Specifications of EMSC moment tensor services: Interactive access and EPOS Thematic Core Service

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Summary

I. Aim of the document

The aim of this document is to describe the specifications of all functionalities the EMSC will develop in order to give access to the moment tensor data of seismic events. This includes the interactive access through the Seismic Portal website and the EPOS Thematic Core Service associated to moment tensor data.

The second section describes the data we receive at the EMSC and the parameters chosen to characterize moment tensor data.

The third section gives specifications of the new functionalities of the seismic portal allowing users to access moment tensor data. This includes visual representation of moment tensor, a web service and an interactive web search of moment tensor data.

Note about "moment tensor"

In this document, moment tensor data refers to all information describing the source mechanism of an earthquake following tensor, double couple or axe representation.

The Seismic Portal

The Seismic Portal has been developed within the NERIES FP7 project. This web site is now operational and is a single point of access to explore and download earthquake information. It's available at the url www.seismicportal.eu. Future development of EPOS services will be integrated into the Seismic Portal.

II. Description of moment tensor data and their association

This section describes moment tensor data and its association with EMSC earthquakes. The issue of whether or not the seismic event is in the EMSC database.

1. Data contributors

Moment tensor data hosted at EMSC comes from data received in near real time from seismological institutes and from catalogs such as the Earthquake Mechanisms of the Mediterranean Area (EMMA) database from Vannucci and Gasperini, 2004 (Described below).

Near real time moment tensors collected at the EMSC comes from:

- National Research Institute of Astronomy and Geophysics -- Helwan, Egypt
- Laboratoire de Détection et de Géophysique -- Pamatai, French Polynesia
- GEOSCOPE, Institut de Physique du Globe de Paris (SCARDEC method) -- Paris, France
- GeoAzur -- Nice, France
- W-Phase CMT -- IPGS/EOST and CALTECH -- France and USA
- GEOFON -- Potsdam, Germany
- National Observatory of Athens -- Athens, Greece
- University of Athens -- Athens, Greece
- Aristotle University of Thessaloniki -- Thessaloniki, Greece
- University of Patras -- Patras, Greece
- QRCMT INGV -- Bologna, Italy
- Instituto Geografico Nacional -- Madrid, Spain
- SED Moment Tensors -- ETH Zuerich, Switzerland
- Kandilli Observatory and Earthquake Research Institute -- Istanbul, Turkey
- Earthquake Research Department -- Ankara, Turkey
- USGS Fast Moment Tensor Solutions -- Denver, Colorado, USA
- Global CMT - Lamont-Doherty Earth Observatory (LDEO) -- Palisades, NY, USA
- Jascha Polet (Cal Poly Pomona) -- Pomona, California, USA

These moment tensor contributors are not restricted to EMSC members and additional institutes can be integrated into the collection process. All moment tensors are collected via email and PDL, the USGS messaging system (Product distribution layer) and are stored on the EMSC database. Formats used by contributors are custom text and xml format, Global CMT and ISOLA format. Depending of the inversion method, we may receive the full moment tensor, or only the double couple solution (IPGP for instance). Table 1 summarizes the data from each contributor.

Geographical coverage of different data contributors may overlap and if it is the case the EMSC will collect several moment tensors for one event (for example 12 moment tensors were collected for an event in Agean Sea the 24th May 2014).

The EMMA database. Alongside the data contributors, the EMSC stores the EMMA database and we explore the possibility to distribute their data. The Earthquake Mechanisms of the Mediterranean Area (EMMA) database is a project to collect focal mechanisms published in the literature of earthquakes in the Mediterranean area. It represents more than 6000 mechanisms of events since 1905 (Vannucci and Gasperini, 2004). The quality and the consistency of the data are checked and the authors defined a preferred mechanism among those available.

	Name of the institute	Region	Min Mw	Type of data	Comments
GCMT	Global CMT - Lamont-Doherty Earth Observatory (LDEO) -- Palisades, NY, USA	Global	4,2	tensor	
USGS	USGS Fast Moment Tensor Solutions -- Denver, Colorado, USA	Global	3	tensor	
GFZ	GEOFON -- Potsdam, Germany	Global	3,2	tensor	
IPGP	GEOSCOPE, Institut de Physique du Globe de Paris (SCARDEC method) -- Paris, France	Global	5,3	DC *	
PPT	Laboratoire de Détection et de Géophysique -- Pamatai, French Polynesia	Global	4,8	tensor	
AZUR	GeoAzur -- Nice, France	Global	3,9	DC	stopped since 2015
INGV	QRCMT INGV -- Bologna, Italy	Mediterranean area	3,9	tensor	
NOA	National Observatory of Athens -- Athens, Greece	Greece	3,1	tensor	
KAN	Kandilli Observatory and Earthquake Research Institute -- Istanbul, Turkey	Turkey	2,9	DC	
IGN	Instituto Geografico Nacional -- Madrid, Spain	West mediterranean area	3,9	tensor	
ETHZ	SED Moment Tensors -- ETH Zuerich, Switzerland	Europe	4,4	tensor	stopped since 2009
THE	Aristotle University of Thessaloniki -- Thessaloniki, Greece	Est mediterranean area	2,9	DC	
ERD	Earthquake Research Department -- Ankara, Turkey	Turkey	3,3	tensor	
UPS	University of Patras -- Patras, Greece	Greece	3,3	tensor	
UOA	University of Athens -- Athens, Greece	Greece	3,4	tensor	stopped since 2015
EOST	W-Phase CMT -- IPGS/EOST and CALTECH -- France and USA	Global	8,2	tensor	only one event
NRIAG	National Research Institute of Astronomy and Geophysics -- Helwan, Egypt	Est mediterranean area	4,6	tensor	only one event
CPPT	Jascha Polet (Cal Poly Pomona) -- Pomona, California, USA	Global	5,3	tensor	stopped since 2014

Table 1 : List of all EMSC contributors sending source mechanisms in near real time and a short description of their data. * DC means double couple.

2. Association of moment tensor data with an EMSC event

In seismology, the moment tensor is a representation of the source for a given event. The association between moment tensor data and EMSC events will be performed through the UNID parameter. The UNID is the unified identifier of events in the EMSC database.

To associate moment tensor data with an EMSC event, we simply search for the first event where the time difference between the origin time and the centroid time is less than one minute and where the difference location is less than 4 degrees. When many events match, we choose the closest in time.

For the specific situation of the addition of an external catalog, the event associated to the moment tensor may not be in the EMSC event database. In that case, the event will be added to the EMSC database and the UNID will be created. This management of event ID issue is strongly related to the event ID services developed for EPOS (See the incoming event ID service document).

3. Preferred moment tensor mechanisms

As long as no authoritative rule exists to define a preferred moment tensor solution for one event, we have chosen the following criteria arbitrarily:

1. First of all, we consider currently available services having a global coverage and providing moment tensors. If possible, the preferred solution will be firstly from Global CMT, then from USGS, then from GFZ and then from INGV.
2. If no solution is found, we choose the moment tensor having the centroid location the closest to the EMSC event location referenced by the UNID, which is determined following the rules regarding authoritative locations established at the EMSC.

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 moment tensors.

4. Quality Assurance

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 V.

5. Parameters describing moment tensors

To describe moment tensors, we select a set of parameters based on the information provided by contributors. These parameters are listed on the following tables are fully compatible with the elements defined in the quakeML format. This set includes collected and computed parameters. The unid parameter corresponds to the ID of the event from which is associated moment tensor data.

Event information			
unid			UNified ID used at the EMSC to identify events

The following parameters are provided by the different contributors. Some of them, such as the IPGP, don't provide the full tensor but instead double couple information.

Focal information			
source_catalog		string	Contributor reference (GFZ, IPGP, EMMA…)
source_id		string	Internal ID
centroid_time	datetime	datetime	Centroid date/time UTC
longitude	degrees	float	Longitude of the centroid
latitude	degrees	float	Latitude of the centroid
depth	km	float	Depth of the centroid
region		string	Flinn-Engdahl region name[1]

Moment information [2]			
m0	Nm	float	Value of m0
m0_exp		integer	Exponent of m0
mw		float	Magnitude Mw

Double couple information		
First nodal plan		
strike	degrees	float
dip	degrees	float
rake	degrees	float
Second nodal plan		
strike	degrees	float
dip	degrees	float
rake	degrees	float

Tensor information [2]		
tensor_exp		integer

[1] Flinn, E.A., Engdahl, E.R. and Hill, A.R., 1974, Seismic and geographical regionalization, Bulletin of the Seismological Society of America, vol. 64, p. 771-993.

[2] All values in Nm are described by an exponent and by the coefficient according the scientific notation. For instance the number 1.3E15 has a coefficient of 1.3 and an exponent of 15.

mrr	Nm	float
mtt	Nm	float
mpp	Nm	float
mrt	Nm	float
mrp	Nm	float
mtp	Nm	float

These four parameters may be collected if they are given by the contributor. Otherwise, they are computed with the tensor coefficients.

additional information			
per_iso		float	Percentage of isotropy
per_dc		float	Double couple percentage
per_clvd		float	CLVD percentage of the tensor

Axe information are computed from tensor or from double couple parameters.

Axe information[3]			
axe_exp		integer	
tval	Nm	float	value of T axis
tplung	degrees	float	plunge of T axis
taz	degrees	float	azimuth of T axis
pval	Nm	float	value of P axis
pplung	degrees	float	plunge of P axis
paz	degrees	float	azimuth of P axis
nval	Nm	float	value of N axis
nplung	degrees	float	plunge of N axis
naz	degrees	float	azimuth of N axis

[3] All values in Nm are described by an exponent and by the coefficient according the scientific notation. For instance the number 1.3E15 has a coefficient of 1.3 and an exponent of 15.

III. Interactive access and Moment Tensor services

The different ways to access moment tensor data will be developed as extensions of the existing Seismic Portal with interactive access and a web service. Three new functionalities are identified:

1. Complete the event page (called the “eventdetails” page) of the Seismic Portal to display moment tensor information of EMSC events;
2. Give access to all moment tensor data available at the EMSC via a web service;
3. Add an interactive query search on the Seismic Portal.

1. Moment tensors on the event page of the Seismic Portal

The aim is to add moment tensor information (when they are available) into the “eventdetails” page of the Seismic Portal (see Figure 1). This functionality is considered as a new section like the existing “origins” and “arrivals” sections. The idea is to have a “moment tensor” item listing for all entries (see Zone B, Figure 1).

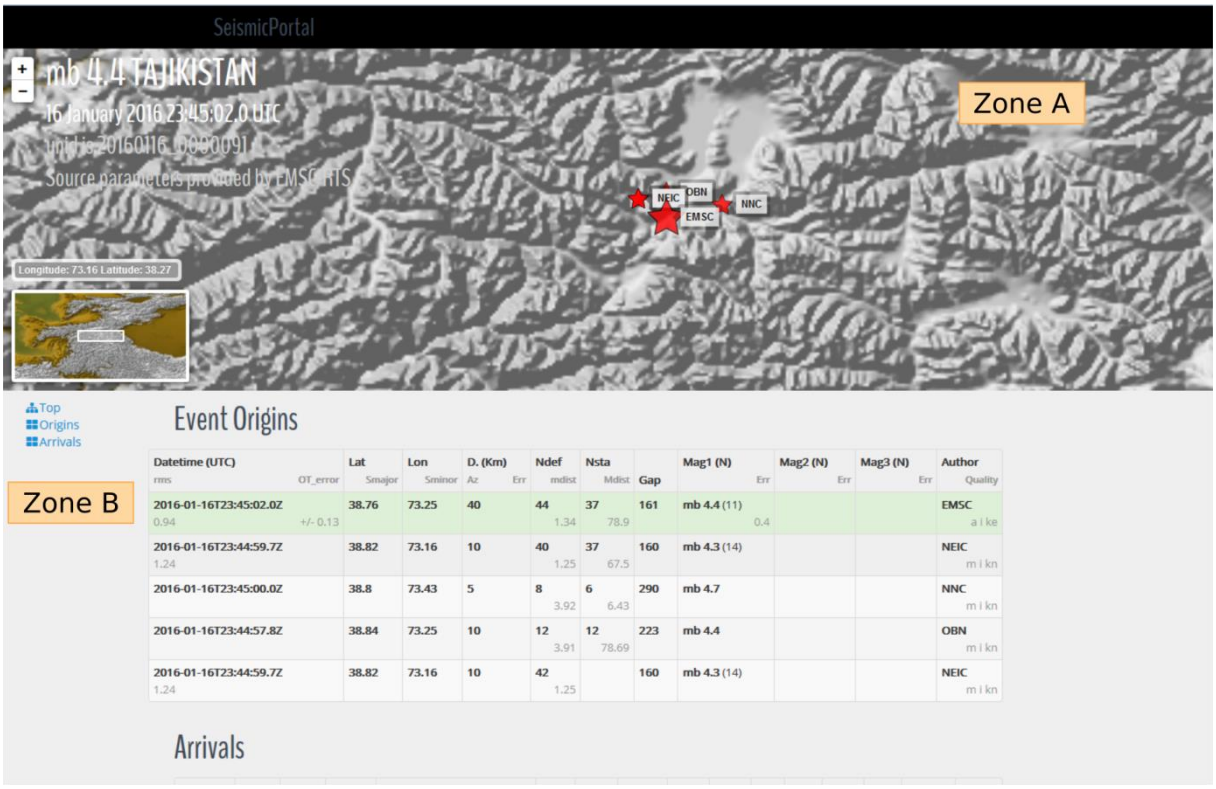

Figure 1 : Example of the “eventdetails” page of the Seismic Portal page. The two zones locate the two modification zones.

This section details the elements to be displayed on the “eventdetails” page of the Seismic Portal. For moment tensor associated to an event, we choose to show:

- Centroid information (date, time, longitude, latitude, depth);
- Author information (source_catalog);
- Moment information (Mw);
- Additional information (%DC, %ISO, %CLVD);
- Nodal plane information (strike, dip, rake for the two nodal planes);
- (if available) Moment tensor components;
- one beachball.

Moreover, on the map (Zone A, Figure 1) the user will have the possibility to switch between origin locations (current display) and the display of all beachballs associated to this event.

In addition to these visual features, the user will have the possibility to download the moment tensor information on the “eventdetails” page in quakeML, CSV or in JSON format.

2. Moment tensor web service

This service is a part of the EPOS Thematic Core Service and aims to give access to moment tensors via a web service integrated into the Seismic Portal. Since it’s not possible to include moment tensor queries into the existing FDSN-event web service of the Seismic Portal, this moment tensor web service will be independent. However, the specifications will follow as closely those of FDSN-event.

This service aims to give access to all data hosted on EMSC servers and moment tensors from catalogs included later such as the EMMA database.

As for the FDSN-event, this service gathers data for a given request, which can be based on:

- a search by region, or
- a search by time period, or
- a search for a specific event defined by an ID.

The user may choose to add other filtering rules on depth, magnitude, plunge of T or N axis or by the data contributors (parameter catalog in the FDSN-event specifications).

Information used for queries. For location, time, depth and magnitude filtering, the parameters used are the source parameters provided by the EMSC earthquake catalog defined by the UNID (see Figure 2). The data provided by the service includes both the moment tensor data and the origin information of the associated event.

Figure 2 : Distinction of moment tensor information and information used for queries.

The output of the available data for a given request may be in quakeML, CSV or in custom json format.

Specifications of this service are very similar to the FDSN-event specifications. The description of all available parameters is listed below.

The specification column refers to:

- FDSN indicates that the parameter behaves the same way as for FDSN-event specification;
- 1 - “from starttime” time constraint allows querying all focal mechanisms with the event time between “starttime” and “dayafter” days.
- 2 - These filter constraints allows to select focal mechanisms with a range of plunge for the T and N axis (like GCMT, see http://www.globalcmt.org/CMTsearch.html) and having a given percentage of double couple (per_dc parameter).
- 3 – If set to true, this option actives the selection of the preferred moment tensor of each event. The rules defining the preferred solution are defined in section II.3. Otherwise, if this option is set to false, all data are selected and the user may get many moment tensors per event.

3. Interactive search of moment tensors

The interactive search is a web interface that should give the user the possibility to request moment tensor data with all filtering options defined in the web service specifications.

	parameter	abbreviation	min	max	type	Units	Specification
time constraints							
date range							
	starttime	start			time	UTC	FDSN
	endtime	end			time	UTC	FDSN
from starttime							
	starttime	start			time	UTC	1
	dayafter		1			integer	1
geographic constraints							
area-rectangle							
	minlatitude	minlat			float	degrees	FDSN
	maxlatitude	maxlat			float	degrees	FDSN
	minlongitude	minlon			float	degrees	FDSN
	maxlongitude	maxlon			float	degrees	FDSN
area-circle							
	latitude	lat			float	degrees	FDSN
	longitude	lon			float	degrees	FDSN
	minradius		0	180	float	degrees	FDSN
	maxradius		0	180	float	degrees	FDSN
specific event							
	eventid				string		FDSN
output control							
	format		quakeml, json, GCMT		string		FDSN
	nodata				string		FDSN
filtering constraints							
	mindepth				float	km	FDSN
	maxdepth				float	km	FDSN
	minmagnitude	minmag			float		FDSN
	maxmagnitude	maxmag			float		FDSN
	orderby						FDSN
	source_catalog	catalog					FDSN
	mintplung		0	90	float	degrees	2
	maxtplung		0	90	float	degrees	2
	minnplung		0	90	float	degrees	2
	maxnplung		0	90	float	degrees	2
	mindc		0	100	float		2
	maxdc		0	100	float		2
	preferred		true,false		boolean		3

IV. Annexes

- Interactive web interface to search moment tensors data as the ISC: http://www.isc.ac.uk/iscbulletin/search/fmechanisms/#quakemlfm

- Specifications of FDSN web services: http://www.fdsn.org/webservices/FDSN-WS-Specifications-1.1.pdf

- Specification of the QuakeML format: https://quake.ethz.ch/quakeml/docs/REC?action=AttachFile&do=view&target=QuakeML-BED-20130214a.pdf

- Specifications of the GlobalCMT interactive search and GCMT moment tensor format http://www.globalcmt.org/CMTsearch.html

V. Annex: EMSC Activity Report

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