

## ISMD USER MANUAL

### INTRODUCTION

**ISMD** (INGV Strong Motion Database) provides in quasi **real time** the **waveforms** and the related **metadata** for **earthquake** with  $M_L \geq 3.0$  occurred in the **Italian** territory and localized by the [INGV](#) (*National Institute for Geophysics and vulcanology*) surveillance system.

**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 fast provide the strong motion data recorded for the most important seismic events.

At first data are published in the **automatic version** (i.e. **check NO** in the last column of the earthquake list). The strong motion data published in version **NO CHECKED** are downloadable in **SAC** format (counts). From January 2019 the raw data are available also in **MisSeed** format (counts).

The Peak Ground Accelerations (**PGA**) calculated from the **NO CHECKED** data have purely an approximate meaning and they may contain [errors](#).

Data recorded in case of earthquakes with **magnitude**  $\geq 3.5$  are **CHECKED** (i.e. **check YES**, in the last column of the earthquake list) by an expert seismologist in the first 24h after the event origin time. In this case, low quality data are removed.

**ISMD** includes all accelerometric stations registered at [FDSN](#) and operated by [INGV](#) and [provided partners](#) that send data in real time to the [National Earthquake Observatory \(INGV-ONT\)](#). Data and metadata are freely open with the exclusion of the [National Accelerometric Network](#) (RAN), [FDSN code: IT](#)) for which just the waveforms metadata are available. Data recorded by RAN are downloadable at [ITACA](#) web site.

### DATA FORMATS

Data recorded by the [strong motion stations](#) included in ISMD are downloadable few minutes after the earthquake occurrence. The origin time (UTC), the hypocentral coordinates and Magnitude ( $M_L$ =local;  $M_w$ =Moment) are provided by the [National Earthquake Observatory \(INGV-ONT\)](#).

In case of a new earthquake with  $M_L \geq 3.0$  the ISMD automatic system downloads 5 minutes of signals, starting from the event origin time. The accelerometric waveforms are selected from the [MiniSeed](#) data stream recorded in continuous mode and archived in real time on a seedlink server, implementing the [Seiscomp3](#) client. The accelerometric waveforms are then converted in [SAC](#) and [ASCII](#) formats.

Data for earthquakes with  $M_L < 3.5$  are **NO checked** and they are available just in raw version (format: **SAC**, unit: count). From January 2019 raw data are provided also in **Miniseed** format (unit counts).

Data for earthquakes with  $M_L \geq 3.5$  are **CHECKED** and then provided in **ASCII** format in  $\text{cm/s}^2$  (*gal*).

The ASCII-files are composed by 50 header-lines (see the [example](#)), providing event, station and waveform metadata, followed by the data column in  $\text{cm/s}^2$  (*gal*).

In order to analyse again the SAC raw-data, users can convert SAC data in counts to  $\text{cm/s}^2$  (*gal*) using for each station the related **channel-sensitivity** (i.e. obtained considering 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:

$$\text{gal-data}=[\text{SAC-counts}*(100/\text{channel-sensitivity})]$$

On the basis of the earthquake magnitude, 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:

$Mag \leq 3.5$  : stations up to 150 km

$3.5 < Mag \leq 5.5$  : stations up to 200 km

$5.5 < Mag \leq 6.5$  : stations up to 250 km

$Mag > 6.5$  : stations up to 300 km

**Magnitude** might be *Local* ( $M_L$ ) or *Moment* ( $M_W$ ) in dependence of the information provided by the [National Earthquake Observatory \(INGV-ONT\)](#).

To request data with different distance or magnitude threshold, mail to [ismd@ingv.it](mailto:ismd@ingv.it)

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## DATA PROCESSING TO OBTAIN CHECKED-DATA

- uniform waveforms resampling at 100 Hz;
- application of a first-order baseline operator to the entire record, in order to have a zero-mean of the signal;
- baseline correction (least square method), in order to remove the linear trend;
- tapering of the signal by applying a cosine function (0.005%) at the beginning and at the end of each selected window;
- application of a 4<sup>th</sup> 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:

$M_L < 4.5$  : 0.2-45 Hz

$4.5 \leq M_L < 5.5$  : 0.15-45 Hz

$M_L \geq 5.5$  : 0.1-45 Hz

For details see [Pacor et al., 2011](#) and [Massa et al., 2010](#).

## AUTOMATIC RESULTS

- 5-minutes windows including for all stations the accelerometric waveforms of the analysed earthquake (version: raw-data in *counts* and checked-data in *gal*);
- related waveforms converted in **velocity** (cm/s) and **displacement** (cm);
- Peak Ground Acceleration (**PGA**), Velocity (**PGV**) and Displacement (**PGD**);
- 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;
- 5%-damped pseudo-velocity response spectra (**PSV**);
- 5%-damped relative displacement response spectra (**Sd**);
- Arias (**AI**, [Arias 1970](#)) and Housner (**HI**, [Housner 1952](#)) intensities;
- directional Horizontal-to-Vertical Spectral Ratio (**HVSR**) calculated at each station considering 10s of strong-motion phase and coda;

and also:

- comparison (in terms of PGA, PGV and acceleration response spectra) between the recorded data and the predicted ones by the **Italian or PanEuropean GMPEs** calibrated by [Bindi et al. \(2011; 2014\)](#);  
(warning for possible bias: Italian GMPEs considers earthquakes with  $4.0 \leq M_w \leq 6.9$  and maximum Joyner-Boore (or epicentral) distance of 200 km);
- **plots** of the recorded waveforms (acceleration, velocity, displacement);
- **plots** of SA, PSV, Sd;

(area of +/- 1° of latitude [N] and +/- 1.5° of longitude [E] around the epicenter)

- plot of the [Italian reference seismic hazard map \(Stucchi et al., 2011\)](#);
- **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 the [CPTI15 catalogue \(Rovida et al., 2016\)](#).

The results above are resumed in the **event web page**, generated automatically soon after the end of the automatic procedure of 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** version (\*.sac, unit counts), **ASCII checked acceleration** (\*.DAT, unit  $\text{cm/s}^2$ ), **ASCII checked velocity** (\*.VEL, cm/s), **ASCII checked displacement** (\*.DIS, cm) and **ASCII response spectra** (acceleration, velocity and displacement). From January 2019 raw-data are also available in **Miniseed** format (\*.seed, unit counts).

In each case the system provided 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:

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tar -xvf file.tar
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bunzip2 file.bz2
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For further information mail to [ismd@ingv.it](mailto:ismd@ingv.it)