ENGINEERING STRONG-MOTION (ESM) FLATFILE: A TOOL TO TEST AND CALIBRATE GROUND MOTION MODELS IN EUROPE AND MIDDLE-EAST


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Introduction. The Engineering Strong-Motion (ESM) flatfile is a parametric table which contains metadata and intensity measures of manually processed waveforms included in the ESM database (http://esm.mi.ingv.it; Luzi et al., 2016). The flatfile has been developed within the European Project EPOS (European Plate Observing System Implementation Phase; http://epos-ip.org/) and it is disseminated throughout a web portal (http://esm.mi.ingv.it/flatfile-2018/flatfile.php) for research and technical purposes. The ESM strong motion flatfile is the result of a collaboration between EPOS Task 8.6.3 European Ground Motion Prediction Equations (GMPEs) Database (Lead GFZ) & Task 8.4.2 Strong Motion Data and Products Services (Lead INGV).

The flatfile has been released in March 2018 and is composed by 23,014 recordings from 2179 earthquakes and 2080 stations. The waveforms in the flatfile are uniformly processed by using the processing service of the Engineering Strong Motion Database (ESM, http://esm.mi.ingv.it/processing/, Puglia et al., 2018). The events are characterized by magnitudes in the range 3.5–8.0 and refer to different tectonic regimes, such as shallow active crustal and subduction zones. A significant effort in the compilation of the flatfile has been spent on metadata revision in order to keep it traceable including specific fields for the references of each metadata (i.e. event, source and station). ESM flatfile updates the previous European datasets, such as ISESD (Internet-Site for European strong motion Data, Ambraseys et al., 2004) and RESORCE (Reference Database for Seismic Ground Motion in Europe; Akkar et al., 2014).

The fields of flatfile can be grouped as 6 main blocks (Lanzano et al., 2018): i) Event-related metadata; ii) Source-related metadata; iii) Station-related metadata; iv) Metrics of source-to-site distances; v) Waveform-related metadata; vi) Intensity Measures (IMs) for each component (2 horizontal and 1 vertical) and with respect to horizontal RotD50, RotD0 and RotD100, proposed by Boore (2010). The flatfile is distributed as a ‘.csv’ file, provided in three files:

- ESM_flatfile_SA.csv table with 36 spectral acceleration ordinates (5% damping) in the period range 0.01–10 s;
- ESM_flatfile_SD.csv table with 36 spectral displacements ordinates (5% damping) in the period range 0.01–10 s;
- ESM_flatfile_FAS.csv table with 103 acceleration Fourier amplitudes smoothed (b=40) using the Konno and Ohmachi (1998) algorithm in the frequency range 0.04–50 Hz.

Intensity measures also include peak and integral parameters and duration of each waveform.

Statistics. Fig. 1a shows the number of recordings and events in the flatfile as a function of time for two distance ranges (i.e. epicentral distances less than 50 and 10 km). The amount of data is nearly constant until 1996 and whereas it significantly increases as a consequence of the rapid growth of the number of strong motion stations. Peaks in the number of recordings are observed when important seismic sequences occurred.

The magnitude-distance distribution is given in Figure 1b, grouped by style of faulting (SoF). The moment magnitude is available for 68% of the data. Local magnitude Mₗ is used when Mₗ is not provided; in the few cases of missing both Mₗ and Mₘ, the surface magnitude Mₛ is considered. In the following, we will refer to a generic “Magnitude” or “M” which corresponds to the mixed magnitude obtained according to the above described procedure. In Fig. 1b, the distance is Joyner-Boore, RJB, if available, otherwise the epicentral distance, REPI.

Data are well sampled in the magnitude range 3.5–6.5 and for distance up to 300 km. There is also a significant number of records related to strong events with magnitude in the range 6.0 - 7.8, corresponding to 6% of the records.
Residual analysis. Bindi et al. (2018) performed a consistency check over the flatfile by analyzing different residual distributions obtained from ad-hoc ground motion prediction equations of the absolute spectral acceleration (SA), displacement and Fourier amplitude spectra (FAS) for shallow crustal earthquakes (focal depth < 40km).

They identified those earthquakes, stations, and recordings showing the largest deviations from the GMPE median predictions, and also evaluated the statistical uncertainty on the median model to get insights on the applicable magnitude–distance ranges and the usable period (or frequency) range.

Robust median predictions are obtained up to 8 s for SA and up to 20 Hz for FAS, although median predictions for Mw ≥ 7 show significantly larger uncertainties with ‘bumps’ starting...
above 5 s for SA and below 0.3 Hz for FAS (Fig. 2a). Fig. 2b shows the standard deviation components, decomposed in between-event, between-station and aleatory (event- and site-corrected) variabilities according to the Al-Atik et al. (2010). Bindi et al. (2018) also report the between-country sigma, since the country regionalization has been introduced as a random effect in the ground motion model calibration.

**Final remarks.** The flatfile will be the primary source of information to develop a regionalized Ground Motion Model (GMM) logic-tree (Weatherill et al. 2018; Douglas 2018) required by the next update of the probabilistic hazard map in Europe in the framework of the SERA EU project (Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe; http://www.sera-eu.org/en/home/). The ESM flatfile is also the reference dataset to derive the update of the ground motion models of shallow crustal events in Italy (Lanzano et al., 2018b).

We plan a periodical release of the flatfile, whereas specific releases can be expected after future significant seismic sequences. The inclusion of additional metadata (i.e. event tectonic regimes, event stress drop, site fundamental frequencies) should be discussed within the engineering seismology community, depending on future research developments.

**Reference**


