Specifications of the EMSC SRCMOD service

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Summary

I. Aim of the document

The aim of this document is to describe the specifications of all the functionalities that EMSC plans to develop in order to give access to Finite-Source Rupture Models (SRCMOD) data. This includes on the Seismic Portal website the:

1. Event Details of seismic events,
2. Interactive access (Graphical User Interface),
3. Web Service.

The second section describes the Martin Mai's database and the relevant parameters chosen to characterize Velocity-Rupture models.

The third section details the specifications of the new functionalities to add to the Seismic Portal allowing users to access SRCMOD services.

1. The Seismic Portal

The Seismic Portal[1] has been developed within the NERIES[2] FP7 project and is fully operational. This web site is a single access point to explore and download earthquake information gathered by the EMSC and provided by its european seismic joined members.

2. SRCMOD

The SRCMOD[3] database (Finite-Source Rupture Model, last access August 2017) collects and disseminates finite-fault rupture models of earthquakes worldwide (currently 334 source models are available from 169 earthquakes, magnitude range Mw 4.1 - 9.2). The database was published for the first time in 2004. Rupture models are presented in several unified formats to expedite subsequent research in earthquake mechanics, dynamic rupture processes, and ground-motion simulations. The intra-event variability of the source models allows assessing the inherent uncertainty in earthquake source inversions that arises due to the non-uniqueness of the inverse problem, different inversion methods and parameterizations, and a variety of data and their processing for the inversion procedures. Mai and Thingbaijam (2014) encourage scientists across the globe to further contribute to the database and utilize it for research on the earthquake source processes.

In this document, SRCMOD refers to all information describing the finite-fault rupture models of past earthquakes. These earthquake source models are obtained from inversion or modeling of seismic, geodetic and other geophysical data, and characterize the space-time distribution of kinematic rupture parameters.

[1] http://www.seismicportal.eu/
[2] http://www.share-eu.org/node/23
[3] http://equake-rc.info/srcmod

II. Description of the SRCMOD database

SRCMOD is the database of finite-fault rupture models of past earthquakes.

The database includes 7 tables (Fig. 1) and is mainly accessible through two keys EquakeID and Ev_TAG.

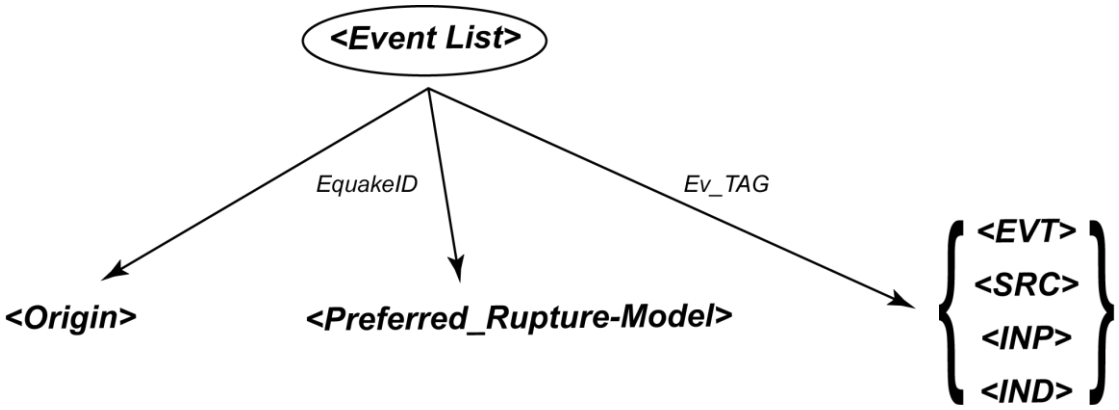

Figure 1: Synoptic description of SRCMOD database. 7 tables and their two main keys: EquakeID and Ev_TAG. <Event List> can been seen as the principal table and the others as attributes.

1. Main SRCMOD's keys

The Ev_TAG key is especially useful because it allow the interoperability between our local database and the SRCMOD website[4] . Especially, the Ev_TAG key allow the user to download each velocity-rupture model one by one. The velocity-rupture models are available in three distinct le formats:

- .SLP
- .FSP
- .MAT

Slip format le (SLP) is an ascii- le with basic header information and simple, single-rupture-plane source-model representation. Finite Source Parameter format le (FSP) is an ascii- le with comprehensive list of modeling/inversion parameters, source geometry, and space-time-dependent rupture model. Matlab format le (MAT) is a binary MATLAB le containing the rupture model as MATLAB structure.

2. Downloading data thanks to Ev_TAG

In practical, downloading data from SRCMOD website is straightforward and the URL-based are summary in the table (1).

Format	URL-based

[4] http://equake-rc.info/SRCMOD/

SLP	http://equake-rc.info/media/srcmod/_slp_ les/Ev_TAG.slp
FSP	http://equake-rc.info/media/srcmod/_fsp_ les/Ev_TAG.fsp
MAT	http://equake-rc.info/media/srcmod/_mat_ les/Ev_TAG.mat

Table 1: Downloading velocity-rupture models from SRCMOD website.

The local SRCMOD database was built from the download of all MAT- les available online. The name of the parameters is kept willingly identical to that exposed on the website in order to maximize interoperability.

3. SRCMOD table Relationship

In this section we detail all the tables contain in the SRCMOD database.

a. <EventList> table

The EventList table (2) contains summary information about the finite-fault earthquake rupture models. Note that the same information is also available online on the Event List[5] page.

Column	Storage Type	Description
01 id	serial, primary key	event id
02 equakeid	integer	equake id
03 ev_tag	varchar(20)	event tag
04 evid	integer	emsc information system id
05 date	timestamp	event date
06 flinnregion	varchar(100)	flinn-engdahl region
07 region	varchar(100)	location area
08 lat	numeric	latitude [$^\circ$]
09 lon	numeric	longitude [$^\circ$]
10 depth	numeric	depth [km]
11 mag	numeric	magnitude [Mw]]
12 author	varchar(100)	publication (short)

Table 2: Event List Table.

b. <EVT> table

The Event table (3) contains the main information used to characterize the seismic event associated to the finite-source rupture model.

Column	Storage Type	Description
01 id	serial, primary key	event id
02 ev_tag	varchar(20)	event tag
03 oldev_tag	varchar(20)	old event tag
04 date	timestamp	event date
05 flinnregion	varchar(100)	flinn-engdahl region
06 region	varchar(100)	location area

[5] http://equake-rc.info/SRCMOD/searchmodels/allevents/

07 lat	numeric	latitude [$^\circ$]
08 lon	numeric	longitude [$^\circ$]
09 depth	numeric	depth [km]
10 author	varchar(100)	author reference (short)
11 pub	text	publication reference
12 credit	varchar(100)	author credit

Table 3: Event Table (EVT).

c. <SRC> table

The Source table (4) contains the main information used to characterize the seismic sources modelised in the finite-source rupture models.

Column	Storage Type	Description
01 id	serial, primary key	event id
02 ev_tag	varchar(20)	event tag
03 mag	numeric	magnitude
04 moment_pow	integer	seismic moment power [10^n]
05 moment_val	numeric	seismic moment mantissa [$N.m$]
06 strike	numeric	strike [$^\circ$]
07 dip	numeric	dip [$^\circ$]
08 rake	numeric	rake [$^\circ$]
09 length	numeric	length of the rupture [km]
10 width	numeric	width of the rupture [km]
11 htop	numeric	depth to top [km]
12 hypX	numeric	Hypocenter first dimension [km]
13 hypZ	numeric	hypocenter second dimension [km]
14 avtr	numeric	average rise time [s]
15 avvr	numeric	average rupture speed [km/s]

Table 4: Source Table (SRC).

d. <INP> table

The Inversion-related parameters table (5) contains information parameters used for the inversion of the finite-source rupture models.

Column	Storage Type	Description
01 id	serial, primary key	event id
02 ev_tag	varchar(20)	event tag
03 nseg	integer	number of segments
04 dx	numeric	grid x-direction [km]
05 dz	numeric	grid z-direction [km]
06 svf	varchar(30)	method
07 nw	integer	number of windows
08 length	numeric	window length [s]
09 overlap	numeric	window overlap [s]

10	fmin	numeric	frequency minimum [Hz]
11	fmax	numeric	frequency maximum [Hz]

Table 5: Inversion-related parameters table (INP).

e. <IND> table

The Inversion data table (6) contains data useful to perform the inversion of finite-source rupture models.

Column	Storage Type	Description
01 id	serial, primary key	event id
02 ev_tag	varchar(20)	event tag
03 Nsta_SGM	integer	-
04 Nsta_TELE	integer	-
05 Nsta_TRIL	integer	-
06 Nsta_LEVEL	integer	-
07 Nsta_GPS	integer	-
08 Nsta_INSAR	integer	-
09 Nsta_SURF	integer	-
10 Nsta_OTHER	integer	-
11 Pmax_SGM	integer	-
12 Pmax_TELE	integer	-
13 Pmax_TRIL	integer	-
14 Pmax_TRIL	integer	-
15 Pmax_GPS	integer	-
16 Pmax_INSAR	integer	-
17 Pmax_SURF	integer	-
18 Pmax_OTHER	integer	-
19 Rmin_SGM	integer	-
20 Rmin_TELE	integer	-
21 Rmin_TRIL	integer	-
22 Rmin_LEVEL	integer	-
23 Rmin_GPS	integer	-
24 Rmin_INSAR	integer	-
25 Rmin_SURF	integer	-
26 Rmin_OTHER	integer	-

Table 6: Inversion data table (IND).

4. Data contributors

SRCMOD: finite-source rupture model database is an initiative taken up by Martin Mai to compile and disseminate earthquake rupture models in order to support relevant research works across the globe. The database is accessible online[6] and more details can be found in Mai and Thingbaijam (2014).

[6] http://equake-rc.info/SRCMOD/

5. Association of SRCMOD data to an EMSC event

The finite-velocity rupture is a cinematic representation of the source for a given event. The association between SRCMOD data and EMSC events will be performed through the UNID parameter.

The UNID is the unified identifier of events in the EMSC information system.

To associate SRCMOD event with an EMSC event, we simply search for the first event where the difference in:

- Origin time is less than 1 day (resolution of the SRCMOD database),
- Location is less than 2 degrees,
- Magnitude (Mw) is less than 1 point.

The result of the association is binary: either the event exists and it is unique and the biggest in the area ever recorded. Either there is no entry match.

In the specific situation where there is no match (which means that the SRCMOD's event is unknown from the EMSC's information system) a newest UNID will be created and the event will be added to the EMSC database.

This management of event ID (create) address the same issue as encountered in the development of Moment Tensor service Landès (2017).

a. Create UNID

The SRCMOD database contains earthquake from 1906 (San-Francisco, California) till 2015 (Gorkha, Nepal): currently, there is 334 models from 169 earthquakes available (last access: August 2017).

On another side, the EMSC information system contains information about earthquakes since October 2004: there is no entry in the EMSC database corresponding to the historical records.

From a static point of view, 68 seismic events are already known from EMSC information system and 101 are not. In that last case, an dedicated UNID will be created in order to aggregate the historical SRCMOD's event to the EMSC's information system.

In the case where the historical SRCMOD's event is unknown from EMSC system and if there is only one SRCMOD model, the origin parameters will be those of the model. But in the case where there is several different velocity-rupture models available for one seismic event, the mean of each parameters (latitude, longitude, depth and Mw magnitude) are computed and associated as the origin parameters of the seismic event.

b. <Origin> table

The Origin table (7) summarize the Origin parameters of the earthquake events used to compute finite-source velocity rupture models.

Column	Storage Type	Description
01 id	serial, primary key	event id
02 equakeid	integer	equake id
03 evid	integer	emsc information system id
04 date	timestamp	event date
05 region	varchar(100)	location area
06 lat	numeric	latitude [°]
07 lon	numeric	longitude [°]
08 depth	numeric	depth [km]
09 mag	numeric	magnitude
10 magtype	varchar(5)	type of magnitude

Table 7: Origin Table.

6. Preferred Velocity-Rupture model

As long as no authoritative rule exists to de ne a preferred velocity-rupture solution for one event, we have chosen arbitrarily the following criteria in order to deal with this issue of practical interest (display on the seismic portal):

1. If there is only one velocity rupture model computed, this model will be the authoritative one until a new publication released.

2. If there is many velocity rupture models, the latest publication solution will be used as the authoritative one.

These criteria are arbitrary and will be applied until we have a validated method. This may be done with the future Test Platform where we plan to test the authoritativeness of the solution in general.

a. <Preferred_Model> table

The Preferred Model table (8) contains information about the preferred velocity-rupture model associated to each earthquake of the SRCMOD catalog.

Column	Storage Type	Description
01 id	serial, primary key	event id
02 equakeid	integer	equake id
03 ev_tag	varchar(20)	event tag
04 author	varchar(100)	publication (short)
05 pub_year	integer	year of publication [*yyyy*]

Table 8: Preferred velocity-rupture model.

III. SRCMOD Services

The different ways to access rupture velocity models data will be developed as extensions of the contains already implemented on the Seismic Portal website. Three new functionalities have been identified:

1. Complete the event page (called the Event Details page).
2. Give access to all SRCMOD data available via a web service.
3. Add an interactive query search (Graphical User Interface).

1. Updating the « Event Details » page

This section details the elements to be displayed on the Event Details page of the Seismic Portal.

The goal is to add Velocity-Rupture information (when this information is available) to the Event Details page on the Seismic Portal. This functionality will be considered as a new section like the attributes already developed and implemented:

- Origin,
- Arrival,
- Moment Tensor,
- Velocity-Rupture.

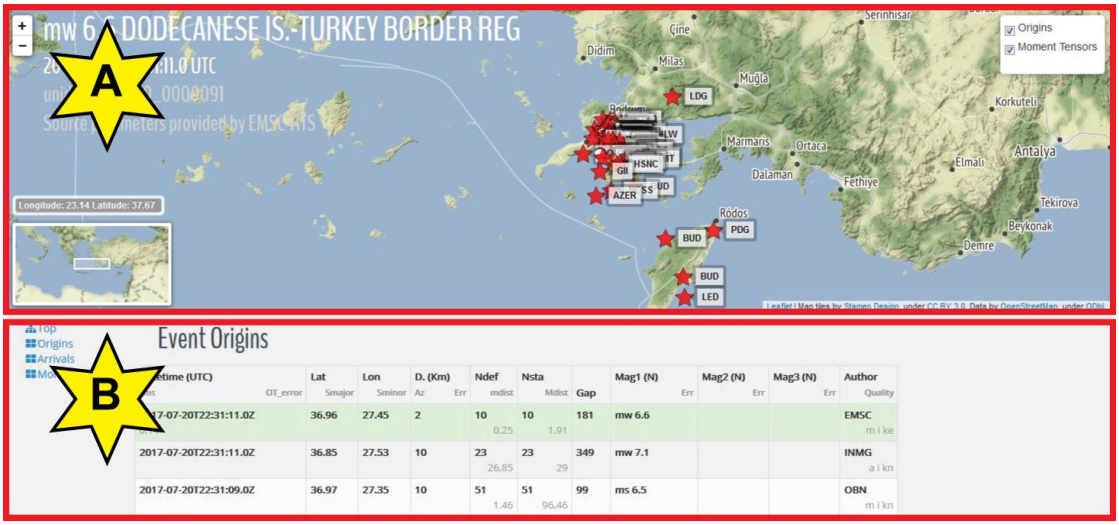

Figure 2: Event details of the Mw 6.6 Dodecanese Island earthquake on July 20, 2017. All the information about this special event is available on the Seismic Portal. The two stars A and B indicate the two zones to update.

For Velocity-Rupture models associated to an event, we choose to show all the parameters listed in the table (9). The update will add an item listing for all entries (FIG 2 - Zone B).

Parameter	SRCMOD <table>
01 author	Preferred_Model
02 date	Origin
03 lat	Origin
04 lon	Origin
05 depth	Origin
06 mag	Origin
07 magtype	Origin
08 moment_pow	SRC
09 moment_val	SRC
10 strike	SRC
11 dip	SRC
12 rake	SRC
13 length	SRC
14 width	SRC
15 avtr	SRC
16 avvr	SRC
17 nseg	INP

Table 9: List of parameters which should be add to the Event Details page of the Seismic Portal.

Moreover, on the map (FIG 2 - Zone A) the user will have the possibility to switch between:

- Origin locations (indicated by red stars).
- Moment Tensor (indicated by beachballs).
- Velocity Rupture locations (indicated by blue square).

In addition to these visual features, the user will have the possibility to download the velocity rupture information on the Event Details page in the formats:

- QuakeML
- CSV
- JSON

2. Developing a Web Service

This service is a part of the EPOS Thematic Core Service[7] and aims to give access to Velocity-Rupture models via a Web Service integrated into the Seismic Portal. Because it is not possible to include velocity-rupture models into the existing FDSN-event Web Service, this velocity-rupture web service will be developed independently. However, the specifications will follow as closely as possible those of FDSN.

This service aims to give access to all data hosted on EMSC servers and Velocity-Rupture models from Martin Mai's SRCMOD database.

Like for the FDSN-event, this newest service gathers data for a given request and the searches can be summarized as follow:

- by Region,
- by Time period, • by ID (SRCMOD ID),
- by UNID.

The user may choose to add other filtering rules on:

- Depth,
- Magnitude,
- Seismic Moment,
- Average Rise Time, • Average Rupture Speed,
- Credit.

The output of the available data for a given request may be in format:

- Text
- Json

It's also possible to limit the number of results with the limit keyword.

Specifications of this service are very similar to the Moment Tensor Specifications (Landès, 2017) which are very similar to the FDSN-event Specifications.

3. Building an Interactive Search

The interactive search is a Graphical Web Interface that should give to the user the possibility to request velocity-rupture models with all the filtering options already defined for the specifications of the web service.

[7] https://www.epos-ip.org/thematic-core-service-index

IV. Annexes

1. Specifications documents of interest

Specifications of FDSN web services[8]
QuakeML specifications[9]

[8] http://www.fdsn.org/webservices/FDSN-WS-Specifications-1.1.pdf
[9] https://quake.ethz.ch/quakeml/Documents

2. SRCMOD's parameter in details

id

Name:	Row identifier
Table:	Event List, Origin, Preferred Model, EVT, SRC, INP, IND
Description:	Used as primary identifer.
Format:	Serial
Missing Value:	not allowed

equakeid

Name:	Earthquake identifier
Table:	Event List, Origin, Preferred Model
Description:	String composed of the reverse date of the earthquake (year + month + day + two more digit).
Format:	Integer
Range:	yyyymmddAB (10 digits)

ev_tag

Name:	Row identifier
Table:	Event List, Preferred Model, EVT, SRC, INP, IND
Description:	Used as main event identifer. String composed of the year of the earthquake plus an abbreviation for the event location plus an abbreviation for the author(s) of the source model.
Format:	varchar(20)
Missing Value:	not allowed
Range:	s + YYYY + NNNNNN + CC + AAAA (17 characters)

oldev_tag

Name:	Row identifier
Table:	EVT
Description:	Used as oldest event identifer. String composed of the year of the earthquake plus an abbreviation for the event location plus an abbreviation for the author(s) of the source model.
Format:	varchar(20)
Missing Value:	not allowed
Range:	YYYY + NNNNNN + CC + AAA (15 characters)

evid

Name:	EMSC event identifier
Table:	Event List, Origin
Description:	identifier used by EMSC to access to its online published events (https://www.emsccsem.org/Earthquake/earthquake.php?id=EVID).
Format:	integer

date	
Name:	Date
Table:	Event List, Origin, EVT
Description:	Time of the seismic event (take into account that the resolution of the SRCMOD model is the day: YYYY-mm-dd).
Format:	timestamp (without time zone)
Missing Value:	not allowed
flinnregion	
Name:	Flinn-Engdahl region
Table:	Event List, EVT
Description:	Flinn-Engdahl region associated to the location of the seismic event.
Format:	varchar(100)
Missing Value:	not allowed
region	
Name:	Region
Table:	Event List, Origin, EVT
Description:	Region associated to the location of the seismic event (used also for the name of the earthquake).
Format:	varchar(100)
Missing Value:	not allowed
lat	
Name:	Latitude
Table:	Event List, Origin, EVT
Description:	Latitude of the hypocenter.
Format:	numeric
Missing Value:	not allowed
Units:	°
Range:	$-90 <$ latitude < 90 (North)
lon	
Name:	Longitude
Table:	Event List, Origin, EVT
Description:	Longitude of the hypocenter.
Format:	numeric
Missing Value:	not allowed
Units:	°
Range:	$-180 <$ longitude < 180 (East)
depth	
Name:	Depth
Table:	Event List, Origin, EVT
Description:	Depth of the hypocenter.
Format:	numeric
Missing Value:	not allowed

Units:	*km*

mag

Name:	Magnitude
Table:	Event List, Origin, SRC
Description:	Magnitude (note that SRCMOD data are always in Mw unit).
Format:	numeric
Missing Value:	not allowed

magtype

Name:	Magnitude type
Table:	Origin
Description:	Magnitude type is explicitly specified (for seismic events known from EMSC information system). Format: varchar(5)

author Name:

	Author
Table:	Event List, Preferred Model, EVT
Description:	Summary of authors and date of the scientific publication associated to the SRCMOD model.
Format:	varchar(100)
Missing Value:	not allowed

pub

Name:	Publication
Table:	EVT
Description:	Reference of the scientific publication associated to the SRCMOD model.
Format:	text
Missing Value:	not allowed

pub_year

Name:	Publication Year
Table:	Preferred Model
Description:	Year of the the scientific publication associated to the SRCMOD model.
Format:	Integer
Missing Value:	not allowed
Range:	yyyy (4 digits)

credit

Name:	Credit
Table:	EVT

Description: Contribution credit of the scientist associated to the SRCMOD model. Format: varchar(100)

---

moment_val

Name: Mantissa of the seismic moment
Table: SRC
Description: Significant (m) of the moment tensor (which is written in scientific notation: $M_0 = m \times 10^n$)
Format: numeric
Missing Value: not allowed
Units: $N.m$

---

moment_pow

Name: Power of ten exponent of the seismic moment
Table: SRC
Description:Power of ten exponent (n) of the moment tensor (which is written in scientific notation: $M_0 = m \times 10^n$)
Format: integer
Missing Value: not allowed

---

strike

Name: Strike
Table: SRC
Description: Mean fault strike (direction created by the intersection of the fault plane and an horizontal plan oriented positively to the North).
Format: numeric
Missing Value: not allowed
Range: $0 <$ strike < 360
Units: °

---

dip Name: Dip
Table: SRC
Description: Mean fault dip (inclination of the fault plan).
Format: numeric
Missing Value: not allowed
Range: $0 < \text{dip} < 90$
Units: °

---

rake
Name: Rake
Table: SRC

Description:	Rake is the direction of a hanging wall block moves during rupture, as measured on the plane of the fault.
Format:	numeric
Missing Value:	not allowed
Range: Units:	-180 < rake < 180

length	
Name:	Length of the fault
Table:	SRC
Description:	Total length of the rupture (integrating the length of all the segments).
Format:	numeric
Missing Value:	not allowed
Units:	km

width	
Name:	Width of the fault plane
Table:	SRC
Description:	Mean width of the total rupture plane.
Format:	numeric
Missing Value:	not allowed
Units:	km

htop	
Name:	Depth to top
Table:	SRC
Description:	Mean vertical depth to the top of the rupture plane.
Format:	numeric
Missing Value:	not allowed
Units:	km

hypX	
Name:	Hypocenter X
Table:	SRC
Description:	Rupture nucleation point in fault-plane coordinates (starting at top-left corner), rst dimension.
Format:	numeric
Missing Value:	not allowed
Units:	km

hypZ	
Name:	hypocenter Z
Table:	SRC

Description:	Rupture nucleation point in fault-plane coordinates (starting at top-left corner), second dimension.
Format:	numeric
Missing Value:	not allowed
Units:	km

srcAveTr	
Name:	Average rise time
Table:	SRC
Description:	At one point on the fault slip takes a finite time called rise time.
Format:	numeric
Missing Value:	not allowed
Units:	s

avvr	
Name:	Average velocity rupture
Table:	SRC
Description:	The speed at which a rupture front moves across the surface of the fault during an earthquake.
Format:	numeric
Missing Value:	not allowed
Units:	km/s

Nseg	
Name:	Number of segments
Table:	INP
Description:	Total number of fault segments.
Format:	integer
Missing Value:	not allowed

dx Name:	
	dx
Table:	INP
Description:	meshing the fault in the strike direction.
Format:	numeric
Missing Value:	not allowed
Units:	km

dz	
Name:	dz
Table:	INP
Description:	meshing the fault in the down-dip direction.
Format:	numeric
Missing Value:	not allowed

Units:	*km*

svf

Name:	SVF
Table:	INP
Description:	Type of Slip Velocity Function used in the inversion.
Format:	varchar(100)
Missing Value:	not allowed

nw

Name:	nw
Table:	INP
Description:	Number of time windows.
Format:	integer
Missing Value:	not allowed

length

Name:	Length
Table:	INP
Description:	Window time scale.
Format:	numeric
Missing Value:	not allowed
Units:	*s*

overlap

Name:	Overlap
Table:	INP
Description:	Window overlap.
Format:	numeric
Missing Value:	not allowed
Units:	*s*

fmin

Name:	Minimum frequency
Table:	INP
Description:	Minimum frequency of bandpass filtered seismic data.
Format:	numeric
Missing Value:	not allowed
Units:	Hz

Fmax

Name: Maximum frequency
Table: INP
Description: Maximum frequency of bandpass filtered seismic data.
Format: numeric
Missing Value: not allowed
Units: Hz

V. Glossary

The seismic moment is a measure of the size of an earthquake based on the area of fault rupture (Fig. 3), the average amount of slip, and the force that was required to overcome the friction sticking the rocks together that were o set by faulting. Seismic moment can also be calculated from the amplitude spectra of seismic waves.

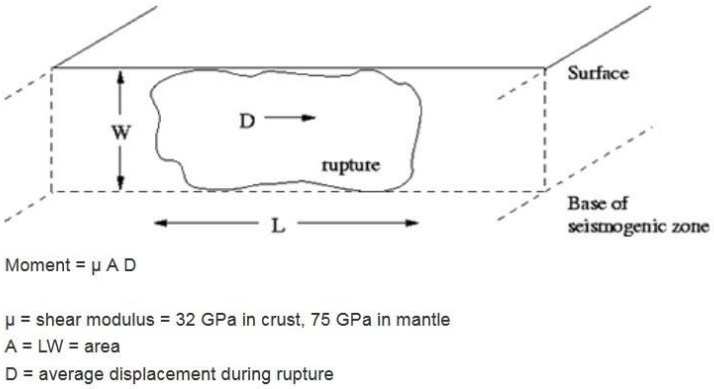

Figure 3: The seismic moment is a measure of the size of an earthquake based on the area of fault rupture.

References

Landès, M. (2017). Specifications of EMSC moment tensor services: Interactive access and epos thematic core service. EMSC specifications for the EPOS Seismology Thematic Core Service, pages 1 13.

Mai, P. and Thingbaijam, K. (2014). Srcmod: An online database of finitefault rupture models. Seismological Research Letters, 85:1 9.

VI. Description of the distributed data and Quality Assurance

The FDSN-EVENT service is accessible at the url : https://www.seismicportal.eu/fdsn-wsevent.html and gives access to earthquake data collected by EMSC in real time. The Annex VIII describes in details the data and the contributors.

The earthquake data distributed by the service are collected by the EMSC in real-time. Once received by the EMSC internal system, these data are then published on the Seismic Portal. The Quality Assurance is done in the internal system with the following actions:

- Daily Feedbacks from users that compare with other seismological apps and from contributors that check the data they have sent.
- Global study of seismicity
- The majority of earthquake origins composed by many contributions are reviewed by seismologists.

More details are available in the Annex VIII.

VII. web service access

The service FDSN event follows the FDSN specifications describes in

https://www.fdsn.org/webservices/fdsnws-event-1.2.pdf

VIII. Annex: EMSC Activity Report

Extract of the EMSC activity report of 2018 that describes the data collected ant its statistics.