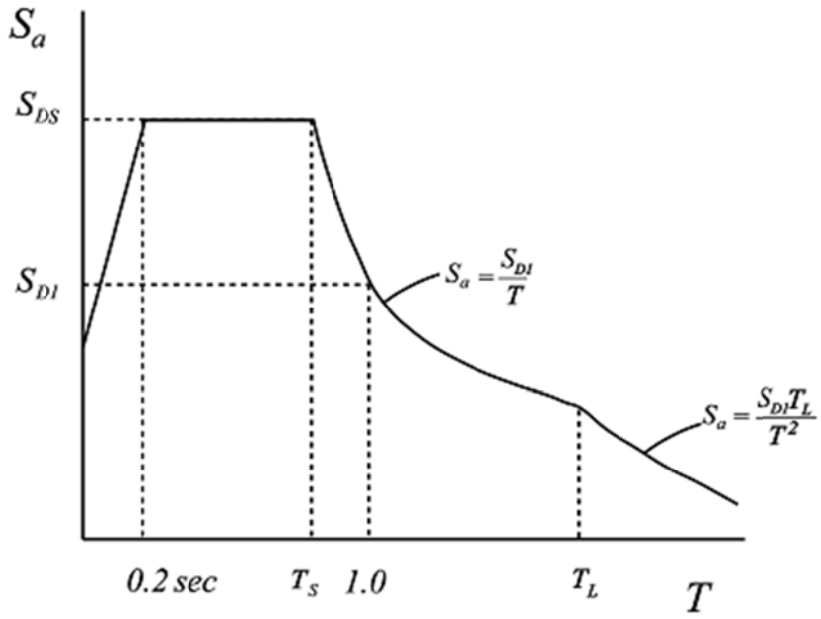
The construction of the design basis response spectrum for different Site Classes can be achieved through the modification of the spectral acceleration (SA(0.2s) and SA(1s)) given by the hazard maps in Chapter 6 or SEE and FEE level earthquakes. The Uniform Hazard Response Spectrum presented in NEHRP (2003, 2009) that will be employed as the appropriate spectral shape is constructed with two parameters: the site-specific short period (S_{MS}); and medium-period (S_{M1}). The shape of the spectrum for 5% damping is illustrated in Figure 8.

The site-specific short-period spectral response acceleration parameter, S_{MS} and medium-period parameter S_{M1} can be obtained as follows:

$S_{MS} = Fa * Ss$ where Ss = SA(0.2s)

$S_{M1} = Fv * S1$ where S1= SA(1s)

Where Ss and S1 are represented by the spectral accelerations at T=0.2 sec and T=1.0 sec at reference soil site ($V_{s,30}$ ≥760m/s.) obtained from the hazard analysis. Fa and Fv are respectively the applicable Short and Medium Period Amplification Factors, defined in NEHRP (2003 and 2009) (Table 3 and Table 4). The site classes indicated on these tables are to be obtained from the geo-technical investigations to be carried along the pipeline route.



*T_S: transition period from constant response acceleration to constant response velocity, in units of seconds, and T_L: transition period from constant response velocity to constant response displacement, in units of seconds

Figure 8. Standard Shape of the Response Spectrum (NEHRP, 2009)

Table 3. Values of Fa as a function of Site Class and 0.2s Spectral Acceleration (at B/C boundary with Vs = 760 m/s)

Site Class	Ss≤0.25	Ss=0.50	Ss=0.75	Ss=1.0	Ss≥1.25
A	0.8	0.8	0.8	0.8	0.8
B	1	1	1	1	1
C	1.2	1.2	1.1	1	1
D	1.6	1.4	1.2	1.1	1
E	2.5	1.7	1.2	0.9	0.9
F	*	*	*	*	*

** Site-specific geotechnical investigation and dynamic site response analyses shall be performed.*

Table 4. Values of Fv as a function of Site Class and 1.0s Spectral Acceleration (at B/C boundary with Vs = 760 m/s)

Site Class	Ss≤0.1	Ss=0.20	Ss=0.3	Ss=0.4	Ss≥0.5
A	0.8	0.8	0.8	0.8	0.8
B	1	1	1	1	1
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	*	*	*	*	*

** Site-specific geo-technical investigation and dynamic site response analyses shall be performed.*

QTM based Site Dependent Hazard Results

The QTM map based site dependent analysis has been conducted for return periods of 72, 475 and 2,475 years corresponding to 50%, 10% and 2 % probabilities of exceedence in 50 years respectively. The selected ground motion parameters of analysis were the Peak Ground

Acceleration (PGA), and the Spectral Accelerations (SA) at periods of 0.2 sec and 1 sec. The results are presented in Figure 9 through Figure 12 in form of the mean of the log normally distributed results obtained from computations with the above GMPEs in site conditions.

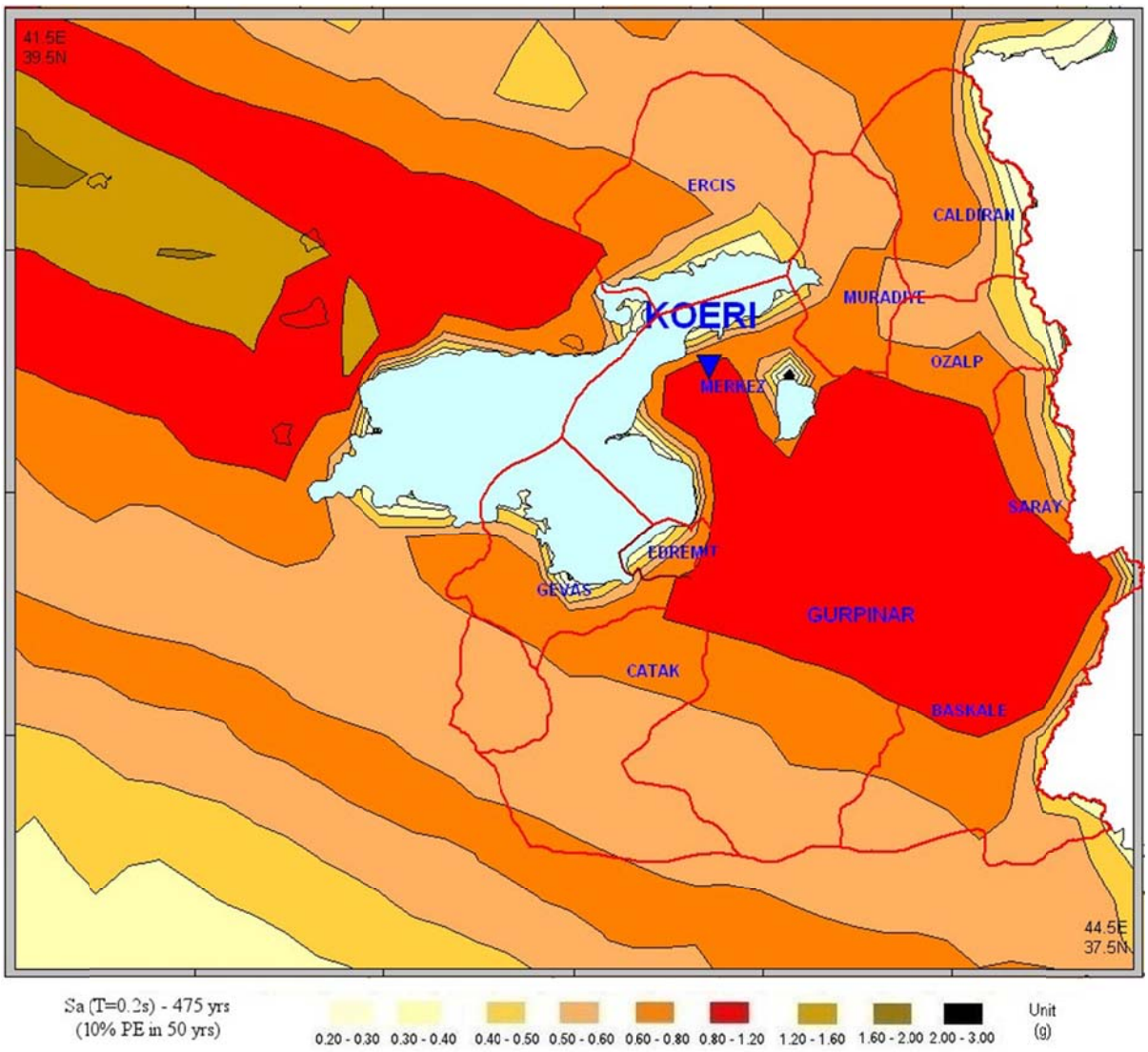


Figure 9. QTM based SA (T=0.2s) for 10% probability of exceedence in 50 years (blue triangle shows the epicenter of the Van earthquake given by KOERI).

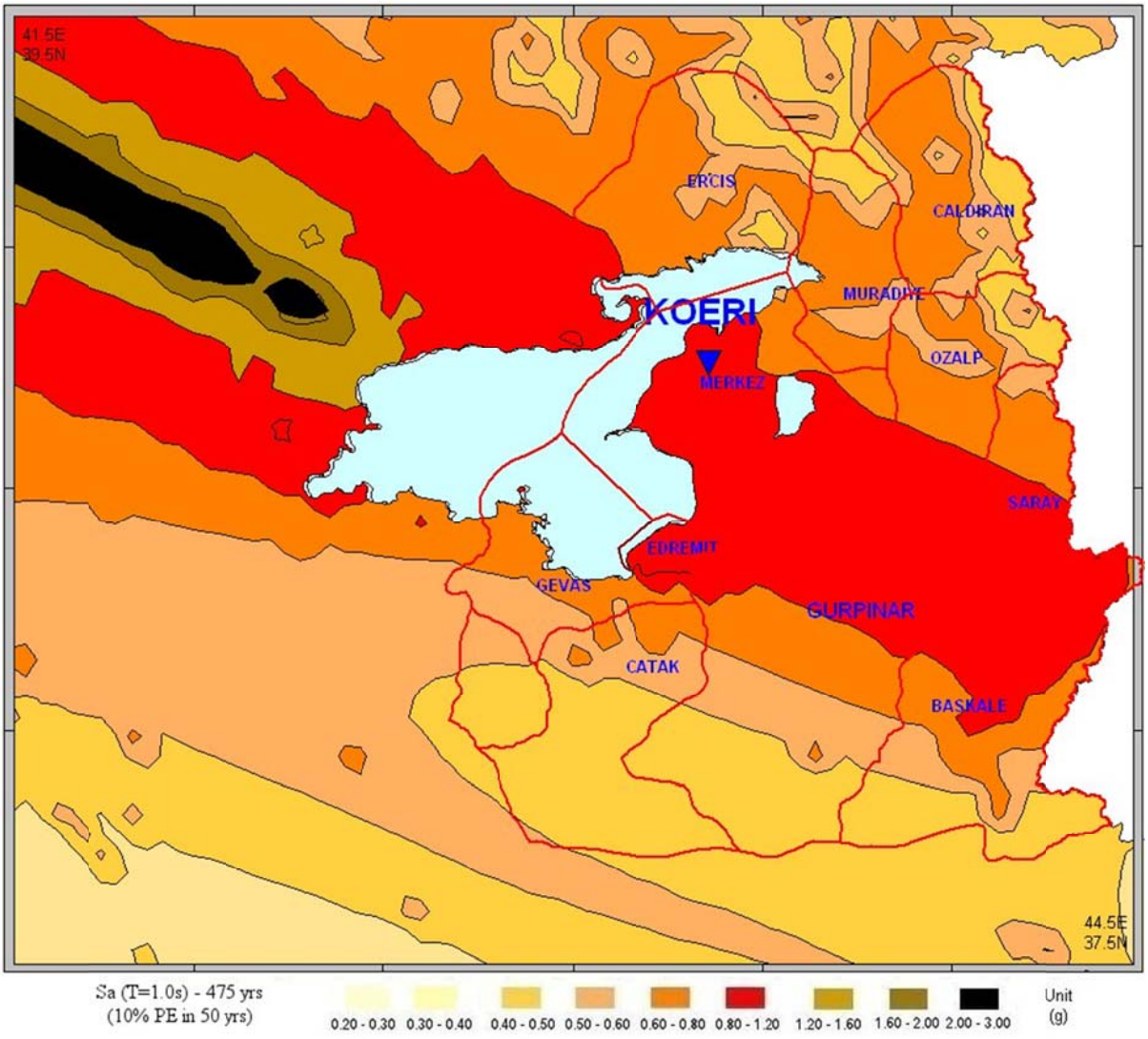


Figure 10. QTM based SA (T=1.0s) for 10% probability of exceedence in 50 years (blue triangle shows the epicenter of the Van earthquake given by KOERI).

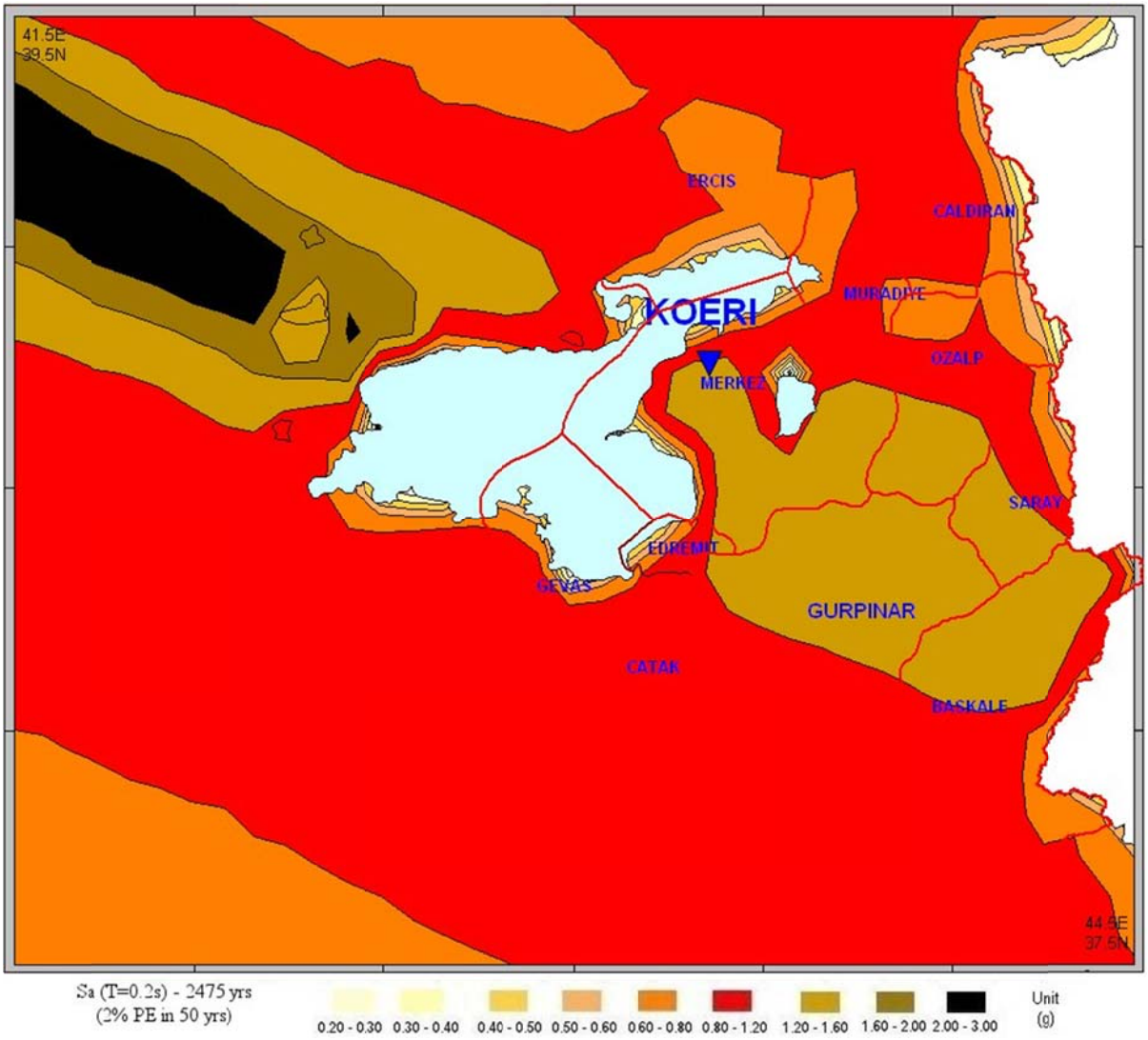


Figure 11. QTM based SA (T=0.2s) for 2% probability of exceedence in 50 years (blue triangle shows the epicenter of the Van earthquake given by KOERI).

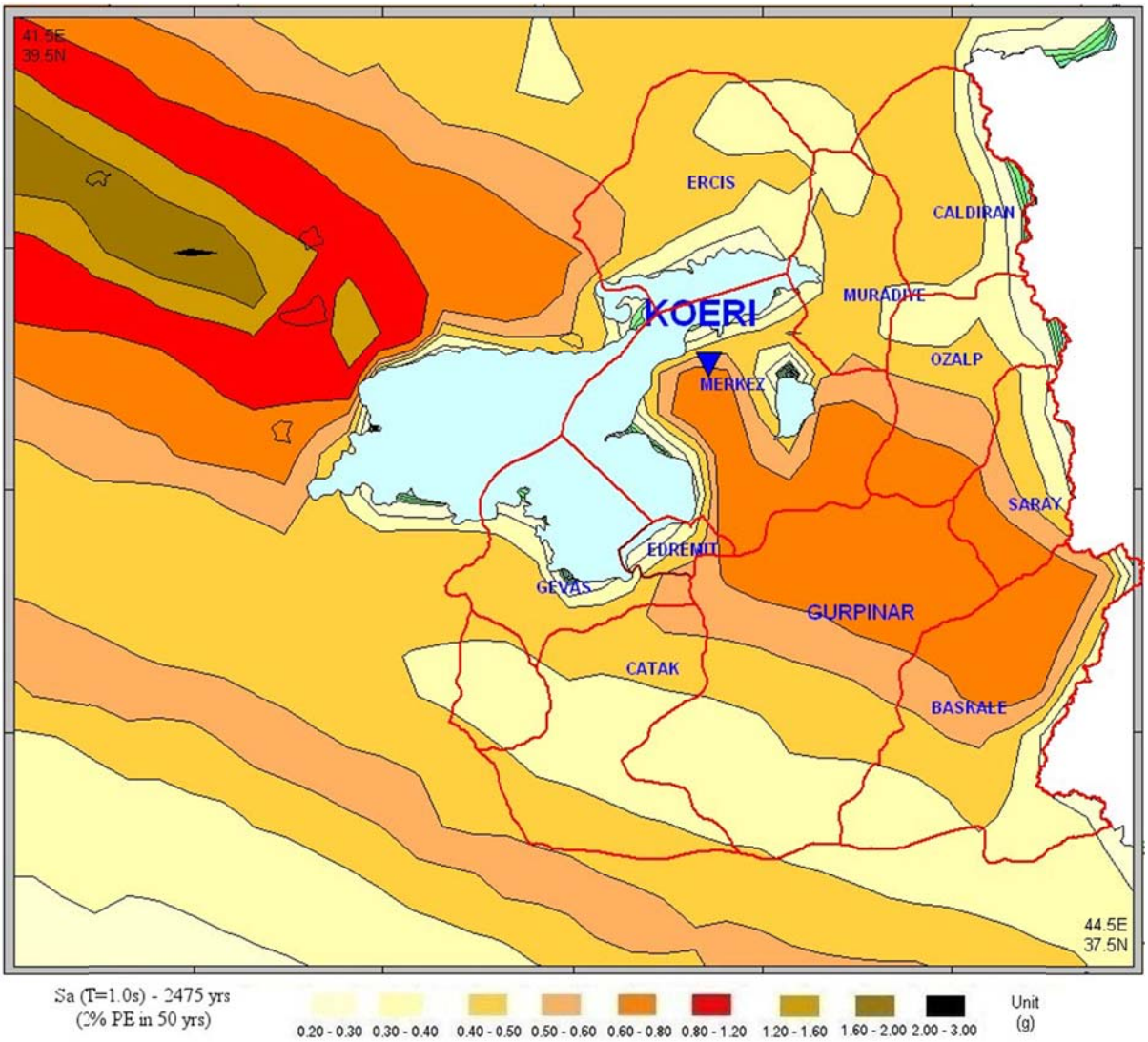


Figure 12. QTM based SA (T=1.0s) for 2% probability of exceedence in 50 years (blue triangle shows the epicenter of the Van earthquake given by KOERI).

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Bogazici University
Kandilli Observatory and Earthquake Research Institute
Department of Earthquake Engineering

The October 23, 2011 Van, Turkey Earthquake (Mw=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 casulaties, 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 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.

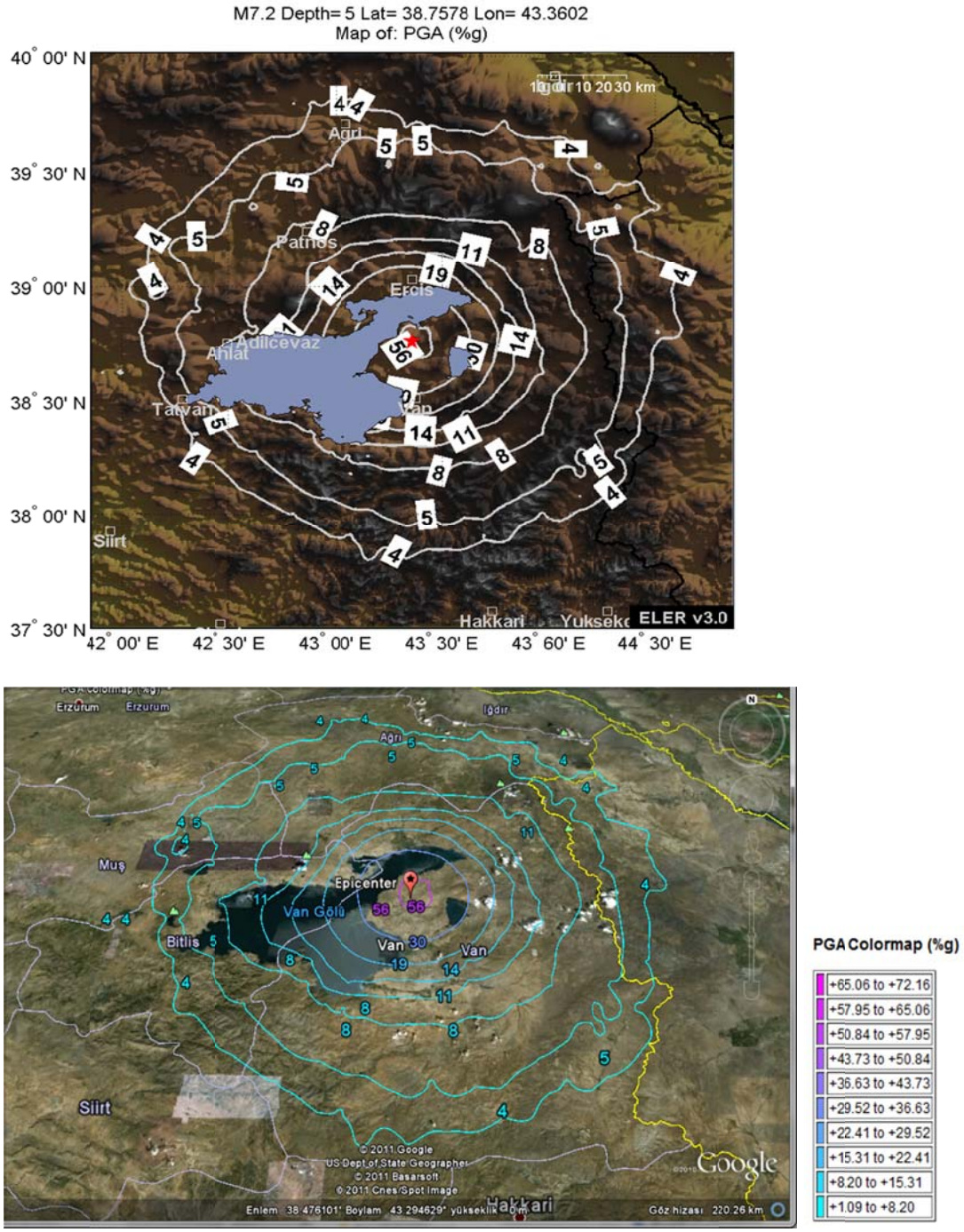

Figure 1. Distribution of peak ground accelerations associated with the mainshock.

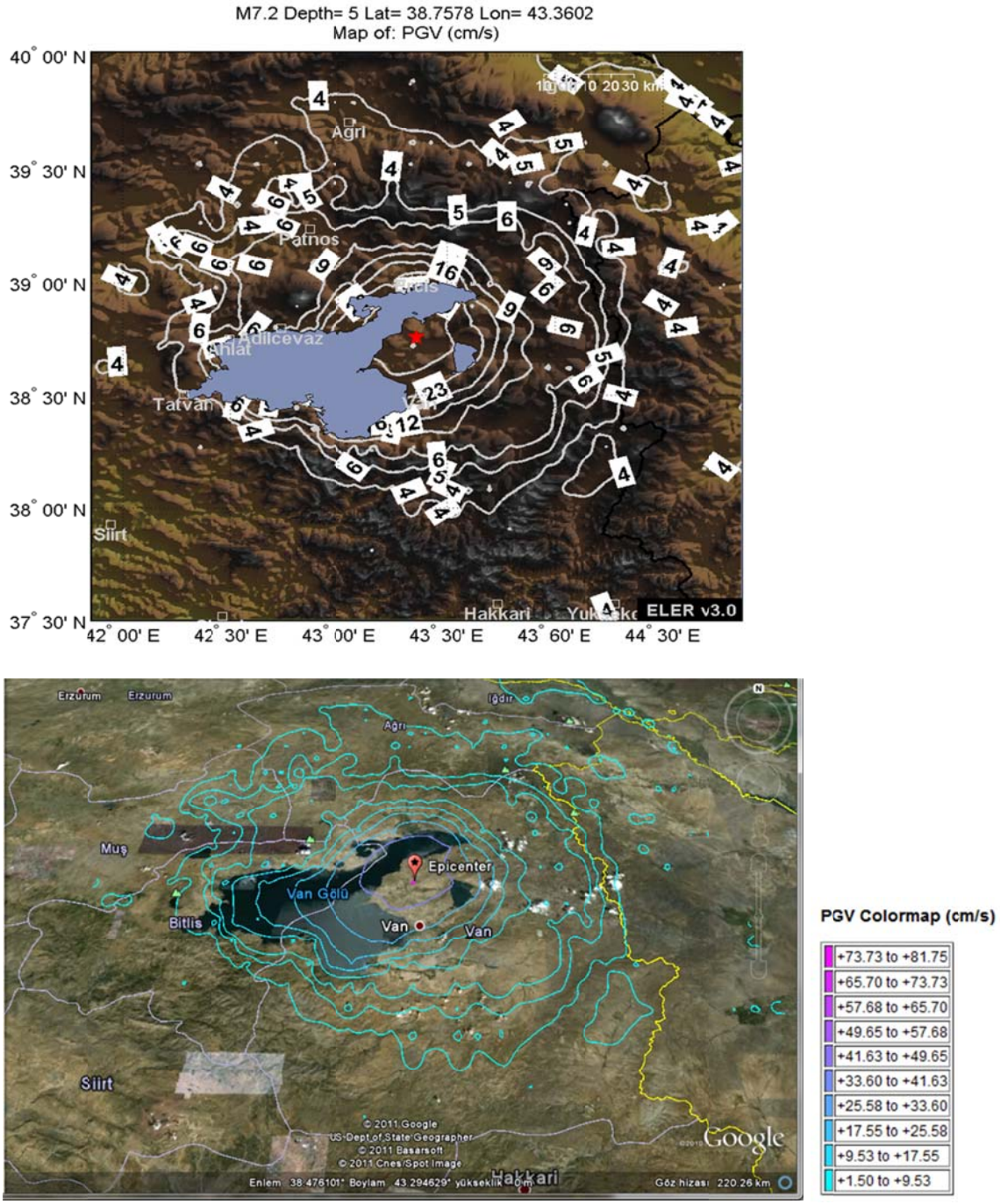

Figure 2. Distribution of peak ground velocities associated with the mainshock.

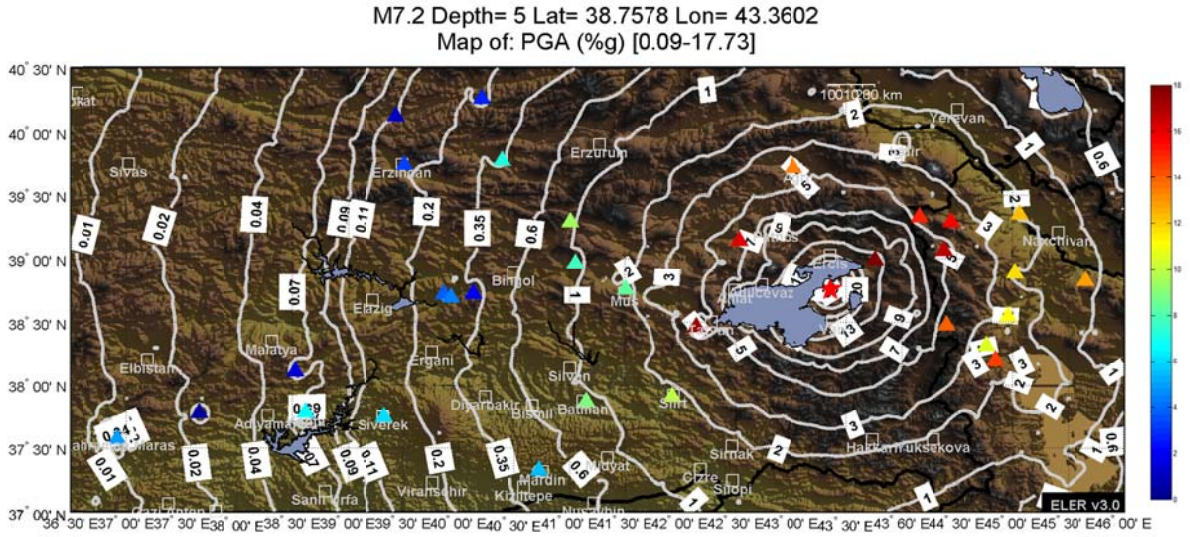

Figure 3. Distribution of peak ground accelerations bias-adjusted using strong ground motion data from regional networks.

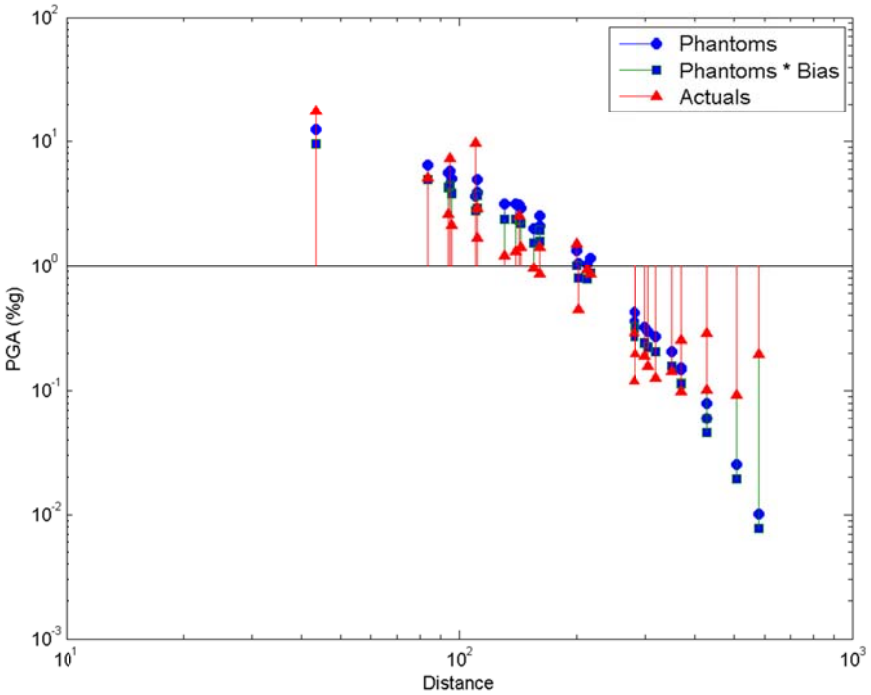

Figure 4. Comparison between the actual and estimated peak ground accelerations for individual stations used in the bias adjustment

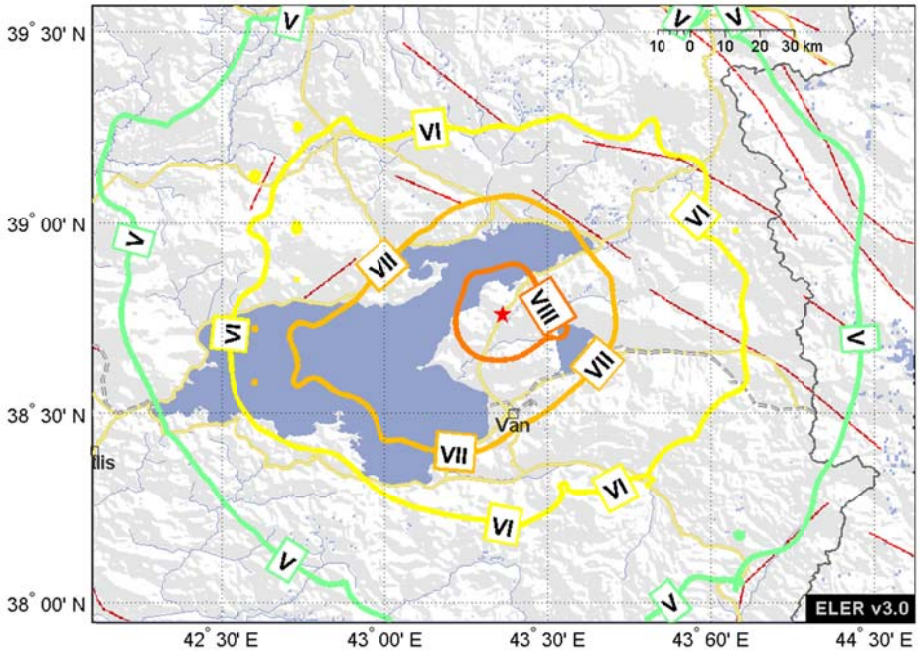

Figure 5. Instrumental intensities associated with the mainshock

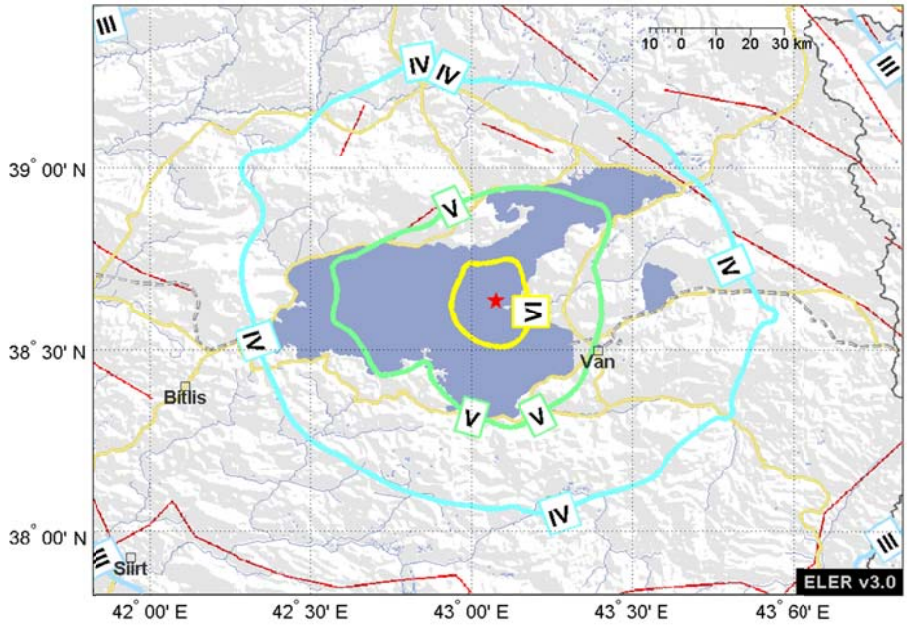

Figure 6. Instrumental intensities associated with the main aftershock (M 5.7)

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.

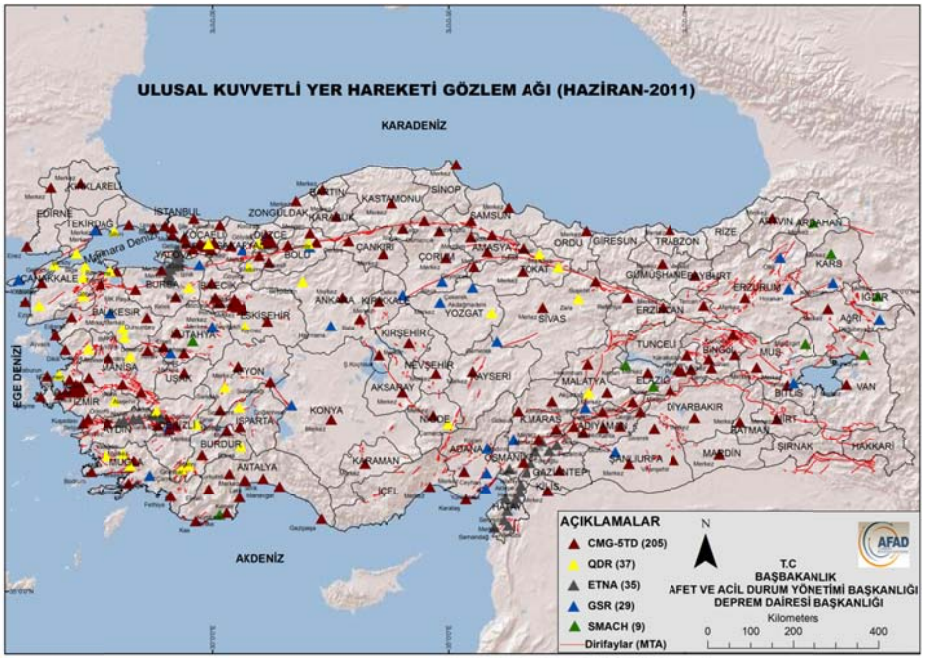

Figure 7. http://kyh.deprem.gov.tr/

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. 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 accelererations, 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 cm/s^2 and 167 cm/s^2 in the NS and EW directions respectively. In Bitlis stations the largest acceleration is 101.5 cm/s^2 in the EW direction. The largest velocities in Muradiye station are obtained as 27 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.

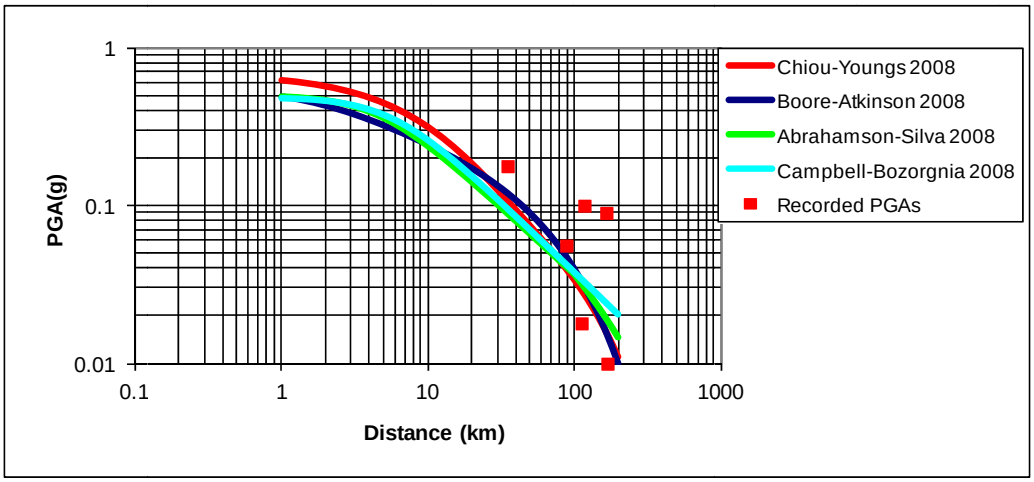

Figure 8. Comparison of recorded ground motion PGAs with NGA GMPEs

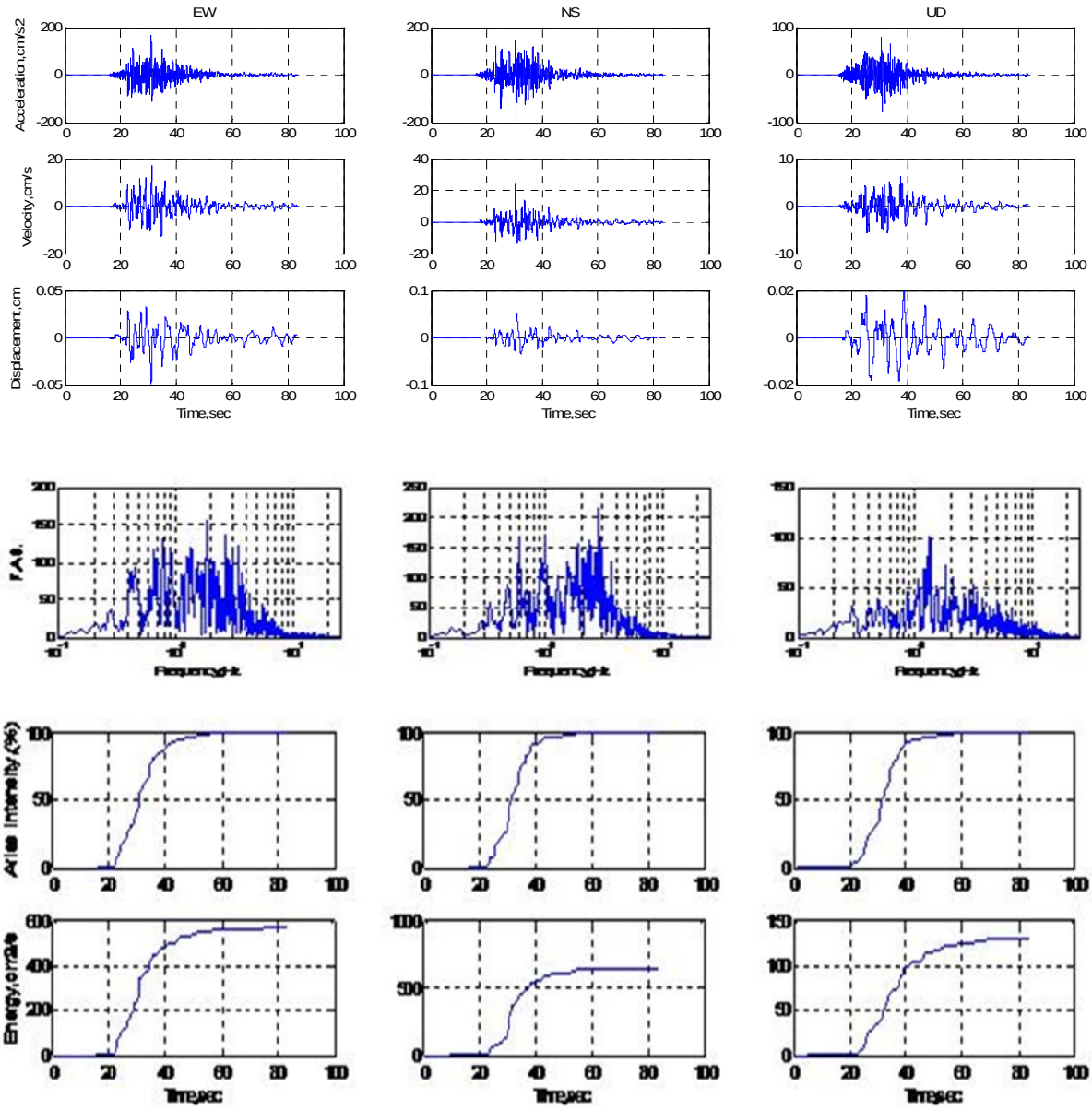

Figure 9. 6503 Muradiye Station. Corrected acceleration, velocity, displacement time histories, FAS, Arias intensities and energy densities in EW, NS and UD directions

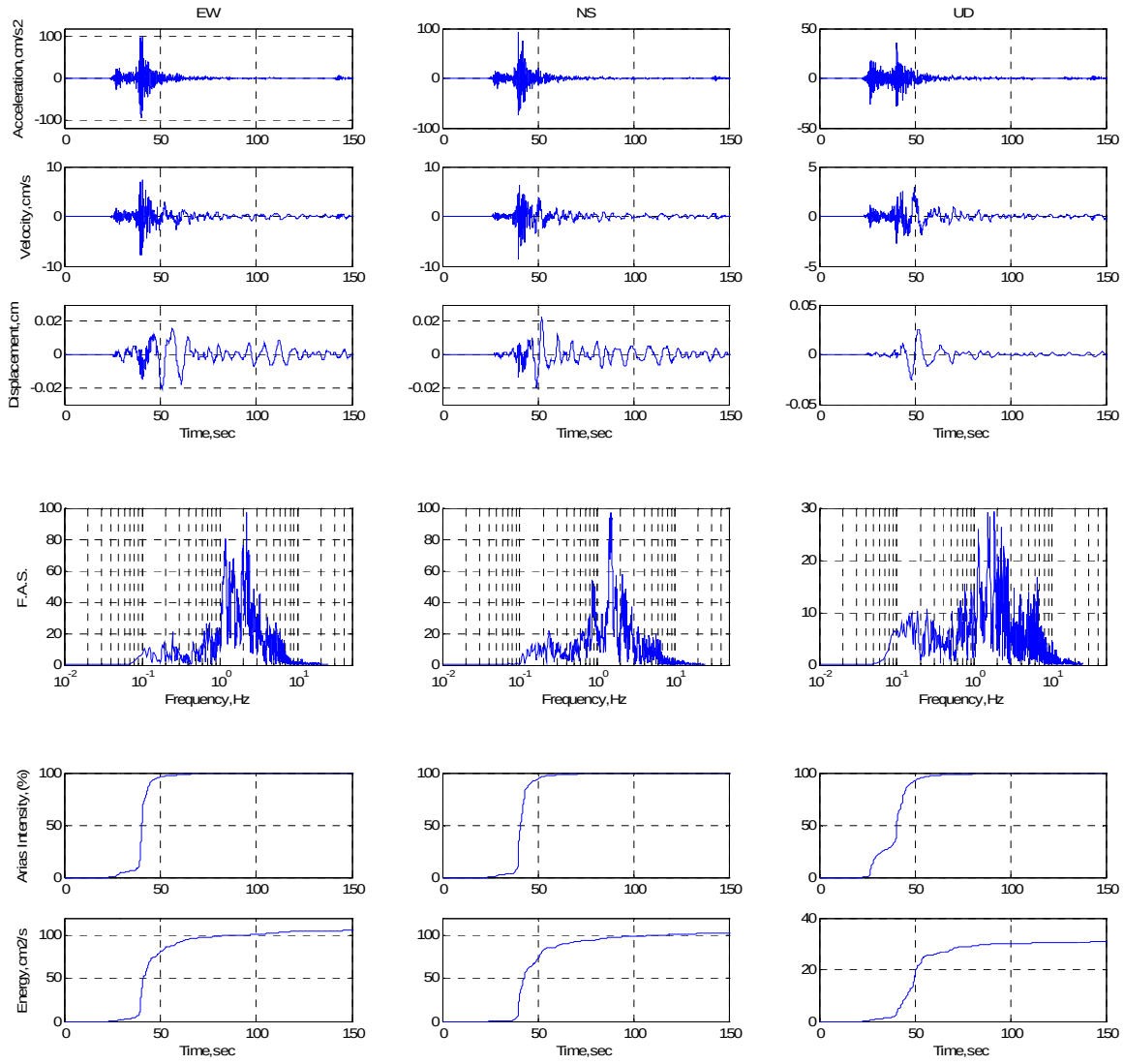

Figure 10. 1302 Bitlis Station. Corrected acceleration, velocity, displacement time histories, FAS, Arias intensities and energy densities in EW, NS and UD directions

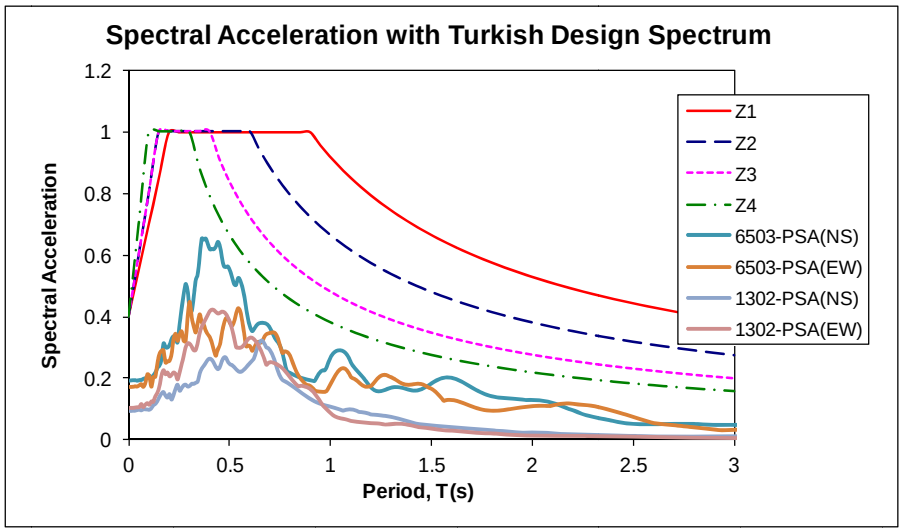

Figure 11. Spectral accelerations of two horizontal components of the 6503 Muradiye ve 1302 Bitlis stations shown with the Turkish Design Spectra for four types of soil conditions.

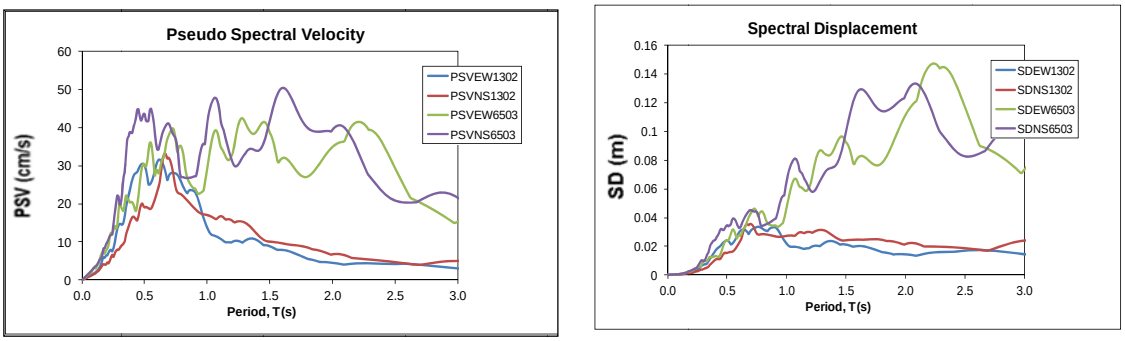

Figure 12. Spectral velocities and displacements of two horizontal components of the 6503 Muradiye and 1302 Bitlis records.

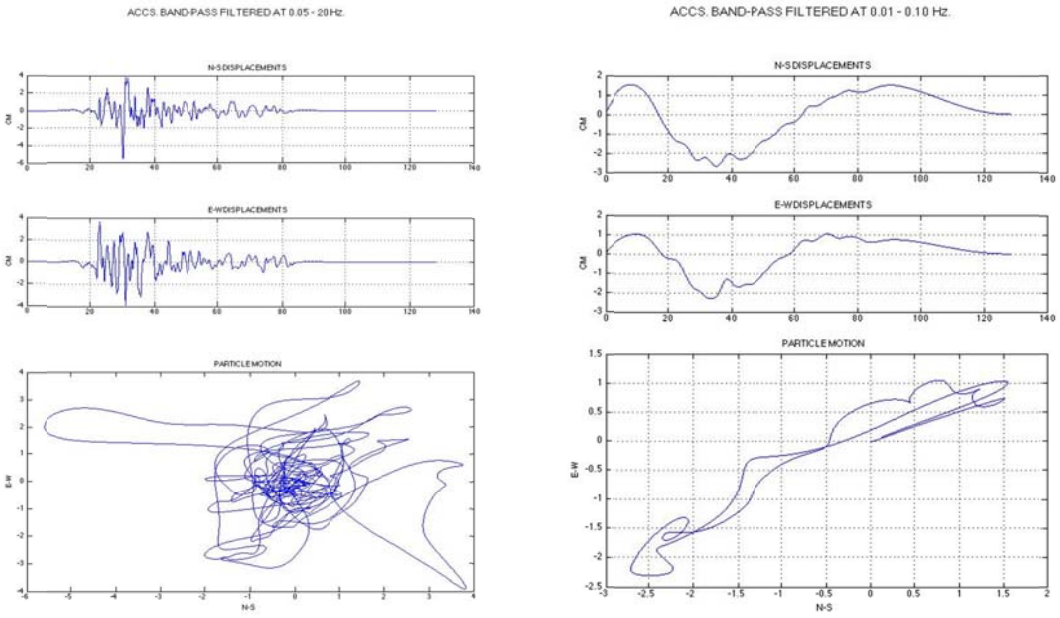

Figure 13. Particle motions, Muradiye record

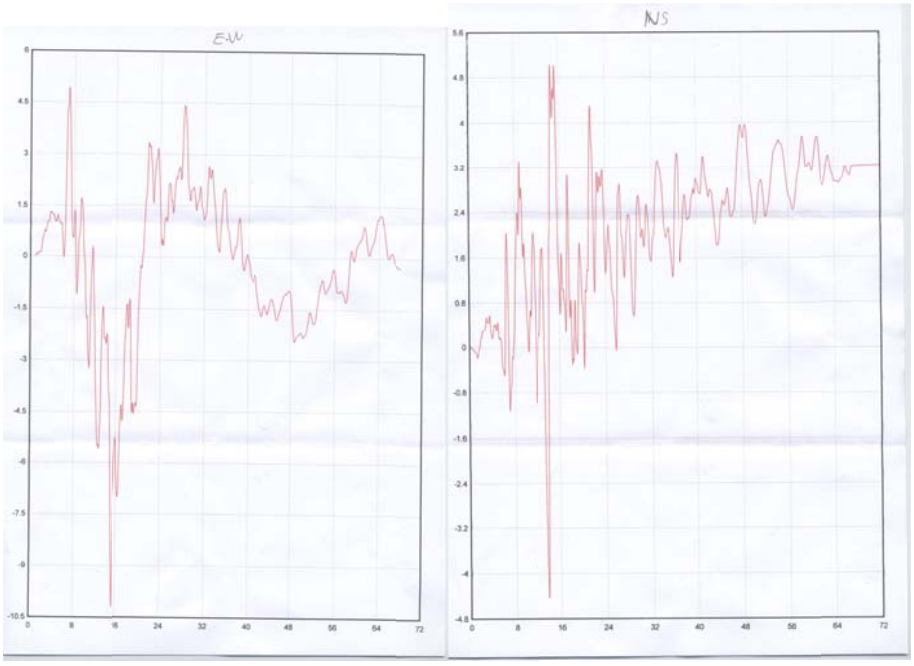

Figure 14. Muradiye record processed for permanent displacements

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

The main shock as recorded by the stations of the Istanbul Earthquake Early Warning System is shown in Figure 16. The distance between Van and Istanbul is about 1250 km. Detailed information on the early warning system is at link http://www.koeri.boun.edu.tr/Research/Early%20WarnIng%20System_13_139.depmuh.

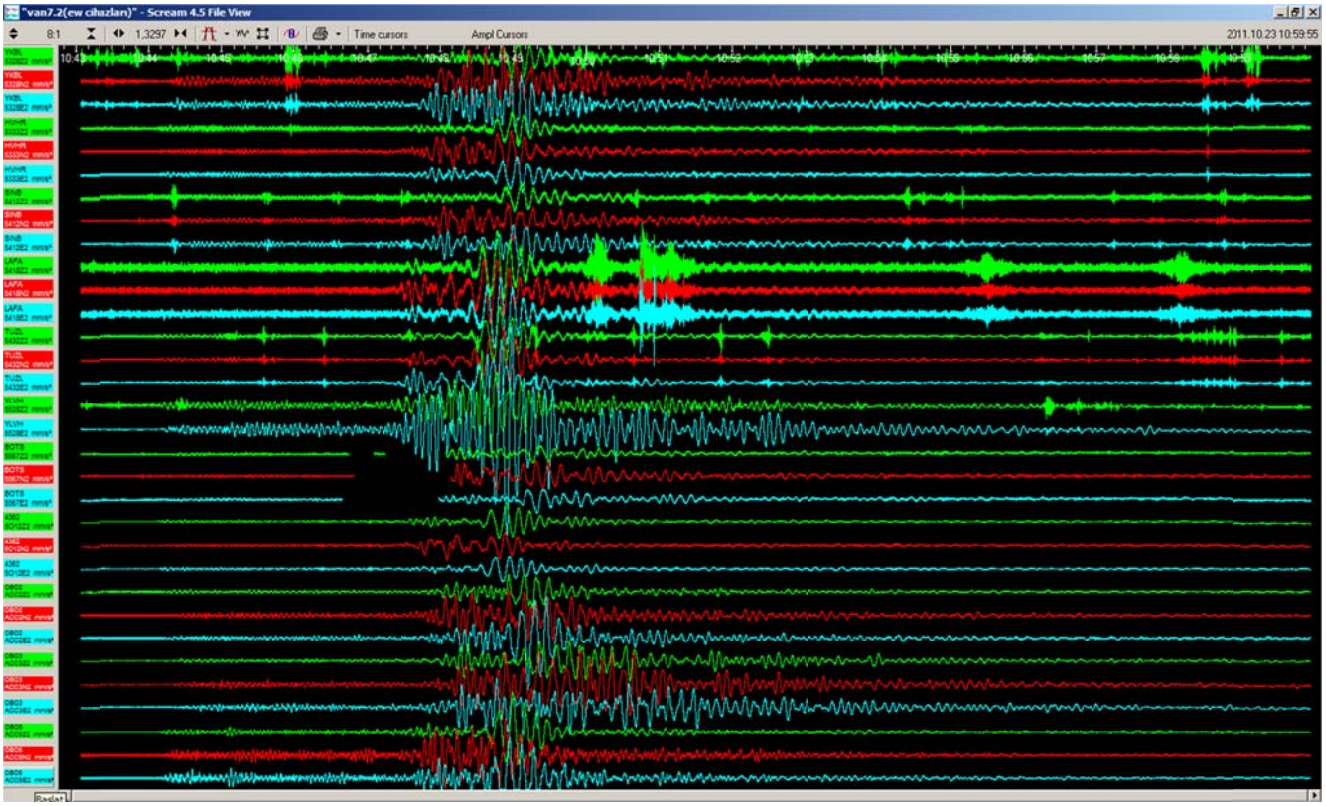

Figure 16. Van earthquake as recorded by the stations of the Istanbul Earthquake Early Warning System.

The main shock as recorded by the stations of the Hagia Sophia Structural Health Monitoring System is shown in Figure 17.

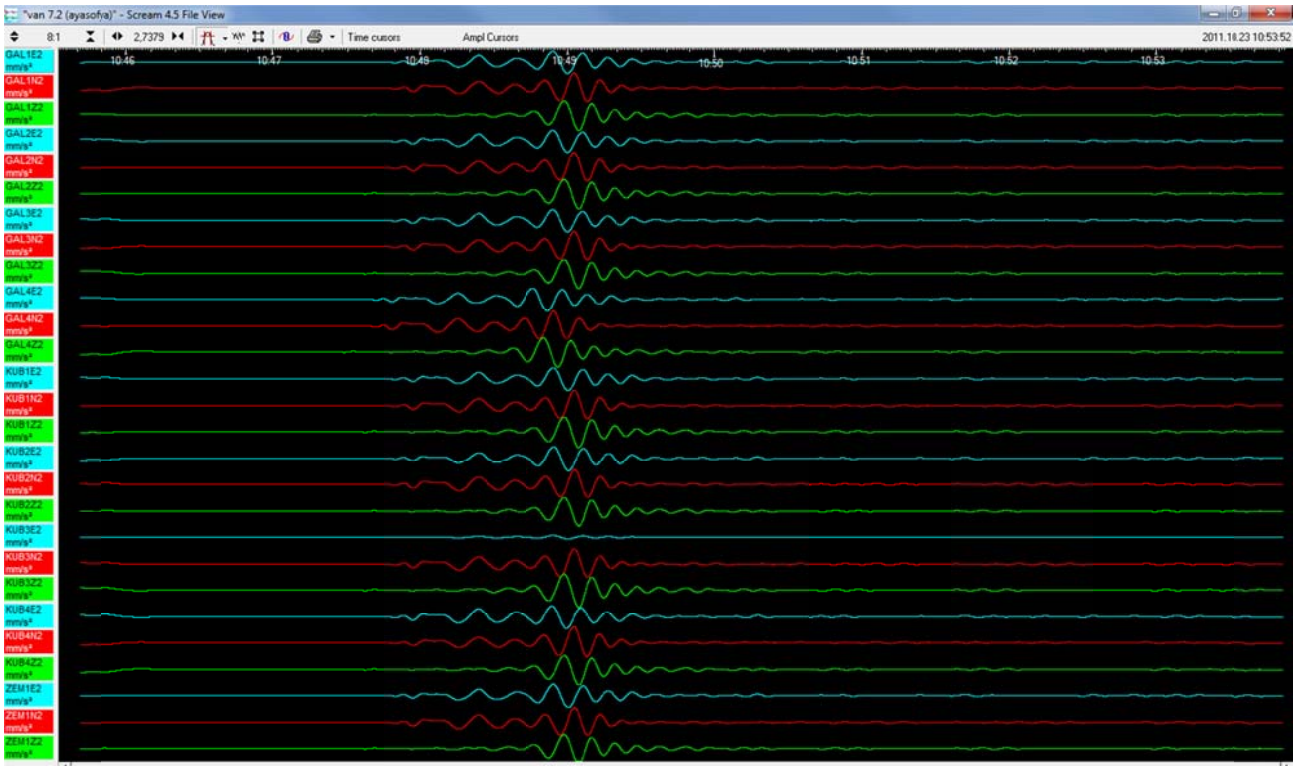

Figure 17. Van earthquake as recorded by the nine stations of the Hagia Sophia Structural Health Monitoring System in Istanbul.

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 avaliable 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

Contributed by: E. Çaktı, M.B. Demircioğlu, M. Erdik, Y. Kamer, B. Sungay, E. Şafak, K. Şeşetyan, E. Uçkan, E. Vuran, C. Yenidoğan, C. Zulfikar (in alphabetical order)

The October 23, 2011 Van, Turkey Earthquake (Mw=7.2)

EARTHQUAKE DAMAGE

The information about the earthquake damage to buildings and utilities, as well as about casualties is becoming more clear with time.

In this document we summarize what is available to date and give general information on the building stock in the province. We also include a summary of damage reports and their links from national institutions and from local media.

According to the distribution of the instrumental earthquake intensities associated with the mainshock of the Van earthquake, presented in Figure 1, the expected epicentral earthquake intensity is VIII.

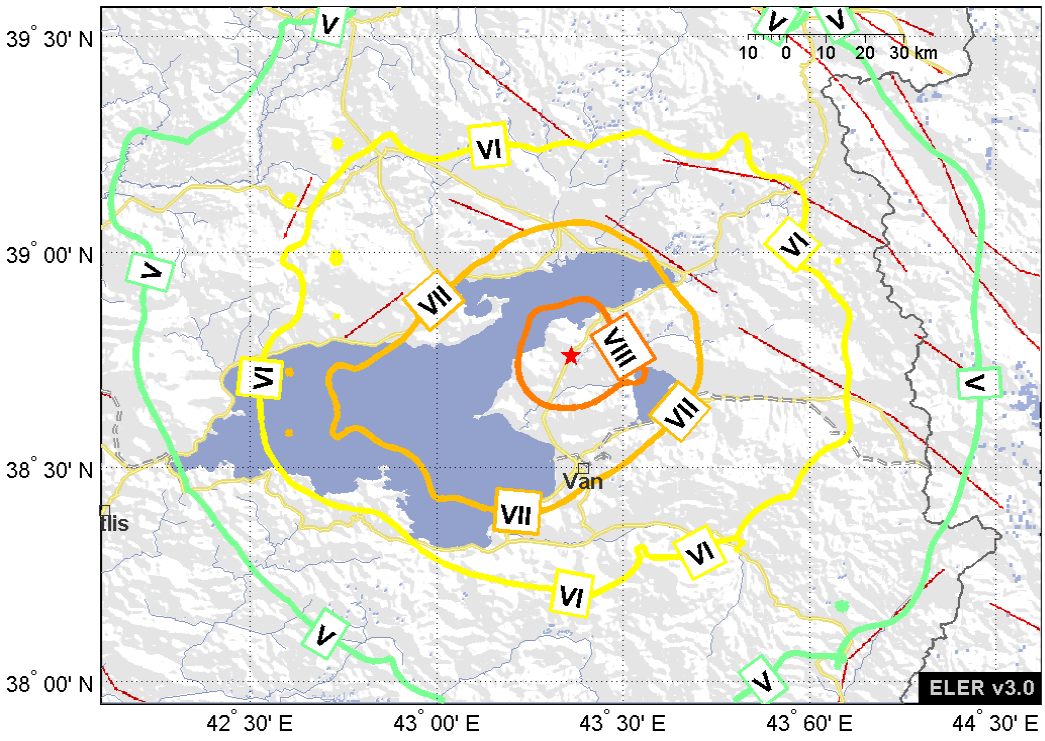

Figure 1. Instrumental earthquake intensities associated with the Van earthquake.

In the region, the province primarily affected by the earthquake is Van. In Figure 2 the administrative units in Van are presented. The provincial population of Van is 1,035,418 as of 2010 according to the Turkish Statistical Institute. 539,619 people live in Van, the center of the province, and in the subprovincial centers. 495,799 people reside in villages.

The building stock in the region can be classified in four groups: reinforced concrete; unreinforced masonry, adobe and rubble stone. Unreinforced masonry type buildings have the largest share in the building stock. The majority of the damage must have occurred in the four subprovinces of Erciş, Merkez and Muradiye based on a comparison of Figures 1 and 2. In Figure 3 the villages in the province of Van that were damaged are shown. The current numbers of damaged units in the villages marked in Figure 3 vary between 1 and 150.

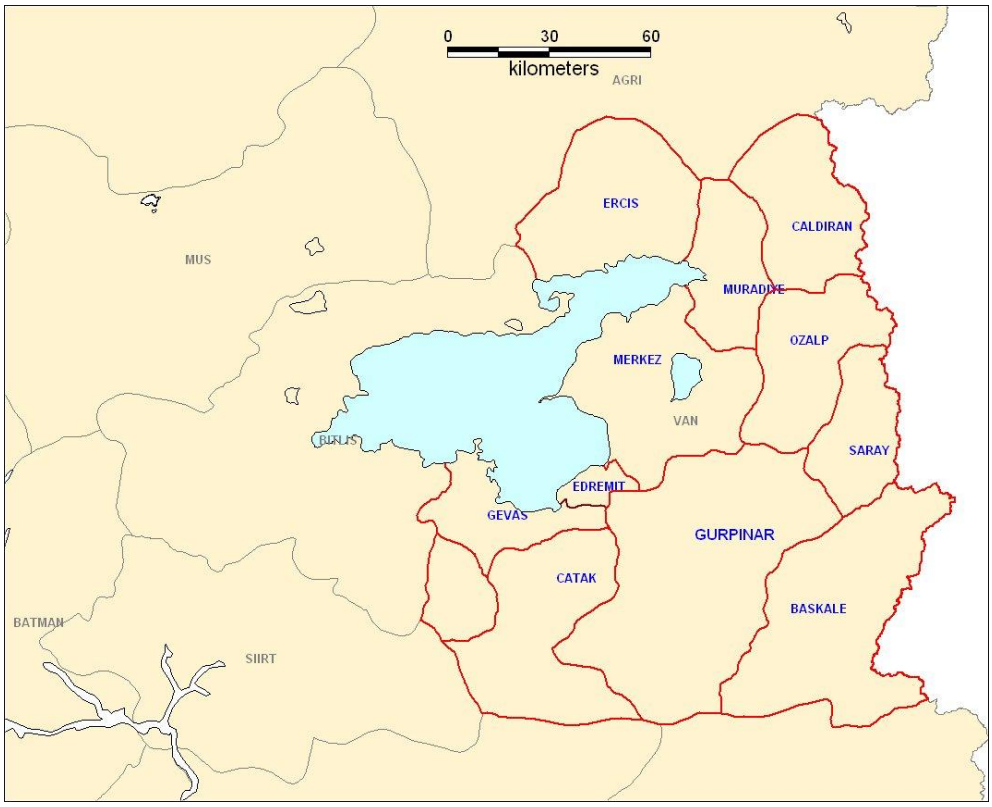

Figure 2. The subprovinces of Van. Merkez is the administrative center of the province.

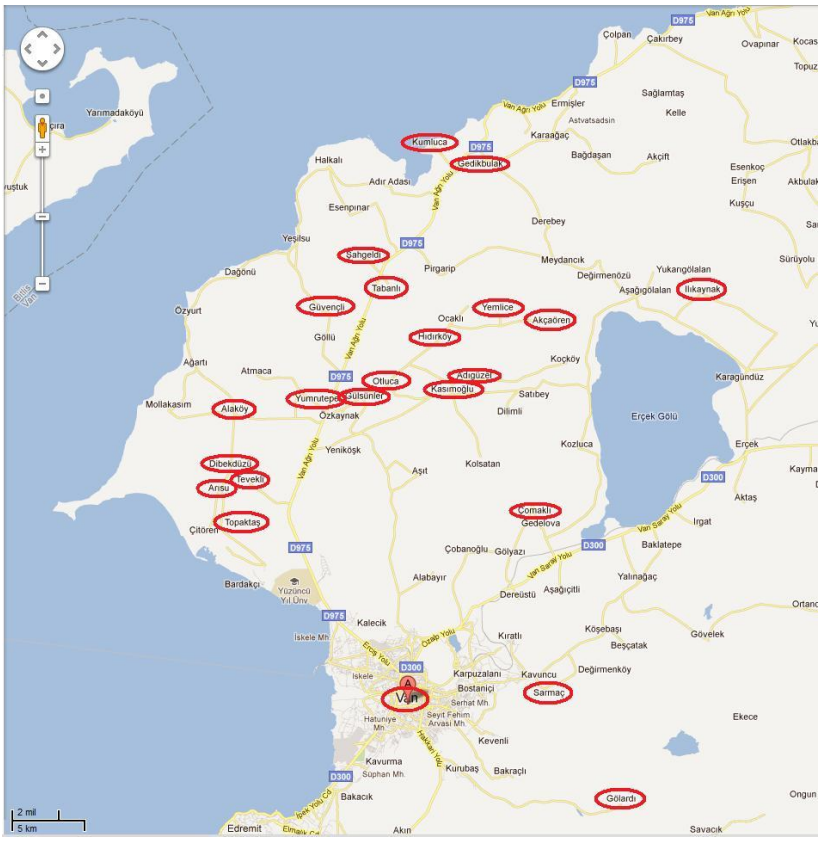

Figure 3. Villages of Van with earthquake damage

Buildings

In Table 1 estimated number of buildings at the provincial and subprovincial level and their percentage breakdown with respect to building types can be found.

In the preliminary damage survey carried out by AFAD in Van, the central town, the villages of the province and central settlements of Erciş Town as of October 28, 2011, 10.00 am. Damage distribution of buildings were as follows:

	Damaged-Nonhabitable	Damaged-Habitable
# Buildings	5739	4882
# Households	8026	7660

We do not know curently the geographical distribution of damaged buildings, nor do we know the structural and damage types of the buildings that were somehow effected by the earthquake. However, the pictures show that the damage patterns are very similar to those of the past earthquakes, namely inadequate reinforcement, lack of confinement at beam-column connections, low quality concrete, and soft first stories. We may assume that 5739 buildings received damage beyond repair. This means, that based on announced numbers, which are subject to change, 12.5% of the buildings in Erciş and Van-Merkez (center) were damaged beyond repair, 10.6% of them received slight, repairable damage.

Table 1.Building Stock Information for Van. These values are obtained by projecting the year 2000 TUIK building census data to the year 2006 based on year 2006 population census data.

	Van(Total)	**Erciş**	**Muradiye**	**Merkez**
Number of Buildings	78,000	10,700	3,600	35,200
Reinforced Concrete	12.7%	27%	5%	5%
Unreinforced Masonry	75%	63%	81%	82%
Adobe	9.5%	8%	12%	9%
Rubble Stone	2.8%	2%	2%	4%

Table 1 suggests that at the provincial level unreinforced masonry buildings, with 75%, constitute the largest group. In the sub-provinces that have experienced significant damage, particularly in Erciş, the reinforced concrete buildings constitute 27% of the total building stock. In Van-Merkez the reinforced concrete structures constitute a relatively small amount of the building stock, only 5%. The rest are unreinforced masonry, adobe, and rubble stone. This may be the reason for the high rate of damage and casualty reports from Erciş.

In Figures 4 and 5, building damages as estimated by software ELER (Earthquake Loss Estimation Routine) are presented. Figure 4 shows grid based, D3+D4+D5 (substantial to heavy damage+very heavy damage+destruction) type damages in the region. It is estimated that 3927 buildings may have received that type of damage (Figure 4, top). The largest damage of this type is estimated in grid cells located in Van city center. In Figure 4 (bottom), percentage of estimated buildings in damage state D3+D4+D5 over the total number of buildings in each grid cell is shown. Figure 5 shows etimated, grid based, D1+D2 (slight damage+moderate damage) type damages in the region. It is estimated that 34537 buildings may have received slight or moderate damage. The distribution of the number of buildings in this damage state is given in Figure 5 (top). The percentage of this number to the total number of buildings in each grid cell is given in Figure 5 (bottom). From these figures it can be concluded that a higher portion of the building stock is expected to be in less critical damage states.

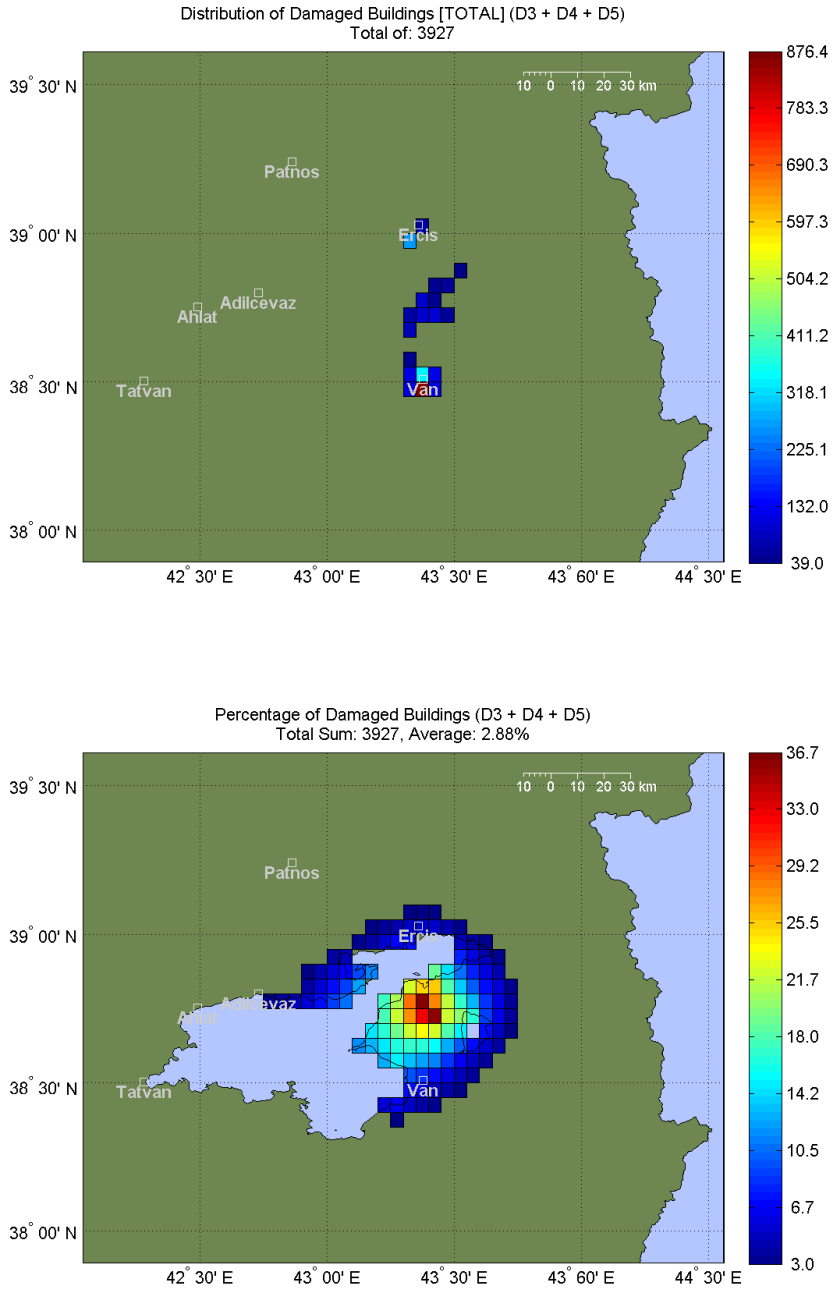

Figure 4. Building damages estimated by ELER, damage type D3+D4+D5. The number of damaged buildings in each grid is shown in the top figure. In the bottom figure grid based percentages of damaged buildings are presented.

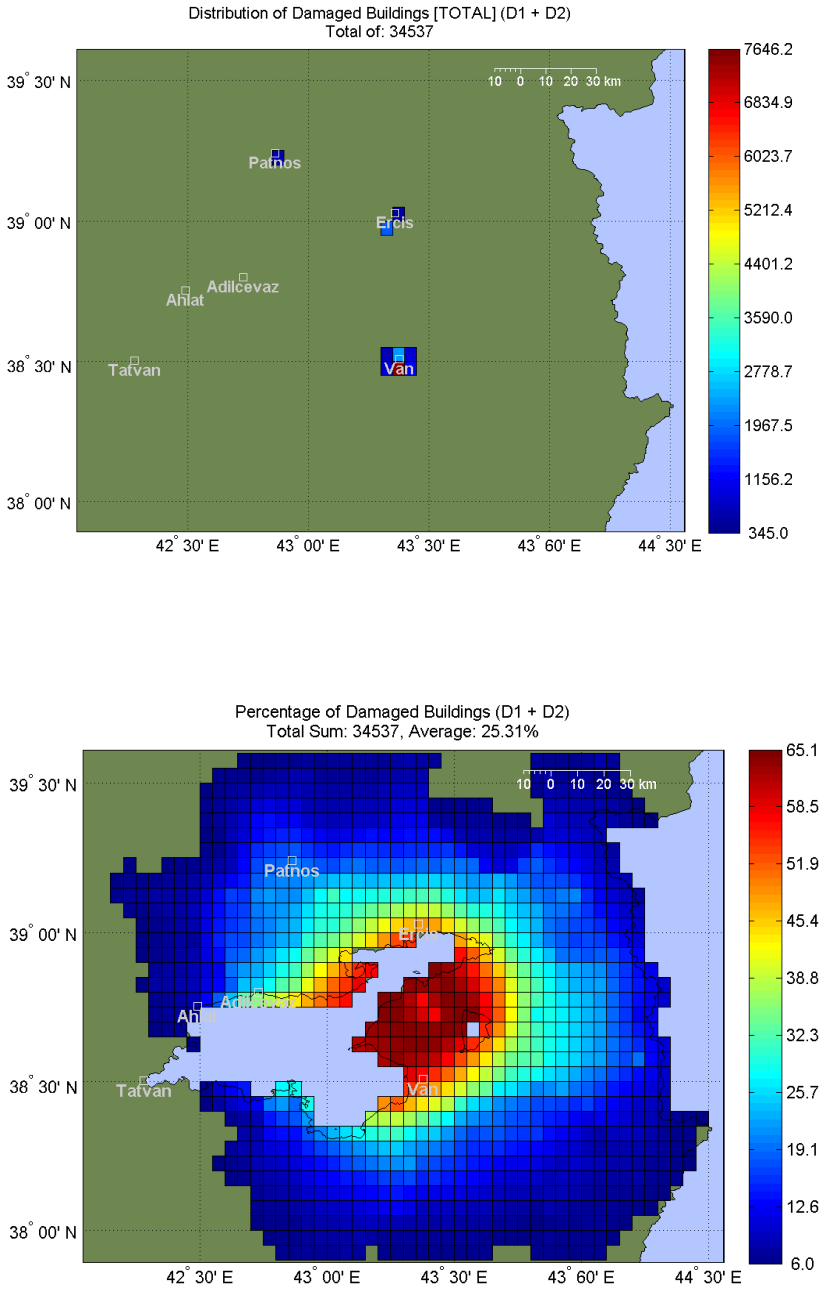

Figure 5. Building damages estimated by ELER, damage type D1+D2. The number of damaged buildings in each grid is shown in the top figure. In the bottom figure grid based percentages of damaged buildings are presented.

Casualties

The numbers of deaths and injuries are still changing. Death toll is expected to increase in the following days. According to the Disaster and Emergency Management Agency of Turkey (AFAD, http://www.afetacil.gov.tr/Ingilizce_Site/index.html#) 604 people died (as of November 5, 2011) and 2.608 people were injured in the earthquake (as of October 31, 2011)

Historical and Cultural Heritage

The museum of Van received damage as a result of the earthquake. The museum building, a modern structure, and the collections were affected by the earthquake. The extent of damage is currently unclear.

Two minarets in Van, two minarets in Muş and two minarets in Erciş collapsed. There is also minaret damage in the villages.

Hospitals

There are governmental and private hospitals in the region. Although the incoming patients are being treated in open spaces, this appears to be due to their large numbers, rather than structural damage. The governmental hospitals in Van and surrounding provinces appear to have received no or very light damage.

Industry

The industrial enterprises in Van can be classified as small and medium. The industry is clustered in three zones. The old and new automotive mechanic shops are in zones 1 and 2 respectively. The third zone is the main industrial zone of Van where most of the production and storage units are located.

Most of the building damage in zone 1 was limited to damage of the partition walls (Figure 6) . No significant damage was observed in the new section (zone 2). Most of the damage concentrated in the main industrial zone (3) where most of the critical facilities and storage units are located. The main cause of damage was ground shaking. No damage was observed due to geotechnical effects such as liquefaction or soil failure. Most of the small size facilities were not insured.

Figure 6. Damaged walls of a mechanic shops in zone 1 (top). Similar damage to a facility in zone 3 (bottom).

Silos and tanks

Storage units in Erciş and Van received extensive damage. Many cement and wheat silos which were full at the time of the earthquake, either fully collapsed or were seriously damaged. Some suffered from rupture at their base due to bending or due to insufficient seating width of the supporting concrete. Local buckling or anchorage failures were also observed Eye wittnesses claimed that nearly all of the tall twin silos collided with each other.

The heavy and slender, elevated steel cement silos collapsed due to improper detailing/dimensioning or suffered from inadequate seating width of the supporting concrete (Figures 7-9.)

A number of wheat silos in Van Industrail Zone, collapsed due to inadequate dimensioning (Figures 10 and 11).

Tank damage was minimal. Some amount of deformation was observed at the weak supports of a small elevated fuel oil tanks in Ercis. Small amount of liquid overflow due to insufficient free board was observed. Similar problems occured in some larger size other tanks in the surroundings of Erciş (Figure 12 and 13).

Figure 7. Collapsed cement silo in the Van Industrial Zone

Figure 8. Damaged cement silo in Van Industrial Zone due to concrete crashing

Figure 9. Collapsed silo on the Ercis-Patnos highway due to failure of the supporting concrete

Figure 10. Collapse of the elevated wheat silos (Facility 1) due to inadequate dimensioning, Van

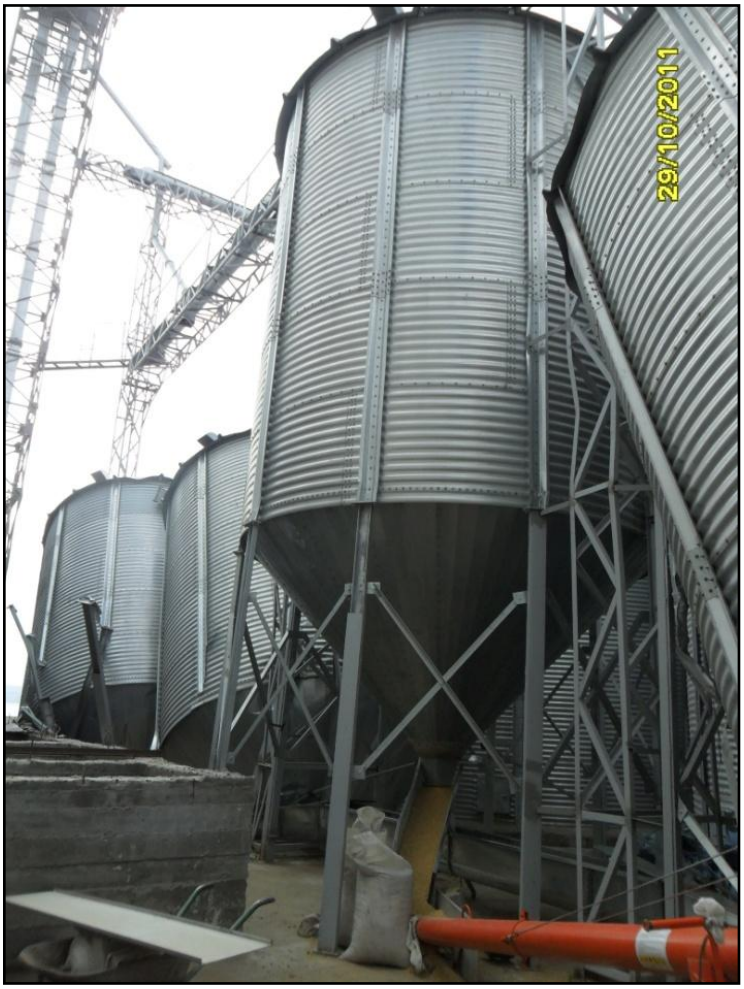

Figure 11. Collapse of the elevated wheat silos (Facility 2) , Van

Figure 12. Overflow of liquid at elevated fuel oil tank (Ercis)

Figure 13. Overflow of asphalt in storage tanks (Ercis-Adil Cevaz highway)

Prefabricated structures

The heavy precast-concrete frames with precast roof beams suffered from connection problems. Noticable movements were observed at the beam- column connections (Figure 14) of the structures located around the Van-Ercis highway. More severe cases were observed at the Industrial zone of Van. The beams slipped-off from their seats because of inadequate steel-concrete bondage (Figures 15-17). Precast-concrete beams collapsed because of inadequate anchorage at the column –beam connections (Figure 17), at the top. Also column bending cracks occured at the bottom of columns (Figure 18).

Figure 14. Joint seperation in prefabricated stuctures

Figure 15. Collapsed prefabricated structure in Van Industrial zone (Facility 1)

Figure 16**.** Failure of precast beams due to weak connection and lack of steel bondage

Figure 17. Collapsed prefabricated structure in new construction in Van

Figure 18. Cantilever column bending cracks at the base

Utilities

Electric distribution system

In Van, the electricity was shut down immediately after the earthquake for safety purposes. Two hours later, it was provided gradually in order not to cause any harm to people. In the second day, 70% of the city started receiving electricity. In the third day temporary housing units received electricity. Elevated transformers located at the balconies of flexible towers were particularly vulnerable to ground shaking. Brittle bushings were crashed because of the fall of building elements on to the interconnected cables between the transformers and buildings. A total of seven transformers (6x400kW and 1x600 kW) were damaged, burned or broken. Images of damage are provided in Figures 19 and 20).

Figure 19. Burned/damaged 400 kW and 600 kW transformers due to fall from elevated locations

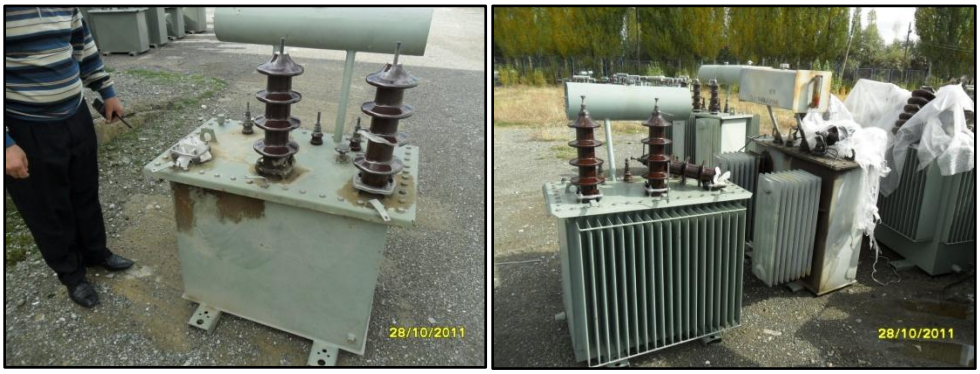

Figure 20. Damage to brittle bushings due to fall of building elements onto the interconnecting cables

Water system

No damage to water supply and sewege systems was reported in Van. The water supply was uninterrupted. However, pipe breaks occured outside the city. The water transmission line of 100. Yıl University had pipe breaks at many locations due to soil liquefaction and settlement/land slide (Figure 21). There was a number of pipe breaks in the transmission line from the source to the city. Many pipes had to be repaired in order to provide water to the surrounding villages and to temporary accommodations.

In Ercis, water distribution interrupted for a couple of days due to pipe breaks in the main system. This created a problem due to negative pressure in the system. There were also some

localized damages in Celebibağ region (Figure 22). However after minor repairs and reconfigurations all services were fully functional.

Figure 21. Pipe breaks and repaired sections in Topakca village due to liquefaction induced lateral spreading

Figure 22. Pipe crash and pullouts and repaired pipes in Celebibag , Ercis

Transportation infrastructure

Damage to transport infrastructure was minimal. There were cracks on the Van-Ercis highway which were immediately repaired.

Geotechnical damage:

In this section examples of soil failures are presented.

In Çelebibağ (Western Ercis near the Erciş-Patnos highway), land slide induced lateral spreading and settlement was observed in weak soils. Permemant ground deformations reached 50 cm in the horizontal and vertical directions. Water transmission/distribution in the vicinity of tension zones were damaged. The damage was repaired immediately after the earthquake (Figure 23).

In Van, extensive liquefaction induced lateral spreading, settlement and rock falls took place near the village Topakca, next to the river in Northern Van, 6 km's to the nortwest of the 100. Yıl University (Figures 24- 28).

Figure 23. Soil cracks due to land slide in Celebibag, Ercis

Figure 24. Liquefaction and settlement zone near Topakca village, Northern Van

Figure 25. Sand boils due to liquefaction in Topakca (Mermit) village, Van

Figure 26. Overall basin settlement (upto 50cm) in the village Topakca

Figure 27. Overall basin settlement nearby the Topaktas village

Figure 28. Rockfall in Topaktas (Mermit) village behind the damaged house

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IMPORTANT LINKS FROM THE PRESS ABOUT 10/23 /2011 (13:41:21,VAN EARTHQUAKE (M_W=7.2, M_L=6.6)

http://www.hurriyetdailynews.com/n.php?n=217-dead-more-than-700-wounded-in-eastern-turkey-interior-minister-2011-10-24

http://english.sabah.com.tr/National/2011/10/23/72-earthquake-hits-van

http://gundem.milliyet.com.tr/olu-tahmini-1000-/gundem/gundemdetay/24.10.2011/1454348/default.htm

http://www.bbc.co.uk/news/world-europe-15425268

http://edition.cnn.com/2011/10/24/world/europe/turkey-quake/index.html?hpt=hp_t1

Airports and highways in close proximity to city of Van are illustrated below

http://www.kgm.gov.tr/SiteCollectionImages/KGMimages/Haritalar/Turkiye.jpg

Contributed by: E. Çaktı, M.B. Demircioğlu, M. Erdik, Y. Kamer, B. Sungay, E. Şafak, K. Şeşetyan, E. Uçkan, E. Vuran, C. Yenidoğan, C. Zulfikar (in alphabetical order)

Photos of the damaged buildings in this document are provided by the Press and their links are indicated as appropriate

http://www.bbc.co.uk/news/world-europe-15429748

http://www18.gazetevatan.com/fotogaleri/resim.asp?kat=20824&page_number=9

http://fotogaleri.ntvmsnbc.com/vanda-siddetli-deprem.html?position=102

http://fotogaleri.ntvmsnbc.com/vanda-siddetli-deprem.html?position=109

http://fotogaleri.ntvmsnbc.com/vanda-siddetli-deprem.html?position=110http://fotogaleri.ntvmsnbc.com/vanda-siddetli-deprem.html?position=111

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http://fotogaleri.ntvmsnbc.com/vanda-siddetli-deprem.html?position=172

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http://www18.gazetevatan.com/fotogaleri/resim.asp?kat=20824&page_number=24

http://www18.gazetevatan.com/fotogaleri/resim.asp?kat=20824&page_number=64

http://fotogaleri.ntvmsnbc.com/vanda-siddetli-deprem.html?position=237

http://www18.gazetevatan.com/fotogaleri/resim.asp?kat=20824&page_number=33

http://fotogaleri.ntvmsnbc.com/vanda-siddetli-deprem.html?position=275

http://fotogaleri.ntvmsnbc.com/vanda-siddetli-deprem.html?position=304

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Photos From Rural Areas

http://www18.gazetevatan.com/fotogaleri/resim.asp?kat=20824&page_number=3

http://www18.gazetevatan.com/fotogaleri/resim.asp?kat=20824&page_number=4

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Courtesy of Anadolu Agency

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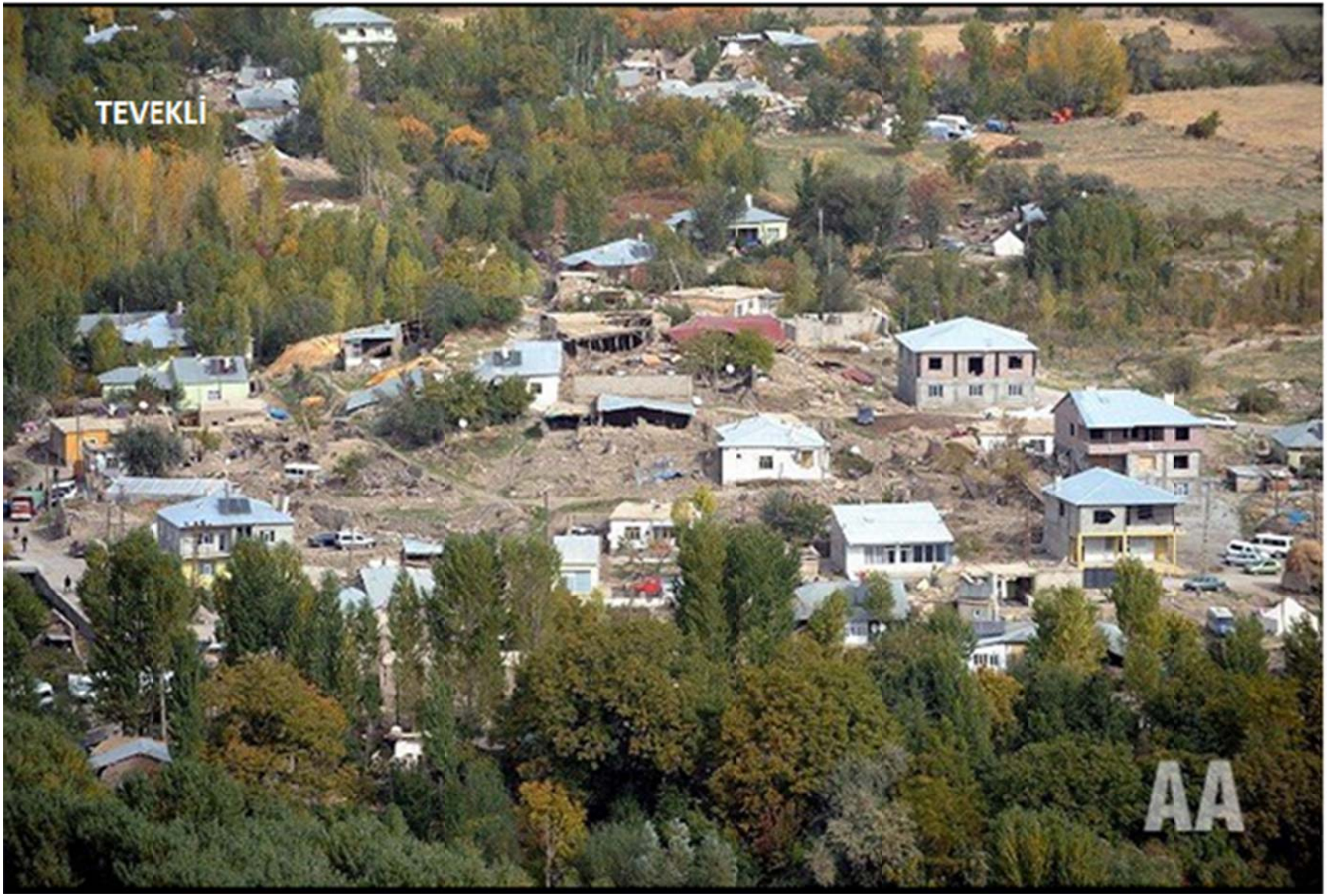
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Photographs from The Site Survey


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GÜVENAL GAZ
MEHMET AKBULUTAP
MASALLAH


YIKAMA
LASTİK –
YIKAMA. KUAFOR

The October 23, 2011 Van, Turkey Earthquake (Mw=7.2) and

The November 09, 2011 Edremit-Van, Turkey Earthquake (ML=5.6)

PRELIMINARY SOCIAL EFFECTS

The information on social impact of the earthquake will become more evident in time as recovery develops.

In this document we compile the information gathered from several primary institutions and NGOs as available from their websites, together with news from the media. The document does not attempt to encompass all issues, news or views; rather aims to give a general opinion. Please note that the information may change over time.

According to the latest press release on November 12th from the Prime Ministry, Disaster and Emergency Management Presidency (AFAD), 604 people (61 in the center, 66 in villages in the vicinity and 477 in Erciş – from Van Governorship) as a result of October 23rd earthquake and 40 people because of November 09th earthquake have died. According to the press release from October 28th, 2608 people were injured. The provincial population of Van is 1,035,418 as of 2010 according to the Turkish Statistical Institute (TUIK). 539,619 people live in Van, the center of the province, and in the subprovincial centers. 495,799 people reside in villages. Both earthquakes have been felt in a wide area including; Erzurum, Ağrı, Mardin, Diyarbakır, Muş, Bitlis, Iğdır, Kars, Batman, Siirt (Figure 1) (http://www.afad.gov.tr/index.html).

CEDIM Forensic Earthquake Analysis Group has compared the loss score - using loss information as of November 2 for Van earthquake - for historic earthquakes in eastern Turkey (Figure 2)

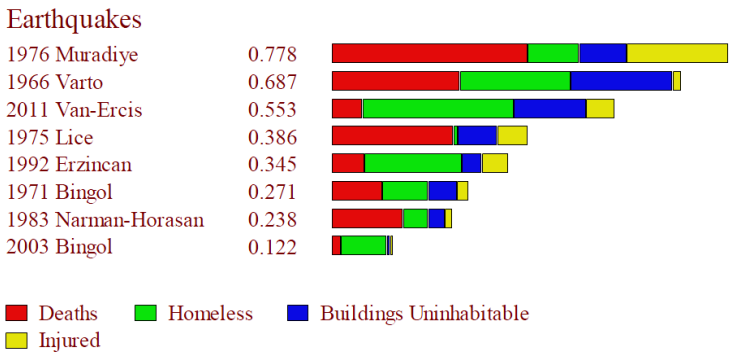

Figure 2. Loss score for historic earthquakes in eastern Turkey
Resource: CEDIM Forensic Earthquake Analysis Group Report #4, 2011

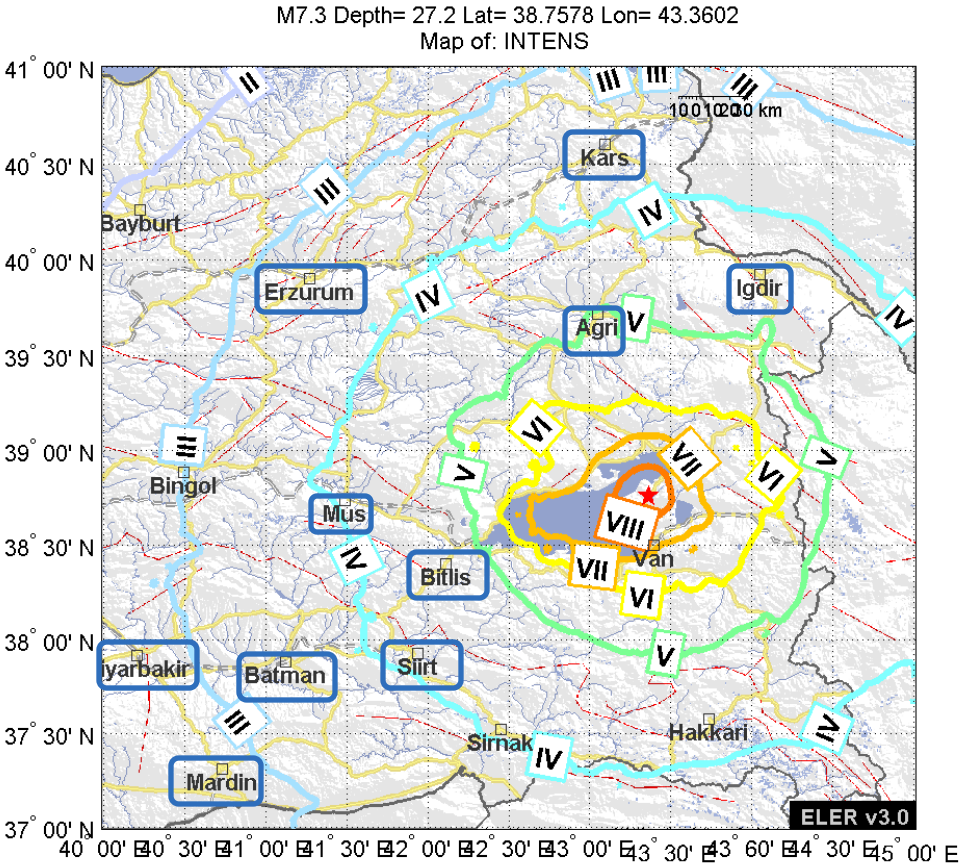

Figure 1. Cities where earhquakes have been felt over the intensity distribution by ELER

Overview of Vulnerable Population in Van

It is generally acknowledged that the children, elderly and disabled are the main vulnerable groups in a society. The illiterate, the poor and the jobless are also vulnerable in the wake of a natural disaster.

TUIK acknowledges age dependency as children between 0-14 ages and elderly 65 ages and over. In Van, the population rate for youth dependency is almost 40% (421,088 children) and for elderly dependency almost 3% (31,696 elderly) – 452,784 in total.

İlliteracy number in the population with ages over 6 is 42,467 in the city / districts center as of 2010, according to address-based population registration system (TUIK).

There are 23,305 (app. 2%) divorced and widowed (both men and women) people with ages over 15 in Van, as calculated from address-based population registration system (as of 2010 –TUIK ABPRS) which may provide a rough picture for single parenthood.

In order to get an overview of disability, in the East Anatolia Region, the proportion of disability in total (together with population having chronic ilnesses) was 11,80%, as of 2002 (TUIK). The rate for Turkey was 12,29%, then.

TUIK has estimated the unemployment rate as 11,9% for the year 2010 throughout Turkey. The unemployment rate in Van has been estimated to be one of the highest with 17,2%. (http://tuik.gov.tr/PreTablo.do?tb_id=25&ust_id=8)

Preliminary Effects on People and Sheltering

The number of the affected people after the October 23rd earthquake was 600.000 according to Kızılay (http://www.kizilay.org.tr/kurumsal/ghaber.php?t=-Genel.Haberler-Genel.Baskan.Akar.dan.Van.Depremi.ne.Iliskin.Aciklamalar). This approximately corresponds to 58% of the population living in the earthquake stricken areas. In this statement, affected people purports the people in need of tents.

After the first earthquake by the end of October, people started to migrate from Van with their belongings they could take out from their damaged houses and it has been stated that rents have increased 30% (http://www.ntvmsnbc.com/id/25293310).

After the second damaging earthquake, it has been declared on November 15th that while the number of collapsed and non-habitable damaged buildings had been 28,000 after the first earthquake, it has increased to over 35,000 after the second one (http://www.cevresehircilik.gov.tr/turkce/sayfa.php?Sayfa=bakanlikbasin&ID=716 - the Minister of Environment and Urbanization's speech in National Assembly)

DASK (Turkish Catastrophe Insurance Pool) announces through its website that after the October 23rd earthquake, the number of notification of claims is 4,714 as of 24.11.2011 (http://www.dask.gov.tr/index.html#). DASK declares the number of buildings to be 64,081, the number of insurance policies to be 7,228 and the ratio of insurance to be 11,28%. Among the number with insurance policies, approximately 65% have claimed.

Harsh weather conditions in the region demand for urgent solutions for temporary housing until permanent houses are commisioned and built. The efforts for temporary shelter focus on three solutions:

(1) Tents + containers (national and international institutions): 72,597 tents (28.140 from international institutions), 200 tent canvas, 480 tents for general purposes (24 from international institutions), 260 prefabricated houses (200 from international institutions), 1155 house containers (128 from international institutions), 3.794 Mevlana Houses (prefabricated houses by Kızılay with a 10.5 – 13 m^2 area of use and made of reinforced aluminun profile frame and walls and roof from polyurathane filled panels) and 151 wc-shower containers have been deployed to the region. 19,500 containers in total have been ordered and their production is proceeding. It is reported that approximately 18,000 citizens in total are being housed in 12 tent cities in Van center and Erciş, and that 2 more tent cities comprising of 1000 tents are being installed (http://www.afad.gov.tr/ - activity report November 23rd).

(2) Transfer to public facilities in other towns (national instititutions): After the second earthquake, with the weather getting cold and continuing afterschocks (Figure 3), AFAD issued a circular stating that earthquake victims having no opportunity to move other places themselves, will be transferred to public social facilities in other cities temporarily. As of November 21st, 10,760 affected citizens have been placed to such facilities (http://www.afad.gov.tr/ - activity report November 23rd).

(3) Allocation of unused housing (public effort, NGO's and individuals organized by national government): After the first earthquake, a journalist initiated a campain called "My Home is Your Home" in a social networking site and had many contributors in a short time. The campaign is now being coordinated by the Ministry of Family And Social Policies. The ministry will be creating a database of volunteers and their houses including information such as number of rooms, whether it is furnished, it's earthquake safety, hospital and school in the vicinity. The project is told to cover the time course until the permanent houses are built and then the victims will return to Van (http://www.zaman.com.tr/haber.do?haberno=1198080&title=evim-evindir-van-bakanlik-projesi-oldu).

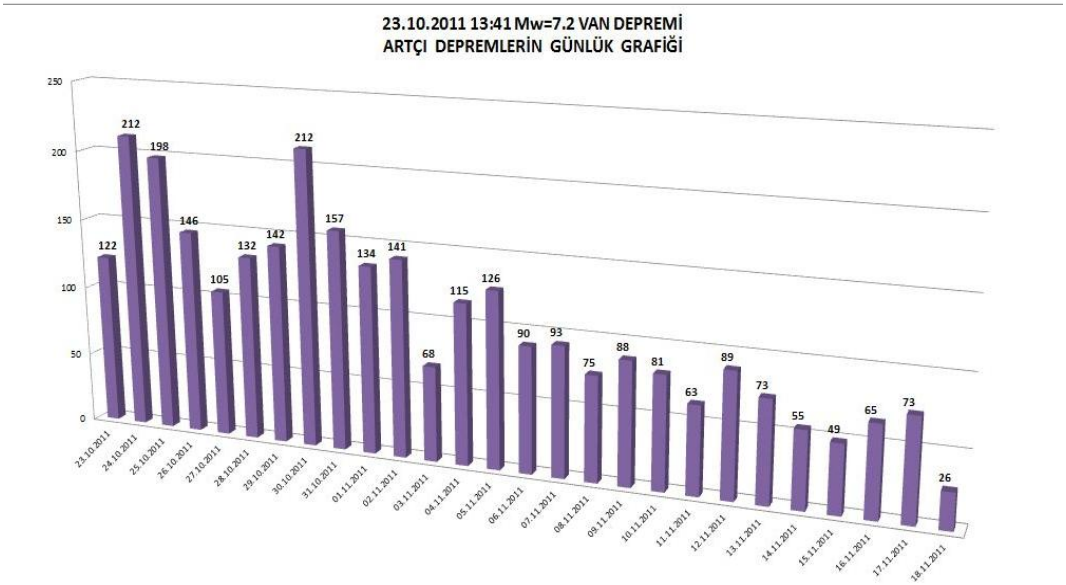

Figure 3. Daily distribution of the number of aftershocks after the earthquake of October 23rd

Source: KOERI

In the meantime, Housing Development Administration of Turkey (TOKİ) has been given instruction to construct permanent houses. Housing projects are being developed in Van Merkez Kevenli for 368, in Van Merkez Bardakçı Köyü for 426, in Van Erciş for 228 (first stage) and 304 (second stage) and in Van Edremit for 1688 housing. Their installments is declared to start in May 2012 (http://www.toki.gov.tr/).

Three years ago, a project was started where it is aimed to make the housing presentable of regional fabric and architectural features, widespread in rural areas, by The Ministry of Environment and Urbanization. Within the context of this project, housing projects that are sanitary, reliable and appropriate for regional architecture that meet the need of locals will be developed for 6 cities and by the beginning of next year it will be being implemented throughout Turkey. After the earthquakes in Van, and their damaging results in rural areas, the project has gained magnitude. This way, it is mentioned that citizens will be able to receive these building projects free of charge (http://beta.interpress.com/(S(gybiw32ncyvhp455ass4w12e))/BasinAyrintiGoster.aspx?IDS=b6kgToxie6%2FG6tY2bCZKFA%3D%3D&lm=0&madi=103&kayitsayisi=1).

As a large part of the GDP is supplied through agriculture and livestock (http://www.van.gov.tr/default_B0.aspx?content=1053), it is also important to mention that 4,281 sheds were damaged, 501 cattles and 491 sheep/goats have been perished. As a result of the demand from citizens 430 tent sheds (338 of them being 70m^2 and 92 being 140m^2) has been

installed. It is aimed to install 3,200 in total. The Governorship is working on providing support in terms of feed (http://www.van.gov.tr/default_B0.aspx?id=1809).

188 children who lost their mothers and/or fathers as a result of earthquakes have been reported to be placed near relatives. Experts are counseling them. 4 disabled and 3 elderly in total have become orphans and 3 of them are taken care in the public institutions while others are with relatives and all are being counseled. Women who were staying in Van Guest-house and the children in Social Rehabilitation Center have been transferred to other cities. 75 children under care in different institutions were moved to Antalya and after the second damaging earthquake, 96 children were moved to Kefken Camp (http://www.van.gov.tr/default_B0.aspx?id=1809).

Preliminary Effects on Two of The Basic Institutions

Health:

There are 18 hospitals in Van; 12 belong to Ministry of Health, 1 university hospital and 5 private hospitals with a bed capacity of 2,129 in total, as of 2010 according to data from TUIK.

In this section, we convey information on hospital building damage, damage assessment, and operation of health services.

It is noted that hospitals that were damaged in Van has gathered under one roof; Van Training and Research Hospital. The 10 hospitals, 6 public and 4 private, served in the field hospital they installed in the garden of the hospital for two days after the second earthquake in November 09th, as a result of the worries of patients and staff. After the examination of damage assessment experts in the hospital, emergency service has started to serve. As of November 16th, together with doctors from the Yüzüncü Yıl University Training and Research Hospital, they also initiated the ambulatory care services in Training and Research Hospital (http://www.byegm.gov.tr/dis-basinda turkiye.aspx?d=17.11.2011&ygid=42&pg=8&ahid=36700&act=2). From another news, we understand that İpekyolu Public Hospital also is on service (http://www.ntvmsnbc.com/id/25296154).

In the same news, it is also mentioned that Maternity and Children Hospital has been damaged. The extent or characteristics of the damages are not mentioned.

The Minister has declared that engineers will assess the condition of the hospitals and that Training and Research Hospital was evaluated primarily. He adds that patients are being transferred to cities in the vicinity as far as possible however, this hospital will probably undertake all the necessary services as the main hospital for another couple of months (http://www.ntvmsnbc.com/id/25296154).

It is mentioned that some doctors and teachers asked for designation. However, the government would like public services staff – especially doctors and teachers – to stay in Van and therefore they declared to provide containers to them (http://www.cevresehircilik.gov.tr/turkce/sayfa.php?Sayfa=gunluk_basin).

Education:

In this section, we compile information on elementary and high school buildings, university buildings damage, damage assessments, actions as a result of the earthquakes such as students' demand for transfer to other cities mainly from declarations of The Ministry of Education (MEB).

There are 1018 elementary and high schools in the province of Van in total and 46 of those (36 in Van center, 1 in Muradiye, 9 in Erciş) are declared to be unusable. In 69 schools with light damage, repair efforts are being undertaken. It is also stated that there 118 lodgings (90 in Van and 28 in Muradiye) received heavy damage. Unfortunately 75 teachers have lost their lives and approximately 15 injured as a result of the earthquakes. The ministry has assigned 800 teachers. It is stated that as some citizens are being transferred temporarily to other cities as a result of the harsh weather conditions, the possible gaps or adequecy of the remaining schools will become clear in time. (http://www.meb.gov.tr/haberler/haberayrinti.asp?ID=9084 and http://www.van.gov.tr/default_B0.aspx?id=1809).

Schools will be closed until December 5th due to the second damaging earthquake and the continuing aftershocks. The Ministry of Education (MEB) states that they are working on providing lodging to the teachers besides examination and repair of schools. 48 flats in Van have been received from TOKI and 200-bed pension in Erciş has been prepared for this purpose. Additionally, ministry allocates one room in each nursery school. Preparations are underway in order to be able to start education on December 5th. http://www.meb.gov.tr/haberler/haberayrinti.asp?ID=9084. The Ministry's Directorate of Van has initiated a public relief campaign (in kind) for teachers (http://van.meb.gov.tr/duyurular/deprem_ayni_yardim_03_11_2011.html).

On the other hand, as a result of the application of high school students requesting to be transferred to other schools in other cities, MEB declared on November 13th that the application is approved and under certain circumstances students will be able to be transfered to or have the chance to study as guest student in other cities. All city governorships were notified. Additionally, school counseling services' concern are invited (http://www.meb.gov.tr/haberler/haberayrinti.asp?ID=9070).

Yuzuncu Yil University anounces to receive some damage in their buildings, however the extent is not clarified. The university mentions it has been decided by the senate that the suspension of education is extended until February. By that time, the faculty buildings are intended to be repaired, prefabricated hostels for all students and classrooms are aimed to be built together with houses for the faculty and administrative staff. Only the specialty in medecine graduate program would carry on as of November 14th , the date when faculty and administrative staff was aimed to get back on work (http://www.yyu.edu.tr/).

Response Efforts

Below, we compile information from reports of related organizations and news from the press under categorized subject headings.

Search & Rescue and Medical Response

Search and rescue efforts have been carried out by institutions and organizations such as local AFAD Civil Defense teams, Turkish Armed Forces (TSK)-Special Forces Natural Disasters SAR Battalion (DAK), Gendarmerie Special SAR Battalion (JAK), National Medical Rescue Teams (UMKE), local Fire Department SAR teams, General Directorate of Security Affairs' Special Operation Rescue and Riot Police SAR Teams, Turkish Hard Coal Authority SAR Teams, LiDAM SAR team, Search and Rescue Association (AKUT), Yeni Yüksektepe GEA Search and Rescue Ecology Team, IHH Humanitarian Relief Foundation SAR.

Following the two earthquakes,it is reported that in total 5,267 SAR, 2,976 medical and first aid personnel, 34 rescue dogs together with equipments, and humanitarian aid supplies from 48 different provinces and 39 different institutions has been delivered to the region via airway and overland. Equipments and vehicles provided included 732 units of rescue machinery, 201 ambulances (18 to be air ambulances), 11 mobile hospitals (6 of them in service), 146 generators and 79 reflectors (http://www.afad.gov.tr/Ingilizce_Site/index.html). Figure 4. shows Deaths, Injured, Medical Personnel and Search and Rescue trends after the earthquake October 23rd by CEDIM Forensic Earthquake Analysis Group – Report #4.

222 citizens were rescued after the October 23rd earthquake and 30 citizens after November 09th earthquake as a result of the S&R efforts (http://www.afad.gov.tr/Ingilizce_Site/index.html).

In 2004, Department of Health Services During Disasters has been formed in order to provide well-equipped and trained medical rescue service in the case of disasters. Its units were formed in 2005 under provincial directorates. Within this context, National Medical Rescue Teams consisting of volunteer medical personnel have been formed (http://www.istanbulumke.org/modules.php?name=Content&pa=showpage&pid=2). Ministry of

Health mentions that there are nearly 5000 UMKE staff. UMKE teams' contribution to S&R activities is significant (http://www.umke.org/bolgeil-umke-duyurulari/erzurum/umkenin-onemi-birkez-daha-anlasildi-h442.html).

Ministry of Health reports that detailed crisis organization was planned before. Health Disaster Coordination Center (SAKOM) of the ministry, working 24 hours routinely, acted immediately and coordinated the communication and transfer of the medical personnel through its vast opportunity for communication. Ministry also state that the medical teams and 112 teams in Van and its districts have reached the scene within 20 minutes. In the meantime 1800 beds throughout the hospitals in the region were prepared while not hampering their routine activities. Field hospitals were installed both in Van and Erciş. It is also mentioned that precautions taken for infectious diseases and psychological support is provided to the victims (http://www.saglik.gov.tr/TR/belge/1-14392/van-depreminde-saglik-hizmetleri.html). Additionally, the Ministry has designed a page at its website in order to accept and manage applications of volunteer health personnel to serve in Van (http://www.sbn.gov.tr/vanicin.aspx).

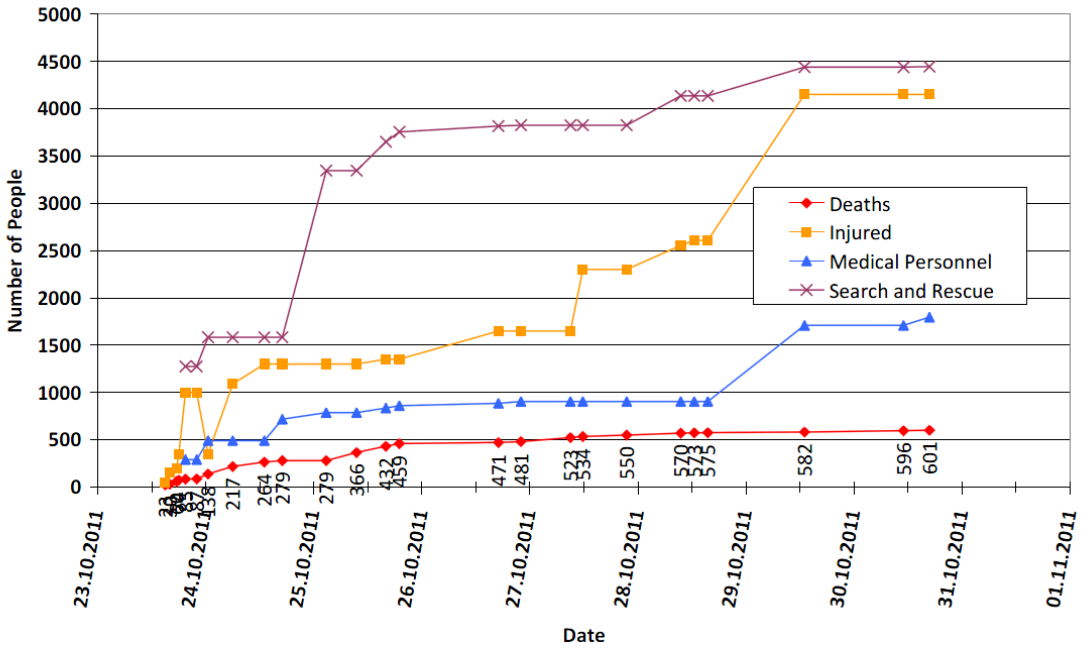

Figure 4. Deaths, Injured, Medical Personnel and Search and Rescue trends as of November 1st (as collected from earthquake-report.com via AFAD)

Resource: CEDIM Forensic Earthquake Analysis Group Report #4, 2011

Logistics

Prime Ministry AFAD mentiones that their center was backed up with personnel and equipment to enable working 7/24 that provided effective and successful coordination nationally.

Governorship of Van established an emergency phone line and crisis desk for citizens. Governorship declared that citizens who cannot communicate with relatives were able to call 122 for information. Additionally, they could apply for damage assessment in their homes and workplaces (http://www.van.gov.tr/default_B0.aspx?id=1797).

The Ministry of Health transferred the information on the hospitals that injured people were being treated, to the communication center SABIM Alo 184, in coordination with SAKOM. The line 184 gave support to people whose relatives were injured (http://www.saglik.gov.tr/TR/belge/1-14392/van-depreminde-saglik-hizmetleri.html).

In total 74,597 tents (28,140 from international institutions), 480 general purpose tents (24 from international institutions), 200 tent canvas, 260 prefabricated houses (200 from international institutions) , 1,155 house containers (128 from international institutions), 3,794 Mevlana houses, 334,876 blankets (94,470 from abroad), 1,909 duvets, 1,773 beds (1000 from abroad), 37 mobile kitchens, 3,149 kitchen sets, 151 wc-shower bath containers, 23,471 catalytic stoves / heaters (684 of them are from abroad), 5,892 sleeping bags, 1,536 folding beds (536 from abroad) and 1 mobile oven have been deployed to the region affected (http://www.afad.gov.tr/ - activity report November 23rd) .

Hot meal is reported to being served on average of 50,000 disaster victims three times in a day (http://www.afad.gov.tr/). More than 7,000 breads are produced in the 15,000 bread capacity mobile bakery provided by Kızılay enabling the disaster victims to receive hot bread (http://www.kizilay.org.tr/kurumsal/ghaber_yazdir.php?t=-Genel.Haberler-Depremzedeye.Uc.Ogun.Sicak.Yemek)

Additionally, the mobile public soup-kitchen of IHH Humanitarian Relief Foundation with a capacity of providing meal to 8,000 people twice a day, has been sent to Van. (http://www.ihh.org.tr/ihh-gezici-asevi-van-merkezde/)

Kızılay reported serving tea and poundcakes to almost 2,000 people daily directed to S&R teams, policemen and press members through its mobile catering vehicle in order to overcome cold (http://www.kizilay.org.tr/kurumsal/ghaber.php?t=-Genel.Haberler-Arama.Kurtarma.Calismalarina.Sicak.Destek).

UN Resident Coordinator report states that the Ministry of Health has warned people to drink only bottled water, as many cases of diarrhea have been detected among the affected population (UN Resident Coordinator, 2011).

AFAD mentiones in the press release that food, food packets and other supplies' delivery continues and that 117,000 food packets have been distributed to date (November 23rd).

30 field tents were also delivered to carry out public services and provide psychological support to disaster victims. All public institutions provided staff backing to avoid hindering services. The disaster centers of related ministries were asked to work 24/7 in order for the S&R, temporary sheltering, removal of debris, health and psychosocial services to carry on without interruption. For psychosocial support, 200 social workers, sociologists, psychologists are working (http://www.afad.gov.tr/).

Among the photographs on AFAD website, we observe that Turkish Pharmacists Association has delivered a mobile pharmacy (http://www.afad.gov.tr/).

Community Volunteers Foundation (TOG), has detected the villages with damages with a team of 20 people and distibute the aid supplies delivered from other city TOG organizations to the families in need (http://tog.org.tr/manset_haber-141)

Over 50,000 tonnes of coal has been deployed to Van Center and villages together with Erciş Center and villages (http://www.afad.gov.tr/ - Press Release of November 21st) .

As important factors for providing logistics; both Van Merkez (with minor exceptions) and villages have access to water after the maintenance of the system. Erciş also has access to water after the restoration of the system by ISU (Kocaeli). 95% of Van Merkez and Erciş received power. In Erciş, remainin 5% is kept unpowered due to continuing removal of debris (http://www.van.gov.tr/default_B0.aspx?id=1809).

Donations Management

Erzurum has been designated as the logistical center for the international aid supplies to arrive via airways. Presidency charged Governorship of Erzurum to set up a logistics center for this purpose and for the transfer of the supplies to Van. In case of capacity overflow for Erzurum Airport, to use Military Airport as an alternative was planned. For the international aid supplies to arrive overland, a logistics admission center was installed by Van Governorship (http://www.afad.gov.tr/ - activity report November 23rd).

A rock concert in Istanbul comprising of 260 musicians and 40 artists and groups had been organized by Kızılay, where 13,990 tickets were sold. It is announced that through the 500,000TL (app.) income from the concert, a primary school will be built in Van

(http://www.kizilay.org.tr/kurumsal/ghaber_yazdir.php?t=-Genel.Haberler-Sarkilar.Van.a.Okul.Olacak).

Earthquakes have put many citizens in action. On October 26th, in a television program with a joint campaign from many channels, an important amount of donation has been gathered (http://www.ntvmsnbc.com/id/25292407). Additionally, many individuals, organizations and companies have either participated/coordinated aid campaigns, or donated to Red Crescent, AFAD or Turkish Religious Foundation's accounts opened for this specific purpose, in order to help deliver the necessary supplies to Van (http://www.afad.gov.tr/).

It is important to make also the place of use of 224,600,000TL gathered (http://www.afad.gov.tr/ as of November 23rd) as a result of the donations, public in detail.

It is also lesson learned that the supplies need to be categorized and then boxed accordingly. It was mentioned in a news that 150 lorries in average delivered aid supplies daily and 400 people were trying to classify them as they were sent in mixed packages, decelerating the work and distribution (http://www.ntvmsnbc.com/id/25293310).

Debris Management

On October 28th, 5 days after the first earthquake, we read from the news that the debris was being poured to Van Lake, one of the most important tourism centers of the region. According to the news, one of the truck drivers mentioned that at first the District Governorship of Erciş requested the debris to be poured to an aggreed destination however, as no such destination could be determined, the truck drivers were told to pour anywhere near the lake. The news highlights that the shape of the lake has already started to change and that 250 trucks are making at least 15 tours everyday (http://www.radikal.com.tr/Default.aspx?aType=Detay&VersionID=15731&Date=20.10.2008&ArticleID=1067736).

On another perspective on debris, it has provided source of income to several local people. According to the news, group of citizens whose house were collapsed in the earthquake, start working in the area 10 km. away from Erciş where the debris is being poured. They set the reinforcing steels apart from the debris and sell it to scrap dealers and earn money (http://aa.com.tr/tr/alt-manset-haberleri/100459-deprem-molozlari-gecim-kaynaklari-oldu). This provides a kind of recycling and therefore forms some part of the debris management spontaneously.

Preparing for such disasters and therefore having a complete disaster plan in advance would have clarified the directions on debris and not result in such a situation. This experience underlines that risk management activities (mitigation and preparedness) should be focused on in order to

acquire effective and complete response to disasters.

Preliminary Reflections on Policy

The earthquakes in Van have raised the issue of building robustness once again leading to several reflections on policies. Below some planned actions can be found (http://www.ntvmsnbc.com/id/25292914/ and http://www.ntvmsnbc.com/id/25292840):

- Draft law on Urban Transformation is being handled once again by the bureaucrats of the Ministry of Environment and Urbanization. It is mentioned that ordinances enabling implementation of urgent expropriation in places exposed to earthquake risk will take place. The regularization will authorize metropolitan municipality and district municipalities to determine the areas for transformation. For public institutions the authorization will be in the Cabinet. It is stated that the regularization will be broached to related institutions before forwarding to the Prime Ministry. It is also mentioned that urban transformation will also be considered for flood risk zones and landslide zones besides seismic zones .
- Changes in the current laws of Property Ownership and Reconstruction Amnesty is indicated to be performed. The sentence indicating " all flat owners' permission" is stated to be removed and "majority verdict" is told to be adequate. The administration will further be empowered.
- We can follow from the same news that efforts for taking building inventory is accelerating. In-depth inventory including number, typology and natural disaster risk analysis of buildings will be completed within 5 years.
- Beginning from 2012, certificate of authorization for craftsmen working in construction or installments is told to be compulsory. It is also planned to provide in-service training to the certified craftsmen.
- Architects or engineers will be put on charge as construction supervisors (site managers) in order to avoid poor quality housing. Contractors will also require certificate of authorization.
- The system of technical consultancy is stated to be adopted under the coordination of Ministry of Environment and Urbanization in order to provide powerful and corporate building investigation.
- As public buildings have also received substancial damage, There will no longer be differentiation between private and public in terms of regularization.
- European Union regulations for constructions materials is indicated to be put into practice as national code on July 2013.

- The ministry to undertake the coordination is planned to work in cooperation with TOKI. It is estimated that TOKI will make an aggreement with owners of demolished unlicenced buildings. Redemption dates up to 20 years are foreseen.

There are hesitations of professional organizations upon these steps; some on their implementation circumstances or on whether they will be implemented.

Additionally, government took some decisions in order to provide economical support for short term recovery:

- The Minister of Labour and Social Security declared that the State will be rendering the payments (between 500-1,200TL) to the earthquake victim labourers – the ones who work in institutions with suitable conditions – for up to 6 months through Short-time Working Subsidy. The Minister adds that they have postponed the insurance premium debts for one year including three month premiums after the earthquake (http://www.ntvmsnbc.com/id/25291805/ and http://ekonomi.haberturk.com/makro-ekonomi/haber/682364-dar-gelirli-calisana-deprem-odemesi).
- The Ministry of Labour and Social Security also state that 3,000 vacancy for the "work projects to the benefit of public" has been reserved for earthquake victims. Therefore 3,000 people will have the chance to work in jobs such as arbouring, school maintenance, in return for minimum wage. Their insurance premiums will be paid and they will be included in health insurance (http://www.ntvmsnbc.com/id/25292970/).

Need for Focusing on Mitigation and Preparedness

We conveyed above, the information we gathered on the preliminary social effects and reflections of the two earthquakes in Van on several fields. In 1999, after the Kocaeli earthquake, it is reported as a lesson learned on emergency response that SAR efforts have started immediately by the surviving residents, however the response from the government and military was slow (Hays, 2000). This was attributed to the large number of trapped victims. It would not be proper to compare Kocaeli earthquake and Van earthquakes' responses for they have disparate units of analysis. Yet, several remarks may be passed:

- As several institutions have established SAR and medical response teams after the 1999 earthquakes such as UMKE teams and TSK DAK or established coordination centers such as SAKOM, excluding discussions on effective response and coordination, we understand that we are in a better position in terms of response capacity.

- DASK has been established after the 1999 earthquakes. Although the penetration rate of the earthquake insurance is only around 27% across the country, it provides a limited amount of risk reduction.
- Public awareness campaigns and education have been initiated after the 1999 earthquakes. They are mostly targeted and effective at Istanbul and the Marmara Region. The materials developed facilitate the communication of the messages also to the rest of the country.
- Higher education institutions developed certificate programmes or courses on the subjects of risk and disaster management, contributing to the development of human resource.
- NGOs have taken initiatives such as MAY and Neighbourhood Disaster Volunteers (MAG) strengthening the solidarity and the coping capacity of the public. Such initiatives need to be conveyed to the whole country.

There is need for making efforts for the risk management phase of the disaster management cycle. This will also strengthen the response activities by making the path to be followed in case of a disaster much more clear and by reducing the possible negative impact of the event through mitigation. Below is a list of significant subjects to consider:

- Involvement of the public to activities in all phases of disaster management and provide the understanding of Community Based Disaster Management: This would also help building solidarity and to create demand for policies. Additionally, we also need to underline that "primary responsibility to prepare for and respond to disasters rests with the individual" (quoted from Kuban ve MacKenzie-Carey, 2001). As the individual gets informed, he will start preparing and demanding for safer environment. Community involvement and capacity building is one of the most important measures against disasters in the case of a metropolitan such as Istanbul, where resources will most likely be not sufficient for all response actions.
- Competent/Accredited Engineering and Effective Building Inspection as complementary sanctions for implementation of the building codes: There is need to improve all pillars of the system of housing. Therefore besides the comprehensive building codes that were updated recently, the human resource to apply the codes and to inspect the application need to be trained competent and held responsible in order for the whole chain to be strong. There are efforts of Ministry of Public Works (new name is The Ministry of Environment and Urbanization) in providing trainings on the application of codes where professors and experts from KOERI take part as instructors and these need to be extended and repeated.
- Planning for all topics for the response phase such as debris management and mutual aggreements with institutions and organizations in advance, for relevant resources: A

comprehensive disaster plan encompasses all activities to be undertaken with the relevant stakeholders and resources in the response phase and therefore clarifies the procedures to be followed, avoiding possible suspenses and delays.

- Integrated Urban Risk Reduction: It is significant to implement mitigation strategies considering the benefit of the society and human needs to reduce losses.

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The November 09, 2011 Edremit-Van, Turkey Earthquake (ML=5.6)

This page covers the most recent information about the November 09, 2011,Van, Turkey earthquake. It will be updated as new information and data become available.

The ML 5.6 earthquake took place on November 09, 2011 at 19:23 GMT in the province of Van, located in Eastern Turkey near Lake Van. The epicenter is in the Edremit subprovince, about 16 km to the south of the Van city center. The earthquake parameters reported by various institutions are presented in Table 1. The moment tensor solutions of USGS and GFZ are given in Table 2 and shown in Figure 1.

A significant aftershock activity is underway in the earthquake region since 23 October 2011. Figure 2 shows the aftershock activity since 23 October 2011 time for events with Ml> 3, with the epicenters of both events marked as appropriate. The instrumental intensity map can be seen in Figure 3.

The Edremit-Van earthquake has a dominantly strike-slip mechanism. This earthquake, as well as the event on 23 October 2011, which took place on a blind fault, did not occur on a fault previously indicated and discussed in the literature except by Koçyiğit (2002) (Figure 4).

The earthquake was recorded by six strong motion stations of the Department of Engineering (DEE) in Van and Erciş, and three strong motion stations of the National Strong Motion network (http://kyh.deprem.gov.tr/ftpe.htm) in Van, Muradiye and Bitlis. The report on and data of the DEE records can be reached at (http://www.koeri.boun.edu.tr/depremmuh/deprem-raporlari/Van_Eq_aftershocks1.pdf). The peak corrected accelerations, velocities and displacements are 230 cm/s^{2,} 22 cm/s and 10 cm respectively. The level of recorded ground motions are comparable to the ones obtained during the previous event on 23 October. See the records and the shakemap with adjusted PGA's at;
http://www.koeri.boun.edu.tr/depremmuh/deprem-raporlari/Van_Eq_SM_31102011.pdf.
Probabilistic PGA's with a return period of 475 years can be seen in Figure 5.

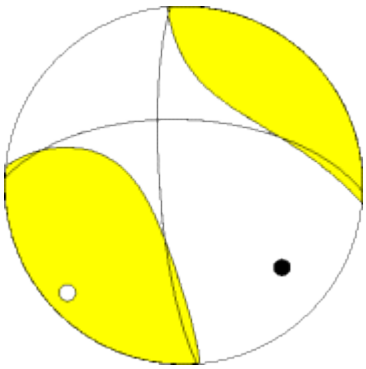
25 buildings collapsed in Van center in this event. 23 of these buildings were inhabited due to previous damage caused by the earthquake on 23 October. Two buildings however, both of them hotels, were open with many people staying at the time of the earthquake. It appears that both of them had received damage on 23 October and allegedly have reports for their habitability afterwards. The earthquake caused further damage to the building stock already effected by the M7.2 event on October 23rd. 40 people lost their lives (http://www.afad.gov.tr/) as a result of this earthquake, most of them in the two collapsed hotels.

Table 1. The earthquake parameters reported by various institutions

Date / Time	2011 / 11/09 21:23:21(Local) (KOERI*)	2011 / 11/09 19:23:33 UTC (USGS*)	2011 / 11/09 19:23:33 UTC (EMSC*)	2011 / 11/09 19:23:37.3 UTC (GFZ*)
Latitude	38.4295N (KOERI)	38.429N (USGS)	38.42N(EMSC)	38.41N (GFZ)
Longitude	43.2342E (KOERI)	43.229E (USGS)	43.29E(EMSC)	43.35E (GFZ)
Depth	5 km (KOERI)	5 km (USGS)	6 km (EMSC)	23 km
Magnitude	5.6 (ML) KOERI	5.6 (USGS)	5.7 (Mw) (EMSC)	5.6 (Mw) (GFZ)
Location	Edremit- VAN	Eastern Turkey	Eastern Turkey	Eastern Turkey

*KOERI- Kandilli Observatory and Earthquake Research Institute
http://www.koeri.boun.edu.tr/scripts/lst2.asp
*USGS- United State Geological Survey
http://earthquake.usgs.gov/earthquakes/recenteqsww/Quakes/usb0006mkw.php
EMSC European-Mediterranean Seismological Centre
http://www.emsc-csem.org/Earthquake/earthquake.php?id=243793
GFZ- German Research Centre for Geosciences
http://geofon.gfz-potsdam.de/eqinfo/event.php?id=gfz2011vzni

Table 2. The moment tensor solutions of USGS and GFZ

USGS	**GFZ**
(http://earthquake.usgs.gov/earthquakes/eqarchives/fm/neic_b0006mkw_fmt.php) 11/11/09 19:23:33.24 Epicenter: 38.429 43.229 MW 5.6 USGS MOMENT TENSOR SOLUTION Depth 8 No. of sta: 44 Moment Tensor; Scale 10**17 Nm Mrr=-0.96 Mtt= 0.45 Mpp= 0.51 Mrt=-0.11 Mrp= 1.16 Mtp=-2.49 Principal axes: T Val= 3.17 Plg=13 Azm=227 N -0.75 58 338 P -2.43 29 130 Best Double Couple:Mo=2.9*10**17 NP1:Strike=176 Dip=79 Slip= -31 NP2: 272 60 -167 	(http://geofon.gfz-potsdam.de/geofon/alerts/gfz2011vzni/mt.txt) GFZ Event gfz2011vzni 11/11/09 19:23:37.33 Turkey Epicenter: 38.41 43.35 MW 5.6 GFZ MOMENT TENSOR SOLUTION Depth 23 No. of sta: 102 Moment Tensor; Scale 10**17 Nm Mrr=-0.37 Mtt=-0.07 Mpp= 0.44 Mrt=-0.69 Mrp= 0.01 Mtp=-0.07 Principal axes: T Val= 2.91 Plg= 8 Azm=227 N -0.32 75 105 P -2.59 13 319 Best Double Couple:Mo=2.8*10**17 NP1:Strike= 93 Dip=87 Slip=-164 NP2: 2 75 -2

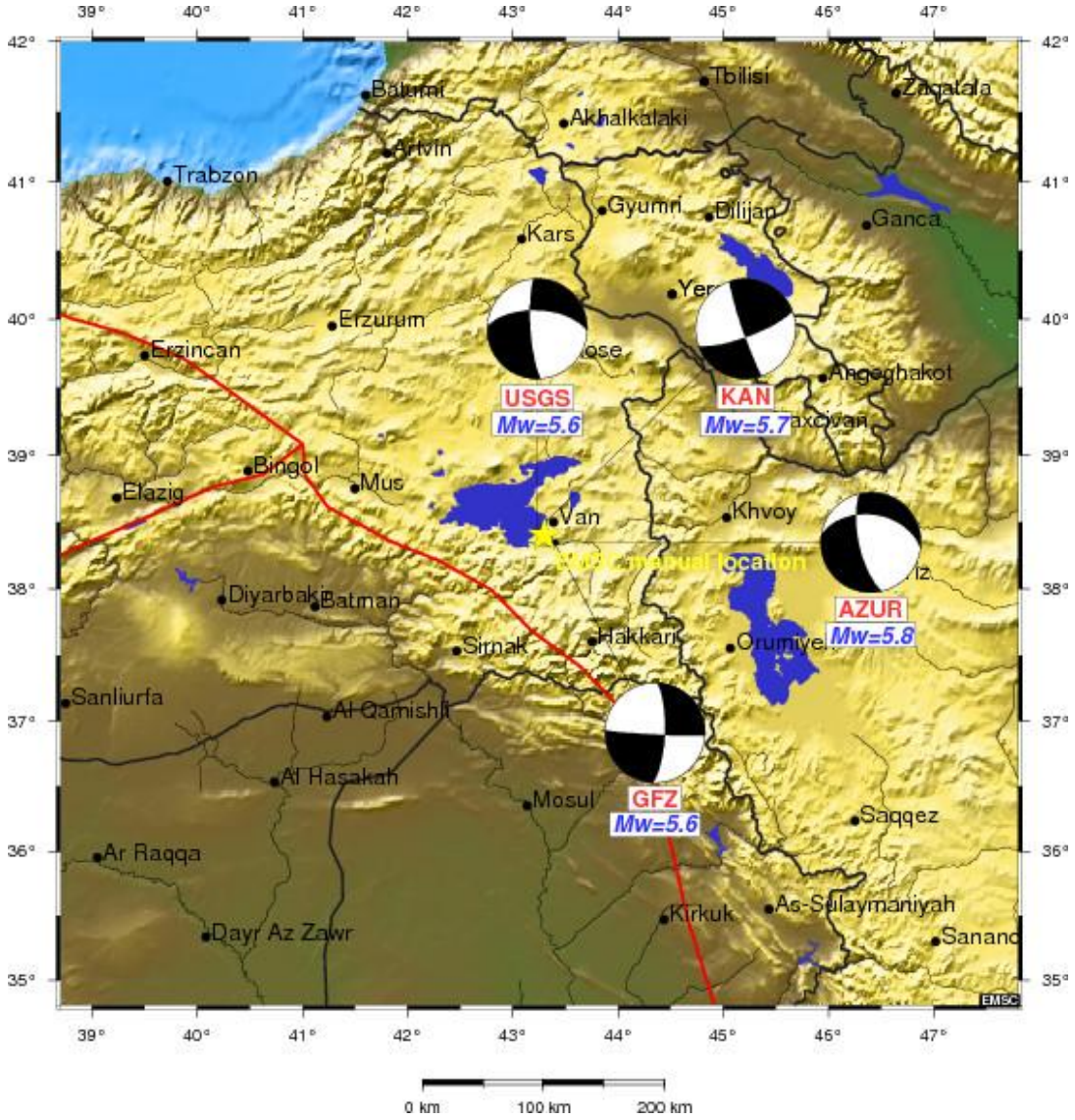


Figure 1. Edremit-Van earthquake as reported by various institutions (Source EMSC)

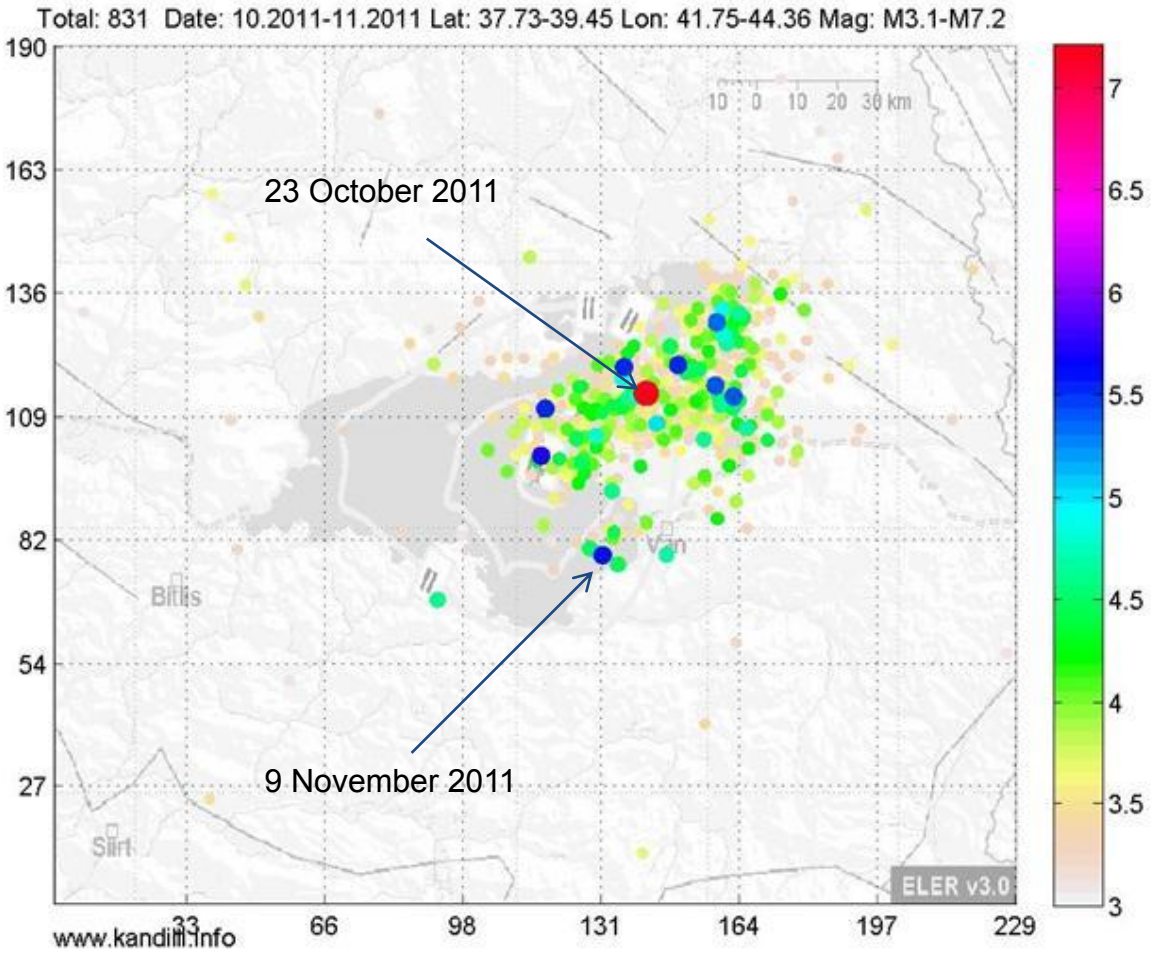


Figure 2. Aftershock activity since 23 October 2011

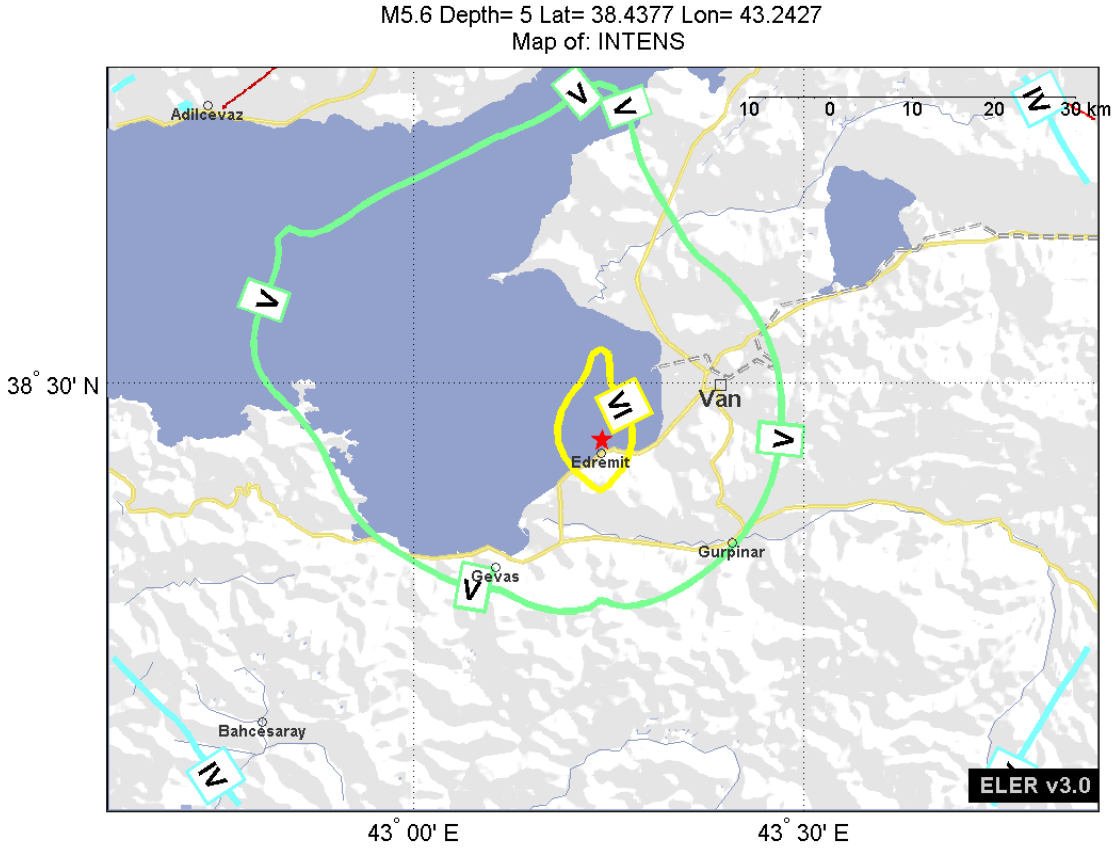


Figure 3. Instrumental intensities

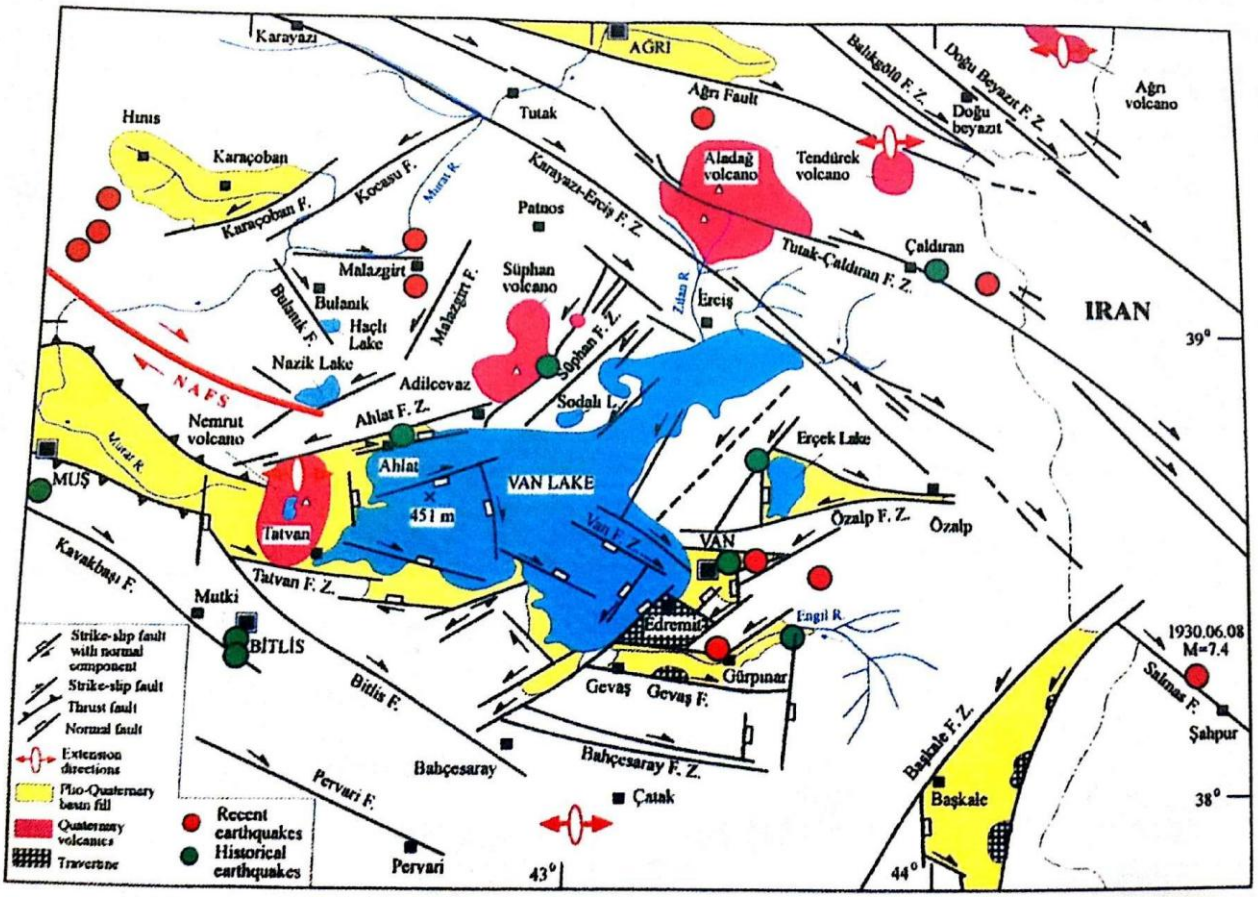


Figure 4. Regional active fault map after Koçyiğit (2002)

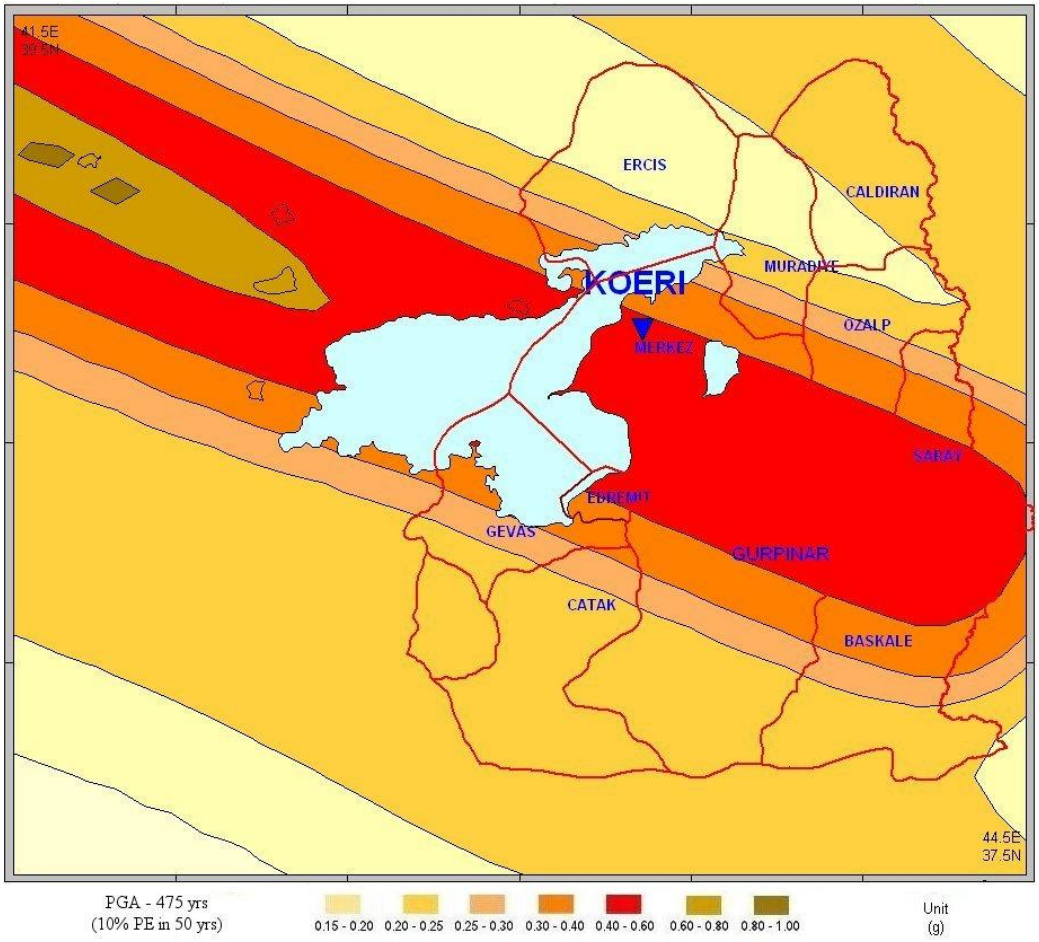


Figure 5. PGA's for a return period of 475 years

Contributed by: E. Çaktı, M.B. Demircioğlu, M. Erdik, Y. Kamer, B. Sungay, K. Şeşetyan, (in alphabetical order)

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Department of Earthquake Engineering

PRELIMINARY ANALYSIS OF DATA FROM THE AFTERSHOCK DEPLOYMENT IN VAN AND ERCİŞ , TURKEY

M=5.6 VAN EARTHQUAKE ON 09/11/2011

Department of Earthquake Engineering
Kandilli Observatory and Earthquake Research Institute
Bogazici University
Istanbul, Turkey

November 2011

SUMMARY

Following the destructive M=7.2 Van Earthquake of 23 October 2011 in Eastern Turkey, we have deployed eight strong motion monitoring equipment to the region to record aftershocks.

Four of the stations were installed in the city of Van, and the remaining four in the city of Ercis, which suffered the most damage and loss of life. The stations in each city are arranged such that one of the stations is located on a stiff soil or a rock site to be used as the reference station, and the remaining three in the flat urban area forming a triangle.

The eight-station network has recorded a large number of aftershocks, including the destructive one with M=5.6 on 9 November 2011 epicentered near the town of Edremit south of Van. Figure 1 shows the location of this earthquake, as well as the deployment regions. For the background information on this earthquake please see the link http://www.koeri.boun.edu.tr/News/%2009%20November%202011,%20M=5.6,%20Van,%20Turkey%20Earthquake_16_206.depmuh. The locations of the eight stations in Van and Erciş can be seen Figures 2 and 3 respectively. Descriptive information on the stations is summarized in Table 1.

This report presents preliminary analysis of the data recorded by the network during the M=5.6 Edremit-Van earthquake. All four stations in Ercis recorded the earthquake. In Van only two stations recorded the event, the rock- site station and one of the soil-site stations. These records can be downloaded through links in Table 1. Processed records from the Van network can be seen in Figure 4 through Figure 10. Records from Erciş are presented in Figure 11 through Figure 19.

We think that the records from the rock-site station in Van may have some calibration problems. So, although they are presented in the report, we do not recommend using them until further tests are done in the instruments. The other Van station that recorded the earthquake was very near the Bayram Hotel that was destroyed completely during this earthquake causing the deaths, among others, of several newspersons and a Japanese aid worker.

Following observations can be made:

- Although they are from the same earthquake, the Van record shows a very distinct impulsive displacement and a velocity pulse (Figure 7), whereas Erciş records are

dominated by long-duration surface velocities and displacements (Figure 13 through Figure 16), suggesting basin effects.

- The velocity and displacement pulses seen in the Van records can also be observed in the Erciş records (Compare Figure 7 with the arrivals at around 10 sec in Erciş records in Figures 13-16).

- There is a strong directionality in the particle motions of the Van records (Figure 8). It appears that the fault normal component is at about 120° N and the fault parallel component is at 30° N. This finding is in line with the fault mechanism solutions for this earthquake.

- Observed accelerations, velocities and displacements are very large for an earthquake of M5.6 magnitude.

- The response spectra in Van are very monochromatic with a single peak around 0.4 s in the EW direction. The same peak can clearly be seen in Erciş response spectra as well (Figure 18).

- There are no distinct dominant frequencies in the spectral ratios (Figure 10) in Van that can suggest site effects. Yet in two frequency ranges, between 0.8-1.4 Hz and 2.6-3.8 Hz average amplifications reach 5 and 8 respectively.

- In Erciş at 1.4 Hz and 2.5 Hz in the EW direction and an uninterrupted, average 4 times amplification between 0.5 and 1.8 Hz in the NS direction are evident (Figure 19).

More detailed investigations on this and other aftershock data are in progress.

Figure 1. Epicentre of M5.6 Edremit-Van earthquake and locations of aftershock monitoring cities, Van and Erciş

Figure 2. Locations of aftershock monitoring stations in Van

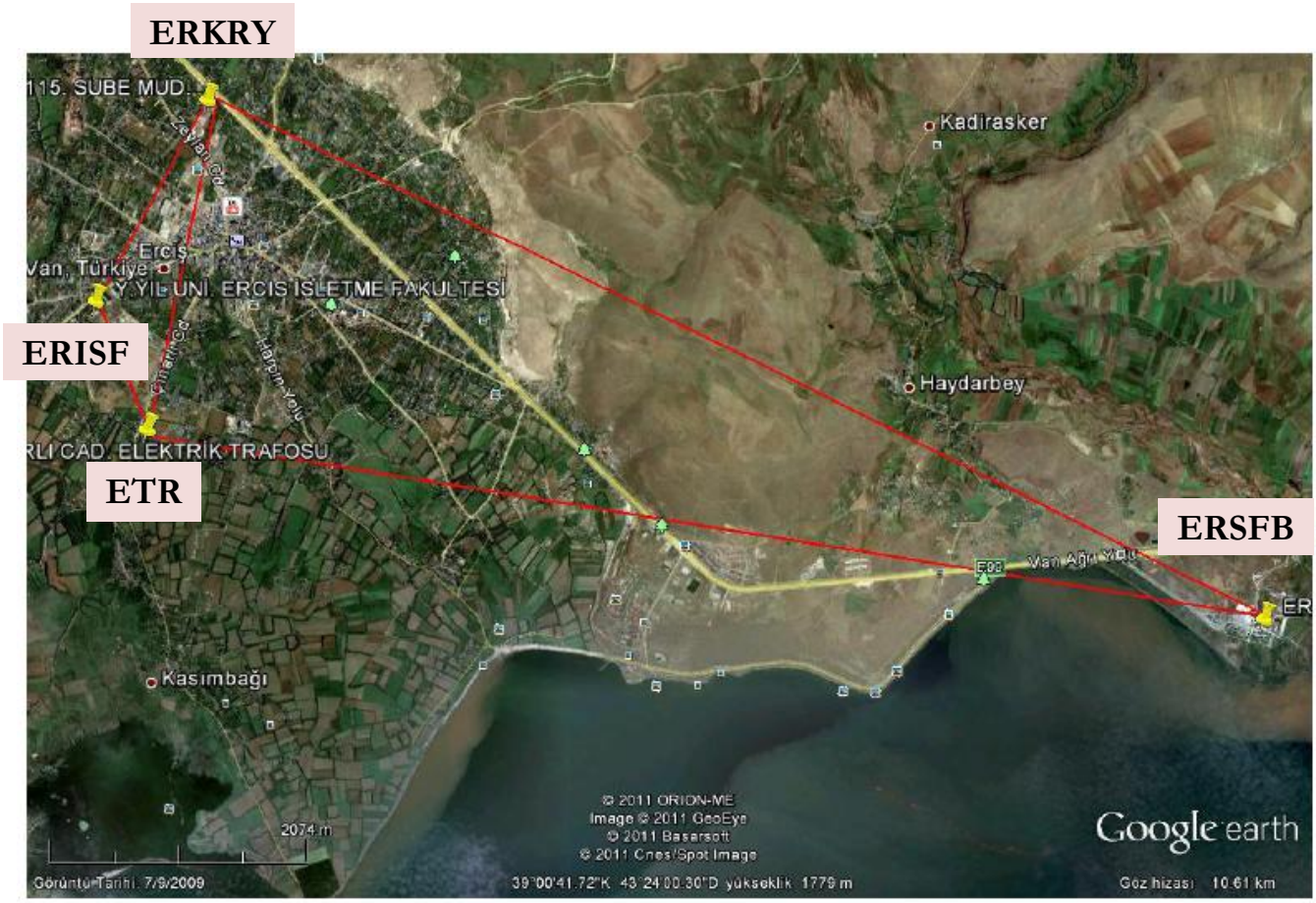


Figure 3. Locations of aftershock monıioring stations in Erciş

Table 1. Station information for the Van and Erciş deployments. Use links at VNS, VNKEA and four Erciş stations to download data

VAN

STATION CODE	STATION COORDINATES	STATION LOCATION
VNS (rock site)	38.33455N 43.19533E	Şemsibey İlkokulu
VNKOI (soil site)	38.33455N 43.19533E	Koç İlköğretim Okulu
VNTGM (soil site)	38.33455N 43.19533E	TEDAŞ Genel Müdürlüğü (Havaalanı kavsağı)
VNKEA (soil site)	38.33455N 43.19533E	TEDAŞ Köy Elektrik Arıza (Valilik yanı, Santral Sok.)

ERCİŞ

STATION CODE	STATION COORDINATES	STATION LOCATION
ERSFB (stiff soil site)	38.59996N 43.27304E	Erciş Şeker Fabrikası
ETR (soil site)	39.00880N 43.21097E	TEDAŞ Trafo Binası (Çınarlı Caddesi sonu)
ERKRY (soil site)	39.02264N 43.21426E	Erciş Karayolları 115. Şube Müdürlüğü
ERISF (soil site)	39.01398N 43.20798E	Yüzüncü Yıl Üniversitesi Erciş İşletme Fakültesi

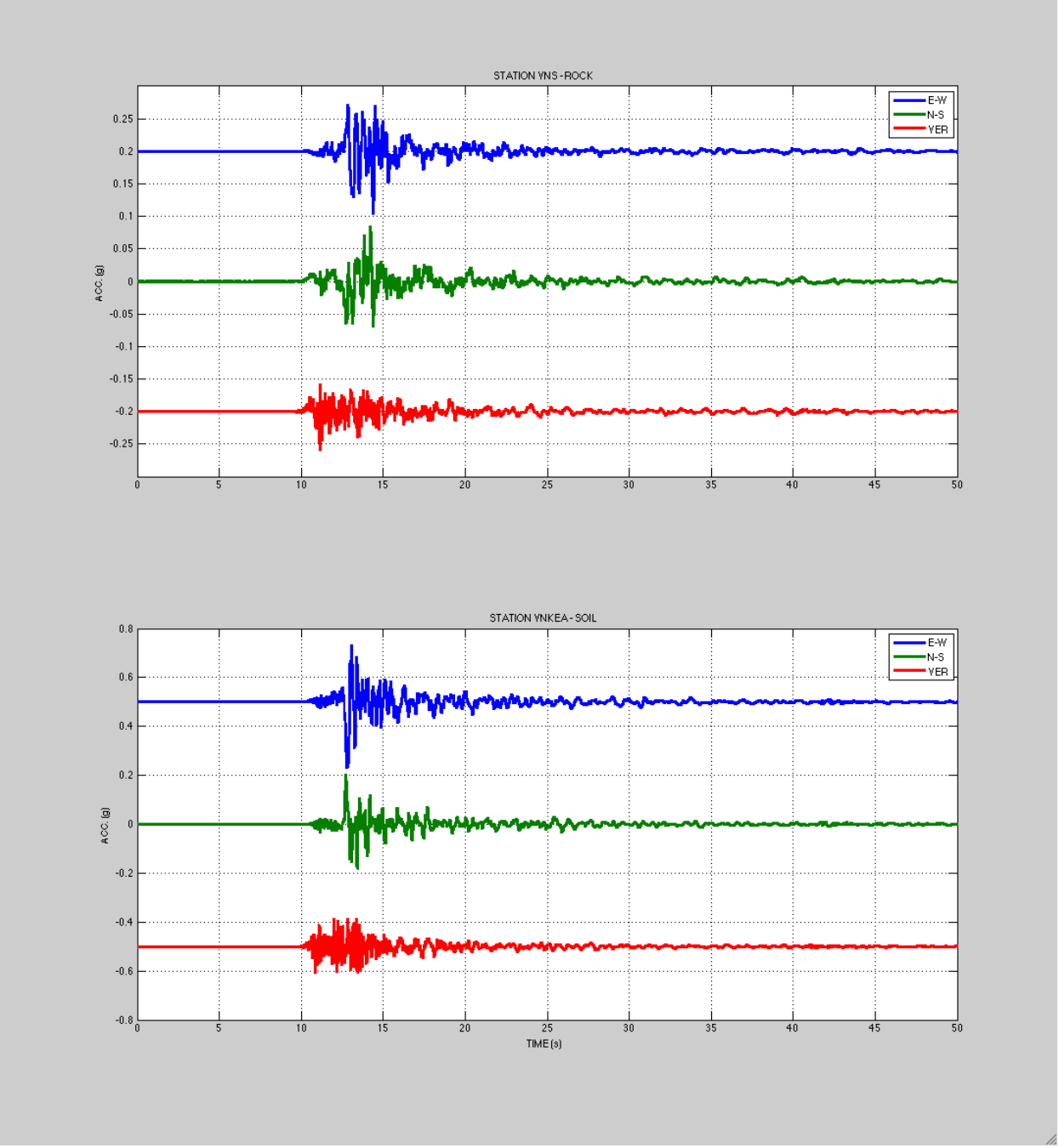


Figure 4. Accelerations recorded at stations VNS (rock) and VNKEA (soil)

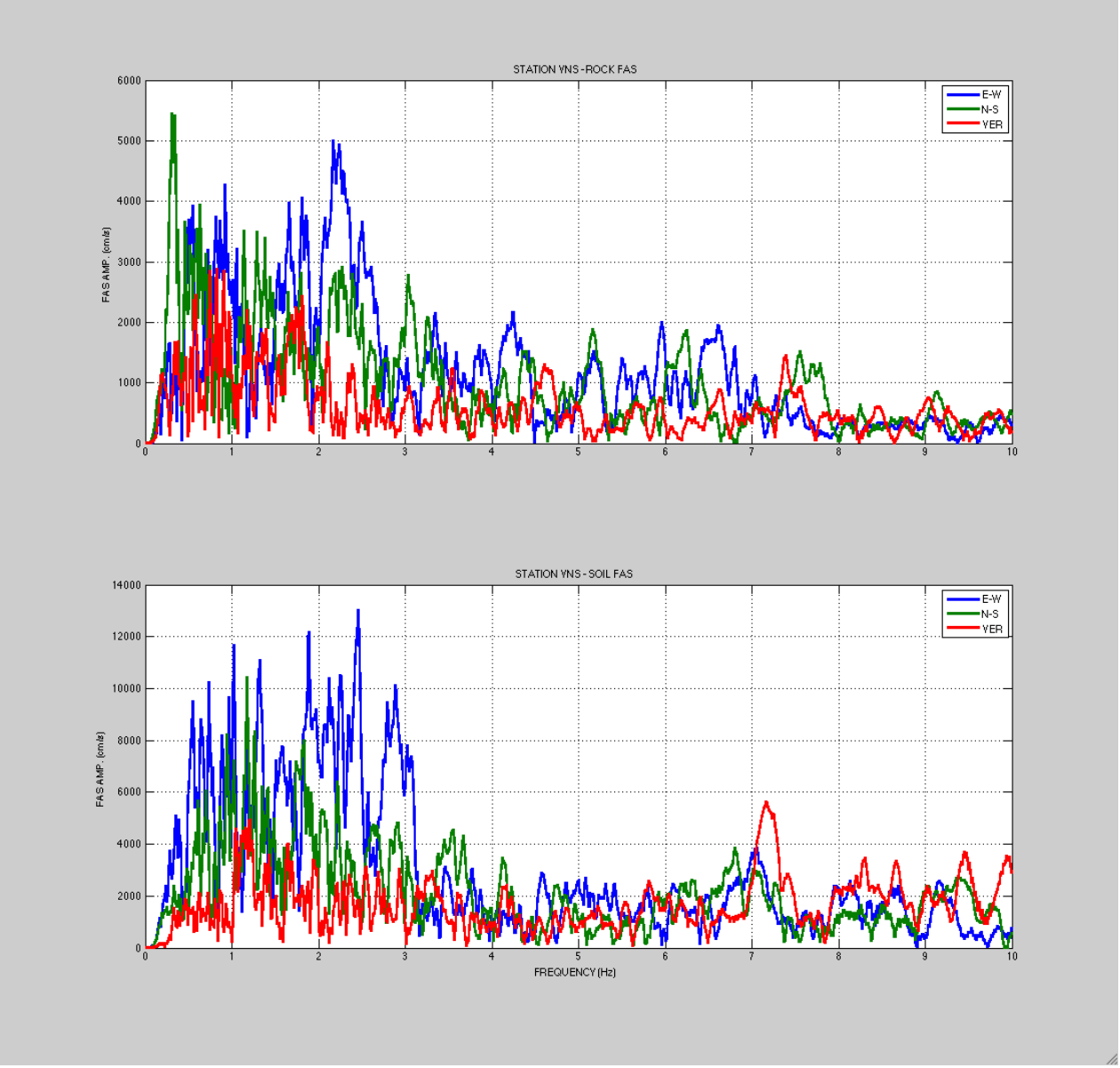


Figure 5. Fourier Amplitude Spectra of accelerations recorded at station VNS (rock) and VNKEA (soil)

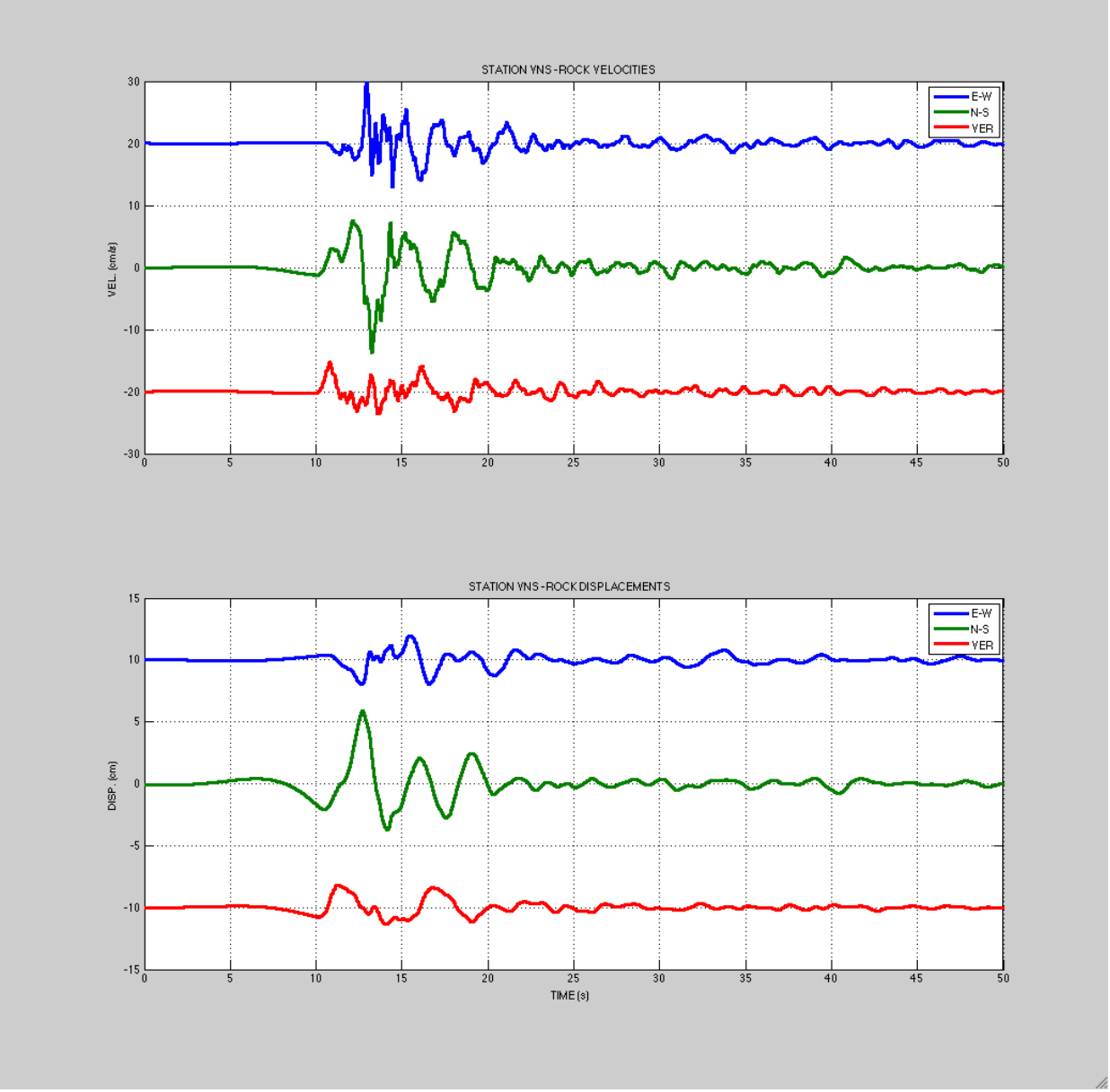


Figure 6. Velocities and displacements at station VNS (rock)
(*Note: Rock site records need to be re-checked for accuracy*)

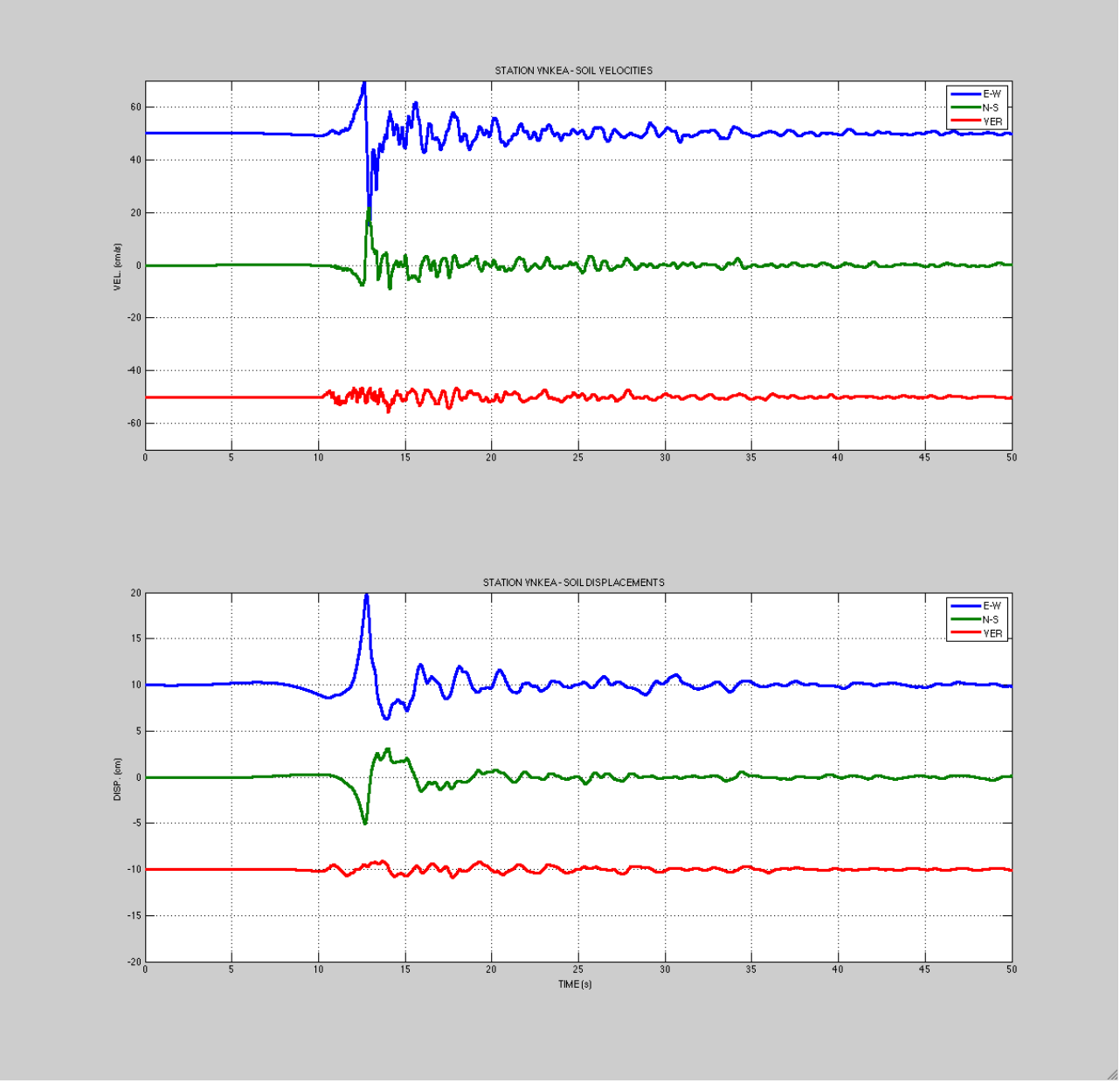


Figure 7. Velocities and displacements at station VNKEA (soil)

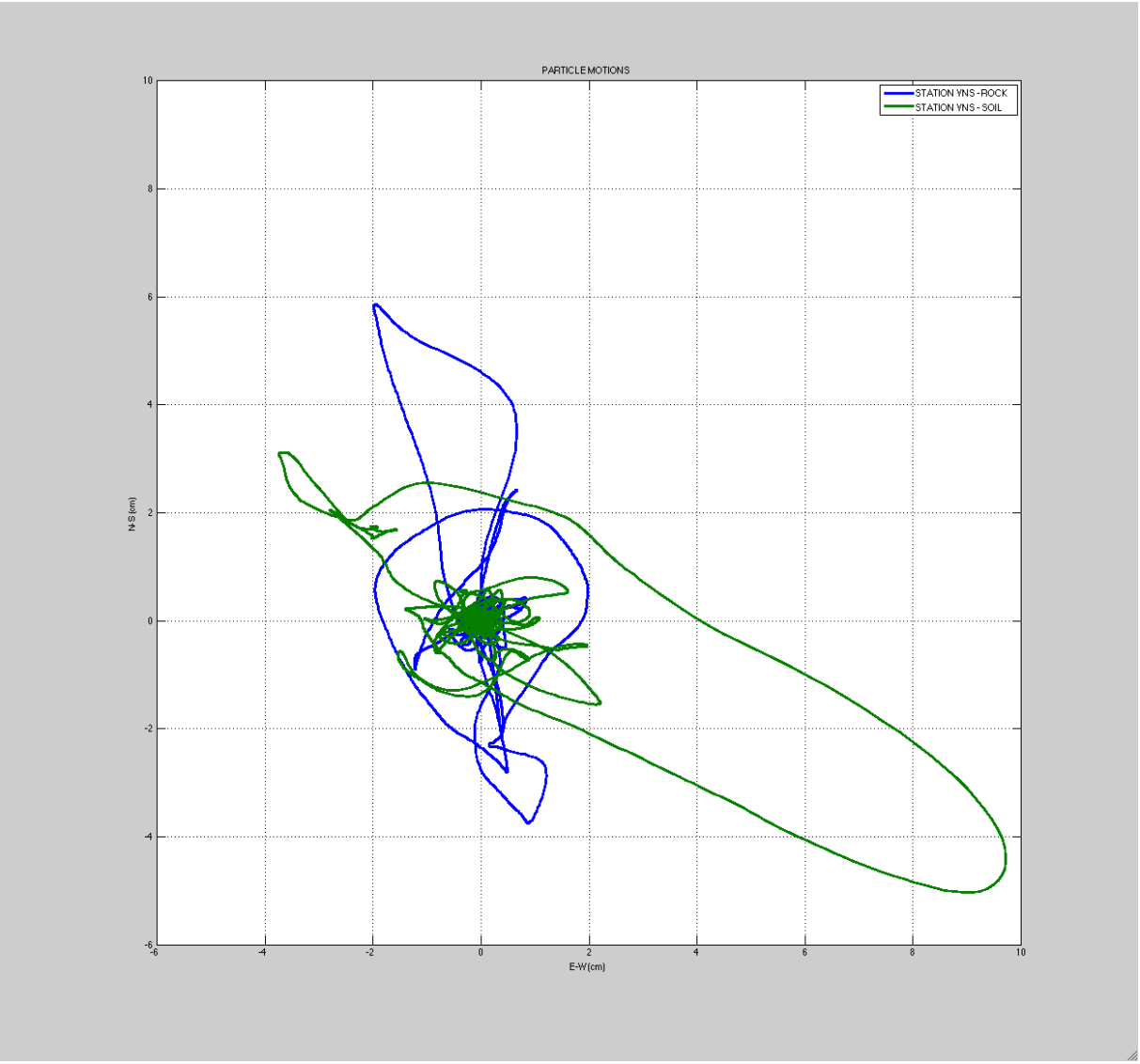


Figure 8. Particle motions at stations VNS (rock) AND VNKEA (soil)
(*Note: Rock site records need to be re-checked for accuracy*)

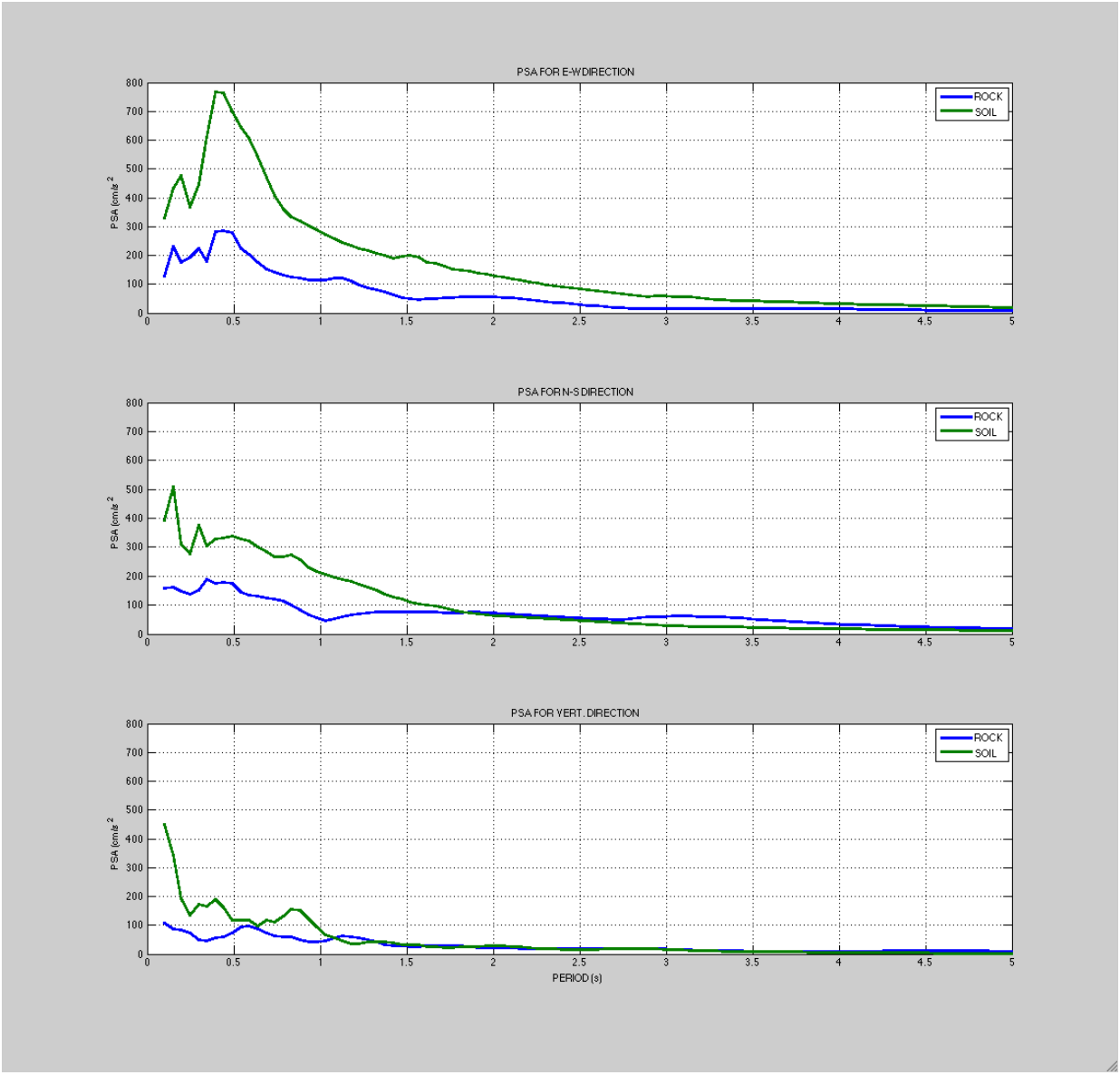


Figure 9. Response spectra (SA) at stations VNS (rock) and VNKEA (soil)
(*Note: Rock site records need to be re-checked for accuracy*

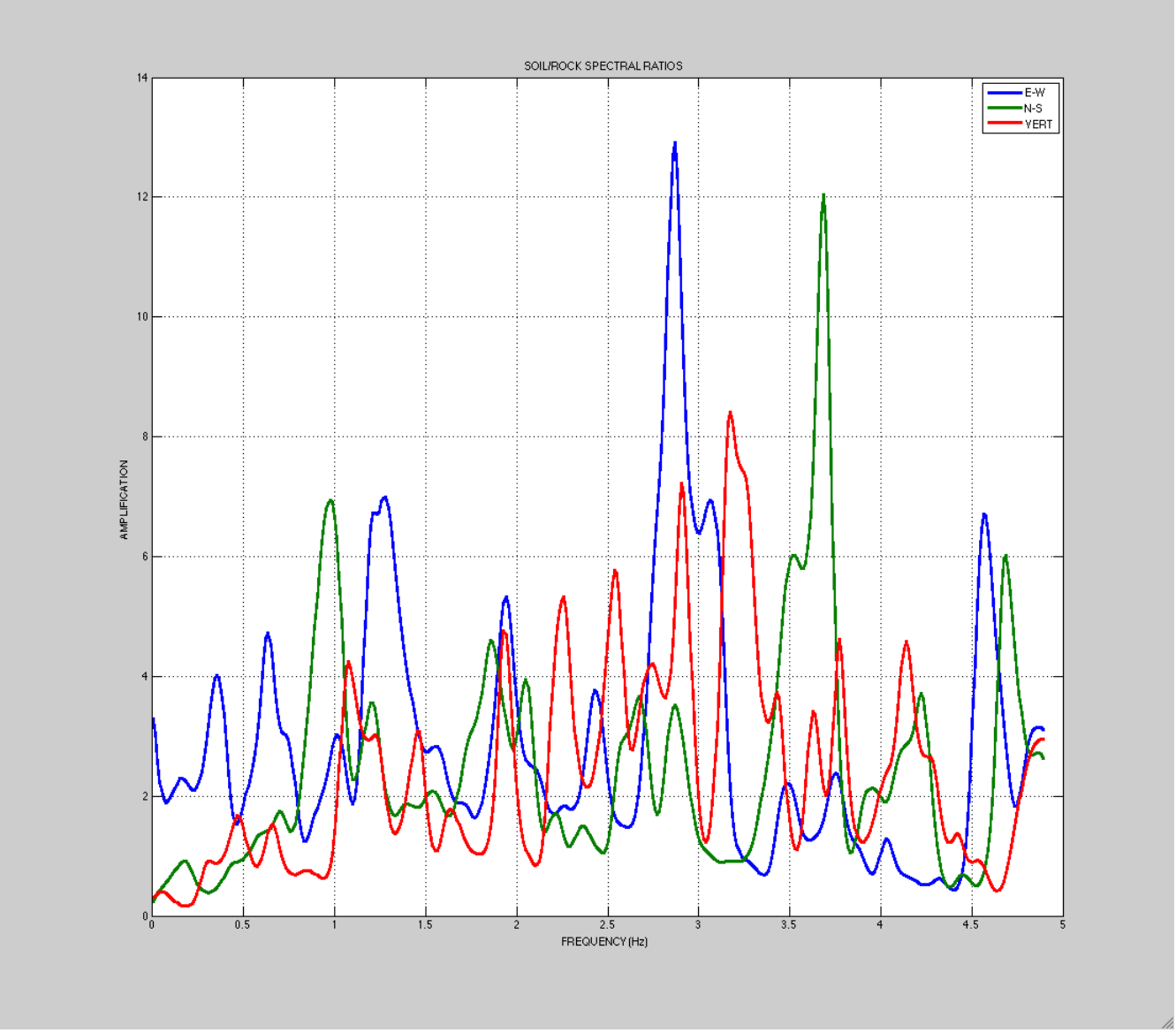


Figure 10. Soil (St. VNKEA) / Rock (St. VNS) spectral ratios
(*Note: Rock site records need to be re-checked for accuracy*)

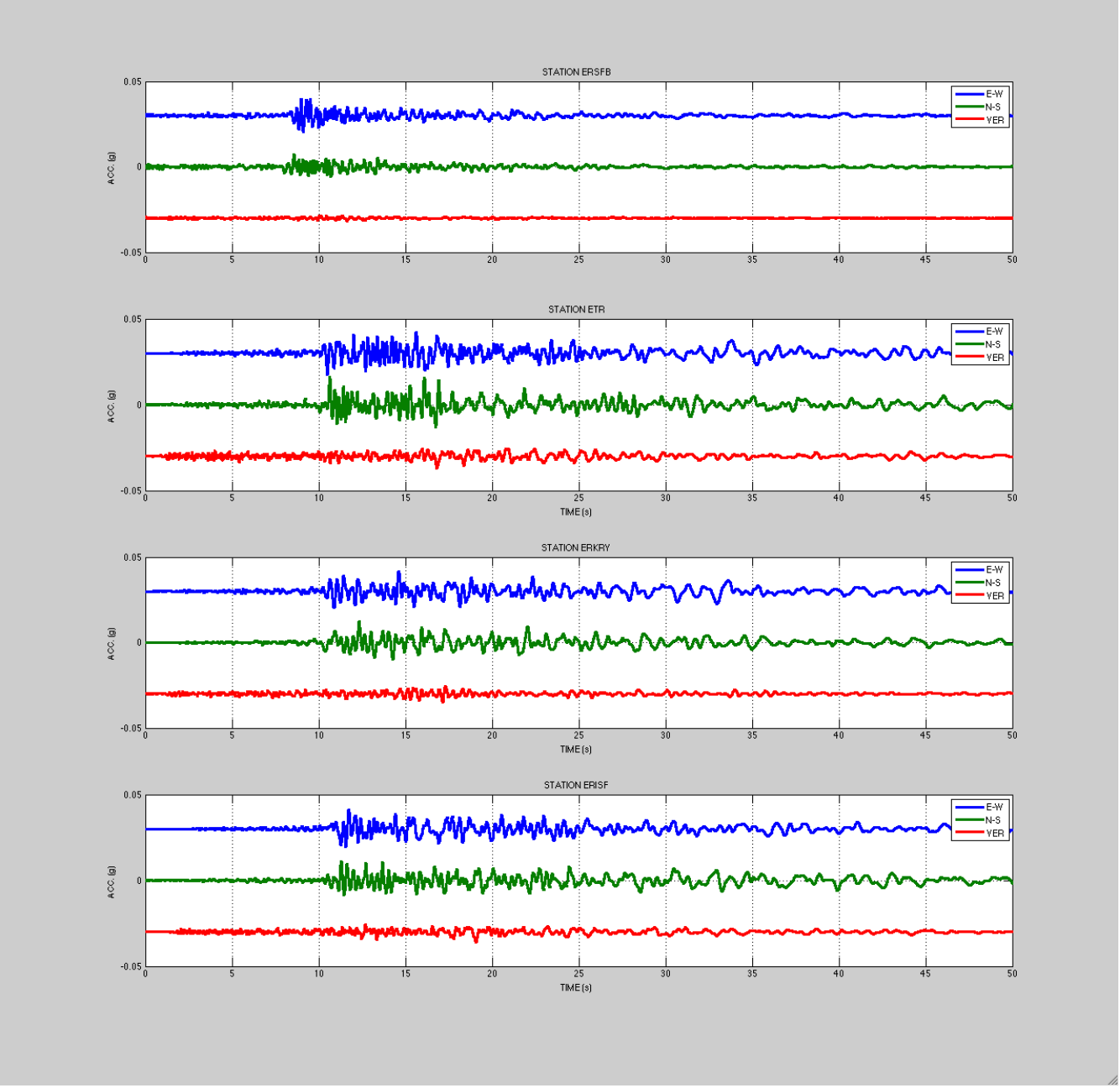


Figure 11. Accelerations recorded at stations ERSFB, ETR, ERKRY, ERISF in Erciş

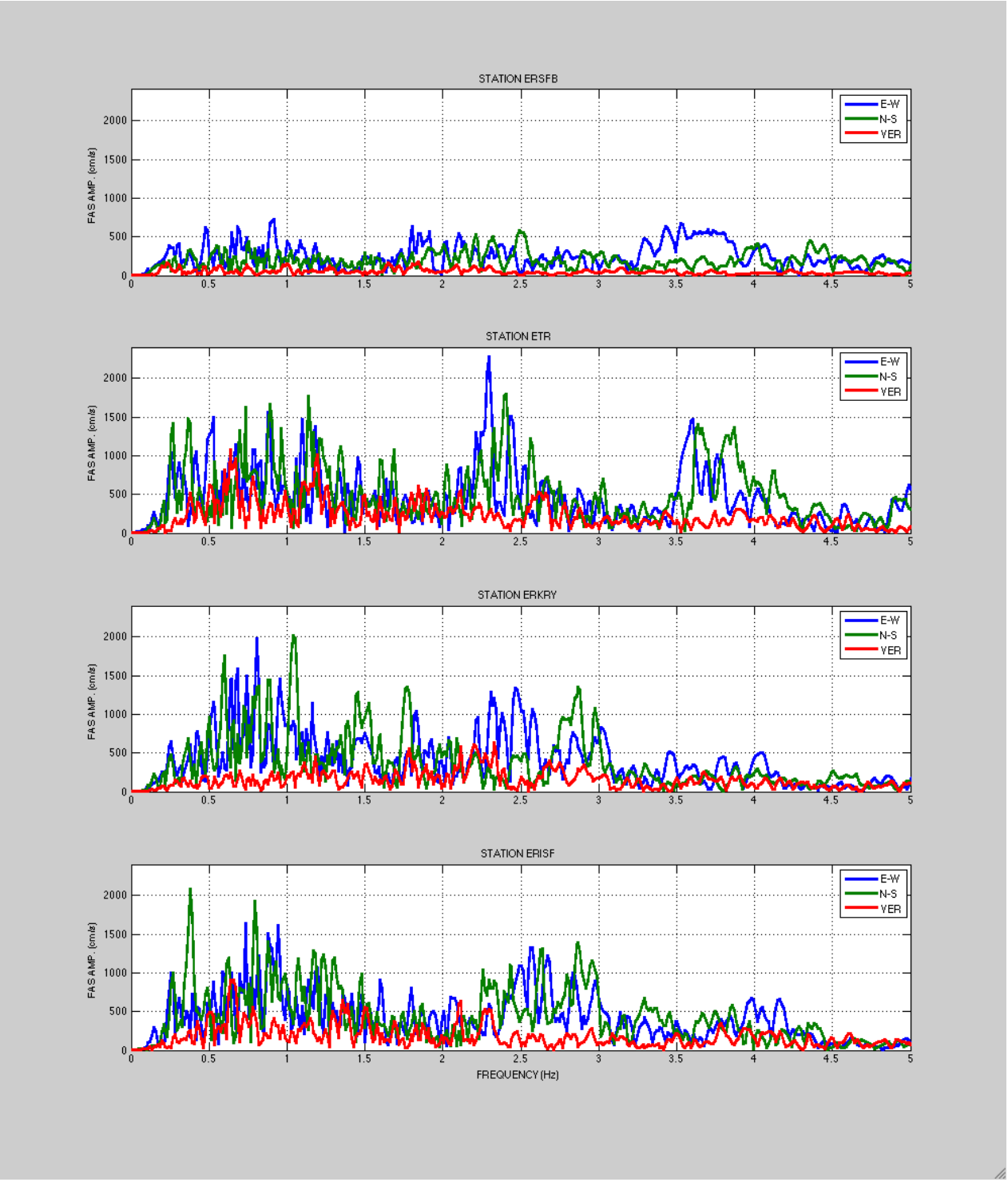


Figure 12. Fourier Amplitude Spectra of accelerations recorded at stations ERSFB, ETR, ERKRY, ERISF in Erciş

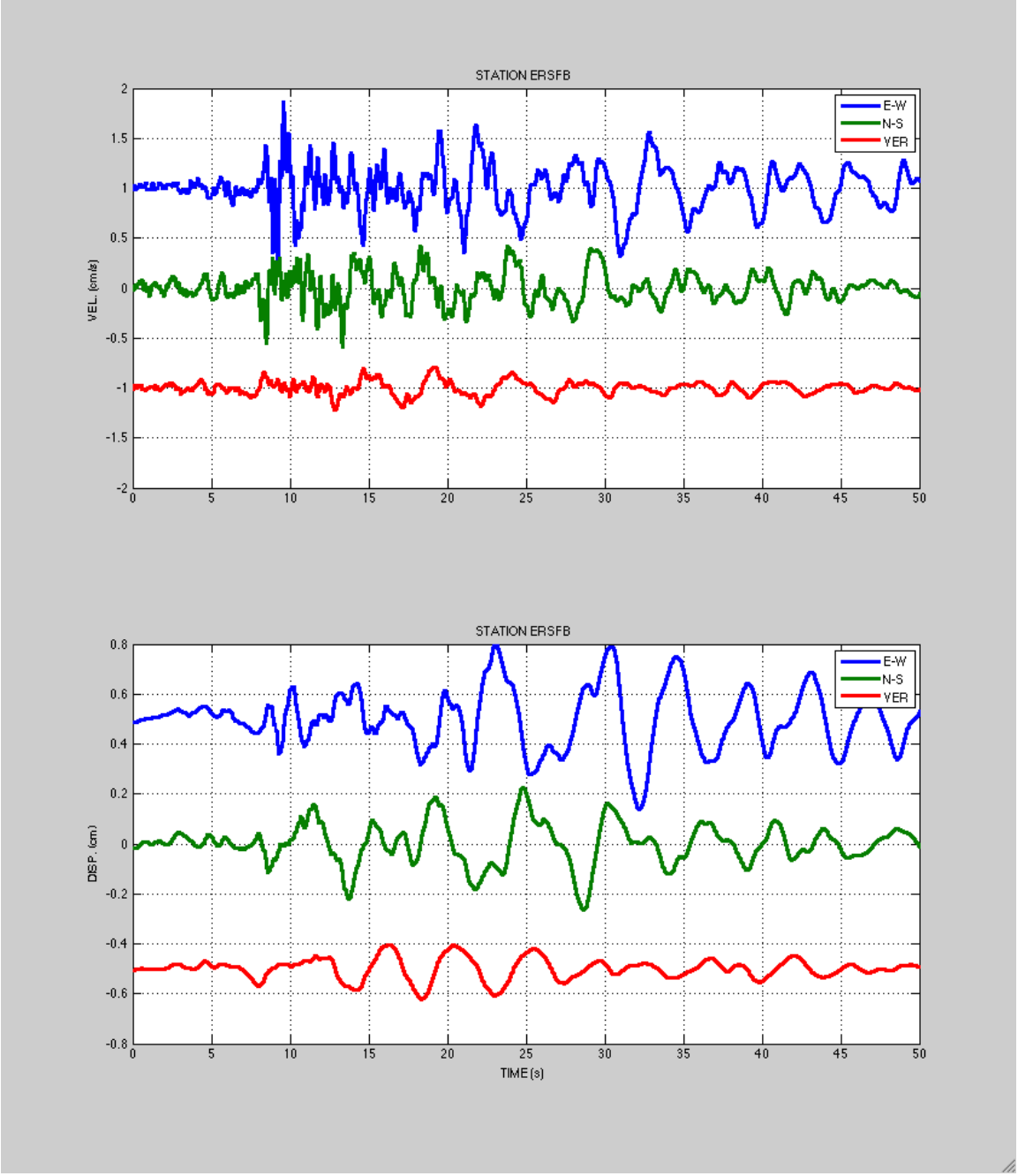


Figure 13. Displacements and velocities at station ERSFB in Erciş

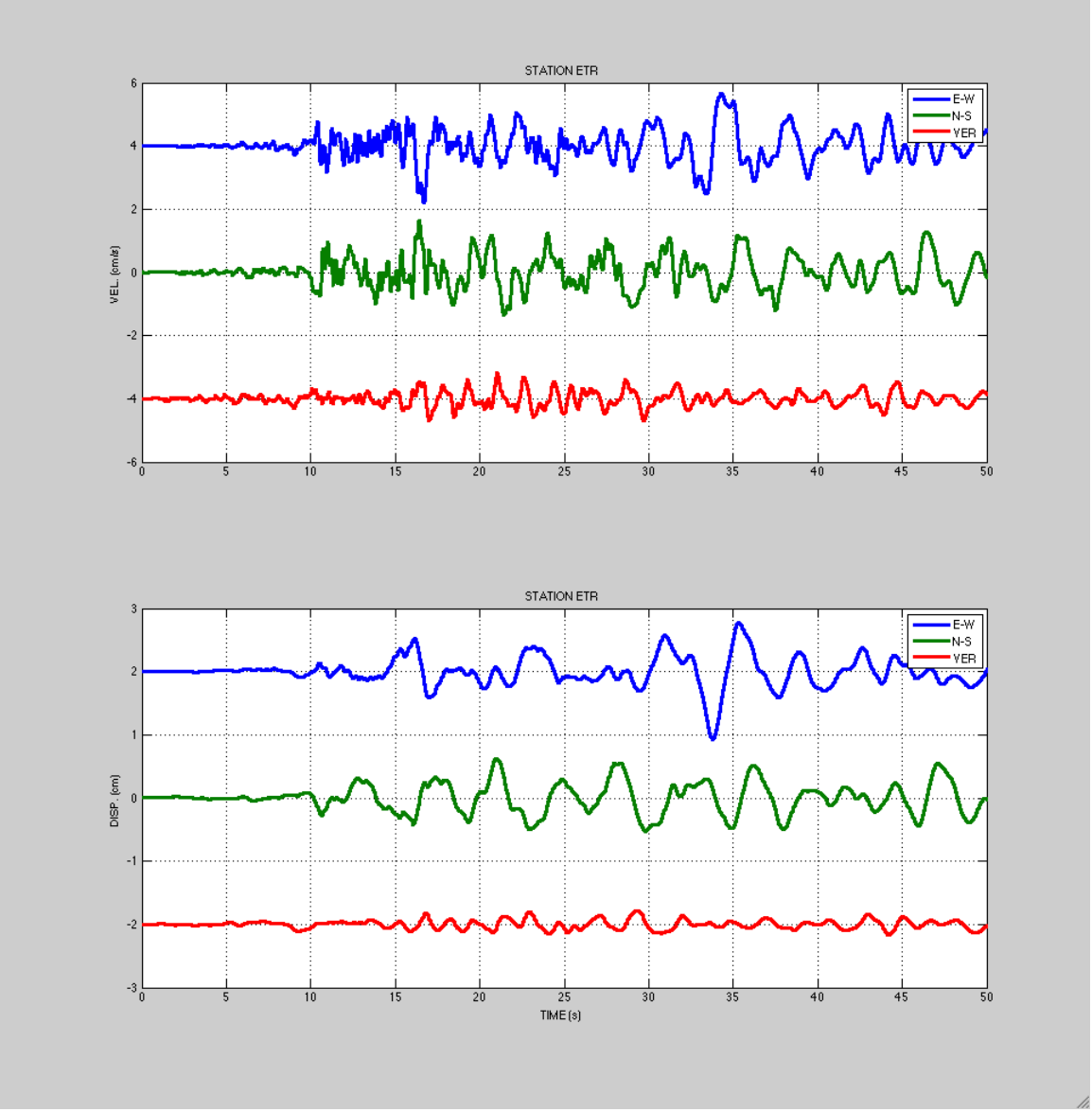


Figure 14. Displacements and velocities at station ETR in Erciş

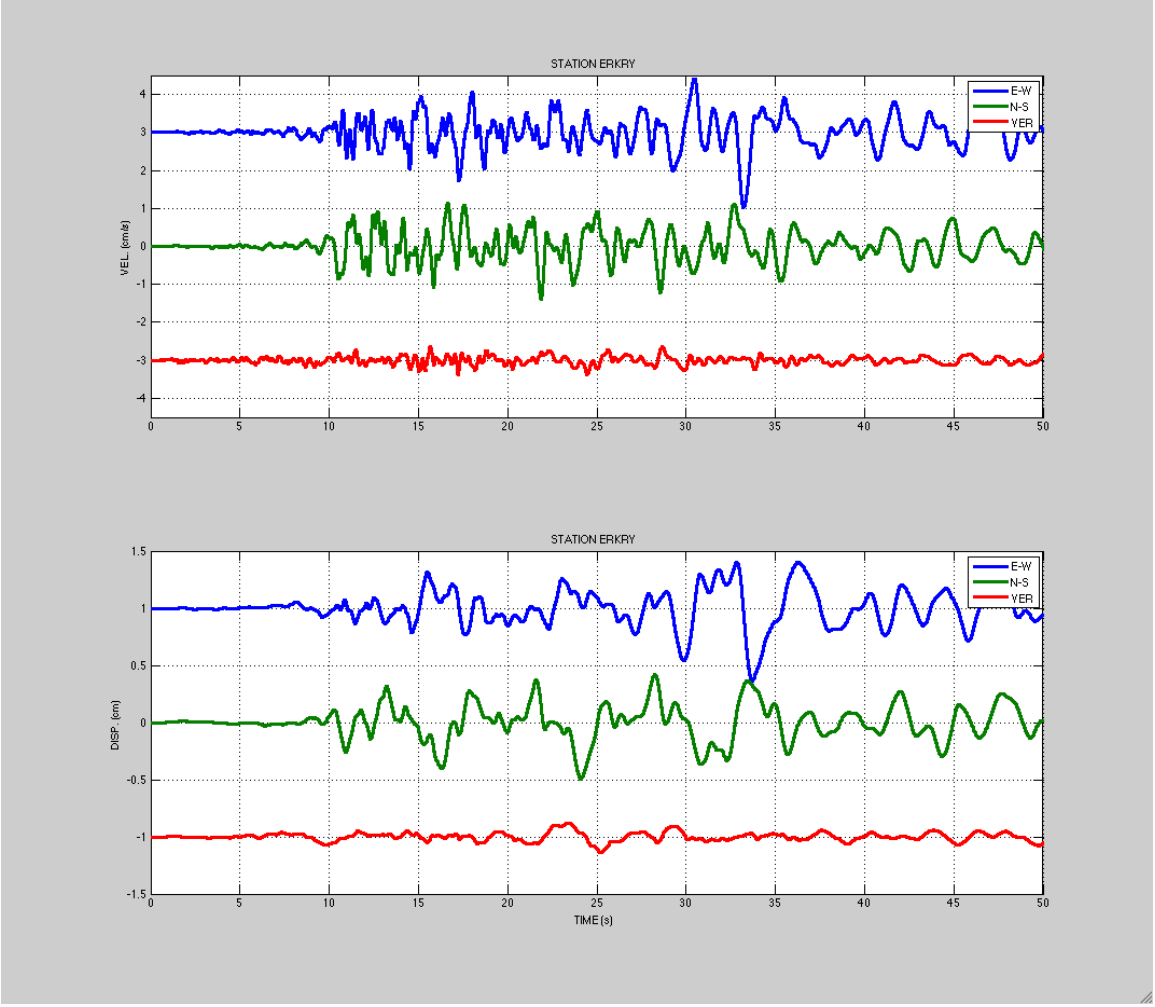


Figure 15. Displacements and velocities at station ERKRY in Erciş

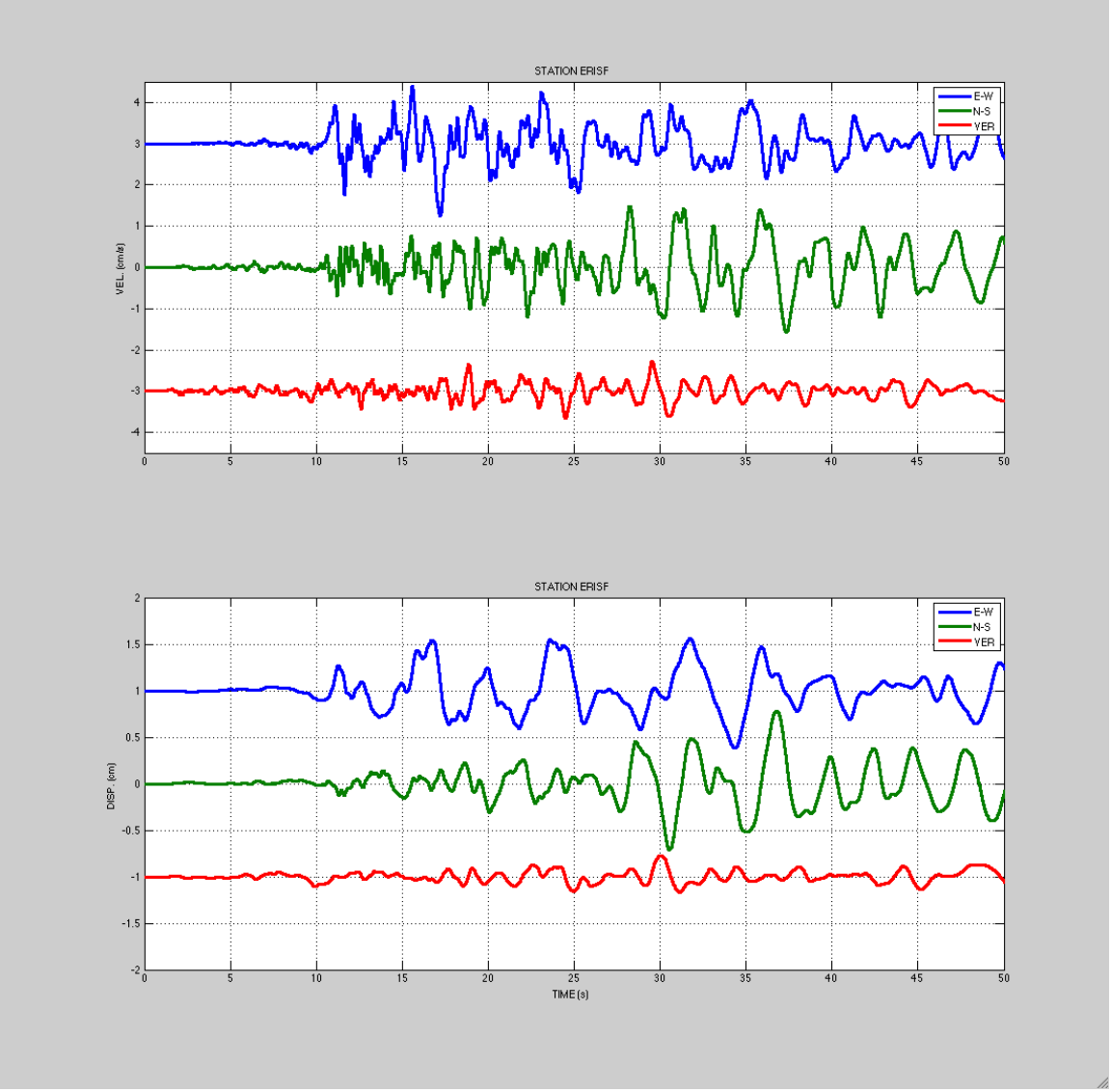


Figure 16. Displacements and velocities at station ERISF in Erciş

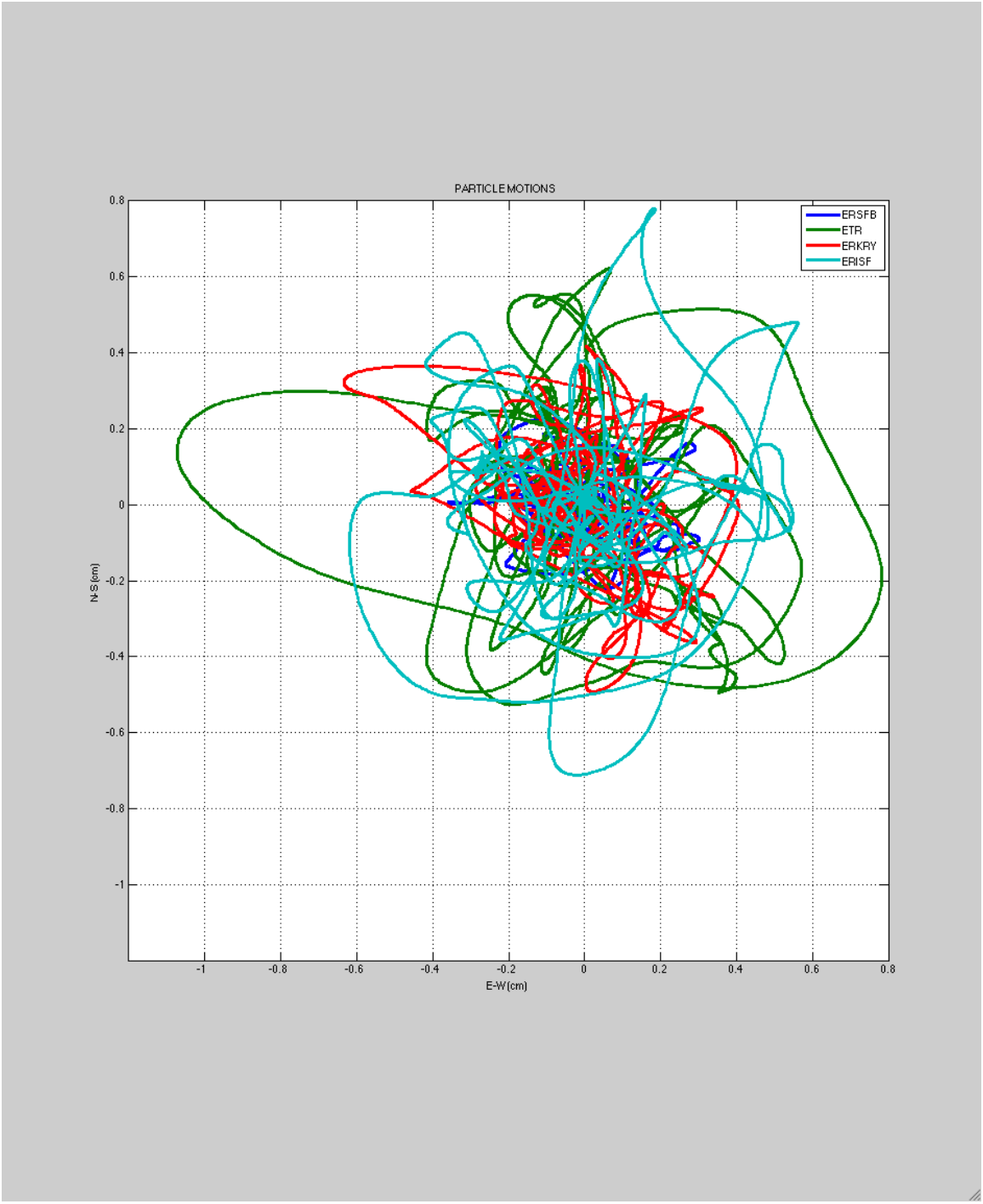


Figure 17.Particle motions at stations ERSFB, ETR, ERKRY, ERISF in Erciş

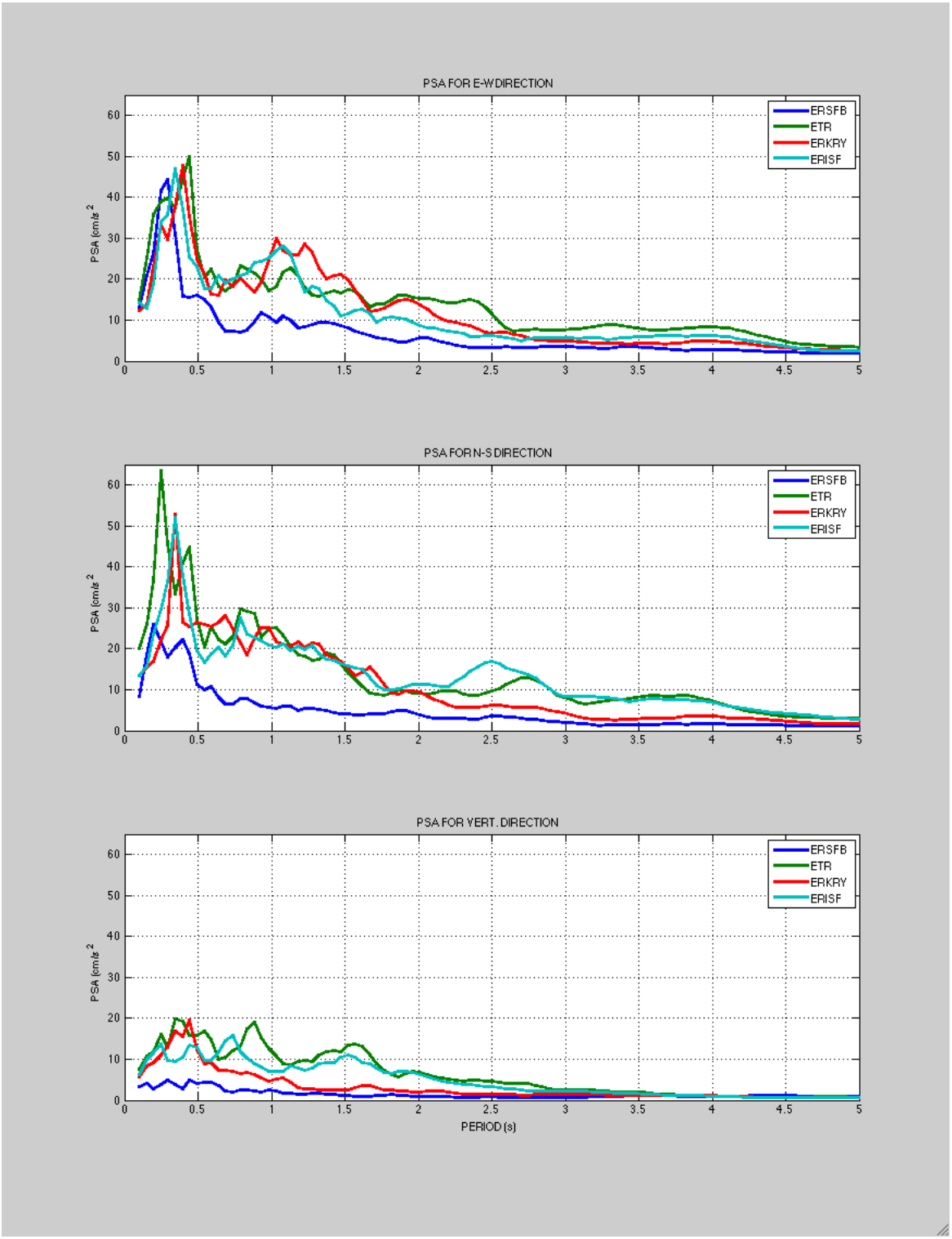


Figure 18.Response spectra (SA) at stations ERSFB, ETR, ERKRY, ERISF in Erciş

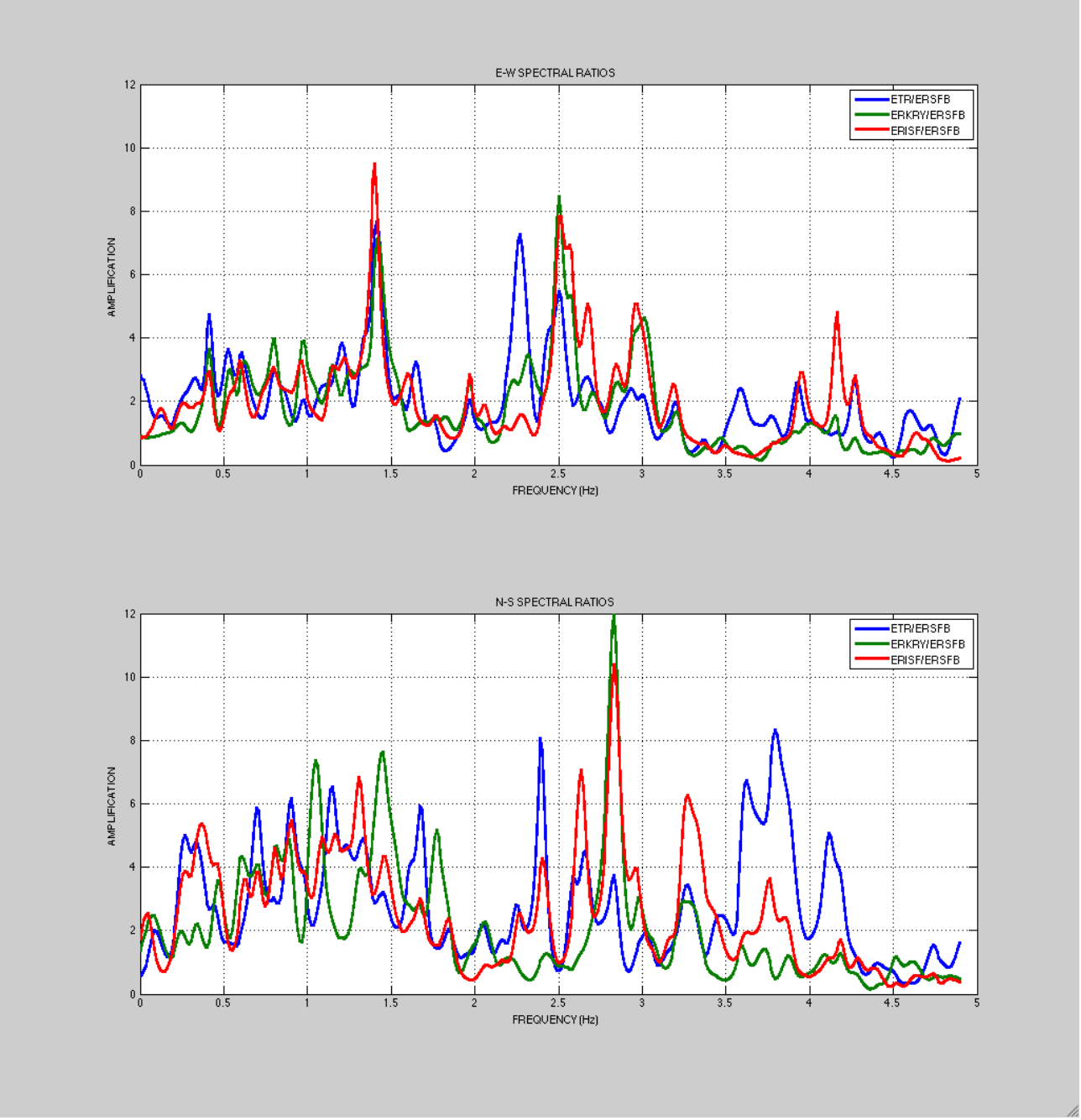


Figure 19. Spectral ratios with respect to ERSFB for stations ETR, ERKRY, ERISF in Erciş

Contributed by: E. Çaktı, O. Çırağ, M. Erdik, N. Kafadar, A. Korkmaz, E. Şafak, E. Uçkan (alphabetical)

PRELIMINARY ANALYSIS OF DATA FROM THE AFTERSHOCK DEPLOYMENT IN VAN AND ERCİŞ , TURKEY

AFTERSHOCKS WITH M≥4.0

Department of Earthquake Engineering
Kandilli Observatory and Earthquake Research Institute
Bogazici University
Istanbul, Turkey

December 2011

SUMMARY

Following the destructive M=7.2 Van Earthquake of 23 October 2011 in Eastern Turkey, we have deployed eight strong motion monitoring equipment to the region to record aftershocks.

Four of the stations were installed in the city of Van, and the remaining four in the city of Erciş, which suffered the most damage and loss of life. The stations in each city are arranged such that one of the stations is located on a stiff soil or a rock site to be used as the reference station, and the remaining three in the flat urban area forming a triangle.

The eight-station network has recorded a large number of aftershocks, including the destructive one with M=5.6 on 9 November 2011 epicentered near the town of Edremit south of Van. Figure 1 shows the deployment regions. The locations of the eight stations in Van and Erciş can be seen Figures 2 and 3 respectively. Descriptive information on the stations is summarized in Table 1.

This document reports on the records from earthquakes with M≥4.0 that were obtained until 3 November 2011 and on the events with M≥4.9 in the period of 03-21 November 2011. All together ten events are considered in this report. The events before 9 November are essentially the aftershocks of the 23 October 2011, Mw7.2 earthquake. All of the reported earthquakes were recorded by the stations in Erciş, whereas in Van only three earthquakes were recorded by two of the four stations. The records can be downloaded through links in Table 2 and Table 3. Table 2 covers events with M≥4.0 in the period of 1-3 November 2011. Table 3 are for the M≥4.9 events between 3 and 21 November 2011. The epicentral properties of all events can be found in Table 4.

Six earthquakes are selected for analysis among the presented ten. The first one is the M4.7 earthquake of 02.11.2011. The second earthquake is the Şahgeldi event, which took place on the same date with the first one, was however recorded by five stations. Processed records from the Akçift event (M4.7) can be seen in pages 11-20. The records of the Şahgeldi event (M4.4) are presented in pages 21-34. The records from the M4.9 Çolpan event are given in pages 35-44, M5.5 Vangölü in pages 45-62, Mollakasım in 63-80 and finally Bodurağaç records are given in pages 81-90.

At link
http://www.koeri.boun.edu.tr/Haberler/23%20October%202011,%20Mw=7.2%20Van,%20Turkey%20Eq._6_205.depmuh, information on the 23 October 2011 earthquake can be found.

For the background information on the 9 November 2011, M5.6 earthquake please see the link http://www.koeri.boun.edu.tr/Haberler/THE%20NOVEMBER%2009,%202011%20EDREMIT-VAN,%20TURKEY%20EARTHQUAKE_6_207.depmuh.

Analysis of records from the 9 November 2011, M5.6 earthquake is covered in a seperate report at link http://www.koeri.boun.edu.tr/depremmuh/deprem-raporlari/Van_Eq_aftershocks1.pdf.

Figure 1. Locations of aftershock monitoring cities, Van and Erciş

Figure 2. Locations of aftershock monitoring stations in Van

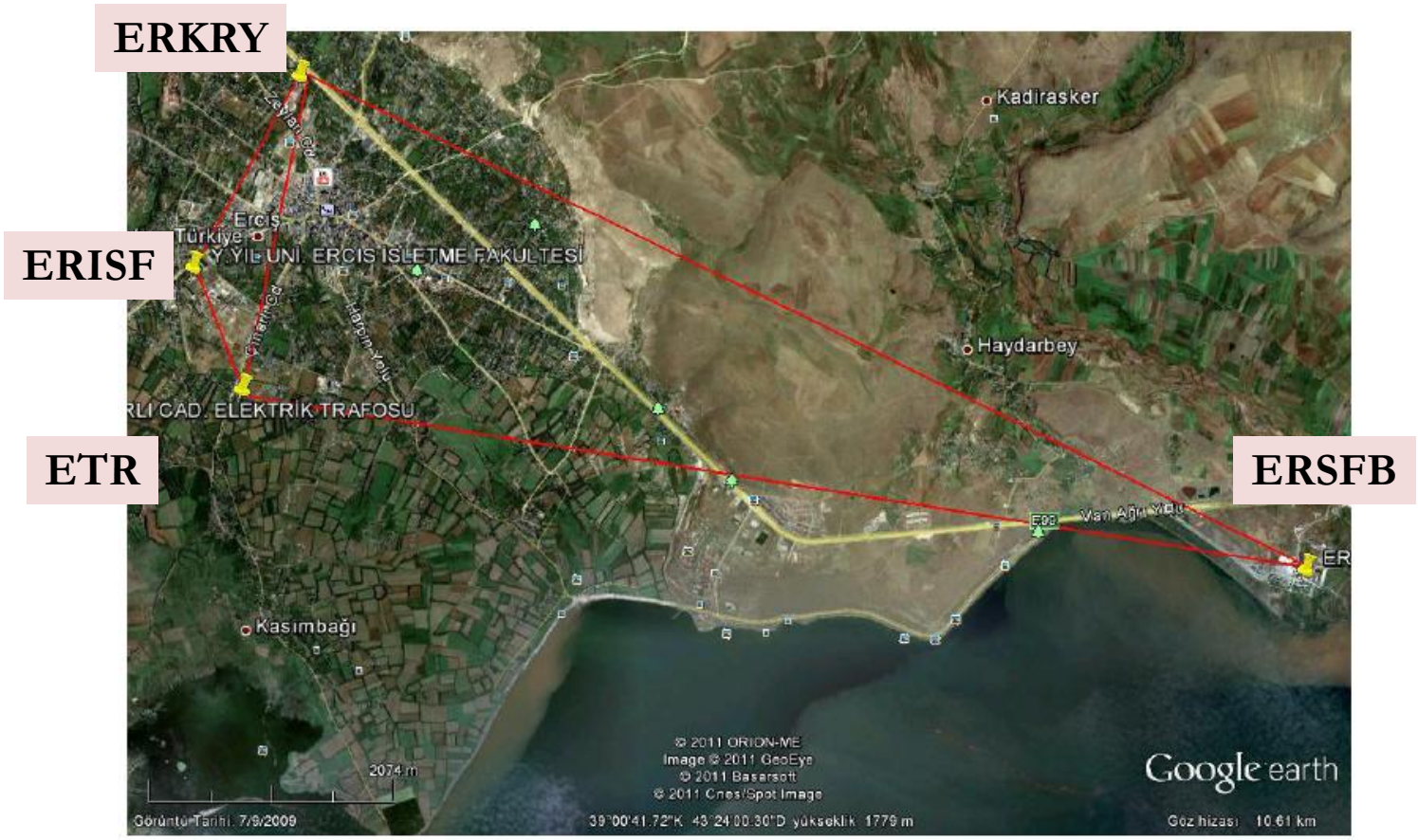


Figure 3. Locations of aftershock moniioring stations in Erciş

Table 1. Station information for the Van and Erciş deployments.

VAN

STATION CODE	STATION COORDINATES	STATION LOCATION
VNS (rock site)	38.33455N 43.19533E	Şemsibey İlkokulu
VNKIO (soil site)	38.33455N 43.19533E	Koç İlköğretim Okulu
VNTGM (soil site)	38.33455N 43.19533E	TEDAŞ Genel Müdürlüğü (Havaalanı kavsağı)
VNKEA (soil site)	38.33455N 43.19533E	TEDAŞ Köy Elektrik Arıza (Valilik yanı, Santral Sok.)

ERCİŞ

STATION CODE	STATION COORDINATES	STATION LOCATION
ERSFB (stiff soil site)	38.59996N 43.27304E	Erciş Şeker Fabrikası
ETR (soil site)	39.00880N 43.21097E	TEDAŞ Trafo Binası (Çınarlı Caddesi sonu)
ERKRY(soil site)	39.02264N 43.21426E	Erciş Karayolları 115. Şube Müdürlüğü
ERISF(soil site)	39.01398N 43.20798E	Yüzüncü Yıl Üniversitesi Erciş İşletme Fakültesi

Table 2. Aftershock records (01.11.2011-03.11.2011, M≥4.0)

STATIONS AND AFTERSHOCKS		Sağlamtaş M=4.3 01/11/2011 23:10:44	Çakırbey M=4.8, 02/11/2011 06:34:20	Akçift M=4.7 02/11/2011 15:24:02	Şahgeldi M=4.4 02/11/2011 22:48:21	Çolpan M=4.1 02/11/2011 23:44:15	Unseli-Muradiye M=4.0 03/11/2011 03:05:46
VAN	VNS 38.33445N – 43.19533E Şemsibey İlkokulu						
	VNKIO 38.30957N – 43.20473E Koç İlköğretimokulu				X		
	VNTGM 38.28571N – 43.21571E TEDAŞ Genel Müdürlüğü				X		
	VNKEA 38.30070N – 43.23898E TEDAŞ Köy Elektrik Arıza						
ERCİŞ	ERSFB 38.59996N – 43.27304E Erciş Şeker Fabrikası	X	X	X		X	X
	ETR 39.00880N – 43.21097E TEDAŞ Trafo			X	X	X	X
	ERKRY 39.02264N – 43.21426E Karayolları 115. Şube Müd.	X	X	X	X	X	X
	ERISF 39.01398N – 43.20798E 100. Yıl Üni. İşletme Fak.	X	X	X	X	X	X

Table 3. Aftershock records (03.11.2011-21.11.2011, M≥4.9)

STATIONS AND AFTERSHOCKS		Çolpan M=4.9 06/11/2011 02:43:12	Van Gölü M=5.5 08/11/2011 22:05:15	Mollakasım M=5.2 14/11/2011 22:08:15	Bodurağaç M=4.9 18/11/2011 17:39:40
VAN	VNS 38.33445N – 43.19533E Şemsibey İlkokulu		X	X	
	VNKIO 38.30957N – 43.20473E Koç İlköğretimokulu	X			
	VNTGM 38.28571N – 43.21571E TEDAŞ Genel Müdürlüğü				
	VNKEA 38.30070N – 43.23898E TEDAŞ Köy Elektrik Arıza		X	X	X
ERCİŞ	ERSFB 38.59996N – 43.27304E Erciş Şeker Fabrikası	X	X	X	X
	ETR 39.00880N – 43.21097E TEDAŞ Trafo	X	X	X	X
	ERKRY 39.02264N – 43.21426E Karayolları 115. Şube Müd.	X	X	X	X
	ERISF 39.01398N – 43.20798E 100. Yıl Üni. İşletme Fak.	X	X	X	X

Table 4. Epicentral properties (Source: UDIM-KOERI)

Date	Latitude	Longitude	Depth	Magnitude	
01.11.2011 23:10:44	38.881N	43.581E	5.0	4.3	Sağlamtaş (Van)
02.11.2011 06:34:20	38.873N	43.569E	5.0	4.8	Çakırbey (Van)
02.11.2011 15:24:02	38.856N	43.578E	5.0	4.7	Akçift (Van)
02.11.2011 22:48:21	38.761N	43.321E	5.0	4.4	Şahgeldi (Van)
02.11.2011 23:44:15	38.939N	43.553E	5.0	4.1	Çolpan (Van)
03.11.2011 03:05:46	38.958N	43.588E	5.0	4.0	Unseli-Muradiye (Van)
06.11.2011 02:43:12	38.924N	43.565E	5.0	4.9	Çolpan (Van)
08.11.2011 22:05:51	38.724N	43.087E	4.3	5.5	Van Gölü (Van)
14.11.2011 22:08:15	38.678N	43.182E	3.1	5.2	Mollakasım (Van)
18.11.2011 17:39:40	38.837N	43.870E	5.0	4.9	Bodurağaç (Van)

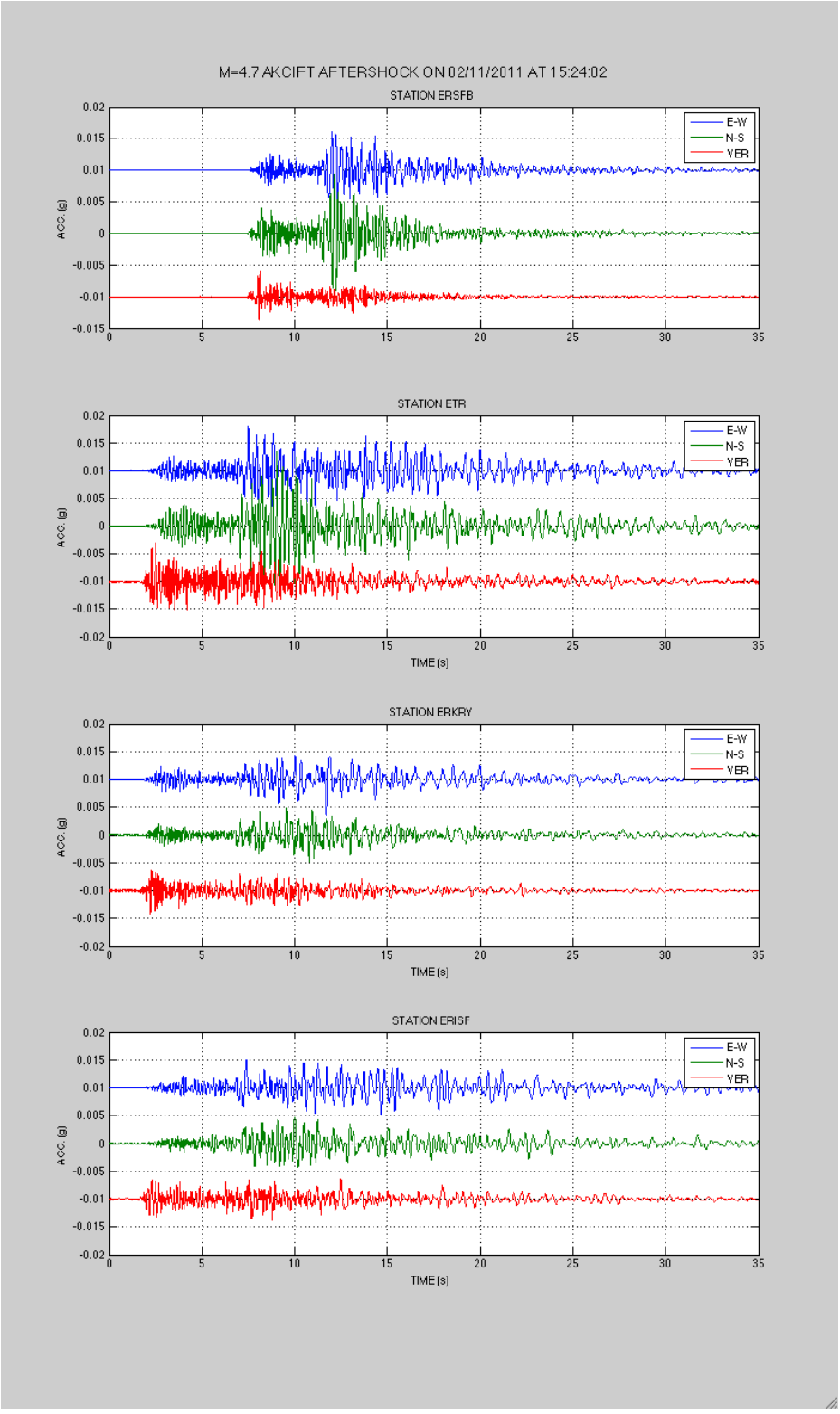
Akçift/Van Aftershock

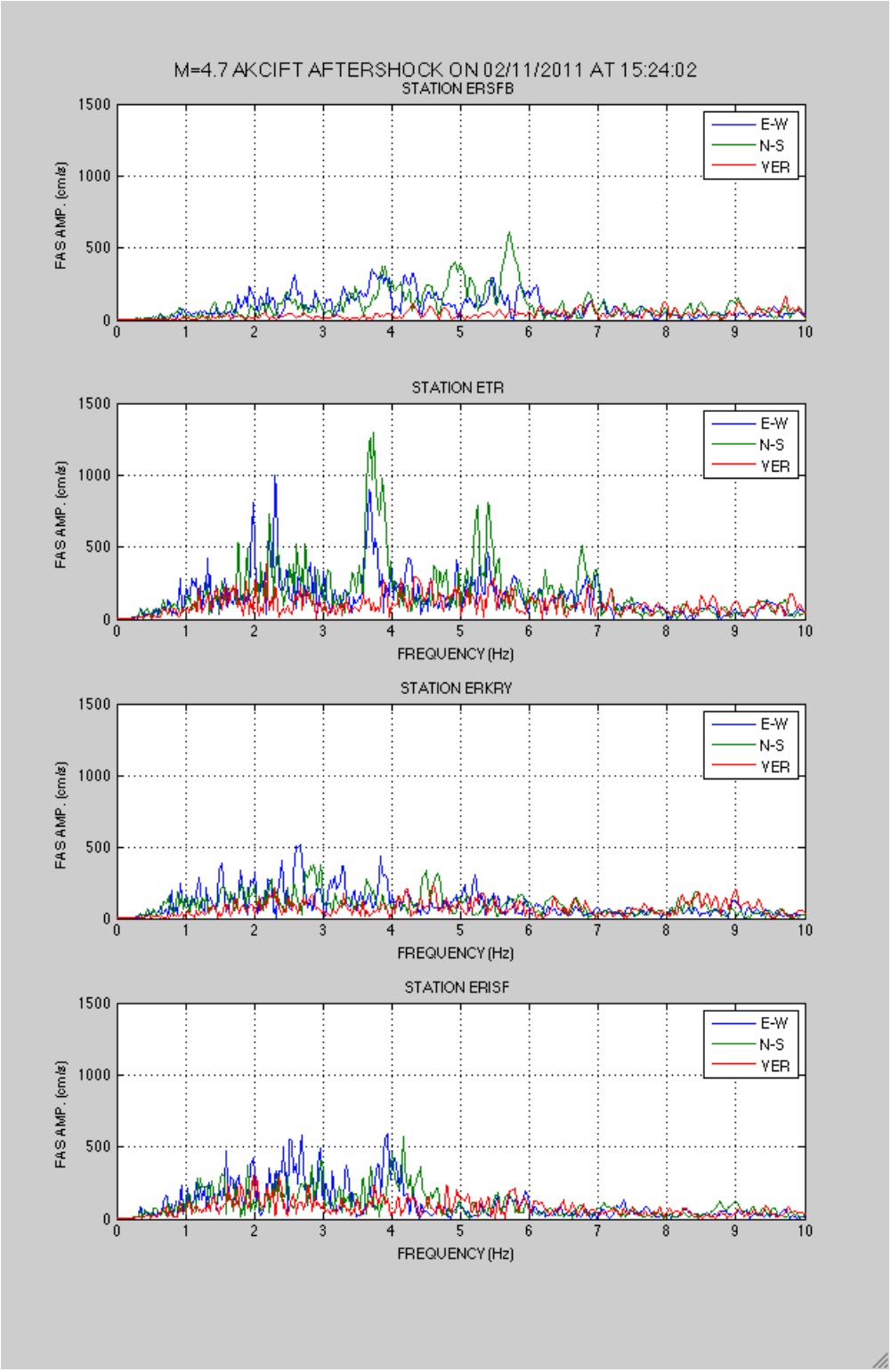
M=4.7

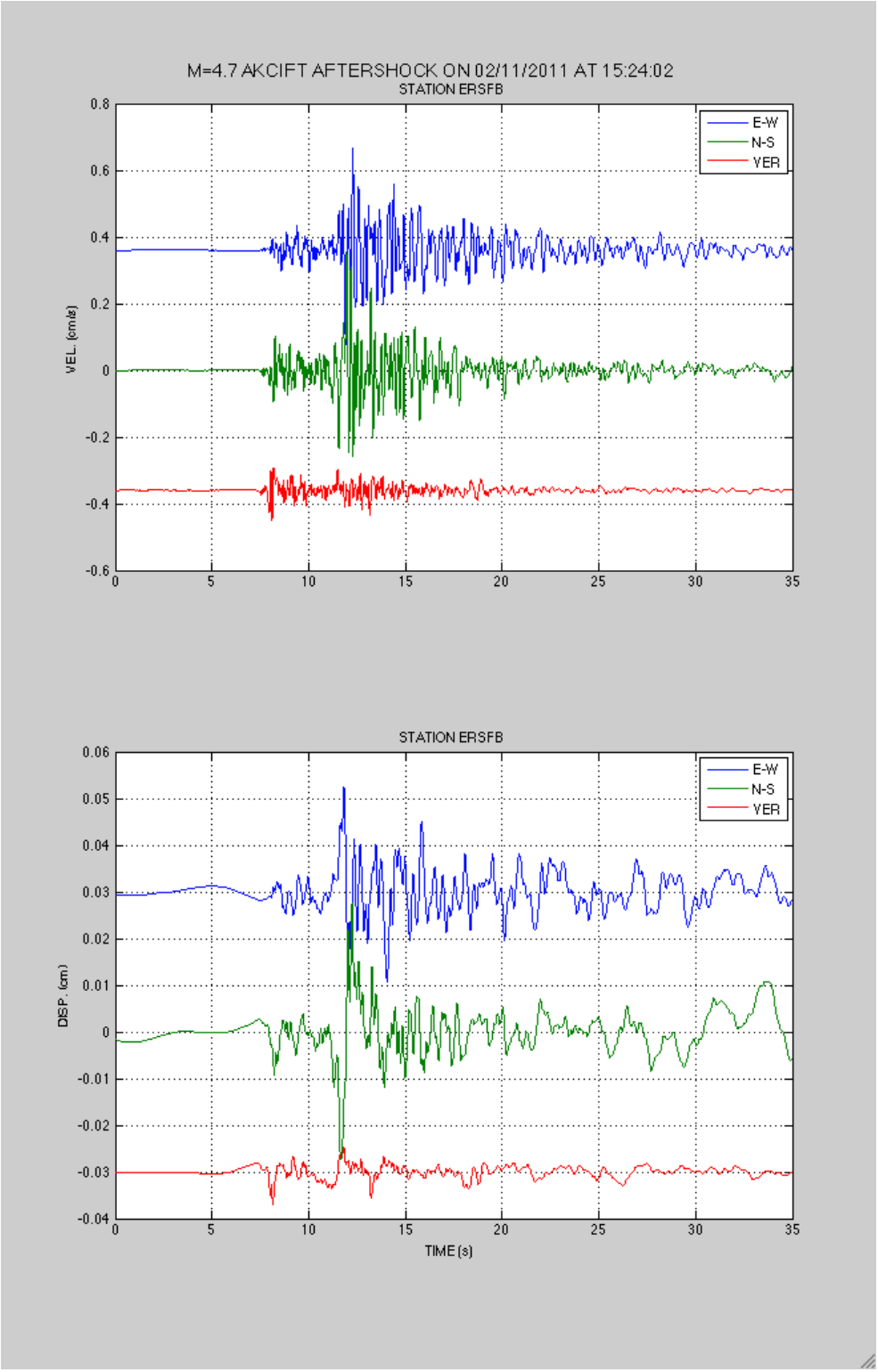
02/11/2011

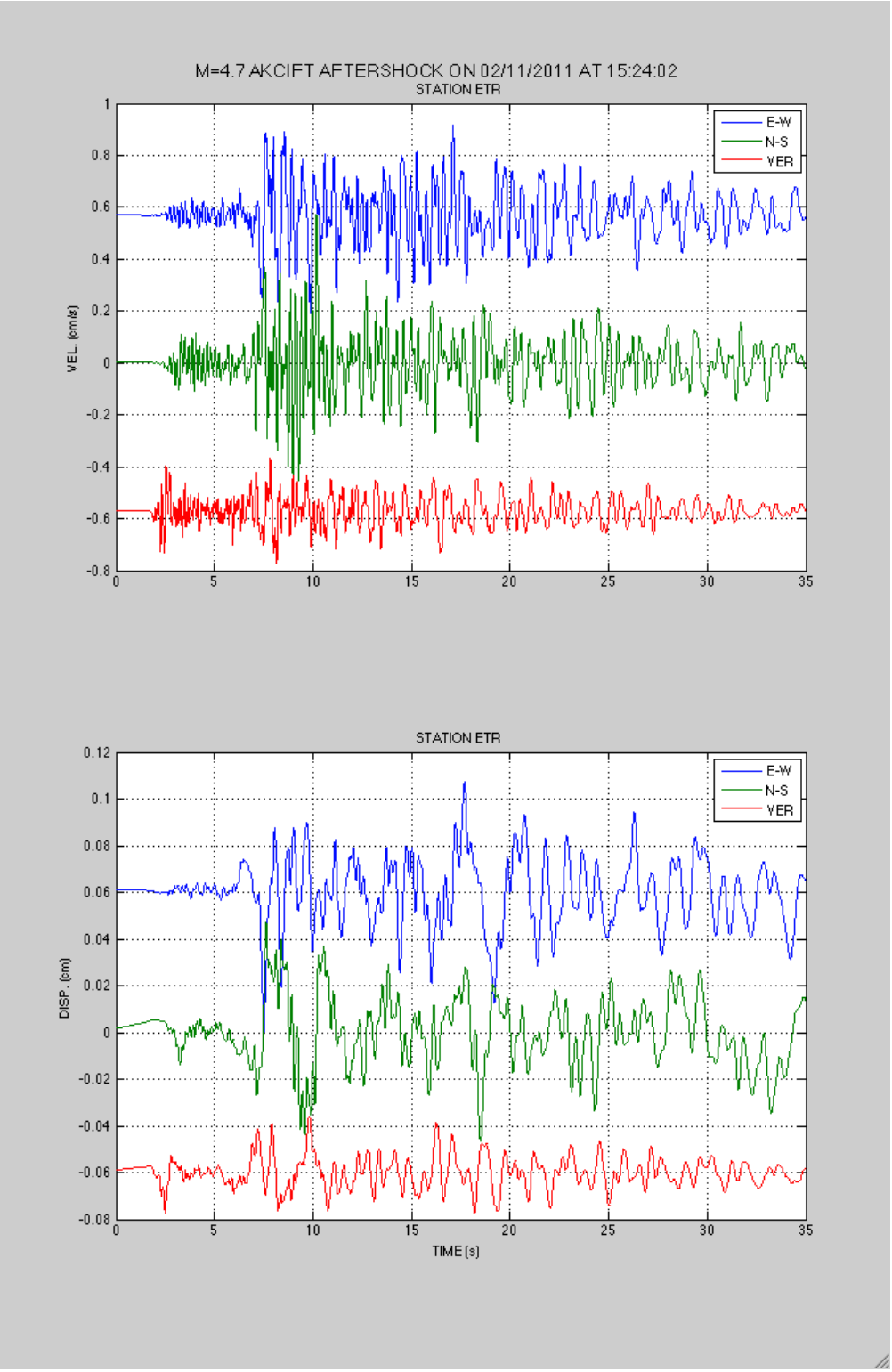
15:24:02

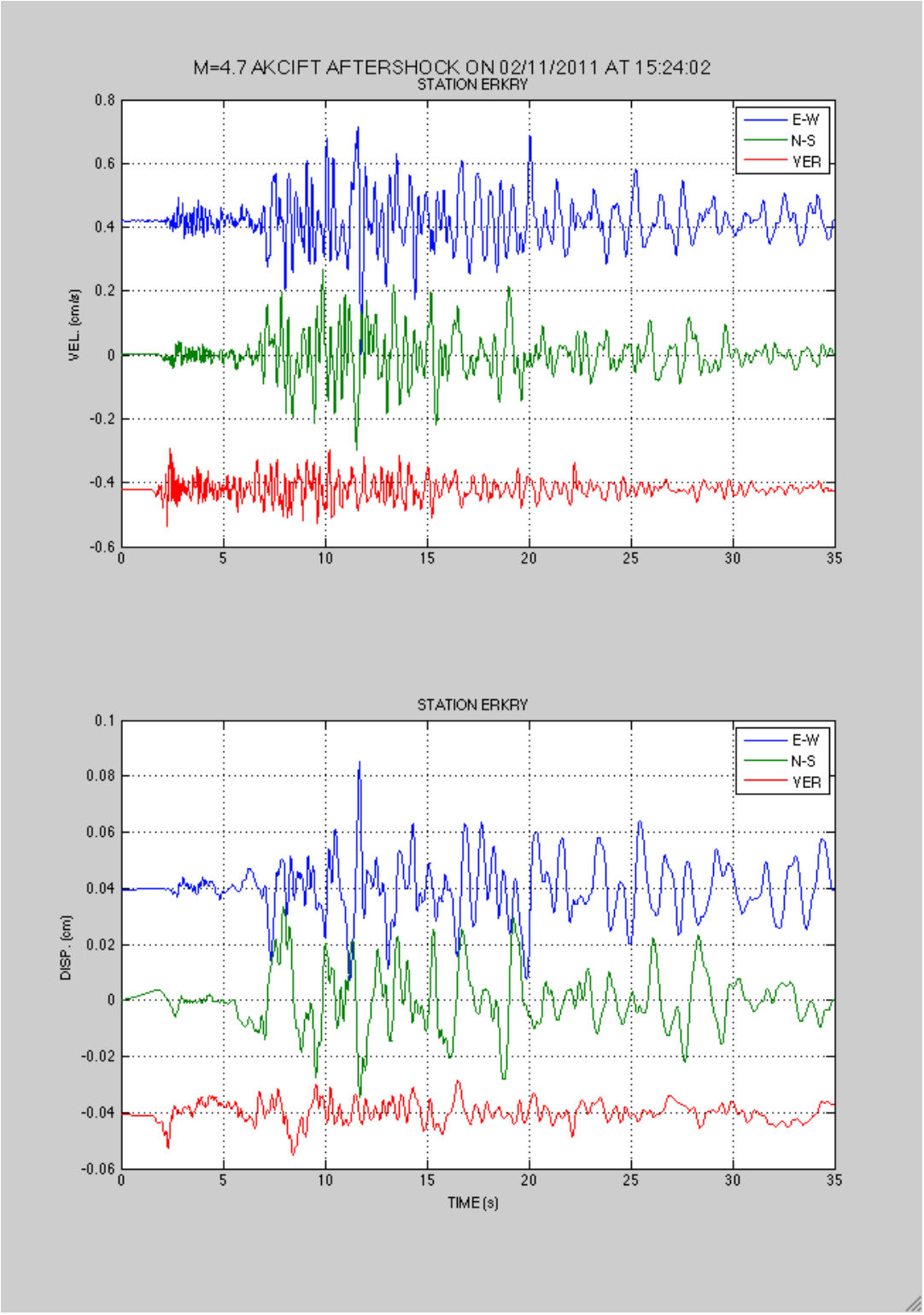
ERCİŞ RECORDS

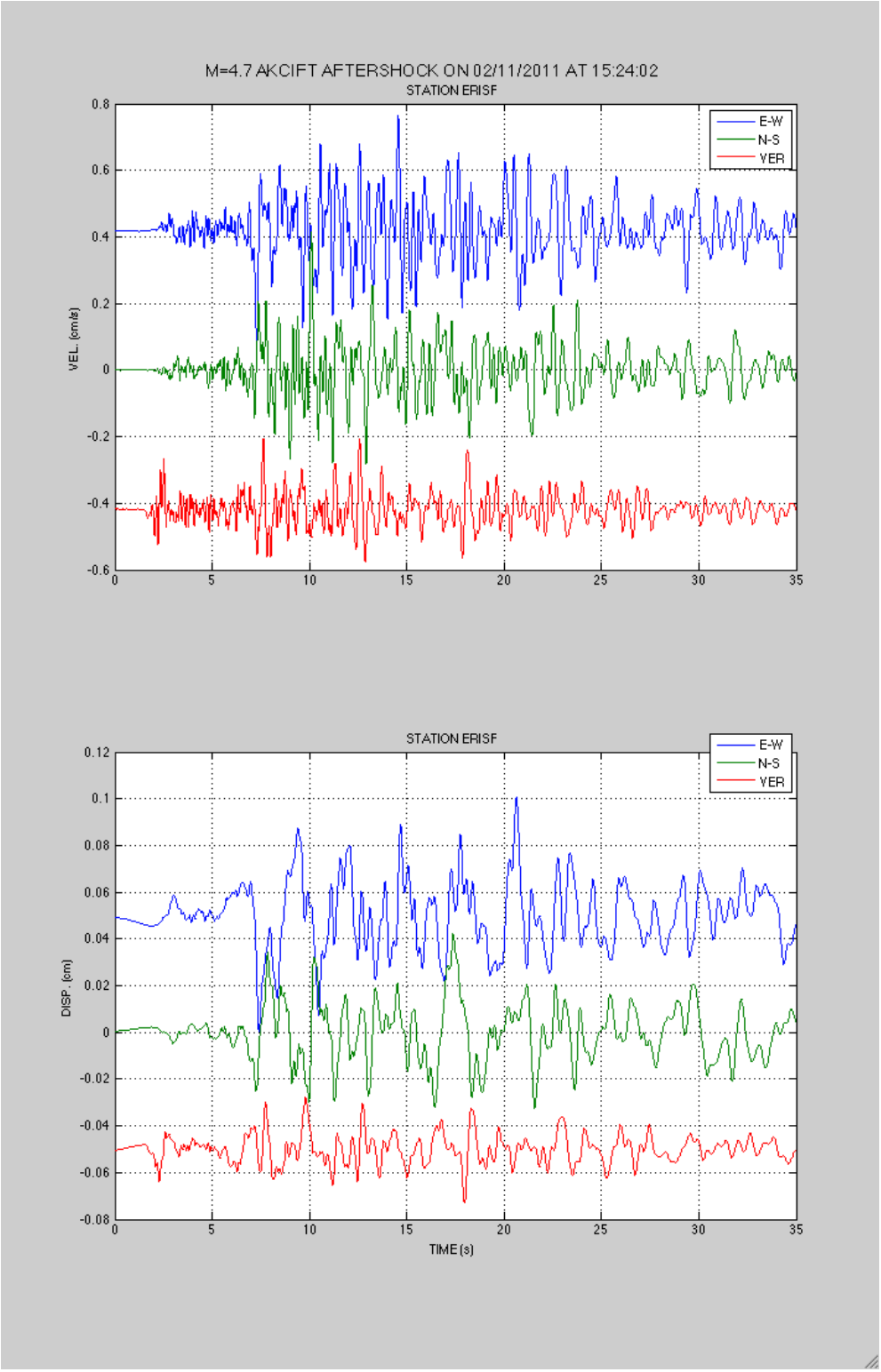

M=4.7 AKCIFT AFTERSHOCK ON 02/11/2011 AT 15:24:02
STATION ERSFB
STATION ETR
STATION ERKRY
STATION ERISF
E-W
N-S
VER
ACC. (g)
TIME (s)

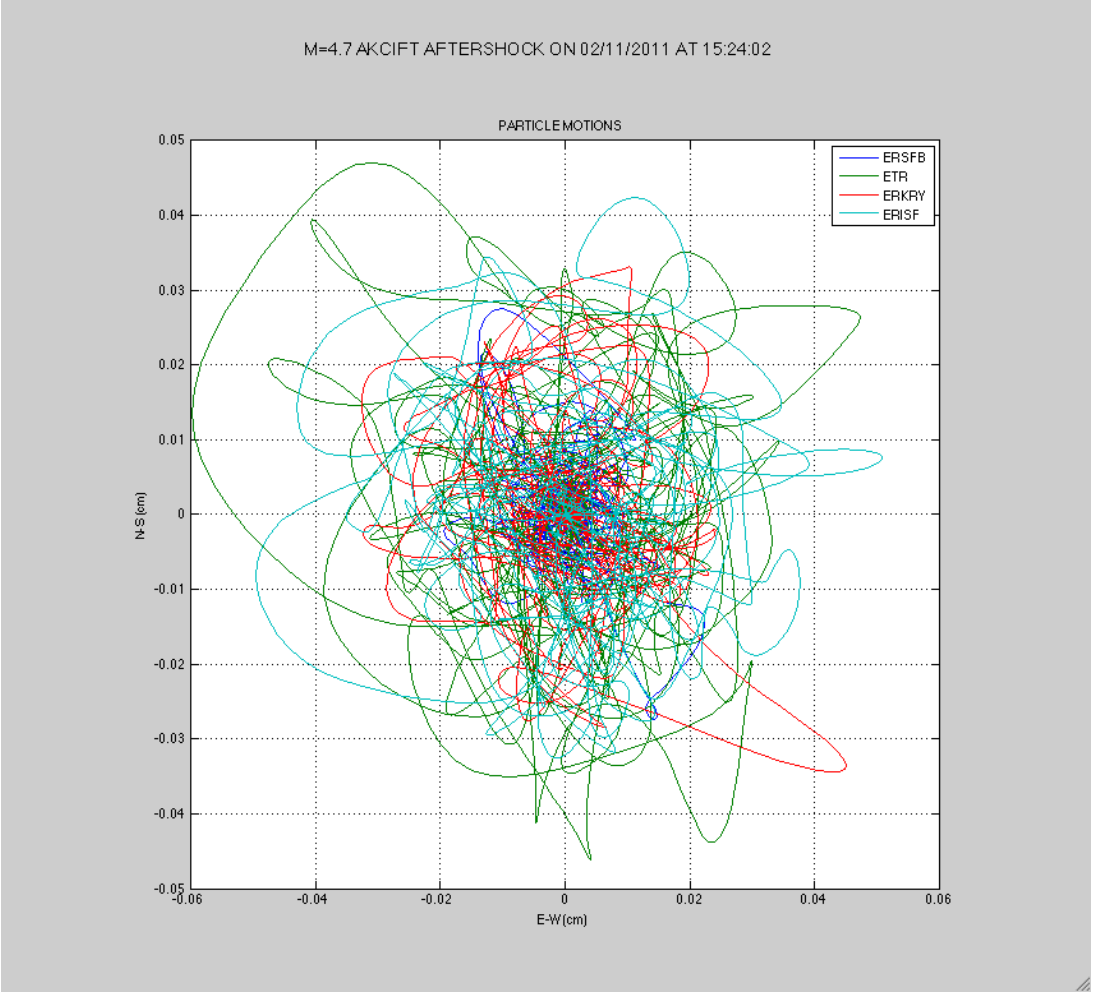

M=4.7 AKCIFT AFTERSHOCK ON 02/11/2011 AT 15:24:02
STATION ERSFB
STATION ETR
STATION ERKRY
STATION ERISF
E-W
N-S
VER
FAS AMP. (cm/s)
FREQUENCY (Hz)

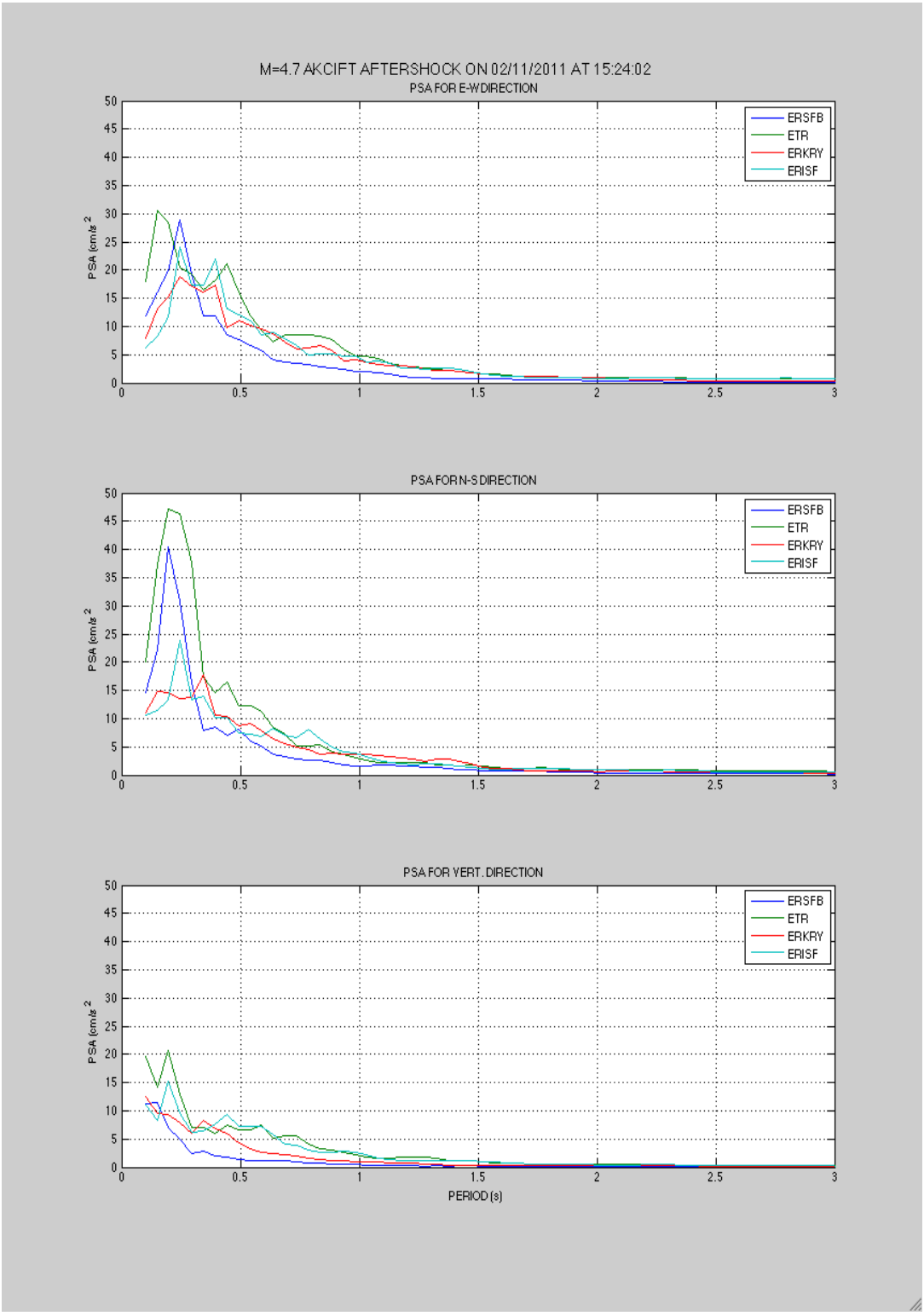

M=4.7 AKCIFT AFTERSHOCK ON 02/11/2011 AT 15:24:02
STATION ERSFB
E-W
N-S
VER
VEL. (cm/s)
STATION ERSFB
E-W
N-S
VER
DISP. (cm)
TIME (s)

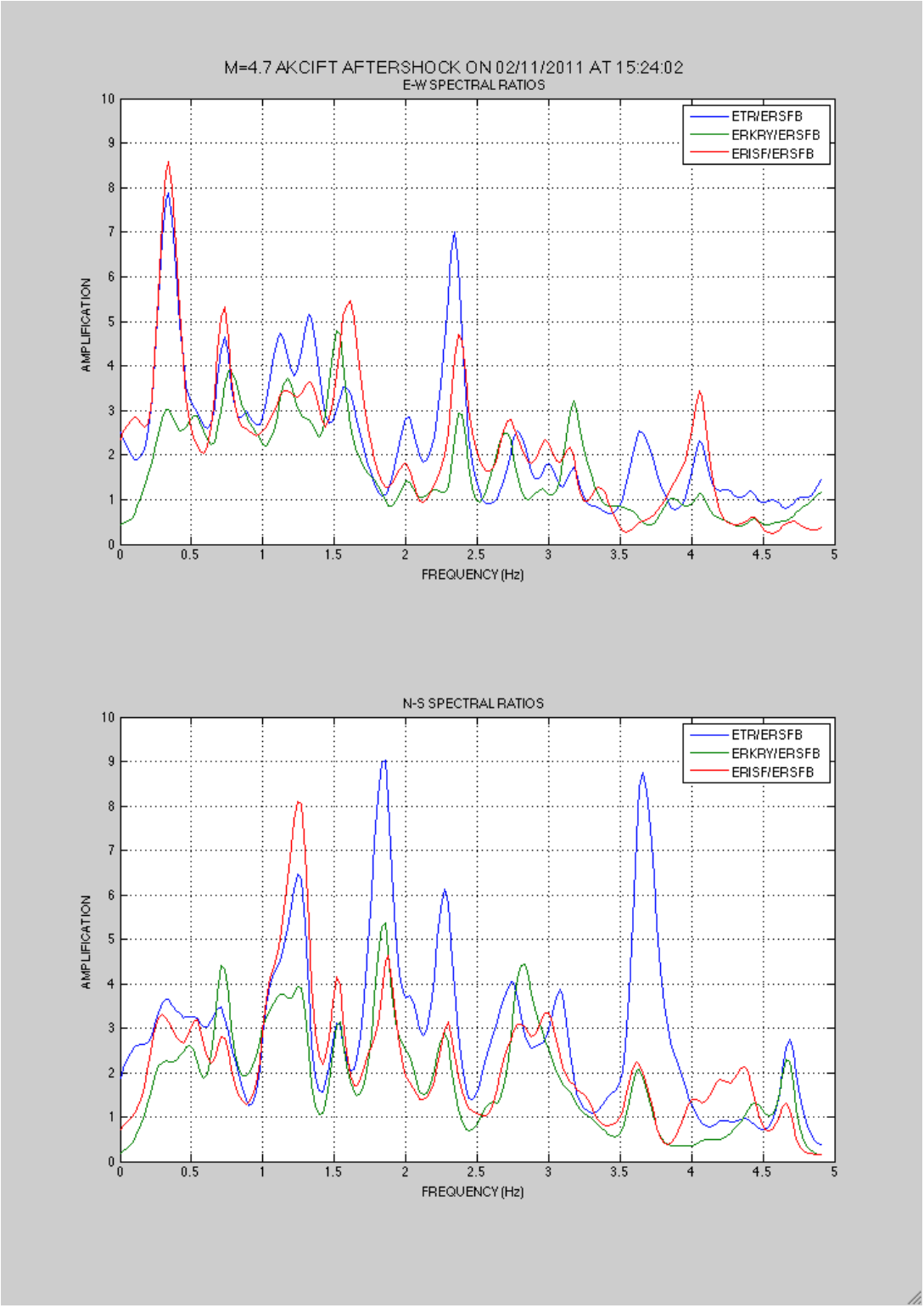

M=4.7 AKCIFT AFTERSHOCK ON 02/11/2011 AT 15:24:02
STATION ETR
E-W
N-S
VER
VEL. (cm/s)
STATION ETR
E-W
N-S
VER
DISP. (cm)
TIME (s)


M=4.7 AKCIFT AFTERSHOCK ON 02/11/2011 AT 15:24:02
STATION ERKRY
E-W
N-S
VER
VEL. (cm/s)
STATION ERKRY
E-W
N-S
VER
DISP. (cm)
TIME (s)


M=4.7 AKCIFT AFTERSHOCK ON 02/11/2011 AT 15:24:02
STATION ERISF
E-W
N-S
VER
VEL. (cm/s)
STATION ERISF
E-W
N-S
VER
DISP. (cm)
TIME (s)


M=4.7 AKCIFT AFTERSHOCK ON 02/11/2011 AT 15:24:02
PARTICLE MOTIONS
ERSFB
ETR
ERKRY
ERISF
N-S (cm)
E-W (cm)
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.04
-0.02
0
0.02
0.04
0.06


M=4.7 AKCIFT AFTERSHOCK ON 02/11/2011 AT 15:24:02
PSA FOR E-W DIRECTION
PSA FOR N-S DIRECTION
PSA FOR VERT. DIRECTION
PSA (cm/s^2)
PERIOD (s)
ERSFB
ETR
ERKRY
ERISF


M=4.7 AKCIFT AFTERSHOCK ON 02/11/2011 AT 15:24:02
E-W SPECTRAL RATIOS
ETR/ERSFB
ERKRY/ERSFB
ERISF/ERSFB
AMPLIFICATION
FREQUENCY (Hz)
N-S SPECTRAL RATIOS
ETR/ERSFB
ERKRY/ERSFB
ERISF/ERSFB
AMPLIFICATION
FREQUENCY (Hz)

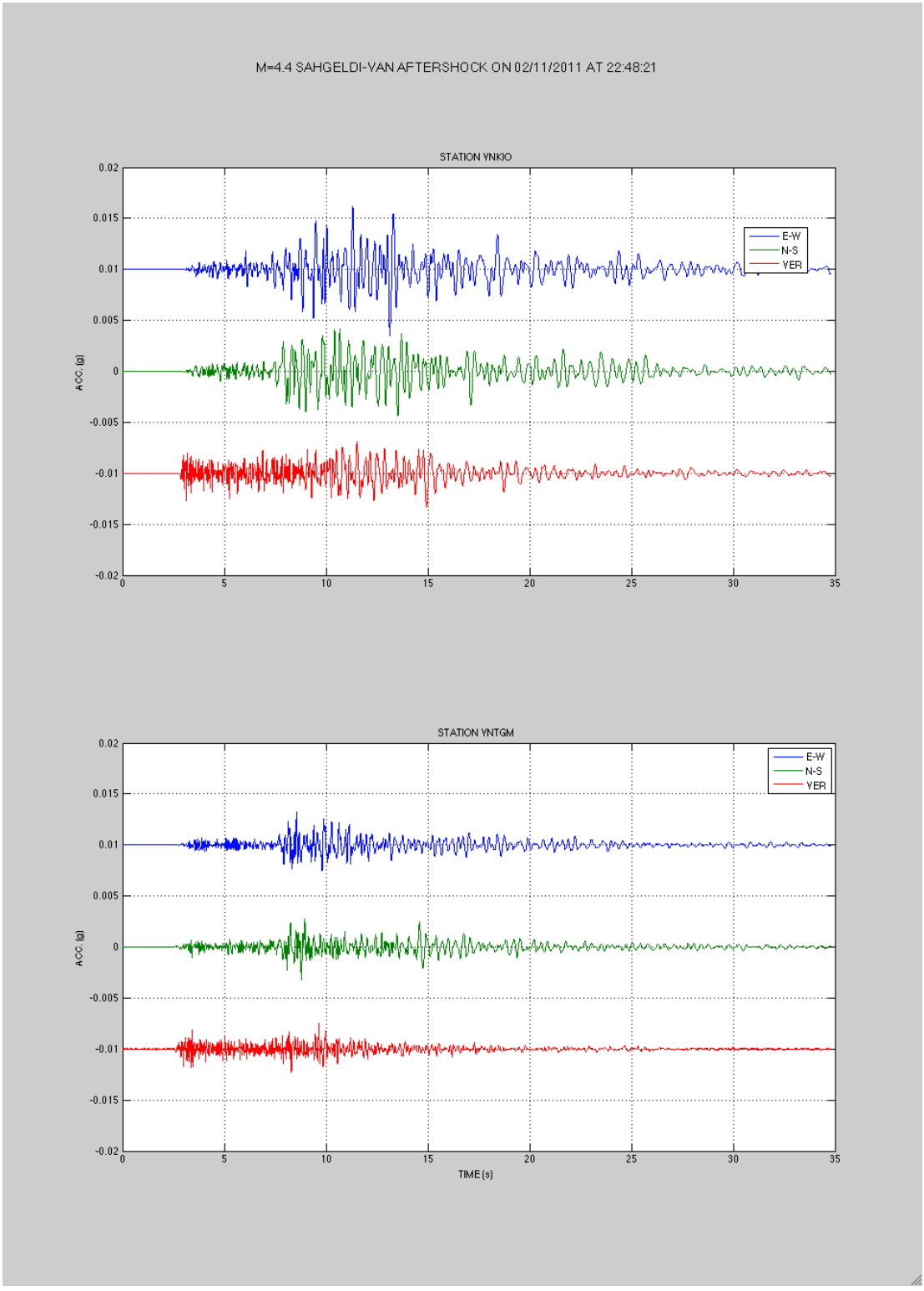
Şahgeldi/Van Aftershock

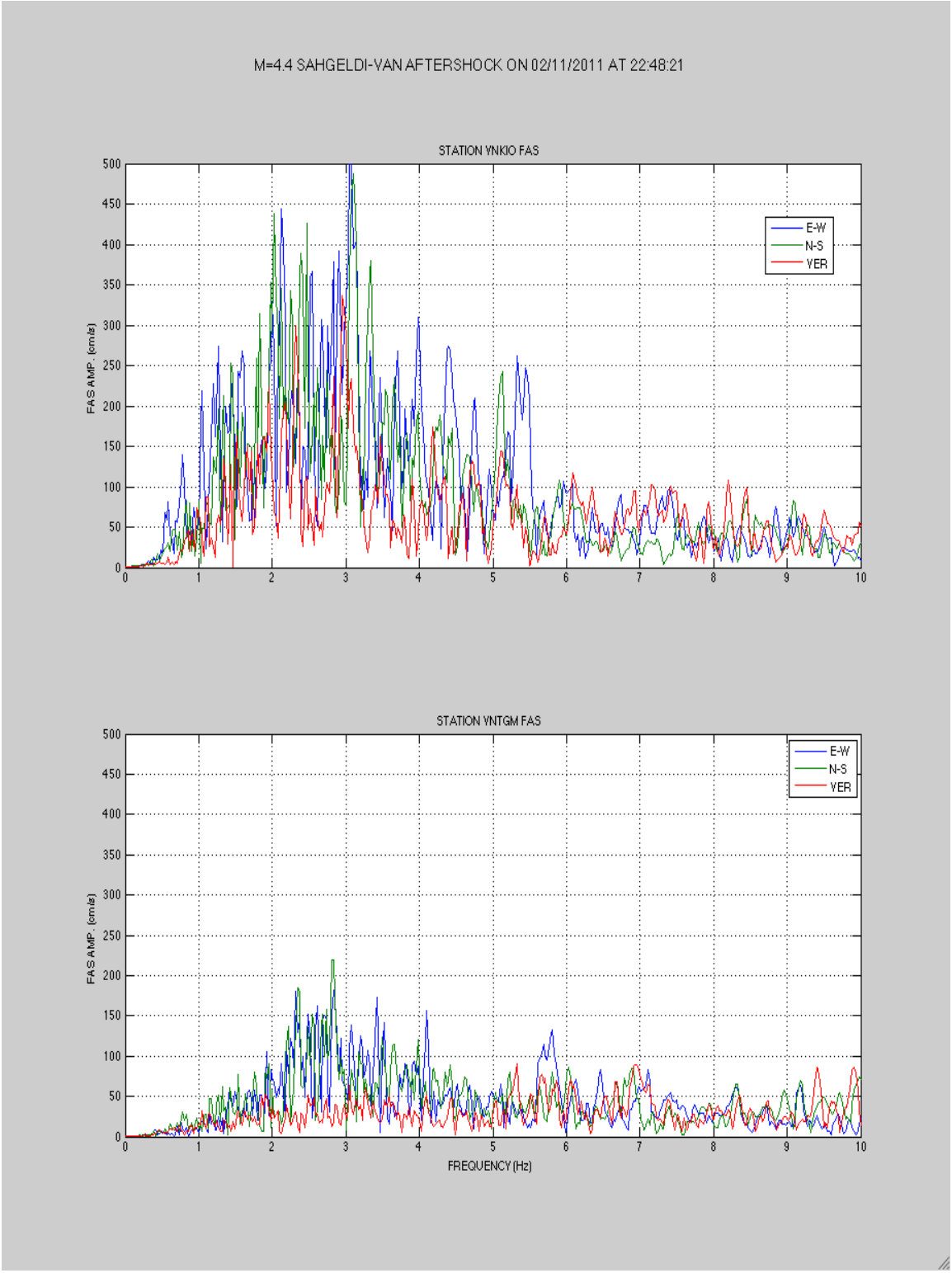
M=4.4

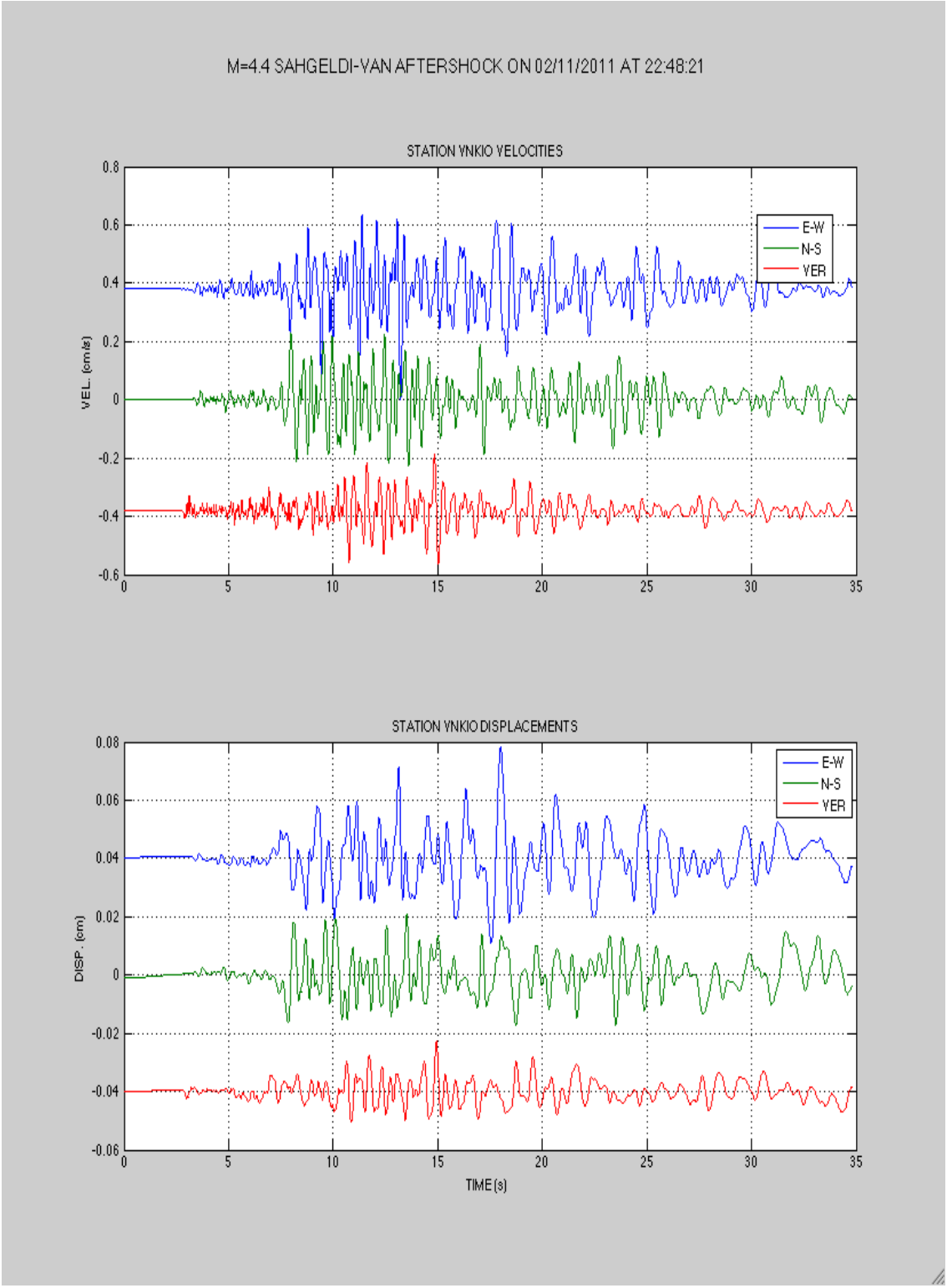
02/11/2011

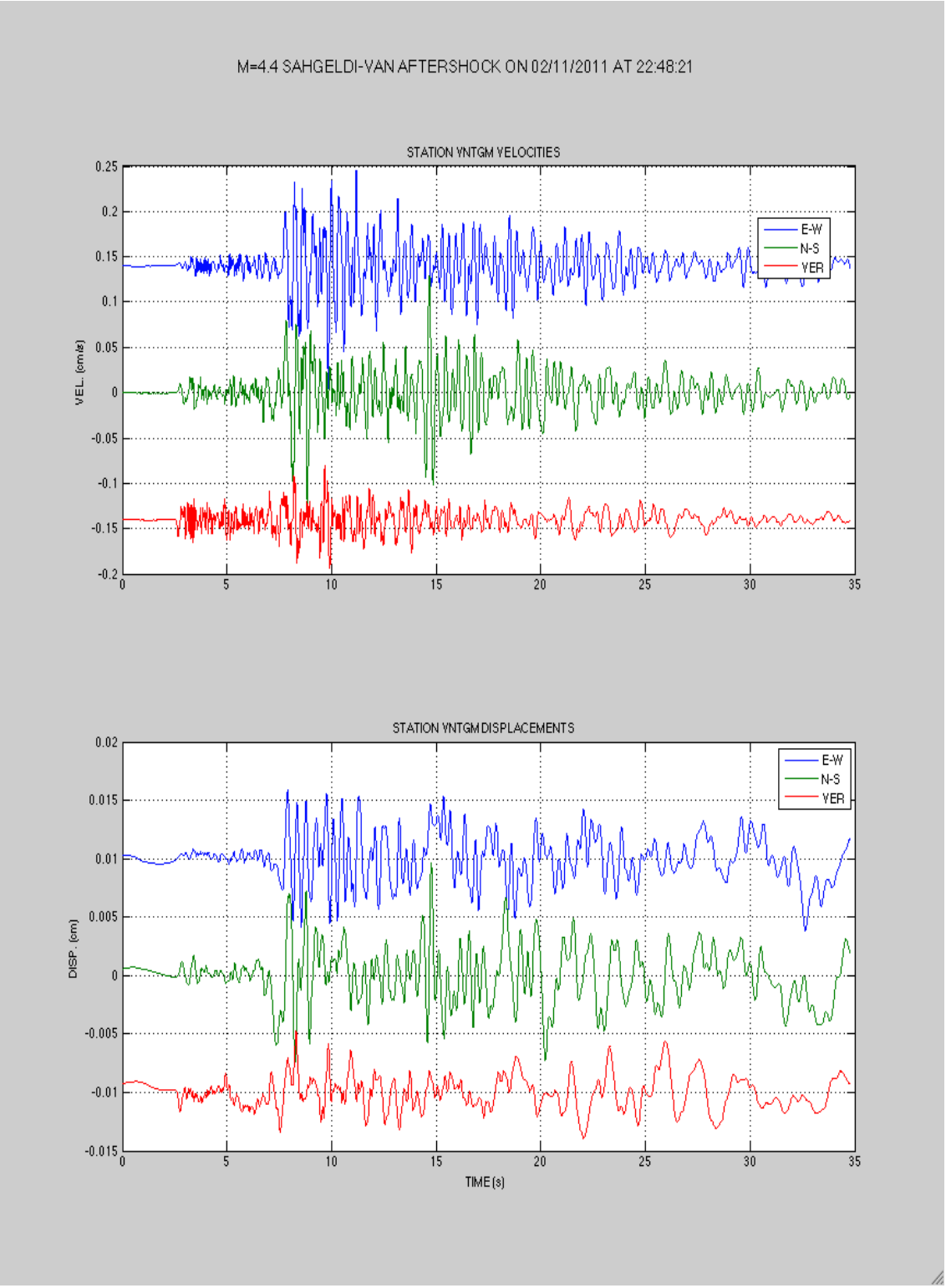
22:48:21

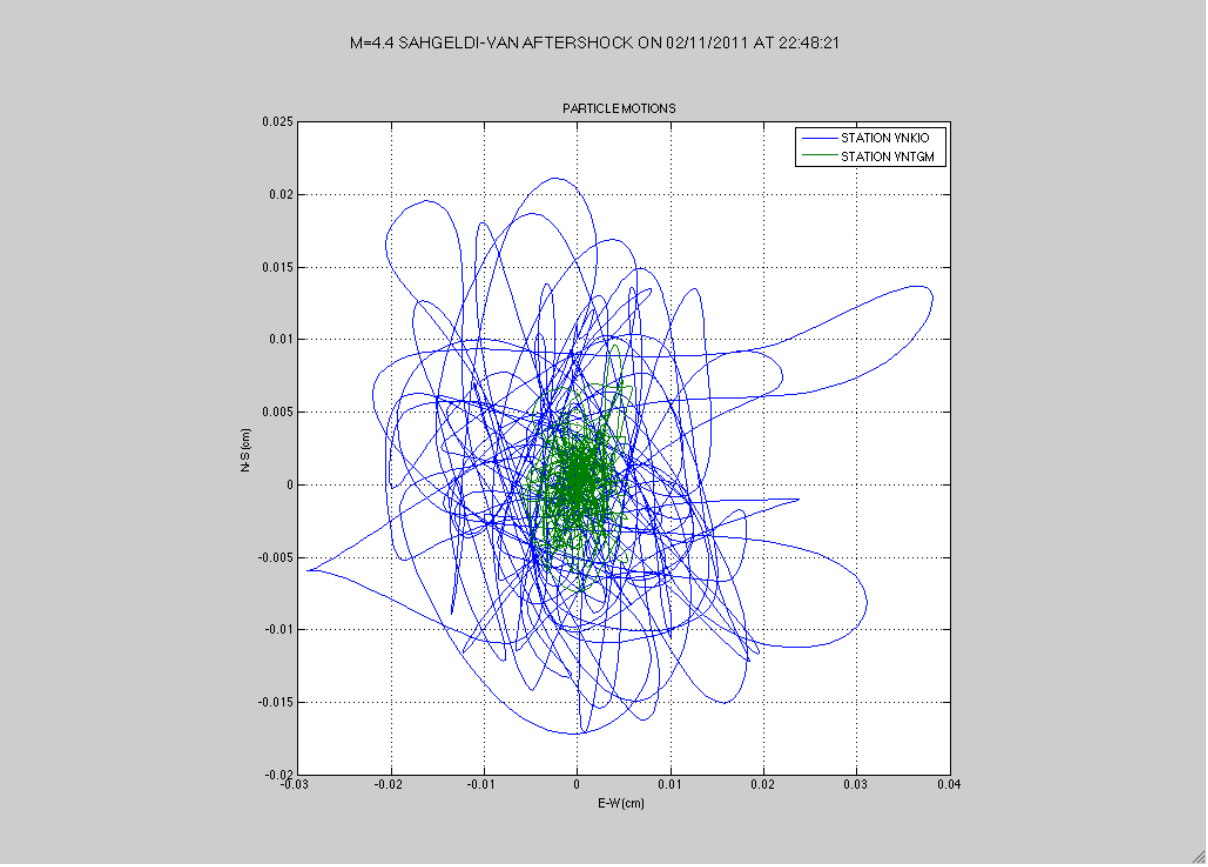
VAN RECORDS

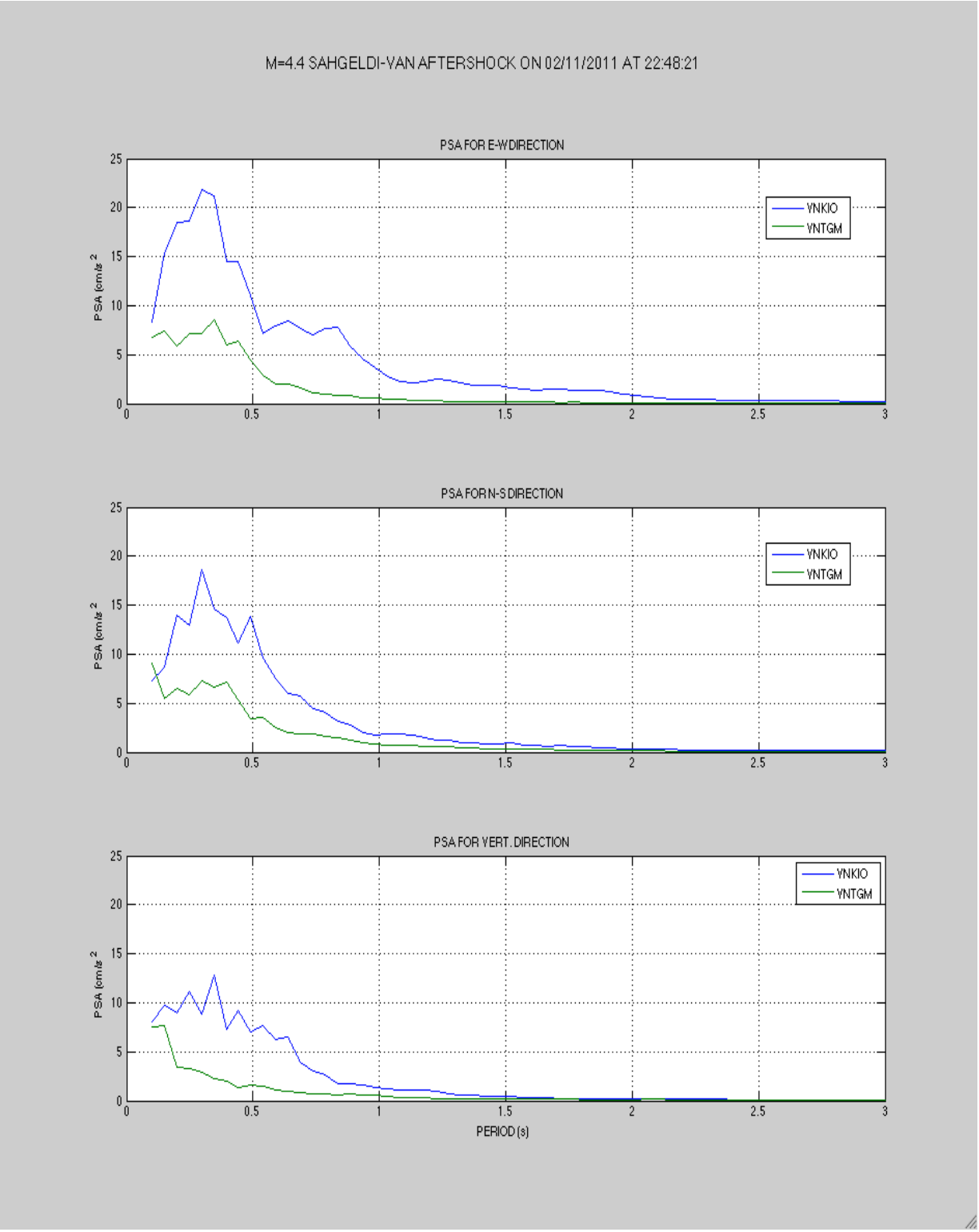

M=4.4 SAHGELDI-VAN AFTERSHOCK ON 02/11/2011 AT 22:48:21
STATION YNKIO
E-W
N-S
VER
ACC. (g)
STATION YNTGM
E-W
N-S
VER
ACC. (g)
TIME (s)


M=4.4 SAHGELDI-VAN AFTERSHOCK ON 02/11/2011 AT 22:48:21
STATION YNKIO FAS
FAS AMP. (cm/s)
E-W
N-S
VER
STATION YNTGM FAS
FAS AMP. (cm/s)
FREQUENCY (Hz)
E-W
N-S
VER


M=4.4 SAHGELDI-VAN AFTERSHOCK ON 02/11/2011 AT 22:48:21
STATION YNKIO VELOCITIES
VEL. (cm/s)
E-W
N-S
VER
STATION YNKIO DISPLACEMENTS
DISP. (cm)
TIME (s)


M=4.4 SAHGELDI-VAN AFTERSHOCK ON 02/11/2011 AT 22:48:21
STATION YNTGM VELOCITIES
VEL. (cm/s)
E-W
N-S
VER
STATION YNTGM DISPLACEMENTS
DISP. (cm)
TIME (s)


M=4.4 SAHGELDI-VAN AFTERSHOCK ON 02/11/2011 AT 22:48:21
PARTICLE MOTIONS
STATION YNKIO
STATION YNTGM
N-S (cm)
E-W (cm)
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.03
-0.02
-0.01
0
0.01
0.02
0.03
0.04


M=4.4 SAHGELDI-VAN AFTERSHOCK ON 02/11/2011 AT 22:48:21
PSA FOR E-W DIRECTION
PSA FOR N-S DIRECTION
PSA FOR VERT. DIRECTION
PSA (cm/s^2)
PERIOD (s)
YNKIO
YNTGM
0
5
10
15
20
25
0.5
1
1.5
2
2.5
3

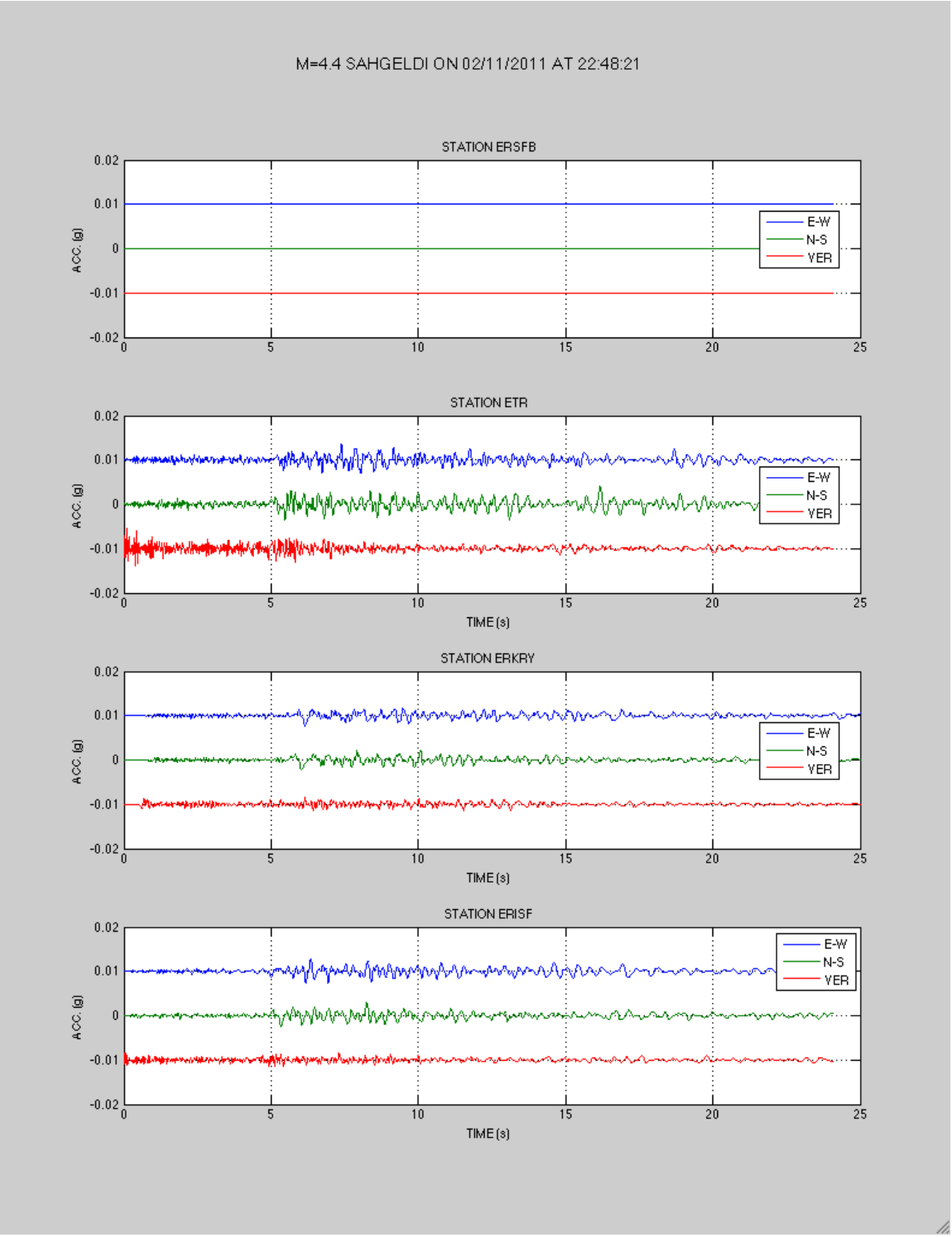
Şahgeldi/Van Aftershock

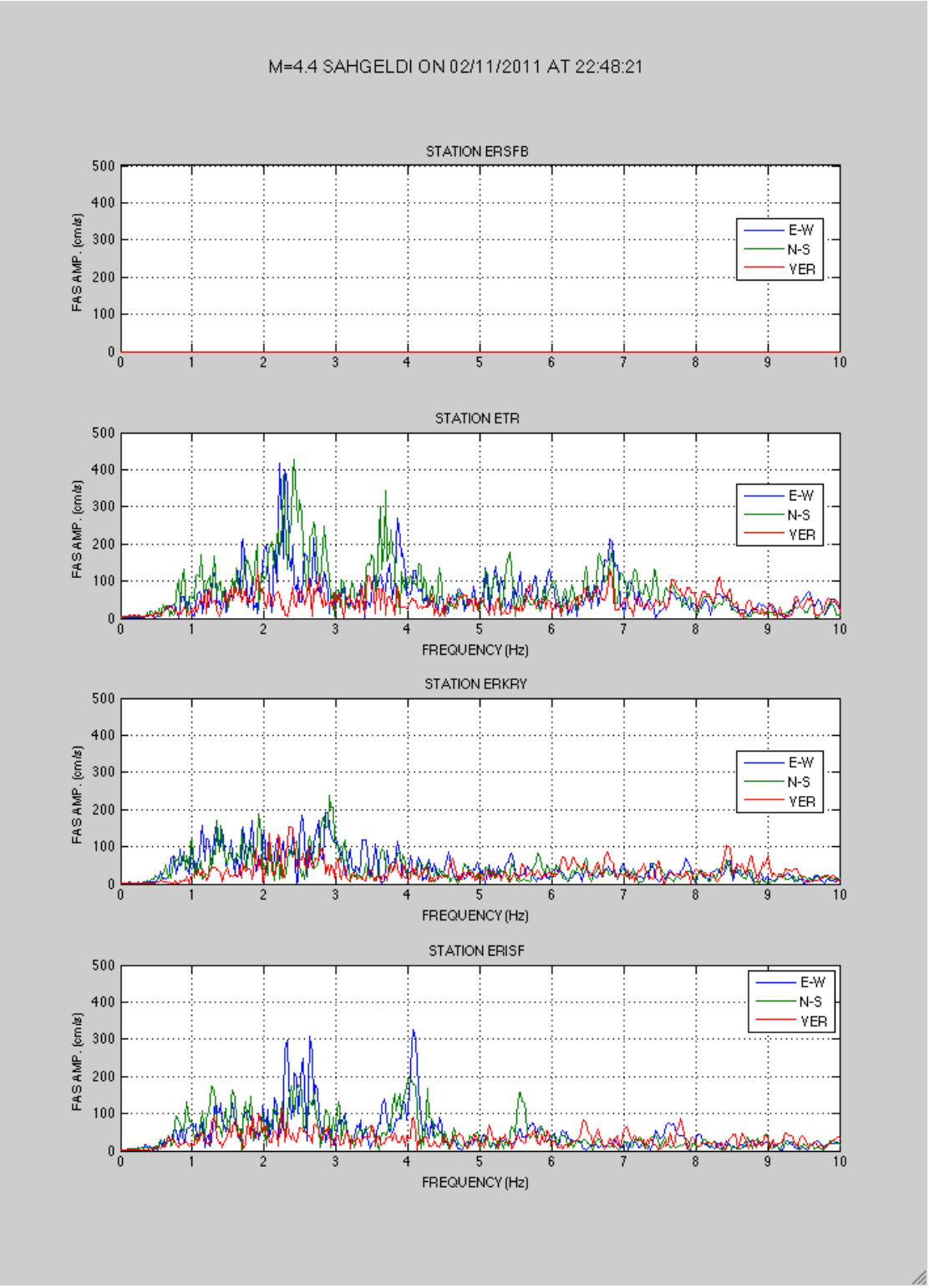
M=4.4

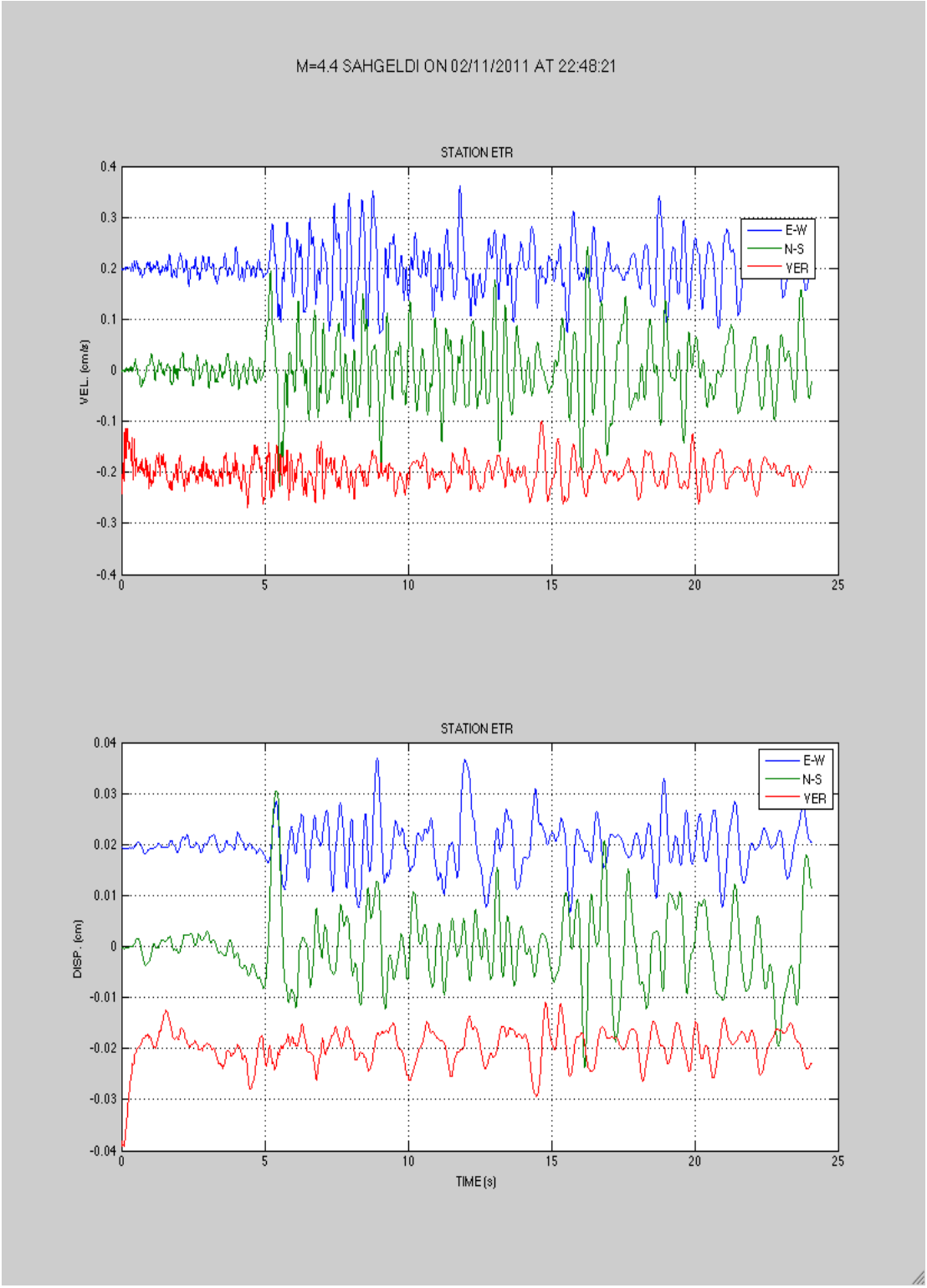
02/11/2011

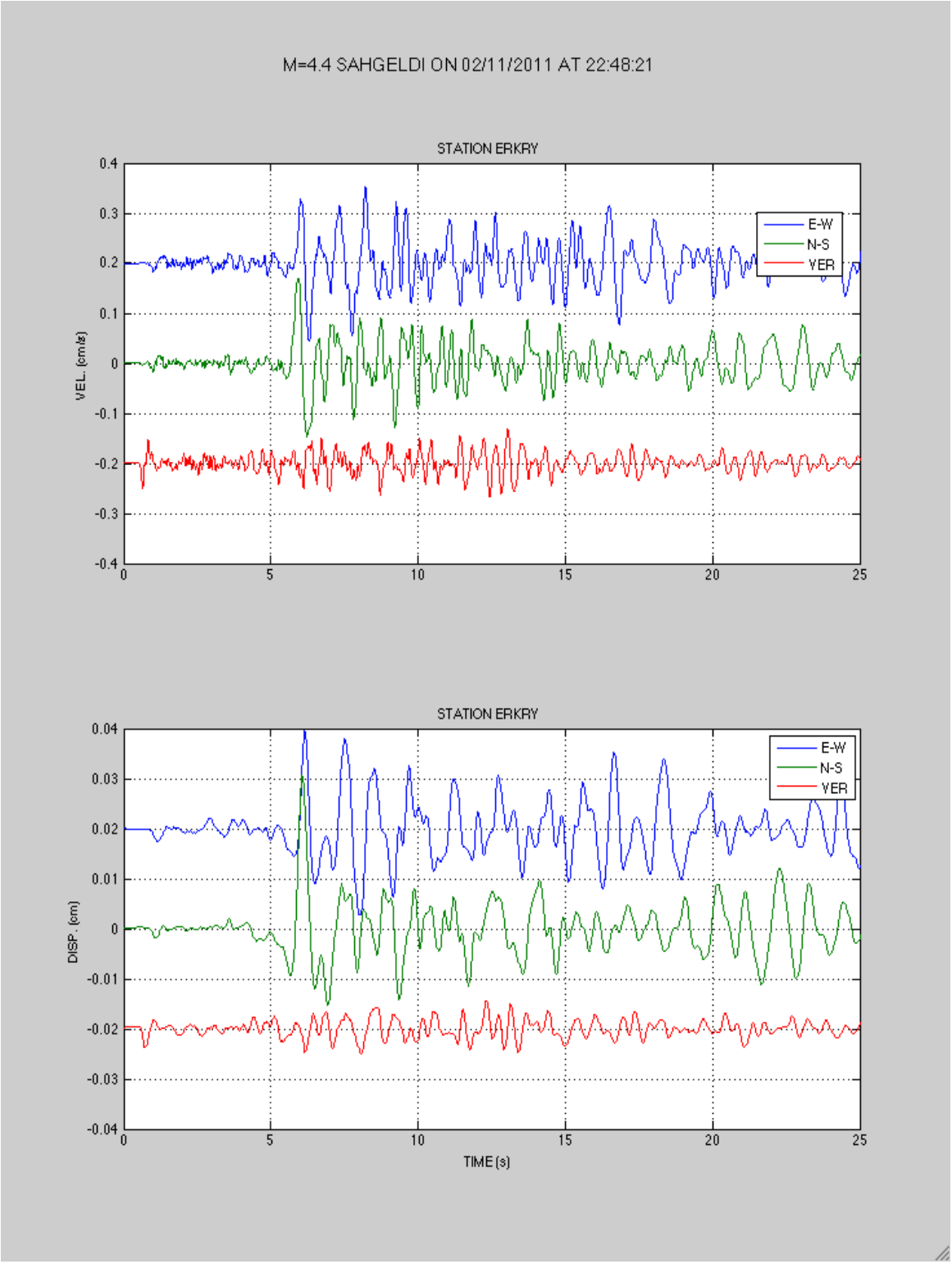
22:48:21

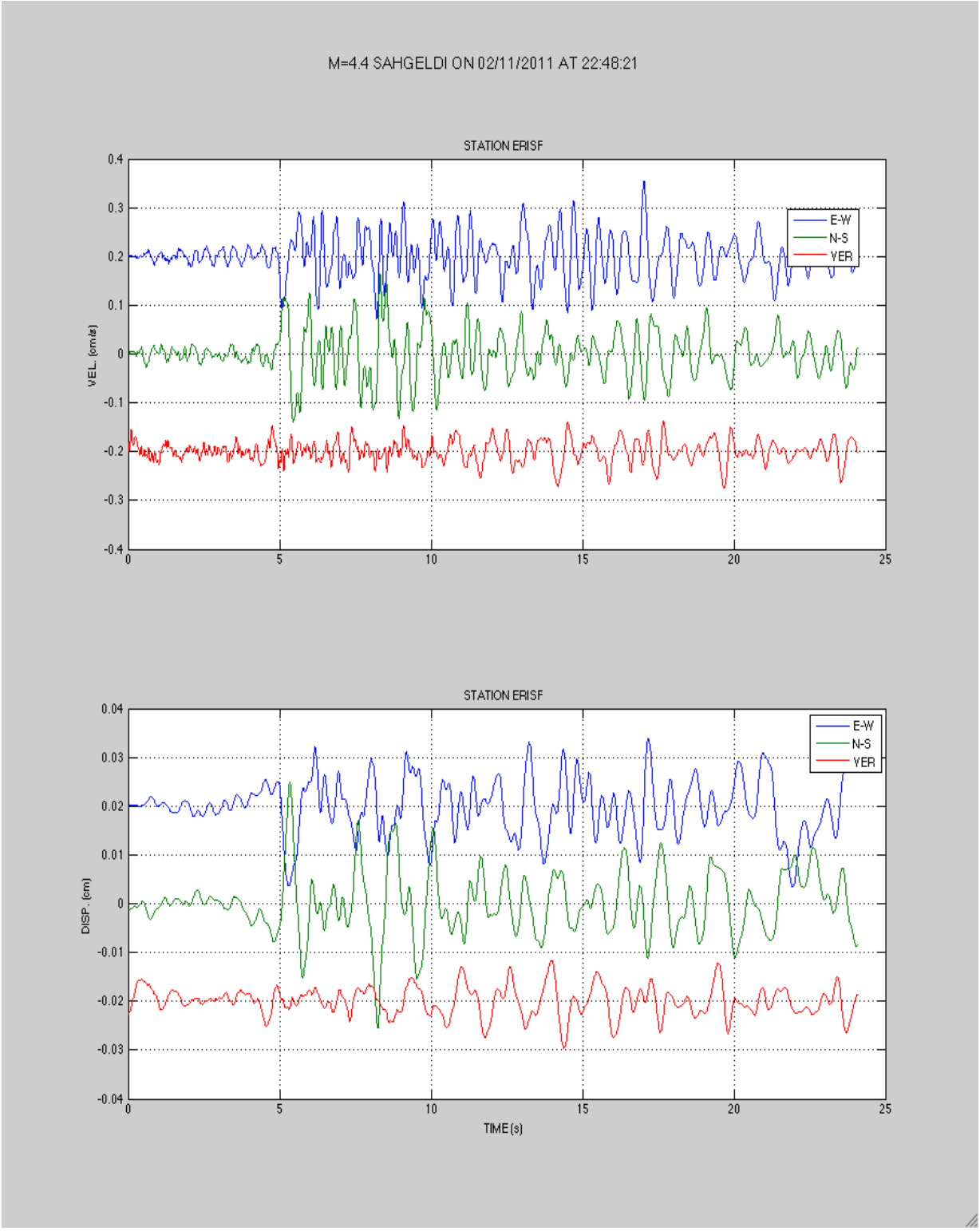
ERCİŞ RECORDS

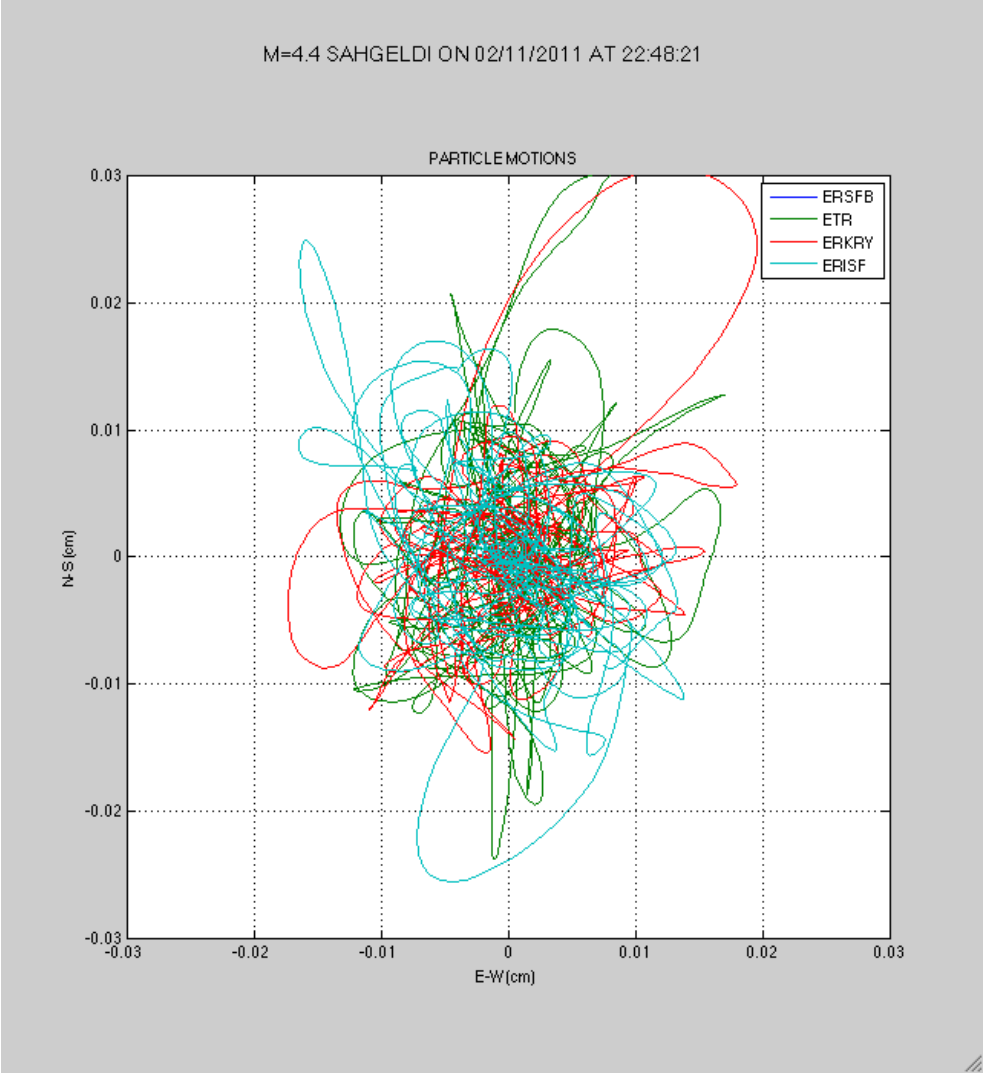

M=4.4 SAHGELDI ON 02/11/2011 AT 22:48:21
STATION ERSFB
STATION ETR
STATION ERKRY
STATION ERISF
E-W
N-S
VER
ACC. (g)
TIME (s)
0.02
0.01
0
-0.01
-0.02
0
5
10
15
20
25


M=4.4 SAHGELDI ON 02/11/2011 AT 22:48:21
STATION ERSFB
STATION ETR
STATION ERKRY
STATION ERISF
FAS AMP. (cm/s)
FREQUENCY (Hz)
E-W
N-S
VER


M=4.4 SAHGELDI ON 02/11/2011 AT 22:48:21
STATION ETR
VEL. (cm/s)
E-W
N-S
VER
STATION ETR
DISP. (cm)
TIME (s)
E-W
N-S
VER


M=4.4 SAHGELDI ON 02/11/2011 AT 22:48:21
STATION ERKRY
VEL. (cm/s)
E-W
N-S
VER
STATION ERKRY
DISP. (cm)
TIME (s)
E-W
N-S
VER


M=4.4 SAHGELDI ON 02/11/2011 AT 22:48:21
STATION ERISF
VEL. (cm/s)
E-W
N-S
VER
STATION ERISF
DISP. (cm)
TIME (s)


M=4.4 SAHGELDI ON 02/11/2011 AT 22:48:21
PARTICLE MOTIONS
ERSFB
ETR
ERKRY
ERISF
N-S (cm)
E-W (cm)
0.03
0.02
0.01
0
-0.01
-0.02
-0.03

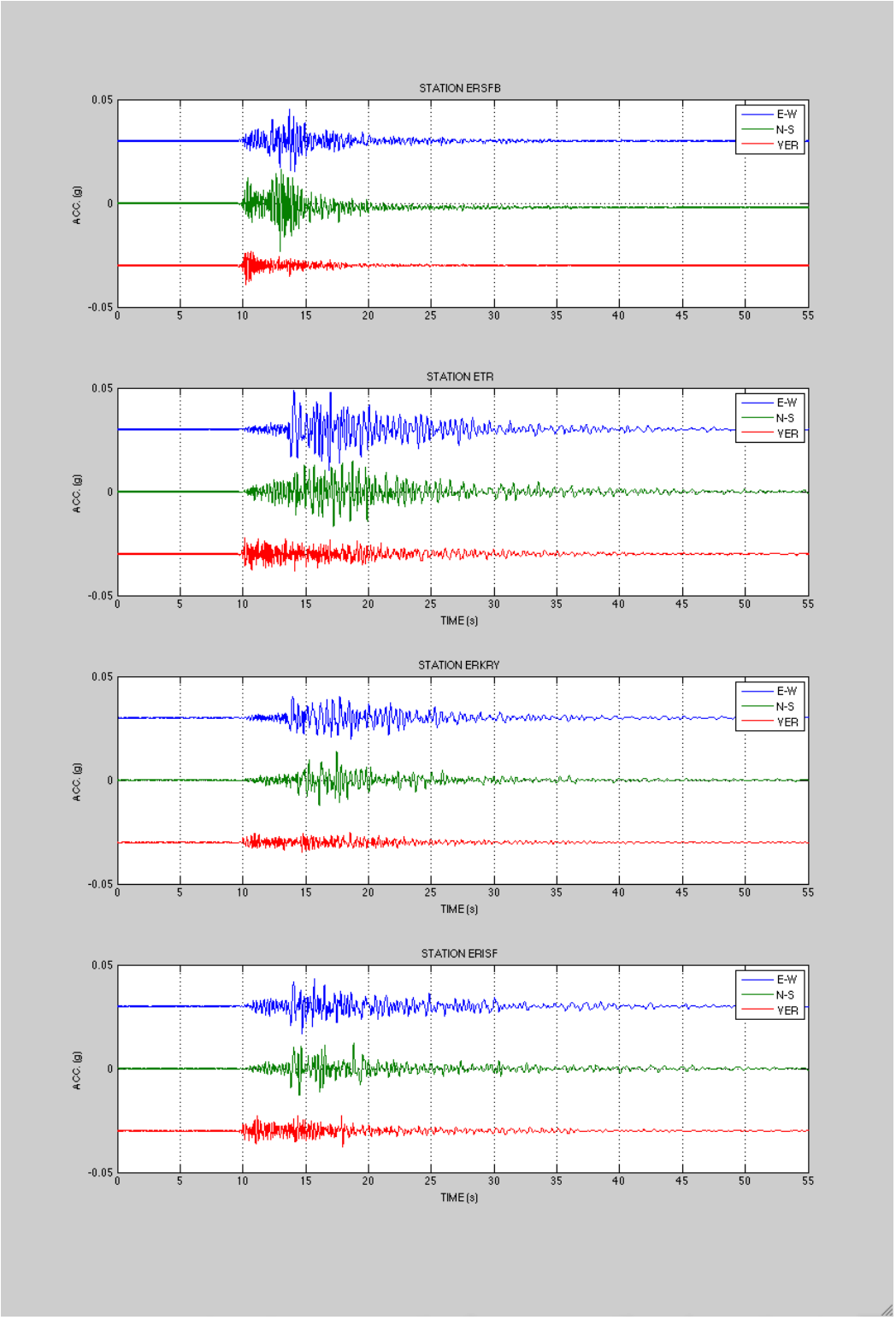
Çolpan/Van Aftershock

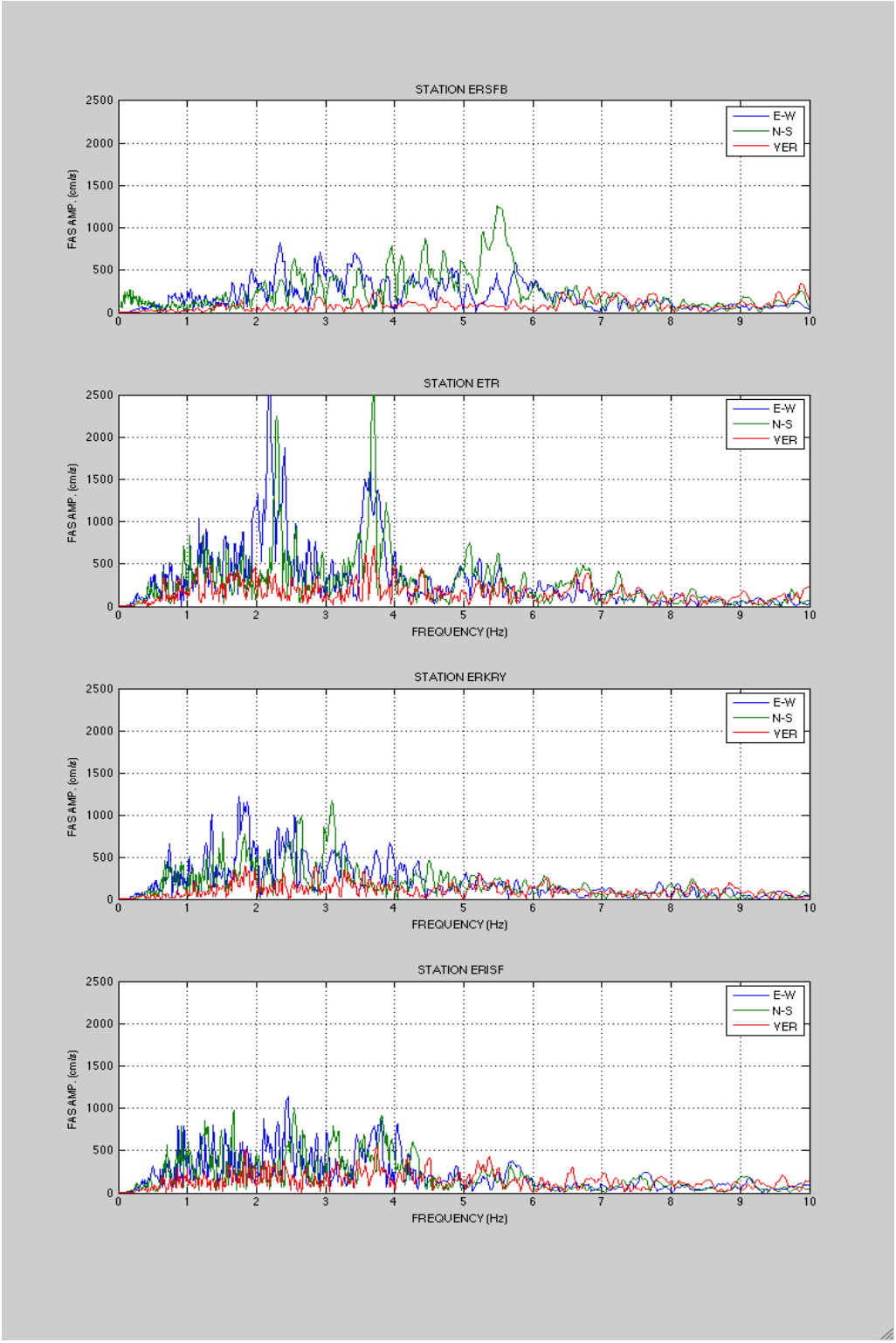
M=4.9

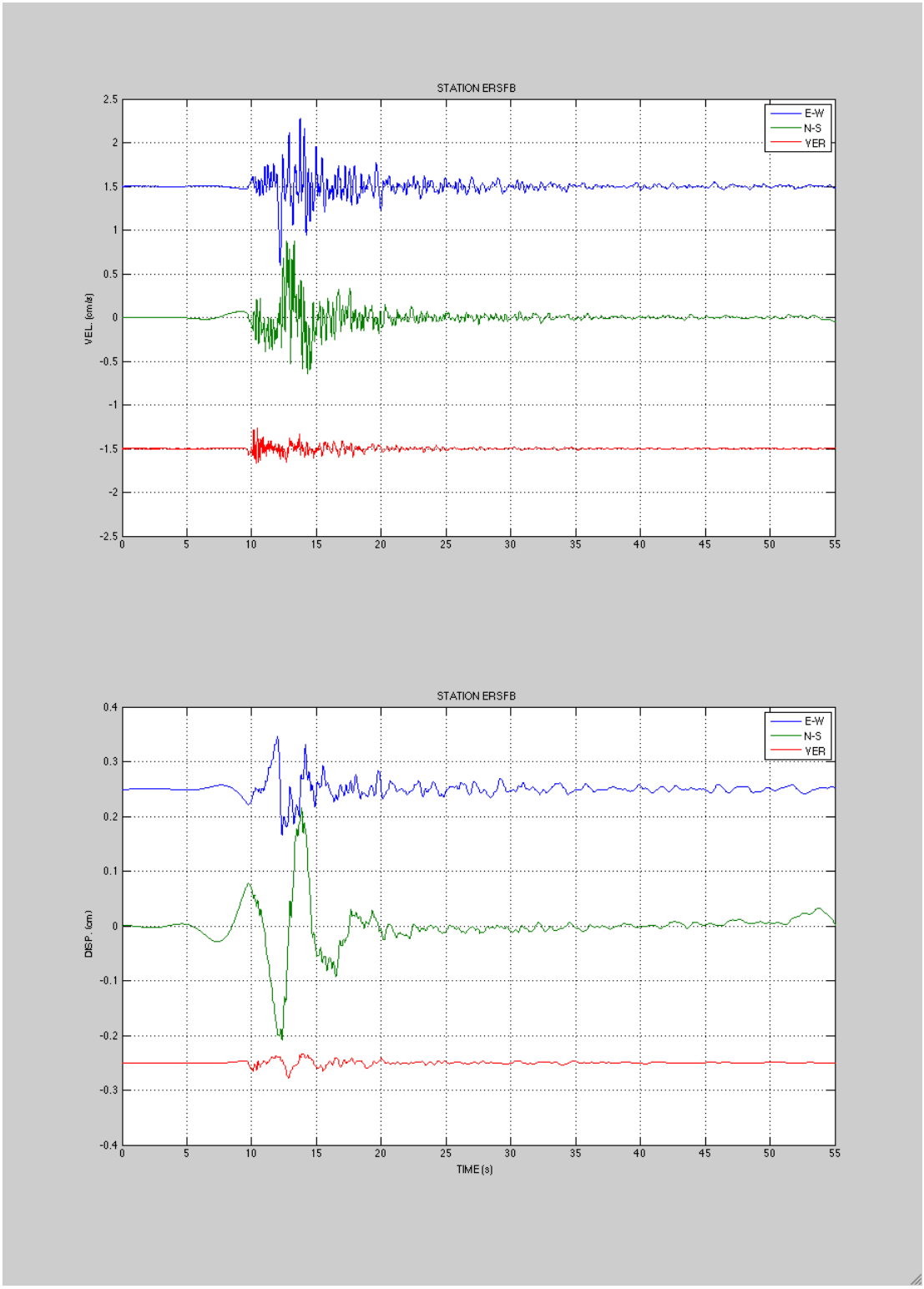
06/11/2011

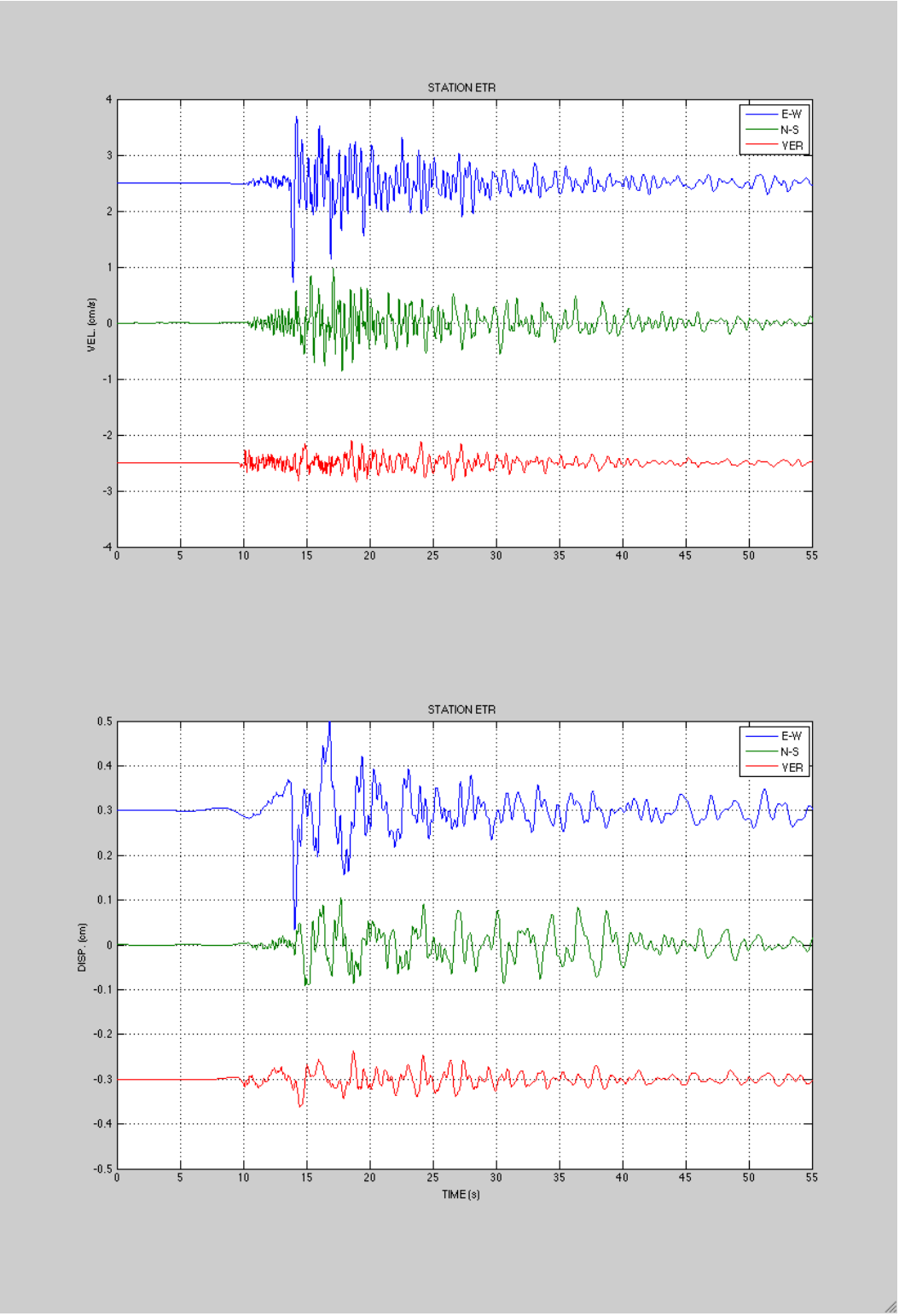
02:43:12

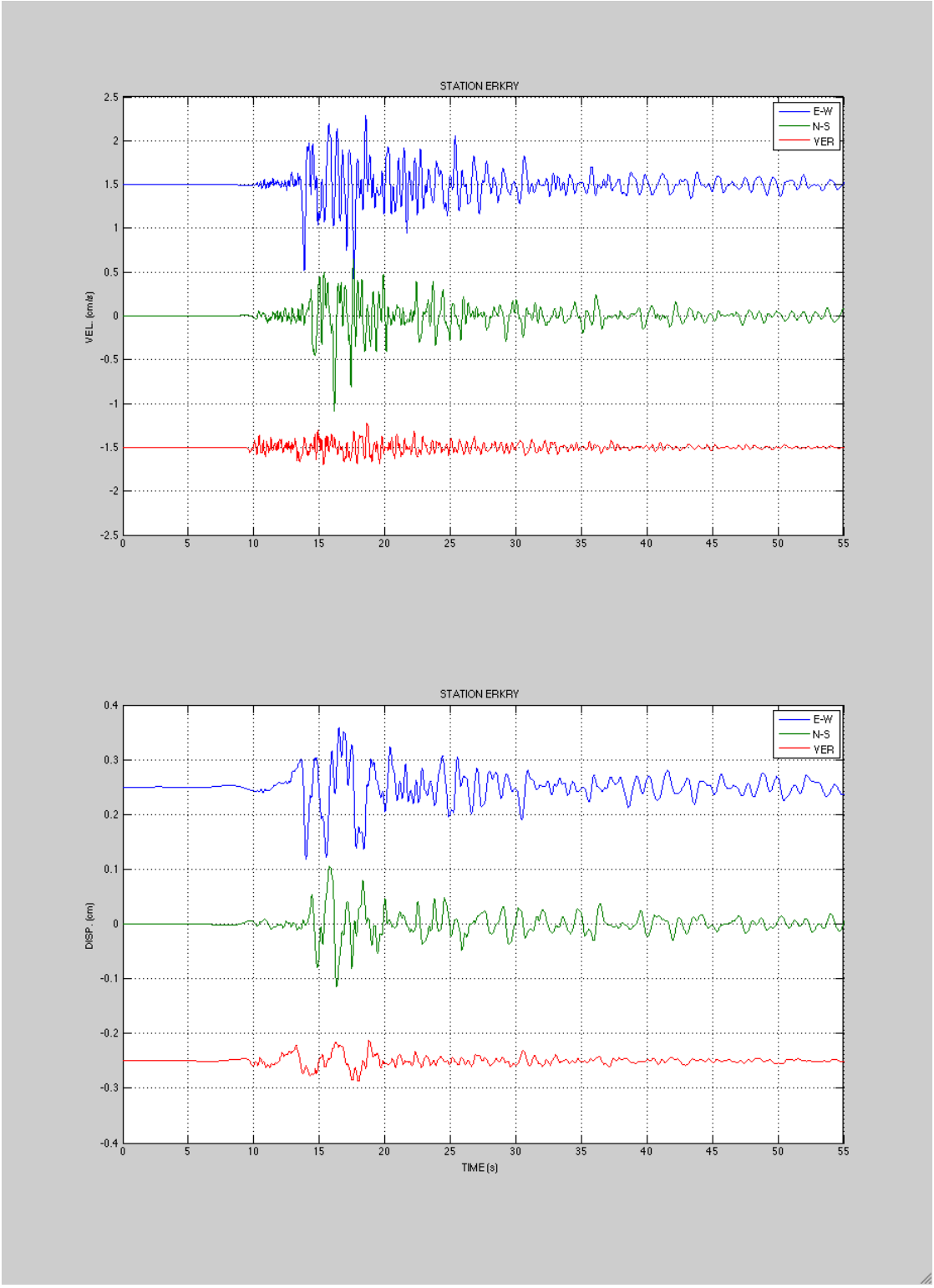
ERCİŞ RECORDS

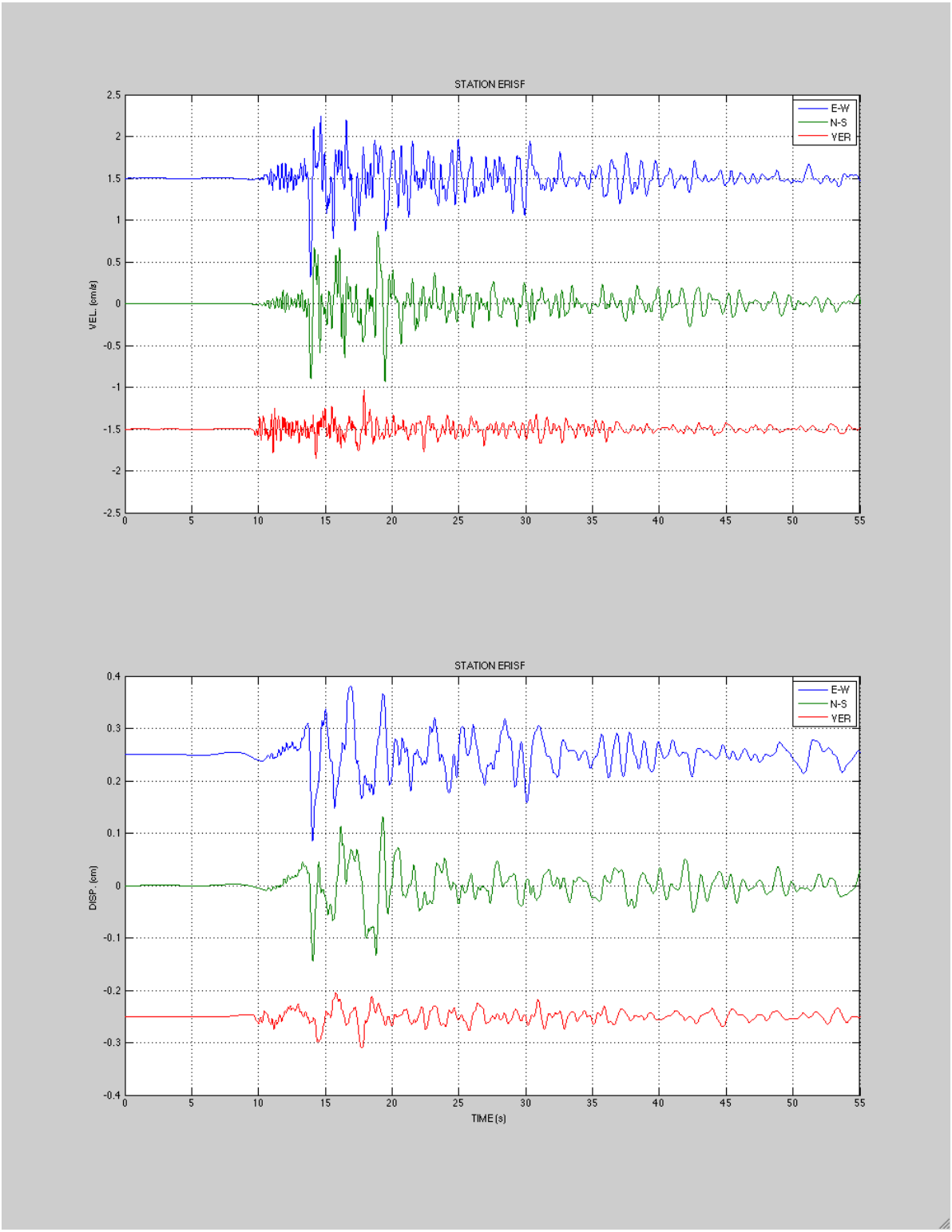

STATION ERSFB
STATION ETR
STATION ERKRY
STATION ERISF
E-W
N-S
VER
ACC. (g)
TIME (s)
0.05
0
-0.05
0
5
10
15
20
25
30
35
40
45
50
55

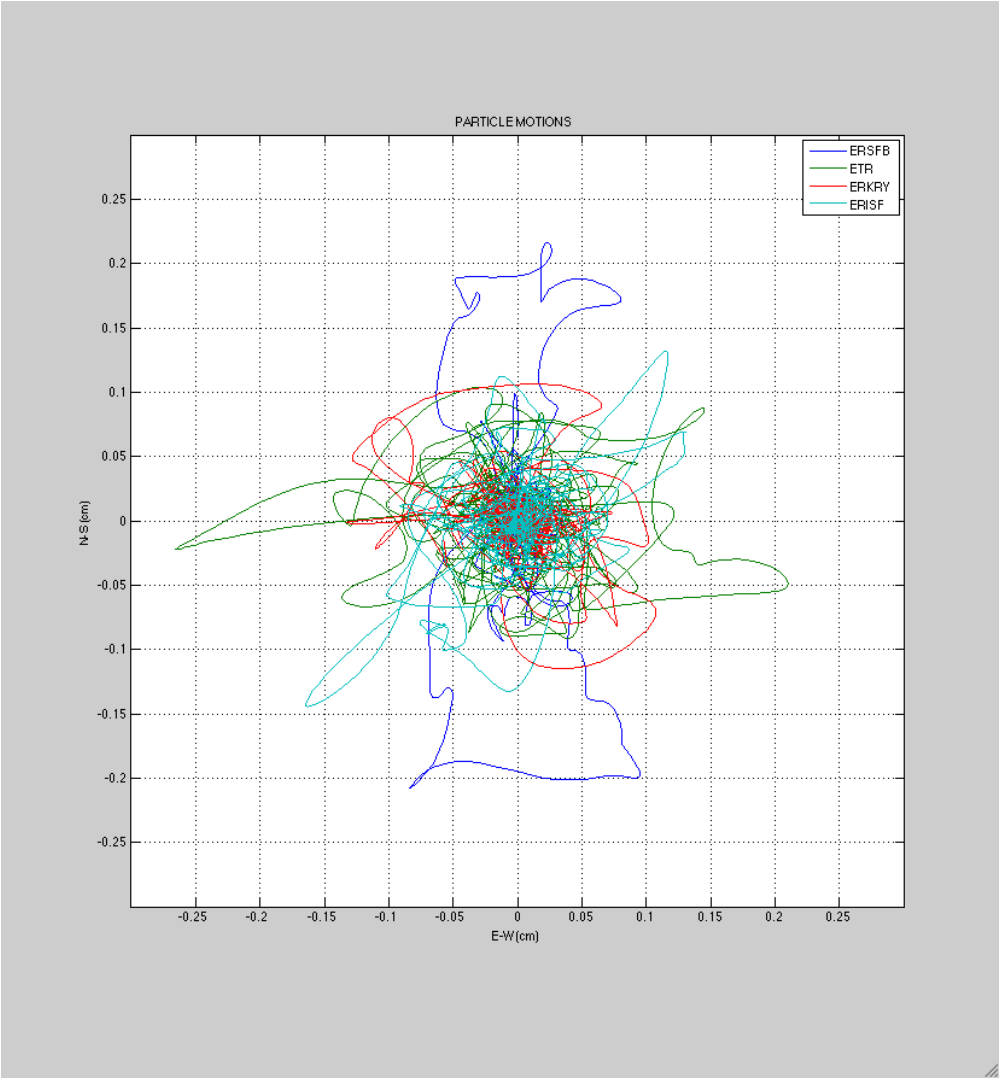

STATION ERSFB
STATION ETR
STATION ERKRY
STATION ERISF
E-W
N-S
VER
FAS AMP. (cm/s)
FREQUENCY (Hz)

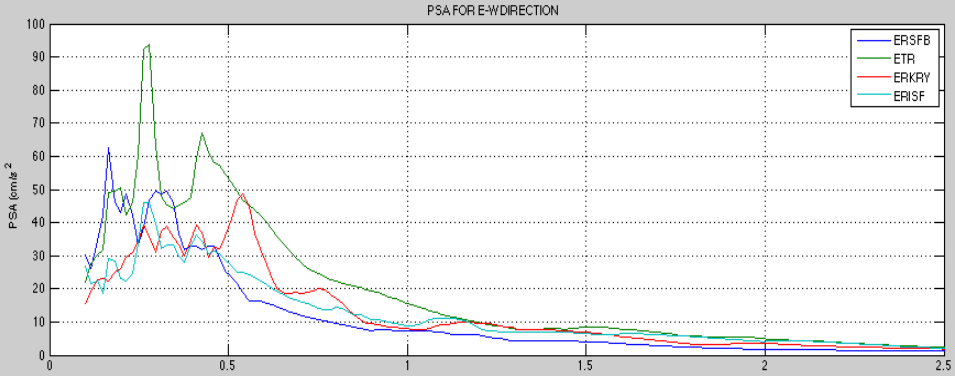

STATION ERSFB
E-W
N-S
VER
VEL. (cm/s)
STATION ERSFB
E-W
N-S
VER
DISP. (cm)
TIME (s)

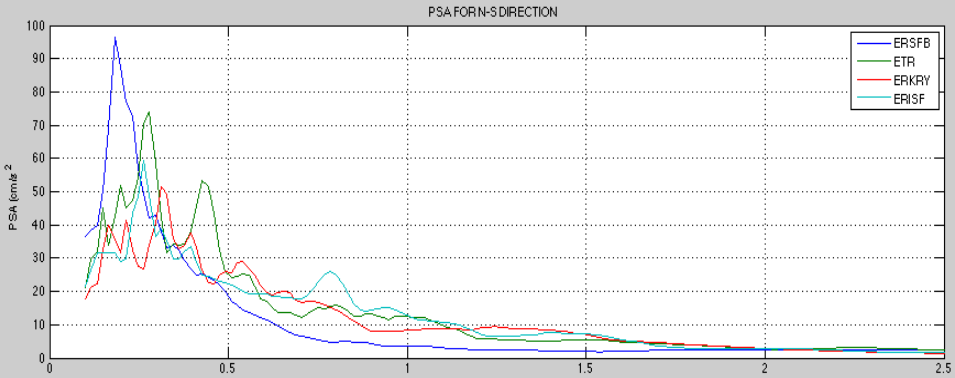

STATION ETR
E-W
N-S
VER
VEL. (cm/s)
STATION ETR
E-W
N-S
VER
DISP. (cm)
TIME (s)

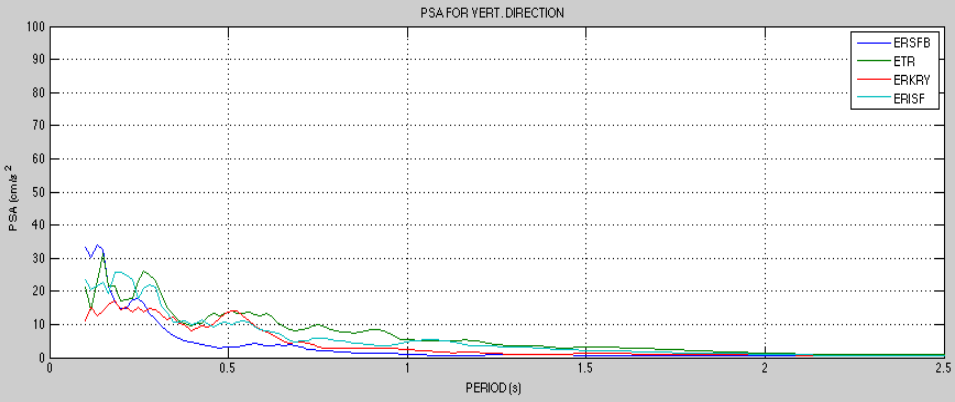

STATION ERKRY
E-W
N-S
VER
VEL. (cm/s)
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
0
5
10
15
20
25
30
35
40
45
50
55
STATION ERKRY
E-W
N-S
VER
DISP. (cm)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
TIME (s)

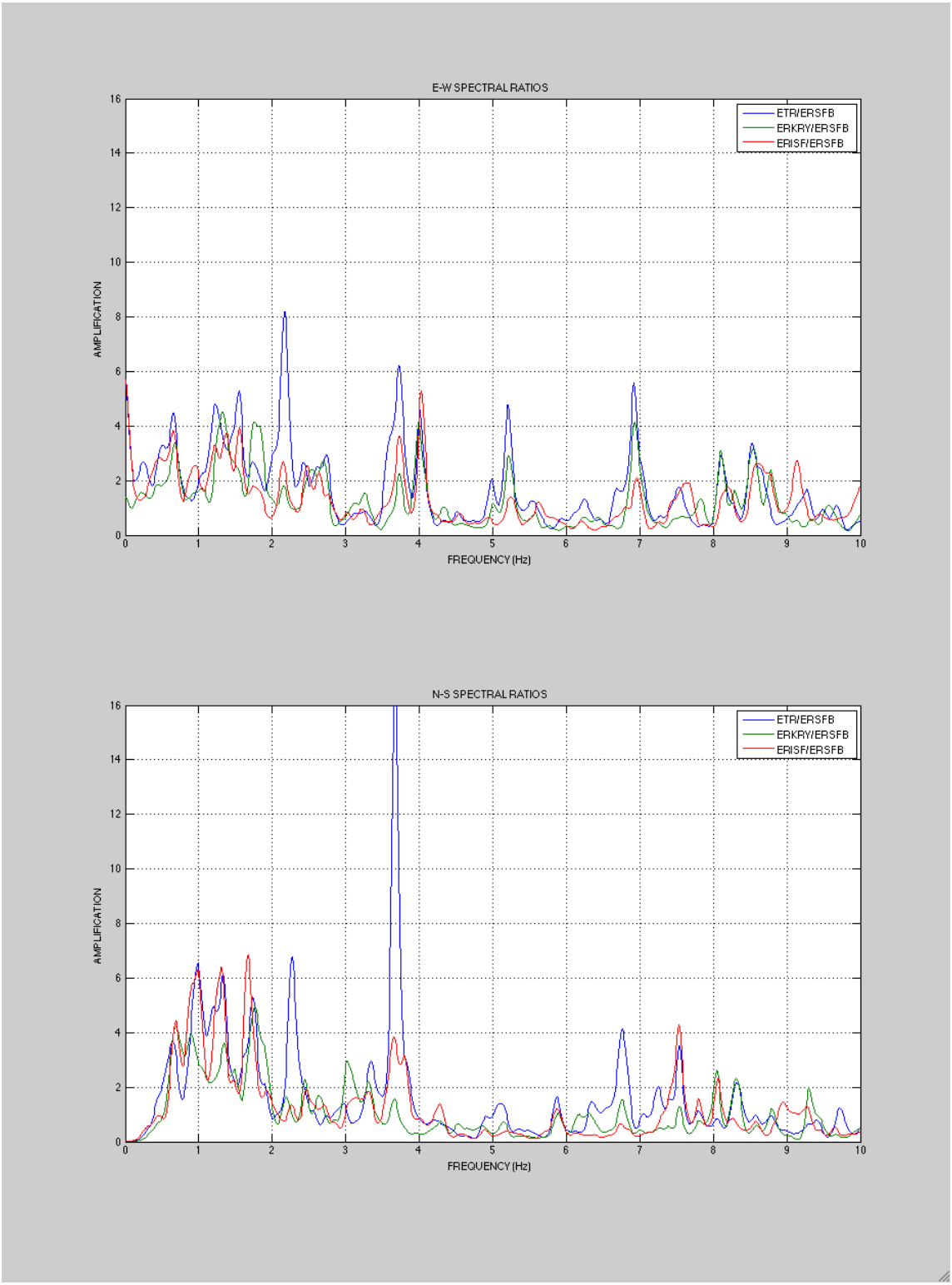

STATION ERISF
E-W
N-S
VER
VEL. (cm/s)
STATION ERISF
E-W
N-S
VER
DISP. (cm)
TIME (s)


PARTICLE MOTIONS
ERSFB
ETR
ERKRY
ERISF
N-S (cm)
E-W (cm)
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25


PSA FOR E-W DIRECTION
PSA (cm/s²)
ERSFB
ETR
ERKRY
ERISF


PSA FOR N-S DIRECTION
PSA (cm/s²)
ERSFB
ETR
ERKRY
ERISF


PSA FOR VERT. DIRECTION
PSA (cm/s²)
PERIOD (s)
ERSFB
ETR
ERKRY
ERISF


E-W SPECTRAL RATIOS
ETR/ERSFB
ERKRY/ERSFB
ERISF/ERSFB
AMPLIFICATION
FREQUENCY (Hz)
N-S SPECTRAL RATIOS
ETR/ERSFB
ERKRY/ERSFB
ERISF/ERSFB
AMPLIFICATION
FREQUENCY (Hz)

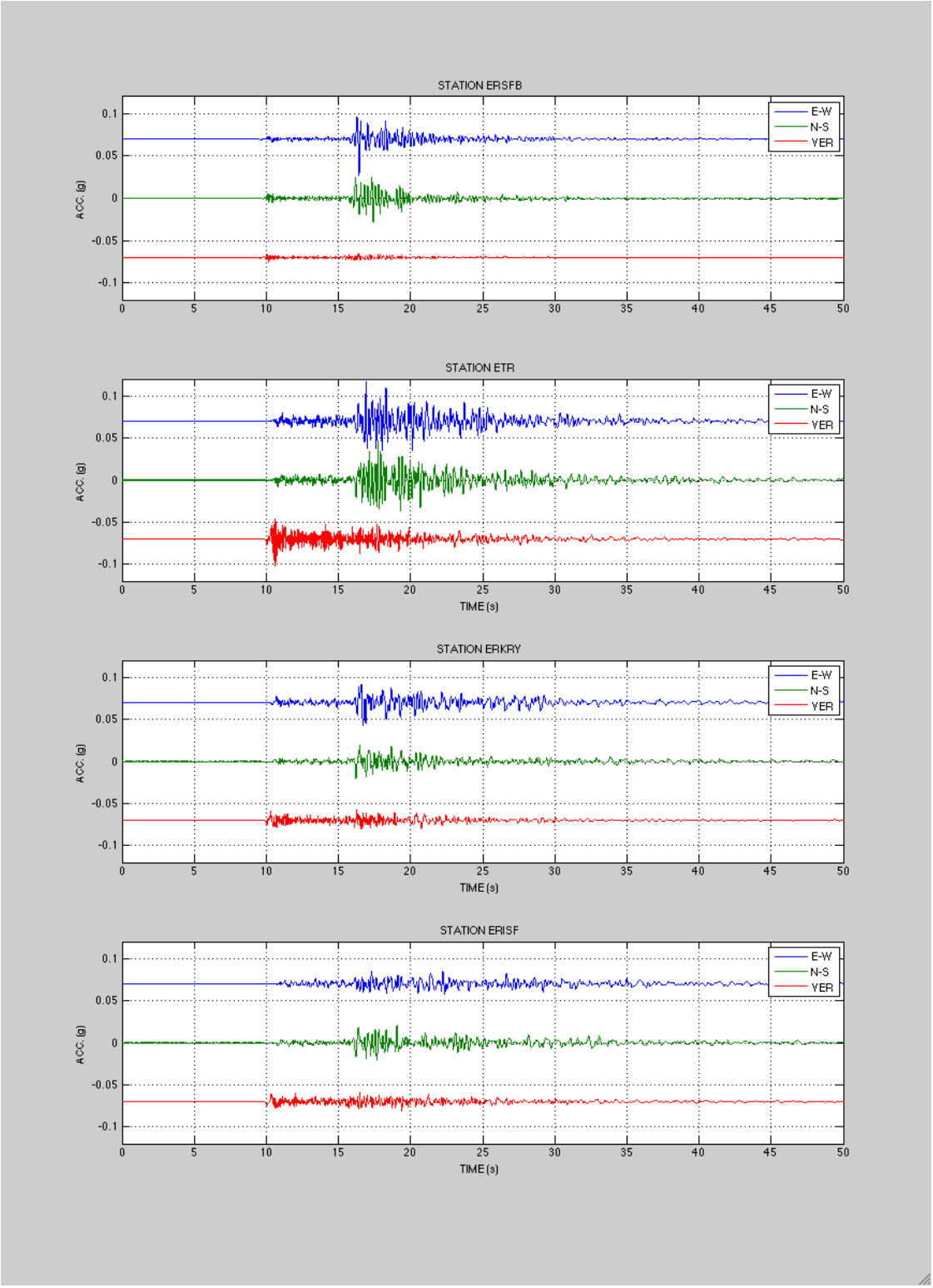
Van Gölü/Van Aftershock

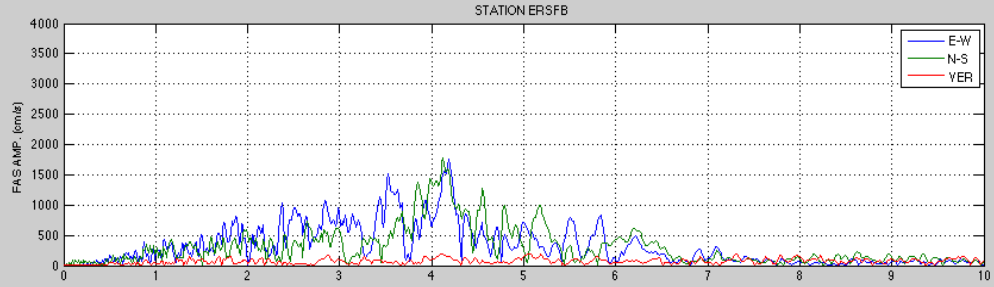
M=5.5

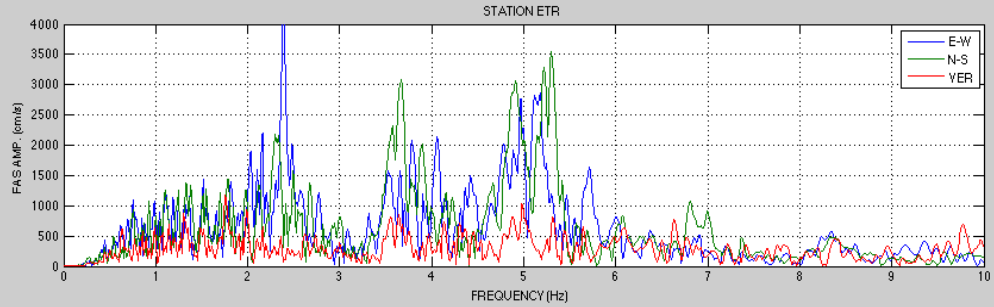
08/11/2011

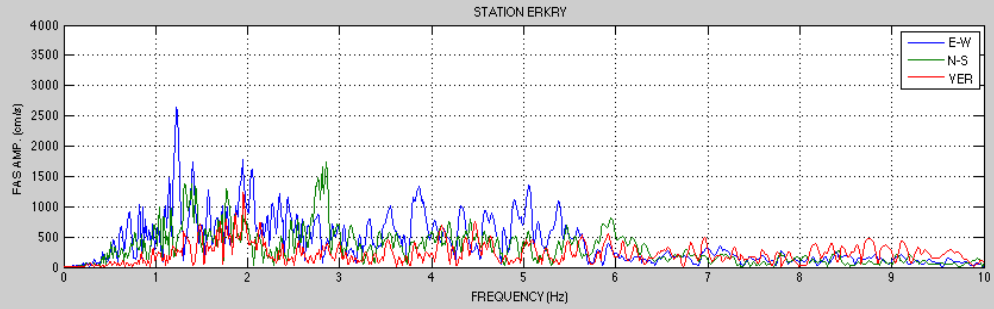
22:05:51

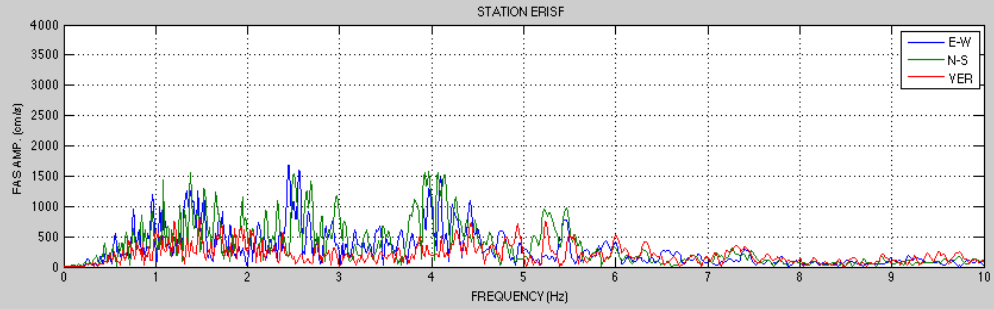
ERCİŞ RECORDS

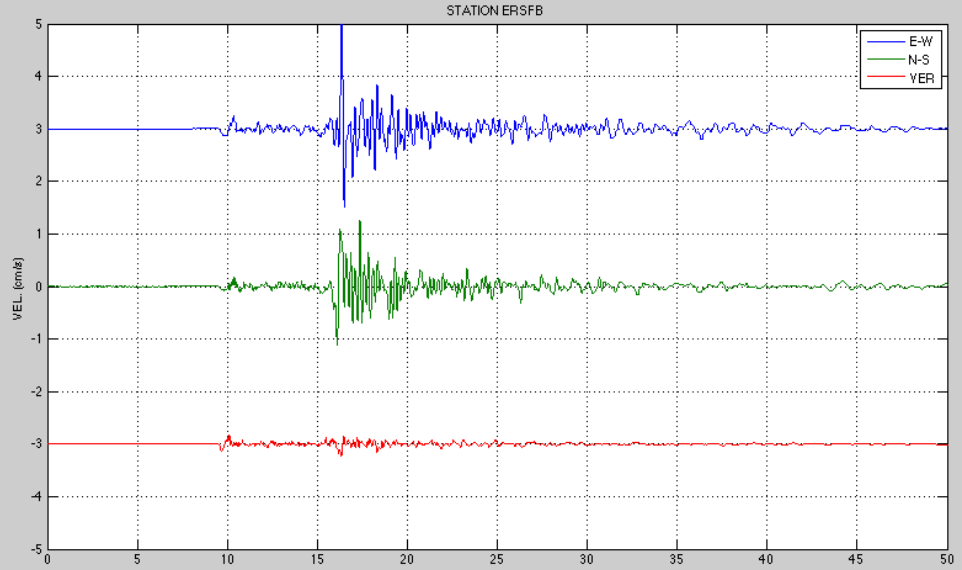

STATION ERSFB
STATION ETR
STATION ERKRY
STATION ERISF
E-W
N-S
VER
ACC. (g)
TIME (s)

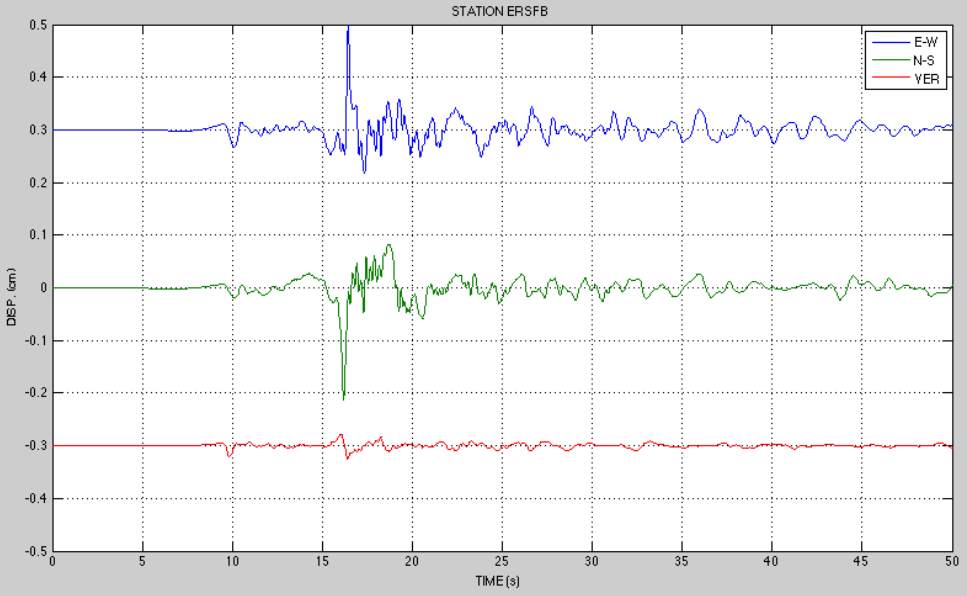

STATION ERSFB
FAS AMP. (cm/s)
E-W
N-S
VER

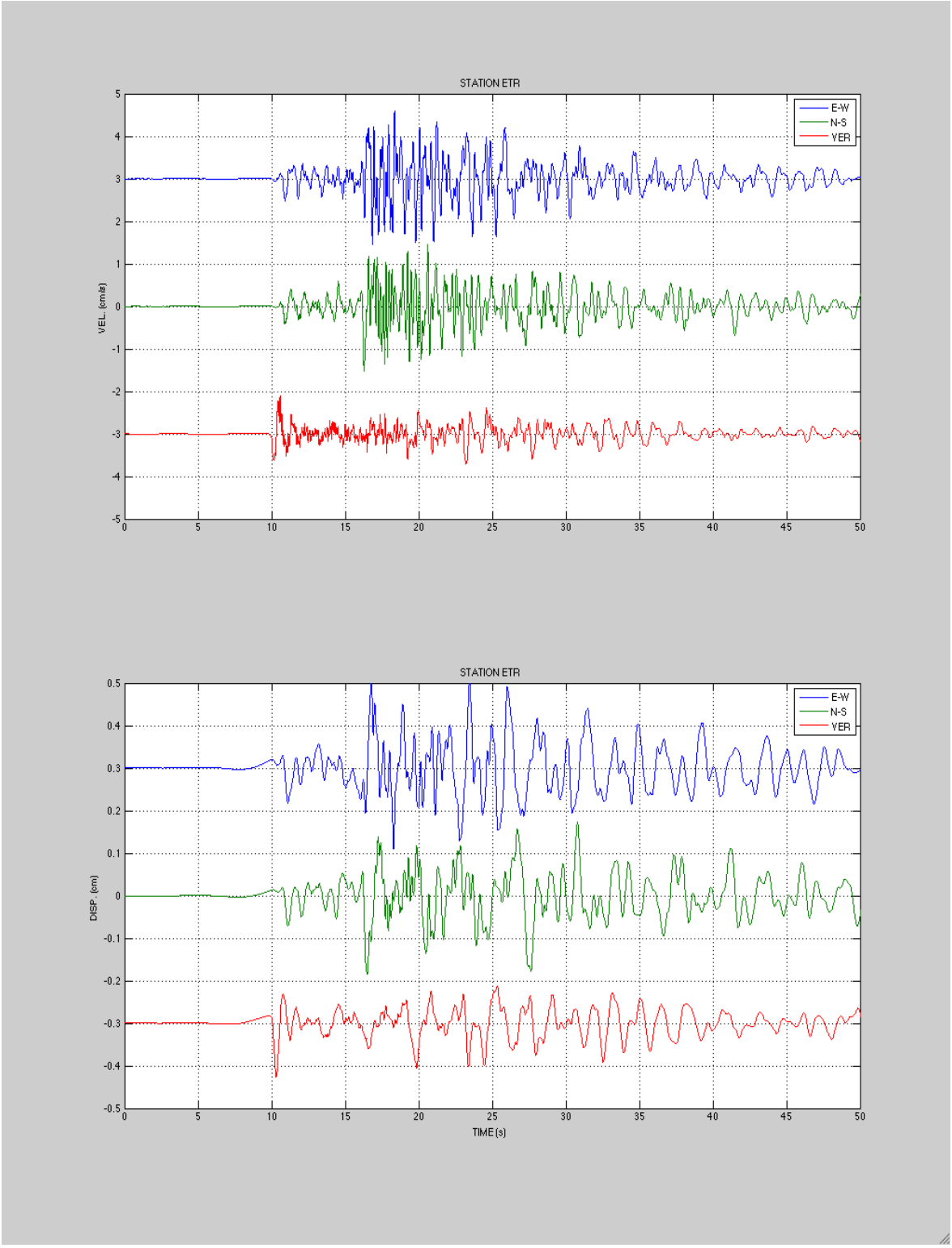

STATION ETR
FAS AMP. (cm/s)
FREQUENCY (Hz)
E-W
N-S
VER

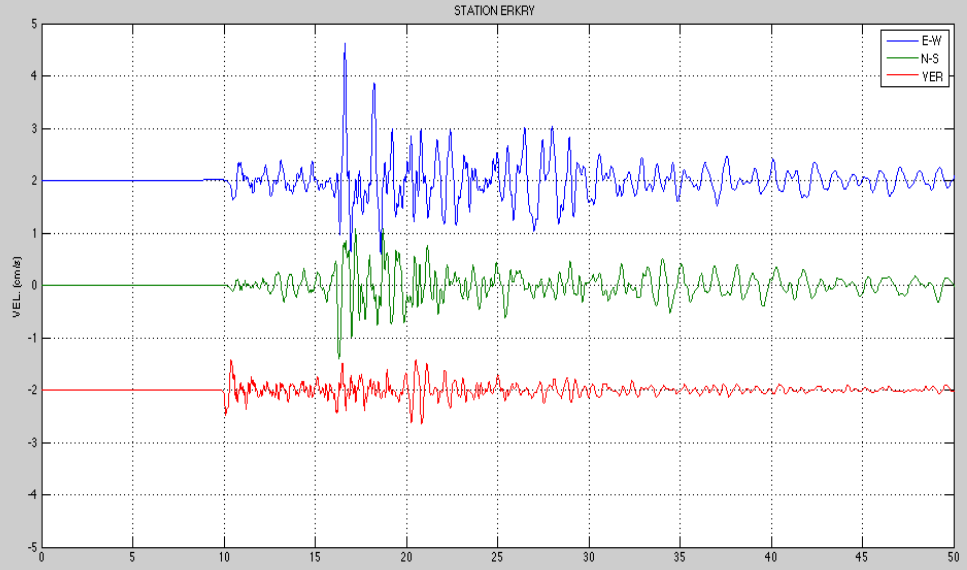

STATION ERKRY
FAS AMP. (cm/s)
FREQUENCY (Hz)
E-W
N-S
VER

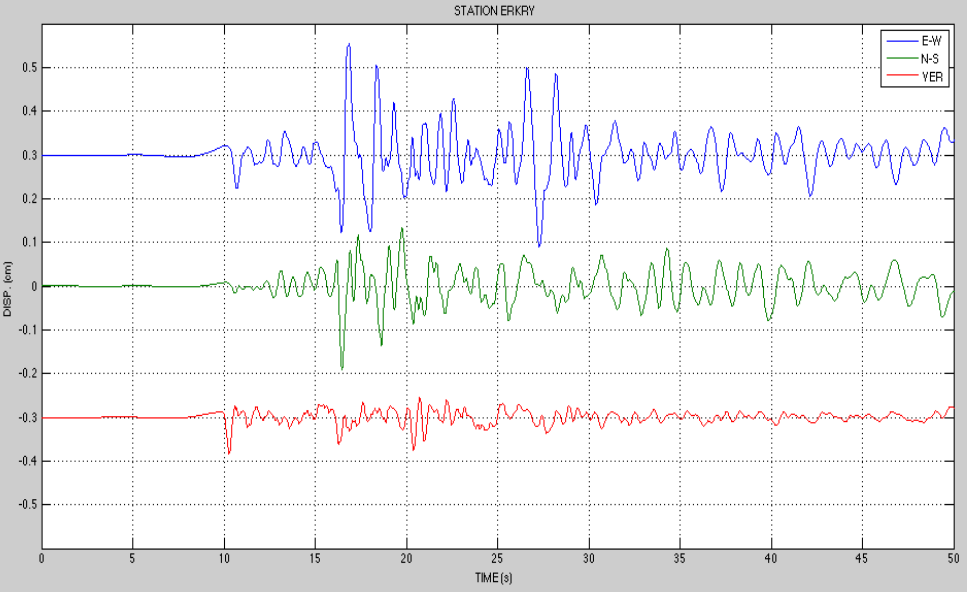

STATION ERISF
FAS AMP. (cm/s)
FREQUENCY (Hz)
E-W
N-S
VER

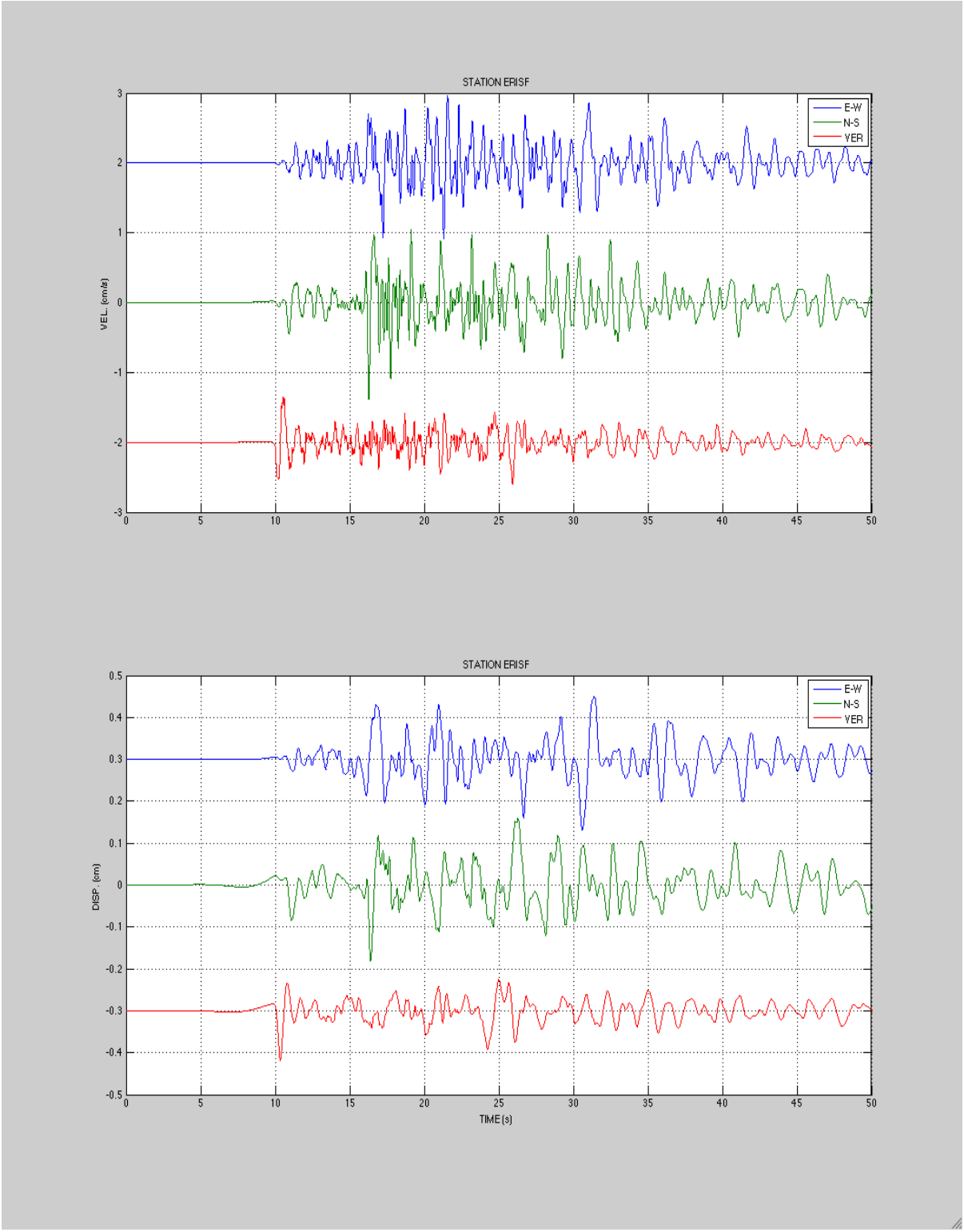

STATION ERSFB
E-W
N-S
VER
VEL. (cm/s)

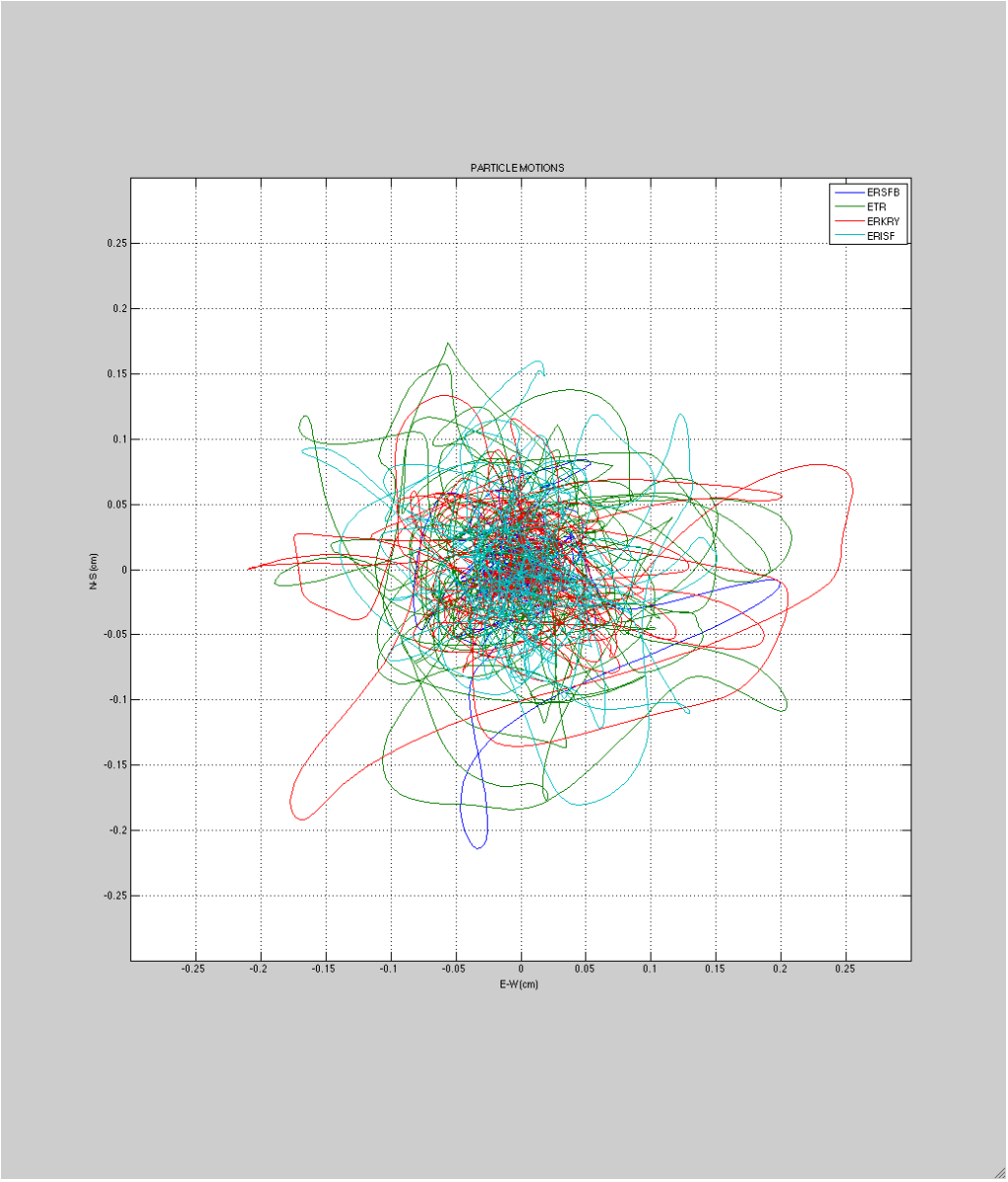

STATION ERSFB
E-W
N-S
VER
DISP. (cm)
TIME (s)

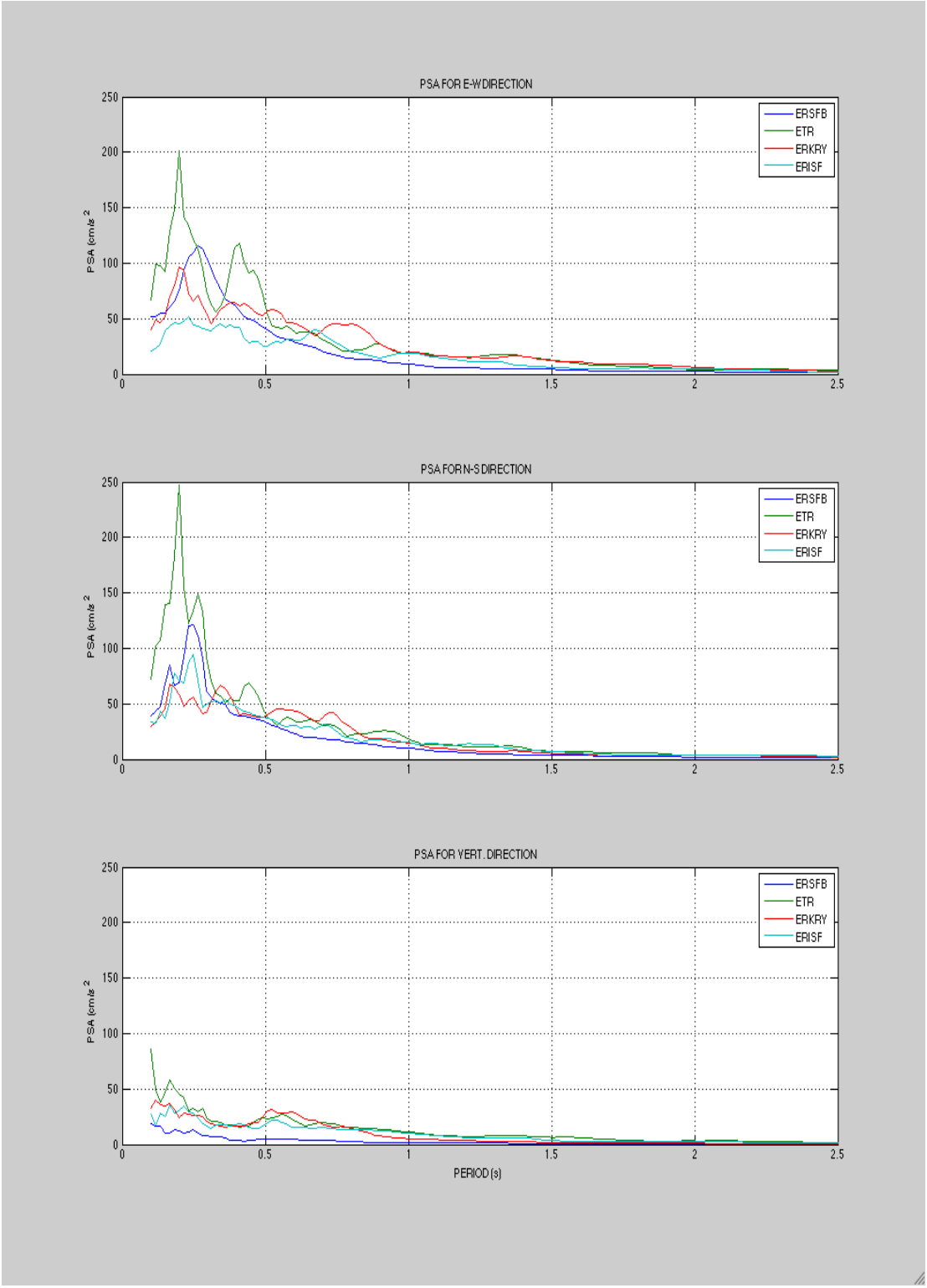

STATION ETR
E-W
N-S
VER
VEL. (cm/s)
STATION ETR
E-W
N-S
VER
DISP. (cm)
TIME (s)

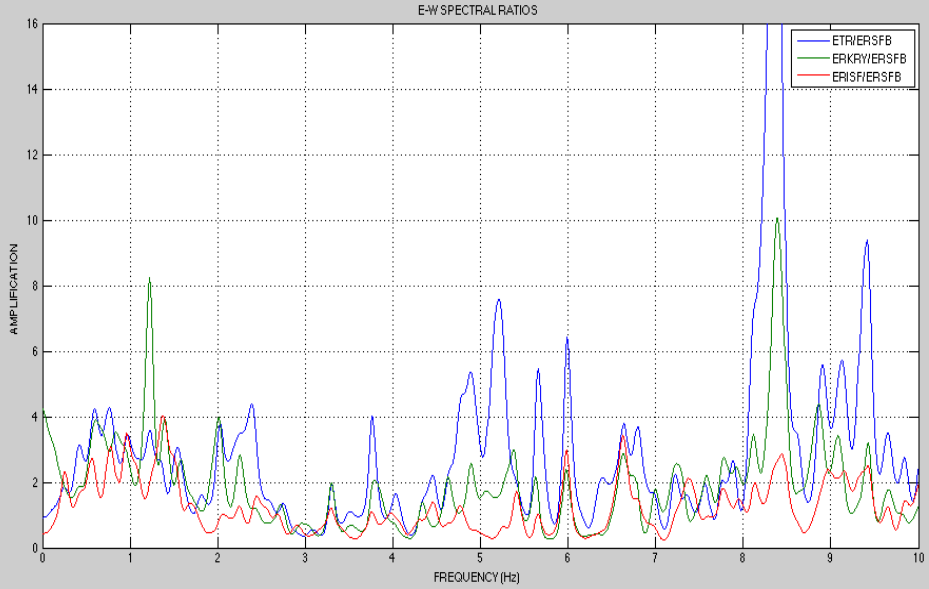

STATION ERKRY
E-W
N-S
VER
VEL. (cm/s)

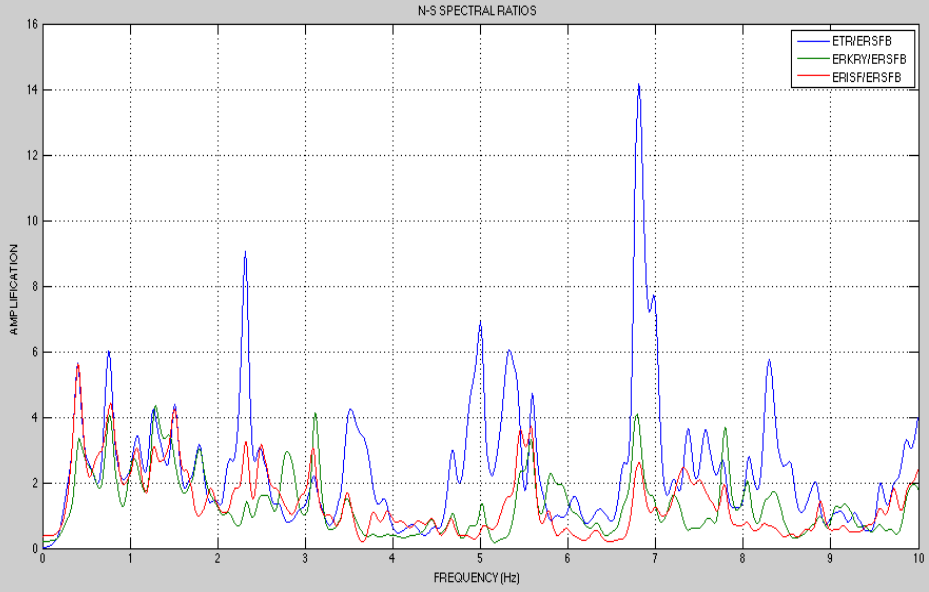

STATION ERKRY
E-W
N-S
VER
DISP. (cm)
TIME (s)


STATION ERISF
E-W
N-S
VER
VEL. (cm/s)
STATION ERISF
E-W
N-S
VER
DISP. (cm)
TIME (s)


PARTICLE MOTIONS
ERSFB
ETR
ERKRY
ERISF
N-S (cm)
E-W (cm)
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25


PSA FOR E-W DIRECTION
PSA (cm/s²)
ERSFB
ETR
ERKRY
ERISF
PSA FOR N-S DIRECTION
PSA (cm/s²)
ERSFB
ETR
ERKRY
ERISF
PSA FOR VERT. DIRECTION
PSA (cm/s²)
ERSFB
ETR
ERKRY
ERISF
PERIOD (s)


E-W SPECTRAL RATIOS
ETR/ERSFB
ERKRY/ERSFB
ERISF/ERSFB
AMPLIFICATION
FREQUENCY (Hz)


N-S SPECTRAL RATIOS
ETR/ERSFB
ERKRY/ERSFB
ERISF/ERSFB
AMPLIFICATION
FREQUENCY (Hz)

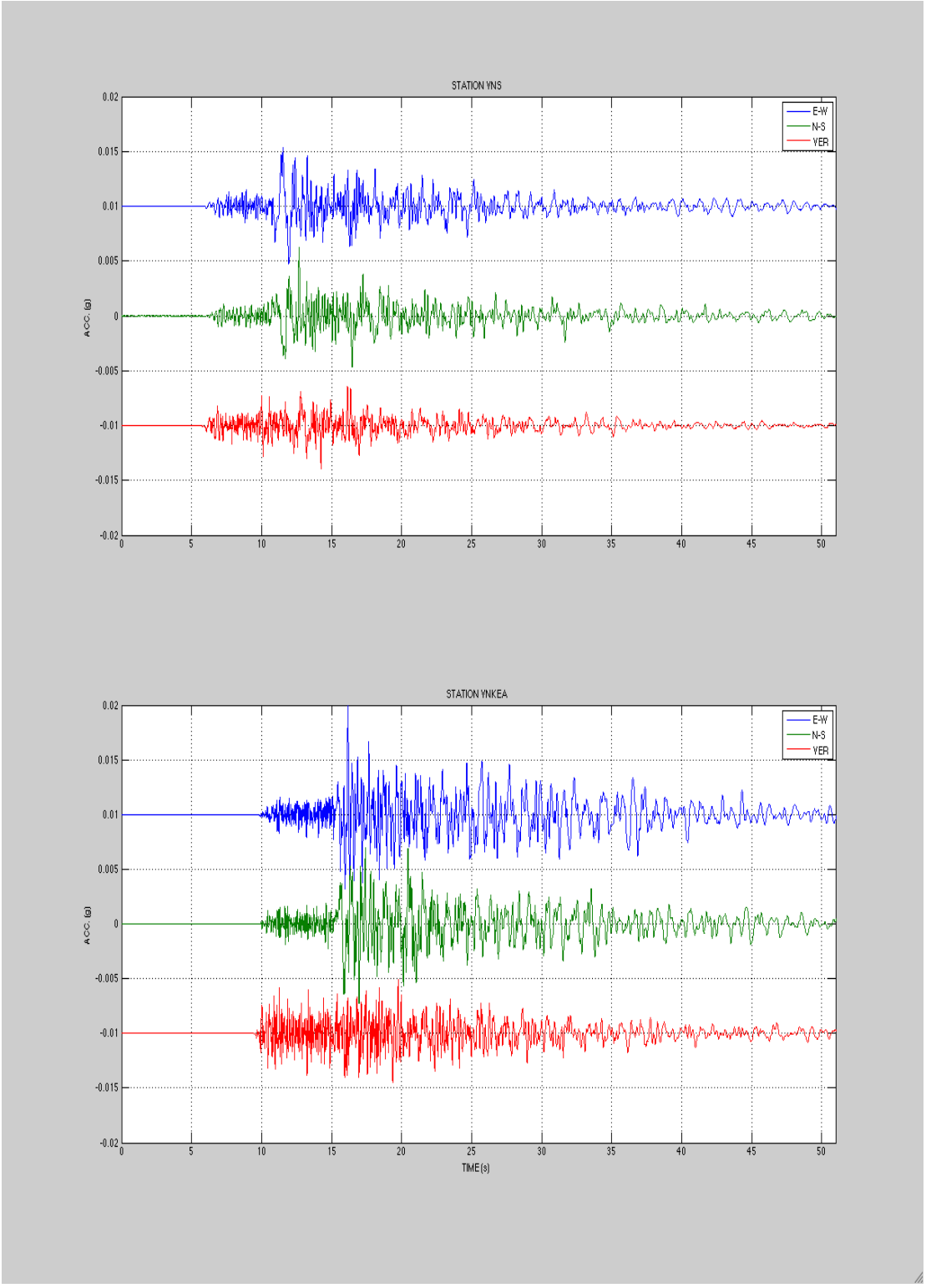
Van Gölü/Van Aftershock

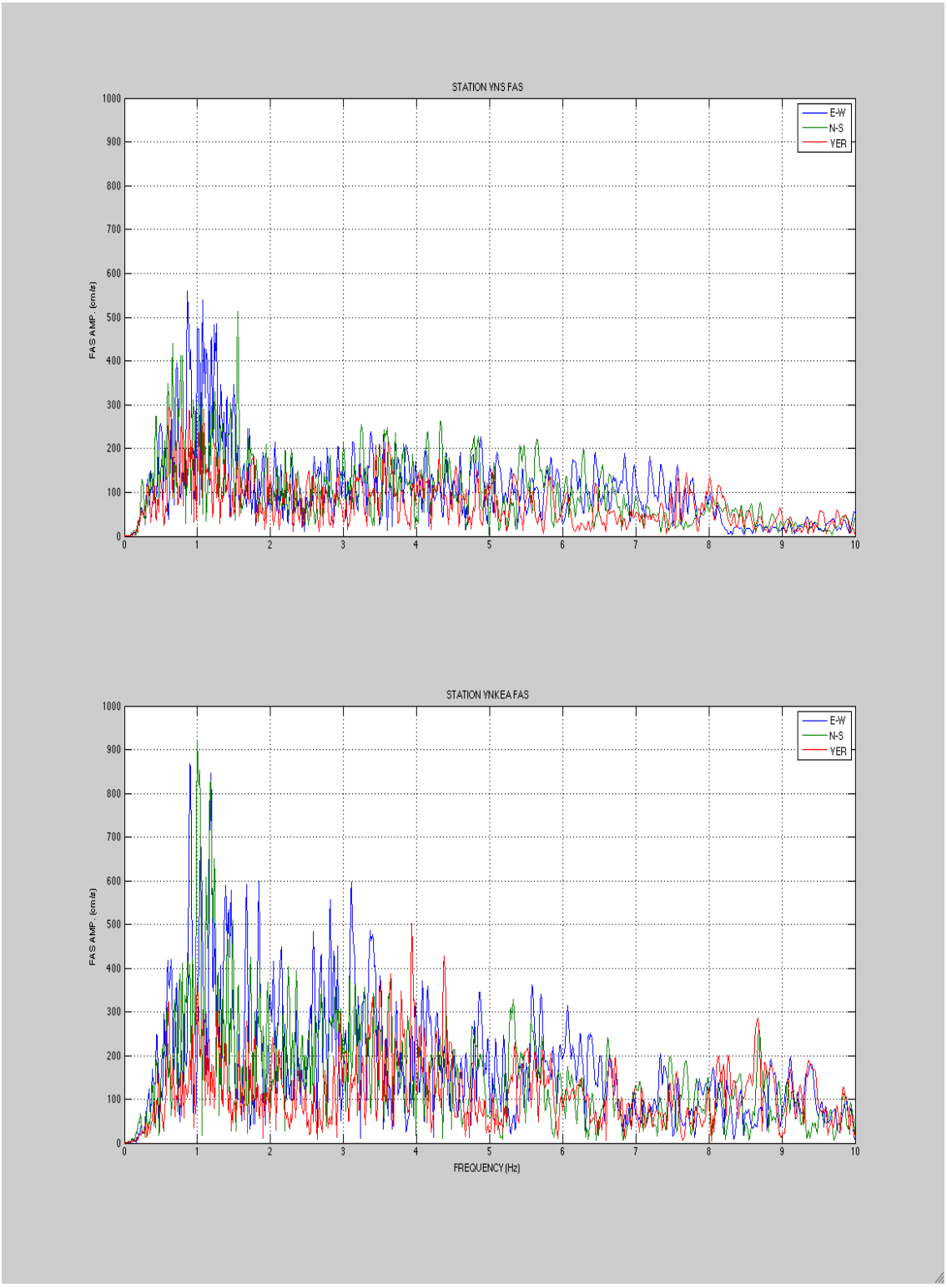
M=5.5

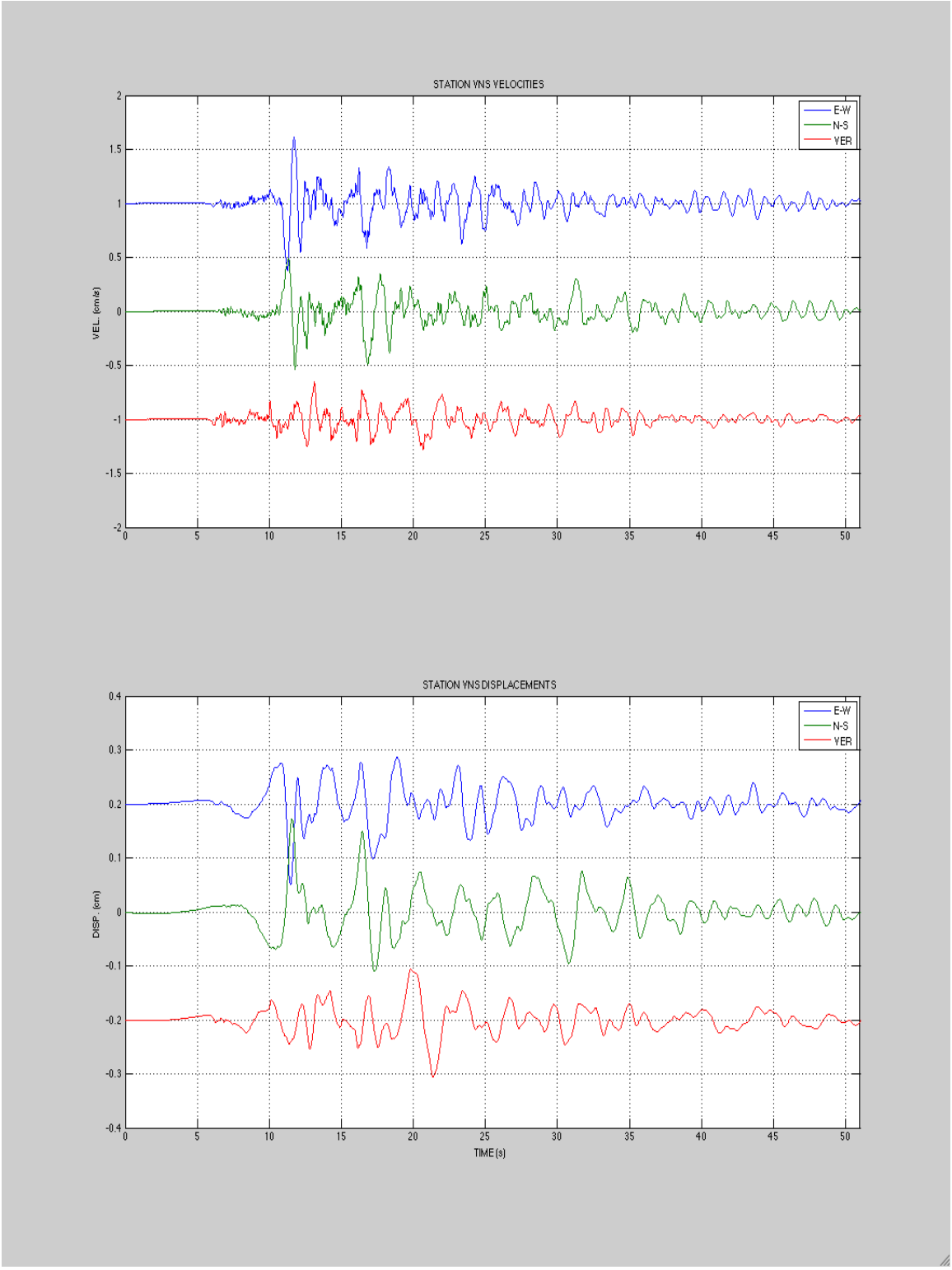
08/11/2011

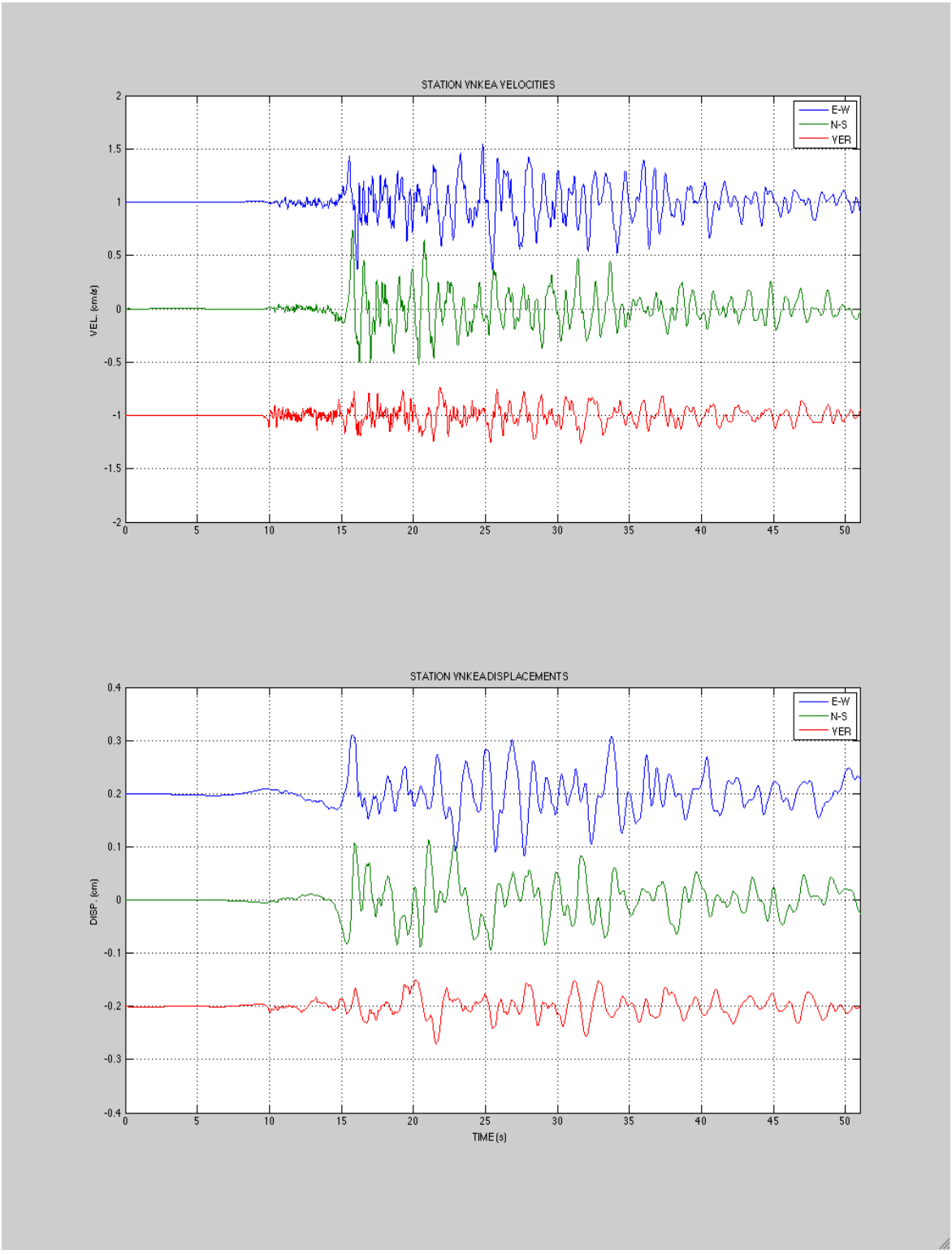
22:05:51

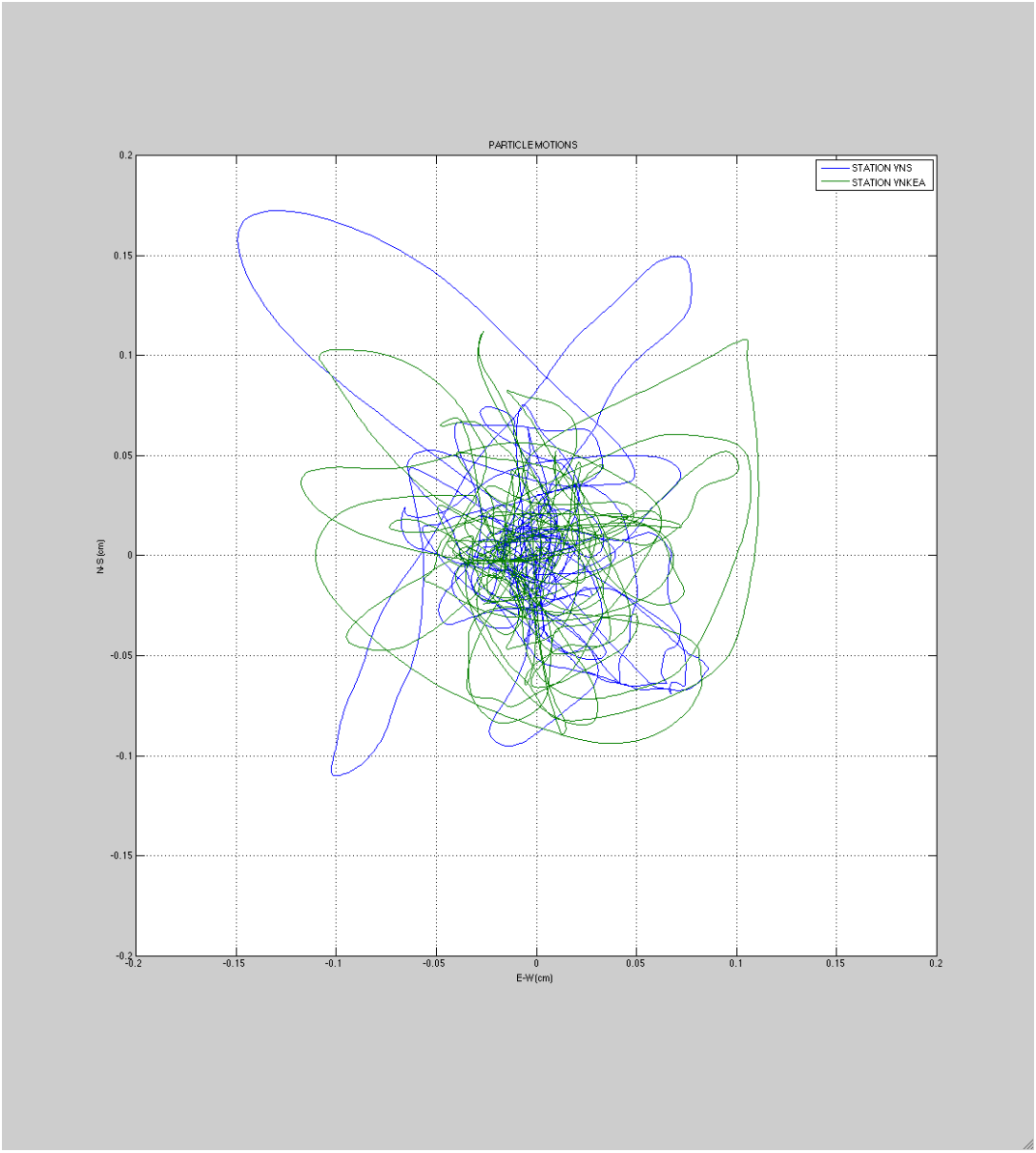
VAN RECORDS

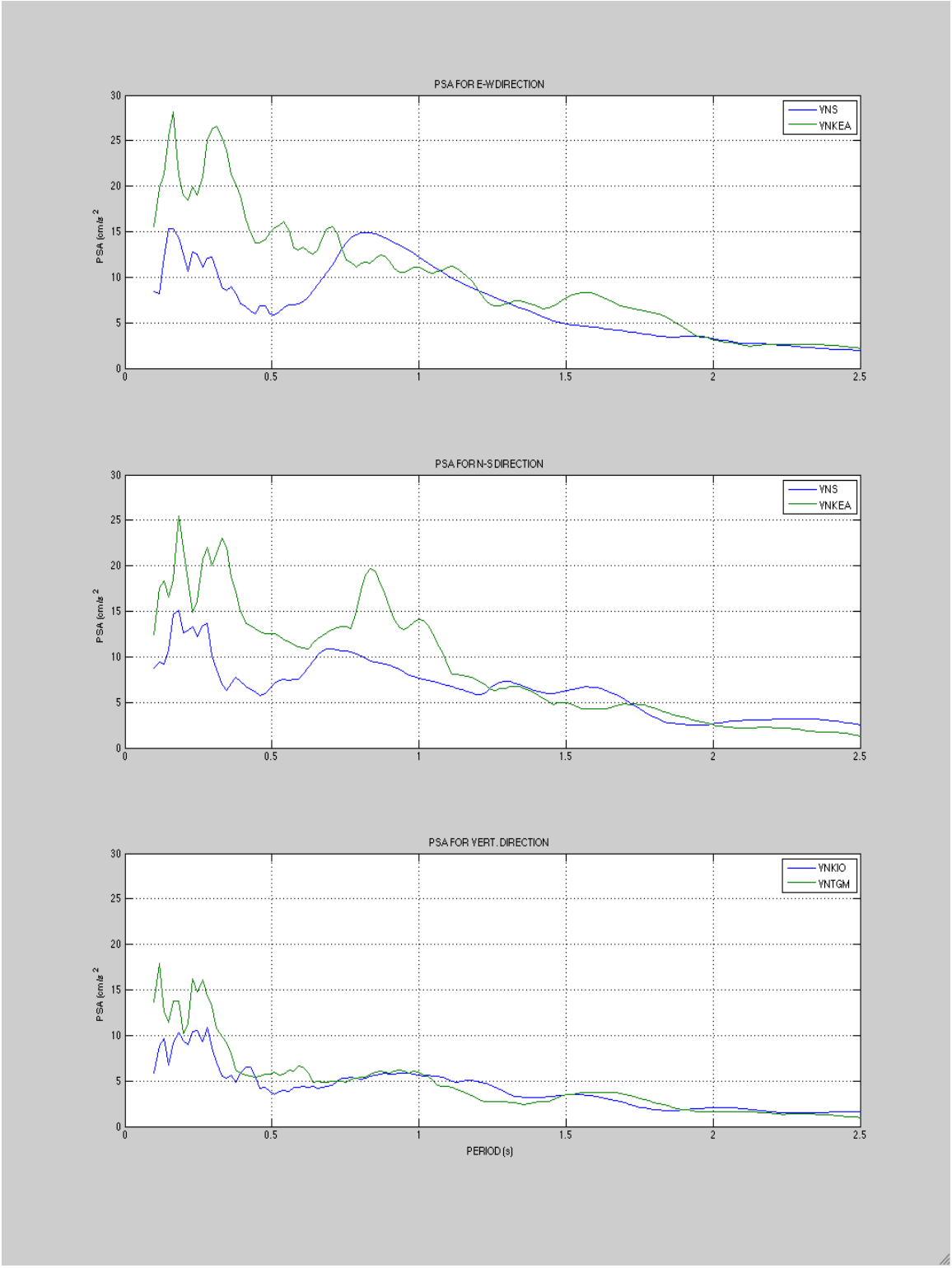

STATION YNS
E-W
N-S
VER
ACC. (g)
STATION YNKEA
E-W
N-S
VER
ACC. (g)
TIME (s)

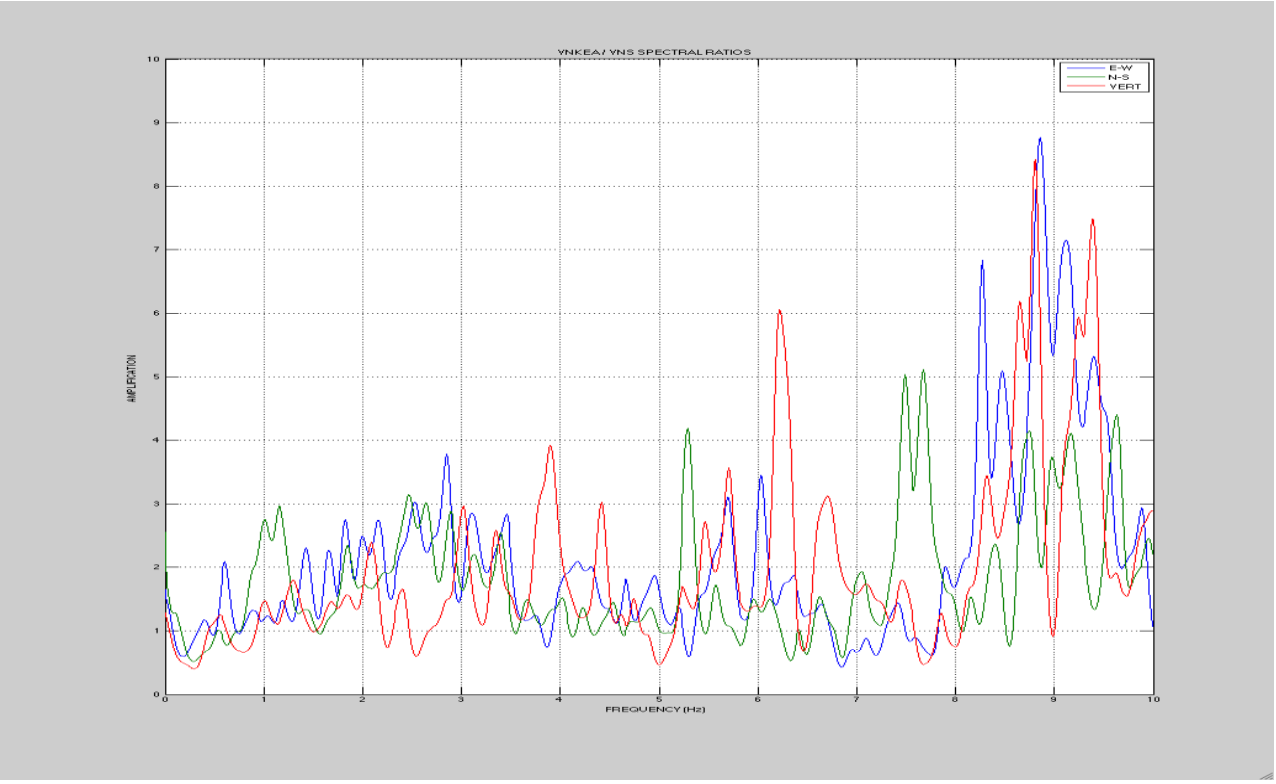

STATION YNS FAS
E-W
N-S
YER
FAS AMP. (cm/s)
STATION YNKEA FAS
E-W
N-S
YER
FAS AMP. (cm/s)
FREQUENCY (Hz)


STATION YNS VELOCITIES
E-W
N-S
VER
VEL. (cm/s)
STATION YNS DISPLACEMENTS
E-W
N-S
VER
DISP. (cm)
TIME (s)


STATION YNKEA VELOCITIES
E-W
N-S
VER
VEL. (cm/s)
STATION YNKEA DISPLACEMENTS
DISP. (cm)
TIME (s)


PARTICLE MOTIONS
STATION YNS
STATION YNKEA
N-S (cm)
E-W (cm)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2


PSA FOR E-W DIRECTION
YNS
YNKEA
PSA (cm/s²)
PSA FOR N-S DIRECTION
YNS
YNKEA
PSA (cm/s²)
PSA FOR VERT. DIRECTION
YNKIO
YNTGM
PSA (cm/s²)
PERIOD (s)


YNKEA/ YNS SPECTRAL RATIOS
E-W
N-S
VERT
AMPLIFICATION
FREQUENCY (Hz)

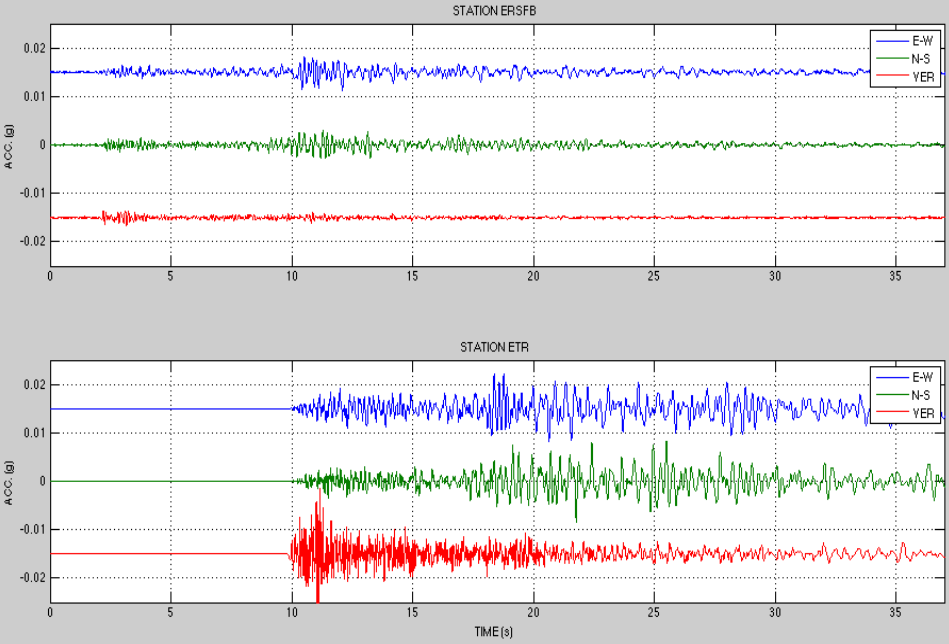
Mollakasım/Van Aftershock

M=5.2

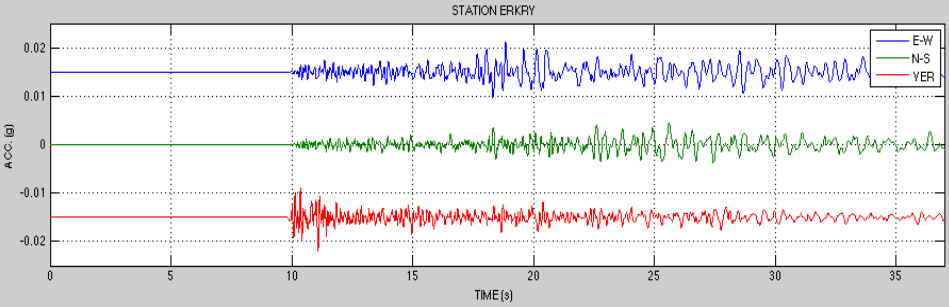
14/11/2011

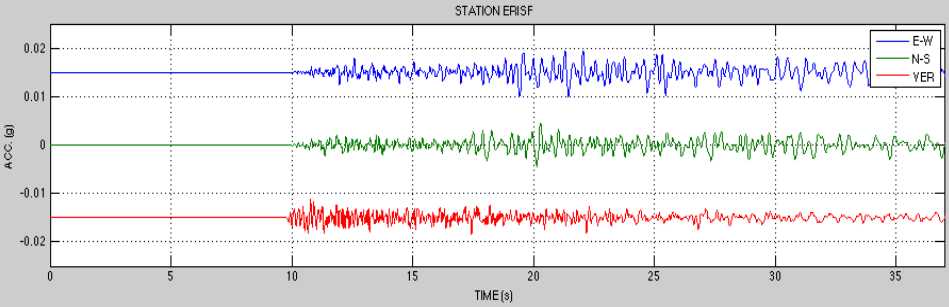
22:08:15

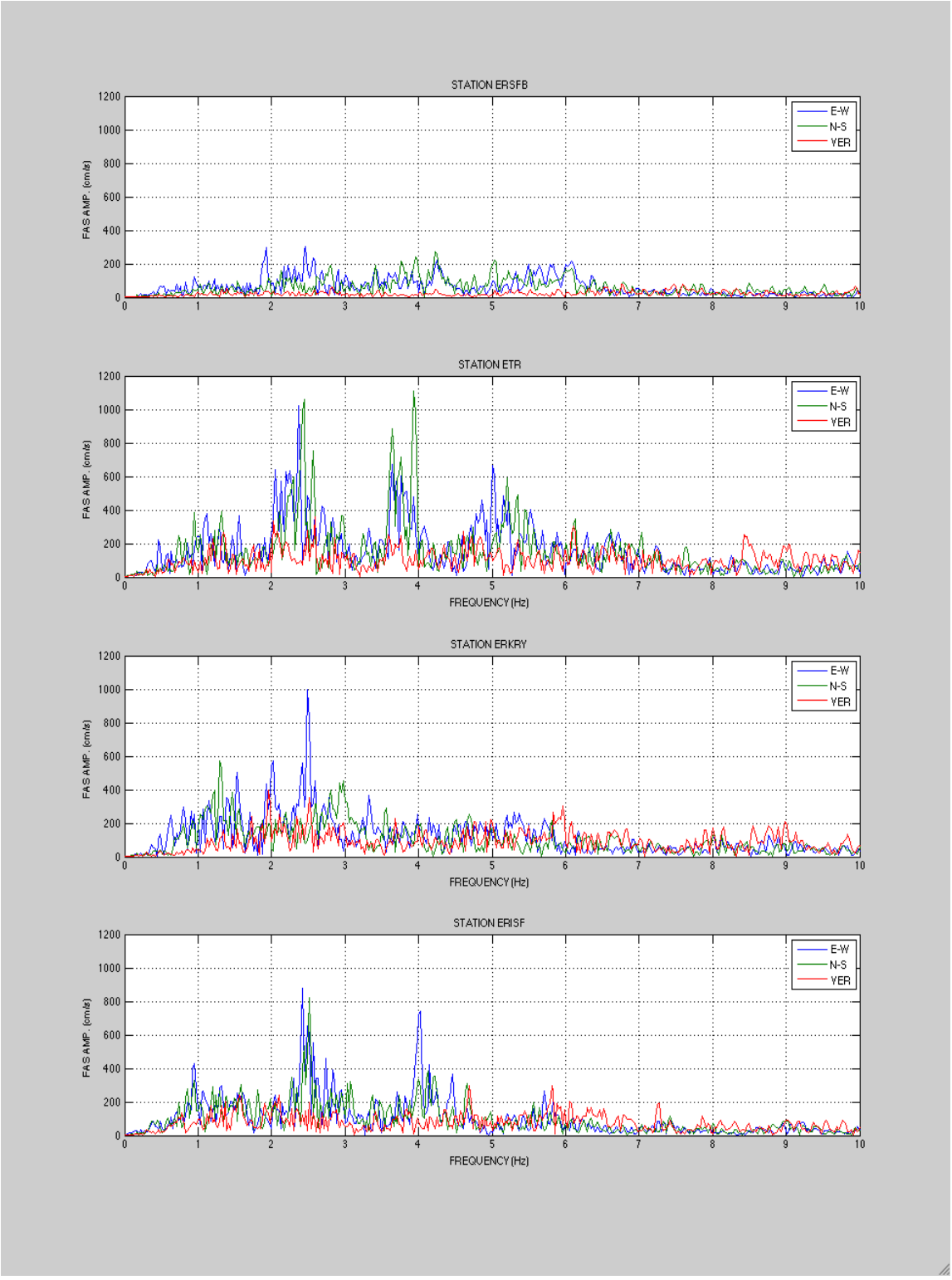
ERCİŞ RECORDS

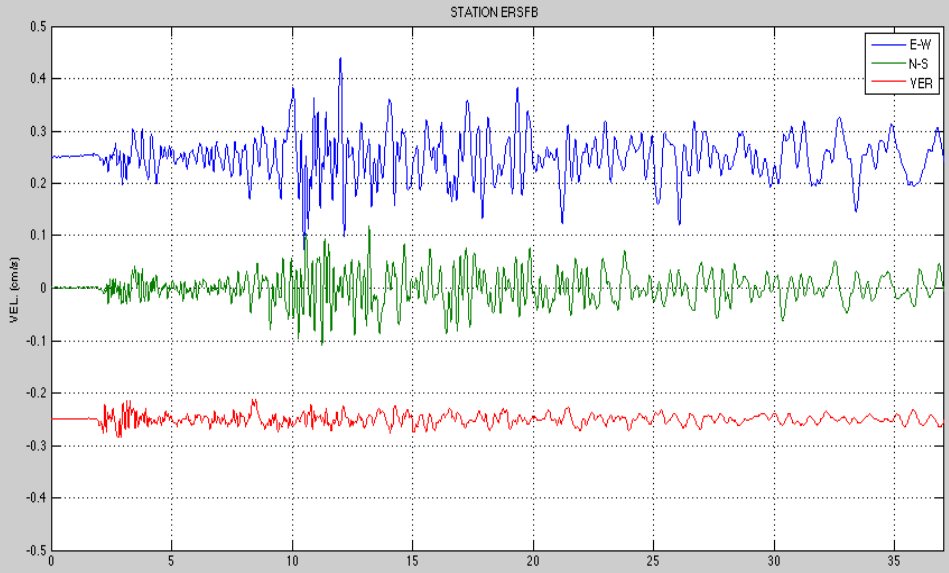

STATION ERSFB
E-W
N-S
VER
ACC. (g)

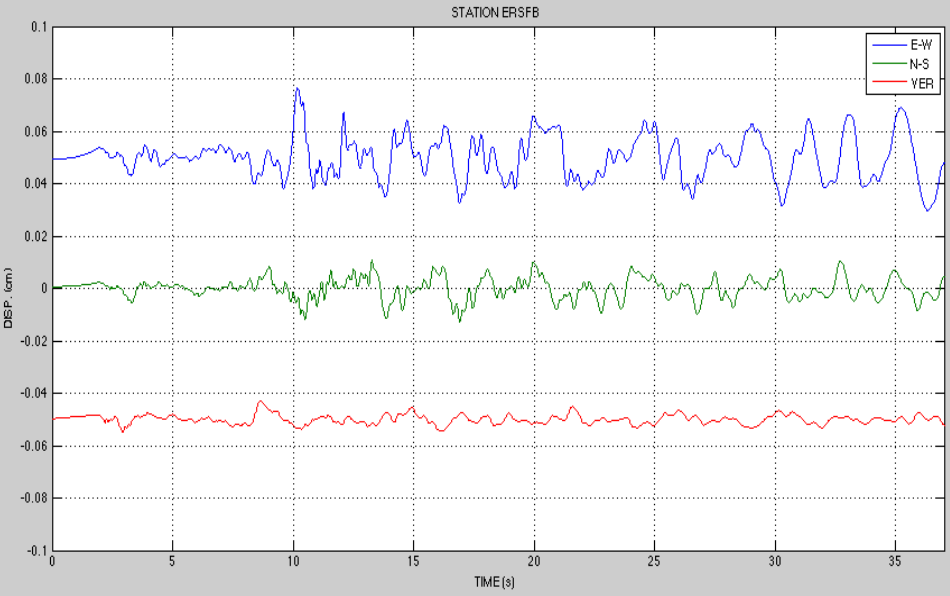
STATION ETR
E-W
N-S
VER
ACC. (g)
TIME (s)

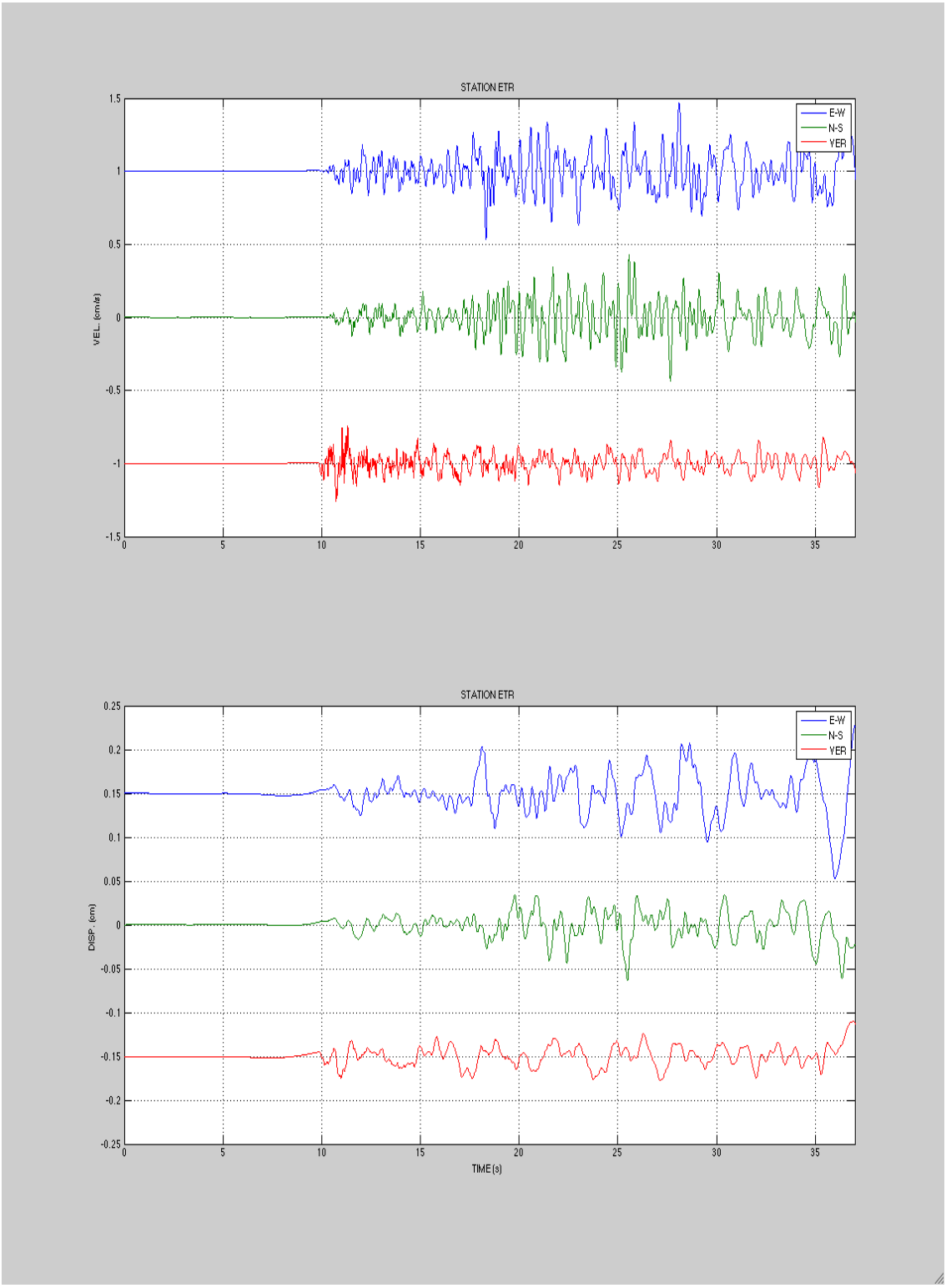

STATION ERKRY
E-W
N-S
VER
ACC. (g)
TIME (s)

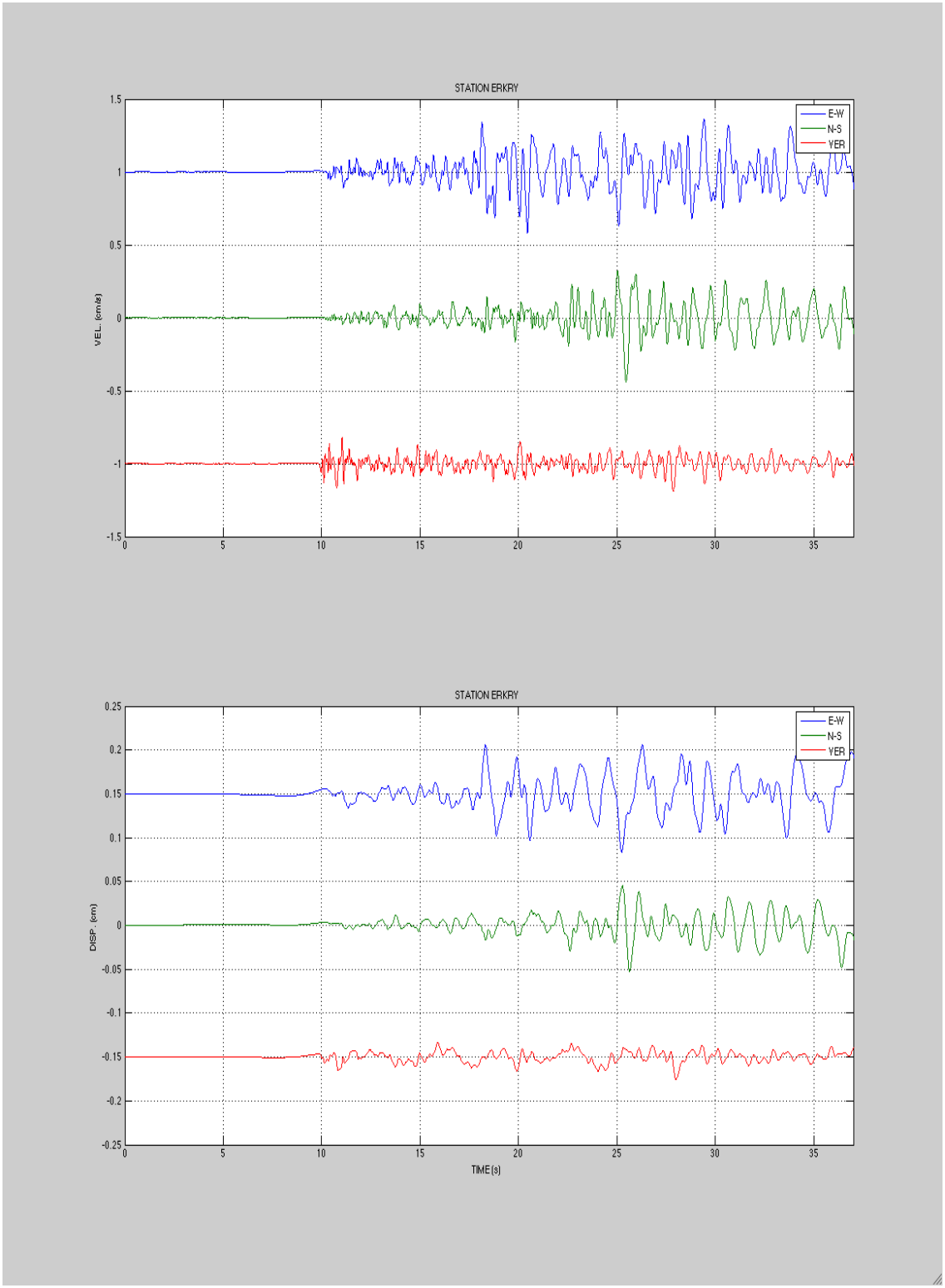

STATION ERISF
E-W
N-S
VER
ACC. (g)
TIME (s)

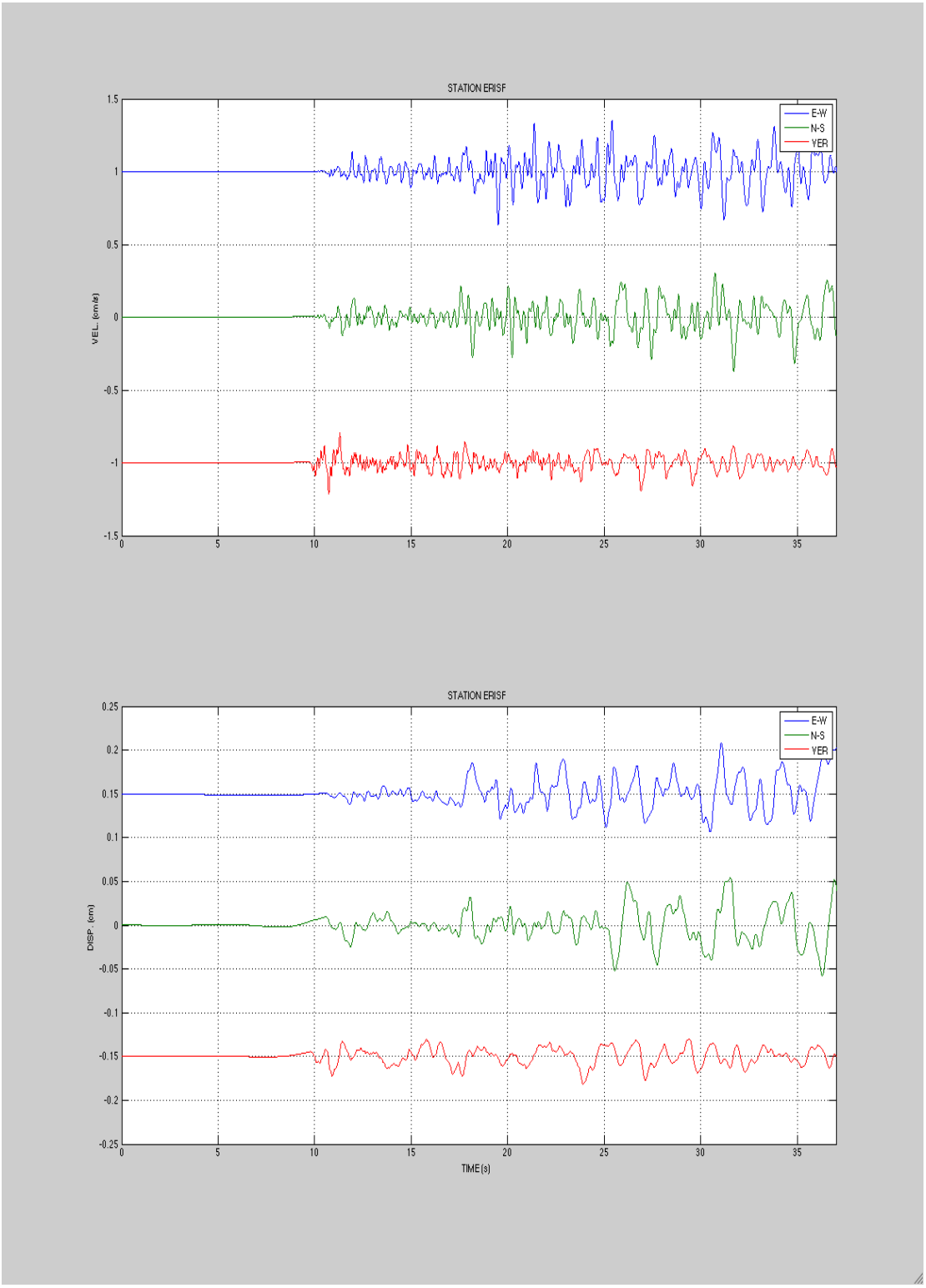

STATION ERSFB
STATION ETR
STATION ERKRY
STATION ERISF
E-W
N-S
YER
FAS AMP. (cm/s)
FREQUENCY (Hz)

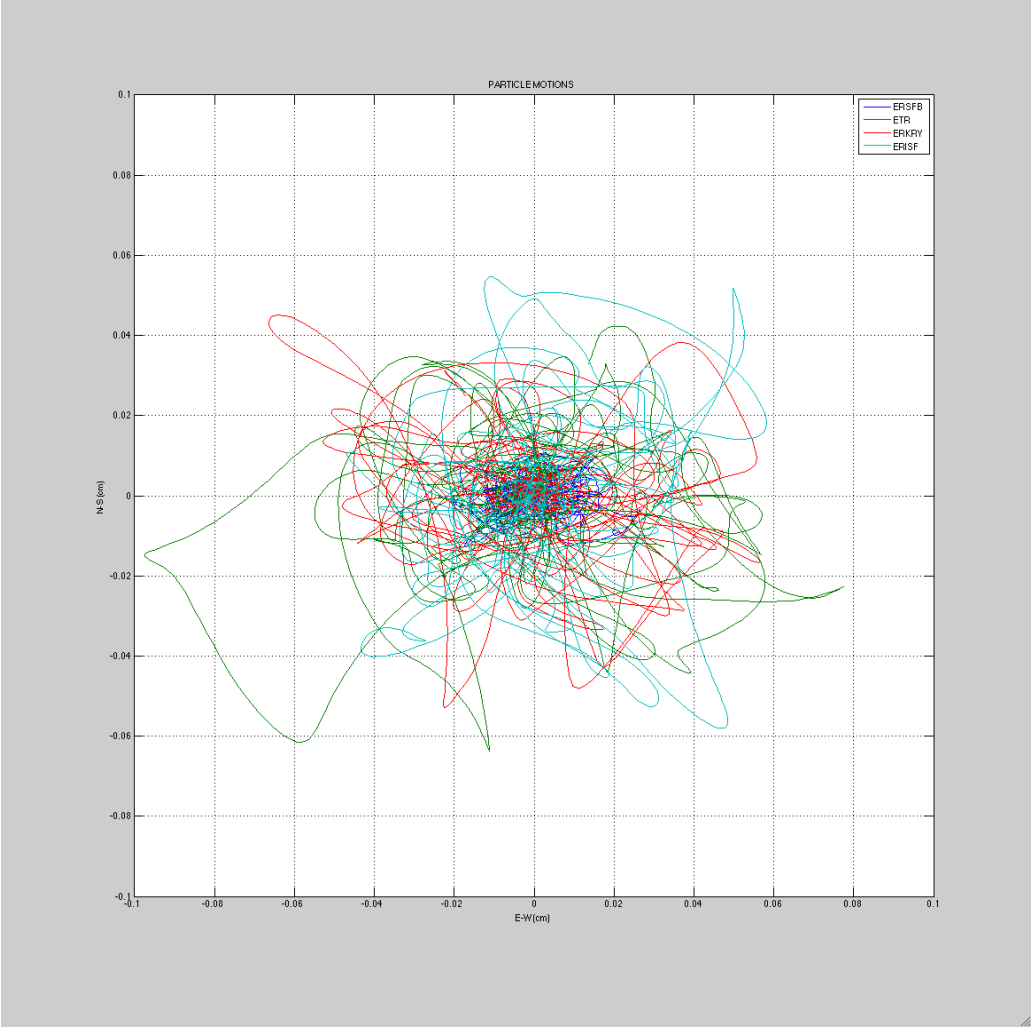

STATION ERSFB
E-W
N-S
VER
VEL. (cm/s)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0
5
10
15
20
25
30
35

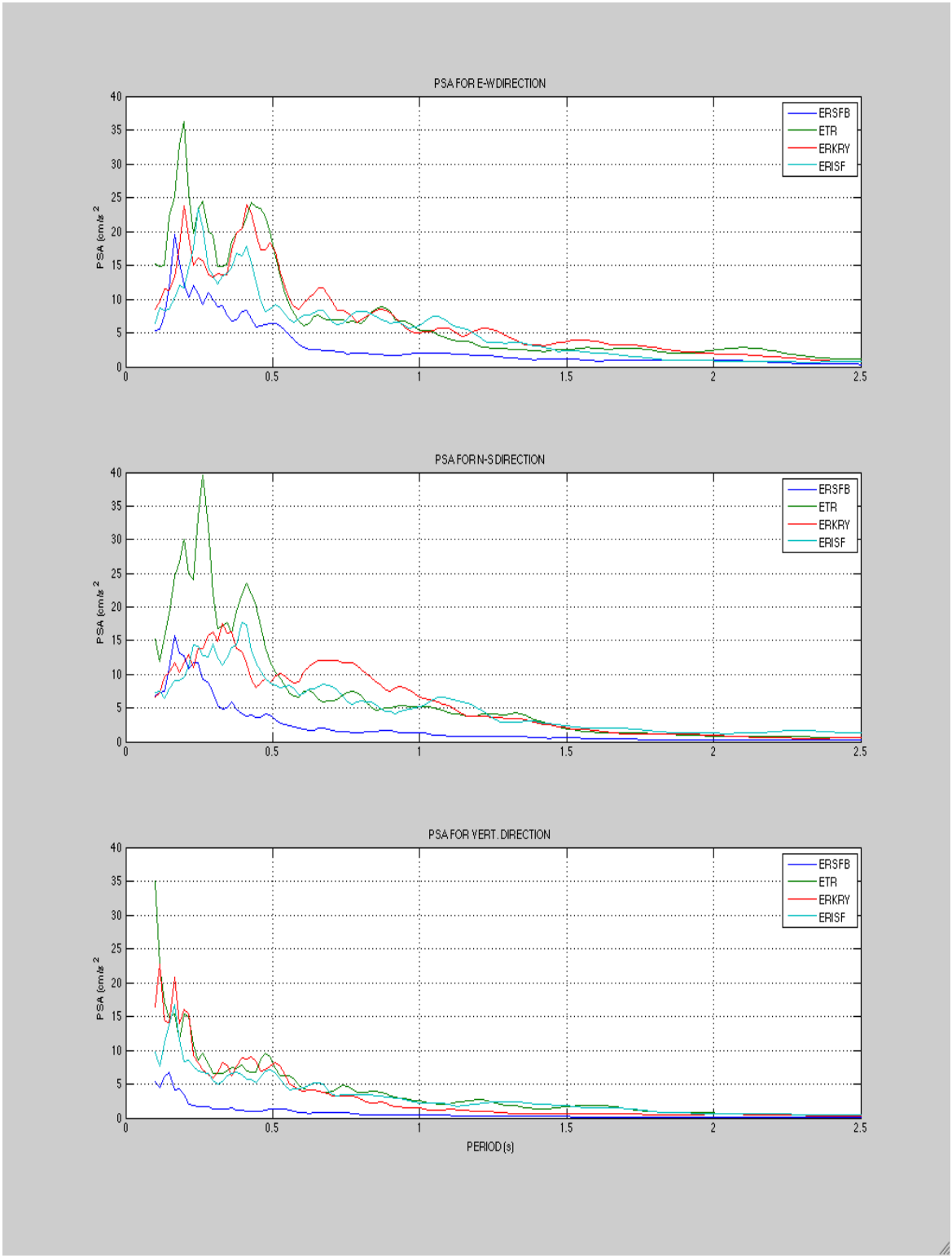

STATION ERSFB
E-W
N-S
VER
DISP. (cm)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
0
5
10
15
20
25
30
35
TIME (s)

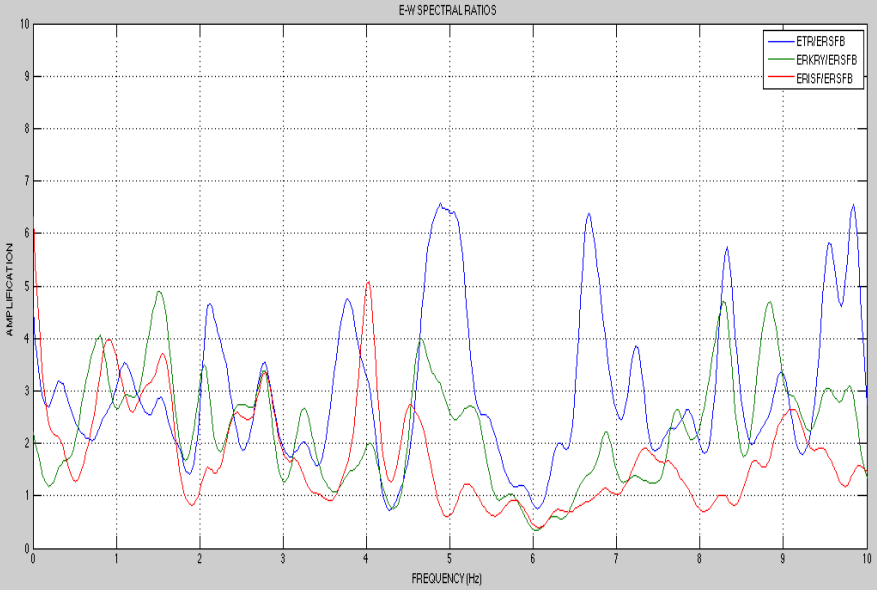

STATION ETR
E-W
N-S
VER
VEL. (cm/s)
STATION ETR
E-W
N-S
VER
DISP. (cm)
TIME (s)

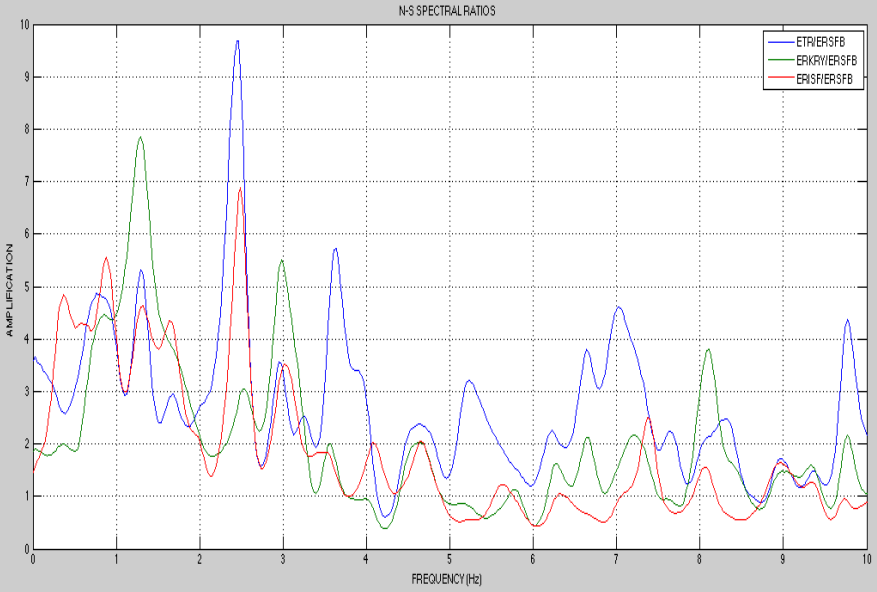

STATION ERKRY
E-W
N-S
VER
VEL. (cm/s)
STATION ERKRY
E-W
N-S
VER
DISP. (cm)
TIME (s)


STATION ERISF
E-W
N-S
VER
VEL. (cm/s)
STATION ERISF
E-W
N-S
VER
DISP. (cm)
TIME (s)


PARTICLE MOTIONS
ERSFB
ETR
ERKRY
ERISF
N-S (cm)
E-W (cm)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1


PSA FOR E-W DIRECTION
PSA (cm/s^2)
ERSFB
ETR
ERKRY
ERISF
PSA FOR N-S DIRECTION
PSA (cm/s^2)
ERSFB
ETR
ERKRY
ERISF
PSA FOR VERT. DIRECTION
PSA (cm/s^2)
ERSFB
ETR
ERKRY
ERISF
PERIOD (s)


E-W SPECTRAL RATIOS
ETR/ERSFB
ERKRY/ERSFB
ERISF/ERSFB
AMPLIFICATION
FREQUENCY (Hz)


N-S SPECTRAL RATIOS
ETR/ERSFB
ERKRY/ERSFB
ERISF/ERSFB
AMPLIFICATION
FREQUENCY (Hz)

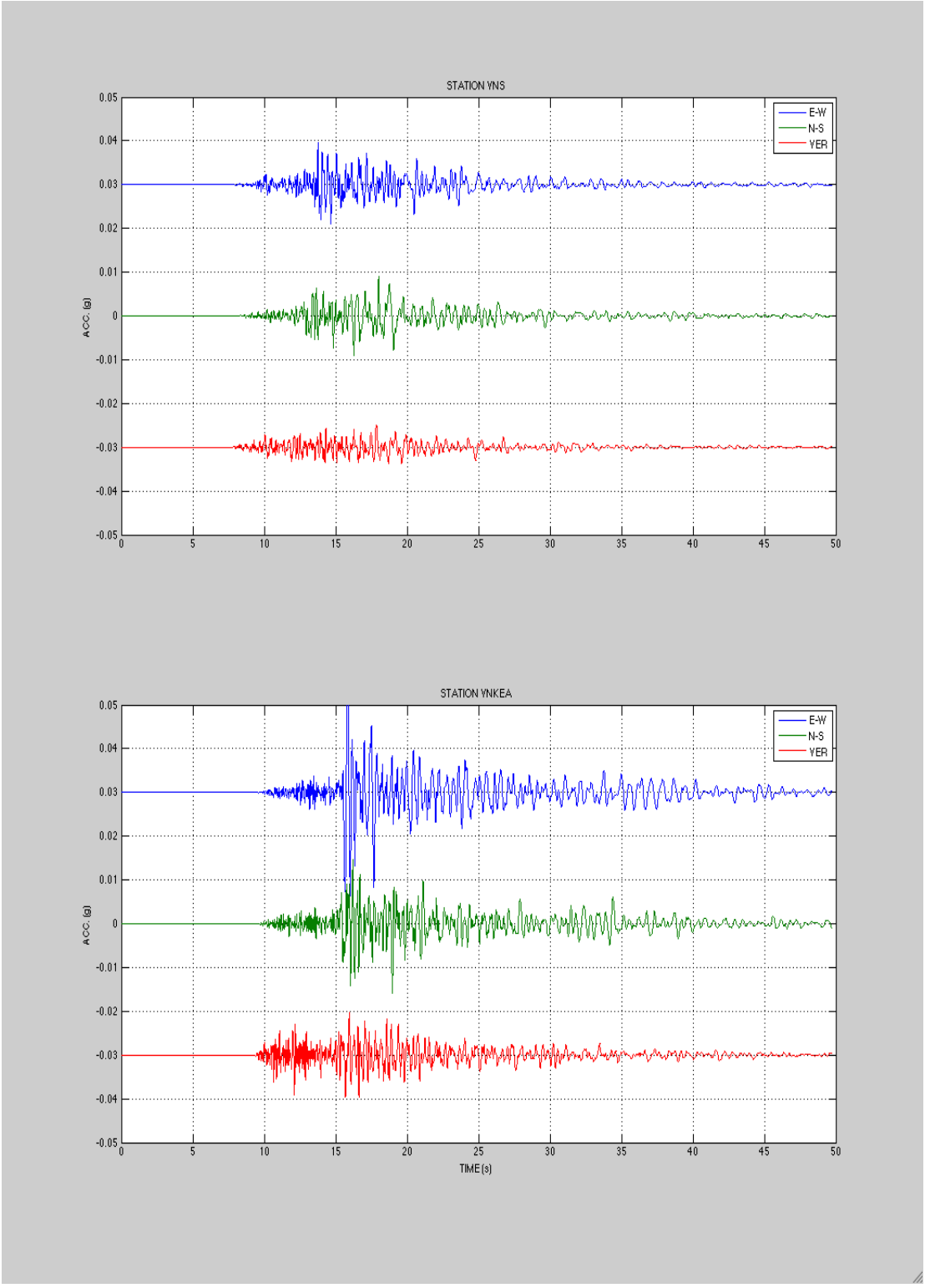
Mollakasım/Van Aftershock

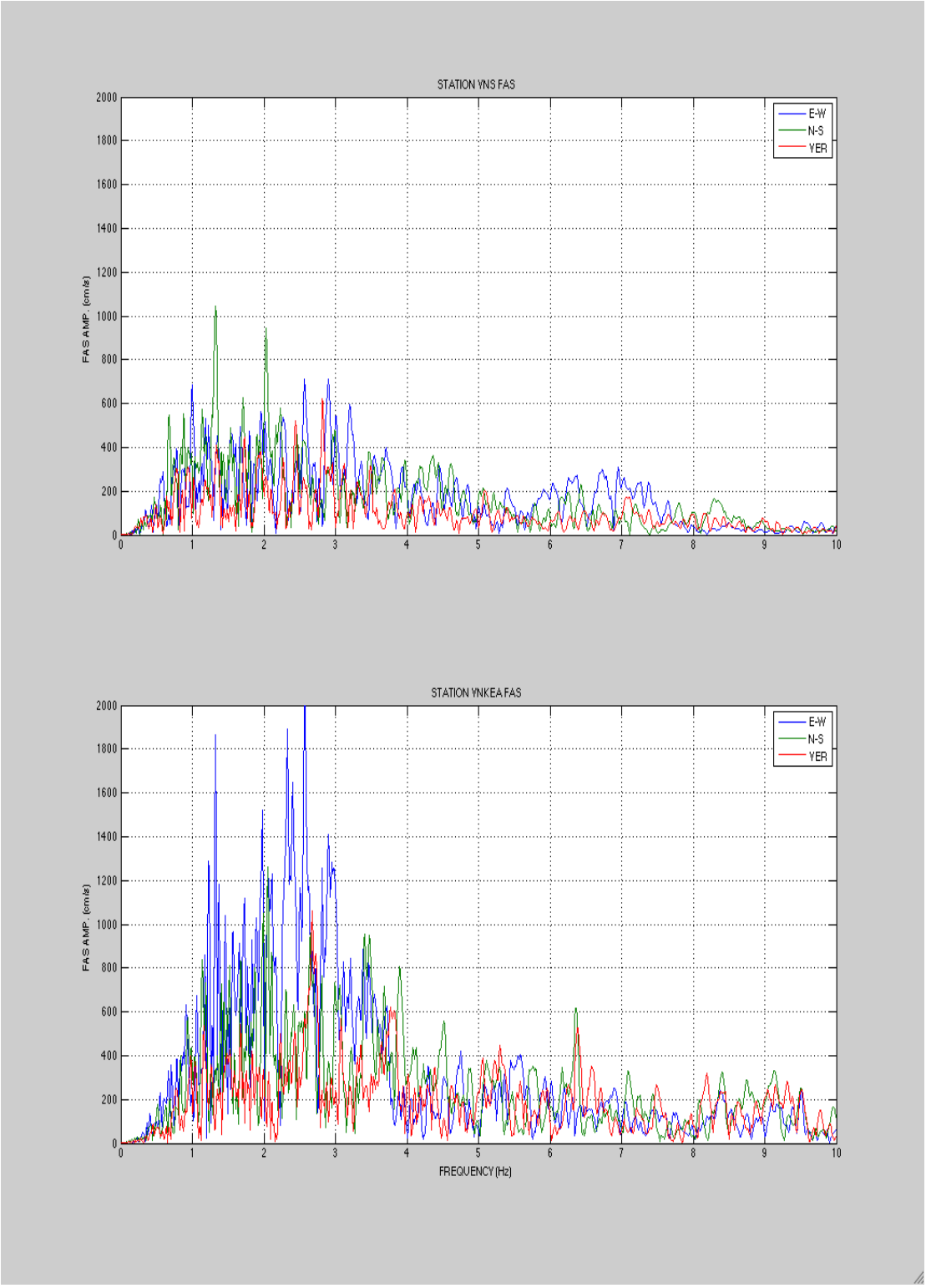
M=5.2

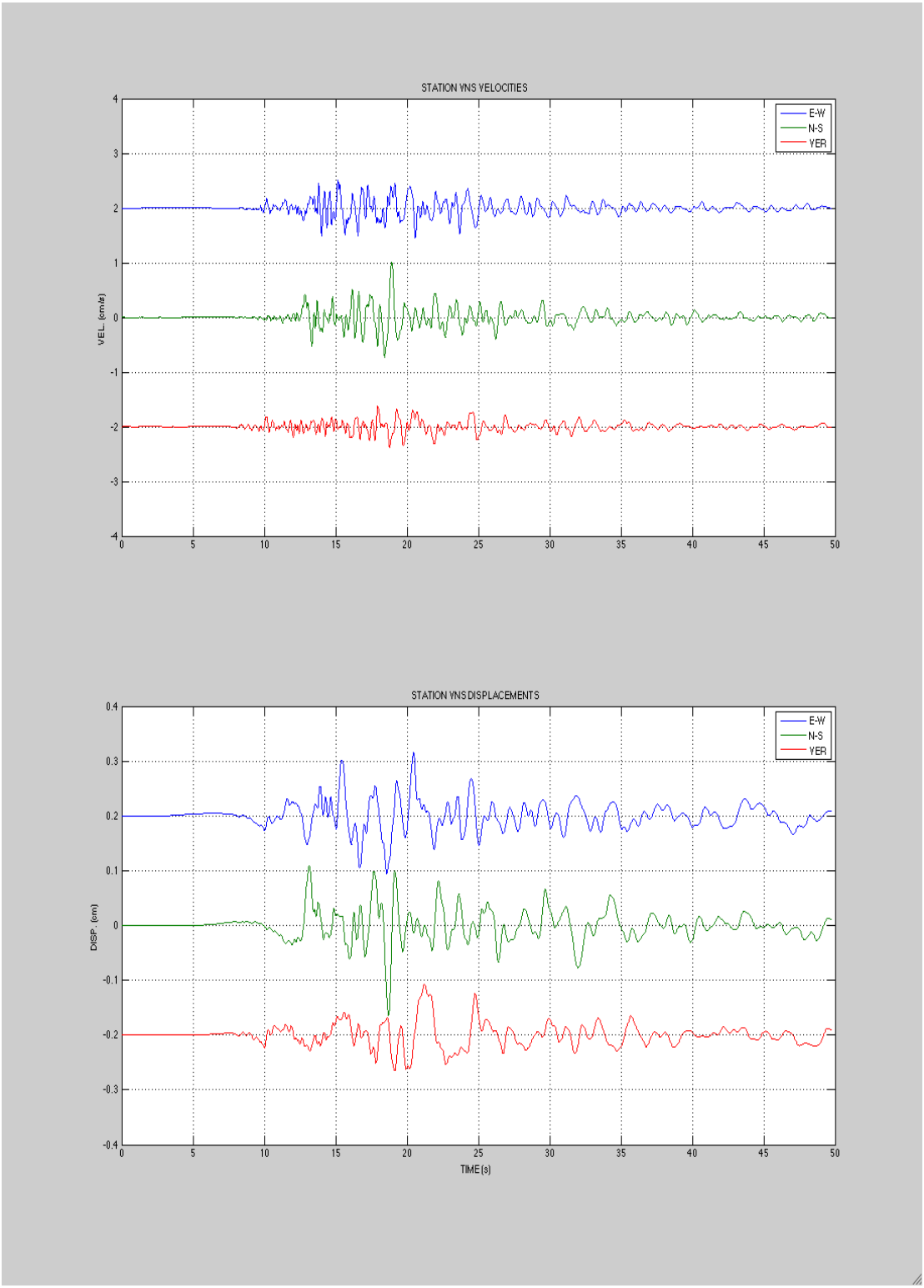
14/11/2011

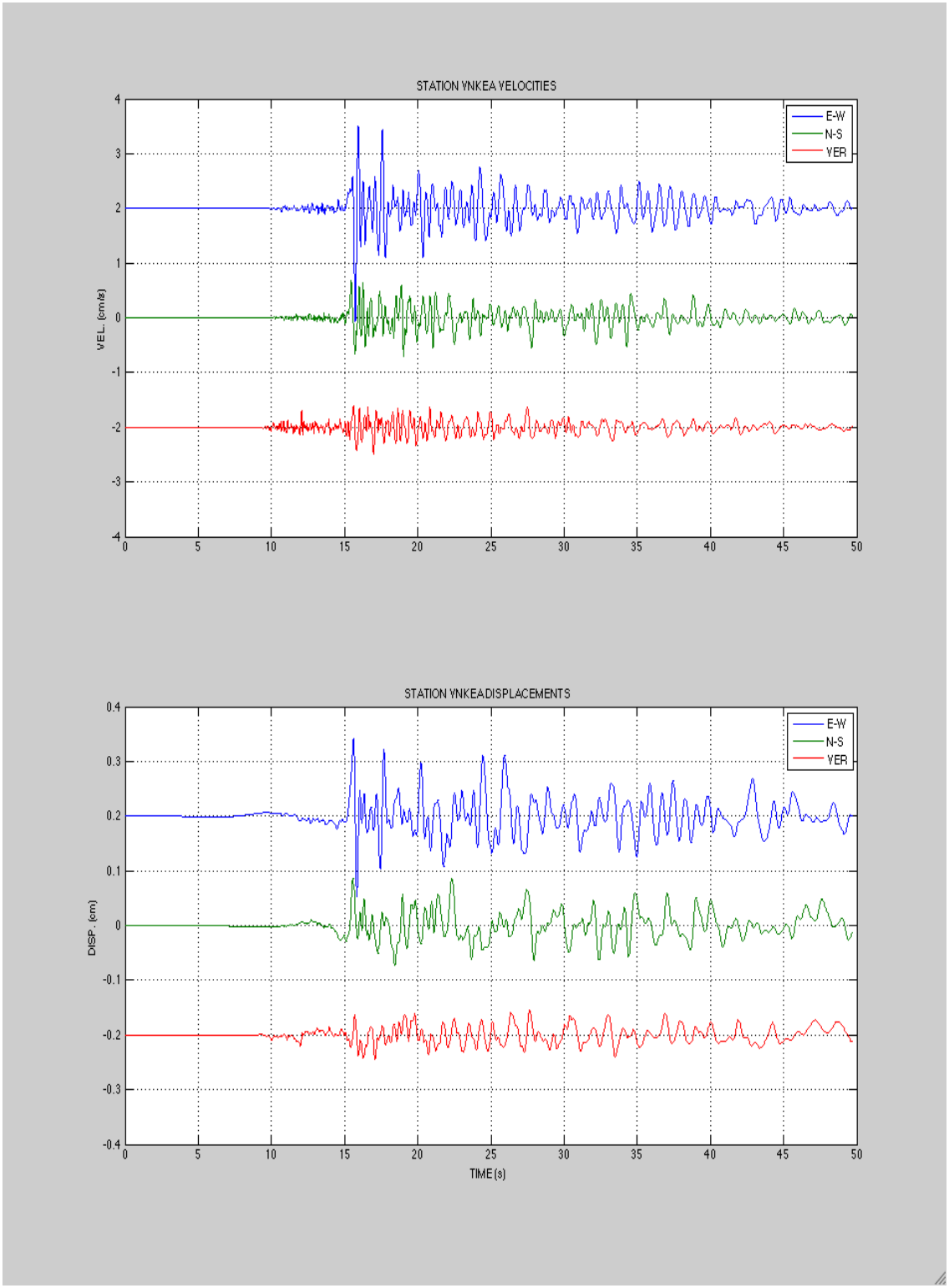
22:08:15

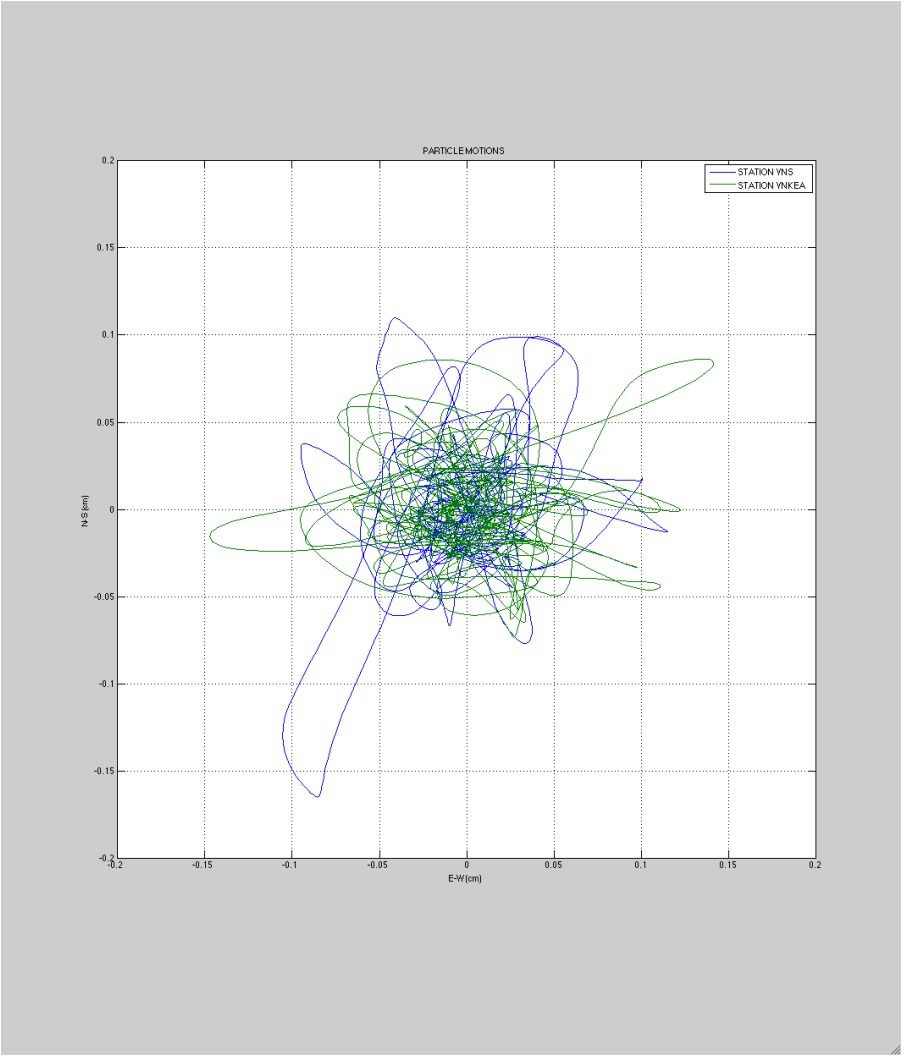
VAN RECORDS

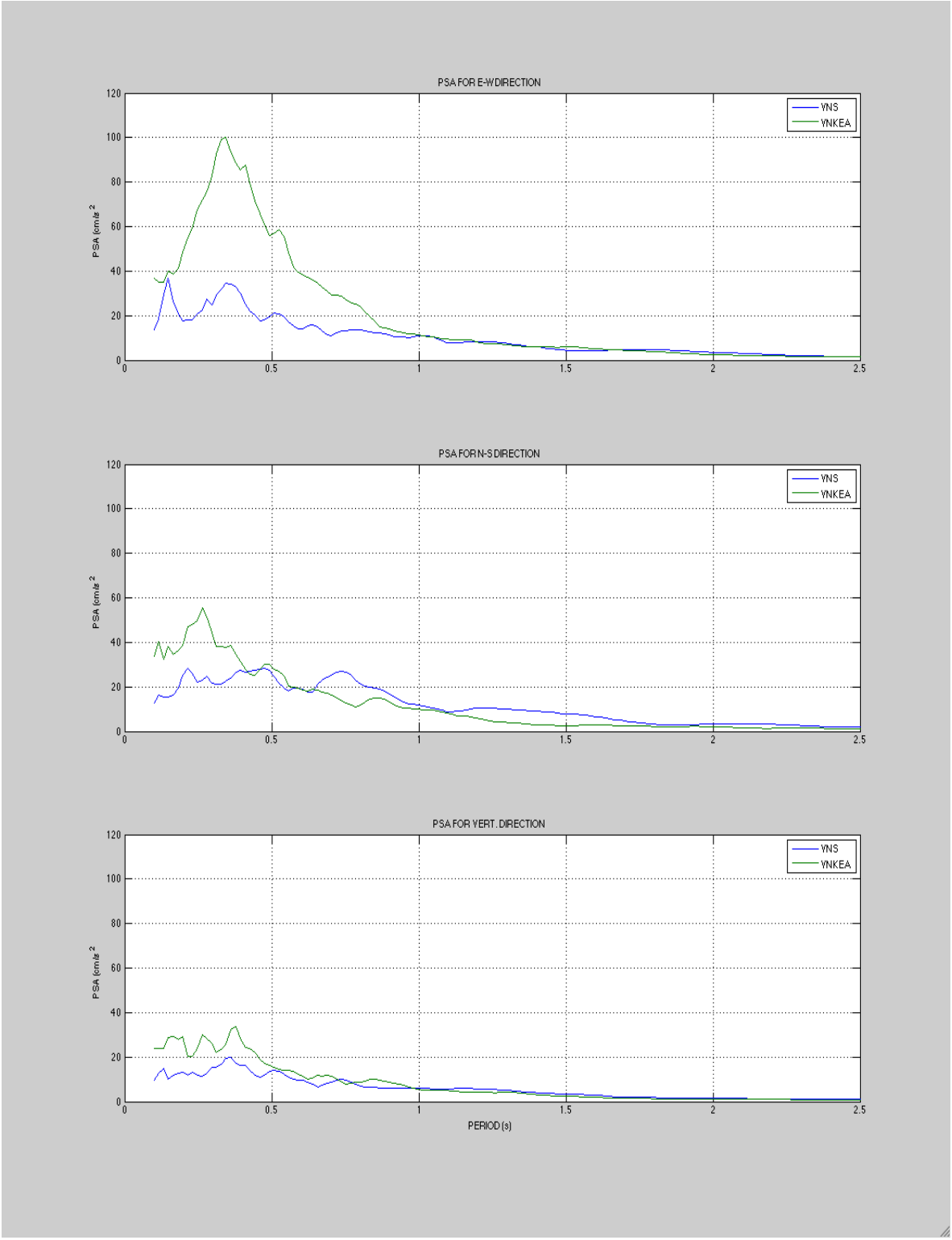

STATION YNS
E-W
N-S
VER
ACC. (g)
STATION YNKEA
E-W
N-S
VER
ACC. (g)
TIME (s)

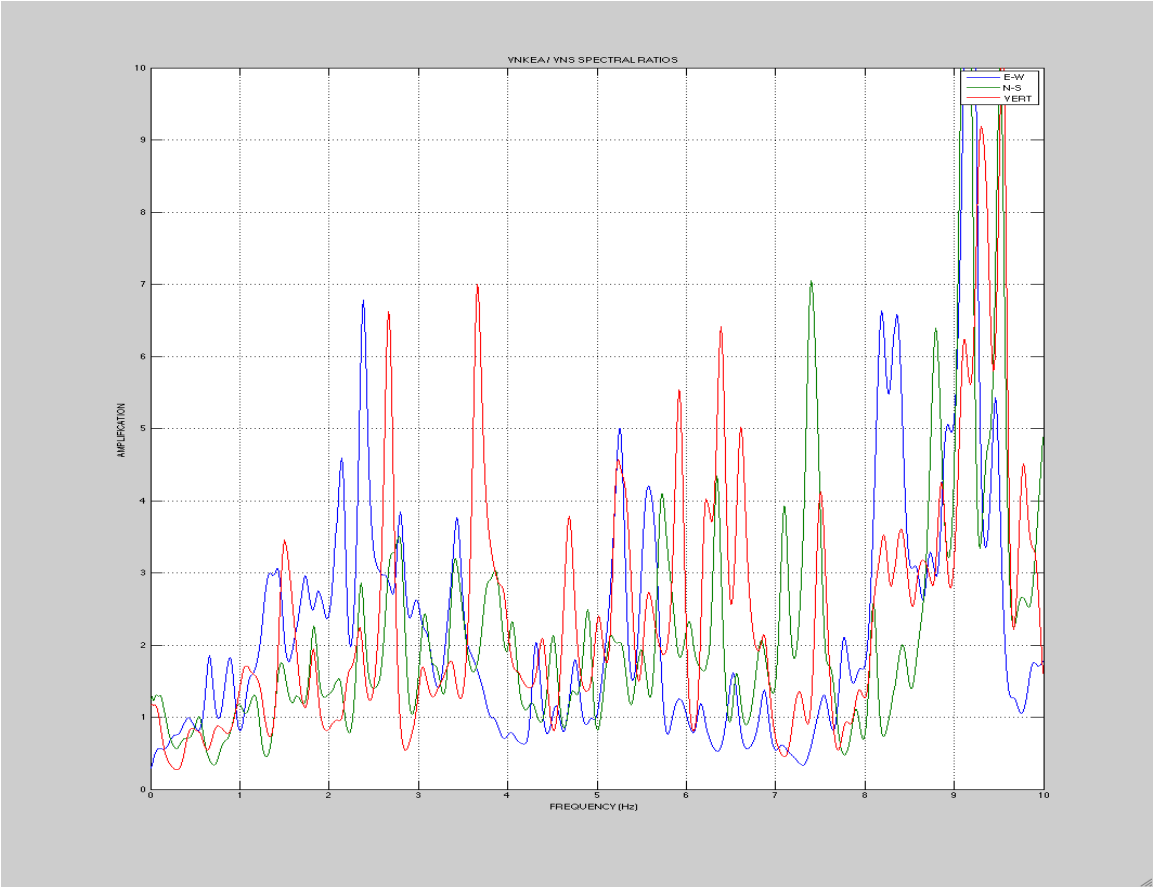

STATION YNS FAS
E-W
N-S
VER
FAS AMP. (cm/s)
STATION YNKEA FAS
E-W
N-S
VER
FAS AMP. (cm/s)
FREQUENCY (Hz)


STATION YNS VELOCITIES
E-W
N-S
VER
VEL. (cm/s)
STATION YNS DISPLACEMENTS
E-W
N-S
VER
DISP. (cm)
TIME (s)


STATION VNKEA VELOCITIES
E-W
N-S
VER
VEL. (cm/s)
STATION VNKEA DISPLACEMENTS
E-W
N-S
VER
DISP. (cm)
TIME (s)


PARTICLE MOTIONS
STATION YNS
STATION YNKEA
N-S (cm)
E-W (cm)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2


PSA FOR E-W DIRECTION
YNS
YNKEA
PSA (cm/s²)
PSA FOR N-S DIRECTION
YNS
YNKEA
PSA (cm/s²)
PSA FOR VERT. DIRECTION
YNS
YNKEA
PSA (cm/s²)
PERIOD (s)


YNKEA/ YNS SPECTRAL RATIOS
E-W
N-S
VERT
AMPLIFICATION
FREQUENCY (Hz)
0
1
2
3
4
5
6
7
8
9
10

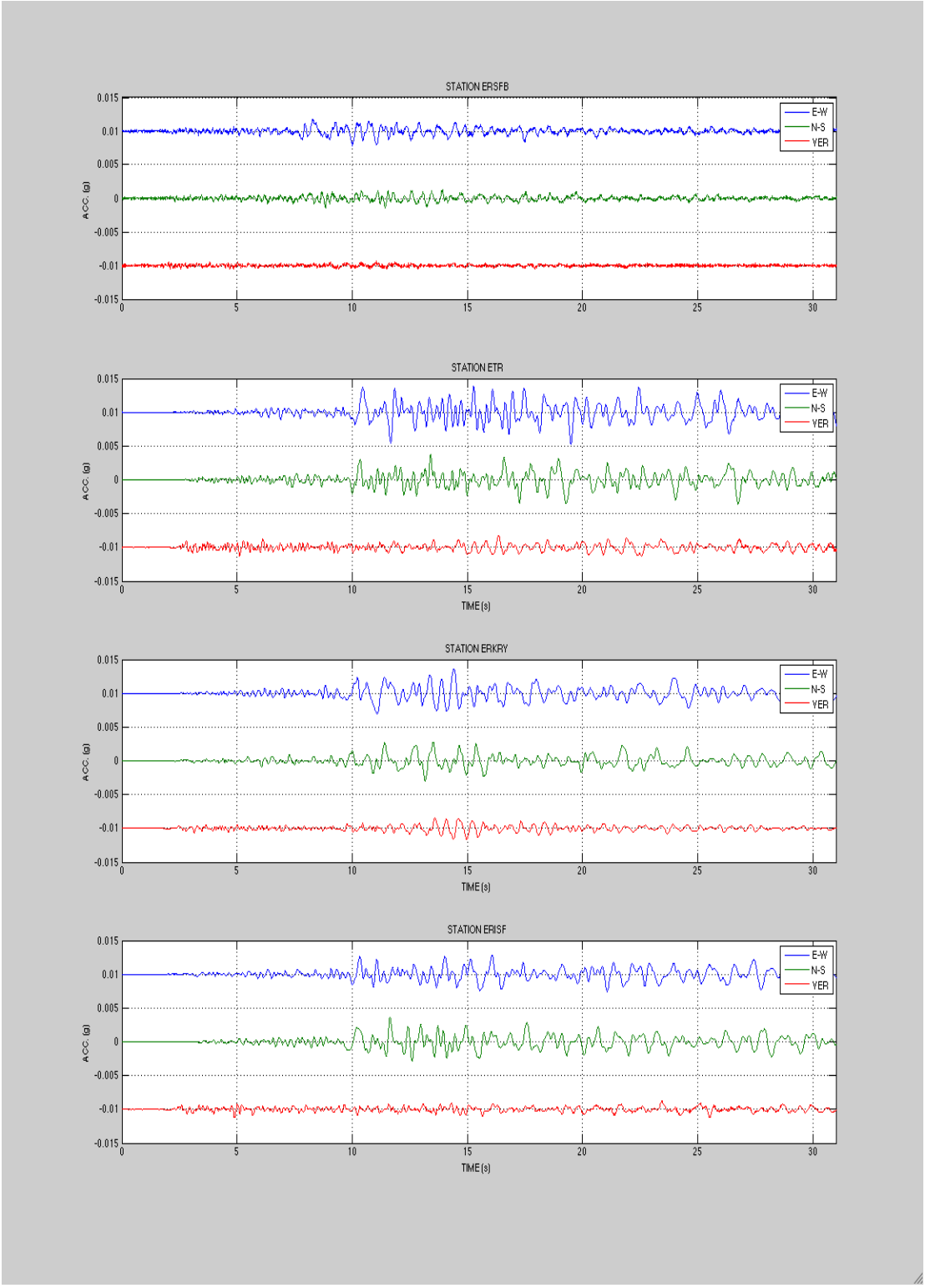
Bodurağaç/Van Aftershock

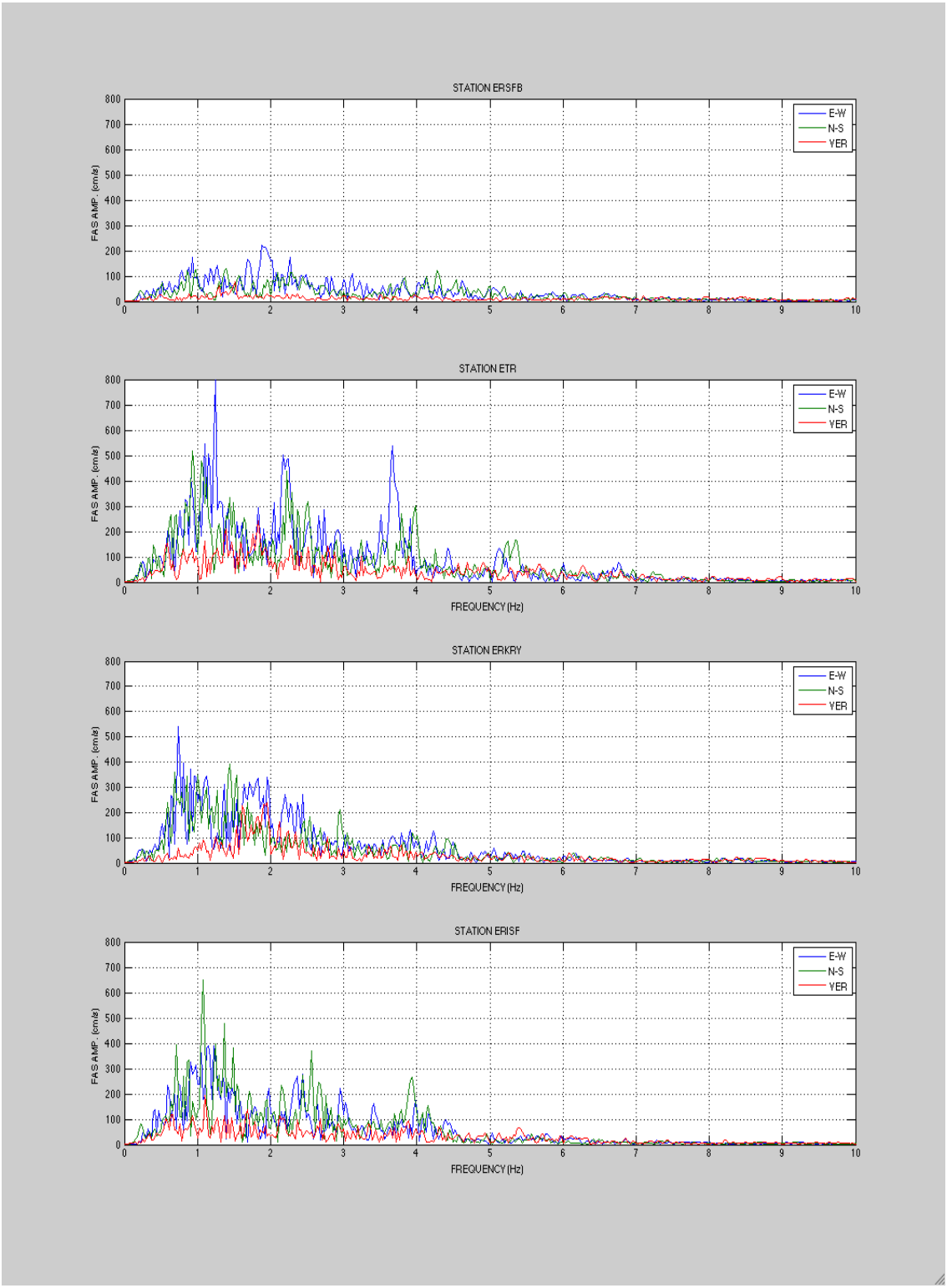
M=4.9

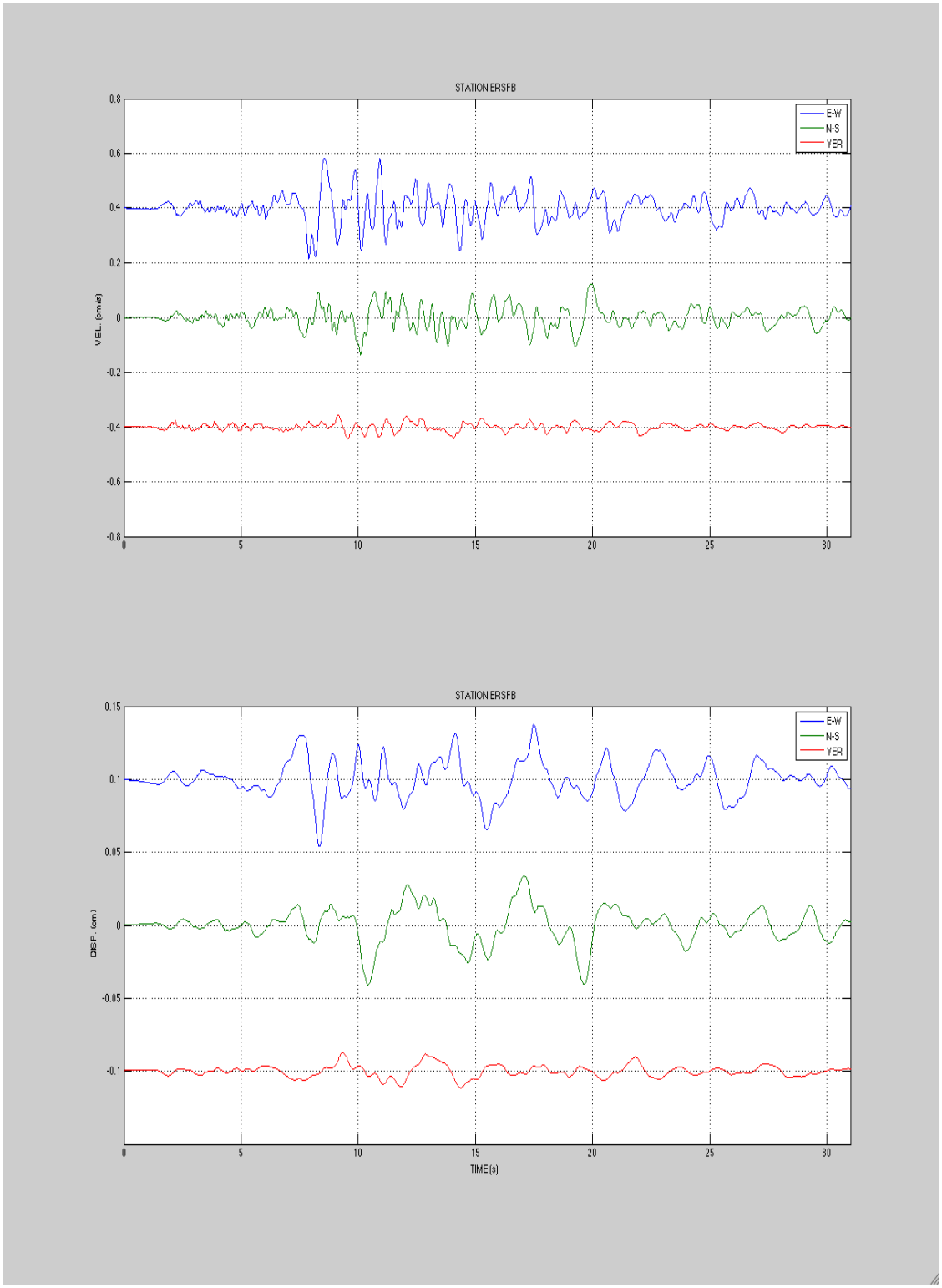
18/11/2011

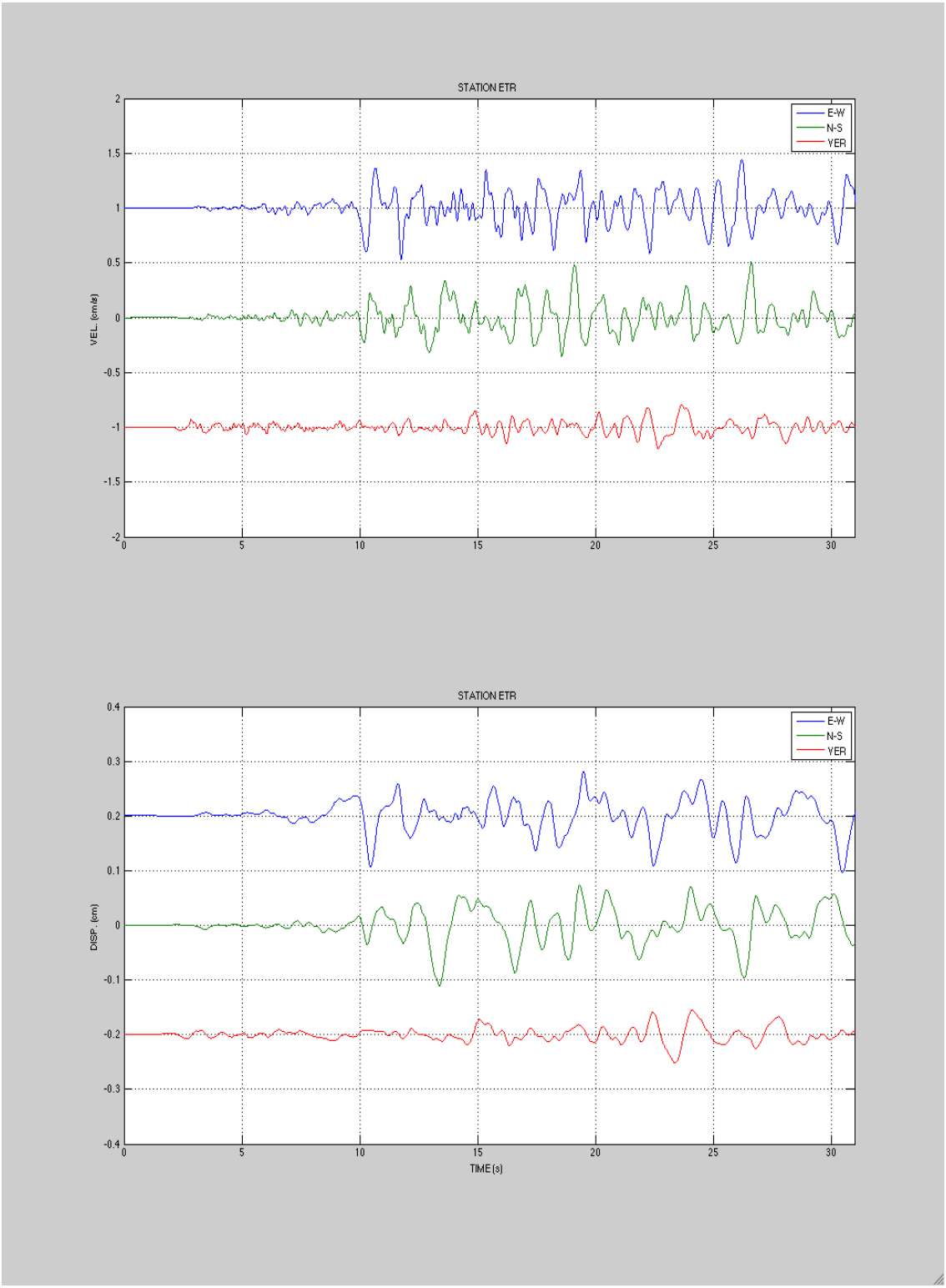
17:39:40

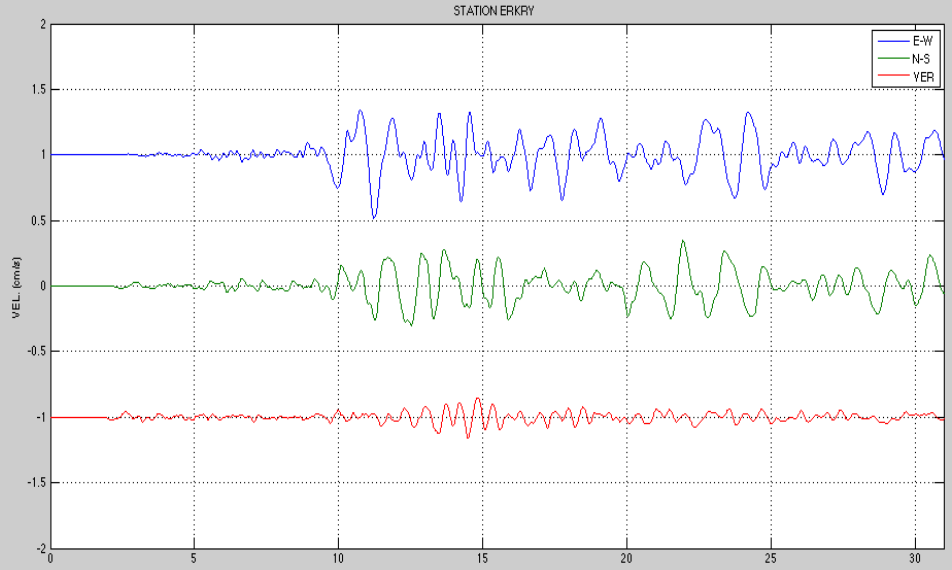
ERCİŞ RECORDS

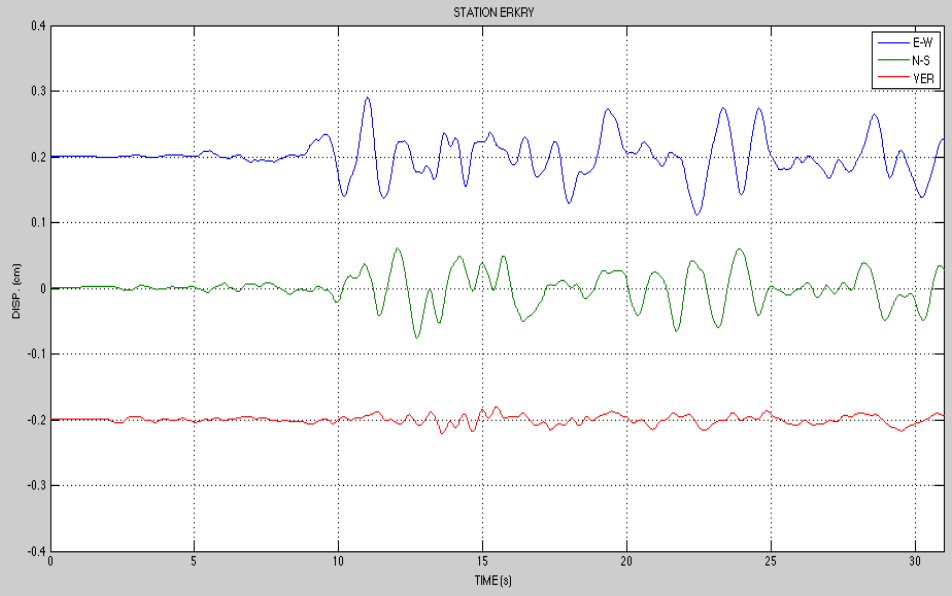

STATION ERSFB
STATION ETR
STATION ERKRY
STATION ERISF
E-W
N-S
VER
ACC. (g)
TIME (s)

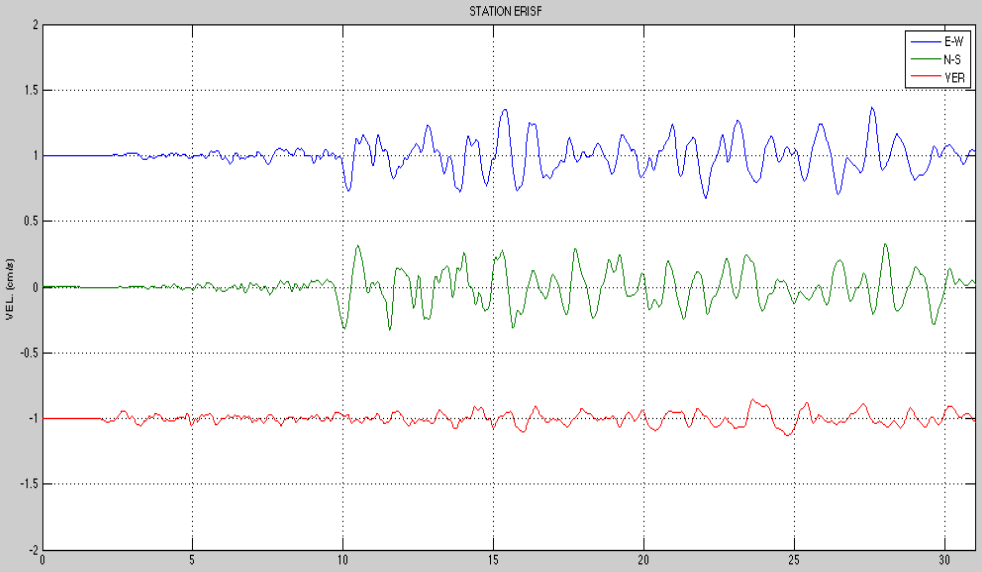

STATION ERSFB
STATION ETR
STATION ERKRY
STATION ERISF
E-W
N-S
VER
FAS AMP. (cm/s)
FREQUENCY (Hz)

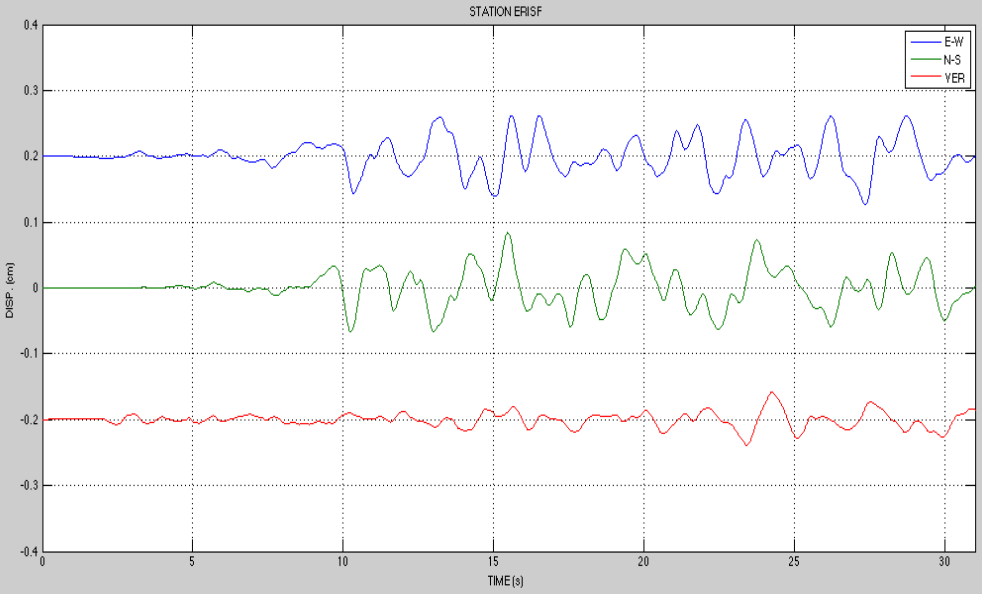

STATION ERSFB
E-W
N-S
VER
VEL. (cm/s)
STATION ERSFB
E-W
N-S
VER
DISP. (cm)
TIME (s)

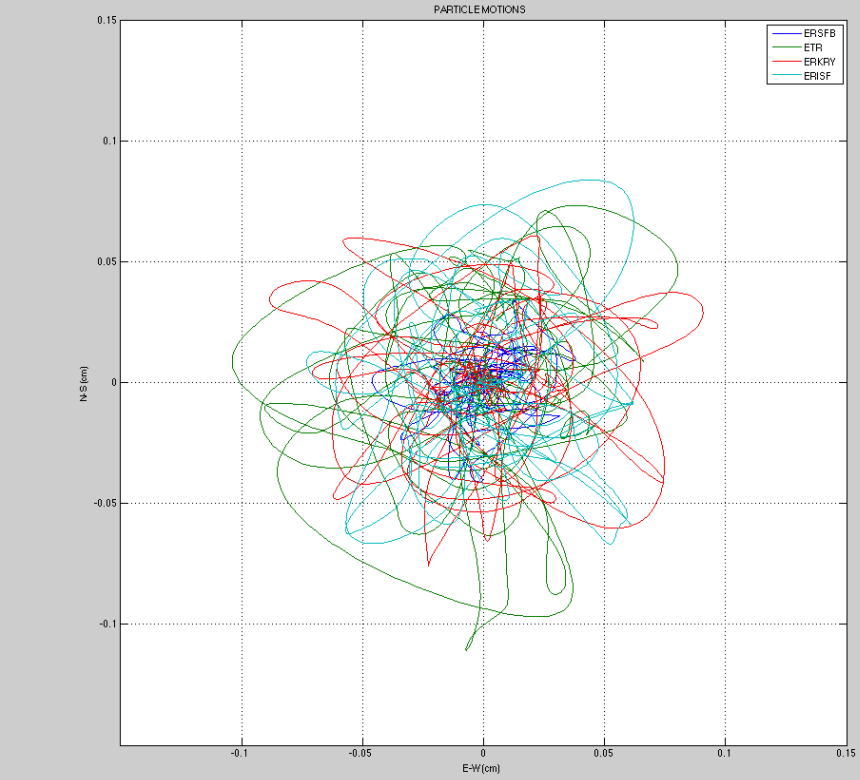

STATION ETR
E-W
N-S
VER
VEL. (cm/s)
STATION ETR
E-W
N-S
VER
DISP. (cm)
TIME (s)

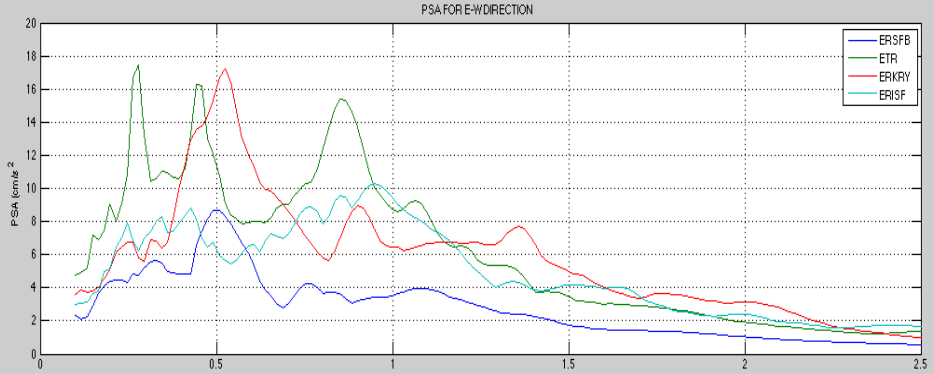

STATION ERKRY
E-W
N-S
VER
VEL. (cm/s)

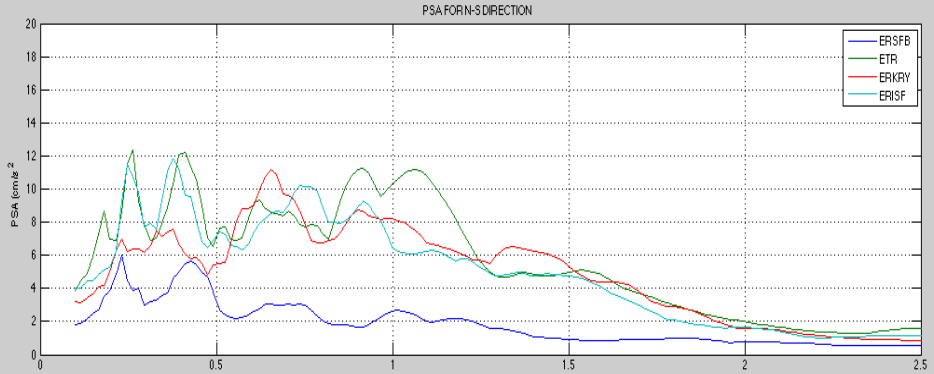

STATION ERKRY
E-W
N-S
VER
DISP. (cm)
TIME (s)

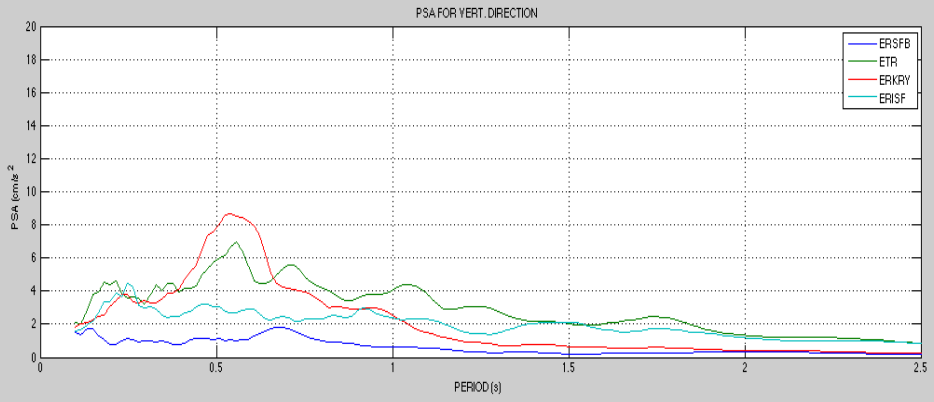

STATION ERISF
E-W
N-S
VER
VEL. (cm/s)

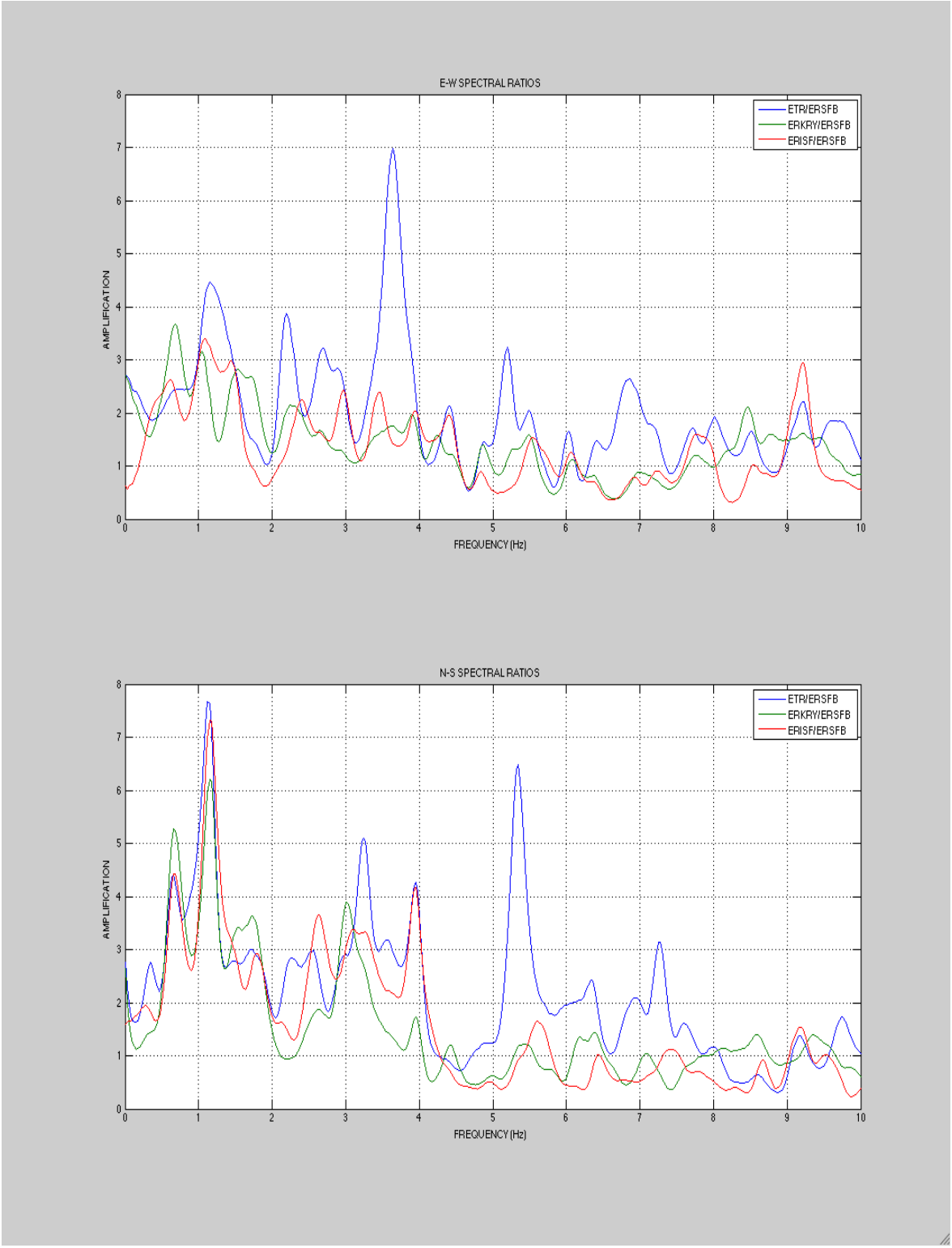

STATION ERISF
E-W
N-S
VER
DISP. (cm)
TIME (s)


PARTICLE MOTIONS
ERSFB
ETR
ERKRY
ERISF
0.15
0.1
0.05
0
-0.05
-0.1
N-S (cm)
-0.1
-0.05
0
0.05
0.1
0.15
E-W (cm)


PSA FOR E-W DIRECTION
ERSFB
ETR
ERKRY
ERISF
P-SA (cm/s^2)


PSA FOR N-S DIRECTION
ERSFB
ETR
ERKRY
ERISF
P-SA (cm/s^2)


PSA FOR VERT. DIRECTION
ERSFB
ETR
ERKRY
ERISF
P-SA (cm/s^2)
PERIOD (s)



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