ESM flat-file

MANUAL

INTRODUCTION

The flat-files are provided in a .zip file, containing:

- three parametric tables in .csv format separated by ";":
  - **ESM_flatfile_SA.csv** contains the spectral acceleration ordinates calculated assuming 5% damping in the range 0.01-10s;
  - **ESM_flatfile_SD.csv** contains the spectral displacement ordinates calculated assuming 5% damping in the range 0.01-10s;
  - **ESM_flatfile_FAS.csv** contains the Fourier spectral amplitudes calculated using a Konno & Ohmachi (1998) smoothing function (b=40) in the range 0.04-50Hz;
- several dictionaries (.txt files) explaining the fields of the parametric table (each dictionary has the same field name);

The idea behind the creation of three .csv tables is to separate the ground motion intensity measures and avoid the distribution of a unique table that would be too large to be handled with spreadsheets. Therefore, the provided tables contain the same metadata and some intensity measures (Peak Ground Acceleration, Peak Ground Velocity, Peak Ground Displacement, Arias Intensity, Housner Intensity, Effective Duration and Cumulative Absolute Velocity) up to the spectral ordinates fields.

The dictionary **Reference.txt** contains the full citations of all the reference fields in the tables.

In the following sections, we provide a brief description of the field, grouping them as i) event metadata, ii) source metadata, iii) station metadata, iv) source to site distances, v) waveforms metadata, and vi) intensity measures.

The EMEC magnitudes (**EMEC_Mw**) are extracted from the Euro-Mediterranean Earthquake Catalogue (EMEC) by Grünthal et al. (2012). The magnitude analysis largely followed the lines of the Grünthal et al. (2009a, 2009b) studies, where fake and duplicate events were identified and removed and existing magnitudes and intensities were converted to Mw. Algorithms to compute Mw are based on regional relations, or on those derived by Grünthal et al. (2009a, 2012) (see Table 4 in Grünthal et al. 2012), and summarized in Table 1. The abbreviations used in the flat-file field **EMEC_Mw_ref** are explained, and references provided in the Tables included in Grünthal et al.

(2012).
Each fault is exemplified with a rectangular plane. For the event with moment magnitude larger than 5.5, a fault geometry is defined. When the geometry is not available from literature studies, the fault geometry has been simulated following the procedure of Kaklamanos et al. (2011), originally developed to convert the different metrics implemented in the Ground Motion Prediction Equations. The virtual fault is constructed using four basic input parameters: strike, dip, seismic moment or moment magnitude and hypocentral coordinates of the event.

Table 1. Dictionary for **EMEC_Mw_type**

EMEC_Mw_type	Reference to Table 4 in Grünthal et al. (2012)		
HaKaM0	Relation (3) in Grünthal et al. (2012)		
MWI074	Imax = I0 & Relation (2) in Grünthal et al. (2012)		
MWML110	ML = Mw		Carillho, pers. comm (2009)
MWML111	for Croatia	Mw = 0.408 + 0.930·ML σ = 0.209	Glavatović B, pers. comm.
	other polygons	Mw = 0.474 + 0.933·ML σ = 0.215	Glavatović B, pers. comm.
MWML90		Mw = 0.99*ML+0.33	
MWML92	Relation (14) in Grünthal et al. (2012)		
MWMs29	Relation (15) in Grünthal et al. (2012)		
Mw	no conversion applied		
Mw-mb	Relation (8) in Grünthal et al. (2012)		
MwML	Relation (2) in Grünthal et al. (2012)		
MwML68	Relation (9) & Relation (4) in Grünthal et al. (2012)		
MwMb	Relation (6) in Grünthal et al. (2012)		

Each fault is exemplified with a rectangular plane. For the event with moment magnitude larger than 5.5, a fault geometry is defined. When the geometry is not available from literature studies, it is simulated following the procedure of Kaklamanos et al. (2011), originally developed to convert the different metrics implemented in the Ground Motion Prediction Equations. The virtual fault is constructed using four basic input parameters: strike, dip, seismic moment or moment magnitude and hypocentral coordinates of the event.

The flat-file includes the source-to-site distance measures introduced into NGA-West2 database (Ancheta et al., 2014). Figure 1 shows how source-to-site

distances are calculated. In particular, the right panel illustrates the distance R_X defined to be positive for sites on the hanging-wall side of the fault and negative for sites on the footwall side of the fault. The distance R_{Y0} is zero or positive (Kaklamanos et al., 2011).

The waveform components are flagged as:

- **U**: 1st component;
- **V**: 2nd component;
- **W**: 3rd component;

We used U, V, W for the waveform components, as they can be oriented not only according to the Traditional North-South, East-West, and vertical directions (see http://www.fdsn.org/seed_manual/SEEDManual_V2.4.pdf, pag. 134).

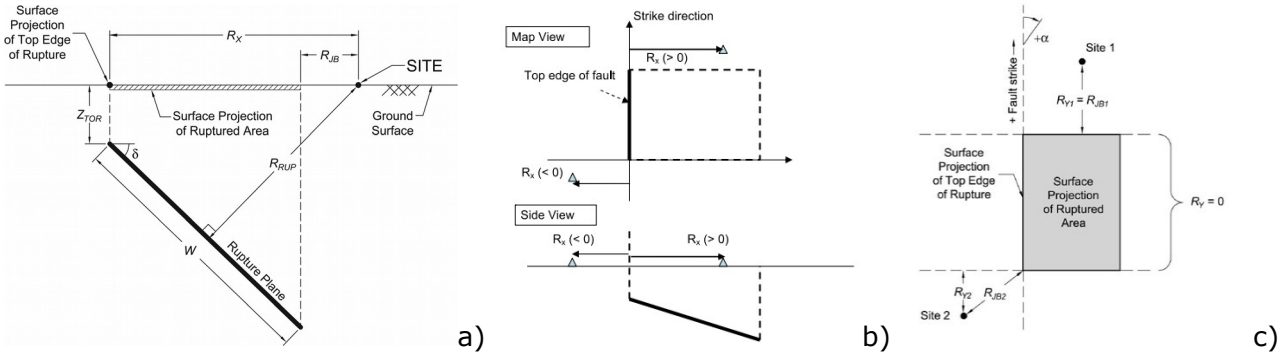

Figure 1. a) Representation of the earthquake source and distance measures using a vertical cross section through a fault rupture plane (taken from Kaklamanos et al., 2011). b) map (top) and side (bottom) view of the source-to-site distance measure (R_X) for an example fault (thick black line) plane and stations located on the hanging wall ($R_X > 0$) and footwall ($R_X < 0$) side (taken from Ancheta et al., 2013). c) map view of R_{Y0} definition.

Combinations of horizontal components of SA and SD are flagged as:

- **RotD50**: median value of the distribution of the intensity measures of the rotated waveforms (Boore 2010);
- **RotD100**: maximum value of the distribution of the intensity measures of the rotated waveforms (Boore 2010);
- **RotD00**: minimum value of the distribution of the intensity measures of the rotated waveforms (Boore 2010).

Event metadata

- **event_id**: the id of the event in ESM (http://esm.mi.ingv.it);
- **event_time**: time of the event (format YYYY-MM-DD HH:MM:SS);
- **ISC_ev_id**: event id in the bulletin of the International Seismological Centre

(ISC, http://www.isc.ac.uk);

- **USGS_ev_id**: event id of the United States Geological Service (USGS, https://earthquake.usgs.gov);

- **INGV_ev_id**: event id in the bulletin of the Istituto Nazionale di Geofisica e Vulcanologia (INGV, http://cnt.rm.ingv.it);

- **EMSC_ev_id**: event id in the bulletin of the Centre Sismologique Euro-Méditerranéen (EMSC-CSEM, http://www.emsc-csem.org);

- **ev_nation_code**: ISO code of the country where the epicenter of the event is located (see Table A1);

- **ev_latitude** and **ev_longitude**: the geographic coordinates (decimal degrees) of the epicenter of the event;

- **ev_depth_km**: depth of the hypocenter of the event (km);

- **ev_hyp_ref**: reference for **ev_latitude**, **ev_longitude** and **ev_depth_km**;

- **fm_type_code**: style of faulting (NF normal fault; TF reverse fault; SS strike-slip fault; O oblique fault; U undefined).

- **ML**: local magnitude;

- **ML_ref**: reference for **ML** estimate;

- **Mw**: moment magnitude;

- **Mw_ref**: reference for **Mw** estimate;

- **Ms**: surface waves magnitude;

- **Ms_ref**: reference for **Ms** estimate;

- **EMEC_Mw**: moment magnitude from EMEC catalog (Grünthal & Wahlström 2012);

- **EMEC_Mw_type**: magnitude type of **EMEC_Mw** estimate;

- **EMEC_Mw_ref**: reference for **EMEC_Mw** estimate;

Source metadata

- **event_source_id**: id of the source;

- **es_strike**: fault strike (degrees from North);

- **es_dip**: fault dip (degrees);

- **es_rake**: fault rake (degrees);

- **es_strike_dip_rake_ref**: reference for **es_strike**, **es_dip** and **es_rake** estimates;

- **es_z_top**: depth of the fault top (km);

- **es_z_top_ref**: reference for **es_z_top** estimate;

- **es_length**: fault length (km);

- **es_width**: fault width (km).

- **es_geometry_ref**: reference for **es_length** and **es_width** estimate;

Station metadata

- **network_code**: the code associated to the recording network according to the International Federation of Seismograph Network (http://www.fdsn.org);

- **station_code**: 3 to 5 characters associated to the station;

- **location_code**: a two characters' code that identifies the sensor location (see http://www.fdsn.org/seed_manual/SEEDManual_V2.4.pdf, pag 37);

- **instrument_code**: the first letter specifies the general sampling rate and the response band of the instrument; The second letter specifies the family to which the sensor belongs (http://www.fdsn.org/seed_manual/SEEDManual_V2.4.pdf);

- **sensor_depth_m**: sensor depth (m);

- **proximity_code**: a numeric code indicating the proximity to structures ('0': free-field; '1': close to structure; '2': no information; '3': inside structure; '4': close to ENEL cabs for Italian stations);

- **housing_code**: 3 alphanumeric characters which denote the sensor housing type (see Dictionary 'housing_code.txt');

- **installation_code**: code related to the instrument installation: 'P' = installed on a pillar; 'PS' = installed on the building basement; 'T' = installed directly on the ground;

- **st_nation_code**: ISO code of the country where the station is located (see Table A1);

- **st_latitude** and **st_longitude**: the geographic coordinates (decimal degrees) of the station;

- **st_elevation:** elevation of the station (m);

- **ec8_code**: EC8 site category (CEN, 2003);

- **ec8_code_method**: the method used to estimate **ec8_code** (see associate dictionary);

- **ec8_code_ref**: reference for **ec8_code** estimate;

- **vs30_m_sec**: the average shear wave velocity $V_{S,30}$ (CEN, 2003) from in-situ measurements (m/s);

- **vs30_ref**: reference for **vs30_m_sec** estimate;

- **vs30_calc_method**: the method used to estimate **vs30_m_sec** (see associate dictionary);

- **vs30_meas_type**: the type of geophysical measurement used to estimate **vs30_m_sec** (see associate dictionary);

- **slope_deg**: topographic slope (degrees), calculated according to Zevenbergen and Thorne (1987), using a 90m DEM (Digital Elevation Map provided by Shuttle Radar Topography Mission);

- **vs30_m_sec_WA**: $V_{S,30}$ inferred from slope, according to Wald and Allen (2007) in m/s;

Source to site distance metrics

- **epi_dist**: epicentral distance (km);

- **epi_az**: event-to-station azimuth (degrees);

- **JB_dist**: Joyner-Boore distance (km);

- **rup_dist**: distance from the rupture plane (km);

- **Rx_dist** and **Ry0_dist**: R_X and R_{Y0} hanging/footwall distances (km), calculated according to Ancheta et al. (2014).

Waveform metadata

- **instrument_type_code**: 'A': analog instrument; 'D': digital instrument; 'U': unknown type of instrument;

- **late_triggered_flag_01**: flag for late triggered waveforms (triggered by S waves arrivals);

- ***X*_channel_code**: channel code of the *X* component according to the SEED convention http://www.fdsn.org/seed_manual/SEEDManual_V2.4.pdf, pag. 134).

- ***X*_azimuth_deg**: azimuth of the *X* component from the North (degrees)

- ***X*_hp**: high pass filter frequency of the *X* component;

- ***X*_lp**: low pass filter frequency of the *X* component;

where *X* = U, V, W, RotD50, RotD100 and RotD00 (see section 'Introduction').

Intensity measures

- ***X*_pga**: peak ground acceleration (cm/s^2);

- ***X*_pgv**: peak ground velocity (cm/s);

- ***X*_pgd**: peak ground displacement (cm);

- ***X*_T90**: duration (s) of the time interval between the points of 5% and 95% of the total energy (Trifunac and Brady, 1975);

- ***X*_housner**: Housner intensity (cm);

- ***X*_ia**: Arias intensity (cm/s);

- ***X*_CAV**: cumulative absolute velocity (cm/s);

- ***X*_Ty_yyy**: spectral ordinates (SA in cm/s^2 or SD in cm) for 'y_yyy' period;
- ***X*_Fz_zzz**: Fourier spectral amplitudes for 'z_zzz' frequency;

where:

- *X* component is defined in section 'Waveform metadata;
- y_yyy identifies the period corresponding to the spectral ordinate (where the character '_' indicates the decimal point, e.g. 0_100 corresponds to T=0.100s);
- z_zzz identifies the frequency corresponding to the Fourier amplitudes (where the character '_' indicates the decimal point, e.g. 1_000 corresponds to F=1.000Hz).

References

Ancheta TD, Darragh RB, Stewart JP, Seyhan E, Silva WJ, Chiou BSJ, Wooddell KE, Graves RW, Kottke AR, Boore DM, Kishida T (2014). NGA-West2 database. Earthquake Spectra, 30(3), 989-1005.

Boore DM (2010). Orientation-independent, nongeometric-mean measures of seismic intensity from two horizontal components of motion. Bulletin of the Seismological Society of America, 100(4), 1830-1835.

CEN (2003). EuroCode 8: Design of structures for earthquake resistance—Part 1: General rules, seismic actions and rules for buildings. Bruxelles: European Committee for Standardization.

Grünthal G, Wahlström R, Stromeyer D (2009a) (GWS09) The unified catalogue of earthquakes in central, northern and northwestern Europe (CENEC) - updated and expanded to the last millennium. J Seismol 13:517–541. doi:10.1007/s10950-009-9154-2.

Grünthal G, Stromeyer D, Wahlström R (2009b) Harmonization check of Mw within the central, northern and northwestern European earthquake catalogue (CENEC). J Seismol 13:613–632. doi:10.1007/s10950-008-9144-9.

Grünthal, G., Wahlström, R. (2012): The European-Mediterranean Earthquake Catalogue (EMEC) for the last millennium. - Journal of Seismology, 16, 3, 535-570, DOI: 10.1007/s10950-012-9302-y.

Kaklamanos, J., Baise, L.G., Boore, D.M. (2011). Estimating unknown input parameters when implementing the NGA ground-motion prediction equations in engineering practice. Earthquake Spectra, 27 (4), 1219-1235.

Konno, K., Ohmachi, T. (1998). Ground-motion characteristics estimated from spectral ratio between horizontal and vertical components of microtremor. Bulletin of the Seismological Society of America, 88(1), 228-241.

Luzi L, Puglia R, Russo E, D'Amico M, Felicetta C, Pacor F, Lanzano G, Çeken U, Clinton J, Costa G, Duni L, Farzanegan E, Gueguen P, Ionescu C, Kalogeras I, Özener H, Pesaresi D, Sleeman R, Strollo A, Zare M (2016). The Engineering Strong-Motion database: a platform to access Pan-European accelerometric

data. Seismological Research Letters, 87(4), 987-997, DOI: 10.1785/0220150278.

Trifunac MD, Brady AG (1975). A study on the duration of strong earthquake ground motion. Bulletin of the Seismological Society of America, 65(3), 581-626.

Wald DJ, Allen TI (2007). Topographic slope as a proxy for seismic site conditions and amplification. Bulletin of the Seismological Society of America, 97(5), 1379-1395.

Zevenbergen L.W., and Thorne C.R. (1987). Quantitative analysis of land surface topography. Earth surface processes and landforms, 12 (1), 47-56.

APPENDIX

Table A1. Nation codes (ISO 3166 Codes).

Code	Country	Code	Country
AL	Albania	JO	Jordan
AM	Armenia	LI	Liechtenstein
AT	Austria	MA	Morocco
AZ	Azerbaijan	MC	Monaco
BA	Bosnia and Herzegowina	MD	Moldova
BG	Bulgaria	ME	Montenegro
CH	Switzerland	MK	Macedonia
CY	Cyprus	PL	Poland
CZ	Czech Republic	PT	Portugal
DE	Germany	RO	Romania
DZ	Algeria	RS	Serbia
ES	Spain	RU	Russia
FR	France	SI	Slovenia
GE	Georgia	SM	San Marino
GR	Greece	SY	Syria
HR	Croatia	TM	Turkmenistan
HU	Hungary	TR	Turkey
IL	Israel	UA	Ukraine
IR	Iran	UZ	Uzbekistan
IS	Iceland	XK	Kosovo
IT	Italy		