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STRONG MOTION DATABASE FOR CRUSTAL EARTHQUAKESIN GREECE AND SURROUNDING AREA

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ABSTRACT

An updated Hellenic database of strong ground motion recordings together with the earthquake source properties and the site characterization of the recording stations are described here. The strong motion database consists of 2751 corrected recordings from 497earthquakes of focal depths h<45km and 338 recording stations, with source to site distances up to 300 km, covering the period from 1973-2015. The strong motion recordings were collected from Hellenic Strong Motion Networks operated by the Institute of Engineering Seismology and Earthquake Engineering (ITSAK), the Institute of Geodynamics, National Observatory of Athens (NOA-IG), as well as from the Civil Engineering Department, University of Patras (UPAN). All recordings were processed based on well-established routines and methodologies applied in worldwide strong motion databases such as the PEER, NGA-West2 database. The final database includes epicenter locations, focal depths, moment magnitudes (directly estimated or equivalently derived after a conversion procedure) for a significant number of earthquakes with **M**>4.5and a number of finite fault plane solutions corresponding to earthquakes with **M**>6.0. The data is compiled from existing catalogs published by Hellenic and international seismological centers. The properties for each recording station include surface geology, a measured or estimated time-averaged shear wave velocity in the upper 30m (V_{S30}), and information on instrument housing. Out of the 338sites, 75 have in-situ shear wave velocity measurements while for the rest V_{S30} values are derived from proxy-based relationships based on terrain or geology combined with surface gradient.

Keywords: Strong motion Database; Greece; Crustal earthquakes

1. INTRODUCTION

Recently, the compilation of global strong motion databases with data from different regions processed in a uniform manner and consistently derived metadata has become increasingly common. There are several engineering applications that use these large databases, such as the NGA-West2 database compiled and maintained by PEER (Ancheta et al, 2014), but among the most significant is data utilization to derive empirical ground motion models (GMMs). GMMs describe the variation of particular intensity measures (such as peak acceleration, spectral acceleration, or duration) with magnitude, site-source distance, site condition, and other parameters so they are dependent on the databases utilized in their development. The development of GMMs requires a database of strong

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motion accelerograms and their intensity measures, a database of site conditions for accelerometers and a database of earthquake source parameters.

The first effort for compiling a homogenous strong motion database for earthquakes in Greece and surrounding area is described by Theodoulidis et al. (2004).This study at hand aims at developing an NGA-quality ground motion database for Greece and ultimately using that database for deriving pertinent regional GMMs. This paper reports on a brief overview of the database component of the work. In this article, we summarize the principal aspects of the Hellenic strong motion database, by describing the protocols and methodologies used to compile the individual databases (ground motion accelerograms, site conditions and source).

2. EARTHQUAKE SOURCE PARAMETERS

The focus of this study is the compilation of an accurate and homogeneous, with respect to magnitude, earthquake catalog that will include the focal parameters of all earthquakes for which strong motion data are available. The main data sources that were used for this purpose are the bulletins of the International Seismological Centre (ISC) and of the National Earthquake Information Centre(NEIC) of the USGS, as well as the online bulletins of the Geophysical Laboratory of Thessaloniki University (AUTH). The basic source for the focal mechanisms is the online CMT catalog (HRVD/GCMT). A detailed description of the procedures and rules followed for the assignment and estimation of the earthquake source parameters included in the catalog is provided in the following sections. The source parameters for all strong motion records are listed in Table E1, which is available in (http://geophysics.geo.auth.gr/~manolis/ECEE/Table-E1.dat). The compilation of Table E1 is based on a large number of references, listed at the bottom of the table.

2.1 Focal Parameters

The earthquake parameters are mainly adopted from the ISC online bulletin. Focal parameters of events not reviewed by ISC are taken from PDE (Preliminary Determination of Epicenters) of NEIC (see Table 1). In some cases, re-estimated, more accurate focal parameters, from previous research works are used. Finally, the focal parameters for the most recent events of the catalog were taken from AUTH bulletins. The column of Table E1 entitled "REFERENCES/Focus" includes the code numbers of the respective references that are listed at the bottom of the table.

2.2 Magnitudes

The earthquake magnitudes in the above data sources are given in different scales (M_s, m_b, M_L, M_D, **M**). The moment magnitude scale, **M**, was adopted as the reference. The other magnitude scales were converted to equivalent moment magnitudes by appropriate, regionally or globally applicable functions (Baba et al., 2000; Papazachos et al., 1997; Scordilis, 2005, 2006). A recently published earthquake catalog (Konstantinou, 2015), homogeneous with respect to **M,** and including 1966 earthquakes spanning a period from 1976 to 2014, was also considered. The finally adopted magnitude for each earthquake is either the original moment magnitude (published by Harvard/GCMT; USGS; Konstantinou, 2015 or other accreditedcenters) or the equivalent moment magnitude estimated as the weighted mean of the converted magnitude values, by weighting each participating magnitude with the inverse standard deviation of the respective converting relation applied.

2.3 Fault Plane Solutions (FPSs)

The majority of focal mechanisms were taken from HRVD/GCMT. Some FPS, corresponding mainly to small magnitude earthquakes, were adopted: i) from other centers (such as AUTH, NOA-IG, MED_RCMT, ZUR_RMT, etc., see Table 1), ii) from publications or reports concerning specific earthquake sequences studies and iii) from review studies dealing with FPS and the stress field in the broader area of Greece. The respective references in Table E1 under the column entitled "REFERENCES/FPS", are given at the bottom of the Table.

Records with the seismic fault identified, are marked with an asterisk ("*") in the first column of Table E1. In these cases, the first of the two nodal planes, "NP1 (Az, Dp, Rk)", corresponds to the seismic fault, which produced the earthquake. The references of publications describing fault characteristics contradicting each other are given in this last column (REFERENCES/FP),along with the suggested fault characteristics deviating from those of NP1.In the few cases of strong aftershocks with unspecified fault planes, nodal planes with characteristics similar to those of the mainshock were adopted.

3. FORESHOCKS, MAINSHOCKS AND AFTERSHOCKS

The catalog consists of 497 earthquakes with focal depths, h<45km. 155 of them are mainshocks, most of the rest are associated shocks (41foreshocks, 150aftershocks) while 151 may be characterized "independent" events, since they cannot be directly related to seismic sequences. The characterization of foreshocks (*f*), mainshocks (*M*) and aftershocks (*a*) (see column "Q" of Table E1) is based on relations connecting the dimension of the seismogenic region and the duration of the aftershock sequence with the mainshock's magnitude:

$$\log d = 0.124 * M + 0.983 \qquad (1)$$

$$\log T = 0.66M - 2.08 \quad (2)$$

Relation (1) was proposed by Gardner and Knopoff (1974)and provides the radius, *d* (in km), of a circle centered on the epicenter of a mainshock of magnitude *M* and delimiting the seismogenic region of the sequence. Relation (2), proposed by Papazachos and Papazachou (2003), gives the duration, *T* (in days) of the aftershock sequence, starting from the origin time of the mainshock, as a function of the mainshock's magnitude, *M*.

Table 1. Sources of focal parameters and FPS information

Center	**Web-address**
AUTH	http://geophysics.geo.auth.gr/the_seisnet/WEBSITE_2005/station_index_en.html
HRVD-GCMT	http://www.globalcmt.org/
ISC	http://www.isc.ac.uk
KOERI	http://www.koeri.boun.edu.tr/sismo/2/moment-tensor-solutions/ http://www.emsc-csem.org/Earthquake/tensors.php
MED_RCMT	http://www.bo.ingv.it/RCMT/
INGV	http://mednet.rm.ingv.it/quick_rcmt.php
NOA	http://bbnet.gein.noa.gr/HL/seismicity/moment-tensors
UPSL	http://www.emsc-csem.org/Earthquake/tensors.php)
USGS	https://earthquake.usgs.gov/earthquakes/search/#{
ZUR_RMT, ETHZ	http://www.seismo.ethz.ch/static/mti/
GDDA-ERD	https://deprem.afad.gov.tr/faycozumleri

We applied the following procedure: First, the catalog was sorted by magnitude. The strongest earthquake is characterized as mainshock (*M*) and its foreshocks, (*f*) and aftershocks, (*a*), are defined and marked by applying relations (1) and (2). This procedure was repeated for the second stronger mainshock, which was the strongest earthquake of the remaining catalog, and so forth until all the earthquakes of the catalog were characterized accordingly (see Figure 1). Special care was taken to avoid errors due to strong earthquakes possibly missing from the initial catalog (earthquakes with no strong motion records). It should be noticed that we considered as mainshocks only earthquakes with **M**$\geq$5.0.

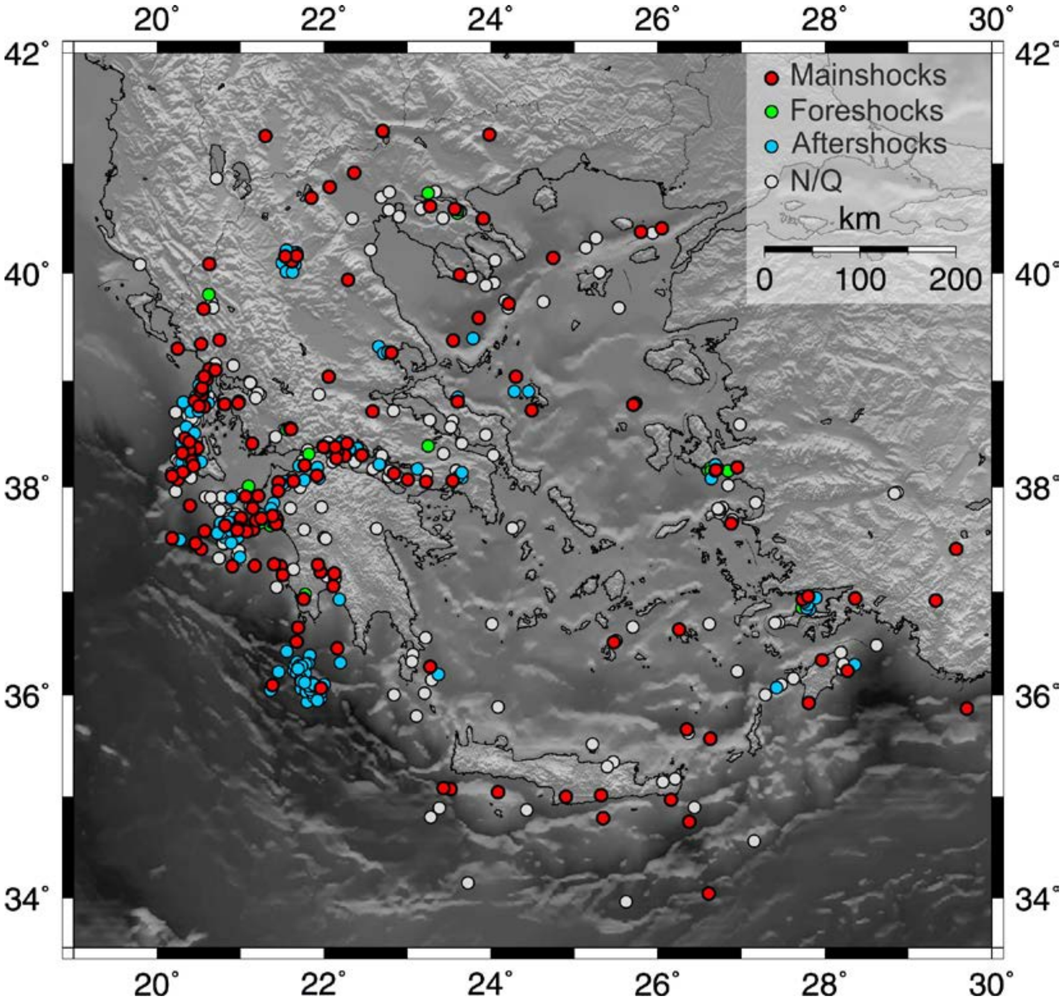

Figure 1. Map of epicenters of the earthquakes listed in Table E1. Different colors denote mainshocks (red), foreshocks (green) and aftershocks (blue). Light gray circles represent “independent”, not qualified (N/Q), earthquakes not belonging to seismic sequences.

4. FINITEFAULTSOLUTIONS AND DISTANCE MEASURES

Finite fault models describe the earthquake source geometry in terms of a plane or series of planes in the earth’s crust. The finite fault geometry in the database was obtained, in the order of preference, from field observations of primary surface rupture, co-seismic slip distribution from inversions of waveform and geodetic data, and aftershock distributions. The parameters compiled include the geodetic coordinates and depth of the upper-left corner of the fault plan (as observed from hanging wall), strike and dip, length of rupture (measured along-strike), and width of rupture (measured down-dip).

The distance measures included in the database are calculated based on the geometry of the finite fault rupture plane and the location of the station. Four source-to-site distance measures (epicentral distance, REPI ; hypocentral distance, RHYP; shortest distance to rupture plane, RRUP; Joyner-Boore distance, RJB) are included in the database. For the events for which no published finite fault solution was available, we followed the method described in Ancheta et al. (2014) to develop an approximate simulated finite fault model based on the earthquake magnitude and style of faulting.

The methodology for simulating the fault plane consists of random sampling of probabilistic distributions of fault rupture area, aspect ratio of ruptured area, and hypocenter position on the fault plane and is a modification of the simulation process developed in Appendix B of Chiou and Youngs (2008). The method involves the use of scaling relationships between moment magnitude and rupture area, RA (km^2), length, LR, and width, WR, of the rupture. For this purpose, we used the scaling relations of fault area, length and width with moment magnitude, proposed by Papazachos et al (2004).

5. STRONG MOTION NETWORK AND SITE DESCRIPTION

5.1 National Network Description

The strong motion instrumentation program in Greece started in early 1970's, with the first instruments being deployed by NOA-IG, followed by the network deployment of ITSAKin 1980's. The evolution of the strong motion networks followed the development of relevant technology from analog to digital instruments, while data processing and dissemination, research products and services followed relevant international practices (Theodouldis et al., 2004; Margaris et al., 2014).

Up through the late1990's the majority of the installed accelerographs consisted of analog SMA-1 units. The deployment of low resolution digital instruments (Kinemetrics SSA-2 and ETNA and Geotech A800/A900) began in the mid-1990s.Beginning after the September 7, 1999 **M**5.9 Athens earthquake and concluding by the end of 2001, the remaining analog units (SMA-1) were replaced by low-resolution digital ones (Kinemetrics QDR). The dynamic range of those "semi-digital" sensors cannot be considered as improved compared to the analog ones, however the significant advantage of those instruments over the aforementioned lies in the elimination of digitization processing errors, remote maintenance and data collection.

Since 2008, a national earthquake infrastructure development project led to a tremendous increase in quantity and quality of the national strong motion instruments, through the purchase of more than 200 CMG-5TD-EAM units by the two aforementioned institutes and their installation at permanent stations. These modern instruments offer numerous advantages including continuous recording, site ambient noise monitoring via the PQLX software, incorporation of the continuous recording to the daily seismicity monitoring, enhancement of seismic parameter estimation (improvement in epicenter location, magnitude determination and focal mechanism solution) as well as "shake-maps" type services. Furthermore, smaller or larger scale projects increase the number of instruments for both institutes. Today, the total number of "free-field" accelerographs in Greece, operated mainly by ITSAK and NOA-IG, is about 380. The majority of the instruments are installed in buildings (mainly of the public sector, e.g. town halls), while the rest are real free-field installations or installations in seismic stations. Accelerographs are installed in a wide range of structure types ranging from 8-story office buildings with several levels of embedment to instrument shelters. A rough classification has been carried out that separates the housing information into two major categories, reflecting different levels of soil-structure interaction (SSI): a) those unlikely to be seriously affected by the instrument housing, and b) those that might be affected. Taking into account these two categories of stations in the data analysis, useful conclusions might result on the role of SSI and the type of structures that affect influence ground motions.

It should be noted that the SYZEFXIS network, the main telecommunication network of the Public Sector in Greece, is used for the internet connection of the instruments, taking advantage of its security, quality, stability and the zero to low cost of use. Detailed information for each strong motion network can be found at the Institutes' web pages:

- https://accelnet.gein.noa.gr/
- http://www.itsak.gr/en/page/networks/acc_network/

6. LOCAL SITE CONDITIONS AND V_{S30} VALUES

Stewart et al. (2014) compiled a local V_S profile database in Greece and developed procedures for estimating V_{S30} values in the absence of seismic velocity data is available for a particular site. For the area of Greece they recommended use of a joint terrain- and geology-based method for proxy-based V_{S30} estimation. According to Stewart et al. (2014) the geologic ages in which all accelerograph stations could be grouped are as follows: Holocene (H), Pleistocene (P), mapped Quaternary, where a more specific age is unknown (Q), Tertiary or Neogene (T) and Mesozoic & Paleozoic (M).
75 out of 338strong motion stations that have recordings included in the presented database had measured V_{S30} values based on active or/and passive methods in the proximity of the station. For the remaining stations an inferred V_{S30} value has been calculated based on the protocols recommended by Stewart et al. (2014).

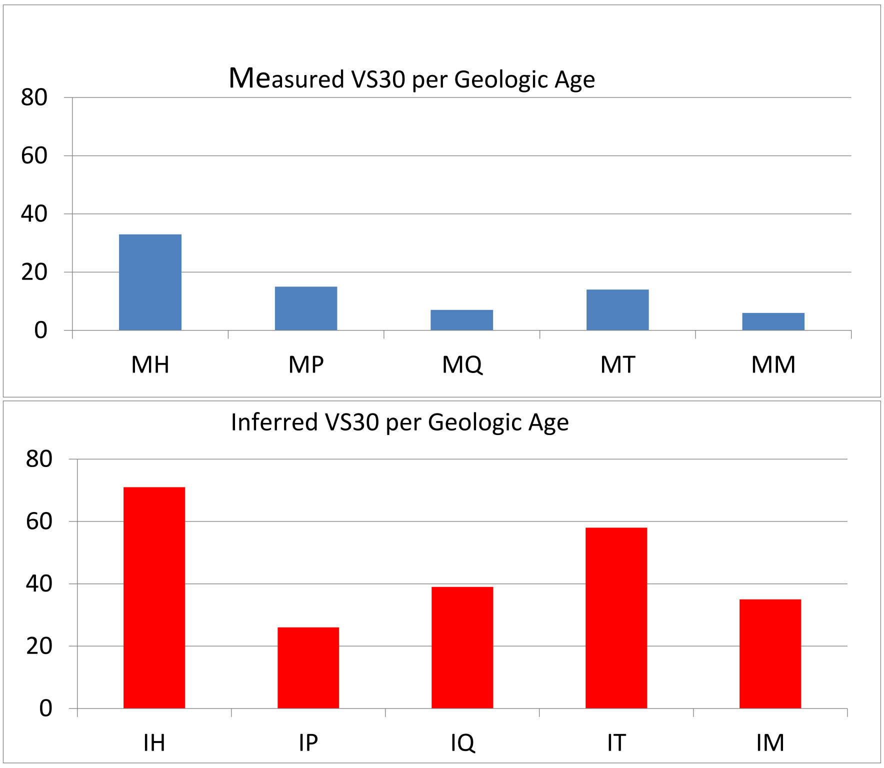

Figure 2. Histogram of the number of stations with measured (M) and inferred (I), V_{SZ} values, for various geologic ages (H: Holocene, P: Pleistocene, Q: Quaternary undivided, T: Tertiary, M: Mesozoic & Paleozoic).

Each of the 338 strong motion sites has been classified with respect to surface geology, including categories related to age and gradation, following the protocols in Stewart et al. (2014). Moreover, for each site it is known whether a profile is available from which VS30 can be measured. Figure 2 shows histograms of the number of sites with measured (M) or inferred (I) VS30 according to five geologic age categories. It is evident that the inferred VS30 values assigned to the stations are almost three times more of those with measured values. The percentage of the inferred VS30 values varies from 64% to 85% with respect to the total number of stations per geologic age.

7. STRONG MOTION RECORD PROCESSING

7.1 Description of the Strong Motion Processing Methodology

Based on the growing number of accelerograms collected mainly by ITSAK, NOA-IGas well as from UPAN (strong motion recordings mainly from the 2014 Cephalonia seismic sequence) an extended dataset was developed. The application of uniform processing and correction procedure is an important step before the final dissemination of this dataset. The strong motion accelerograms from the analog instruments were digitized twice so far. Before 1990 a semi-automatic digitization procedure was applied (Margaris, 1986; Margaris et al., 1989).This method was further improved with the rapid evolution of digital technology resulting in a fully automatic digitization and correction procedure which involved a scanner-based technique (Nigbor and Kodama, 1990).The second time, the procedure involved the estimation of the characteristic frequencies of a digital band-pass filter, based on comparisons of the Fourier Amplitude Spectra (FAS) of the digitized horizontal components with the FAS of the corresponding fixed traces. Attempts for further reducing noise levels were made by estimating characteristic frequencies based only on the energy window from 5% to 95% of the total energy of the accelerogram (Skarlatoudis et al. 2003, 2004). These efforts led to the compilation of the NOA-IG’s strong motion database (Kalogeras, 2002) and of the unified Hellenic Accelerograms Database (HEAD) by Theodulidis et al. (2004).

In order to process and to further improve the available strong motion dataset a new correction procedure was utilized in the accelerograms, specifically focusing on optimization of the low-cut corner frequency f_c. Boore (2001; 2005; 2009) proposed an efficient technique based on time and frequency domain analysis, which was adopted to reprocess the complete dataset. An example of this analysis is presented in Figure3. The displacement time series of the examined dataset, are calculated for thirty specific *fc*-values (logarithmically equally spaced in three tens 0.05-0.5, 0.1–1 and 0.5–5Hz) and after visual inspection by three different operators, the appropriate *fc* was selected in which the displacement time series is stable without including long period effects or transients. The filtering procedure involves zero-padding in the beginning and at the end of each record based on the order of the applied digital filter and an acausal band-pass filter for digital noise removal (Boore, 2005, 2009). Based on this technique and using the free software (TSPP – Boore, 2012), the available dataset was processed and corrected and spectral values were derived. The intensity measures computed from this dataset are PGA, PGV, PGD and spectral acceleration for a selected range of natural periods. While values of PGD are present in the database, they are especially sensitive to processing details and are not considered to be as robust as other intensity measures.

7.2 Component Selection for Intensity Measures (RotD50)

Within the framework of the GMM development in the NGA-West2 the RotDnn spectra (Boore, 2010) for the horizontal components of the strong ground motion are calculated. Those spectral values represent alternate single-azimuth ground motion intensities in the horizontal plane. The “*nn*” represents the percentile of the spectral values sorted by the amplitude. In the context of this analysis the RotD50 and RotD100 are calculated which means the 50th and 100th percentile amplitudes among all possible azimuths per each accelerogram. Records with only one horizontal component are precluded from this dataset.

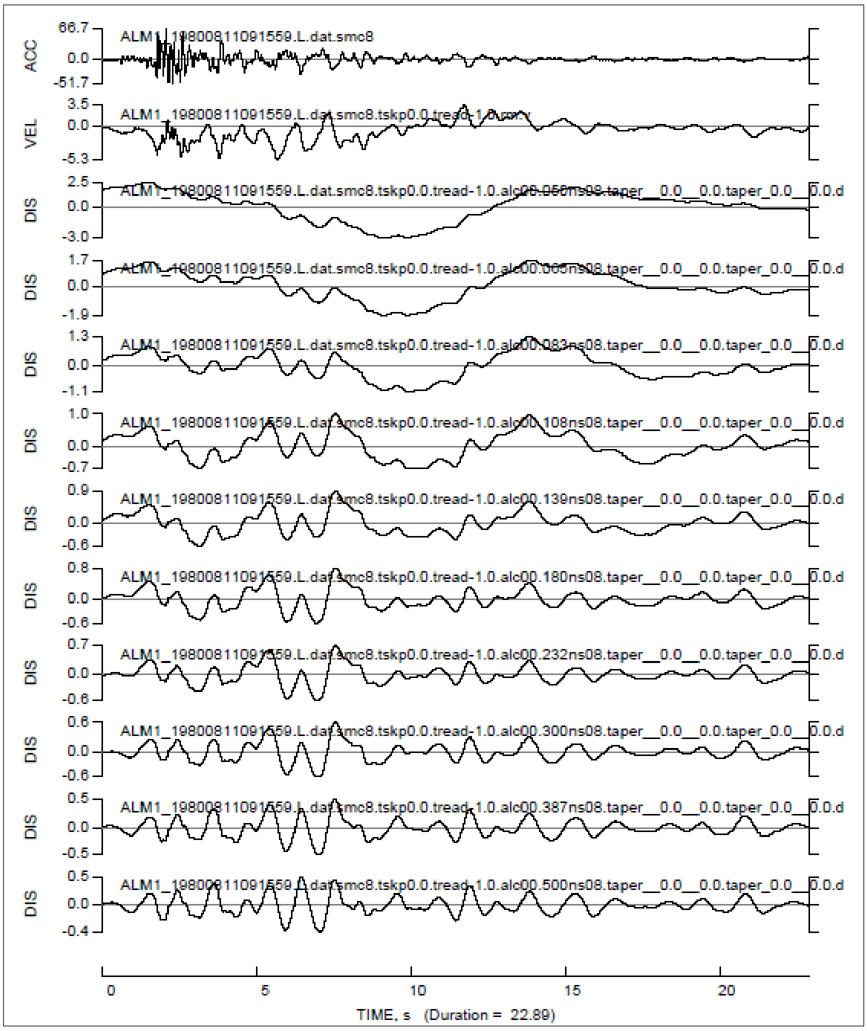

Figure 3. Displacement time histories for a specific accelerogram corrected by various $f_c$values (logarithmically equally spaced) from 0.05 to 0.50 Hz. The same procedure is repeatedly applied for 0.1 to 1.0 and 0.5 to 5.0 Hz for each component as well.

8. SUMMARY

In this article, we describe the development of a unified, homogeneously processed, strong motion database for earthquakes in Greece and surrounding area. The basic aim of the publication is to introduce a Hellenic strong motion database, for active tectonic regions and facilitate its use by other researchers worldwide. This remains a work in progress, and the final report on this database will be presented in a forthcoming journal article.

This database is an update of the previous one (HEAD) developed by Theodulidis et al. (2004),in terms of significantly improved metadata and additional recordings since 2000. The number of three-component recordings in the database is 2751 from 497shallow crustal events. The included time series were uniformly processed with the PEER methodology using an acausal filter. Spectral accelerations at5% of critical damping, were computed for periods ranging from 0.01s to 5s. The horizontal-component intensity measure reported is RotD50.

Metadata were collected to define important events, path, and station information used in GMM development as well as for other engineering applications. The earthquake source information was compiled based on data from literature as well as from Hellenic and international seismological centers. Moment tensor solutions derived from instrumental recordings are available for most events, providing estimates of source location, seismic moment, and moment magnitude. For selected earthquakes finite fault source parameters, such as fault strike, dip, rake, along-strike rupture length, down-dip width, and depth to top of rupture are also available.

The site parameters have been substantially updated and expanded with V_{S30}values, based on measurements as well as on application of proxy-based relations to estimate $V_{S30}$and its uncertainty in the absence of *in-situ* geophysical or/and geotechnical measurements.

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10.REFERENCES

Ancheta, T.D., R.B. Darragh, J.P. Stewart, E. Seyhan, W.J. Silva, B.S.-J. Chiou, K.E. Wooddell, R.W. Graves, A.R. Kottke, D.M. Boore, T. Kishida and J.L. Donahue (2014). NGA-West 2 database, *Earthquake Spectra*, 30, 989-1005.

Baba, A.B., Papadimitriou, E.E., Papazachos, B.C., Papaioannou, Ch.A. and B.G. Karakostas (2000). Unified local magnitude scale for earthquakes of south Balkan area. *Pure Appl. Geophys*, 157, 765-783.

Boore D.M. (2001). Effect of baseline corrections on displacement and response spectra for several recordings of the 1999 Chi-Chi Taiwan, earthquake, *Bull. Seism. Soc. Am.*, 91, 1199-1211.

Boore D.M. (2005). On pads and filters: Processing strong-motion data. *Bull. Seism. Soc. Am.*, 95,745-750.

Boore, D.M. (2009). Comparing stochastic point-source and finite-source ground-motion simulations: SMSIM and EXSIM, *Bull. Seism. Soc. Am.*, 99, 3202-3216.

Boore D.M. (2010). Orientation-independent, non geometric-mean measures of seismic intensity from two horizontal components of motion,*Bull. Seism. Soc. Am.*,100, 1830–1835.

Boore D.M. (2012). TSPP--- A Collection of FORTAN Programs for Processing and Manipulating Time Series, *U.S. Geological Survey Open File rept 2008-1111*, V4.3, 09 Oct.. 2012, 47pp.

Chiou, B.S.J. and R.R. Youngs (2008). NGA Model for Average Horizontal Component of Peak Ground Motion and Response Spectra, *PEER Report 2008/09”, Pacific Engineering Research Center College of Engineering, University of California, Berkeley, November 2008*, 293pp.

Gardner, J.K. and L. Knopoff (1974). Is the sequence of earthquakes in southern California with aftershocks removed, Poissonian?, *Bull. Seism. Soc. Am.*, 64, 5, 1363-1367

Kalogeras I.S. (2002). A strong motion data base in Greece, *Nat. Haz.*, 26, 265-277.

Konstantinou, K.I. (2015). Moment Magnitude Estimates for Earthquakes in the Greek Region: A Comprehensive Comparison, *Bull. Seism. Soc. Am.*, 105, No. 5, doi: 10.1785/0120150088.

Margaris B. (1986). Digitizing errors and filters,*Report ITSAK*, Rept: 86-03.

Margaris B., Papastamatiou D., Theodulidis N. (1989). ITSAK: Strong motion data processing, *Report ITSAK*, Rept:89-02.

Margaris, B., I. Kalogeras, Ch. Papaioannou, A. Savvaidis and N. Theodoulidis (2014). Evaluation of the national strong motion network in Greece: Deployment, data-processing and site characterization, *Bull. Eqk. Eng*. 12, 237-254.

Nigbor R.L., and D.A. Kodama. (1990). Scanner-based film accelerogram digitization system user's manual, Kinemetrics /Systems, 1.1-6.2.

Papazachos, B.C., Kiratzi, A.A. and B.G. Karacostas (1997). Toward a homogeneous moment-magnitude determination for earthquakes in Greece and the surrounding area. *Bull. Seism. Soc. Am.*, 87, 2, 474-483.

Papazachos, B. and Papazachou, C. (2003). The earthquakes of Greece. *Ziti publications, Thessaloniki*, 317pp, (in Greek).

Papazachos B. C., Scordilis E. M., Panagiotopoulos D. G., Papazachos C. B. and Karakaisis G. F. (2004). Global Relations Between Seismic Fault Parameters and Moment Magnitude Of Earthquakes, *Bull. Geol. Soc. Greece* vol. XXXVI, 1482-1489.

Scordilis, E.M. (2005). Globally valid relations converting Ms, mb and MJMA to Mw. *NATO advanced research workshop on Earthquake Monitoring and Seismic Hazard Mitigation in Balkan Countries, Borovetz-Rila Mountain-Bulgaria, 11-17 September 2005*, Book of Abstracts, 158-161.

Scordilis, E.M. (2006). Empirical global relations converting Ms and mb to moment magnitude, *J. Seismology*, 10, 225-236.

Skarlatoudis A.A.,C.B. Papazachos, B.N. Margaris, (2003). Determination of noise spectra from strong motion data recorded in Greece, *J. Seismology*, 7, 533-540.

Skarlatoudis A.A.,B.N. Margaris, C.B. Papazachos (2004).Recent advances in Greece on strong motion networking and data processing, *Proc. COSMOS Meeting, Berkeley Ca. May 2004*.

Stewart J.P., N. Klimis, A. Savvaidis, N. Theodoulidis, E. Zargli, G. Athanasopoulos, P. Pelekis, G. Mylonakis and B. Margaris, (2014). Compilation of a Local Vs Profile Database and its Application for Inference of VS30 from Geologic and Terrain-Based Proxies,*Bull.Seism. Soc. Am.*, Vol. 104, No 6, p. 2827-2841..

Theodoulidis N., I. Kalogeras, C.B. Papazachos, V. Karastathis, B.N. Margaris, Ch. Papaioannou, Skarlatoudis A.A., (2004).HEAD v1.0: A unified Hellenic Accellerogram Database, *Seis. Res. Lett.*, 75, 36-45.

Yong, I., S.E. Hough, J. Iwahashi, and A. Braverman (2012). A Terrain-Based Site-Conditions Map of California with Implications for the Contiguous United States, *Bull. Seism. Soc. Am.*, 102, 1, 114-128.