



## Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation

### Report

#### Fast magnitude and moment tensor determinations

Activity:	<i>JRA2: Tools for real time seismology, acquisition and mining</i>
Activity number:	<i>D12.2</i>
Deliverable:	<i>Toolbox 2: seismic moment and earthquake size</i>
Deliverable number:	<i>D12.2</i>
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Seventh Framework Programme  
EC project number: 262330



## Summary

This report addresses the work done within the WP12 for what concerns the development and the enablement of software for the rapid calculation of magnitude and moment tensors. The activity carried out by the work package partners spans methodologies to be used at different scale-lengths (i.e., from local/regional events to teleseismic distances). The toolbox software includes the following procedures

1. [WavesDownloader](#) (INGV) - Software for data and metadata request, download and pre-processing.
2. [MWFMNear](#) (CNRS) - integrated package for the rapid and automated determination of earthquake source parameters using near source records.
3. [SCARDEC](#) (CNRS) - very rapid calculation of source-time function and moment tensor.
4. [Early-Est](#) (INGV/AL Software) - very rapid calculation of mb, Mwp, Mwpd, source duration and focal mechanism from broadband seismograms at global scale obtained through real-time seedlink connections.
5. [pyTDMT](#) (INGV) - moment tensor calculation at regional scale.

With the exception of WavesDownloader which is designed to “discover” and download the data – an essential task for the rapid earthquake size determination analysis - all the other software/procedures have been developed and/or enabled as part of the work package.

For all software, there has been made available a short description and the corresponding references on the NERA project web-site (<http://www.nera-eu.org>).

## Preamble

This deliverable makes ample reference to the software procedures published on correspondent software web sites. To this regard and to provide the “glue” between the developed software and the contents of the deliverable, it has been prepared a work package web portal on the NERA, JRA2 work package page (<http://www.nera-eu.org>) on which the individual software is both described concisely and made accessible. It follows that this deliverable is to be assessed in conjunction with the material made available on the corresponding web pages.

## Earthquake size software description

Rapid earthquake size estimation is extremely important to seismologists because it provides, together with hypocenter depth and, when available, local strong motion recordings (and resulting shakemaps), information for first assessments of the impact of the seismic event on population and buildings, and for large earthquakes occurring offshore, estimates on the likelihood for the generation of tsunami waves.

The software suite comprised in this deliverable includes methodologies implemented at various partner’s sites and to which we refer to in the following.

### *WavesDownloader (INGV)*

This software has been developed by INGV (Fabrizio Bernardi) to discover, select, download and pre-process waveform data made available at both EIDA (European Integrated Data Archive) and IRIS (Incorporated Research Institutes for Seismology). It

is essentially a “broker” procedure which merges the services provided through the web-services of either data archives to make data access and download transparent to the users. The software uses python (<http://www.python.org>) and the obspy seismological software library (<https://github.com/obspy/obspy/wiki>).

The software is fully documented and made available on the following web site <http://webservices.rm.ingv.it/wavesdownloader/>.

#### *MWFMNEAR (CNRS)*

This software developed primarily by Bertrand Delouise of GeoAzur (Nice), incorporates two methodologies targeting the fast determination of magnitude and of focal mechanism at local/regional scales ([http://www.nera-eu.org/content/mm\\_files/do\\_916/WMFMNEAR.pdf](http://www.nera-eu.org/content/mm_files/do_916/WMFMNEAR.pdf)). More specifically, it determines the rapid and automated determination of earthquake source parameters using near source records. In a first step, it provides a fast (< 5 min) estimation of the moment magnitude (M<sub>w</sub>) with the MWSYNTH approach. In a second step, it computes the double couple focal mechanism from waveform inversion (FMNEAR method). The software procedure is implemented at both the Geoazur laboratory (CNRS, <http://www.geoazur.net/sismoazur/>), France and at the National Observatory of Athens, Greece ([http://bbnet.gein.noa.gr/mw\\_rt/mw\\_list\\_2013.html](http://bbnet.gein.noa.gr/mw_rt/mw_list_2013.html))

#### *SCARDEC (CNRS)*

The software ([http://www.nera-eu.org/content/mm\\_files/do\\_916/SCARDEC.pdf](http://www.nera-eu.org/content/mm_files/do_916/SCARDEC.pdf)), developed by Martin Valle of GeoAzur (Nice), determines the earthquake source parameters (depth, magnitude, focal mechanism, source-time function) in near real time. Body waves recorded at the broadband stations of the global network are analyzed to provide a solution for most of the earthquakes with magnitude larger than 6. On a computer with a few tens of core, SCARDEC provides the information 45 minutes after earthquake origin time. A dedicated web page (<https://geoazur.oca.eu/SCARDEC>) provides information about the technique with some examples.

#### *Early-Est (INGV/AL Software)*

Early-Est ([http://www.nera-eu.org/content/mm\\_files/do\\_916/Early-Est.pdf](http://www.nera-eu.org/content/mm_files/do_916/Early-Est.pdf)) is a system for rapid, real-time earthquake monitoring, including phase picking, phase association and event detection, location, magnitude determination, first-motion mechanism determination, discriminants for earthquake tsunami potential, and tabular, graphical and web output. More specifically, the earthquake size estimation is implemented through the calculation of several magnitudes (m<sub>b</sub>, M<sub>w</sub>, M<sub>w</sub>pd), the source-time duration and the mechanism by calculation the fault plane solutions using the software HASH. The methodology is part of the real-time seismic monitoring activities of the INGV seismic center (<http://early-est.rm.ingv.it>) and it is implemented in experimental mode also at the National Observatory of Athens (<http://icp.gein.noa.gr/early-rtm/warning.html>).

#### *pyTDMT (INGV)*

This software, developed by Fabrizio Bernardi of INGV, determines the time domain moment tensor ([http://www.nera-eu.org/content/mm\\_files/do\\_916/pyTDMT.pdf](http://www.nera-eu.org/content/mm_files/do_916/pyTDMT.pdf)). The method entirely written in python, is designed for the inversion of the moment tensor from seismic waveforms of local and regional earthquakes. pyTDMT does not require data pre-processing and input file pre-formatting. The following data format are allowed: fseed, mseed, sac (alpha/binary). The package is available at

<http://webservices.rm.ingv.it/pyTDMT/> together where it can be found a thorough description of the code and some examples.

### **Conclusions**

The earthquake size software packages made available through the JRA2 work package appear to be “nice additions” to be used by seismic observatories willing to test methodologies which are not yet incorporated in systems like Earthworm or SeisComp3. Although some of the presented software procedures are already implemented at the seismic monitoring centers of the projects partners (e.g., INGV, GeoAzur, NOA), the software will be thoroughly tested during the second and final part of the project with more implementation at the other partners’ operating centers.