RESORCE

– Reference database for seismic ground-motion in Europe –

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Summary

RESORCE

Conception criteria for the ground-motion European database

1. Summary

With the aim of improving seismic ground-motion models and reducing associated uncertainties, the compilation of a high quality database of seismic-motion recordings and associated meta-parameters is of primary importance.

This document summarizes the framework, the objectives, the structure and the content of the RESORCE (Reference database for seismic ground-motion in Europe) database. RESORCE is meant to be an up-dated, integrated European seismic-motion database for developing and testing the ground-motion models used for engineering seismology and earthquake engineering purposes.

METU (Middle East Technical University, Ankara) is in charge of collecting, checking and formatting the data and meta-data. The EMSC (Euro-Mediterranean Seismological Centre, on the other hand, is charged to implement and maintain the database and to create an access and distribution node (through an internet portal). A Scientific Board is responsible for the choices concerning the choices, the structure and the content of the seismic-motion database. This Scientific Board is composed by S. Akkar, F. Cotton, J. Douglas, P. Traversa, T. Van Eck.

The Scientific Board also ensures the communication, coordination, exchange and transparency with both, related research projects and European seismological agencies.

2. Background

The idea of creating this seismic ground-motion database, devoted to the development and testing of ground-motion models to be used for seismic hazard studies, emerges from the need of having a single integrated database for Europe, constructed with high standards and only verified data. Indeed the quality, completeness and level of information associated to data are highly heterogeneous among the different seismological networks and agencies in Europe. On top of this, ground motion developers have their own data and meta-data processing, which increases the epistemic uncertainties associated to ground-motion models.

The most successful attempt to gather strong-motion data in and around Europe was led by Prof. Ambraseys and the earthquake research group of the Imperial College (London), through FP4 and FP5 (and earlier) projects. The group has collected, compiled and processed the accelerometric data through collaborations with the seismic agencies since 1971. One of the remarkable products of this endeavor is a CD-ROM released in 2004 (Ambraseys et al., 2004) and a web site known as ISESD (Internet Site for European Strong-motion Data), which disseminate the available pan-european strong-motion recordings assembled till that time. The metadata information, as well as the data processing of strong-motion recordings disseminated in these sources has uniform structure. Several ground-motions models (e.g. Ambraseys et al., 2005, Berge-Thierry et al., 2003) have benefited from this database. This attempt has become silent after 2004 because of lack of financial support, inadequate manpower as well as the limited involvement of seismic agencies providing data to this initiative.

After this initiative, the European Research Council founded various relevant projects within the context of the 6th and 7th Framework Programs (i.e. FP6 and FP7). Notwithstanding, none of these projects have been devised for delivering an up-dated version of the pan-European strong-motion database.

Among these projects, the recently concluded NERIES (Network of Research Infrastructures for European Seismology) project focused on the implementation of a database of real-time accelerometric data. Several tools for accessing (e.g. NERIES portal) and processing accelerometric data (e.g. PARAMAC software) have been built within NERIES. The goal of this kind of approach is to provide data and tools for earthquake monitoring and real-time strong-motion data processing (e.g. real-time hazard and shake maps). The products are not structured to conduct detailed seismological and engineering studies, as specifically the development of ground-motion models. Currently, NERIES project is succeeded by NERA (Network of European Research Infrastructure for Earthquake Risk Assessment and Mitigation) project. NERA ensures the continuity and improvement of previously developed tools and research interactions.

During the last 5-6 years, countries like Turkey and Italy improved their strong-motion databases through national projects. These databases, as well as other strong-motion datasets worldwide (e.g. NGA, Kik-Net etc) are brought together within the framework of SHARE ("Seismic HARmonization in Europe") project. The goal is to test candidate ground-motion models to be used in European hazard studies. However, because of lack of funding, the so-called SHARE strong-motion databank does not consider any improvement or homogenization in the metadata information of the collected data.

SHARE project is one of the regional programs of GEM (Global Earthquake Model). This latter is aimed at building a global scale seismic risk model. The sister project of SHARE, the EMME (Earthquake Model of the Middle East region) project, is funded by GEM and one of its major tasks is to establish a strong-motion databank concerning the Middle East, Iran, Pakistan and Caucuses. The strong-motion recordings of some of these countries are also included in the SHARE strong-motion databank. The project EMCA (Earthquake Model of Central Asia) extends the seismic hazard assessment goals to Central Asia. Because of the lack of funding, EMCA metadata have also not been improved.

3. Objectives

Today SIGMA project integrates this rich context, with the aim of improving ground motion models and associated seismic hazard-related research infrastructure in France and neighboring countries. SIGMA is therefore strongly related to the above mentioned projects and aims at collaborating with them to attain the common objectives. These will allow improving the quality of accelerometric data in Europe.

SIGMA, NERA and other projects are then joining forces towards a single implementation plan for a single integrated, homogeneous, high quality database of seismic ground-motion, that we call RESORCE. Each project can then extract the data needed for a specific application. In particular, given the common objectives, SIGMA WP2 and NERA WP3 will be represented one into each other to ensure a good coordination.

Within this framework, the specific goal of SIGMA WP2, is to contribute up-dating and improving the European seismic ground-motion database. This will help decreasing the epistemic uncertainty of future European Ground-Motion models. In particular, the work carried out within SIGMA WP2 includes the extension of the limits of the database both, in magnitude (extension of the lower earthquake magnitude bound) and in source-to-site distances. This will allow adapting, deriving and testing ground-motion models for low-to-moderate seismicity countries, like France. SIGMA WP2 focuses as well on the improvement of meta-parameters and the homogenization of data processing. Procedures developed during the database implementation will be published as guidelines for the seismological community.

SIGMA WP2 will also take care of the dissemination of the resulting database. Such dissemination will ensure the feedbacks on the database from a large community, which will help improving progressively the quality of the database. This dissemination has to be performed in close connection with data providers and seismological networks.

The final goal of RESORCE is to be an updated, homogeneous high-quality, verified database that can be used by the engineering seismology and earthquake engineering communities, e.g. to develop new ground-motion prediction models for Europe, including for low-to-moderate seismicity countries like France. Contribution and suggestions from research groups of different research fields will make RESORCE very versatile and useful for a large range of purposes and applications.

4. RESORCE structure

RESORCE is being designed as a "living database", whose quality and content completeness evolve with time through successive versions. The first version of RESORCE database is under implementation. This simple version of the database, containing only already available data, is expected to be available for review by the end of 2011. Once validated by the SIGMA Scientific Committee, by the RESORCE Scientific Board and by the concerned European seismological agencies, this version will be available online.

Users of the RESORCE database will have the possibility of sending feedbacks and suggestions through a specific online form associated to the database. Reasonableness and validity of these feedbacks will be discussed by the RESORCE Scientific Bard and, when agreed, included into the following version of RESORCE.

RESORCE first version consists mainly in the 2011 version of the European subset of the SHARE databank, and integrates the databases collected by the Bommer et al. (2007) and by the Akkar & Bommer (2010) studies. For this first version, these databases are accepted "as is" during the compilation process. Significant improvements, inclusions and completions are expected for the following versions of RESORCE. Figure 1 illustrates the components of RESORCE first version. Appendix A describes each of the origin databases in detail.

RESORCE will be continuously updated and improved over the duration of SIGMA project. Each version of the database that will be used to derive ground motion prediction models (GMPEs) will be frozen in order to ensure researchers the possibility of getting back to a given GMPE at any time.

RESORCE database will be openly accessible by the scientific community through the internet portal under development by the CSEM/EMSC. The first version of the database will be open to the scientific community after receiving the agreement of data-providers, of the SIGMA Scientific Committee and of the RESORCE Scientific Board, composed of representatives of research projects related to SIGMA WP2 (SHARE, EPOS, NERA). The internet portal opening is expected by the end of 2011.

SIGMA SM DATABANK

- ESMD
- ITACA
- NGA
- TNSMP
- ISESD
- Cauzzi and Faccioli(2008)
- Bommer et al. (2007)
- Akkar and Bommer (2010)

SHARE SM DATABANK

Figure 1. Database components of the SIGMA strong-motion databank (ESMD: European strong-motion database (CD-ROM, 2004); ITACA: Italian accelerometric archive (http://itaca.mi.ingv.it/ItacaNet/); NGA: Next Generation Attenuation; TNSMP: Turkish national strong-motion project; ISESD: Internet site for European strong-motion data (http://www.isesd.hi.is/ESD_Local/frameset.htm); Cauzzi and Faccioli (2008): A global strong-motion database compiled for the specific purposes of Cauzzi and Faccioli (2008) study; Bommer et al. (2007): European strong-motion data compiled for the specific purposes of Bommer et al. (2007) study; Akkar and Bommer (2010): a modified version of Ambraseys et al. (2005) for the specific purposes of Akkar and Bommer (2010) study).

Data and metadata will be requested through a parameter-based search engine from the RESORCE internet portal. For the data access, we will draw inspiration from ITACA and ISESD databases.

The first version of RESORCE portal will be a simplified version, with a few parameter-search engine and only data (seismic recordings and associated meta-parameters) already available from the origin databases. By the end of 2012, the definitive structure of the database is expected to be openly available. From then on, the following database versions will concern new data inclusions and/or metadata improvements.

Each version of RESORCE that will be used for deriving a ground-motion model will be frozen as flat file. In the future, this will allow the scientists to go back at any time to the input dataset of any ground-motion model derived from these data.

5. RESORCE content

As already mentioned, the first current version of RESORCE is a collection of different databases compiled in different projects and studies. This dataset is currently poorly homogeneous as regarding to data processing and information associated to recordings and meta-parameters. Work aimed at improving the quality and the homogeneity of both, data processing and meta-data information is currently ongoing. This task is coordinated by METU. Data providers will be involved in these activities of data improvement through both, seminar/workshop participation, and possible specific actions that may be carried out to improve the information on most significant station sites, instruments and seismic events. These latter actions will be planned for a second phase, following sensitivity studies aimed at identifying the key data and stations.

In its future versions, RESORCE will contain all ground motion recordings of engineering significance, or important to anchor prediction models (i.e. corrected recordings from crustal earthquakes $M \geq 4$, $R \leq 200$ km). The database will include both, accelerometric and broad-band data. Future versions will be characterized by homogeneous data processing and uniformly processed information associated to data and meta-data.

The current version of SIGMA strong-motion databank includes more than 5000 strong-motion recordings and their metadata parameters. The overall metadata of the databank includes information given as below. Appendix B details the meta-parameters currently included in the database.

- *Earthquake information*: Earthquake ID, reference for event information, earthquake code, earthquake date, earthquake name, earthquake country, epicenter coordinates, magnitude in various scales, strike, dip, slip information for available fault planes, selected fault plane, focal depth and style-of-faulting.

- *Station information*: Station ID, station name, station coordinates, station information reference, VS30 information (if available), site class information (Eurocode 8; CEN 2004) and site class reference (i.e., agency, which estimates the site class from geology).

- *Recording information*: Waveform ID, Ground-motion code reference, recording type (analog vs. digital), peak ground motion amplitudes, site-to-source distances (i.e., R_{epi}, R_{hyp}, R_{jb}, R_{rup}) and spectral values for each component, as well as low- and high-cut filter values used in the processing of each waveform.

Table 1 presents the geographic (country-based) distribution of strong-motion data that is included in the current version of RESORCE database. Almost all of these recordings are from the shallow active crustal regions in Europe and surrounding countries. A total of 5281 recordings from 1734 events are studied in the current version of the database. Most of the strong-motion recordings are from Turkey and Italy.

Table 1. Contributing countries to SIGMA strong-motion databank

Country	Event #	Rec. #	Country	Event #	Rec. #
Greece	283	512	Georgia	12	44
Italy	301	1424	Netherlands	1	3
Uzbekistan	13	30	Spain	18	47
Turkey	766	2035	Egypt	3	9
Romania	4	32	France	13	33
Iran	44	396	Slovenia	14	32
Armenia	14	40	Iceland	48	212
Syria	1	10	Cyprus	3	4
Macedonia	3	9	Albania	4	5
United Kingdom	3	3	Bulgaria	3	3
Bosnia and Herzegovina	7	13	Croatia	9	10

Israel	3	6	Lebanon	1	1
Kyrgyzstan	2	5	Hungary	1	1
Norway	7	10	Jordan*	1	1
Portugal	60	125	Germany	13	35
Montenegro	28	64	Algeria	22	28
Switzerland	23	85	Austria	3	7
Liechtenstein	1	4	Serbia	2	3

* Accelerogram was recorded in Jordan but the event was occurred in the Kingdom of Saudi Arabia (after the comments of J. Douglas).

In order for RESORCE to be adapted to the needs of the different research groups, a “wish list” of meta-parameters for various specific applications has been asked to the other SIGMA WP actors. These contributions and specific requests will allow to orientate at best the database content and to include a large amount of useful information. In this way, RESORCE will be very versatile and useful for a large range of seismological and engineering purposes and applications.

Appendix C details the WP3 suggestions for additional meta-parameters useful for local site effects assessment. After discussion, the RESORCE Scientific Board decided to integrate as additional database fields the simplest (more current) of the proposed metadata. The other metadata, when available, will be included in an “event monograph”, a downloadable pdf file associated to the data. This will allow not to introduce too many constrains on the database structure. As already mentioned, for key recording stations and/or for key data, specific research/work actions will be planned in a second phase. The results of these actions will allow to fill-in the database with missing important information.

APPENDIX

A. Information on the databases contributing to RESORCE seismic motion database

As briefed in Section 2 SIGMA strong-motion databank consists of several databases. The major component of the databank is the SHARE strong-motion databank that is compiled from the Turkish (TNSMP), Italian (ITACA), Next Generation Attenuation (NGA), European (ISESD and ESMD) and Cauzzi and Faccioli (2008) databases. Apart from SHARE the databases used in particular Akkar and Bommer (2010) and Bommer et al. (2007) studies are also investigated while assembling the SIGMA strong-motion databank. The latter 2 databasets are actually assembled from ISESD and ESMD databases. This section gives a summary of specific features of each considered database in SIGMA.

A.1. Cauzzi and Faccioli (C&F) strong-motion database

The C&F database includes 1163 horizontal and 1131 vertical component records from 60 worldwide earthquakes. These earthquakes are mainly shallow crustal events and are almost exclusively from the USA, Italy, Iceland, Turkey and Japan. For the specific purposes of SIGMA project we focused on the recordings of Italy, Iceland and Turkey of this database. The earthquake dates, epicentral locations, earthquake magnitudes, focal depths, source-to-site distances and faulting styles are provided in the database. In terms of source-to-site distance metrics, the epicentral distance (R_{epi}), hypocentral distance (R_{hyp}) and for some records R_{rup} distance measures are available.

C&F also provides station codes, station names, station coordinates, mean shear-wave velocities (VS30) and Eurocode 8 (CEN, 2003) site classification in terms of available VS30 values. (In cases where shear-wave velocity does not extend to 30 m the authors used their own procedure that is based on Boore (2004) to approximate fair VS30 values). The instrument models and applied data processing procedures to remove the long-period noise from the raw acelerograms are given as complementary information in the C&F database. In most cases, removing the pre-event mean and acausal high-pass filtering with a 0.05 Hz filter cut-off is applied for removing the long-period noise. Few records are processed by causal filters and one particular ground motion is processed by a tri-linear baseline correction applied to the velocity time series.

A.2. European strong-motion database (ESMD)

This database consists of major earthquakes occurred in and around Europe between 1973 and 2003. The ESMD includes 462 records from 110 events that are obtained from the Volume 2 CD-Rom (Ambraseys et al., 2004). It is one of the well-detailed global strong-motion datasets and many parameters related to events, records and stations are available in this dataset. Earthquake dates, epicentral coordinates, station locations, depth of events are given. Different earthquake magnitude scales, style-of-faulting and fault-plane solution information is also provided in the database. The estimated fault geometries are used in calculating different distance metrics (R_{epi}, R_{hyp}, R_{JB}, R_{rup} etc). Although the database gives information on the fault geometry (strike, dip and slip angles) whenever available, this information is provided for both planes without indicating the correct plane. The database contains events of magnitudes (Mw) between 4.28 and 7.64 and makes point-source assumption for events less than Mw 5.5 when fault geometry is unknown. This assumption facilitates the calculations of R_{JB} and R_{rup} for such cases.

Whenever available, the database gives detailed information about the sheltering type of the instruments (structural properties, building type, dimensions etc). A total of 261 stations have EC8 site classes but only 135 of the ESMD sites have VS30 values. Detailed site information is given in many of the recording stations (i.e., geologic information, local site conditions etc). All records provided by the ESMD are processed, if available the instrument correction is firstly applied and then a-causal Butterworth filtering is used for removing the long-period noise in the record. The filter cut-off frequencies are determined either from the noise in the fixed trace (analog records) or by examining the Fourier acceleration spectra (FAS), and velocity and displacement traces.

A.3. Next Generation Attenuation (NGA) strong-motion database

The database was established by examining the properties of 173 worldwide earthquakes from 1456 sites. A total of 3551 3-component records are available in the NGA database. Most of the events are from California and Taiwan that are not considered in the SIGMA strong-motion databank. The event, site and waveform properties are presented in detail. Event related information consists of earthquake dates, epicentral coordinates, if available locations, depths, moment magnitude (almost in all cases), rupture geometries, fault solutions and faulting styles. In addition, a detailed study was performed for the fault modeling of the 63 earthquakes (Chiou et al., 2008). Site characterization is primarily made by VS30 according to the NEHRP site classification (BSSC, 2003). Other site classification methods such as Geomatrix, Campbell and Bozorgnia (2003), Bray and Rodriguez-Marek (1997), etc. are also presented in the database. The metadata of NGA database includes information about the instrument type, recording type, building type and various distance metrics (R_{epi}, R_{hyp}, R_{JB}, R_{rup}, R_{seis} etc.). Hanging wall indicator and other rupture parameters are also described in this database.

The waveforms are processed by examining their FAS and displacement traces and by applying either causal or acausal Butterworth band-pass filtering. If this procedure is not adequate (i.e. if the time series still have unexpected variations), the baseline adjustment is applied to the filtered records by subtracting the 2nd time derivative of a polynomial from the acceleration time series that is fitted to the filtered displacement data.

A.4. Turkish national strong-motion (TNSMP) database

The recently compiled Turkish strong-motion database gives information on the seismological, station and recording parameters that are collected and compiled from the international and national seismic sources (Akkar et al., 2010). The earthquake information gathered for each event in the database consists of the earthquake date, epicentral coordinates and earthquake magnitude in various scales (moment magnitude (Mw), surface-wave magnitude (Ms), body-wave magnitude (mb), duration magnitude (Md), and local magnitude (ML)), depth, and faulting type and solution. In the interest of obtaining more homogenous magnitude information and increasing the number of events associated with moment magnitude values, empirical magnitude-conversion equations were developed relying on the database. The station information for each record involves coordinates, location, ID, altitude and site conditions. The first four parameters were generally obtained from the header information of the records provided by the local seismic agency, GDDA (General Directorate of Disaster Affairs). The local site conditions were obtained by conducting field tests. The field tests carried out at each site of interest involved multi-channel analysis of surface waves (MASW), standard penetration test (SPT) and geotechnical laboratory tests (Sandıkkaya et al., 2008). Borehole seismic tests (BST) were also conducted for some sites to validate the VS (S-wave velocity) measurements of MASW. The VS30 obtained at each strong-motion site through MASW was used for describing the pertaining soil classification.

All records with Mw ≥ 3.5 are processed for both horizontal and vertical components. The waveform qualities of all records are categorized as specified in Douglas (2003) based on the following five categories of non-standard errors: spike, insufficient digitizer resolution (IDR), multi-event (or multiple shock, MS, events), S-wave triggered (S-WT), early termination during coda (ETDC). The IDR non-standard error is further divided into three categories: moderate, poor and very poor based on the number of levels of acceleration in the records; an objective method suggested by Douglas (2003). Records with non-standard errors of spike, moderate IDR and MS are processed after special treatment but the rest of the records are excluded from the TNSMP database. After eliminating poor quality records with incurable non-standard problems, accelerograms with Mw ≥ 3.5 are processed. A bi-directional, fourth-order Butterworth filter is used during the filtering process. Before starting the actual filtering, an initial baseline adjustment is applied to the accelerograms. If there is a pre-event buffer in the accelerograms (digital records), the mean of 90 percent of this pre-event time is removed from the entire record (i.e. if there is 10 seconds long pre-event time in the record, the average of 9 seconds portion of this was removed from the whole accelerogram). If there is no pre-event information in the acceleration time series (analog records), the mean of the entire record is computed and removed from the entire acceleration time series. The long-period (low-frequency) filter cut-offs for removing the noise in the mean-removed-accelerograms are estimated in the frequency domain based on the iterative procedure suggested by Akkar and Bommer (2006). For about 70% of the recordings in TNSMP was processed to remove the high-frequency noise by using the procedures explained in Douglas and Boore (2011) and Akkar et al. (2011).

Depending on the level of fault geometry information gathered from the seismic agencies, the R_{JB}, R_{epi}, R_{hyp}, and R_{rup} are calculated. In the case of events whose true rupture locations are determined by special studies, that information was used for the computation of source-to-site distances. For cases where rupture parameters are unknown (i.e., subsurface rupture length, rupture width and rupture area) the finite-source distance measures were estimated from the empirical relationships of Wells and Coppersmith (1994)

The faulting styles are primarily determined from the criteria proposed by Frohlich and Apperson (1992) after obtaining the fault plane solutions from the seismic agencies and other sources in the literature. The method of Frohlich and Apperson uses the plunges of P, T and B axes for the fault plane solutions. For cases when these parameters are not provided by the seismic agencies or if the events are classified as “odd ” by Frohlich and Apperson, then the rake angle intervals proposed by Boore et al. (1997), Campbell (1997) and Sadigh et al. (1997) are used in the determination of faulting style. In the case of conflicting results between these three methods, the commonly estimated faulting style was accepted as the optimally “correct” style-of-faulting. In order to increase the number of database entries with known fault mechanisms, locations of events were correlated with the locations of known faults. A total of 1708 recordings from 754 earthquakes are used from this database. These strong motions are recorded from 164 sites and 138 of them have VS30 values.

A.5. Internet Site for European Strong-motion Data (ISESD) database

The Internet Site for European Strong-motion Data (ISESD) database is an internet source that provides strong-motion records from Europe and surrounding countries (Ambraseys et.al, 2004). The site enables user to search records based on the choices of earthquakes, records or station information (magnitude, site class, epicentral distance, etc). The parameter and record files contain event date, Flinn Engdahl region, country, epicentral coordinates, depth, magnitudes on different scales, style-of-faulting, station network, station coordinates, elevation, shelter type, local geology, V_{S30}, distance metrics (e.g., epicentral and Joyner-Boore distance), source to station azimuth, location and orientation of instrument, instrument type, instrument operator, instrument properties (i.e. sensitivity, natural frequency, damping, full scale amplitude, sampling interval, number of data, resolution of A/D converter, poles of anti-alias filter) and processing scheme.

Instrument correction, as part of strong-motion processing, is applied to the ground-motion records if the necessary information is available. Most of the accelerograms are processed by the 8th order elliptical band-pass filter. The band-pass filter types of a few records are not identified whereas two accelerograms are filtered by the Ormsby band-pass filter. Finally, linear baseline correction is applied to all of the acceleration and velocity time histories.

Events with magnitudes greater than 3 (in any magnitude scale) are selected from the ISESD website by excluding the tremors from mine explosions. A total of 2844 records from 897 events are gathered from this database. These ground motions are recorded by 1079 stations from 34 countries. The site classification of the ISESD database is carried out either by using the shear wave velocity profiles, or the local site geology. A total of 228 sites have V_{S30} values and 442 sites have local site geology descriptions. The remaining sites do not reveal any information on site characterization.

A.6. Italian Accelerometric Archive (ITACA) database

ITACA project (Luzi et al., 2008) has compiled the strong motion and site class information of the national strong-motion network in Italy. This information in ITACA consists of the following components: event date, location, epicentral coordinates, depth, magnitudes, style-of-faulting, station abbreviation, coordinates, elevation, EC8 site classification, morphological classification, R_{epi}, R_{JB} and R_{hyp} distances, back azimuth, sampling interval, number of data, instrument properties and ground-motion data processing.

ITACA database includes a total of 1165 records obtained from 202 events. Of the entire collection, 156 earthquakes have both moment magnitude and local magnitude information. Number of events with only local or moment magnitude information is 45 and 1, respectively. Style-of-faulting information is available for 150 events.

There are 331 strong-motion stations in the ITACA database. The shear-wave velocity profiles are provided only for 79 stations. The VS profiles of 70 stations extend up to 30 m whereas the rest of the stations do not cover a full range of 30 m to obtain proper VS30 values. The VS30 values of stations with VS profiles less than 30 m are calculated by extending the shear-wave velocity of the last layer to 30 m. ITACA database presents the estimated EC8 site classes for the remaining sites (i.e., 252 stations).

Analog recordings in the ITACA database are first subjected to instrument correction before any other processing. All strong-motions are processed for baseline shifts. They are then band-pass filtered using a 2nd order acausal Butterworth filter. The procedure followed in band-pass filtering is the one described in Boore and Bommer (2005). The velocity and displacement time series are examined for their consistent variation after the data processing.

A.7. Akkar and Bommer (2010) strong-motion database

The strong-motion database is almost the same as that employed by Ambraseys et al. (2005) but excludes those records that were available only as filtered traces. One important difference with respect to the database of Ambraseys et al. (2005) concerns the style-of-faulting classification. Following Frolich and Apperson (1992), Ambraseys et al. (2005) included a class of fault ruptures identified as odd. Akkar and Bommer (2010) reclassified the odd ruptures (most of which are oblique) according to the dominant mechanism, using the rake angle as suggested by Sadigh et al. (1997). In the final database, the records are distributed among reverse, normal, and strike-slip ruptures.

The recording stations were classified according to the average shear-wave velocity over the uppermost 30 m at the site (V_{S30}), with those having values above 750 m/sec being classified as rock and those with values below 360 m/sec as soft soil; intermediate values are classified as stiff soil. Just 2% of the records are from very soft soil sites (V_{S30} < 180 m/sec).

The magnitude scale used to classify the size of the earthquake events is M_w. The distance metrics in the database are R_{epi} and Joyner–Boore distance (R_{JB}). For earthquakes smaller than M_w 5.5, the two distance metrics are considered equivalent. The scarcity of near-source recordings is clearly a deficiency of this database. The database contains depth information for almost all events. Although the metadata of the database is essentially the same as that of Ambraseys et al. (2005), this is not the case for data processing because the records have been reprocessed in this database by the procedure described in Akkar and Bommer, 2006.

A.8. Bommer et al. (2007) strong-motion database

The European Strong-Motion Database (Ambraseys et al., 2004) with events less tan Mw 5 and distances of 100 km or lees is the main source of this database. Determination of site classification of the recording stations and style-of-faulting is the same as in Akkar and Bommer (2010).

The smallest magnitude is M_w 3. The dataset contains a total of 465 records from 158 earthquakes and all recordings are filleted with a low-frequency cut-off at 0.25 Hz.

B. Detail on RESORCE seismic motion database meta-parameters (version 1)

In its current version, RESORCE includes about 5,000 recordings. The meta-parameters available concern three main types of information:

- Earthquake : source and fault information
- Station : location, instrument and site information
- Waveform : processing and parameters information

In the following sections we detail the database fields which are being implemented for the version 1 of RESORCE.

B.1. Earthquake information

Each organisation has defined its own earthquake parameters (location, magnitude) following its own procedures. A unified identifier of event is therefore the basic element for linking together all the data related to a same event. Within the NERIES project, this unique identifier UNID has been defined for the period 1998 to today. In the framework of SIGMA, we will adapt and incorporate it to the RESORCE database.

Table 2 summarizes the meta-data related to each earthquake event.

Table 2 Earthquake information

FIELD NAME	DESCRIPTION
EARTHQUAKE ID	*Earthquake ID given by METU group*
REFERENCE 4 EVENT INFO	Reference database (1)
ADDITIONAL REFERENCE 4 EVENT INFO	Additional Source database (2)
Earthquake CODE	This shows earthquake date in YYYYMMDDHHMM format
Earthquake YEAR	Earthquake date (Year)
Earthquake MONTH	Earthquake date (Month)
Earthquake DAY	Earthquake date (Day)
Earthquake HOUR	Earthquake date (Hour)
Earthquake MIN	Earthquake date (Minute)
Earthquake SEC	Earthquake date (Second)
Earthquake NAME	Name of the earthquake in the source database
Earthquake COUNTRY	Location of earthquake in terms of country
EPICENTER LATITUDE	Coordinates of earthquake
EPICENTER LONGITUDE	Coordinates of earthquake
FOCAL DEPTH (km)	Focal depth in km
MW	Moment magnitude
MD	Duration magnitude
MS	Surface wave magnitude
MB	Body wave magnitude

ML	Local magnitude
STRIKE 1 (deg)	Strike information for the first fault plane
STRIKE 2 (deg)	Strike information for the second fault plane, if available
DIP 1 (deg)	Dip information for the first fault plane
DIP 2 (deg)	Dip information for the second fault plane, if available
SLIP 1 (deg)	Slip information for the first fault plane
SLIP 2 (deg)	Slip information for the second fault plane, if available
S. Plane	Selected Plane (3)
S. Strike	Selected Strike Information
S. Dip	Selected Dip Information
S. Slip	Selected Slip Information
Distance Flag	Criteria to compute Rjb and Rrup (4)
REPI (km)	Epicentral distance from reference database
RHYP (km)	Hypocentral distance from reference database or computed
RJB (km)	Joyner-Boore distance (4)
RRUP (km)	Rupture distance (4)
STYLE-OF-FAULTING	Style of faulting in the reference database

Numbers into brackets refers to “flags” for the corresponding database meta-data. Section B.4 describes theses flags more in detail:

(1) Reference database : cf section B.4.1.
(2) Additional source databases : cf section B.4.2.
(3) Selected plane : cf section B.4.3.
(4) Criteria to compute R_{jb} and R_{rup} : cf section B.4.4.

B.2. Station information

Table 3 summarizes the meta-data related to each recording station.

Table 3 Recording station information

FIELD NAME	DESCRIPTION
STATION ID	*Station ID given by METU group*
STATION NAME	Name of the station given in the database
STATION CODE	International station code
STATION COUNTRY	Location of the station (Country)
STATION LATITUDE	Location of the station (Coordinates)
STATION LONGITUDE	Location of the station (Coordinates)
ALTITUDE (m)	Location of the station (Altitude)
REFERENCE (STATION INFORMATION)	Source database for station information
VS30 (m/s)	Average shear wave velocity over 30m
MEASURED/INFERRED VS30	Flag of measured or inferred values of VS30. (5)

ESTIMATED SITE CLASS (EC8)	Estimated EC-8 site class
REFERENCE (SITE CLASS INFO)	Source database for site class information
INSTRUMENT MODEL	Digitizer of the recording instrument
RECORDING TYPE	Type of recording (Analog/Digital)
STRUCTURE TYPE	Type of the structure
NUMBER OF STORIES	Total storey number of the building
FLOOR WHERE DEVICE HAS BEEN SET	Storey number where the recording information is set
INSTRUMENT OPERATOR	Instrument operator
INSTRUMENT OPERATOR CODE	International operator code FDSN or ISSR
Monograph ID	Additional pdf file on station information

Numbers into brackets refers to “flags” for the corresponding database meta-data. Section B.4. describes theses flags more in detail:

(5) Information on Vs30 measurements : cf section B.4.5.

Fields with blue background are RESORCE additional metadata fields which will ensure the stability of the station referencing (station and operator codes) and will give access to detailed information when available (through the event monographs).

B.3. Waveform information

For each recording, the only unique field is waveform ID. This is the core of the database and of the metadata. SHARE databank includes a specific identification number defined by the METU group. In the RESORCE database, we will use different identification numbers and the record files directory will be adapted.

Table 4 summarizes the meta-data related to each waveform in the database.

Table 4 Waveform information

FIELD NAME	DESCRIPTION
WAVEFORM ID	*Waveform ID given by the METU group*
RECORD FILE DIRECTORY\NAME (COMP1)	Original destination of the record for Horizontal 1 component
RECORD FILE DIRECTORY\NAME (COMP2)	Original destination of the record for Horizontal 2 component
RECORD FILE DIRECTORY\NAME (COMP3)	Original destination of the record for Vertical component
ORIENTATION OF COMP1	Orientation of the component 1
ORIENTATION OF COMP2	Orientation of the component 2
ORIENTATION OF COMP3	Orientation of the component 3
COMP1 PROC PGA (cm/s2)	Peak ground acceleration for Comp1
COMP2 PROC PGA (cm/s2)	Peak ground acceleration for Comp2
COMP3 PROC PGA (cm/s2)	Peak ground acceleration for Comp3
INSTRUMENT CORRECTION	Instrument correction
COMP1 BASELINE CORRECTION	Processing procedures for Comp1
COMP2 BASELINE CORRECTION	Processing procedures for Comp2

COMP3 BASELINE CORRECTION	Processing procedures for Comp3
COMP1 FILTER TYPE	Processing procedures for Comp1
COMP1 FILTER ORDER	Processing procedures for Comp1
COMP1 NUMBER OF PASSES	Processing procedures for Comp1
COMP1 NROLL	Processing procedures for Comp1
COMP1 LOW-CUT FREQ (Hz)	Processing procedures for Comp1
COMP1 HIGH-CUT FREQ (Hz)	Processing procedures for Comp1
COMP2 FILTER TYPE	Processing procedures for Comp2
COMP2 FILTER ORDER	Processing procedures for Comp2
COMP2 NUMBER OF PASSES	Processing procedures for Comp2
COMP2 NROLL	Processing procedures for Comp2
COMP2 LOW-CUT FREQ (Hz)	Processing procedures for Comp2
COMP2 HIGH-CUT FREQ (Hz)	Processing procedures for Comp2
COMP3 FILTER TYPE	Processing procedures for Comp3
COMP3 FILTER ORDER	Processing procedures for Comp3
COMP3 NUMBER OF PASSES	Processing procedures for Comp3
COMP3 NROLL	Processing procedures for Comp3
COMP3 LOW-CUT FREQ (Hz)	Processing procedures for Comp3
COMP3 HIGH-CUT FREQ (Hz)	Processing procedures for Comp3

B.4. Detailed references

This section describes more in detail the information identified by numbers into brackets in the previous sections.

B.4.1. Reference database

Seven main databases were used to gather the SHARE databank. Information on a particular event is extracted from one of them according to the criteria described below. The following table summarizes these origin databases (Number (1) in section B.1).

REFERENCE 4 EVENT INFO	
ESMD	European strong-motion database
NGA	Next Generation Attenuation
TNSMP	Turkish national strong-motion project
ISESD	Internet site for European strong-motion data
AB10	Akkar & Bommer (2010), a modified version of Ambraseys et al. (2005)
Bommer et al, 2007	European strong-motion data compiled for the specific purposes of Bommer et al. (2007)
ITACA	Italian accelerometric archive

For the identification of the reference database, the following strategy has been adopted:

- If ground motion is from Turkey, TNSMP information is used (see Akkar et al., 2010 for details on the compilation of Turkish strong-motion database).
- If ground motion is from Italy, ITACA information is used (see Luzi et al., 2008 for ITACA project).
- For Turkish and Italian recordings, if no information (or insufficient information) exists in TNSMP and ITACA, we refer to the others database, in the following order of priority :
    - ESMD
    - ISESD
    - NGA
    - Cauzzi and Faccioli (2008)
- The information of ESMD, ISESD, NGA or Cauzzi and Faccioli (2008) is used for recordings (or events) other than Italian and Turkish. The priority among these databases is the following:
    - ESMD
    - ISESD
    - NGA
    - Cauzzi and Faccioli (2008).

For a particular event (or recording), however, if one of the above databases has more complete metadata information (e.g. on source parameters, as they are significant for source-to-site distance calculations, that database is preferred.

B.4.2. Additional source database

When one of the meta-parameters from the reference database is considered of less quality than from another database, the used information is this latter. The flag informs then about the source of the selected information. The following table summarizes the possible cases (number (2) in section B.1.).

ADDITIONAL REFERENCE 4 EVENT INFO	
FM(ESMD)	Fault Mechanism information was taken from ESMD.
FM(NGA)	Fault Mechanism information was taken from NGA.
FD(NGA)	Fault Dimension information was taken from NGA.
Depth(C&F)	Depth information was taken from (C&F).
FS(ISESD)	Style of Faulting information was taken from ISESD.
FS(C&F)	Style of Faulting information was taken from (C&F).
MW(ISESD)	Mw information was taken from ISESD.
FS(ISESD)	Style of Faulting information was taken from ISESD.

B.4.3. Selected plane

When several fault planes are available for the same event, this flag indicates which one is the selected (preferred) plane (number (3) in section B.1.).

0	fault plane taken from reference database
1	1st fault plane is selected for calculations
2	2nd fault plane is selected for calculations
3	no fault plane is selected
none	no fault plane solution is available in the reference database therefore no fault plane is selected

B.4.4. Criteria to compute R_{jb} and R_{rup}

In this field RESORCE provides information on distance calculations (number (4) in paragraph B.1). The following table summarizes the criteria used for distance claculations. Discussions are still in progress with the Scientific Board for agreement.

0	If M<4.8 (i.e. no specific Mw exists in the reference database) and if fault solution is not provided along with no depth information, Rjb and Rrup are not computed and left empty.
1	Flag 0 conditions but either Rjb or Rrup information is given by the reference database. In that case information provided by the reference database is taken as is.
2	Both Rjb and Rrup are taken directly from the reference database.
3	Rjb and Rrup are not provided by the reference database but it gives all relevant information (rupture width, area, length, dip, slip, rake etc) for their reliable calculation. Therefore they were computed.
4	If only Mw and fault plane information is given by the reference database but neither Rjb nor Rrup are provided, the following assumptions were made to approximate the missing information: If Rw (rupture width) and Rl (rupture length) information were not provided, Wells and Coppersmith (1994) were implemented using Mw information If depth-to-top of rupture (Dtor) information was not provided, the nucleation point was assumed at the middle of rupture area. Note that, if rupture is at the surface Rw is extended along down dip direction starting from surface.
5	Reference database provides the fault plane solution (Dtor, Rl and Rw) and Rjb is given but Rrup is not given: Rrup was calculated from the given Rjb value (Kaklamonos et al., 2011).
6	Fault plane, Rjb and one of the pairs among Rl, Rw and Dtor is provided but Rrup is not given: Rrup was calculated from the given Rjb value using the assumptions in Kaklamonos et al. (2011).
7	Fault plane and Rjb are provided but Rl, Rw and Dtor are not provided: Rrup was calculated from the given Rjb value using the assumptions in Kaklamonos et al. (2011).
8	2 fault plane solutions as well as Rjb are given by the reference database: Using Wells and Coppersmith (1994) relationships, Rjb values for each fault plane were computed. The computed Rjb values were compared with the originally given Rjb information. The fault plane that yields the closest Rjb value to the original Rjb was considered as the consistent fault plane and corresponding Rrup value was assumed as the correct finite-source distance.

9	2 fault plane solutions are given but neither Rjb nor Rrup are given: Recordings that pertain to the same event associated with Rjb or Rrup information were used to select the consistent fault plane and then missing Rrup and Rjb values were computed.
10	Due to the lack of information to compare the distance values computed for one of the fault plane solutions, the 1st plane was accepted as the correct plane for Rrup and Rjb calculations. These recordings belong to the following countries: Greece, Italy, Spain, Portugal and Armenia.
11	Specific to Fruili and Kocaeli events. For these events all distance measures were computed using the fault-plane solutions studied in specific papers. (See Section 3 for distance calculations of Fruili events).

To note that R_{epi} exists in all source databases, such that the information is directly taken from the reference database. R_{hyp} is taken directly from the reference database if provided; otherwise R_{hyp} is computed by using the depth and R_{epi} information.

B.4.5. Information on Vs30 measurements

Information on shear wave velocity measurement methods are given below (number (5) in section B.3). For the following versions of RESORCE database, additional information may be added, according to the needs and suggestions of WP3 actors.

0	Measured
1	Inferred Vs from Borcherdt and Fumal and from CGS assignments - (from NGA)
2	Inferred from Geomatrix Site Class - (from NGA)
3	Inferred from Vs profile less that 20 m in depth - (from NGA)
4	Inferred from Spudich and others (1997; 1999; Spudich, personal communications, 2003) - (from NGA)
5	Anchorage Alaska maps of Vs30 from measured VIC data - (from NGA)
6	Inferred from Anchorage Alaska maps of Vs30 from VIC data (Martirosyan et al., 2002) - (from NGA)
7	Inferred from Vs profile less that 30 m in depth by Cauzi and Faccioli (2008)
8	Inferred from Vs profile less that 30 m in depth by extending the lower most measured Vs to 30 m.
9	Inferred from Vs measurement of a close site - (from T-NSMP)
10	Unknown

C. Suggestions from WP3 for additional metadata for site effect assessment

In order to take into account site effects and reduce biases and uncertainties in ground-motion estimation, while avoiding any "double counting", we need:

- To evaluate as well as possible the amplification of the studied sites (transfer functions,…)
- To use incident motion in which the contribution of site effects under accelerometric stations was removed. This implies that Ground Motion Prediction Equations (GMPEs) should provide a reference rock ground-motion, free of site effects.

Some approaches exist to "deconvolve" the site effects from accelerograms in order to obtain a corrected "reference" signal. New approaches have to be developed. Reliable approaches need more than a single "Vs30" value to be physically relevant. When more detailed information is available on a given station (whole crosshole profile, fundamental frequency, empirical estimation of transfer function…), this should be included as metadata of the database. In addition, within the framework of the SIGMA/CASHIMA projects, the improvement of the characterization of key-stations is to envisage. In this context, RESORCE database can be an important tool to identify those stations that need an effort of characterization in order to optimize further studies.

In order to attain the above objectives (applying on accelerograms accurate déconvolution techniques and optimize future characterization actions), we propose to enrich the RESORCE "station metadata", by taking inspiration from ITACA Italian databank.

We can split the information we need in 3 categories :

- Cat. 1: information that can be used in the "station search" tool (example: EC8 site category, number of records, existence of a borehole measurement…)
- Cat. 2: information not from Cat. 1 but that is digitalized (example: whole Vs and Vp profile) (example: "Station details" page in ITACA base)
- Cat. 3: all other information which can be gathered in a pdf files (called "Station monography" in ITACA Base)

Cat. 1:

- All "classic" information: Station code, Lat. Long. Elev, instrument type, etc.,
- EC8 code
- Type of evaluation of EC8 code value
- Vs30 value
- Type of evaluation of the Vs30 value
- Morphology type (see ITACA nomenclature)
- Topography (see ITACA nomenclature)
- Number of records
- Availability (yes or no) of an borehole Vs/Vp profile
- Availability (yes or no) of a dispersion curve
- Availability (yes or no) of an geophysical based Vs/Vp profile (surface wave method or other)
- Availability (yes or no) of an empirical transfer function estimation (e. g. Drouet method)

Cat. 2:

All Cat. 1 information +

- date of installation/removal
- map
- whole borehole Vs / Vp profile + method of estimation
- whole non-invasive based Vs / Vp profile + method of estimation
- dispersion curve (including std) + method of estimation (without limitation of frequency range or "frequency sampling")
- fundamental frequency + method of estimation
- empirical transfer function (including std) + method of estimation
- for all measurements : distance from the measuring point (or center) to the station

Cat. 3:

All Cat. 2 information +

- Photo of the station
- All important geological information (including estimation of basin depth, stratigraphic description of the profile if available; map, cross-section)
- H/V measurement results (see ITACA presentation)
- Date of measurement + name of company / entity who performed borehole or non-invasive measurements, empirical transfer function estimation + reference, any indication on where we can find the corresponding detailed reports.
- Map representing measuring points or profiles and station.

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SIGMA – Seismic Ground Motion Assessment

Report on the deliverable D2-1 (Seismic motion databank for France and nearby countries).

The RESORCE project consists in the building of a unified (and homogeneous) databank reference for ground-motion in France and its adjacent areas (in fact, this is at a European level considering the contributing countries to SIGMA strong-motion databank), the last attempt to build such a compiled European ground-motion database was the remarkable work done by Prof. Ambraseys and the earthquake research group of the Imperial College of London.

One (the main) scientific goal will be to build an up-to-date databank in order to develop and to check models of ground-motion for seismic hazard studies, engineering seismology and earthquake engineering purposes. When it becomes operational, the community will benefit of a single and integrated European ground-motion database, based on high standards and on verified and qualified data.

Two institutions are responsible for the implementation of the database: the METU (Middle East Technical University – Ankara) and the EMSC (European Mediterranean Seismological Centre). On one hand, METU will be in charge of collecting, checking and formatting the data and metadata. On the other hand, ESMC is charged to implement and maintain the databank and to create all the tools needed for access and distribution of the data through an internet portal.

In addition a scientific board is responsible for the political and scientific choices concerning the database structure and its content. It is composed of S. Akkar (METU Turkey), F. Cotton (OSUG-UJF, France), J. Douglas (BRGM, France), P. Traversa (EDF, France) and T. Van Eck (ORFEUS, The Nederlands).

The document:

- Recalls the main objectives of WP2;
- Gives a detailed and comprehensive view on the future structure of the database (especially the metadata described in appendix B) with an internet portal which is expected to open by the end of 2011;
- Provides a very detailed review (however, nothing from France?) of the existing European ground-motion databases (origin, content: information on earthquake, station information, and recording information), authors, current state …), that is (and which is also developed in appendix A):
    - Cauzzi & Faccioli (C & F) strong-motion database;
    - European strong-motion database (ESMD);
    - Next Generation Attenuation (NGA) strong-motion database;
    - Turkish national strong-motion (TNSMP) database;
    - Internet Site for European Strong-Motion Data (ISESD) database;
    - Italian Accelerometric Archive (ITACA) database;
    - Akkar & Brommer (2010) strong-motion database;
    - Bommer et al. (2007) strong-motion database.

This synthesis is a main output of the document.

In addition, appendix B provides a description of the RESORCE metadata; it concerns earthquake information, station information, and waveform information.

A last chapter gives the suggestions from the WP3 group for additional metadata devoted for site effect assessment. This shows a thorough reflection on the content and organization of the database.

Globally, I find this first report of WP2 very well documented (especially with a very detailed description about some European existing strong-motion databases).

However, I think that the report lacks of information about the scientific use of the database. It was also interesting to clarify which type of earthquakes would be most relevant for modeling (for example: the lowest magnitude, the range of epicentral distances ...). This is not enough to say that the main use will be to develop and to test ground-motion models. I would have appreciated to read more about some scientific applications (This also has implications for what should be the content). It lacks some thoughts on possible links between RESORCE and other national databases on strong ground motion (I refer specifically to the French RAP databank). Also, it would be interesting to sketch some ideas on possible articulation between RESORCE and other European seismological databases.

From this first report, I must be very optimistic concerning the opening of the internet portal by the end of this year.

Michel Granet

Sunday, May 22, 2011.

General comments on the deliverable D2_1 (SIGMA-2011-D2-09 A)

In order to improve the seismic ground motion models and reduce the associated uncertainties, it was identified the need to dispose of a high-quality database of recordings and the related meta-information.

The present deliverable reports on the development of a reference database for seismic ground-motion in Europe (so called RESORCE) within the framework of the SIGMA project. This database will be used to adapt, test existing GMPE or derive new GMPE for seismic hazard applications in Europe.

This document presents briefly the objectives, the structure and the content of RESORCE;

In summary, it has to be noticed that SIGMA, NERA as well as other projects planned to work together to implement a single, homogeneous database. SIGMA WP2 will then contribute to up-date and improve the European database, and in particular extend it in magnitude and distance (useful for application in low-to-moderate seismicity countries).

This report points out the fact that:

1. This WP2 will aim at improving the metadata as well as at homogenizing the data processing (under the coordination of METU).
2. Transparency will be ensured by publishing the procedures as guidelines.
3. It is planned to make it open to a large community (through a portal hosted by the EMSC), which will facilitate to get feedback from the end-users, and to make it evolve with time ;
4. It is planned to freeze the structure of the database at the end of 2012;

At this stage, RESORCE only includes data from existing databases. In the Appendix A, there is a description of each database on which the first version of RESORCE will rely.

Overall, at this stage the report remains largely prospective.

<u>Questions:</u>

In the report, it is mentioned that this project is meant to compile both accelerometric and broadband data. However, at this stage, only the accelerometric aspects are discussed. How do the authors envisage collecting these data? What type of data are searched for?

It is not clear to me whether, the authors will be able to get or aim to get back to original raw data in order to apply the same procedure or protocol to process the data in a homogeneous way.

The project at this stage relies strongly on collecting the data from existing databases. Concerning the French metropolitan territory, do RESORCE will include the data collected by the GIS-RAP?

It is planned to involve the data-providers in the process of data improvement. Is it planned to conduct specific measurements to better characterize the sites on which are installed the stations ?

Station information: Did you consider/envisage to report on the predominant frequency to qualify each station?

David Baumont