ISMD USER MANUAL

ISMD (INGV Strong Motion Database) publishes in quasi **real time** the **waveforms** and the related **metadata** for each **earthquake** with $M_L \geq$ **3.0** localized in the **Italian territory**.

During important seismic sequences the minimum magnitude threshold might be set to higher values (usually ranging from 3.5 to 4.0) in order to publish as soon as possible the strong motion data recorded for the most important seismic events.

Data are at first published in the **automatic version** (see *auto* in the last column of the earthquake list). Strong motion data published in version *auto* are downloadable in **SAC-raw** format (counts) only.

The Peak Ground accelerations deduced from raw data have purely an approximate meaning and they may contain errors.

For all earthquakes with **magnitude $\geq$ 3.5** (i.e. $\geq$ **4.0 before October 2016**) the automatic results are **manually revised** (see *MAN* in the last column of the earthquake list) by an expert seismologist in the first 48h after the event origin time, in order to remove the low quality data.

DATA FORMATS

Data recorded by the INGV strong motion stations and related partners are downloadable few minutes after the earthquake occurrence. The Origin time (UTC), the hypocentral coordinates and the local magnitude are provided by the INGV National Earthquake Center. Soon after the alert the ISMD automatic system downloads 5 minutes of signals, starting from the event origin time. Earthquakes strong-motion waveforms are selected from the continuous recordings in MiniSeed format and then archived in real time on a seedlink server, implementing the Seiscomp3 client. The accelerometric waveforms are then converted in **SAC** and **ASCII** formats.

The waveforms are provided both in binary raw **SAC** (counts) and **ASCII** (in automatic) processed versions. The ASCII-files include 50 header-lines, providing the information of the event and the recording stations, followed by data in cm/s^2.

In order to manually reprocessed the SAC raw data, it is possible to convert SAC counts to cm/s^2 using for each station the related **conversion factor** (i.e. a number that consider both the gain of the digitizer and the sensitivity of the sensor) available in the stations instrumentation table.

The simple formula to be used is:

*[raw-SAC-counts * ((1 / Conversion Factor) * 100)]*

On the basis of the earthquake magnitude, the ISMD automatic system selects **data** from the recordings stations considering **fixed distance cut-off thresholds**, empirically determined on the basis of the signal to noise ratio analyses. In particular:

M_L	$\leq$		3.5	stations	up	to	150	km
3.5	$< M_L \leq$		5.5	stations	up	to	200	km
5.5	$< M_L \leq$		6.5	stations	up	to	250	km
M_L	$\geq$		6.5	stations	up	to	300	km

Magnitude might be *Local* (M_L) or *Moment* (M_w) in dependence of the information available at INGV National Earthquake Center web site.

To request data with different distance or magnitude threshold, mail to ismd@mi.ingv.it

AUTOMATIC DATA PROCESSING

- the waveforms resampling at 100 Hz;
- the application of a first-order baseline operator to the entire record, in order to have a zero-mean of the signal;
- the baseline correction (least square method), in order to remove the linear trend;
- the tapering of the signal by applying a cosine function (0.01%) at the beginning and at the end of each selected window;
- the application of a 4th order Butterworth band-pass acausal filter (Boore and Akkar, 2003) in order to remove the high and low-frequency noise.
  The **filter cut-off thresholds** are automatically selected on the basis of the earthquake magnitude, as indicated below:

$M_L < 3.5$	0.5-25 Hz
$3.5 \leq M_L < 4.3$	0.3-35 Hz
$4.3 \leq M_L < 5.5$	0.2-35 Hz
$M_L \geq 5.5$	0.1-40 Hz

- the final conversion of the processed **acceleration in velocity (cm/s) and displacement (cm)**.

(Pacor et al., 2011; Massa et al., 2010)

AUTOMATIC RESULTS

- the Peak Ground Acceleration (**PGA**), Velocity (**PGV**) and Displacement (**PGD**);
- the 5%-damped elastic acceleration response spectra (**SA**), for periods up to 4 sec, calculated considering the portion of signal from 5% to 90% of the total energy;
- the 5%-damped pseudo-velocity response spectra (**PSV**);
- the 5%-damped relative displacement response spectra (**Sd**);
- the Arias (**AI**, Arias 1970) and Housner (**HI**, Housner 1952) intensities;
- the directional Horizontal-to-Vertical Spectral Ratio (**HVSR**) calculated at each station considering 10s of strong-motion phase and coda;

and also:

- the comparison (in terms of PGA, PGV and acceleration response spectra) between the recorded data and the predicted ones by the **Italian GMPEs** calibrated by Bindi et al. (2011);
  warning for possible biases: Italian GMPEs considers earthquakes with $4.0 \leq M_w \leq 6.9$ and a maximum (Joyner-Boore or epicentral) distance of 200 km;
- **the plots** of the recorded waveforms (acceleration, velocity, displacement);
- **the plots** of SA, PSV, Sd;

Moreover, considering an area of +/- 1° of latitude [N] and +/- 1.5° of longitude [E] around the epicenter:

- the plot of the Italian reference seismic hazard map (Stucchi et al., 2011);
- **the historical and the instrumental seismicity maps** of the epicentral area. The instrumental seismicity is provided by the INGV official instrumental bulletin, while historical events are provided by theCPTI11 catalogue (Rovida et al., 2011).

The results listed above are resumed in the **event web page**, generated automatically soon after the end of the analyses.

DATA DOWNLOAD

To view and download the available data, the users have to select one of the three sections available in the right box of the ISMD home page (i.e. **EARTHQUAKES, STATIONS, WAVEFORMS**).

After user registration and/or login the waveforms and the response spectra are **downloadable both from the event and the station web pages**.

Moreover, from the session **WAVEFORMS**, it is possible **to search and download the waveforms (and metadata) associated to different earthquakes**, through a selection based on several ground motion parameters and/or site classification.

Data are downloadable as:

SAC raw format (*.sac, counts), **ASCII processed acceleration** (*.DAT, cm/s^2), **ASCII processed velocity** (*.VEL, cm/s), **ASCII processed displacement** (*.DIS, cm) and **ASCII response spectra** (acceleration, velocity and displacement).

In each case the system provide a single "**tar**" file
(e.g. *ismd_list_event_20160710003706_acc_dw160715135248.tar*),

including data compressed in "**bz2**" format
(e.g. *IV.ACER..HNE.D.20160710.003706.ISMD.DAT.bz2*).

In order to obtain the usable data, please use the commands:
tar -xvf   file.tar
bunzip2   file.bz2

For further information mail to ismd@ingv.it (Last Update April 20, 2017)