



**European-Mediterranean  
Seismological Centre**

<http://www.emsc-csem.org>

***EMSC Real Time Earthquake  
Information Services***

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# Table of content

|                    |   |           |
|--------------------|---|-----------|
| <b>I.</b>          | <b>INTRODUCTION</b> .....   | <b>5</b>  |
| <b>II.</b>         | <b>REAL TIME DATA AND REAL TIME EARTHQUAKE INFORMATION SERVICES</b> .....   | <b>7</b>  |
| <b>II.1.</b>       | <b>DATA DESCRIPTION AND PROCESSING</b> .....                                | <b>7</b>  |
| <b>II.1.1.</b>     | <b>DATA DESCRIPTION</b> .....   | <b>7</b>  |
| <b>II.1.2.</b>     | <b>QWIDS: An actual real time communication system</b> .....                | <b>7</b>  |
| <b>II.1.2.1.</b>   | <b>General features</b> .....   | <b>7</b>  |
| <b>II.1.2.2.</b>   | <b>Configuration</b> .....  | <b>7</b>  |
| <b>II.1.2.3.</b>   | <b>Firewall issues</b> .....  | <b>8</b>  |
| <b>II.1.3.</b>     | <b>MESSAGES PROCESSING</b> .....  | <b>8</b>  |
| <b>II.1.4.</b>     | <b>STRATEGY TO ASSIGN A LOCATION TO AN EVENT</b> .....                      | <b>9</b>  |
| <b>II.1.4.1.</b>   | <b>Event reported by one network</b> .....                                  | <b>9</b>  |
| <b>II.1.4.2.</b>   | <b>Event reported by several networks</b> .....                             | <b>9</b>  |
| <b>II.1.4.2.1.</b> | <b>Automatic locations</b> .....  | <b>9</b>  |
| <b>II.1.4.2.2.</b> | <b>Manual locations</b> .....   | <b>10</b> |
| <b>II.1.4.2.3.</b> | <b>Case of redundant phases</b> .....                                       | <b>10</b> |
| <b>II.2.</b>       | <b>REAL TIME EARTHQUAKE INFORMATION SERVICES</b> .....                      | <b>11</b> |
| <b>II.2.1.</b>     | <b>PUBLISHED INFORMATION</b> .....  | <b>11</b> |
| <b>II.2.1.1.</b>   | <b>EMSC web site</b> .....  | <b>11</b> |
| <b>II.2.1.1.1.</b> | <b>“For Seismologist only” and “Public” pages</b> .....                     | <b>11</b> |
| <b>II.2.1.1.2.</b> | <b>Information associated to each event</b> .....                           | <b>13</b> |
| <b>II.2.1.1.3.</b> | <b>Moment tensors solutions</b> .....                                       | <b>16</b> |
| <b>II.2.1.1.4.</b> | <b>Quick Mw values provided by other institutes</b> .....                   | <b>16</b> |
| <b>II.2.1.1.5.</b> | <b>Special web pages</b> .....  | <b>17</b> |
| <b>II.2.1.1.6.</b> | <b>Seismicity maps, Google tools</b> .....                                  | <b>17</b> |
| <b>II.2.1.1.7.</b> | <b>Members section</b> .....  | <b>17</b> |
| <b>II.2.1.2.</b>   | <b>Imode and WAP pages</b> .....  | <b>17</b> |
| <b>II.2.2.</b>     | <b>DISSEMINATED INFORMATION</b> .....                                       | <b>18</b> |
| <b>II.2.2.1.</b>   | <b>Earthquake Notification Service</b> .....                                | <b>18</b> |
| <b>II.2.2.1.1.</b> | <b>Principle</b> .....  | <b>18</b> |
| <b>II.2.2.1.2.</b> | <b>Criteria to disseminate a notification</b> .....                         | <b>18</b> |
| <b>II.2.2.1.3.</b> | <b>Dissemination in alert mode</b> .....                                    | <b>19</b> |
| <b>II.2.2.1.4.</b> | <b>Notification definitions and formats</b> .....                           | <b>19</b> |
| <b>II.2.2.1.5.</b> | <b>Evolution of the ENS early 2006</b> .....                                | <b>22</b> |
| <b>II.2.2.1.6.</b> | <b>Role of the IGN</b> .....  | <b>22</b> |
| <b>II.2.2.1.7.</b> | <b>A specific alert system: EUR-OPA agreement</b> .....                     | <b>22</b> |
| <b>II.2.2.2.</b>   | <b>RSS feed</b> .....   | <b>22</b> |
| <b>II.2.2.3.</b>   | <b>Widget for real time seismic information</b> .....                       | <b>22</b> |
| <b>II.2.2.4.</b>   | <b>AutoDRM</b> .....  | <b>22</b> |
| <b>II.2.3.</b>     | <b>COLLECTION OF IN-SITU INFORMATION</b> .....                              | <b>24</b> |
| <b>II.2.3.1.</b>   | <b>Felt maps: Area where the earthquake has potentially been felt</b> ..... | <b>24</b> |
| <b>II.2.3.2.</b>   | <b>Online macroseismic questionnaire</b> .....                              | <b>25</b> |
| <b>II.2.3.3.</b>   | <b>Intensity maps: A damage assessment using testimonies</b> .....          | <b>25</b> |
| <b>II.2.3.4.</b>   | <b>Pictures: Actual damage caused by the earthquake</b> .....               | <b>26</b> |
| <b>III.</b>        | <b>APPENDIX A: REAL TIME CONTRIBUTORS IN 2008</b> .....                     | <b>27</b> |
| <b>IV.</b>         | <b>APPENDIX B: EMSC MEMBERS IN 2008</b> .....                               | <b>29</b> |
| <b>V.</b>          | <b>REFERENCES</b> .....   | <b>31</b> |



## I. INTRODUCTION

The European Mediterranean Seismological Center (EMSC) is an international NGO which members are seismological institutes and observatories of the Euro-Med region (Appendix C) and hosted since 1992 by the LDG (Laboratoire de Détection et de Géophysique, France). Its main scientific activities are the Real Time Earthquake Information (RTEI) services and the production of the Euro-Med Bulletin (Godey et al.).

The RTEI services are operating thanks to the operational technical support of the LDG by compiling the real time parametric data provided, received by email and provided by 66 seismological networks. EMSC provides several services in the field of rapid information on the European-Mediterranean seismicity and significant earthquakes worldwide.



## II. REAL TIME DATA AND REAL TIME EARTHQUAKE INFORMATION SERVICES

### II.1. DATA DESCRIPTION AND PROCESSING

#### II.1.1. DATA DESCRIPTION

The Real Time Earthquake Information services are based on the reception, by email or via QWIDS (see §II.1.2), of parametric data (source parameters, phase pickings, amplitudes) provided by 66 data contributors (i.e. seismological networks) (Appendix A). Some data contributors send their data automatically and very shortly (few minutes) after the earthquake occurrence. For others, the data are sent by the person on duty. Some agencies provide data during working hours only.

The messages sent by the data contributors contain different types of data:

- Source parameters (origin time, epicenter location, focal depth, magnitude).
- Phase pickings (station code, arrival times, phase type, amplitudes and periods). Some messages only contain a group of phase pickings without any associated location.
- Moment tensors solutions, Focal mechanisms.

#### II.1.2. QWIDS: An actual real time communication system

In order to improve its performances and especially the speed and robustness of the reception of real time data, EMSC implemented a software named QWIDS (Quake Watch Information Distribution System) which has been developed by ISTI (Instrumental Software Technologies Inc.; <http://www.isti.com/>) and has been kindly provided by the U.S. Geological Survey. QWIDS provides a quick and robust data exchange system through permanent TCP connections. At the difference with emails that can sometimes be delayed or lost, QWIDS is an actual real time communication system that ensures the data delivery.

##### II.1.2.1. General features

QWIDS uses a server-client technology in which the information published by the server is immediately pushed (via CORBA methods), in xml format, to the connected clients. For this, a permanent TCP/IP connexion through 2 dedicated ports must be established between the server and the client.

Its performances show that it is able to push a single message to 1000 connected clients within 1.4 seconds.

QWIDS is a free (for non-commercial purposes) and open-source software developed in java and is therefore multi-platform. It also provides security features (user authorization + message authentication), a high level of configurability, a persistent archiving of messages, and a message recovery system which allows the client to catching up the missed messages during the period of time it has been down.

##### II.1.2.2. Configuration

QWIDS can be configured in a way to provide redundancy and scalability. In a typical configuration, several QWIDS Servers are permanently connected to the Data Providers (Figure 1). As soon as a Data Provider publishes new data, they are immediately pushed to the connected Servers. As a consequence the Servers that are connected to the same Data Providers receive the same data at the same time. Each Client is also permanently connected to both Servers (Figure 1) which provides redundancy in the collection and dissemination of data. Indeed, in such a configuration, in case of failure of Server 1, the client will receive automatically the data through Server 2.

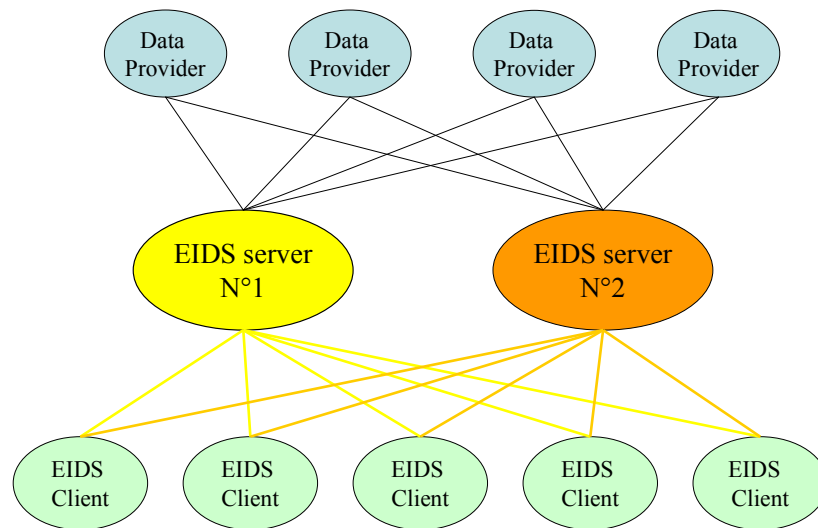


Figure 1: Typical architecture of QWIDS components

Other servers can also be added and even direct Server-Server connections can also be established to further improve the redundancy.

Currently, the NEIC and ORFEUS are both providing real time data to EMSC via QWIDS. Two QWIDS Relay servers are operated respectively at EMSC and ORFEUS.

### II.1.2.3. Firewall issues

In a typical connection, a server and a client communicate through 2 dedicated ports: one for the data transfer and one for the notification service. For security reasons, these ports are generally chosen greater than 1024 (n°38977 and 38988 by default). It is thus important to have in mind the difficulties that may be encountered on the server or client side while opening the ports through the different routers/firewalls that may be involved.

ISTI has also developed a client which runs through web services (port 80 (http) or 443 (https)) and therefore does not require any extra port opening however this solution does not provide the same quality of service.

## II.1.3. MESSAGES PROCESSING

Here after is presented how the data are processed, how EMSC computes locations and the rules used to assign a location to an event. In this part, the word “message” refers to email messages that contain source parameters/phase pickings information.

The mailbox is checked every minute and every incoming message is processed following the same procedure:

- Identification of the network which provides the data.
- Conversion of the data into GSE2.0 format.
- Conversion of local station codes into international ones.
- Archiving into an Oracle database which makes the data available through an autoDRM (Figure 2).
- Discard events with magnitude lower than 2.0 for further processing. If no magnitude has been reported, the message is kept for further processing.
- Association to the group of messages previously received (i.e. from other networks) for the same event.

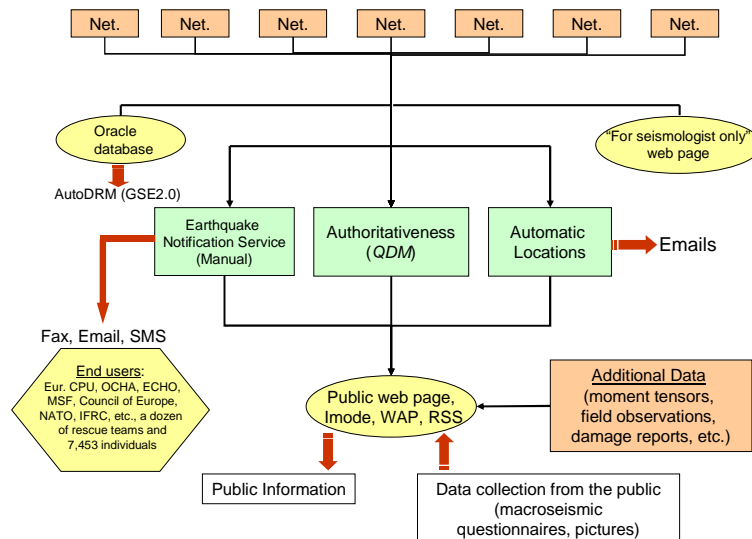


Figure 2: Data flow for the Real Time Earthquake Information services

## II.1.4. STRATEGY TO ASSIGN A LOCATION TO AN EVENT

### II.1.4.1. Event reported by one network

A geographical region defined as a polygon is associated to each network. An earthquake reported by this network and which location falls within this region is considered as reliable. One says the network is **authoritative** in the region. For example, the French national network is authoritative in France and border regions. A software named QDM (Quake Data Merge), provided by the U.S. Geological Survey (written by A. Jones and D. Oppenheimer) is used to determine the authoritativeness of the network in the region of event occurrence.

When an event is reported by only one network, its location is assigned to the event only if this network is authoritative in the region of occurrence.

### II.1.4.2. Event reported by several networks

When an event is reported by several networks, EMSC performs a location by merging and associating the phase pickings provided by the different networks. The location is assigned to this event. These locations can be either automatically or manually (by EMSC staff or the seismologist on call) computed.

#### II.1.4.2.1. Automatic locations

An automatic location is performed as soon as data from several networks are available for the same event. Then, when new data coming from another network is made available, the location is updated by integrating the new phase pickings.

Automatic locations are computed thanks to a program called **Fusion** provided by the LDG (EMSC host institute). The result of an automatic location is disseminated 65 minutes after the event occurrence to a list of seismological institutes. Some use them to trigger automatic moment tensors computations.

### **II.1.4.2.2. Manual locations**

Afterwards, each automatic location is manually reviewed by a seismologist. For potentially damaging earthquake, the manual review is performed quickly after the event occurrence in the framework of the Earthquake Notification Service (Part II.2.1.) otherwise it is performed in the next hours or the next working day by EMSC staff or by the seismologist on call.

### **II.1.4.2.3. Case of redundant phases**

Because of transnational data exchange and the development of virtual networks, the same seismic station recording may be used and reported by several networks but with different phase pickings. One has then to select one pick among the whole list during the location process. Therefore, in each location performed by EMSC, the following rules are applied:

- A manual pick replaces the automatic one (for the same station and same phase type) as long as its time residual is lower than the automatic pick.
- A pick to which an amplitude is associated replaces the one without amplitude (as it brings additional information) as long as its residual is lower than the one without amplitude.

## II.2. REAL TIME EARTHQUAKE INFORMATION SERVICES

Thanks to the real time data received from the data contributors and the different successive processing, EMSC provides several real time services, among which information published on a web site or active dissemination of seismological information such as the Earthquake Notification Service or the autoDRM.

### II.2.1. PUBLISHED INFORMATION

This part presents all the information available on the web site, the Imode and the WAP pages.

#### II.2.1.1. EMSC web site

The EMSC web site is accessible at the following URL: <http://www.emsc-csem.org>. It gathers several real time services described below.

##### II.2.1.1.1. “For Seismologist only” and “Public” pages

###### II.2.1.1.1.1. The “For Seismologist Only” web page

This page is dedicated to the seismological community and displays groups of messages that refer to the same event (Figure 3). All the messages received from the data contributors and which magnitude exceeds 2.0 (as long as a magnitude is reported) are published on a web page called “**For Seismologist Only (FSO)**” page (<http://www.emsc-csem.org/index.php?page=current&sub=msg>).

###### II.2.1.1.1.2. The “Public” web page

Because the FSO page is more dedicated to the seismologist community and because it may be difficult to understand by the general public, the “**Public page**” has been developed late 2004 and in order to show a single set of source parameters per event. As a result, a list of latest earthquakes is available through the Public page (<http://www.emsc-csem.org/index.php?page=current&sub=list>). It is updated each minute and presents for each event its associated source parameters: origin time, epicenter coordinates, focal depth, magnitude type and value, region of occurrence and the time when the location of the event has been updated (Figure 4).

| Date & Time<br>UTC  | Latitude<br>degrees | Longitude<br>degrees  | Depth<br>km | Mag.          | A/M       | Region name                             | Network     |
|---|---------------------|-----------------------|-------------|---------------|-----------|---|-------------|
| More recent start <<< 81 - <b>82</b> - 83 - 84 - 85 - 86 - 87 - 88 - 89 - 90 >>> Back in time |                     |                       |             |               |           |   |             |
| 2007-12-16 08:09:54.5   | 17.0 S              | 64.0 W                | 30          | mb 5.6        | A         | SANTA CRUZ, BOLIVIA                     | ZAMG        |
| 2007-12-16 08:09:30.7   | 21.6 S              | 68.8 W                | 48          | M 6.4         | M         | ANTOFAGASTA, CHILE                      | BGR         |
| 2007-12-16 08:09:18.0   | 22.8 S              | 70.0 W                | 60          | MS 6.5        | M         | ANTOFAGASTA, CHILE                      | GSRC        |
| 2007-12-16 08:09:17.7   | 22.9 S              | 70.1 W                | 45f         | M 6.7         | M         | ANTOFAGASTA, CHILE                      | NEIR        |
| 2007-12-16 08:09:16.7   | 23.0 S              | 70.1 W                | 28          | M 6.9         | A.        | ANTOFAGASTA, CHILE                      | GFZ         |
| 2007-12-16 08:09:16.5   | <b>22.8 S</b>       | <b>69.9 W</b>         | <b>50f</b>  | <b>Mw 6.7</b> | <b>M+</b> | <b>ANTOFAGASTA, CHILE</b>               | <b>INFO</b> |
| 2007-12-16 08:09:15.5   |                     | <i>Moment tensors</i> |             |               | M#        | ANTOFAGASTA, CHILE                      | MT          |
| 2007-12-16 08:09:15.2   | 21.5 S              | 70.9 W                |             | mb 5.4        | M         | OFFSHORE ANTOFAGASTA, CHILE             | RNS         |
| 2007-12-16 08:09:13.5   | 22.8 S              | 70.3 W                |             | mb 6.4        | M         | ANTOFAGASTA, CHILE                      | MAD         |
| 2007-12-16 08:09:00.0   | 22.0 S              | 70.0 W                |             | Mw 6.7        | M.        | ANTOFAGASTA, CHILE                      | PPTm        |
| 2007-12-16 07:50:24.0   | 37.0 N              | 29.2 E                |             | ML 3.2        | A         | WESTERN TURKEY                          | NOA         |
| 2007-12-16 07:50:21.1   | <b>37.0 N</b>       | <b>29.3 E</b>         | <b>10</b>   | <b>ML 3.3</b> | <b>M+</b> | <b>WESTERN TURKEY</b>                   | <b>INFO</b> |
| 2007-12-16 07:50:21.0   | 37.0 N              | 29.2 E                | 21          | ML 3.3        | M         | WESTERN TURKEY                          | DDA         |
| 2007-12-16 07:50:20.8   | 36.9 N              | 29.3 E                | 16          | MD 3.5        | M         | WESTERN TURKEY                          | KAN         |
| 2007-12-16 06:32  |                     |                       |             |               | A         |   | INGV        |
| 2007-12-16 06:20:17.9   | 41.1 N              | 20.1 E                |             | ML 3.2        | M         | ALBANIA                                 | THE         |
| 2007-12-16 06:20:17.3   | 41.0 N              | 20.0 E                |             | ML 2.8        | M         | ALBANIA                                 | SKO         |
| 2007-12-16 06:20:17.0   | 41.1 N              | 20.0 E                | 11          | ML 2.9        | M         | ALBANIA                                 | MSO         |
| 2007-12-16 06:20:16.8   | <b>41.1 N</b>       | <b>20.0 E</b>         | <b>2</b>    | <b>ML 3.0</b> | <b>M+</b> | <b>ALBANIA</b>                          | <b>INFO</b> |
| 2007-12-16 05:27  |                     |                       |             |               | M         |   | MCSM        |
| 2007-12-16 05:27  |                     |                       |             |               | M         |   | BUC         |
| 2007-12-16 05:15:56.0   | 41.0 N              | 145.1 E               | 70          | mb 4.8        | A         | HOKKAIDO, JAPAN REGION                  | GFZ         |
| 2007-12-16 05:15:51.4   | 40.4 N              | 143.4 E               | 33          | M 4.6         | M         | OFF EAST COAST OF HONSHU, JAPAN         | BGR         |
| 2007-12-16 05:15:44.4   | 40.1 N              | 144.8 E               | 18          | M 4.8         | M         | OFF EAST COAST OF HONSHU, JAPAN         | NEIR        |
| 2007-12-16 05:15:43.9   | 40.1 N              | 144.9 E               | 33          | mb 5.0        | M         | OFF EAST COAST OF HONSHU, JAPAN         | GSRC        |
| 2007-12-16 05:15:42.3   | 39.5 N              | 143.9 E               | 25          | mb 4.1        | A         | OFF EAST COAST OF HONSHU, JAPAN         | NEWS        |
| 2007-12-16 05:15:42.2   | <b>40.1 N</b>       | <b>144.8 E</b>        | <b>19</b>   | <b>mb 4.8</b> | <b>M+</b> | <b>OFF EAST COAST OF HONSHU, JAPAN</b>  | <b>INFO</b> |
| 2007-12-16 05:15:41.3   | 39.5 N              | 144.5 E               | 25          | mb 3.9        | A         | OFF EAST COAST OF HONSHU, JAPAN         | NEWS        |
| 2007-12-16 05:15:27.0   | 38.2 N              | 148.5 E               |             | mb 5.5        | A         | NORTH PACIFIC OCEAN                     | BRA         |
| 2007-12-16 05:03:51.3   | 34.7 N              | 32.8 E                | 8           | MD 3.0        | M         | CYPRUS REGION                           | NCSS        |
| 2007-12-16 04:57:26.0   | 35.6 N              | 92.4 E                |             | ML 3.2        | A         | SOUTHERN QINGHAI, CHINA                 | NNC         |
| 2007-12-16 04:31  |                     |                       |             |               | M         |   | BUC         |
| 2007-12-16 04:28:51.2   | 39.1 N              | 29.0 E                | 8           | MD 3.0        | M         | WESTERN TURKEY                          | KAN         |
| 2007-12-16 04:27  |                     |                       |             |               | A         |   | ISN         |
| 2007-12-16 04:06:20.0   | 35.1 N              | 67.1 E                |             | ML 3.4        | A         | CENTRAL AFGHANISTAN                     | NNC         |
| 2007-12-16 03:44:35.8   | 37.6 N              | 38.6 E                | 7           | ML 3.0        | M         | EASTERN TURKEY                          | DDA         |
| 2007-12-16 03:44:33.1   | 37.5 N              | 38.6 E                | 13          | MD 2.7        | M         | EASTERN TURKEY                          | KAN         |
| 2007-12-16 03:44:32.5   | <b>37.4 N</b>       | <b>38.5 E</b>         | <b>10</b>   | <b>ML 2.9</b> | <b>M+</b> | <b>EASTERN TURKEY</b>                   | <b>INFO</b> |
| 2007-12-16 03:35:40.9   | 41.1 N              | 25.4 E                | 30          |               | A         | GREECE                                  | BUC         |
| 2007-12-16 03:35:15.7   | 39.4 N              | 26.2 E                | 13          | ML 4.1        | M         | NEAR THE COAST OF WESTERN TURKEY        | THE         |
| 2007-12-16 03:35:14.9   | 39.5 N              | 26.3 E                | 7           | ML 4.0        | M         | NEAR THE COAST OF WESTERN TURKEY        | DDA         |
| 2007-12-16 03:35:14.5   | 39.4 N              | 26.2 E                | 10          | Ms 4.2        | M         | NEAR THE COAST OF WESTERN TURKEY        | BUC         |
| 2007-12-16 03:35:14.0   | 39.4 N              | 26.3 E                |             | ML 3.2        | A         | NEAR THE COAST OF WESTERN TURKEY        | NOA         |
| 2007-12-16 03:35:13.7   | 39.4 N              | 26.3 E                | 11          | ML 3.7        | M         | NEAR THE COAST OF WESTERN TURKEY        | KAN         |
| 2007-12-16 03:35:13.4   | <b>39.4 N</b>       | <b>26.3 E</b>         | <b>10</b>   | <b>ML 4.0</b> | <b>M+</b> | <b>NEAR THE COAST OF WESTERN TURKEY</b> | <b>INFO</b> |
| More recent start <<< 81 - <b>82</b> - 83 - 84 - 85 - 86 - 87 - 88 - 89 - 90 >>> Back in time |                     |                       |             |               |           |   |             |

Figure 3: Extract of the "For Seismologists Only" web page

| Date & Time<br>UTC       | Latitude<br>degrees | Longitude<br>degrees | Depth<br>km | Mag.          | Region name                             | Last update             |
|--------------------------|---------------------|----------------------|-------------|---------------|---|-------------------------|
| 1 - 2 - 3 > Back in time |                     |                      |             |               |   |                         |
| 2007-12-16 23:40:08.8    | 35.82 N             | 61.00 E              | 21          | ML 3.7        | NORTHEASTERN IRAN                       | 2007-12-17 00:00        |
| 2007-12-16 22:35:33.4    | <b>44.33 N</b>      | <b>10.15 E</b>       | <b>10</b>   | <b>ML 2.7</b> | <b>NORTHERN ITALY</b>                   | <b>2007-12-17 07:03</b> |
| 2007-12-16 19:11:46.3    | 44.32 N             | 129.30 W             | 10G         | M 4.7         | OFF COAST OF OREGON                     | 2007-12-16 19:28        |
| 2007-12-16 18:28:06.8    | <b>35.40 N</b>      | <b>13.92 W</b>       | <b>30f</b>  | <b>ML 3.0</b> | <b>AZORES-CAPE ST. VINCENT RIDGE</b>    | <b>2007-12-16 20:17</b> |
| 2007-12-16 17:16:32.7    | 53.47 N             | 159.98 E             | 70          | mb 4.1        | NEAR EAST COAST OF KAMCHATKA            | 2007-12-17 05:18        |
| 2007-12-16 15:22:12.4    | <b>25.95 S</b>      | <b>177.58 W</b>      | <b>172</b>  | <b>mb 4.9</b> | <b>SOUTH OF FIJI ISLANDS</b>            | <b>2007-12-16 20:15</b> |
| 2007-12-16 14:36:57.9    | 37.66 N             | 38.49 E              | 16          | ML 3.0        | EASTERN TURKEY                          | 2007-12-16 14:51        |
| 2007-12-16 14:28:47.9    | 47.35 N             | 156.44 E             | 20          | mb 4.2        | EAST OF KURIL ISLANDS                   | 2007-12-16 20:27        |
| 2007-12-16 11:06:08.6    | <b>14.61 N</b>      | <b>91.81 W</b>       | <b>100f</b> | <b>mb 4.6</b> | <b>GUATEMALA</b>                        | <b>2007-12-16 20:12</b> |
| 2007-12-16 10:05:06.9    | <b>71.86 N</b>      | <b>0.84 E</b>        | <b>10f</b>  | <b>mb 4.3</b> | <b>NORWEGIAN SEA</b>                    | <b>2007-12-16 20:07</b> |
| 2007-12-16 09:14:09.3    | <b>3.42 S</b>       | <b>100.59 E</b>      | <b>164</b>  | <b>mb 4.5</b> | <b>KEP. MENTAWAI REGION, INDONESIA</b>  | <b>2007-12-16 20:10</b> |
| 2007-12-16 09:10:39.0    | 41.24 N             | 74.34 E              |             | ML 3.5        | KYRGYZSTAN                              | 2007-12-16 10:23        |
| 2007-12-16 08:12:48.8    | 39.42 N             | 26.26 E              | 7           | ML 3.0        | NEAR THE COAST OF WESTERN TURKEY        | 2007-12-16 09:10        |
| 2007-12-16 08:09:16.5    | <b>22.83 S</b>      | <b>69.92 W</b>       | <b>50f</b>  | <b>Mw 6.7</b> | <b>ANTOFAGASTA, CHILE</b>               | <b>2007-12-16 08:57</b> |
| 2007-12-16 07:50:21.1    | <b>37.00 N</b>      | <b>29.33 E</b>       | <b>10</b>   | <b>ML 3.3</b> | <b>WESTERN TURKEY</b>                   | <b>2007-12-16 09:20</b> |
| 2007-12-16 06:20:16.8    | <b>41.10 N</b>      | <b>20.03 E</b>       | <b>2</b>    | <b>ML 3.0</b> | <b>ALBANIA</b>                          | <b>2007-12-16 20:05</b> |
| 2007-12-16 05:15:42.2    | <b>40.08 N</b>      | <b>144.84 E</b>      | <b>19</b>   | <b>mb 4.8</b> | <b>OFF EAST COAST OF HONSHU, JAPAN</b>  | <b>2007-12-16 09:18</b> |
| 2007-12-16 04:28:51.2    | 39.12 N             | 28.97 E              | 8           | MD 3.0        | WESTERN TURKEY                          | 2007-12-16 05:01        |
| 2007-12-16 03:44:32.5    | <b>37.44 N</b>      | <b>38.51 E</b>       | <b>10</b>   | <b>ML 2.9</b> | <b>EASTERN TURKEY</b>                   | <b>2007-12-16 09:16</b> |
| 2007-12-16 03:35:13.4    | <b>39.41 N</b>      | <b>26.28 E</b>       | <b>10</b>   | <b>ML 4.0</b> | <b>NEAR THE COAST OF WESTERN TURKEY</b> | <b>2007-12-16 09:13</b> |
| 1 - 2 - 3 > Back in time |                     |                      |             |               |   |                         |

Figure 4: Extract of the public web page.

### II.2.1.1.2. Information associated to each event

For each event reported on the public page, the following information is available:

- Source parameters: Origin time (in UTC), epicenter location, focal depth, magnitude and region of occurrence. Since mid-October 2006, the name of the geographical regions which appear on the public page are defined following the 3<sup>rd</sup> level of Flinn-Engdahl regionalization (J. B. Young et al.; 1996), defined by Bruce Presgrave (USGS). The main improvement from 2<sup>nd</sup> to the 3<sup>rd</sup> level of regionalization is that the latter fits the political border which is crucial to correctly assign a region to an epicenter.
- Distances from epicenter to nearby cities + local time in these cities when the event occurred (Figure 5).

| Summary:    |  |
|-------------|--|
| ➡ Magnitude | <b>Mw 5.0</b>  |
| ➡ Region    | <b>IONIAN SEA</b>  |
| ➡ Date time | <b>2007-12-30 at 06:42:40.2 UTC</b>  |
| ➡ Location  | <b>37.66 N ; 20.92 E</b>   |
| ➡ Depth     | <b>20 km</b>   |
| ➡ Distances | 96 km SW Pátrai (pop 163,360 ; local time 08:42 2007-12-30)<br>15 km S Zákynthos (pop 11,541 ; local time 08:42 2007-12-30)<br>10 km SE Lithakiá (pop 1,300 ; local time 08:42 2007-12-30) |

Figure 5: Source parameters of the event. Distance to nearby cities and local time of occurrence of the event in these cities.

- Links to networks which provided data for this event and links to regional seismological institutes where more information on the event may be available.
- Three epicenter views at global, regional and local scales + a Satellite Google Map centered on the region (Figure 6).
- List of regional deadly earthquakes from 1500 to 2000 (Utsu; 2002) (Figure 7).
- Moment tensors solutions provided by the different institutes (Figure 8).
- Past focal mechanisms in the region (Figure 9). Source: EMMA database (Vanucci et al.; 2004).
- Maps of regional instrumental seismicity (Figure 10). Source: 1964-2001 ISC catalog.

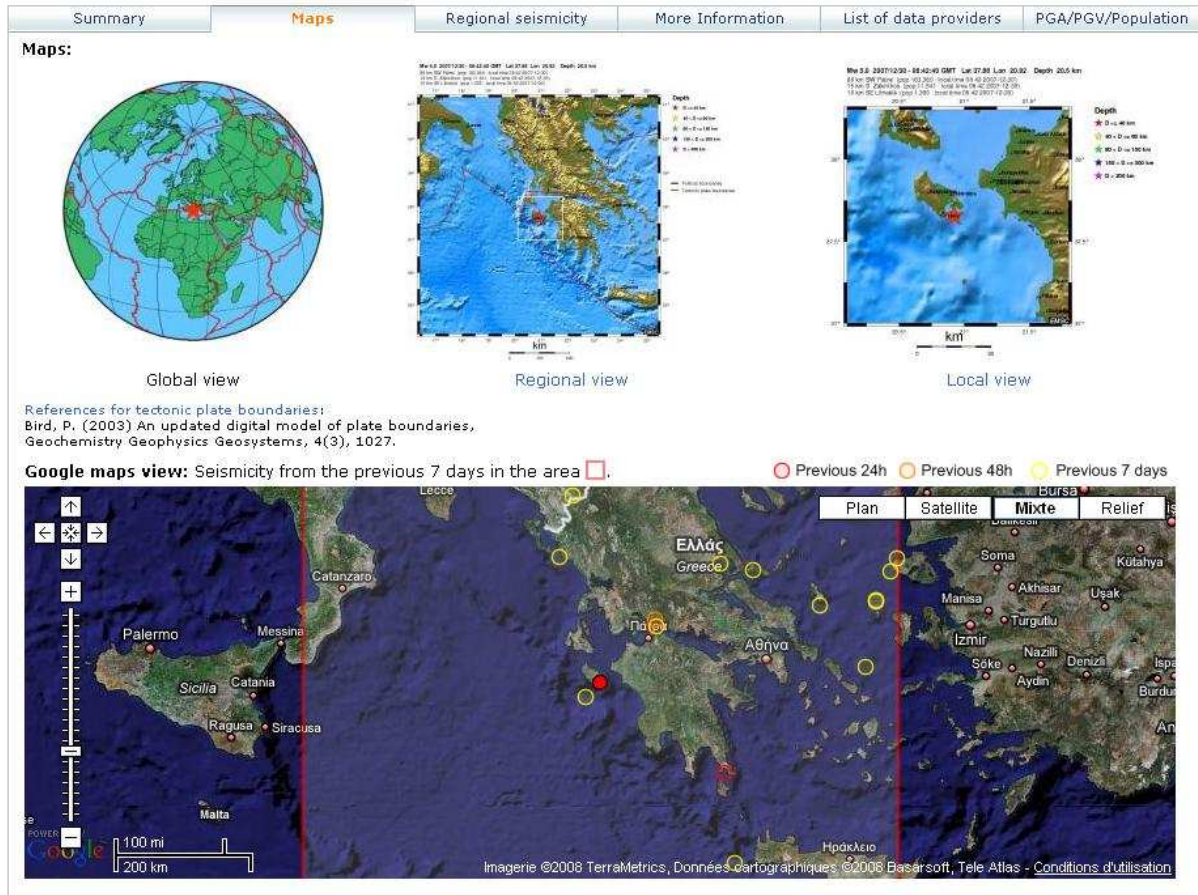


Figure 6: Snapshot of the different maps generated for each event reported on the public page

Regional deadly earthquakes from 1500 to 2000

| Date       | Long. | Lat. | Mag. | Death | Location                     |
|------------|-------|------|------|-------|------------------------------|
| 1514-04-16 | 21.0  | 37.7 | 6.5  | many  | SOUTHERN GREECE              |
| 1544-04-22 | 22.6  | 38.8 | 6.8  | many  | GREECE                       |
| 1566-07-11 | 21.7  | 39.0 | 6.5  | many  | GREECE                       |
| 1622-05-05 | 21.0  | 37.6 | 6.6  | many  | SOUTHERN GREECE              |
| 1630-07-22 | 20.9  | 38.3 | 6.9  | many  | GREECE                       |
| 1633-11-05 | 21.0  | 37.6 | 6.9  | many  | SOUTHERN GREECE              |
| 1636-09-30 | 20.7  | 38.0 | 7.2  | 520   | GREECE                       |
| 1658-08-24 | 20.5  | 38.3 | 6.8  | 320   | GREECE                       |
| 1674-01-01 | 20.0  | 39.5 | 6.5  | 200   | GREECE-ALBANIA BORDER REGION |
| 1704-11-22 | 20.7  | 38.7 | 6.6  | 34    | GREECE                       |
| 1723-02-22 | 20.7  | 38.6 | 7.0  | many  | GREECE                       |
| 1742-02-14 | 20.6  | 37.8 | 6.5  | 120   | IONIAN SEA                   |
| 1748-05-25 | 22.2  | 38.2 | 6.8  | many  | GREECE                       |
| 1750-06-07 | 22.8  | 36.3 | 7.0  | 2000  | SOUTHERN GREECE              |
| 1767-07-11 | 20.3  | 38.2 | 7.2  | 253   | GREECE                       |
| 1783-03-23 | 20.5  | 38.6 | 7.0  | 35    | GREECE                       |
| 1785-01-30 | 21.7  | 38.2 | 6.6  | 38    | GREECE                       |

Source: T. Utsu ; International Handbook of Earthquake and Engineering Seismology; vol. A; 691-718

Figure 7: List of regional deadly earthquakes since 1500

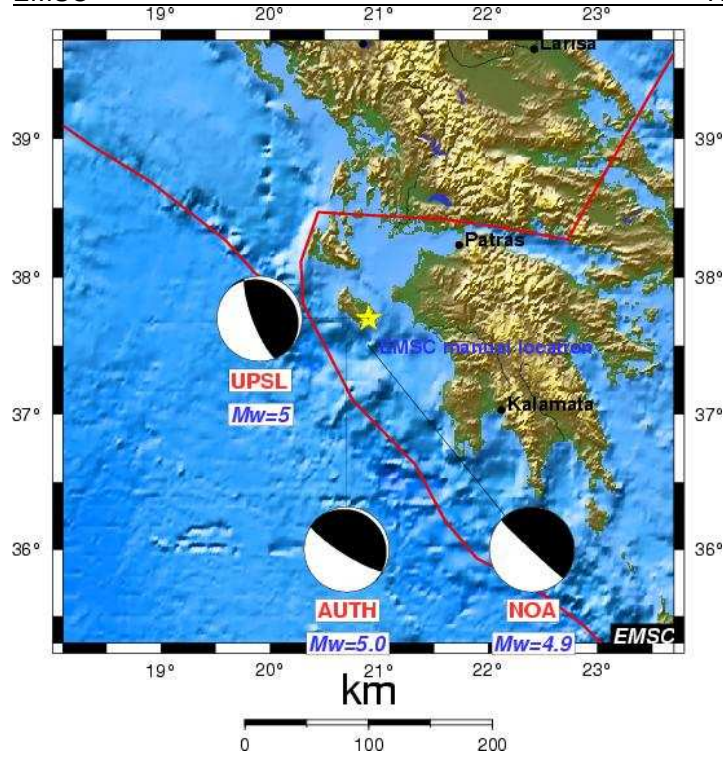


Figure 8: Moment tensors solutions provided by different institutes for the same event

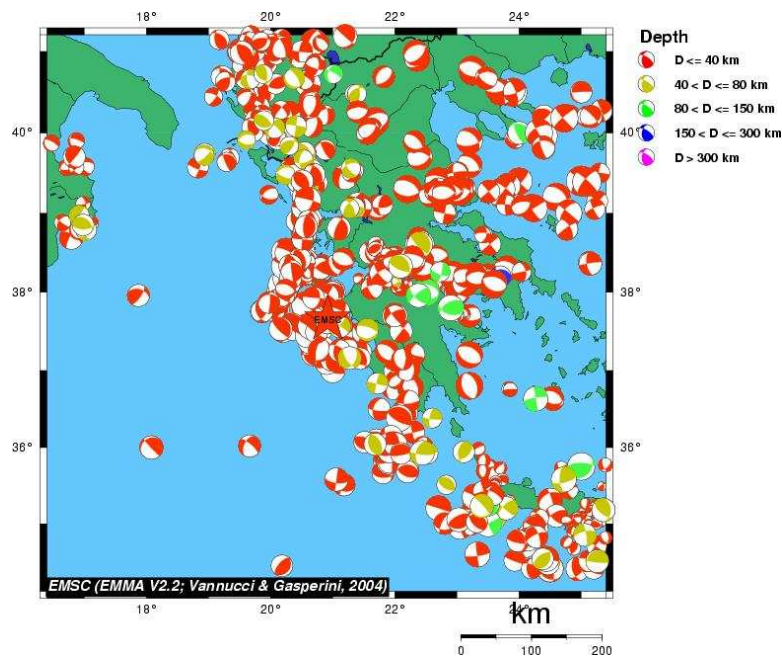


Figure 9: Map of past focal mechanisms

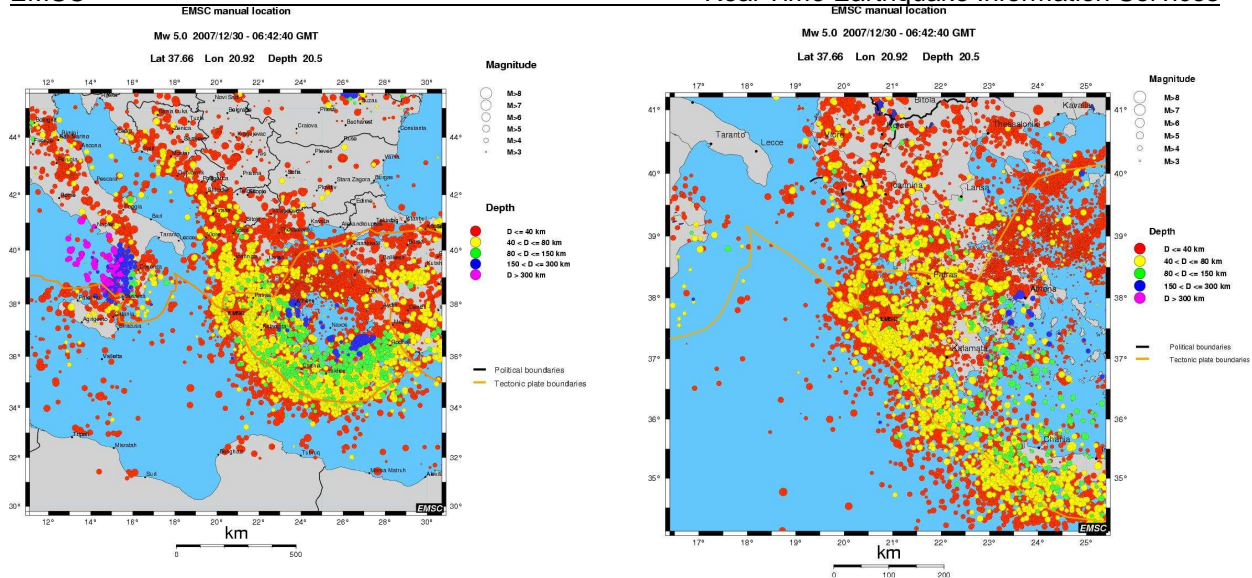


Figure 10: Regional instrumental seismicity maps (Source ISC catalog: 1964-2001)

### II.2.1.1.3. Moment tensors solutions

EMSC receives moment tensors (MT) solutions from 12 institutes listed below. For each event, all the available MT solutions are plotted on the same map (Figure 8):

- AUTH:** Department of Geophysics, University of Thessaloniki, Thessaloniki, Greece
- CPPT:** Centre Polynésien de Prévention des Tsunamis, French Polynesia
- ERD:** Earthquake Research Department, Ankara, Turkey
- ETH:** Swiss Federal Institute of Technology, Zurich, Switzerland
- HARVARD:** Seismological group of Harvard University.
- IGN:** Instituto Geográfico Nacional, Madrid, Spain
- INGV:** Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy
- IPGP:** Institut de Physique du Globe de Paris, Paris, France
- KOERI:** Kandilli Observatory and Earthquake Research Institute, Istanbul, Turkey
- NOA:** National Observatory of Athens, Geodynamic Institute, Athens, Greece
- UPSL:** University of Patras. Seismological Laboratory, Patras, Greece
- USGS:** U.S. Geological Survey, Denver, USA

A web page gathers all MT solutions received until now (i.e. for all events and from the different agencies): <http://www.emsc-csem.org/index.php?page=current&sub=qmt>

### II.2.1.1.4. Quick Mw values provided by other institutes

EMSC also receives quick Mw values from three institutes which are extremely useful to quickly and reliably assess the magnitude of large events:

- Via the Tsunami Bulletin Board, EMSC receives the bulletins of the *Pacific Tsunami Warning Center* which contain rapid determinations of Mw magnitudes above 6.5, for events of the Pacific or Indian Oceans or in the Caribbean. These bulletins are quickly issued after earthquake occurrence and revised if necessary.
- The Japanese Meteorological Agency which provides quick Mw estimations for events in the Pacific Ocean.
- The Centre Polynésien de Prévention des Tsunamis in French Polynesia provides quick Mw estimations for events in the Pacific Ocean.

### **II.2.1.1.5. Special web pages**

When an event raises a particular interest and/or causes significant damage (Indonesia (Sumatra) 26/12/2004, Pakistan 08/10/2005, Azores Cape Saint Vincent Ridge 12/02/2007, Chile (Antofagasta) 17/1/2007, etc.), EMSC publishes a special web page gathering additional information such as aftershocks distribution, field observations, damage reports, moment tensors solutions, macroseismic questionnaires results, preliminary source studies, etc.

### **II.2.1.1.6. Seismicity maps, Google tools**

In order to represent the current seismic activity in different regions of the world, EMSC gives the possibility to display the seismic activity of the last 30 days in 6 different regions: Worldwide, Euro-Med region, North America, South America, Africa/Indian Ocean, Pacific Ocean. The seismicity can be animated day by day.

EMSC web site also allows to download a *kmz* file (to be viewed on GoogleEarth) which contains the last 2 weeks of seismic activity through the following link:

<http://www.emsc-csem.org/index.php?page=current&sub=ge>

### **II.2.1.1.7. Members section**

In December 2006, a specific web page has been opened on EMSC web to provide specific information at the attention of EMSC members. Its access is restricted. It proposes services such as macroseismic questionnaire results, maps of expected Peak Ground Acceleration (PGA) and Peak Ground Velocity (PGV) (Akkar et al., 2007), number of inhabitants, a discussion forum, the list preliminary information<sup>1</sup> for events processed in the framework of the Earthquake Notification Service (Part II.2.) and the feltmaps<sup>2</sup>.

### **II.2.1.2. Imode and WAP pages**

The Real Time Seismicity is also available in Imode ([http://www.emsc-csem.org/rts\\_imode.html](http://www.emsc-csem.org/rts_imode.html)) and WAP ([http://www.emsc-csem.org/rts\\_wap.wml](http://www.emsc-csem.org/rts_wap.wml)) for events with magnitude larger than 4.0. This permits viewing the current world seismic activity on a cell phone or on a PDA.

---

<sup>1</sup> The preliminary information is the first information published on the public page for a given seismic event. It may be either the location provided by the authoritative network or the EMSC automatic location depending which is available first.

<sup>2</sup> The felt maps are generated thanks to the increase of traffic on EMSC web site consecutive to events that have been felt by the population. By locating the additional visitors thanks to their IP in the first minutes following the earthquake occurrence, it is possible to map the area where the event has been felt. The way feltmaps are generated is not described in this report.

## II.2.2. DISSEMINATED INFORMATION

Apart from the web-based services, EMSC operates seismic information dissemination services like the Earthquake Notification Service (for potentially damaging earthquakes), the RSS feed and the autoDRM.

### II.2.2.1. Earthquake Notification Service

#### II.2.2.1.1. Principle

For potentially damaging earthquakes, EMSC operates an Earthquake Notification Service (ENS) which is operational 24/7. It consists in quickly notifying the end-users who subscribed to this service of the event occurrence, by fax (restricted to the operational organizations), email or SMS. The determination of the event source parameters and the dissemination of the message to the end-users are done manually by the seismologist on call for EMSC.

The subscription to this service can be done through the web site at: <http://www.emsc-csem.org/index.php?page=receive&sub=email>. The end-users of the ENS are ECHO (*Humanitarian Aid Agency of the EU*), OCHA (*Humanitarian Aid Agency of the UN*), the Council of Europe, the European Civil Protection Unit, the EADRCC (*Euro-Atlantic Disaster Reaction and Coordination Centre, NATO*), MSF (*Médecins sans Frontières*), IFRC (*International Federation of Red Cross and Red Crescent*) a dozen of rescue teams and several thousands of individuals.

#### II.2.2.1.2. Criteria to disseminate a notification

##### II.2.2.1.2.1. Definition of local magnitude thresholds

A set of magnitude thresholds has been defined for events which are processed in the framework of the Earthquake Notification Service (Figure 11). These magnitude thresholds are:

- 5.0 in Europe
- 5.2 in Northern Africa and Azores region
- 5.5 in Arabic Peninsula, Iran, Caucasus, Caspian region and a part of Northern Atlantic Ocean
- 6.0 in Russia and Continental Asia and Sub-Saharan Africa
- Spanning from 5.0 to 6.5 in areas around the French overseas territories.
- 7.0 in the rest of the world

##### II.2.2.1.2.2. Alert triggering

As soon as either the authoritative network or two non-authoritative networks report a magnitude that exceeds the local threshold for the same event, the seismologist on call is warned via phone calls. He immediately locates the event by merging all the available data, refines the location and disseminates the notification to the end-users.

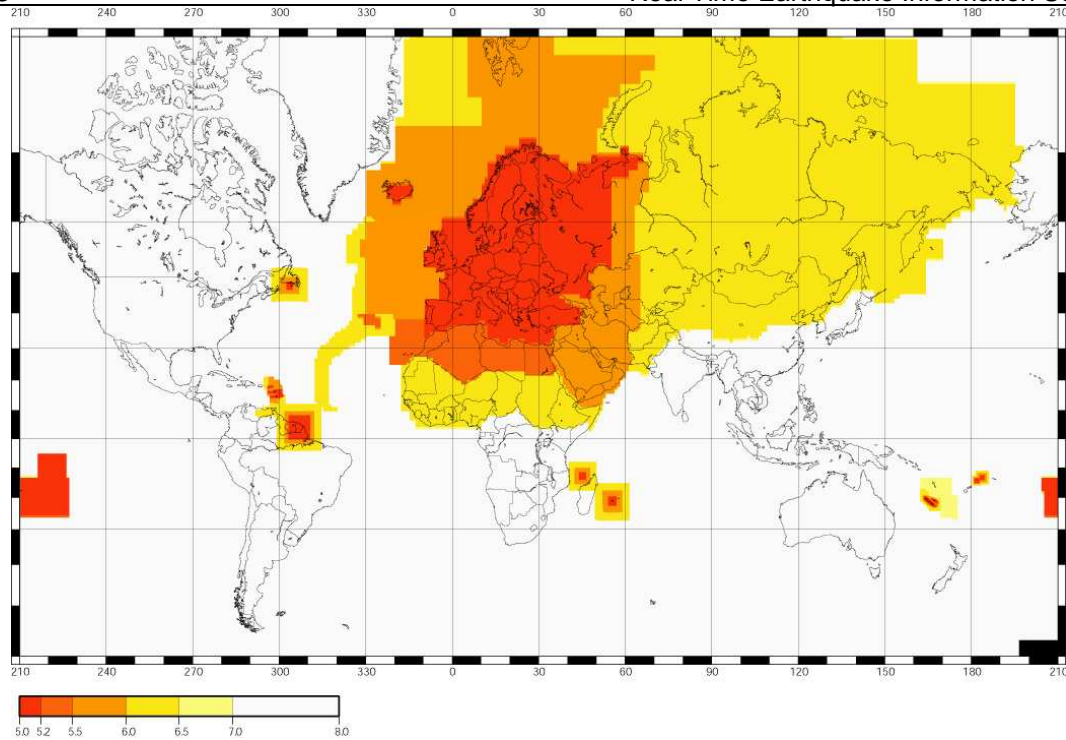


Figure 11: Local magnitude thresholds for the Earthquake Notification Service

### II.2.2.1.3. Dissemination in alert mode

If the magnitude computed by the seismologist on call for the processed event exceeds the local magnitude threshold (Figure 11), the event is processed in alert mode. This means that the notification must be disseminated in less than 1 hour after the earthquake occurrence (generally in 20-40 minutes for Euro-Med events). The objectives of this rapid dissemination are:

- To give redundancy to alerts systems operated by national institutes.
- To ensure the information outside the affected country(ies).
- To provide reliable locations in border regions and off shore.
- To provide a unique source of information for European and International organizations.

### II.2.2.1.4. Notification definitions and formats

While subscribing at the Earthquake Notification Service, the user can define up to two geographical regions for which he wants to receive the notifications. It is also possible to choose between four formats to receive the notifications defined as follows:

#### 1. SMS

This format is very concise and is adapted to the reception of messages on a cell phone or on a PDA. It contains the main characteristics of the event: origin time, epicenter location, focal depth and distance to a nearby city (Figure 12).

```

28/06/2006 21:02
Magnitude 5.7
SOUTHERN IRAN
Latitude 27.04 North
Longitude 55.81 East
Depth 35 kilometers
49 km SW Bandar-e 'Abbas

```

Figure 12: Example of message disseminated by EMSC in SMS format

## 2. Standard

This format is dedicated to the general public and contains information such as distances to several nearby cities, population and local time at these cities when the event occurred and links to regional seismological institutes (Figure 13).

## 3. Advanced

This format is mainly dedicated to the scientific community and contains additional seismological information (Figure 14).

## 4. Pickings

This format is restricted to the seismological community. It adds to the Advanced format the phase pickings used in the location process.

```
EMSC earthquake notification

Magnitude 5.7 28/06/2006 21:02 SOUTHERN IRAN

These parameters are preliminary and subject to revisions.
For updates, please consult: http://www.emsc-csem.org

A magnitude 5.7 earthquake has occurred SOUTHERN IRAN at:
27.04N 55.81E Depth 35km 28/06/2006 at 21:02:12 (Universal Time)

Earthquake location with respect to nearby cities:
    49 km SW Bandar-e 'Abbas (pop 317946, local time 01:32)
    40 km W Qeshm (pop 16691, local time 01:02)

Comments :

Manual location disseminated on 28/06/2006 21:35 (UTC)
EMSC cannot guarantee the receipt or timeliness of an e-mail after
sending.

For maps and additional data, please consult:
http://www.emsc-csem.org

Links to regional seismological observatories:
http://www.iiees.ac.ir/english/index\_e.asp
http://irsc.ut.ac.ir
http://www.bhrc.ac.ir/

This location has been computed thanks to the data provided by the
following seismological institutes:
BEO BRA BUC GFZ INGV LDG LED LJU NEIA SED THR
See the full list of data providers at:
http://www.emsc-csem.org/index.php?page=current&sub=contrib

This EMSC service is jointly operated by the LDG (Laboratoire de
Détection et de Géophysique, Bruyères-le-Châtel, France) and the
IGN (Instituto Geografico Nacional, Madrid, Spain).

Subscribe/Unsubscribe/Modifications, please consult:
http://www.emsc-csem.org/index.php?page=receive&sub=email
```

Figure 13: Example of message disseminated by EMSC in Standard format

```

Centre Sismologique Euro-Mediterraneen
European-Mediterranean Seismological Centre

Rapid Determination of Source Parameters
operated at LDG (Paris) and IGN (Madrid)

*****
***** ALERT MESSAGE *****
*****

WARNING : These parameters are preliminary and subject to revision.
Location and magnitude estimations may be revised if necessary in
an INFORMATION message.

-----

EARTHQUAKE on 28/06/2006 at 21:02 (UTC)
SOUTHERN IRAN                7 km E Pahl

MAGNITUDE: mb 5.7

Data provided by: BEO  BRA  BUC  GFZ  INGV LDG  LED  LJU  NEIC NEWS
                  NOR  SED  THR

Latitude   = 27.04 N
Longitude  = 55.81 E
Origin Time = 21:02:12.4 (UTC)
Depth      = 35 Km
RMS        = 1.14 sec
Gap        = 57 degrees
95% confidence ellipse: - Semi major = 7.5 Km
                        - Semi minor = 4.6 Km
                        - Azimuth of major axis = 10 degrees

Number of data used = 337

Preliminary location computed on Wed Jun 28 21:35:43 2006 (UTC)
Done by Julien VERGOZ

Comments :

Message number: 733

All magnitudes estimations :
mb5.6 (BEO)   mb5.7 (BRA)   Ms5.4 (BUC)   mb5.8 (GFZ)
mb5.4 (INGV) mb5.7 (LDG)   mb5.3 (LED)   mb5.8 (NEIC)
mb4.8 (NEWS) mb5.2 (NOR)   mb6.0 (SED)   ML5.4 (THR)

```

Figure 14: Example of message disseminated by EMSC in Advanced format

### II.2.2.1.5. Evolution of the ENS early 2006

The Earthquake Notification Service has been upgraded on 11/01/2006 in order to give to the end-users the possibility to receive earthquake information for a specific geographic area and from a minimum magnitude. Before that, each manually reviewed location was sent to the whole list of end-users in the Advanced (Figure 14) or Pickings formats. Moreover, a distinction was made between the earthquakes for which the magnitude exceeds the local threshold and the others. Therefore, in the current service, the Advanced and Pickings formats still use this distinction:

- **Alert message:** if the magnitude of the event is higher than or equal to the local threshold.
- **Information message:** if the event raises a particular interest and/or if it is widely felt but its magnitude is lower than the local threshold.
- **Revision message:** sent as revisions of the initial messages (may be Alert or Information message) for significant variations of one of the source parameters (location, depth, or magnitude). Revisions messages are often used for large events for which the magnitude is generally difficult to estimate within the first hour. For minor revisions, the update is published on the web page only. The notion of Revision is also used for the Standard and SMS format.

### II.2.2.1.6. Role of the IGN

When EMSC is not able to operate the Earthquake Notification Service, the IGN (Instituto Geografico Nacional, Madrid, Spain) is in charge of it. This occurs for example during maintenance intervention at or outside EMSC (internet service providers, electric backbone ...) which may disturb the data processing although the real time services may remain on line during the intervention. However, the IGN operates this service in a degraded mode in which each earthquake notification is sent to all end-users.

### II.2.2.1.7. A specific alert system: EUR-OPA agreement

EMSC also provides a specific alert system for the Council of Europe for events with magnitude larger than 6.0 in one of the countries which have signed the EUR-OPA (Open Partial Agreement on Major Hazards) agreement: Albania, Algeria, Armenia, Azerbaijan, Belgium, Bulgaria, Cyprus, Spain, France, Georgia, Greece, Italy, Lebanon, Luxembourg, FYR of Macedonia, Malta, Moldova, Morocco, Monaco, Portugal, San-Marino, Romania, Russia, Turkey, Ukraine.

### II.2.2.2. RSS feed

RSS feeds are commonly used for frequently updated web pages. Users of RSS feeds use programs called feed readers or aggregators which can check the feeds to see if it has new content since the last time it checked. If so, it retrieves the content and presents it to the user.

A RSS feed for the real time seismic activity has been opened in December 2006 (<http://www.emsc-csem.org/rss.php>). As a difference with the public web page, the RSS feed does not display the EMSC automatic locations.

### II.2.2.3. Widget for real time seismic information

In October 2007, EMSC developed a widget that allows viewing the last Euro-Med and worldwide events on a map that is updated automatically and that can be added to a personal web portal such as Google Desktop, Igoogle or Netvibes.

### II.2.2.4. AutoDRM

As explained before, the messages received from the data contributors are all included into an Oracle database. The content of this database is available by autoDRM (Automatic Data Request Manager) to the users who subscribed to it (Subscription at <http://www.emsc-csem.org/index.php?page=data&sub=register>). The autoDRM sends data back to the user in GSE2.0 format.

There are 2 ways to use the autoDRM, either by filling a web form ([http://www.emsc-csem.org/index.php?page=data&sub=request\\_rts&db=rts](http://www.emsc-csem.org/index.php?page=data&sub=request_rts&db=rts)) or by sending a formatted email to EMSC which is automatically processed (Figure 15).

```
BEGIN GSE2.0
MSG_TYPE REQUEST
MSG_ID 00001
E-MAIL address@domain.com
TIME 2006/12/19 10:00:00 TO 2006/12/19 12:00:00
LAT -90 TO 90
LONG -180 TO 180
DEPTH 0 TO 700
NETWORK *
ORIGIN GSE2.0
STOP
```

Figure 15: Example of autoDRM request

## II.2.3. COLLECTION OF IN-SITU INFORMATION

In order to complement its services of rapid earthquake information, EMSC developed a number of tools to rapidly collect in-situ observations of the earthquake effects and better evaluate the reaction of the population. Here below is presented how peaks of web traffic are used to generate felt maps (Bossu at al, 2008), as well as a few examples of intensity maps and pictures received from the witnesses.

### II.2.3.1. Felt maps: Area where the earthquake has potentially been felt

The felt map tool is an original EMSC development. It uses the observed surge of traffic on EMSC web site (Figure 16) to rapidly (within 5 to 10 minutes of the earthquake's occurrence) map the area where an earthquake has been felt and to determine whether there has been significant widespread damage. When an earthquake is felt, people rush to the Internet to find out the cause of the shaking, generating brutal surge of traffic on EMSC web site. The area where the earthquake was felt is determined by locating the IP addresses and identifying the localities which exhibit a significant increase of visitors (Bossu at al, 2008).

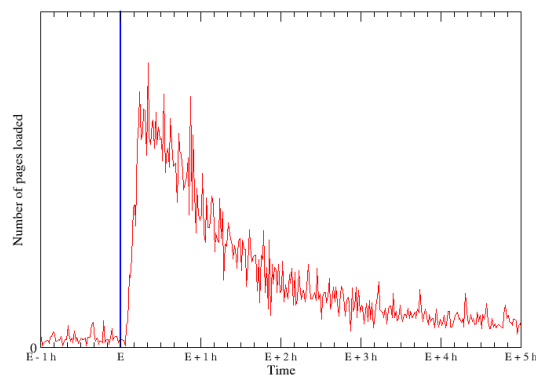


Figure 16: Typical surge of web traffic on EMSC web site after a felt earthquake

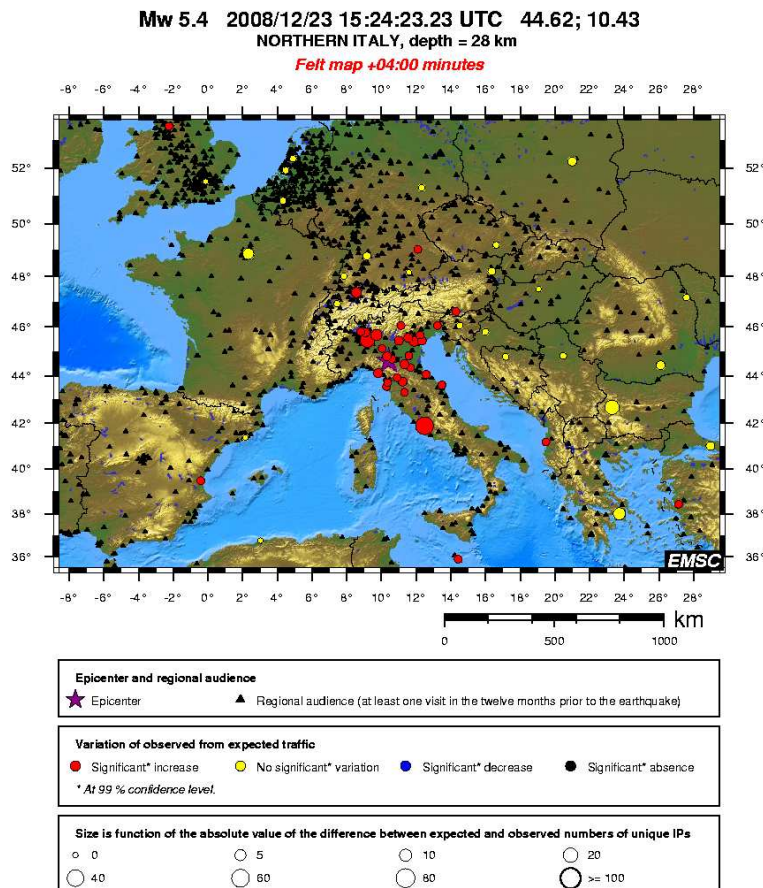


Figure 17: Felt map generated 4 minutes after the Mw 5.4 event in Northern Italy on 23/12/2008 at 15:24 UTC.

### II.2.3.2. Online macroseismic questionnaire

Since July 2006, a macroseismic questionnaire is available on EMSC web site for people who wish to report their experience after an earthquake. The goal of collecting macroseismic questionnaires is first to characterize the effects of earthquakes on people, objects and structures. Eventually, the results of the questionnaires can be used to compute intensities and to plot macroseismic intensity maps.

The questionnaire was initially available in English but thanks to the help of EMSC members and data contributors, it has been translated in 20 languages (at the time of this report) and is now available in Albanian, Arabic, Armenian, Bulgarian, Croatian, Dutch, English, Farsi, French, German, Greek, Hungarian, Montenegrin, Polish, Portuguese, Romanian, Russian, Slovakian, Spanish and Turkish (Figure 18). The results of the questionnaires are available for EMSC members in the dedicated Members section of the web site.

Before filling the questionnaire, the visitor selects the event felt. An online help is provided to people who can not identify the event they have felt in the list of latest events. The visitor then determines the place (country + administrative subdivision + city) where the observation was made. This information is crucial in order to be able afterwards to associate a macroseismic intensity with an observation. For this, a database of 145,504 cities worldwide is used to help the observer to determine accurately the place of the observations. The exact postal address of the user is also collected (though optional) as it can be useful to the national institutes in charge of producing intensity maps to locate the observations with more accuracy.

The procedures to compute intensities are currently in development at EMSC in collaboration with the BGS (British Geological Survey, Edinburgh, UK) and the ETHZ (Eidgenössische Technische Hochschule, Zürich, Switzerland).



Figure 18: Snapshot of the links proposed to the web users to access the macroseismic questionnaire

### II.2.3.3. Intensity maps: A damage assessment using testimonies

Since April 2008, intensity maps are computed and updated automatically upon reception of new questionnaires. Intensities are expressed in EMS-98 scale. An intensity can be assigned to a location only if at least 5 questionnaires are available for this location (Colored dots on Figure 19-20). Otherwise a default intensity (*Felt*) is assigned (White dots on Figure 19-20).



Figure 19: Intensity map generated after the Mw6.4 event near Patras, Greece on 08/06/2008 at 12:25 UTC. Legends on Figure 21



Figure 20: Intensity map generated after the Mw 5.4 event in Northern Italy on 23/12/2008 at 15:24 UTC. Legends on Figure 21

| Intensity  | F    | I        | II            | III  | IV             | V      | VI                | VII      | VIII             |
|--|------|----------|---------------|------|----------------|--------|-------------------|----------|------------------|
| Effects  | Felt | Not felt | Scarcely felt | Weak | Large observed | Strong | Slightly damaging | Damaging | Heavily damaging |
| Intensity calculation algorithm : <i>Automatic assessment of EMS-98 intensities by FMW Musson (BGS)</i>  |      |          |               |      |                |        |                   |          |                  |
| Location method : Per nearest city   |      |          |               |      |                |        |                   |          |                  |
| Intensity calculated in communities with at least 5 questionnaires.  |      |          |               |      |                |        |                   |          |                  |
| <input type="radio"/> 1 forms <input type="radio"/> <= 5 forms <input type="radio"/> <= 10 forms<br><input type="radio"/> <= 20 forms <input type="radio"/> <= 30 forms <input type="radio"/> > 30 forms |      |          |               |      |                |        |                   |          |                  |

Figure 21: Legends for Intensity maps

Testimonies give the actual level of shaking at a given site but they also confirm what has been observed on the felt map. Indeed, the felt maps and the intensity maps for Italian event (Figure 17 and 20) reproduce more or less the same pattern.

#### II.2.3.4. Pictures: Actual damage caused by the earthquake

Witnesses have the opportunity to share their pictures of the damage. Once validated by a seismologist, they are published on EMSC web site. This proves valuable to provide local constraints on the actual damage but also to document the earthquake phenomenon. Rare pictures have already been collected as in Greece (Figure 22). Collected pictures are made available through the web site.

A tutorial available on the web site explains how to provide pictures (by email, by MMS or by direct file upload) and how to link the file to the right seismic event. However, so far no picture has been received via MMS probably because it is not free of charge for the sender.



Figure 22: Rock falls in Porto Katsiki, Lefkada Islands, Greece caused by the shake after the Mw6.4 event near Patras, Greece on 08/06/2008 at 12:25 UTC.

**III. APPENDIX A: REAL TIME CONTRIBUTORS IN 2008**

| CODE | INSTITUTE   | TYPE | COUNTRY         |
|------|---|------|-----------------|
| BEO  | Seismological Survey of Serbia, Beograd   | OP   | Serbia          |
| BER  | University of Bergen, Bergen  | OP   | Norway          |
| BGR  | Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover & Erlangen                  | OPA  | Germany         |
| BGS  | British Geological Survey, Edinburgh  | OPA  | United-Kingdom  |
| BGSG | British Geological Survey, Global network ( <i>EarlyBird</i> system), Edinburgh         | OP   | United-Kingdom  |
| BRA  | Seismology Division, Slovak Academy of Sciences, Bratislava                             | OPA  | Slovakia        |
| BUC  | National Institute for Earth Physics, Bucharest   | OP   | Romania         |
| CNRM | Centre National de la Recherche Scientifique et Technique, Geophysics Laboratory, Rabat | OP   | Morocco         |
| CRAA | Centre de Recherche en Astronomie, Astrophysique et Géophysique, Algiers                | OP   | Algeria         |
| CYP  | Geological Survey Department, Nicosia   | OP   | Cyprus          |
| DDA  | Earthquake Research Department, Ministry of Public Works and Settlement, Ankara         | OP   | Turkey          |
| DHMR | National Seismological Observatory Centre, Dhamar                                       | OPA  | Yemen           |
| DJI  | Observatoire Géophysique d'Arta, Arta   | OP   | Djibouti        |
| GFU  | Geophysical Institute of Academy of Sciences, Prague                                    | OP   | Czech Republic  |
| GFZ  | GeoForschungsZentrum (GEOFON), Potsdam  | OPA  | Germany         |
| GII  | Seismology Division, Geophysical Institute of Israel, Tel Aviv                          | OP   | Israel          |
| GRAL | National Center for Geophysical Research, Beirut  | OP   | Lebanon         |
| GSRC | Geophysical Survey, Russian Academy of Sciences, Obninsk                                | OP   | Russia          |
| HSNC | Technological Educational Institute of Crete, Seismological Network of Crete            | P    | Greece          |
| ICC  | Instituto Cartografico de Catalunya, Barcelona  | OP   | Spain           |
| IGUT | Institute of Geophysics, University of Tehran, Tehran                                   | OPA  | Iran            |
| IMO  | Department of Geophysics, Icelandic Meteorological Office, Reykjavik                    | OP   | Iceland         |
| IMP  | Instituto de Meteorologia, Seismologia, Lisbon  | OPA  | Portugal        |
| INGV | Italian National Seismic Network, Roma  | OPA  | Italy           |
| INMT | Institut National de la Météorologie, Tunis   | OP   | Tunisia         |
| IRSA | Romanian Institute for Applied Seismology, Bucharest                                    | OP   | Romania         |
| ISN  | Iraqi Meteorological Organization and Seismology, Bagdad                                | OP   | Iraq            |
| JSO  | Jordan Seismological Observatory, Amman   | OP   | Jordan          |
| KAN  | Kandilli Observatory and Earthquake Research Institute, Istanbul                        | OP   | Turkey          |
| LDG  | Laboratoire de Détection et de Géophysique, Bruyères-le-Châtel                          | OPA  | France          |
| LED  | Landsamt für Geologie, Rohstoffe und Bergbau, Baden Württemberg                         | OP   | Germany         |
| LJU  | Environmental Agency of the Republic of Slovenia, Seismological Office, Ljubljana       | OP   | Slovenia        |
| LVV  | Carpathian Seismological Dept., Ukraine Academy of Science, Lviv                        | P    | Ukraine         |
| MAD  | Instituto Geografico Nacional, Madrid   | OPA  | Spain           |
| MCSM | Ukrainian NDC, Main Center of Special Monitoring, Kiev                                  | P    | Ukraine         |
| MOLD | Institute of Geophysics and Geology, Chisinau   | P    | Moldova         |
| MON  | Direction de l'Environnement, de l'Urbanisme et de la Construction                      | P    | Monaco          |
| MSO  | Montenegro Seismological Observatory, Podgorica   | OPA  | Montenegro      |
| NEIR | USGS/NEIC, Denver   | OPA  | USA             |
| NEWS | Norwegian Seismic Array, Kjeller  | OPA  | Norway          |
| NNC  | Kazakhstan National Data Center, Institute of Geophysical Research, Almaty              | OP   | Kazakhstan      |
| NOA  | National Observatory of Athens, Geodynamic Institute, Athens                            | OPA  | Greece          |
| NOR  | Norwegian Seismic Array, Kjeller  | OPA  | Norway          |
| NRIA | National Research Institute of Astronomy and Geophysics, Cairo                          | OP   | Egypt           |
| NSSP | National Survey of Seismic Protection, Yerevan  | OP   | Armenia         |
| ODC  | Observatories and Research Facilities for European Seismology, De Bilt                  | OP   | The Netherlands |
| OGS  | Osservatorio Geofisico Sperimentale, Trieste  | OP   | Italy           |
| PDA  | Instituto de Meteorologia, Azores University, Ponta Delgada, Azores                     | OP   | Portugal        |
| RNS  | Réseau National de Surveillance Sismique, Strasbourg                                    | OP   | France          |
| RSSC | Azerbaijan National Academy of Sciences, Baku   | OP   | Azerbaijan      |
| SASN | South African Seismological Network, Pretoria   | OP   | South Africa    |
| SED  | Swiss Seismological Service, Zurich   | OP   | Switzerland     |
| SGS  | Saudi Geological Survey, Jeddah   | OP   | Saudi Arabia    |
| SKO  | Seismological Observatory of Skopje, Skopje   | OPA  | Macedonia       |
| SOF  | Bulgarian Academy of Science, Bulgarian Academy of Sciences, Sofia                      | OP   | Bulgaria        |
| SNSN | Swedish National Seismological Network, Uppsala   | OP   | Sweden          |
| SPGM | Département de Physique du Globe, Rabat   | OP   | Morocco         |
| THE  | Department of Geophysics, University of Thessaloniki, Thessaloniki                      | OP   | Greece          |

## EMSC

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|      |  |     |         |
|------|--|-----|---------|
| THR  | International Institute of Earthquake Engineering and Seismology, Tehran | OP  | Iran    |
| TIF  | Georgian National Survey of Seismic Defense, Tbilisi                     | OP  | Georgia |
| TIR  | Institute of Seismology, Academy of Sciences, Tirana                     | OP  | Albania |
| UCC  | Royal Observatory of Belgium, Brussels                                   | OP  | Belgium |
| UPSL | University of Patras, Seismological Laboratory, Patras                   | OP  | Greece  |
| WAR  | Institute of Geophysics, Polish Academy of Sciences                      | OPA | Poland  |
| ZAG  | Seismological Survey, University of Zagreb, Zagreb                       | OP  | Croatia |
| ZAMG | ZentralAnstalt für Meteorologie und Geodynamik, Vienna                   | OP  | Austria |

Appendix A: Seismological networks that have provided real time parametric data to EMSC in 2008 (in orange: new contribution). Legends: O: Source parameters; P: Phase pickings; A: Amplitudes.

## IV. APPENDIX B: EMSC MEMBERS IN 2008

| Key Nodal Members   | Country            | Contact                   |
|---|--------------------|---------------------------|
| Laboratoire de Détection et de Géophysique (LDG)                                    | France             | Dr. B. FEIGNIER           |
| GeoForschungsZentrum (GFZ)  | Germany            | Dr. W. HANKA              |
| Istituto Nazionale di Geofisica e Vulcanologia (INGV)                               | Italy, Roma        | Dr. M. OLIVIERI           |
| Istituto Nazionale di Geofisica e Vulcanologia (INGV)                               | Italy, Milano      | Dr. P. ALBINI             |
| Instituto Geografico Nacional (IGN)   | Spain              | Dr. E. CARRENO<br>HERRERO |
| Active Members  |                    |                           |
| Seismological Institute (ASN)   | Albania            | Dr. E. DUSHI              |
| Centre de Recherche en Astronomie, Astrophysique et Géophysique (CRAAG)             | Algeria            | Dr. K. YELLES             |
| National Seismological Center (NSC)   | Armenia            | Dr. A. Sh. ANTONYAN       |
| Central Institute for Meteorology and Geodynamics (ZAMG)                            | Austria            | Dr. W. LENHARDT           |
| Republican Seismic Survey Center of Azerbaijan National Academy of Sciences (RSSC)  | Azerbaijan         | Dr. V. FARAJOV            |
| Center of Geophysical Monitoring  | Belarus            | Dr. A. G. ARONOV          |
| Observatoire Royal de Belgique (ORB)  | Belgium            | Dr. F. COLLIN             |
| Republic Hydrometeorological Institute (RHI)  | Bosnia-Herzegovina | Prof. D. TRKULJA          |
| Federal Meteorological Institute (FMI)  | Bosnia-Herzegovina | Dr. I. BRLEK              |
| Bulgarian Academy of Sciences   | Bulgaria           | Dr. E. BOTEV              |
| A. Mohorovicic Geophysical Institute and Croatian Seismological Survey (AMGI & CSS) | Croatia            | Dr. M. HERAK              |
| Geological Survey Department (GSD)  | Cyprus             | Dr. P. MICHAELIDES        |
| Institute of Physics of the Earth, Brno (IPE)                                       | Czech Republic     | Dr. J. SVANCARA           |
| Geophysical Institute of the Academy of Sciences (GFU)                              | Czech Republic     | Dr. J. ZEDNIK             |
| National Survey and Cadastre  | Denmark            | Dr. S. GREGERSEN          |
| Observatoire Géophysique d'Arta (DJI)   | Djibouti           | M. K. MOHAMMED            |
| National Research Institute of Astronomy and Geophysics (NRIAG)                     | Egypt              | Prof. ABUO EL ELA AMIN    |
| Institute of Seismology (ISF)   | Finland            | Dr. P. HEIKKINEN          |
| Bureau Central de Sismologie Français (BCSF)  | France             | Dr. M. GRANET             |
| Bureau de Recherches Géologiques et Minières (BRGM)                                 | France             | Dr. P. DOMINIQUE          |
| Laboratoire Central des Ponts et Chaussées (LCPC)                                   | France             | Dr. P.-Y. BARD            |
| Bureau of Seismic Risk Evaluation for the Safety of Nuclear Facilities (BERSSIN)    | France             | Dr. D. BEAUMONT           |
| Laboratoire de Géophysique Interne et de Tectonophysique                            | France             | Dr. F. COTTON             |
| Institute of Geophysics (TIF)   | Georgia            | Prof. T. CHELIDZE         |
| BGR Seismological Observatory Graefenberg (BGR)                                     | Germany            | Dr. K. KLINGE             |
| National Observatory of Athens (NOA)  | Greece             | Dr. K. MAKROPOULOS        |
| University of Thessaloniki (AUTH)   | Greece             | Dr. E. SCORDILIS          |
| Institute of Engineering Seismology and Earthquake Engineering (ITSAK)              | Greece             | Dr. C. PAPAIOANNOU        |
| Laboratory of Seismology, University of Patras (UPSL)                               | Greece             | Prof. A. TSELENTIS        |
| Icelandic Meteorological Office (IMO)   | Iceland            | Dr. S. JACOBSDOTTIR       |
| Dublin Institute for Advanced Studies (DIAS)  | Ireland            | Prof. P. READMAN          |
| Geophysical Institute of Israel (GII)   | Israel             | Dr. Y. GITTERMAN          |
| National Data Center (NDC) of Israel, Soreq Nuclear Research Center                 | Israel             | Dr. Y. BEN HORIN          |
| Istituto Nazionale di Oceanografia e Geofisica Sperimentale (OGS)                   | Italy              | Dr. E. PRIOLO             |
| Storia Geofisica Ambiente srl (SGA)   | Italy              | Dr. E. GUIDOBONI          |
| Jordan Seismological Observatory (JSO)  | Jordan             | Dr. T. AL-YAZJEEN         |
| Seismological Institute of Kosovo (SIK)   | Kosovo             | M. N. HASI                |
| Geophysics Centre at Bhannes (SGB)  | Lebanon            | Dr. A. SURSOCK            |
| Libyan Center for Remote Sensing and Space Science (LCRSSS)                         | Libya              | Dr. H. GASHUT             |
| European Center for Geodynamics and Seismology (ECGS)                               | Luxembourg         | M. E. BUTTINI             |
| Seismological Observatory   | Macedonia          | Dr. L. PEKEVSKI           |
| Physics Department, University of Malta (PDUM)                                      | Malta              | Dr. P. GALEA              |
| Academy of Sciences of Republic of Moldova  | Moldova            | Dr. V. ALCAZ              |
| Direction Environnement Urbanisme et Construction (DEUC)                            | Monaco             | Dr. P. MONDIELLI          |

## EMSC

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|  |                 |                         |
|--|-----------------|-------------------------|
| Montenegro Seismological Observatory (MSO)                             | Montenegro      | Dr. B. GLAVATOVIC       |
| Centre National de la Recherche (CNR)                                  | Morocco         | Prof. A. I. IBRAHIM     |
| Département de Physique du Globe                                       | Morocco         | Pr. B. A. TADILI        |
| University of Bergen (BER)   | Norway          | Dr. J. HAVSKOV          |
| Norwegian Seismic Array (NORSAR)                                       | Norway          | Dr. J. SCHWEITZER       |
| Institute of Geophysics, Polish Academy of Sciences (IGPAS)            | Poland          | Dr. W. DEBSKI           |
| Instituto de Meteorologia (IMP)  | Portugal        | Dr. F. CARRIHLO         |
| Instituto Superior Tecnico (IST)                                       | Portugal        | Dr. J. FONSECA          |
| Universidade de Evora  | Portugal        | Dr. M. BEZZEGHOUD       |
| Universidade de Lisboa (UL)  | Portugal        | Dr. J. M. A. DE MIRANDA |
| National Institute for Earth Physics (NIEP)                            | Romania         | Dr. G. MARMUREANU       |
| Bucharest Seismic Alert Centre (BSAC)                                  | Romania         | M. A. AILENEI           |
| Geological Survey of the Russian Academy of Sciences (GSRAS)           | Russia          | Dr. A. MALOVICHKO       |
| Center of Geophysical Computer Data Studies (CGDS)                     | Russia          | Dr. A. GVISHIANI        |
| King Abdulaziz City for Sciences and Technology (KACST)                | Saudi Arabia    | Dr. T. AL-KHALIFAH      |
| Seismological Survey of Serbia (SSS)                                   | Serbia          | Dr. S. RADOVANOVIC      |
| Geophysical Institute, Department of Seismology                        | Slovakia        | Dr. P. LABAK            |
| Geophysical Survey of Slovenia (ARSO)                                  | Slovenia        | Dr. I. CECIC            |
| Institut Geologic de Catalunya (IGC)                                   | Spain           | Dr. A. ROCA             |
| Real Instituto y Observatorio de la Armada (ROA)                       | Spain           | D. J. M. DAVILA         |
| Universidad Politecnica de Madrid (UPM)                                | Spain           | Dr. B. BENITO           |
| Swedish National Seismic Network (SNSN)                                | Sweden          | Dr. R. BODVARSSON       |
| Schweizerischer Erdbebendienst (ETH)                                   | Switzerland     | Dr. F. HASLINGER        |
| Royal Netherlands Meteorological Institute (KNMI)                      | The Netherlands | Dr. R. SLEEMAN          |
| Institut National de la Météorologie (INMT)                            | Tunisia         | Dr. M. RAJHI            |
| Earthquake Research Department (ERD)                                   | Turkey          | Dr. Y. IRAVUL           |
| Kandilli Observatory and Earthquake Research Institute (KOERI)         | Turkey          | Prof. G. BARBAROSOGLU   |
| Main Center for Special Monitoring (MCSM)                              | Ukraine         | M. I. KACHALIN          |
| Dubai Municipality   | UAE             | M. Y. A. ALMARZOOQI     |
| British Geological Survey (BGS)  | United Kingdom  | Dr. B. BAPTIE           |
| National Seismological Observatory Centre (NSOC)                       | Yemen           | Dr. J. SHOLAN           |
| <b>Members by Right</b>  |                 |                         |
| European Seismological Commission (ESC)                                |                 | Dr. M. GARCIA           |
| Observatories and Research Facilities for European Seismology (ORFEUS) |                 | Dr. B. DOST             |
| International Seismological center (ISC)                               |                 | Dr. D. STORCHAK         |
| U.S. Geological Survey (USGS)  |                 | Dr. S. SIPKIN           |

Appendix C: List of 2007 EMSC members (in orange: new memberships in 2008)

## V. REFERENCES

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