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European Strong-Motion database: a platform to access accelerometric data

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Abstract

This paper describes the European Strong-Motion database (ESM), developed in the framework of the European project NERA (www.near-eu.org). ESM is specifically designed to provide end-users only quality-checked, uniformly processed strong-motion data and relevant parameters since 1969 in the Euro-Mediterranean region. It has been designed for a large variety of stakeholders (expert seismologists, earthquake engineers, students and professional) with a user friendly and straightforward web interface.

Users can access earthquake and station information and download waveforms of events with magnitude ≥ 4.0 (unprocessed and processed acceleration, velocity and displacement and acceleration and displacement response spectra at 5% damping). Specific tools are also available to users to process strong-motion data and select ground motion suites for code-based seismic structural analyses.

European Strong-Motion database: a platform to access accelerometric data

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Introduction

The repeated attempts of building unified European strong-motion databases are motivated by the increasing demand of strong motion data, that are one of the primary sources of information used by engineering seismologists and earthquake engineers to predict ground shaking and perform structural seismic analysis.

The first coordinated collection of pan-European strong-motion data was established within the framework of the Internet Site for European Strong-Motion Data (ISESD), a project supported by the European Commission during the 5th Framework Programme (1998-2002). The latest database version, available at ISESD (http://www.isesd.hi.is, last access December 2015; Ambraseys et al., 2004) contains about 2,000 strong-motion records in the time span 1973 - 2008.

During the 6th Framework Program of the European Commission, within the project NERIES (2006-2010, http://www.neries-eu.org/, last access December 2015), a new collection of accelerometric waveforms recorded in the Euro-Mediterranean region was promoted. That time 8,000 digital data recorded since 1995, including very weak events (M>= 1.0), were gathered and uniformly processed with a fixed cut-off frequency of 0.1 Hz (Roca et al., 2011), but, unfortunately, data are no longer available on the web.

An additional strong motion data collection was promoted within the project SHARE (7th Framework Program of the European Commission, 2010-2014) with the aim of testing the performance of candidate ground-motion prediction equations (GMPEs) for the probabilistic seismic hazard map of Europe (Yenier et al. 2010). Accelerograms were gathered from European or regional databases (e.g. Turkish national strong-motion database, described in Akkar et al 2010; Italian ACcelerometric Archive, described in Luzi et al. 2008) and from worldwide databases (e. g. K-Net and KIK-Net database http://www.kyoshin.bosai.go.jp/, last access December 2015; Next Generation Attenuation database, NGA, Chiou et al, 2008; a dataset compiled by Cauzzi and Faccioli, 2008). Data are as in the original database and neither metadata update nor uniform processing has been carried out (Yenier et al. 2010). This databank contains 2448 events and 14193 records and only a flatfile with waveform parameters is distributed at http://www.efehr.org:8080/jetspeed/portal/hazard.psml (last access December 2015).

A recent attempt of gathering European strong-motion data was carried out within the project SIGMA (SeIsmic Ground Motion Assessment, http://projet-sigma.com/, last access December 2015). The RESORCE database (Akkar et al. 2103) contains pan-European strong-motion data and has been compiled with the goal of improving seismic hazard assessment in France and neighbouring regions. It includes 5,882 multi-component and uniformly processed accelerograms from 1,814 events in the magnitude range $2.8 \leq Mw \leq 7.8$, mainly from the pan-European subset of the SHARE strong-motion collection. At the moment data are not public, although the database can be accessed upon request.

A different approach was followed within the NERA project (2010-2014, 7th FP of the European Commission, www.nera-eu.org, last access December 2015), since the data collection was performed through the networking of strong-motion data operators with the aim of creating long-term infrastructures.

Two repositories were created:

1. *Rapid Response Strong-Motion database* (RRSM, www.orfeus-eu.org/rrsm/, last access December 2015) for the rapid access to earthquake information, peak ground motion parameters, response spectral amplitudes and download of earthquake waveforms within minutes after an earthquake with magnitude ≥ 3.5.

Data are processed automatically using the scwfparam (http://www.seiscomp3.org/doc/jakarta/current/apps/scwfparam.html, last access December 2015), a waveform parametrization module of the SeisComP3 software package (http://www.seiscomp3.org/, last access December 2015), in order to make them immediately available. The complete database dates back to 2005 (Cauzzi et al, this issue).

2. *European Strong-Motion database* (ESM, http://esm.mi.ingv.it, last access December 2015) specifically designed to provide end-users only quality-checked, uniformly processed strong-motion data and relevant parameters. This database is tailored to serve engineers and scientists alike in the assessment of seismic hazard.

The European Strong-Motion database is the subject of this paper.

The framework of the European Strong-Motion database

At present times, new generation instruments can record weak-to-strong motions using real-time data transmission and data are soon available after a seismic event. A recent initiative within Observatories and Research Facilities for European Seismology (ORFEUS, http://www.orfeus-eu.org/, last access December 2015) is the European Integrated Data Archive (EIDA, http://www.orfeus-eu.org/eida/eida.html, last access December 2015), structured as a distributed data centre, to securely archive seismic waveforms gathered by European research infrastructures, and providing transparent access to the archives. Several European data centres act as EIDA nodes, collecting and archiving data from seismic networks deploying broad-band sensors, short period sensors, accelerometers, infrasound sensors or other geophysical instruments. IRIS (Incorporated Research Institutions for Seismology) data centre support access to time-series data, related metadata and event parameters through web services (http://service.iris.edu/, last access December 2015). Both data centres are coordinated within the International Federation of Digital Seismograph Networks (FDSN, http://www.fdsn.org/, last access December 2015).

ESM is designed to automatically extract data using standard FDSN web services (http://www.fdsn.org/webservices/, last access December 2015) available from EIDA and IRIS data centres, but also to host offline records from providers that do not distribute data using standard FDSN or through international organizations, thus preserving the existing patrimony of “historical” data, mainly recorded by analogue instruments, operating before 2000.

The ESM database structure is based on the ITACA architecture (Luzi et al., 2008; Pacor et al., 2011), a robust system used to store and distribute the Italian accelerometric records. The underlying framework is tailored on the peculiarity of these data, that need support from a variety of metadata regarding seismic events and recording stations to be fully exploited for engineering applications (e. g. derivation of ground motion prediction equations, selection of accelerograms compatible with target spectra, derivation of seismic codes).

The infrastructure is formed by a centralized relational database, with a core formed by about 80 tables, a web interface and several tools to search data from online archives and catalogues, automatically populate the database, perform data quality check and processing.

In the paragraphs that follow we illustrate the process of data maintenance and distribution.

Data upload from webservices

Continuous data are automatically extracted from EIDA and/or IRIS Data Centres, using FDSN webservices, and uploaded into the ESM database. The procedure from a new earthquake occurrence to the record publishing consists in three steps.

Step 1: data upload after an event alert

After any event with magnitude larger than or equal to 4, reported in the European-Mediterranean Seismological Centre (EMSC) standard FDSN event webservice (see data and Resources), records available through EIDA and/or IRIS DCs (see Data and Resources) are extracted, using an automatic procedure for signal windowing, and uploaded into the database. At this stage only preliminary location parameters are assigned to the earthquake. Offline data are then searched in several repositories and uploaded after the network operators make them available.

Step 2: data processing

Bad quality records (e.g. records containing spikes or with low signal to noise ratio) are not processed, but made available to users in the unprocessed version.

Good quality waveforms are manually processed using the procedure proposed by Paolucci et al (2011) and processed acceleration, velocity and displacement time series are obtained together with acceleration and displacement response spectra at 5% damping.

Step 3: data release

All records manually processed are released in a time interval ranging from few hours (relevant events) to few days, with the preliminary earthquake information.

Data upload from offline files

“Historical” strong-motion data are obtained from different sources. The following regional databases are preferred to pan-European compilations:

- The Unified HEllenic Accelerogram Database (HEAD, see Data and Resources), released in 2004 and containing Greek data from 1973 to 1999 (Theodulidis et al., 2004);
- The ITalian ACcelerometric Archive (ITACA, see Data and Resources), containing Italian data from 1972 to 2015 (Luzi et al. 2008; Pacor et al. 2011);
- The strong motion database of Turkey (TR-NSMN, see Data and Resources) from 1976 to 2007.

Pan-European data from 1972 to 2008, not included in regional databases, have been extracted from the Internet Site for European Strong-Motion data (ISESD, see data and Resources).

The procedure of offline data upload into the ESM database is semi-automatic and consists in several routines for the conversion of waveforms into standard formats.

Where not available, FDSN standard network codes (http://www.fdsn.org/networks/, last access December 2015) are assigned to all providers, included the ones no longer operating (e.g. networks belonging to the former Yugoslavia). Waveforms are named following the SEED convention (www.iris.edu/manuals/SEEDManual_V2.4.pdfhttp://www.fdsn.org/networks/, last access December 2015).

Metadata revision and data processing

Event and station metadata contained in the database are periodically revised. The event-based information collected from earthquake-specific literature studies are always ranked as the primary reference for large seismic events. For moderate to small events the source of earthquake information are regional catalogues (e.g. the INGV Bulletin, see Data and Resources) or the Bulletin of the International Seismological Centre, ISC (see Data and Resources), in case regional catalogues are unavailable. The ISC bulletin relies on the contributions from seismological agencies around the world and is typically 24 months behind real-time, therefore events can be revised with one year delay. Different magnitudes (Mw, Ml, Mb, Ms) are reported in the database as well as moment tensor solutions from different agencies. Information on the geometries of the seismic sources come from regional or international catalogues (e.g. Ambraseys et al 2004 for several European events; DISS for Italy; GREDASS for Greece; SRCMOD for large events occurred worldwide; see data and Resources) or from specific source-model studies.

Station metadata are periodically updated, after they become available by network operators or specific studies are published in the literature or after national and international projects. The existent station information is obtained from regional databases (ITACA, T-NSMP, HEAD, see Data and Resources) or specific literature studies (e. g. Zare et al 1999; Régnier et al 2010; Michel et al 2014).

Individual waveforms are processed manually following the general procedure described in Paolucci et al (2011), that consists of:

- mean removal from the uncorrected acceleration signal;

- linear detrend of the uncorrected acceleration signal (subtraction of a first order polynomial);
- application of a cosine taper, with percentage fixed to 5% of the signal length, with the possibility of being modified by the user;
- visual inspection of the Fourier spectrum to select the band-pass frequency range (band-pass frequency may be different for the three components);
- application of a 2nd order acausal time-domain Butterworth filter to the acceleration time-series; zero-pads are added at the beginning and end of the signal before the acausal filter is applied (Boore 2005);
- removal of zero pads from the acceleration trace;
- (begin / end) taper of the acceleration signal, with percentage fixed to 5%;
- computation of the velocity signal and linear detrend;
- (begin / end) taper of the velocity signal, with percentage fixed to 5%;
- computation of displacement signal and linear detrend;
- (begin / end) taper of the displacement signal, with percentage fixed to 5%;
- recursive differentiation to obtain the velocity and the acceleration time-series, respectively.

Data access and download

Currently the ESM portal (Figure 1) allows to access records relative to events with magnitude larger than or equal to 4, occurred in Europe and Middle East since 1969. Table 1 reports the complete list of the events with magnitude larger than 6.0 and the number or recordings for each event.

Seismic events can be retrieved entering the page "Events" of the portal. User can select 13 parameters including date and time of the event, magnitude range, hypocentral coordinates or style of faulting. The query returns a list of earthquakes that can be individually accessed.

As an example we select the event occurred on 2014-04-07 at 19:27:01 UTC (Mw = 4.93) at the border between Italy and France (Figure 2). The event has been recorded by 102 stations belonging to 7 different networks (codes IT, RA, CH, GU, G, FR and MN, according to http://www.fdsn.org/networks/, last access December 2015) and is associated to the ID's of major catalogues in order to provide complete information to the user. In this example the preferred location is by the Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences (see Data and Resources), while several magnitude determinations are attributed from international agencies. Focal mechanism solutions and style of faulting are also provided.

The list of stations that have recorded the event appears at the bottom of the page and includes EC8 site class, channel and location codes, epicentral distance and the maximum among the three components of peak ground parameters.

Station information can be accessed entering the page "Stations", where recording sites can be retrieved according to 14 parameters including location, network and station codes, but also parameters related to the site characterization, such as the average velocity in the uppermost 30 m (Vs_{30}). As an example we show the station AQV (Figure 3), belonging to the network IT (Italian accelerometric network, operated by the Italian Department of Civil Protection). The station is displayed on a topographic map and information related to location, housing, site class are provided. The information related to each station is also available as a report ("Monography" button on the station page) containing detailed information, such as site stratigraphy, geophysical logs or the horizontal to vertical spectral ratio from noise measurements.

Waveforms information can be accessed entering the page "Waveforms", where 35 parameters can be specified related to stations, events, or strong-motion parameters. Waveforms can be explored with the aid of a visualization tool, that allows zooming and exporting the time-series as images.

Upon user registration, time-series can be downloaded in ASCII format, as unprocessed or processed acceleration, pseudo-velocity, displacement, acceleration and displacement response spectra (5% damping) for 105 periods (0.01 - 10s). The client dyna-convert.py, written in python language, can be downloaded from the ESM home page in order to convert ASCII files in standard seismological formats (e.g. sac or mseed).

Data citation, acknowledgments and license for data distribution

Each waveform can be tracked, since the metadata to reproduce the complete path that leads from the original data source to the processed data are included. The appropriate citation is also reported, together with the network DOI, if available. A license can be provided by network operators, following the Creative Commons standards (http://creativecommons.org, last access December 2015) in order to enable the sharing and use of data through free legal tools and guarantee visibility to the original author.

Figure 4 shows the example of citations and acknowledgements for the E component of a waveform recorded by the station MLR on 2008-01-30 13:09:30 (GMT) by INFP (National Institute for earth Physics of Bucharest, network code RO).

ESM tools

Data processing

A data processing web front-end is available at http://esm.mi.ingv.it/processing (last access December 2015) The service provides access to all waveforms included in the ESM database. Registered users can select waveforms, do their own processing and save the results. The workflow implemented in the software is based on the procedure by Paolucci et al. (2011) and is described in a previous paragraph. Figure 5 shows two screenshots representing the processing of the three components of the ground motion recorded at Nir station (Iran) on 1997-02-28 at 12:57:22 GMT (Mw = 6.0). Figure 5a displays the three components of the unprocessed and processed acceleration time-series, while Figure 5b displays the Fourier spectra, in order to check the effect of the filtering.

The following processing parameters can be modified by the user:

- length of the waveform cut (begin / end) in seconds;
- percentage of signal tapering;
- flag “normal / late-triggered” (where late-triggered is a signal triggered by S-waves or later phases), that implies different processing in Paolucci et al (2011);
- output sampling interval;
- constant for the multiplication of the signal;
- band-pass corners and order of the acausal Butterworth filter.

Spectrum-compatible data selection

The ESM database is linked to the REXELite application, which is the online version of the computer program REXEL (Iervolino et al., 2009), for the selection of ground motion suites for code-based seismic structural analyses. REXELite is an application that allows searching for combinations of seven 1- or 2-components strong motion records, compatible, in average, with a specified code spectrum.

More specifically, REXELite: i) automatically builds code spectra for any limit state according to Eurocode 8 (CEN 2003); ii) finds the set of seven records having the most similar spectral shape with respect to that of the code, and whose average also matches the target spectrum in a user-specified period range and with a desired tolerance.

The records are pre-selected by the user according to specific features, such as magnitude range, source-to-site distance range, style of faulting or soil conditions, expressed as Eurocode 8 site classes. The set of accelerograms of the combination may include unscaled (original) or amplitude-scaled records and may be used for code-compliant non-linear time history analyses of structures.

Figure 6 displays the seven accelerograms with the best compatibility with an Eurocode 8 Type 1 spectrum and site class B, anchored to 0.05g, after the user has pre-selected accelerograms in the magnitude range 5 - 6, distance range 30 - 70 km, for site class B and any style of faulting.

Discussion and future developments

We described the European Strong-Motion database (ESM), developed in the framework of the European project NERA.

ESM is tailored to enable users to fully exploit pan-European strong motion data spanning over 46 years and includes: i) data obtained from international webservices (EIDA and IRIS) that provide continuous data from more than 30 strong-motion networks and ii) offline data available from European providers.

ESM has been designed for a large variety of stakeholders (expert seismologists, earthquake engineers, students and professional) and for this reason the web interface is friendly and straightforward. In addition, expert users may benefit from specific tools for data management and selection.

This database is not only the result of a project, but it is also part of a long-term vision for the distribution of strong-motion data in Europe. A thematic working group has been established within ORFEUS (WG5 acceleration and strong motion data) in order to create a network of strong-motion data operators in Europe. They are directly involved in the decisional process (e.g. setting rules for data dissemination) and are continuously updated on the technological progress and on the state of the art of techniques for metadata compilation and data processing. To ensure sustainability and facilitate data ingestion, ORFEUS will foster the usage of standard FDSN web services and promote the exposure of data through the EIDA distributed archive.

Data should be not only distributed and exchanged in an open data framework, but they should also be interoperable with other disciplines. This is the near-future goal that will be pursued within the

European Plate Observing System (www.epos-eu.org, last access December 2015), a long-term plan for the integration of national and transnational Research Infrastructures for solid Earth science in Europe, to provide seamless access to data, services and facilities.

Data and resources

Accelerometic time-series are obtained from different online databases: HEAD (http://www.itsak.gr/en/head or http://accelnet.gein.noa.gr) for Greece; ITACA (http://itaca.mi.ingv.it) for Italy; TR-NSMN (http://kyhdata.deprem.gov.tr/2K/kyhdata_v4.php) for Turkey; ISESD (http://www.isesd.hi.is) for former Yugoslavia, Portugal, Armenia and Algeria.
Online accelerometric time series are obtained though the IRIS webservice (http://service.iris.edu/) or EIDA (http://www.orfeus-eu.org/).
Event location and magnitudes are obtained from INGV bulletin (http://webservices.rm.ingv.it/fdsnws/event/1/), ISC bulletin (http://www.isc.ac.uk/iscbulletin/), EMSC bulletin (http://www.seismicportal.eu/fdsnws/event/1/) and GFZ Bulletin (http://geofon.gfz-potsdam.de/eqinfo/event.php?id=gfz2014guwo catalogue).
Fault geometries are obtained from regional catalogues such as DISS (http://diss.rm.ingv.it/diss/), GREDASS (http://gredass.unife.it/) or SRCMOD (http://equake-rc.info/SRCMOD/).
All the websites were last accessed on December 2015.

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- National Observatory of Athens (NOA), Greece: HEAD, the Unified HEllenic Accelerogram Database;
- Italian Department of Civil Protection (DPC) and Istituto Nazionale di Geofisica e Vulcanologia (INGV): ITACA, the ITalian ACcelerometric Archive;
- Disaster and Emergency Management Presidency of Turkey (AFAD): strong motion database of Turkey (TR-NSMN) from 1976 to 2007;
- Earthquake Engineering Research Centre of the University of Iceland (EERC): Internet Site for European Strong-Motion data (ISESD);
- Building and Housing Research Center, Iran (BHRC);
- Institute of GeoSciences, Energy, Water and Environment (IGEWE) Tirana, Albania;
- Helmholtz Centre Potsdam (GFZ) German Research Centre for Geosciences;
- French seismologic and geodetic network (RESIF);
- Bogazici University Kandilli Observatory And Earthquake Research Institute (KOERI), Turkey;
- National Institute for Earth Physics (NIEP), Bucharest, Romania;
- Swiss Seismological Service (SED);
- Friuli accelerometric network (RAF), Trieste, Italy;
- National Institute of Oceanography and Geophysics (OGS) Trieste, Italy

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Table 1. List of earthquakes with magnitude larger than 6.0 (Lat = latitude; Lon = longitude; Mw = moment magnitude; Nrec = number of records)

Event ID	**Date**	**Time**	**Name**	**Nation**	**Lat**	**Lon**	**Depth**	**Mw**	**Nrec**
EMSC-20151117_0000025	2015-11-17	07:10:08	Greece	Greece	38.800	20.390	2.0	6.1	10
EMSC-20150416_0000081	2015-04-16	18:07:45	Crete Greece	Greece	35.040	26.890	6.1	6.1	7
EMSC-20140203_0000008	2014-02-03	03:08:45	Greece	Greece	38.260	20.320	2.0	6.0	12
EMSC-20140126_0000046	2014-01-26	13:55:43	Greece	Greece	38.190	20.410	18.0	6.1	14
EMSC-20131012_0000044	2013-10-12	13:11:54	Crete Greece	Greece	35.560	23.310	35.0	6.4	8
EMSC-20130616_0000095	2013-06-16	21:39:05	Crete Greece	Sea or international waters	34.347	25.159	19.0	6.0	7
EMSC-20120811_0000036	2012-08-11	12:34:36	Northwestern Iran	Iran	38.480	46.750	10.0	6.3	1
EMSC-20120811_0000034	2012-08-11	12:23:18	Northwestern Iran	Iran	38.410	46.810	10.0	6.4	1
IT-2012-0011	2012-05-29	07:00:02	Emilia 2nd Shock	Italy	44.842	11.066	8.1	6.0	335
IT-2012-0008	2012-05-20	02:03:50	Emilia 1st Shock	Italy	44.896	11.264	9.5	6.1	314
EMSC-20111023_0000031	2011-10-23	10:41:22	Van	Turkey	38.758	43.478	10.0	7.3	1
EMSC-20110401_0000033	2011-04-01	13:29:11	Crete	Sea or international waters	35.732	26.547	75.5	6.1	3
IT-2009-0009	2009-04-06	01:32:40	L' Aquila	Italy	42.342	13.380	8.3	6.1	66
IR-2005-0044	2005-02-22	02:25:21	Northern And Central Iran	Iran	30.770	56.807	13.0	6.4	25
IR-2004-0043	2004-05-28	12:38:43	Northern And Central Iran	Iran	36.321	51.588	17.0	6.3	119
IR-2003-0041	2003-12-26	01:56:53	Southern Iran	Iran	28.965	58.304	15.0	6.6	23
TK-2003-0038	2003-05-01	00:27:04	Turkey	Turkey	38.999	40.464	10.0	6.4	5
TK-2003-0003	2003-01-27	05:26:23	Turkey	Turkey	39.479	39.848	10.0	6.2	3
IR-2002-0035	2002-06-22	02:58:21	Western Iran	Iran	35.589	49.022	10.0	6.5	58
TK-2002-0008	2002-02-03	07:11:31	Turkey	Turkey	38.520	31.202	22.1	6.0	7
TK-2002-0007	2002-01-22	04:53:52	Crete	Greece	35.574	26.627	94.6	6.2	1
TK-2001-0123	2001-07-26	00:21:38	Aegean Sea	Greece	39.097	24.268	19.0	6.4	4
TK-1999-0415	1999-11-12	16:57:19	Duzce	Turkey	40.806	31.187	10.4	7.0	27
TK-1999-0077	1999-08-17	00:01:38	Izmit	Turkey	40.756	29.955	17.0	7.4	23
IR-1999-0032	1999-05-06	23:00:51	Southern Iran	Iran	29.534	51.917	17.2	6.2	19
PT-1998-0019	1998-07-09	05:19:07	Azores Islands	Portugal	38.614	-28.571	10.0	6.2	5
TK-1998-0063	1998-06-27	13:55:53	Turkey	Turkey	36.845	35.325	46.6	6.2	9
IR-1998-0031	1998-03-14	19:40:31	Northern And Central Iran	Iran	30.161	57.612	43.5	6.6	5
GR-1997-0020	1997-11-18	13:13:48	Ionian Sea	Greece	37.478	20.910	46.2	6.0	6
GR-1997-0019	1997-11-18	13:07:38	Ionian Sea	Greece	37.482	20.692	10.0	6.4	13
TK-1997-0126	1997-11-14	21:38:49	Aegean Sea	Greece	38.824	25.821	2.3	6.0	4
GR-1997-0014	1997-10-13	13:39:36	Southern Greece	Sea or international waters	36.348	22.105	13.3	6.4	5
IT-1997-0006	1997-09-26	09:40:24	Umbria Marche 2nd Shock	Italy	43.031	12.862	5.7	6.0	22
IR-1997-0030	1997-05-10	07:57:29	Northern And Central Iran	Iran	33.878	59.823	6.7	7.2	20

IR-1997-0029	1997-02-28	12:57:22	Iran-Armenia-Azerbaijan Border Region	Iran	38.088	48.040	39.2	6.0	19
IR-1997-0025	1997-02-04	10:37:51	Iran-Turkmenistan Border Region	Iran	37.738	57.289	35.7	6.5	10
TK-1996-0053	1996-10-09	13:10:50	Cyprus Region	Sea or international waters	34.528	32.096	19.0	6.8	1
TK-1996-0029	1996-07-20	00:00:41	Dodecanese Islands	Turkey	36.131	27.053	26.8	6.2	1
TK-1995-0041	1995-10-01	15:57:12	Turkey	Turkey	38.056	30.152	5.0	6.4	7
GR-1995-0047	1995-06-15	00:15:47	Greece	Greece	38.404	22.272	2.9	6.5	17
GR-1995-0017	1995-05-13	08:47:13	Greece	Greece	40.167	21.686	13.9	6.4	10
MK-1994-0004	1994-09-01	16:12:40	Balkan Peninsula	Macedonia (FYROM)	41.181	21.205	12.4	6.1	2
GR-1994-0007	1994-05-23	06:46:15	Crete	Sea or international waters	35.541	24.697	67.7	6.1	4
TK-1992-0004	1992-11-06	19:08:09	Aegean Sea	Turkey	38.109	26.956	17.2	6.0	3
TK-1992-0002	1992-03-13	17:18:39	Turkey	Turkey	39.716	39.629	22.6	6.6	3
GE-1991-0009	1991-06-15	00:59:20	Western Caucasus	Georgia	42.438	44.019	8.8	6.0	3
GE-1991-0002	1991-04-29	09:12:48	Western Caucasus	Georgia	42.415	43.671	17.2	6.8	6
GR-1990-0014	1990-12-21	06:57:43	Balkan Peninsula	Greece	41.006	22.302	13.3	6.1	6
IR-1990-0004	1990-06-20	21:00:10	Western Iran	Iran	36.989	49.346	18.5	7.4	15
RO-1990-0004	1990-05-31	00:17:48	Romania	Romania	45.810	26.767	90.1	6.3	3
RO-1990-0003	1990-05-30	10:40:06	Romania	Romania	45.847	26.662	89.0	6.9	5
AM-1988-0001	1988-01-07	07:41:24	Spitak	Armenia	40.910	44.250	6.0	6.7	1
TK-1986-0001	1986-05-05	03:35:38	Turkey	Turkey	38.017	37.790	4.4	6.0	1
TK-1983-0002	1983-10-30	04:12:28	Turkey	Turkey	40.352	42.180	16.1	6.6	2
GR-1983-0010	1983-08-06	15:43:51	Aegean Sea	Sea or international waters	40.140	24.745	2.0	6.6	3
TK-1983-0001	1983-07-05	12:01:27	Turkey	Turkey	40.332	27.210	6.9	6.1	5
GR-1983-0008	1983-03-23	23:51:05	Greece	Greece	38.232	20.294	12.6	6.2	2
GR-1983-0001	1983-01-17	12:41:30	Greece	Greece	38.070	20.246	14.0	6.9	3
GR-1981-0002	1981-02-25	02:35:53	Greece	Greece	38.168	23.119	30.0	6.3	1
GR-1981-0001	1981-02-24	20:53:37	Greece	Greece	38.225	22.969	17.6	6.6	2
IT-1980-0012	1980-11-23	18:34:53	Irpinia	Italy	40.760	15.310	15.0	6.9	21
PT-1980-0004	1980-01-01	16:42:38	Azores Islands	Portugal	38.751	-27.750	0.0	6.9	1
ME-1979-0012	1979-05-24	17:23:17	Balkan Peninsula	Montenegro	42.241	18.749	5.0	6.2	8
ME-1979-0003	1979-04-15	06:19:41	Balkan Peninsula	Montenegro	42.045	19.053	3.8	6.9	11
IR-1978-0002	1978-09-16	15:35:56	Northern And Central Iran	Iran	33.369	57.437	34.1	7.3	7
IT-1978-0004	1978-04-15	23:33:47	Patti Gulf	Italy	38.270	15.110	22.0	6.0	5
RO-1977-0001	1977-03-04	19:21:54	Romania	Romania	45.827	26.718	85.8	7.5	2
TR-1976-00	1976-11-24	12:22:15	Iran-Armenia-Azerbaijan Border Region	Turkey	39.051	44.037	9.7	7.0	1
IT-1976-0030	1976-09-15	09:21:18	Friuli 3rd Shock	Italy	46.300	13.174	11.3	6.0	12
UZ-1976-0001	1976-05-17	02:58:41	Northwestern Uzbekistan	Uzbekistan	40.352	63.449	13.7	6.7	1

IT-1976-0002	1976-05-06	20:00:12	Friuli 1st Shock	Italy	46.280	13.250	6.4	6.4	10
PT-1969-0001	1969-02-28	02:40:31	Azores-Cape St Vincent Ridge	Sea or international waters	35.970	-10.580	14.0	7.8	1

Figure 1. European Strong-Motion database homepage

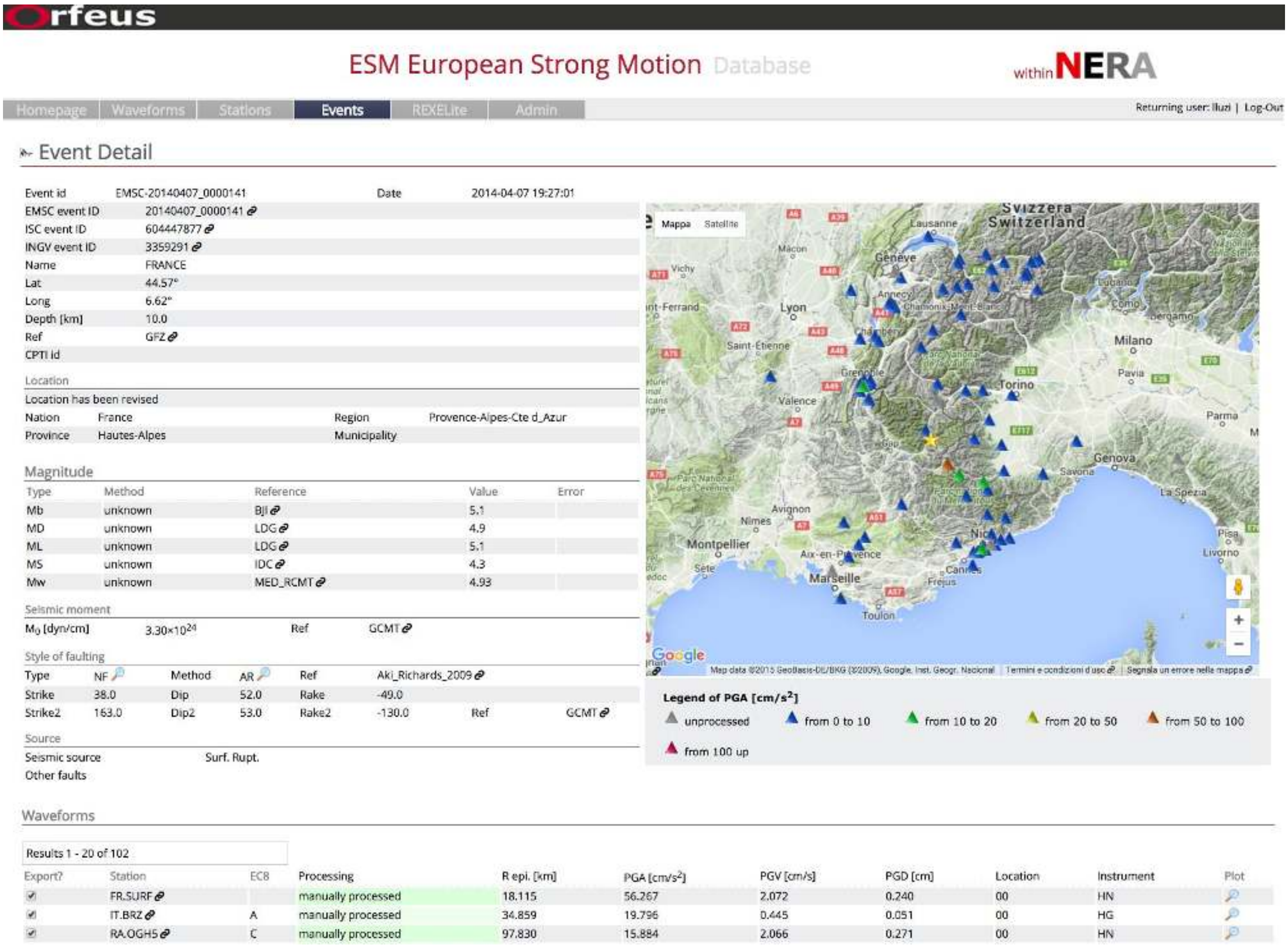


Figure 2. Detail of the event occurred on 2014-04-07 at 19:27:01 UTC (Mw = 4.93).

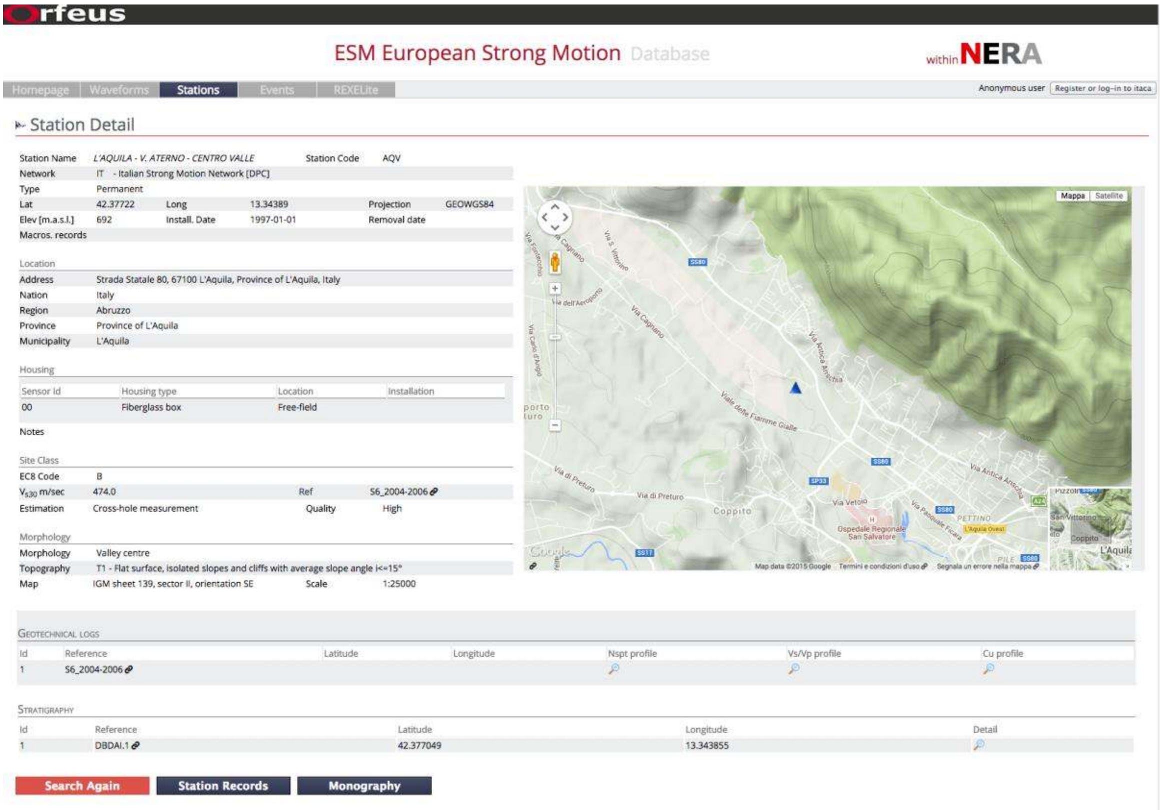
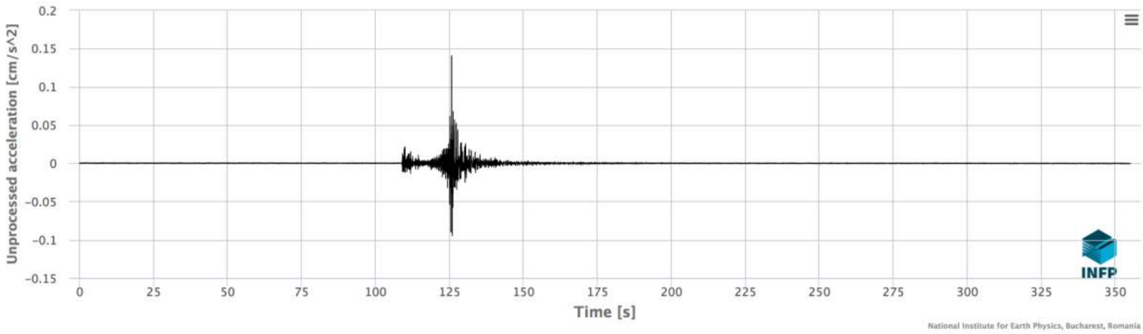


Figure 3. Details of the station L'Aquila - Valle Aterno - Centro Valle, belonging to the network IT, operated by the Italian Civil Protection.

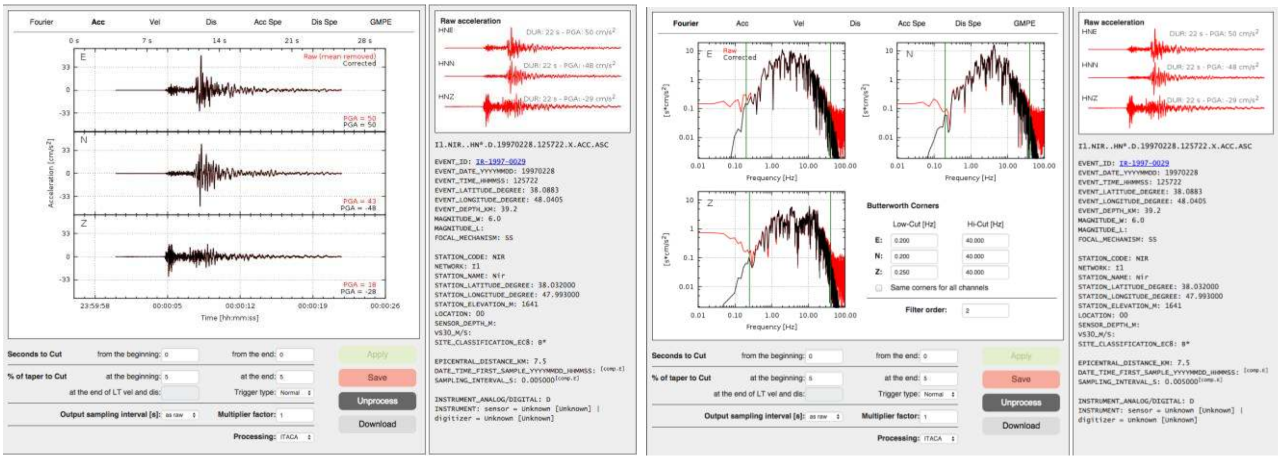


a)

Licensing and Acknowledgements	
Data license	unknown license
Data citation	ESM working group (2015), European Strong-Motion database, version 0.1, Network Activity 3: Networking acceleration networks and SM data users. Project NERA (www.nera-eu.org)
Data creator	ESM working group
Original data mediator	Orfeus - European Integrated Data Archive (EIDA)
Original data mediator citation	Orfeus - European Integrated Data Archive (EIDA) http://www.orfeus-eu.org/eida/
Original data creator	National Institute for Earth Physics, Bucharest, Romania RO - Romanian Seismic Network
Original data creator citation	National Institute for Earth Physics (NIEP Romania) (1994): Romanian Seismic Network. International Federation of Digital Seismograph Networks. Other/Seismic Network. doi:10.7914/SN/RO

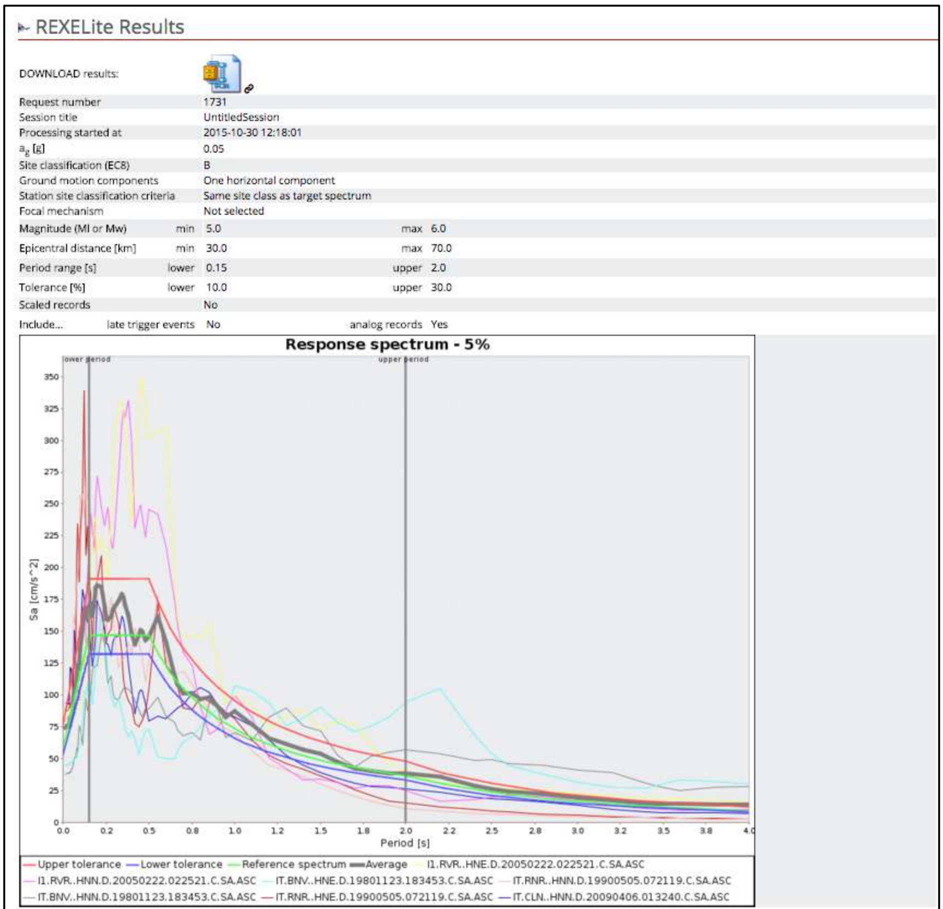
b)

Figure 4. a) Waveform recorded at station MLR on 2008-01-30 13:09:30 (GMT) by INFP (network code RO); b) panel with acknowledgment and citation of the waveform.



(a) (b)

Figure 5. Three components of the ground motion recorded at Nir (Iran) on 1997-02-28 at 12:57:22 GMT (Mw = 6.0): a) unprocessed (red) and processed (black) acceleration time-series; b) Fourier spectra of unprocessed (red) and processed (black) acceleration.



Network	Station code	Event time	Scale factor	Usable Bandwidth [Hz]	Orientation	Response spectrum
I1 - Iranian Strong Motion Network [BHRC]	RVR	2005-02-22 02:25:21	1.0	39.9	HNE	
I1 - Iranian Strong Motion Network [BHRC]	RVR	2005-02-22 02:25:21	1.0	39.9	HNN	
IT - Italian Strong Motion Network [DPC]	BNV	1980-11-23 18:34:53	1.0	29.9	HNE	
IT - Italian Strong Motion Network [DPC]	BNV	1980-11-23 18:34:53	1.0	29.9	HNN	
IT - Italian Strong Motion Network [DPC]	RNR	1990-05-05 07:21:19	1.0	17.7	HNE	
IT - Italian Strong Motion Network [DPC]	RNR	1990-05-05 07:21:19	1.0	17.7	HNN	
IT - Italian Strong Motion Network [DPC]	CLN	2009-04-06 01:32:40	1.0	39.95	HNN	

Figure 6. Example of Rexelite run: seven accelerograms having the best compatibility with an Eurocode Type 1 spectrum, site class B anchored to 0.05g, after a pre-selection of accelerograms in the magnitude range 5 - 6, distance range 30 - 70 km and site class B.