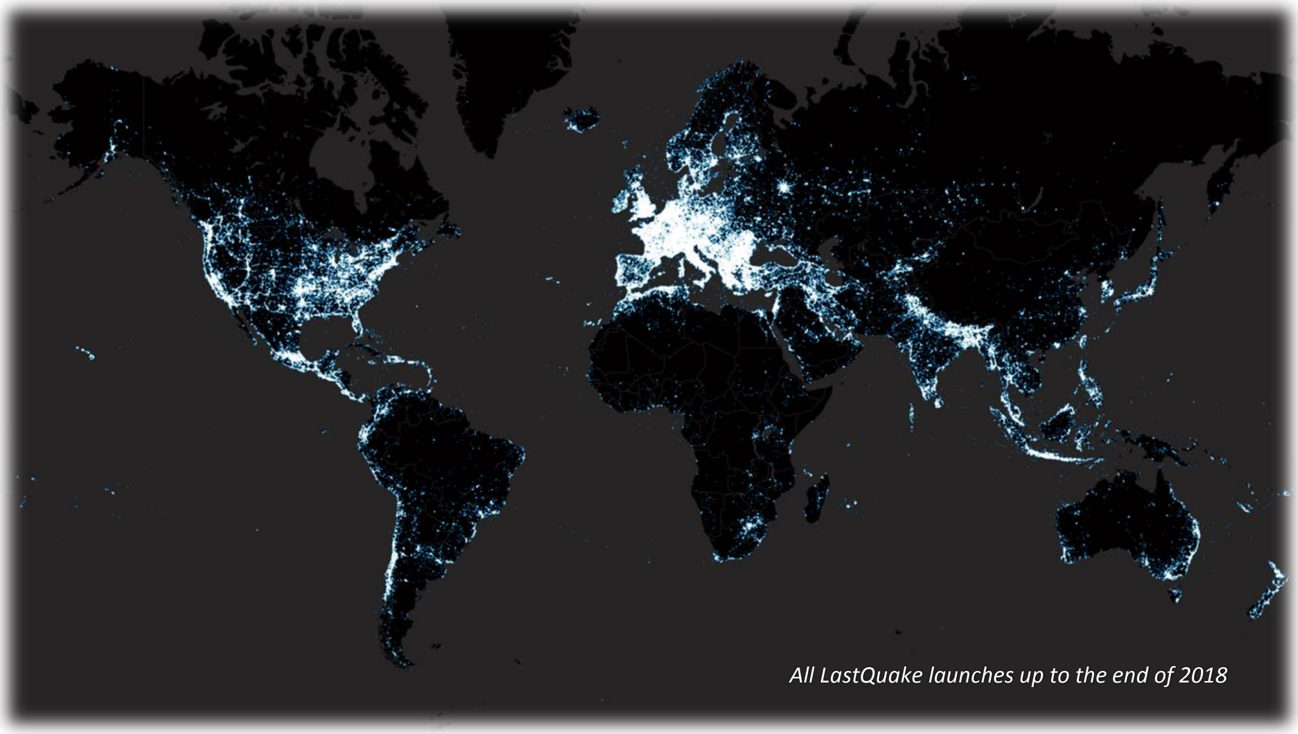
European-Mediterranean
Seismological Centre

https://twitter.com/LastQuake

Report on 2018 Operational Activities



Date	Version	Remark
15/05/2019	1	Diffusion to EMSC Members and data contributors

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EXECUTIVE SUMMARY

- The EMSC has put a lot of effort towards improving its communication with users in 2018. Firstly, within the European project EPOS, we have improved our engagement with the scientific community via web services. These give access to earthquake products like moment tensors, rupture models or felt reports via programmable interfaces. Secondly, we have improved how we report information to eyewitnesses and the general public. We have enhanced our smartphone application to display any felt events without seismic confirmation and we have studied the sociological aspects of the seismic sequence of Mayotte particularly with regard to the comprehension of information from social media.

- Even without any major seismic sequences in 2018, the EMSC collected more felt reports in more regions. Our popularity with eyewitnesses continues to increase and this validates our efforts to improve our communication with the general public.

- The popularity of the desktop and mobile websites are relatively constant. However we note, as in previous years, an increase in the usage of our app and our twitter account. Diversity and complementarity is important since the each user and country has their own preferred communication channel. This multipronged approach increases the EMSC's global audience.

TABLE OF CONTENTS

I INTRODUCTION

The European Mediterranean Seismological Centre (EMSC), hosted by the LDG (*Laboratoire de Détection et de Géophysique*, Bruyères-le-Châtel, France), is a non-profit and non-governmental scientific international organization which provides rapid earthquake information in coordination with the national seismological institutes in the Euro-Mediterranean region. 81 seismological institutes are members from 56 countries covering the whole Euro-Med region.

The main scientific activities of the EMSC are the real time information services which are presented in this report. These services are operated thanks to the operational and technical support of the LDG and of the IGN (Madrid, Spain) by compiling the real time parametric data provided by 96 seismological agencies, in the Euro-Med region but also worldwide.

The real time catalogue is available on various media: websites, smartphone App, Twitter, Browser add-ons, FDSN webservice etc.

In addition to seismological data, the EMSC collects rapid in-situ data thanks to the eyewitnesses who provide felt reports, comments and/or geo-located pictures of earthquake effects. Seismic data along with in-situ data allow the EMSC to quickly detect felt and potentially damaging earthquakes and to rapidly publish information on these significant earthquakes through various media: websites, email services, Twitter, smartphone App, etc.

The different earthquake information services and the publication media are presented in this report as well as their performance's evolution over the last few years. The report also presents recent developments carried out by the EMSC.

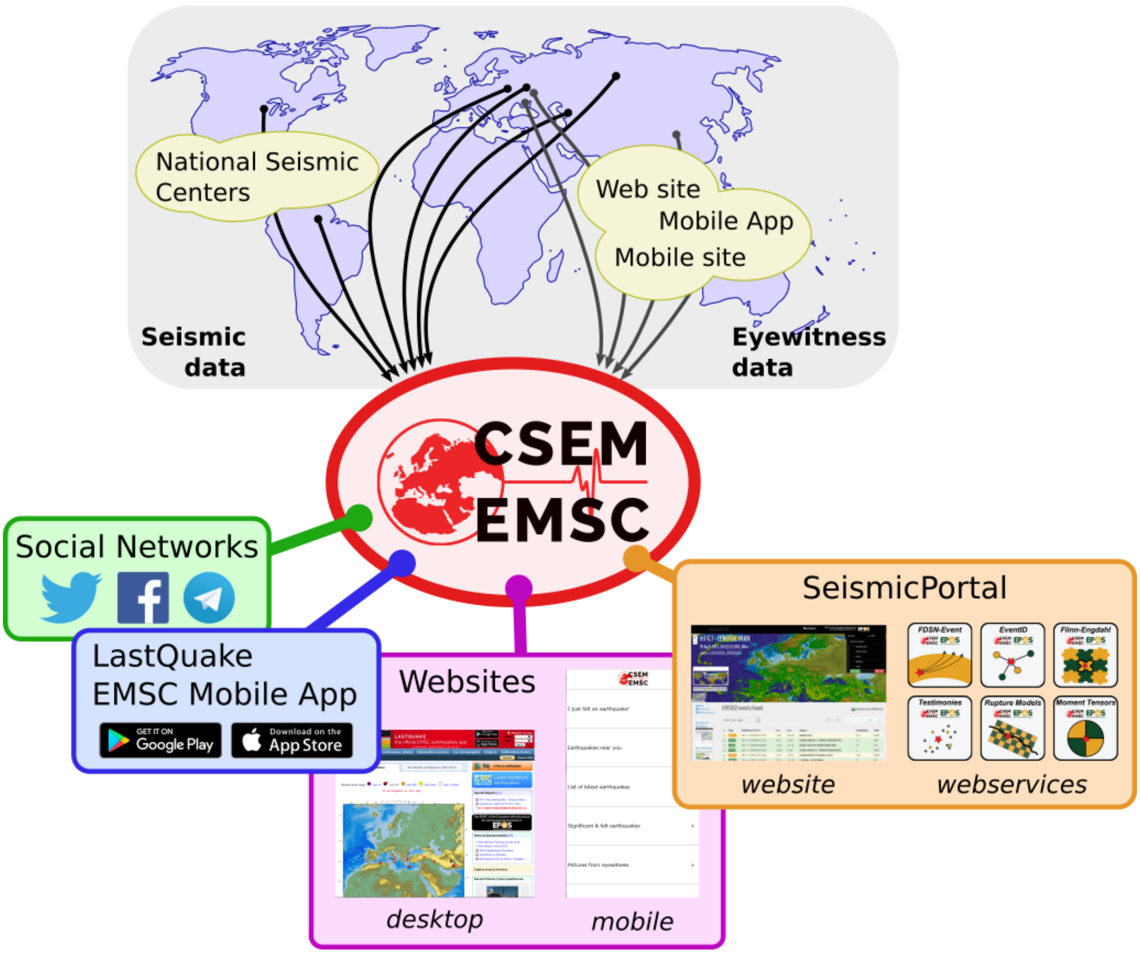


Figure 1 : Overview of the EMSC and its main services for the general public and for seismologists (www.seismicportal.com)

II STATUS AND PERFORMANCE OF THE REAL TIME SERVICES

Each year, we assess the status and the performance of the EMSC real time services using the following metrics:

- Status and performance of the email Earthquake Notification Service
- Seismological data received and number of earthquakes published
- In-situ data provided by the eyewitnesses (felt reports, comments, pictures)
- Who uses EMSC real time services and how?

II.1 EARTHQUAKE NOTIFICATION SERVICE (ENS)

II.1.1 PRESENTATION

The EMSC operates an email Earthquake Notification Service (ENS), thanks to the technical and operational support of the **LDG** (Bruyères-le-Châtel, France), and of the **IGN** (Madrid, Spain). The ENS is a free public service[1] which consists of quickly disseminating (within 10-20 minutes after earthquake occurrence) an email notification to its users for potentially damaging earthquakes (i.e. M5+ in Europe; M6+ for continental Asia; M7+ worldwide). The earthquake location and dissemination is performed by a seismologist on call. On average, 100-150 messages are disseminated each year via the ENS.

In the framework of the ENS, the seismologist on call is also in charge of relocating, when necessary, the earthquakes published on the EMSC website during the week-end. This task allows the seismologist on call to remain aware of the recent seismicity and to quickly detect any technical problems.

II.1.2 ROLE OF THE LDG

The Laboratoire de Détection de de Géophysique (LDG) is the EMSC's host institute. The LDG is part of the Commissariat à l'Energie Atomique (CEA) and is located in Bruyères-le-Châtel, France.

The LDG covers EMSC's overheads (premises, phone lines, …) as well as the computer infrastructure. All servers and computer are the property of the CEA. The CEA provides facilities to the EMSC to insure that it remains operational 24/7 thanks to people on call: seismologists, IT's, technicians. A dedicated vehicle, a laptop and a cell phone are at the disposal of the seismologist on call so that he/she can easily and securely connect to the EMSC from his/her home and therefore quickly disseminate messagesto the ENS users.

II.1.3 ROLE OF THE IGN

The **Instituto Geografico Nacional** (IGN), in Madrid, Spain, operates a back-up of the Earthquake Notification Service (ENS) when the EMSC is not able to operate it for maintenance reasons for example. When the EMSC website is offline, the real time seismicity is available on IGN website:

http://www.01.ign.es/ign/resources/sismologia/www/csem/csem.htm

It's important to notice that due to an hardware update, this backup system provided by the IGN is no longer operational. However, with our effort to update the data collection core system (see IV.3), it's now one of our main objectives and plan to install this system at IGN as soon as possible.

[1] http://www.emsc-csem.org/service/register.php

II.1.4 ENS USERS

The number of users registered to the Earthquake Notification Service is rather stable since 2013, with a total of 12,020 users on 01/01/2019 (Table 1). With the soar in smartphones devices and the release of numerous smartphone applications for earthquakes information, classical email-based services have become less interesting to the general public.

The database of ENS users is regularly cleaned and the email addresses that are not valid anymore are removed from the database.

II.1.5 ENS PERFORMANCE

We present here the evolution, over the last few years, of the response time performance of the ENS. Only Euro-Med earthquakes are considered because this is the region on which the ENS is focused. For each earthquake that has been processed via the ENS, we consider separately:

- **The Preliminary information time**

The preliminary information is the very first source parameters published on the EMSC website for a given earthquake (generally an automatic location).

The time delay between earthquake occurrence and publication of the preliminary information has continually decreased since 2006 to 2017 with a median value of 4.0 minutes. In 2018 this value increased to 5.5 minutes for Euro-Med earthquakes (Table 1 and Figure 3).

- **The Alert triggering time**

The Alert triggering time is the time elapsed between the earthquake occurrence and the time when the seismologist on call is automatically called, when the magnitude of an earthquake exceeds the local threshold[2] (Figure 2). The regular decrease of the Alert triggering time since 2004 is mainly due to the improvements in the performance of the individual seismological agencies in detecting and locating earthquakes more rapidly.

In 2018, the median Alert triggering time was 3.2 minutes (Table 1 and Figure 3).

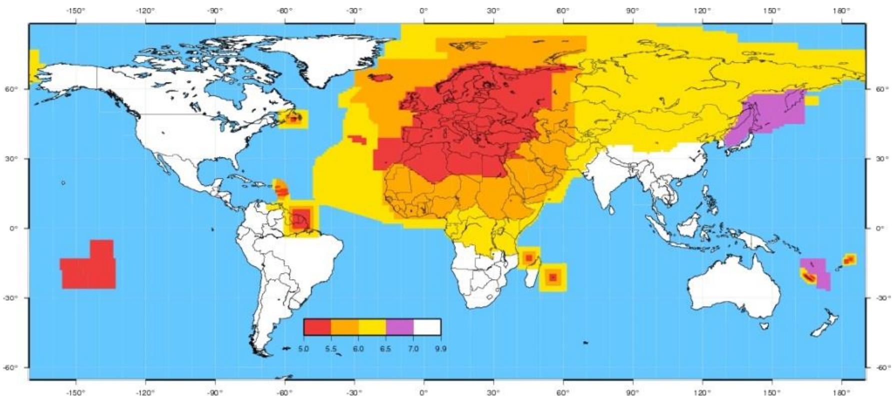


Figure 2: Map of magnitude thresholds for the alert triggering

[2] http://www.emsc-csem.org/Images/threshold.jpg

- **The Alert dissemination time**

The Alert dissemination time is the time elapsed between the earthquake occurrence and the time when the seismologist on call disseminates the alert message to the ENS users. After slightly increasing in 2016 due to the arrival of 3 new seismologists in the on-call team, who needed some training, the alert dissemination time decrease in 2017 to 15.4 min and stayed stable in 2018 (Table 1 and Figure 3).

Earthquake Notification Service												
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
Number of users	6,570	7,541	8,644	9,667	10,862	11,461	11,628	11,888	11,881	11862	12020	+1.3%
Number of disseminated earthquake notifications	157	135	122	137	152	156	208	119	131	151	170	+12.6%
Median preliminary information publication time for Euro-Med earthquakes	9.9	9.5	9.1	7.6	7	7	6	4.2	4.3	4	5.5	+37.5%
Median Alert triggerring time for Euro-Med earthquakes	7	7	7.5	7	7	6	6	3.5	3.7	2.6	3.2	+23.1%
Median Alert dissemination time for Euro-Med earthquakes	22	20	18	18	17	16	16	14.5	18.1	15.4	15.4	+0.0%

Table 1: Change in the response time performance of the Earthquake Notification Service over the last 10 years for Euro-Med earthquakes

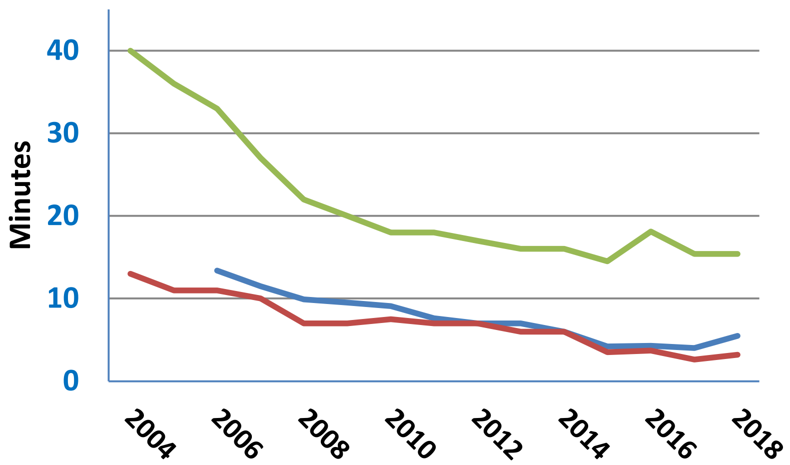


Figure 3: Earthquake Notification Service: improvement of the median values of the alert triggering time (in red), the preliminary information publication time (in blue) and the dissemination time (in green) since 2004 for Euro-Med earthquakes.

- **Location and magnitude accuracy**

Until 2013, we used to assess each year the location and magnitude accuracy of the information published or disseminated in the framework of the ENS. To perform this, we used to consider the location provided by the Euro-Med Bulletin (EMB; Godey et al.; 2007) as a reference location. However, the EMSC 2014 General Assembly, held during the ESC 2014 in Istanbul, decided to stop the production of the EMB which prevented us from assessing these performance anymore. Nevertheless, we showed in the report on 2013 real time activities that these performance had been rather stable in recent years, with a median accuracy of the disseminated locations of 10-12km and a median magnitude accuracy of 0.1 for Euro-Med earthquakes.

The reasons why the EMB production stopped and the final status of the EMB are presented in the report on Euro-Med Bulletin activities in 2015 (Godey et al. 2015).

II.2 SEISMOLOGICAL DATA

II.2.1 DATA CONTRIBUTORS

In 2018, a total of 96 seismological agencies provided real time data to the EMSC. This count can be compared to the 86 contributors of 2017 and this change shows our efforts to have our contributor list as up-to-date as possible. We have 6 new contributors:

- INSN: Irish National Seismic Network
- BRGM: Bureau de Recherches Géologiques et Minières, France
- UASD: Universidad Autonoma de Santo Domingo
- KIS: Kyrgystan
- CNRM: Morocco
- VEN: Venezuela

And we have also 4 contributors that are reactivated:

- MLT: Malte
- NSC: Nepal
- PIVS: Philippines
- UPSL: University of Patras Seismological Laboratory

II.2.2 DATA COLLECTED

The amount of data contributions has regularly increased since 2004 (Figure 4). In 2018, the 96 agencies contributed to the EMSC:

- Source parameters and phase pickings (see VII.1):
  - 151,276 origins (Figure 4) or 4,660,688 arrival times from 7,260 seismic worldwide stations (Figure 4; Figure 5; Table 2)
- Moment tensors solutions (see VII.2):
  - 3,703 moment tensor solutions[3] (Table 2)

[3] List of moment tensors received: http://www.emsc-csem.org/Earthquake/tensors.php

Data received																
Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
Nb of origins received	13,992	18,030	31,537	35,644	43,151	50,789	60,628	78,756	81,828	84,060	92,421	89,954	103,495	122,702	151,276	+23.3%
Arrival times received	447,552	671,225	731,878	1,032,159	1,244,879	1,532,786	1,670,703	2,084,588	2,304,648	2,262,900	2,440,773	2,329,705	2,650,725	3,077,100	4,660,688	+51.5%
Nb of contributing Euro-Med stations	1,100	1,249	1,359	1,624	1,672	1,782	1,896	1,996	2,100	2,236	2,415	2,459	2,431	2,603	2,653	+1.9%
Moment Tensors solutions received	1,013	1,139	1,105	1,175	1,328	1,285	1,303	2,488	2,886	3,024	3,972	3,557	3,438	3,868	3,703	-4.3%
Earthquakes with Moment Tensor solutions	182	640	622	699	725	703	701	1,037	1,198	1,230	2,052	1,910	1,612	1,348	1,299	-3.6%
Data published																
Nb of worldwide earthquakes	*NA*	9,814	11,109	14,342	15,386	16,582	17,540	24,237	32,944	36,181	42,530	39,471	49,731	52,459	75,776	+44.4%
Nb of Euro-Med earthquakes	*NA*	6,228	6950	8,993	9,819	11,018	12,189	18,049	24,771	24,908	22,168	18,674	18,800	23,278	14,533	-37.6%
Proportion of Euro-Med [2]earthquakes	*NA*	63.5%	62.6%	62.7%	63.8%	66.4%	69.5%	74.5%	75.2%	68.8%	52.1%	47.3%	37.8%	44.4%	19.2%	-56.8%

Table 2: Trends in the amount of data received and the number of earthquakes published in EMSC real time catalogue since 2004. NA=Not applicable

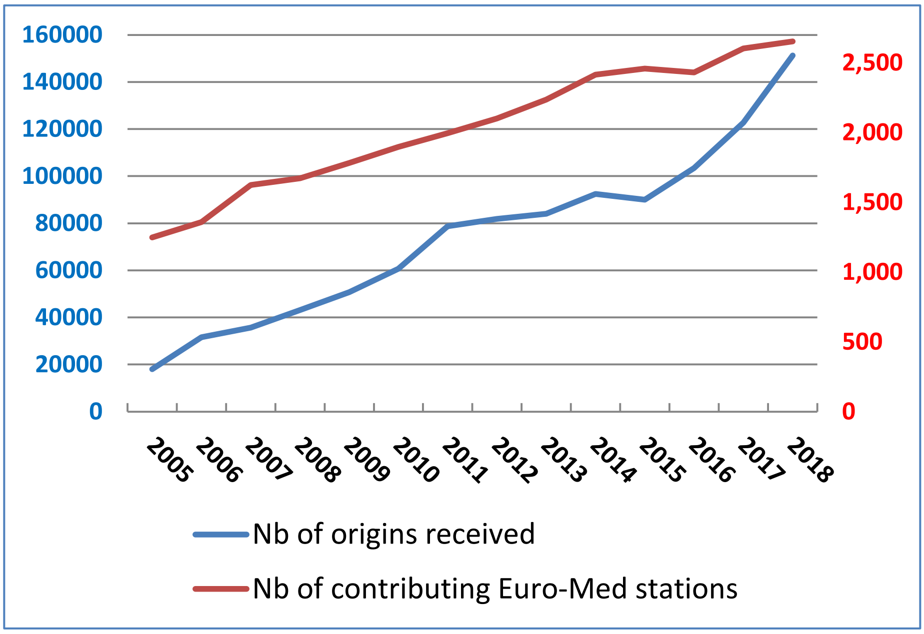


Figure 4: Growth in the number of origins received by the EMSC from the data contributors (in blue) and the number of Euro-Med stations that provided phase pickings (in red) in real time since 2004

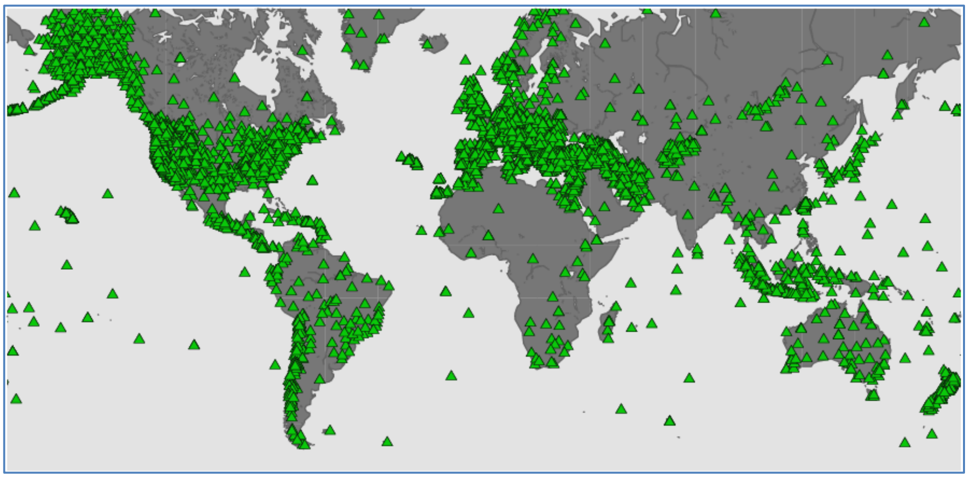


Figure 5 : Maps of the 7,260 contributing stations for 2018 referenced in the station book of ISC.

II.3 REAL TIME CATALOGUE

II.3.1 NUMBER OF EARTHQUAKES PUBLISHED

The number of worldwide earthquakes published each year by the EMSC in its real time catalogue has kept on increasing since 2004 and reached 75776 earthquakes in 2018 (Table 2, Figure 6 and Figure 7). The huge increase of seismic events (+44%) in 2018 is mostly due to a seismic crisis in Hawaii where we received a lot a small events (<M3).

The curve of daily distribution of earthquakes collected by EMSC is composed of different periods:

- In 2017, the number of earthquakes increased by 23.8 % compared to 2016 and this trend is probably linked to 3 main earthquake sequences: in Italy in January 2017, in Western Turkey in February 2017 and in Macedonia in July 2017.
- The regular increase observed between 2005 and 2012 is mostly due to the additional seismological stations available in real time (red curve on Figure 4) and the improvement of the detection capacities of the different seismological agencies which provide real time earthquake data to the EMSC. Concerning the Euro-Med earthquakes, their number did not increase since 2012. In this case, the year-to-year changes are mostly governed by the natural changes in the seismic activity.

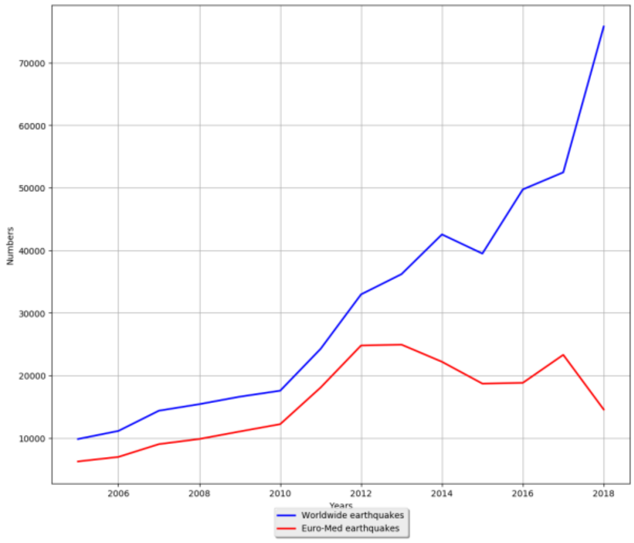


Figure 6: Change in the number of worldwide (in blue) and Euro-Med (in red) earthquakes published in EMSC real time catalogue per year since 2005

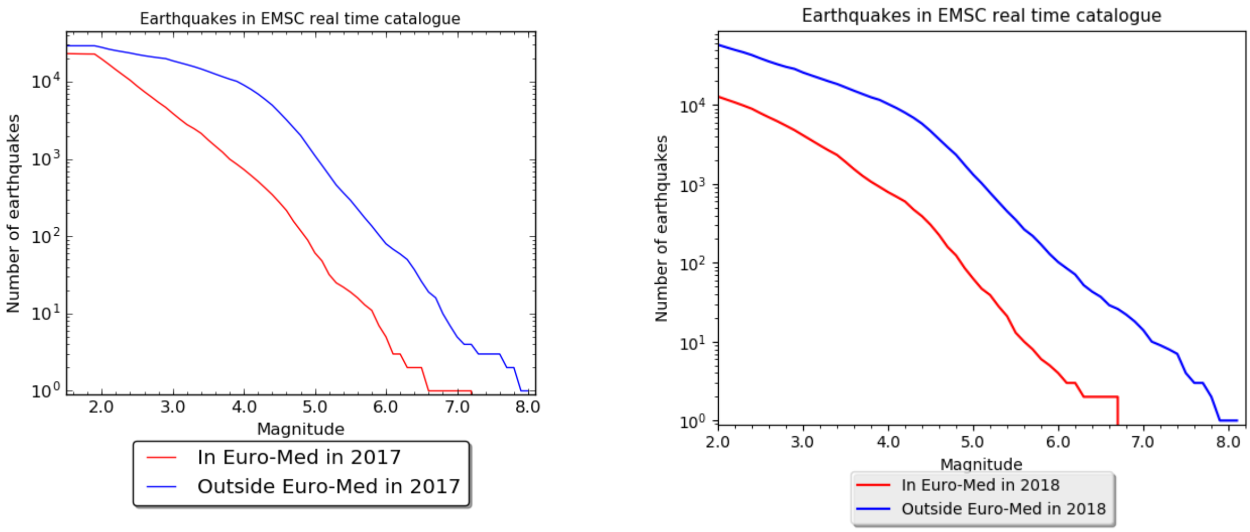


Figure 7: Comparisons of Gutenberg-Richter magnitude distribution of the earthquakes published in EMSC real time catalogue in 2017 (left) and in 2018 (right)

II.3.2 TYPES OF LOCATIONS

Among the tens of thousands of earthquakes in the EMSC real time catalogue, we distinguish four types of locations (Table 3):

- 1. Reported locations: earthquakes reported by only one contributor/agency which is the local agency but for which its location is not authoritative (Bossu et al.; 2011). The EMSC does not relocate them.
- 2. Authoritative locations: earthquakes for which at least one of the locations provided by the contributing agencies is authoritative (Bossu et al.; 2011). The EMSC does not relocate them.
- 3. Data Selected Locations (DSL): locations computed by the EMSC where no authoritative location is available but where a Ground Truth (GT) location (Engdahl et al.; 2001 and Bondar et al.; 2004) can be obtained by merging the data of the different agencies. DSL are accurate locations by definition.
- 4. EMSC locations: locations computed by the EMSC using all the pickings provided by the data contributors.

Table 3 clearly shows that the vast majority of the locations published in EMSC real time catalogue are not computed by the EMSC. In 2018, 87.3% of the worldwide seismic events (70.0% of the Euro-Med ones) diffused by the EMSC use a location directly provided by individual seismological agencies.

Type of locations	Worldwide	Euro-Med only	Computed by the EMSC
Reported locations	58.8%	49.9%	No
Authoritative locations	28.5%	20.1%	No
Data Selected Locations	0.1%	0.3%	Yes
Locations computed using all available stations	12.5%	29.8%	Yes
Locations not computed by the EMSC	*87.3%*	*70.0%*	-

Table 3: Distribution of the different types of locations published in EMSC real time catalogue in 2018

II.4 DATA COLLECTED FROM EYEWITNESSES

This section is dedicated to the information collected from the earthquake eyewitnesses in terms of felt reports, comments and pictures.

The EMSC collects eyewitnesses felt reports for several reasons:

- It provides a way to collect felt reports in countries where no online questionnaire is available.
- It supplies redundancy to macroseismic questionnaires provided by the local institutes.
- It is a way to collect and process felt reports over frontiers and in a homogenous way.

The EMSC collects felt reports:

- Either via the classic online questionnaire available on the EMSC desktop website[4] (i.e. for desktop)
- Or via the thumbnails describing each level of shaking (Figure 8) and made available on the mobile website[5] and LastQuake application.

In this report, the word “felt report” stands for both types.

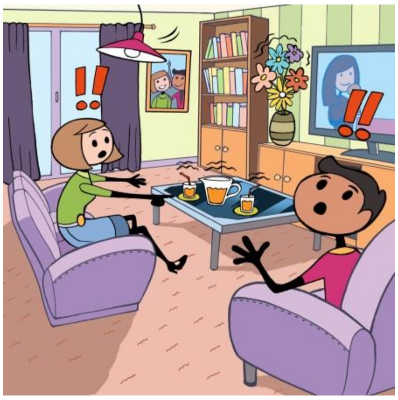


Figure 8: Example of thumbnails proposed to eyewitnesses to share their experience, corresponding to an intensity of 3.

II.4.1 FELT REPORTS

The number of felt reports collected by EMSC has continued to increase over these past 10 years and reached 120474 in 2018 (Figure 9, Figure 10, Figure 11 and Table 4).

Main observations:

- The number of felt reports collected has increased through all collection channels, the app, mobile website and desktop website; by 23% for LastQuake app and by 40% on the desktop.
- Compared to 2017, the coverage improved in Oceania and in particular in Indonesia (Figure 11) thanks to the Lombok sequence

Although the EMSC collection system is now well established, It’s interesting to note that the repartition between the collection channels depends strongly on the region and shows the complementarity of the global collection system (Figure 13).

[4] http://www.emsc-csem.org

[5] http://m.emsc.eu

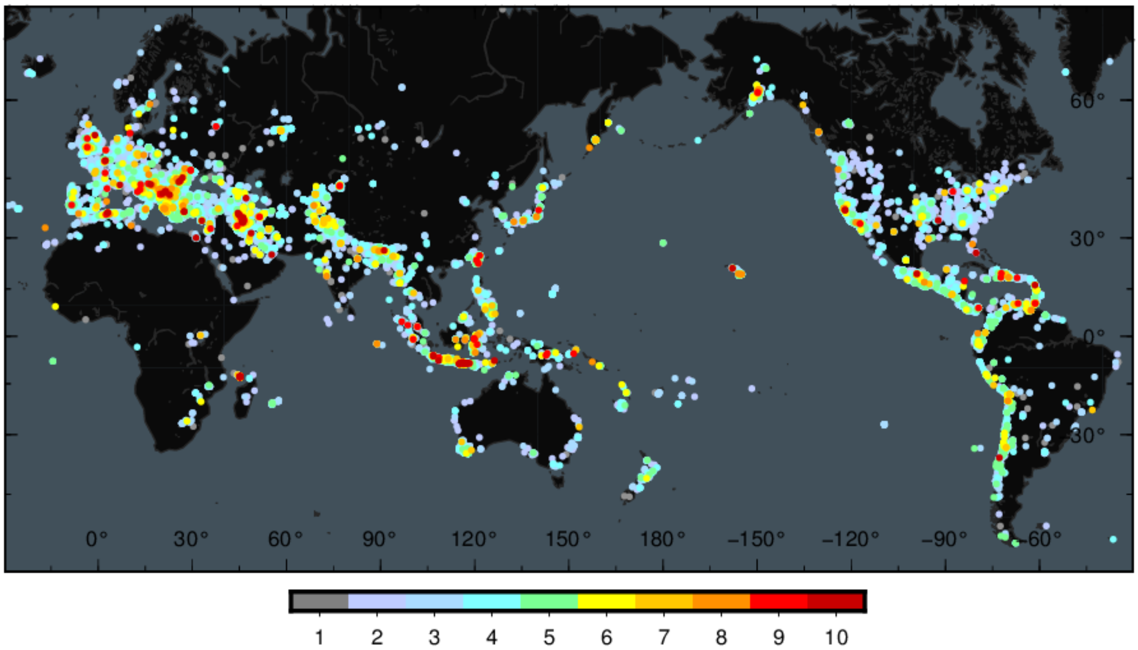


Figure 9: The 119,622 geolocated felt reports collected in 2018. On this map, higher intensity values overlay lower intensity ones.

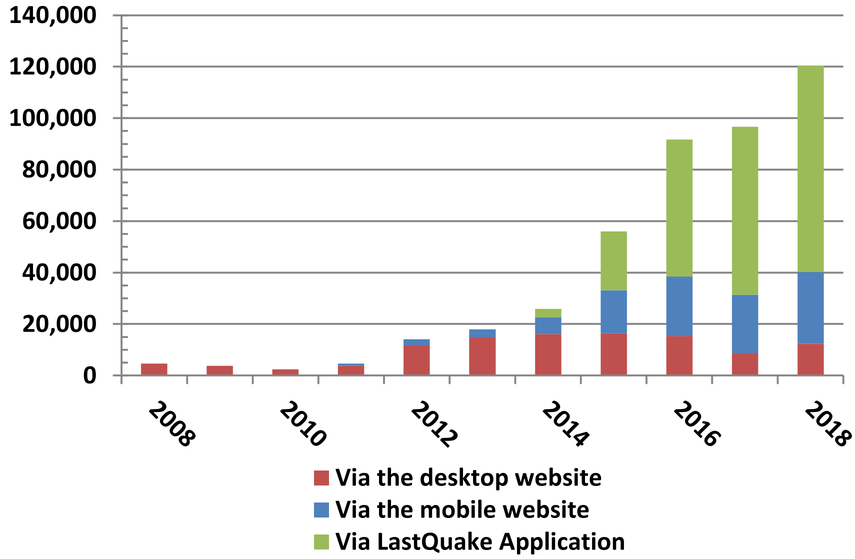


Figure 10: Yearly distribution of felt reports collected every year over the last 10 years.

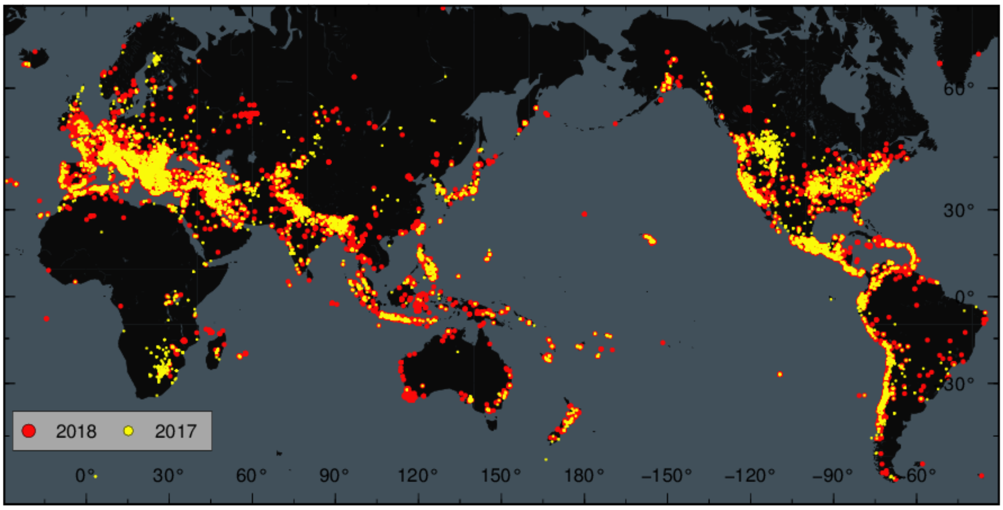


Figure 11: Comparison of the felt reports distribution in 2017 and 2018.

Felt reports collected from eyewitnesses												
Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
Via the desktop website	4,581	3,778	2,400	3,831	11,909	14,909	16,056	16,506	15,366	8,782	12,332	+40.4%
Via the mobile website	*NA*	*NA*	*NA*	783	2,235	2,991	6,491	16,581	23,134	22,562	27,818	+23.3%
Via *LastQuake* Application	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	3,314	22,927	53,138	65,293	80,324	+23.0%
TOTAL	**4,581**	**3,778**	**2,400**	**4,614**	**14,144**	**17,900**	**25861**	**56014**	**91638**	**96637**	**120474**	+24.7%
Earthquakes with at least one testimony	686	795	693	841	1410	1526	2041	2705	3737	5152	4319	-16.2%

Table 4: The numbers of felt reports collected from eyewitnesses every year over the last 10 years

The “felt report” number gives a good indicator for evaluating the performances of all components of the collection system, that encompasses the hardware and the software as well as the overall popularity of EMSC. This year, there was no increase in collection speed. However, there were 12 events for which we collected more than 1000 reports and half of these had a magnitude less than M5. Of course these observations depend strongly on the seismic event distribution and so it is difficult to extract global trends. In 2018, the record set in 2016 was beaten twice. In 2016, we collected 4423 reports for an M5.6 event in Oklahoma on 2016/09/03. In 2018, we collected 4480 reports in Romania for a M5.5 on 2018/10/28 and the new “record” is 5407 reports for a M4.4 in the UK on 2018/02/17.

In term of performance, the Figure 12 shows that 60% of the felt reports collected in 2018 came within 15 minutes of earthquake occurrence for thumbnails and 25 minutes for questionnaires. Moreover thumbnails (felt reports from mobile and LastQuake) represent the majority of collected reports (90%). This shows the efficiency of the collection system enabled by the app and the cartoon thumbnails for choosing the felt intensity.

This optimal behavior is possible thanks to the effort made in 2016 to optimize some analysis, to upgrade our web servers and to upgrade our front-end servers (F5-Big-IP load balancers) which manage the traffic peaks generated by sudden visitor arrivals.

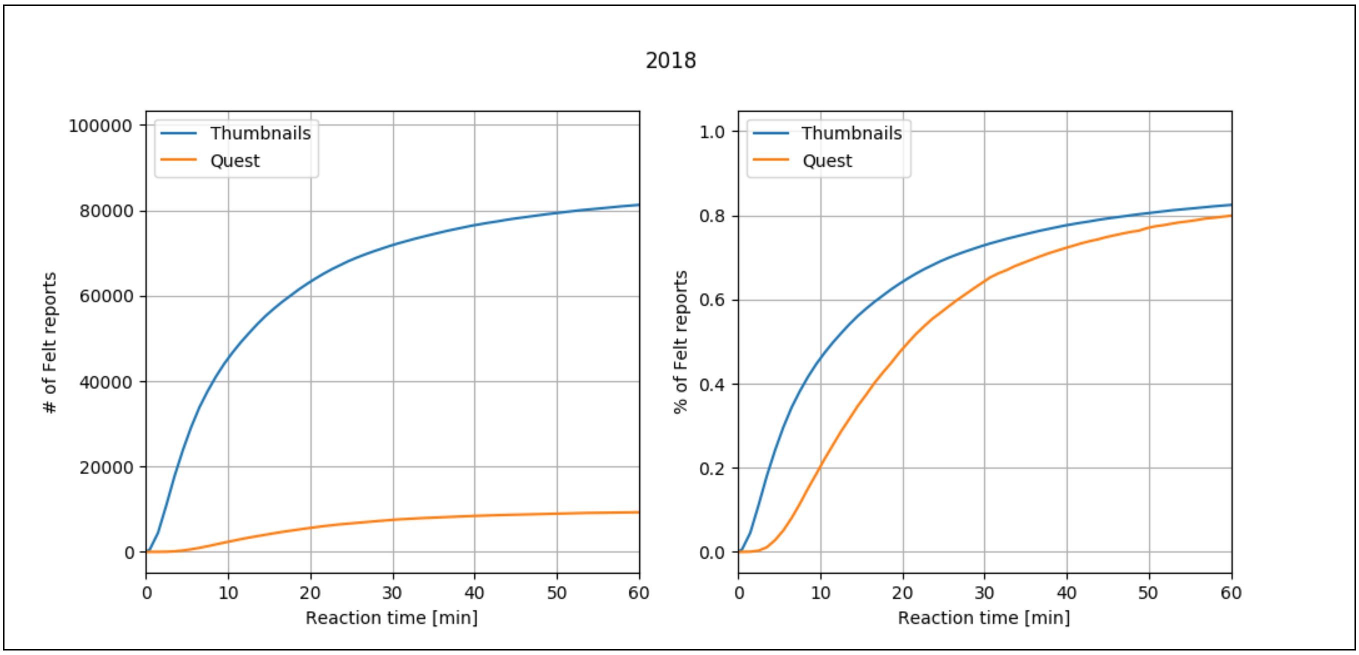


Figure 12: Number (left) and percentage (right) of all felt reports collected in 2018, with respect to time elapsed since earthquake occurrence, by thumbnails-based and online questionnaires.

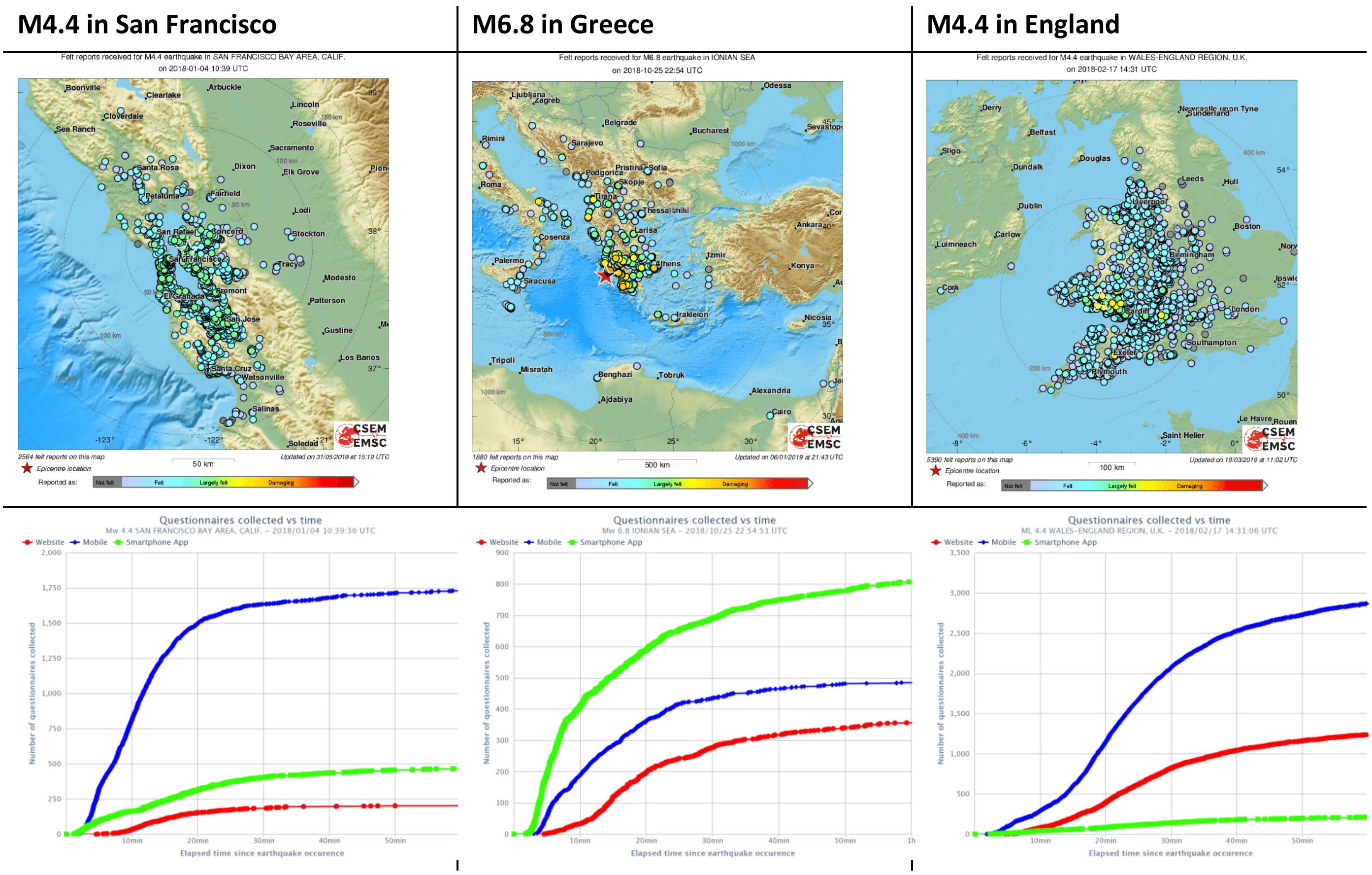


Figure 13: Examples of the three distinct collection mechanisms for three seismic events in 2018.

II.4.2 Comments

Through the EMSC websites and LastQuake app, we also collect comments (Figure 15) posted by the eyewitnesses. They provide rapid complementary information on the level of shaking, on damage and on feelings (“*Scared!*”, “*I felt dizzy*”…) and reactions (“*I ran away!*” …). In 2018, we received more than 50,000 comments and almost 75% were collected from LastQuake (Figure 14; Table 5). Compared to previous years, these numbers increased strongly and we got 32% more comments in 2018.

Comments posted by eyewitnesses												
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
Via the desktop website	942	757	547	1,299	3,187	3,897	4,905	5,304	4,522	2,533	3,609	42.5%
Via the mobile website	*NA*	*NA*	*NA*	315	813	1,197	2,818	7,425	9,871	7,847	9,094	15.9%
Via *LastQuake* Application	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	1,536	12,322	25,412	27,554	37,434	35.9%
TOTAL	942	757	547	1,614	4,000	5,094	9,259	25,051	39,805	37,934	50,137	32.2%
Percentage of testimonies with comments	20.6%	20.0%	22.8%	35.0%	28.3%	28.5%	35.8%	44.7%	43.4%	39.3%	41.6%	6.0%

Table 5 : Change in the number of comments posted by eyewitnesses over the last 10 years

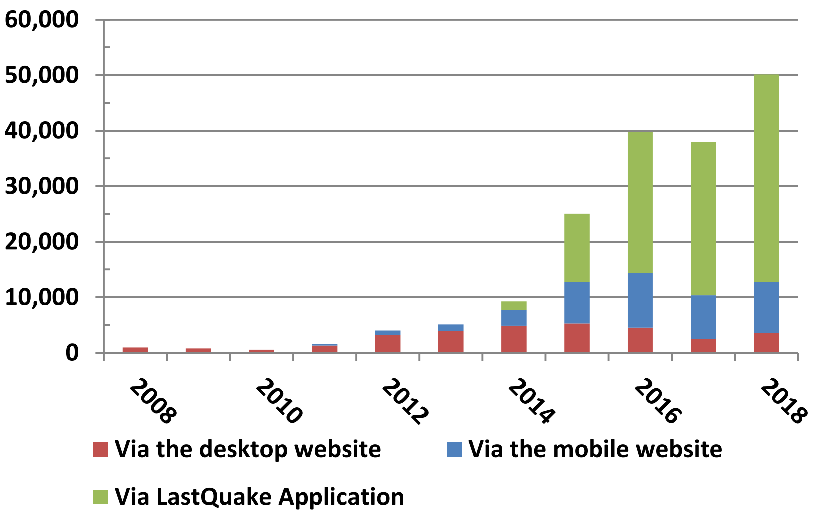


Figure 14: Number of comments collected over the last 10 years

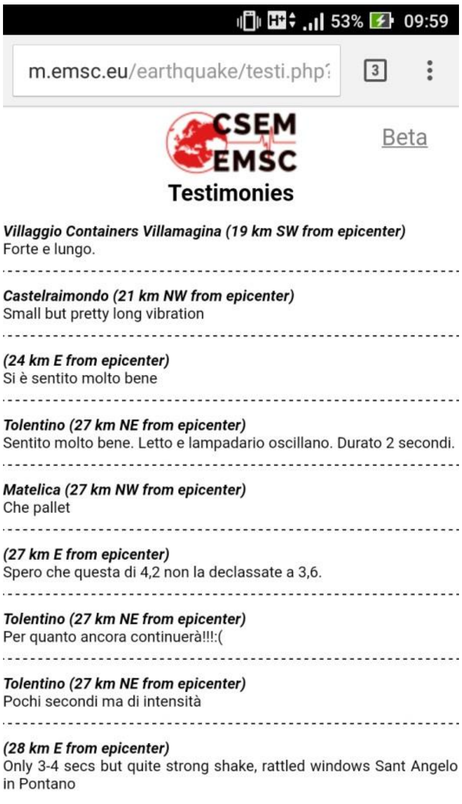


Figure 15: Examples of comments provided by earthquake eyewitnesses

II.4.3 Pictures

The number of pictures of earthquake effects collected by the EMSC is almost stable with 2017 with 229 pictures. However, as a result of seismic events in Indonesia, the number of events with pictures almost doubled between 2017 and 2018 (Table 6 and Table 7). As shown in the Figure 16, pictures from eyewitnesses can be very informative on damage sustained due to an earthquake.

Here we count only pictures that are validated by the EMSC staff. Images have to be informative, consistent with the expected ground shaking of the event, not to be already referenced by google and they should respect human dignity.

Pictures posted by eyewitnesses												
Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
Number of pictures received and published	13	136	118	17	156	96	62	145	150	248	229	-7.7%
Number of earthquakes with at least one picture	3	8	6	9	15	12	14	15	28	26	48	84.6%

Table 6: The number of pictures posted by eyewitnesses over the last 10 years. Only pictures whose content has been manually validated by the EMSC are considered

Earthquake	Number of pictures collected
2018-08-19 14h M6.9 LOMBOK REGION, INDONESIA	36
2018-08-05 11h M6.9 LOMBOK REGION, INDONESIA	32
2018-11-30 17h M7.0 SOUTHERN ALASKA	28
2018-08-19 04h M6.3 LOMBOK REGION, INDONESIA	17
2018-08-09 05h M5.9 LOMBOK REGION, INDONESIA	10

Table 7: Earthquakes for which at least 10 pictures have been collected in 2018

Figure 16: Pictures of damage provided by eyewitnesses for the M6.9 earthquake in Indonesia on 19/08/2018 on the left and for the M7 in Anchorage (Alaska) on the 30/11/2019.

II.5 DETECTION OF SIGNIFICANT AND FELT EARTHQUAKES

The EMSC has developed several innovative methodologies to quickly and automatically detect significant and felt earthquakes (Bossu, Steed et al., 2015; Bossu, Steed et al., SRL 2018; Bossu, Roussel et al., IJDR 2018). They are based on :

- Peaks in web traffic observed on EMSC websites
- Twitter Earthquake Detections (TED; Earle, 2011)
- Collection of felt reports, comments or pictures provided by the eyewitnesses
- Automatic estimations of earthquake impact via EQIA[6]
- Tsunami alerts issued by the PTWC
- Existence of a seismic event confirmed by a seismic signal on close stations

II.5.1 NUMBER OF DETECTED EARTHQUAKES

In 2018, among the 75,776 earthquakes collected by the EMSC, 2,051 (2.7%) were characterized as significant (Figure 17). Most of these designations came from the collection of several felt reports for a particular earthquake (Table 8), which does not necessarily imply that such detections were rapid or that the earthquakes were large magnitude. Widely felt earthquakes are generally first detected with App launch detection and with Twitter detection. Regions of significant events with smaller magnitudes are correlated with regions where the EMSC LastQuake mobile app was popular: South-Eastern Europe and California.

[6] Earthquake Qualitative Impact Assessment. Developed by the EMSC in the framework of NERIES-JRA3 FP6 project. The estimated impact is based on empirical relationships between magnitude, population density and death toll.

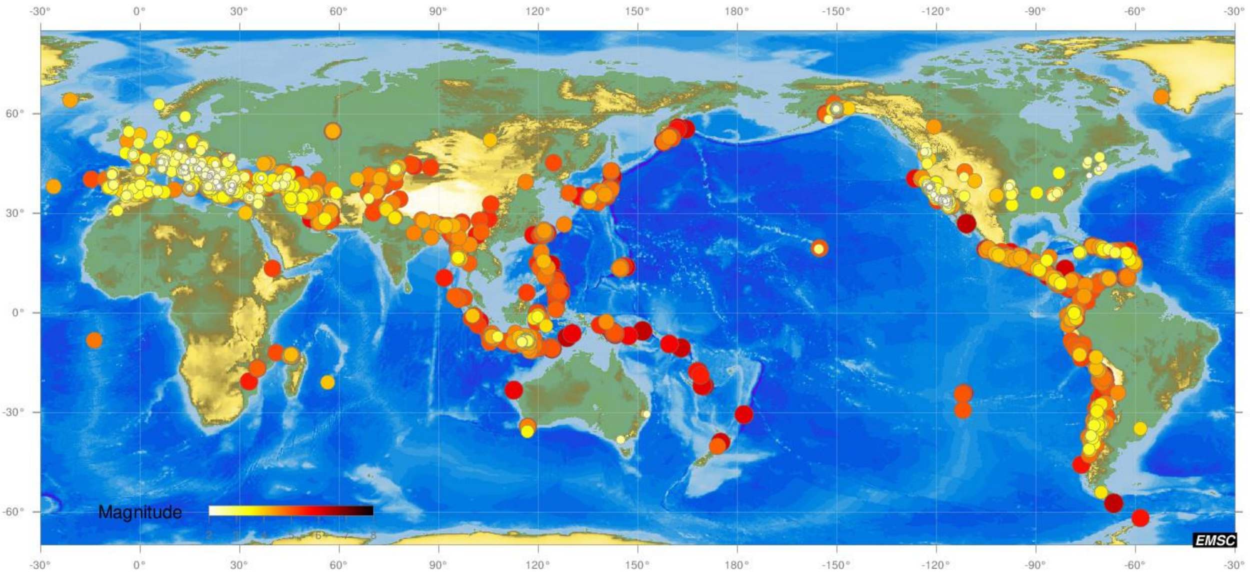


Figure 17: The 2,051 significant and felt earthquakes detected by the EMSC in 2018.

Detection type	2016	2017	2018
Collection of felt reports	1208	1543	1437
Twitter Earthquake Detections	421	260	123
Traffic detections (web, desktop and app)	158	349	382
Automatic estimation of earthquake impact (EQIA)	33	37	63
Tsunami warning issued by the PTWC	20	29	30
Very large earthquakes not detected by other method	9	2	2

Table 8: Number of detected significant and felt earthquakes in 2018 by type of detection. In case of multiple detections, we only consider the fastest one.

II.5.2 Traffic Detections (web and app traffic, TED)

Among the 2,051 felt and significant earthquakes detected in 2018, 844 resulted from peaks seen in web traffic, LastQuake app traffic or the Twitter Earthquake Detection system (TED) (Table 9). The 3 methods have a good complementarity with 68% of earthquakes only detected by one of the three methods (Figure 18). For instance, TED is able to detect earthquakes in regions where Twitter is popular. In 2018, a version of the TED system was installed at the EMSC (rather than relying on emails from the USGS's system). This has reduced latency between the TED detections and the EMSC system's responses to them.

The TED and LastQuake app traffic detections generally occurred faster than the detections of website traffic peaks. The median time delay was 72 seconds for the app, 62 seconds for TED and of 106 seconds for website traffic. False triggers were more common for the TED system (Table 9) but this was partly due to technical issue that was erroneously marking some detections as false peaks, this was corrected during the year – 78 of the TED false peaks should have been good detections but they have not been reassigned category in order to maintain consistency.

One advantage of the app traffic system is the possibility to have access to precise geolocation due to the internal GPS of mobiles. Half of the LastQuake app detections were located to within 50km of the published epicentre (when an association to an earthquake could be found). The website traffic peaks had a median location accuracy of 106km and the TED system of 81km. This allows us to associate the peaks with their causal earthquakes.

We have recently released an article in Science Advances (Steed et al., 2019) where we used these crowdsourced detections to trigger seismic analyses (see section IV.2).

Method	Number of quake detections	Number of false or problematic quake detections	Average detection time	Median detection time	Fastest detection	Countries with the most detections
Web traffic	282	20	161sec	106sec	23sec	United States, Greece, North Macedonia
TED@EMSC	449	147	73sec	62sec	15sec	United States, Chile, Japan
LastQuake App	465	49	88sec	72sec	18sec	Mayotte, Greece, Indonesia

Table 9: Comparison of web traffic, TED and app detections performance in 2018

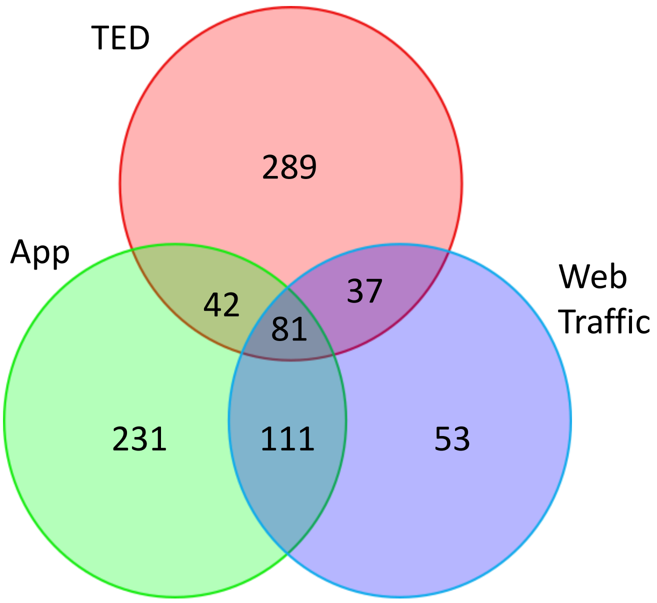


Figure 18: Complementarity of web traffic, TED and app detection systems in 2018. Detection numbers are defined by earthquake. Among the all detections represented here, 231 detections were only possible thanks to the App users, 53 with the web traffic only and 289 with TED only. 81 of the detections were possible with the 3 methods.

II.6 EMSC DATA USE AND USERS

II.6.1 MONITORING METHODS

Each year, in our activity report, we provide:

- The websites (desktop and mobile) traffic statistics. They have been extracted using the same software since 2004: *StatCounter*[7].

[7] www.statcounter.com

- For the smartphone App (*LastQuake*), we don't use the metrics provided by the applications marketplaces (e.g. Google Play or iTunes) which only give the number of downloads without taking into account the uninstalled Apps. We rather assess the number of active Apps by taking into account the number of notifications that were actually acknowledged by the remote mobile devices. If a device doesn't receive a notification, it means the App has been uninstalled.

- For Twitter we take into account the evolution of the number of followers.

- For the browser add-ons, Seismic Portal web services, RSS feeds, etc. we use the log of our LOG F5 load balancer to identify IP addresses of access of all EMSC URL. Locations are determined from IP addresses with Netaquity database.

II.6.2 Results per service

Among EMSC services, on a daily basis in 2018, the EMSC desktop website (http://www.emsc-csem.org) remains the most used media. Indeed it is used every day, whatever the seismic activity by a core of regular users, mostly seismologists. On the other hand, the mobile website and the App are mainly used by eyewitnesses during a limited period of time.

II.6.2.1 Desktop and mobile website

The daily traffic on the desktop website started to decrease in 2012 and did not vary much between 2014 and 2018 with 33,600 daily users on average in 2018 (Figure 27 and Table 11). Although the traffic on the mobile website decrease this year to 18,000 daily unique users, numbers are of the same order of magnitude.

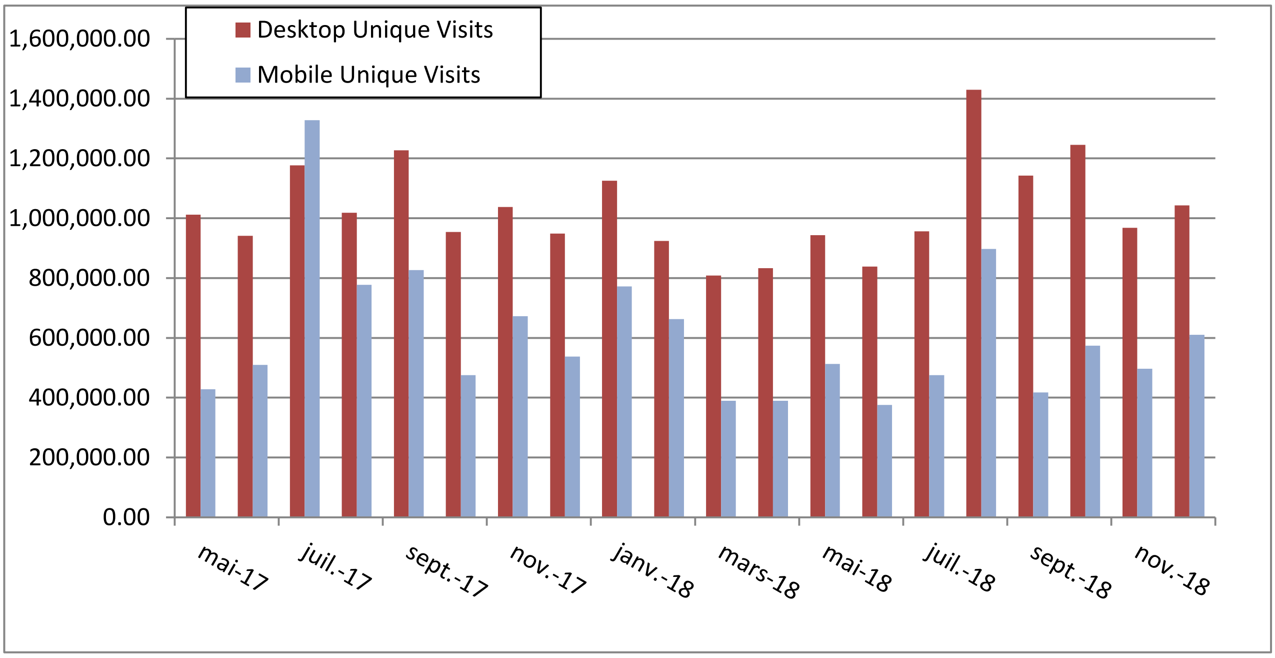


Figure 19: Monthly desktop and mobile site traffic for the last two years

In summary for the whole year 2018, the mobile site represents 21.3 millions of page views and the desktop website represents 113.8 millions of page views.

II.6.2.2 LASTQUAKE APP

With a total of more than 348,071 active users at the time of this report (Table 12), an average of 11,323 users launched the App every day in 2017 (Table 11). Users are distributed worldwide and most active users are located in North America, in Europe and in Indonesia (Figure 20).

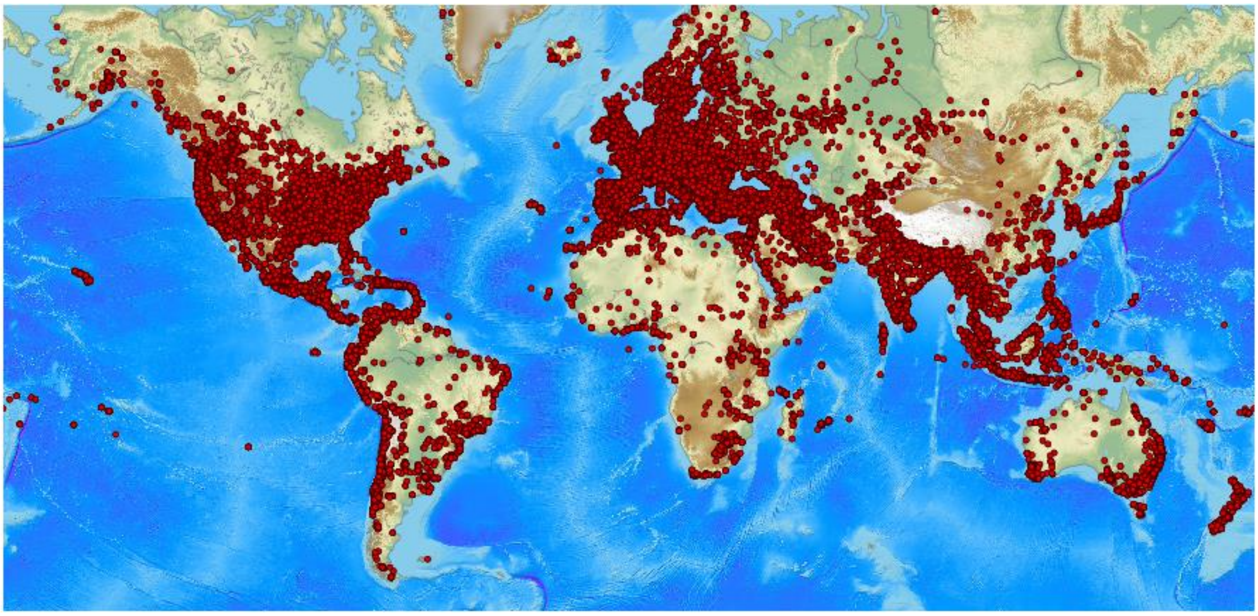


Figure 20: Worldwide distribution of LastQuake users.

II.6.2.3 TWITTER

The EMSC has two twitter accounts. The main account is @LastQuake and it contains all information for felt earthquakes. Whereas information for all earthquakes are published on @emsc. Both EMSC Twitter accounts have seen their number of followers increasing significantly in 2018 (Table 12):

- 14,000 followers (+40% in one year) for *AllQuakes* account (@emsc)
- 88,000 followers (+23% in one year) for *LastQuake* account (@LastQuake)

Another parameter to evaluate the popularity of our Twitter feeds is the total number of views of EMSC tweets. The Figure 21 shows a continuous increase in our popularity on Twitter with annual views increasing from 48.5 million in 2017 to 68.1 million 2018 (+40%). These numbers have to be compared with total page views of desktop and mobile website which to total 134 million of views. Although the @LastQuake Twitter account is quite recent, these numbers could be interpreted that already one third of EMSC visibility is done on Twitter…

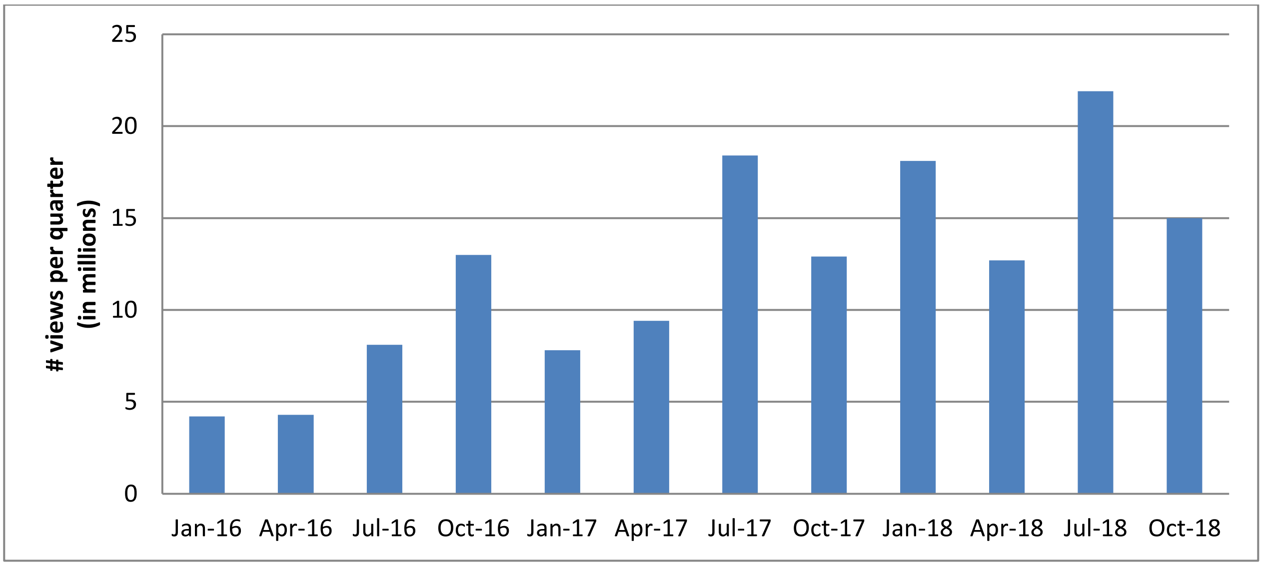


Figure 21 : Time evolution of the number of views of EMSC tweets per quarter from 2016 to 2018.

II.6.2.4 TELEGRAM

To be more popular in Iran, we began to published in 2017 the content of Twitter on the messaging application Telegram. In contrary to Twitter or Facebook, it's one of the uncensored in the country. We have two channels #LastQuake2 with 95 members and #AllQuakes2 with 22 members.

II.6.2.5 BROWSER ADD-ONS

LastQuake and AllQuakes services are also available via browser add-ons[8] (or extensions). Their use hasn't grown much for several reasons:

- They require a desktop computer
- They are not available for *Internet Explorer*
- Most people don't know this technology or think it is intrusive or not safe
- We never really advertise it

In 2018, these add-ons have been used by 824 unique users per day on average.

II.6.2.6 SEISMIC PORTAL AND ITS WEB SERVICES

The SeismicPortal is now the main EMSC portal to access seismological data. In addition to origin and phase parameters, It's now possible to access to moment tensors and felt reports. These developments have been possible within the European project EPOS.

The SeismicPortal contains (Figure 22):

- A web site http://www.seismicportal.eu/
- A near Real-Time notification service useful for monitoring real time events
- 6 web services http://www.seismicportal.eu/webservices.html (fdsn-event, eventid, Flinn-Engdhal regions, testimonies, rupture model, moment tensors).

[8] http://www.emsc-csem.org/service/Browser-extension/

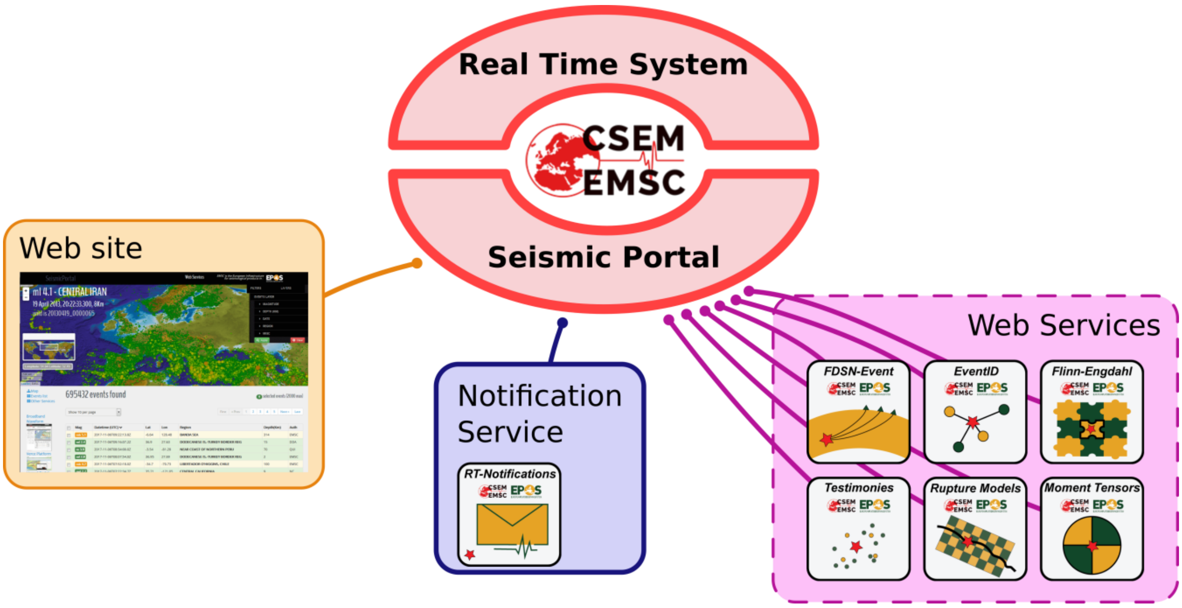


Figure 22: Overview of the different components of the SeismicPortal

All 6 web services are built on standards (mostly FDSN and QuakeML) or on an extension of standards.

- **Fdsn-event**: web service dedicated to the exchange of all EMSC event data and parameters (origins and arrivals).
- **Flinn-Engdhal lookup**: the service identifies the Flinn-Engdahl region from a geolocalisation entry point.
- **Moment tensors**: web service that allows querying and retrieving all EMSC moment tensors collected in real time.
- **EventID**: the service allows a dynamic mapping of event identifier of seismological institutions that provide fdsn-event service. It concerns identifiers from EMSC, UNID (SeismicPortal), USGS, INGV and ISC.
- **Rupture Models**: the web service allows to recover all rupture models from the SRCMOD database of M. Mai (which is the database of 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.
- **Testimonies**: this service allows downloading all the felt reports collected from eyewitness during earthquakes. This collection system includes EMSC websites and Lastquake mobile application.

Apart from the FDSN-event web service, all the others are new and are not well known to the scientific community. Without distinguishing services, the Seismic Portal was actively used by 1.8 different users during 2018. Table 10 shows clearly the domination of the FDSN-event service over the others since it represents 97% of all Seismic Portal users. It's interesting to note that 19% comes from Southern America, 17% from Europe and 12% from the US (Table 10 and Figure 23).

Unique IP distribution of Seismic Portal users per service

Services	Unique IP	ratio
Fdsn-event	1782054	97.21%
Seismic Portal Website	66150	3.61%
Wms	11252	0.61%
Felt reports	5478	0.30%
Moment tensor	5450	0.30%
Near Real Time	2760	0.15%
Eventid	777	0.04%
Rupture model	396	0.02%
FE-region	134	0.01%
Internal	184	0.01%

Unique IP distribution of Seismic Portal users per country (10 first)

Counties	Unique IP	ratio
USA	225817	12.32%
Brazil	173973	9.49%
Italy	133395	7.28%
Germany	130046	7.09%
Chili	127858	6.97%
Indonesia	97915	5.34%
Turkey	81905	4.47%
India	55924	3.05%
Mexico	55346	3.02%
Spain	54077	2.95%

Table 10: Seismic Portal traffic statistics in 2018 per service (left) and per country (right) for the whole year. Wms service is a tile server designed to be used internally by the Seismic Portal. However this service seems to be used by others!

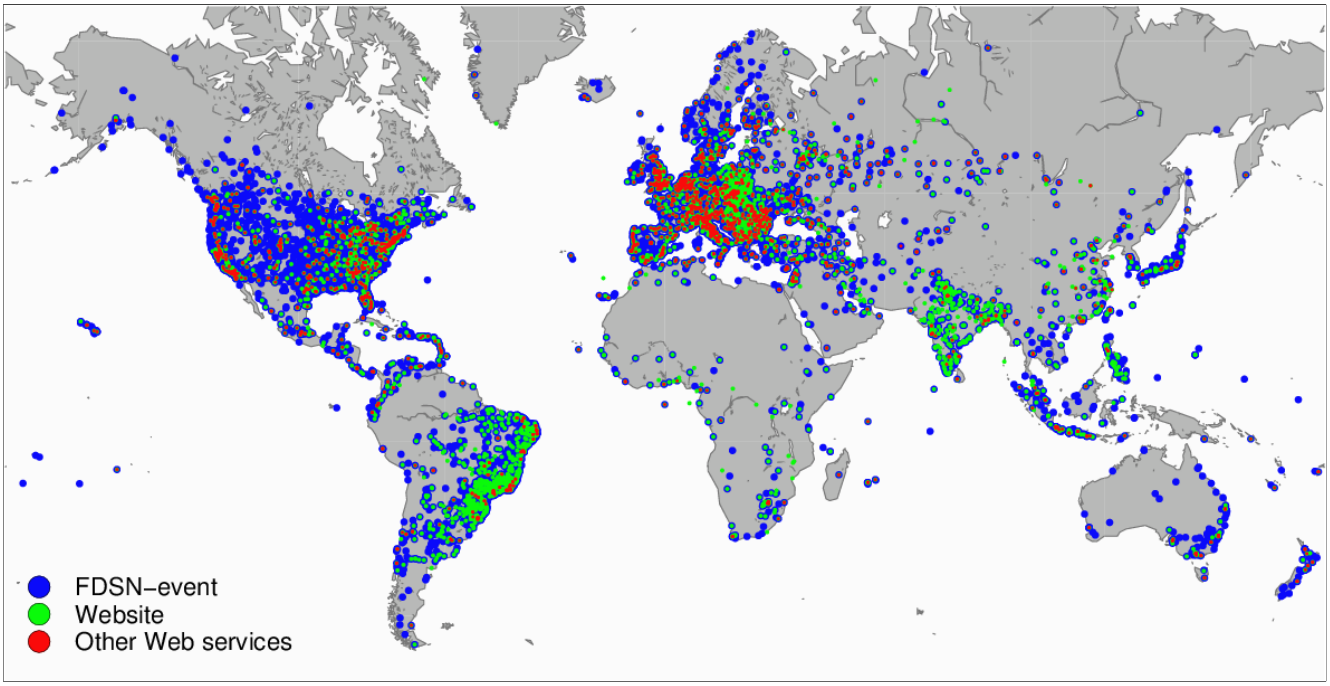


Figure 23 : Geolocation of Seismic Portal users in 2018.

In 2018, traffic curves could not be monitored continuously during 4 months (January, February, June and July) because of two upgrades to our F5 load balancer. This server is our main gateway to all EMSC websites and its logs are used to generate the statistic logs.

However, the usage of all Seismic Portal services are stables:

- The popularity of the **FDSN-event** is quite stable with more than 10000 unique users per day in 2018 and this corresponds to an average of almost 20 million hits per month. The clear increase observed at the end of 2016 is probably associated to the intense seismic activity in Central Italy following the Amatrice earthquake on August 24th (Figure 24).

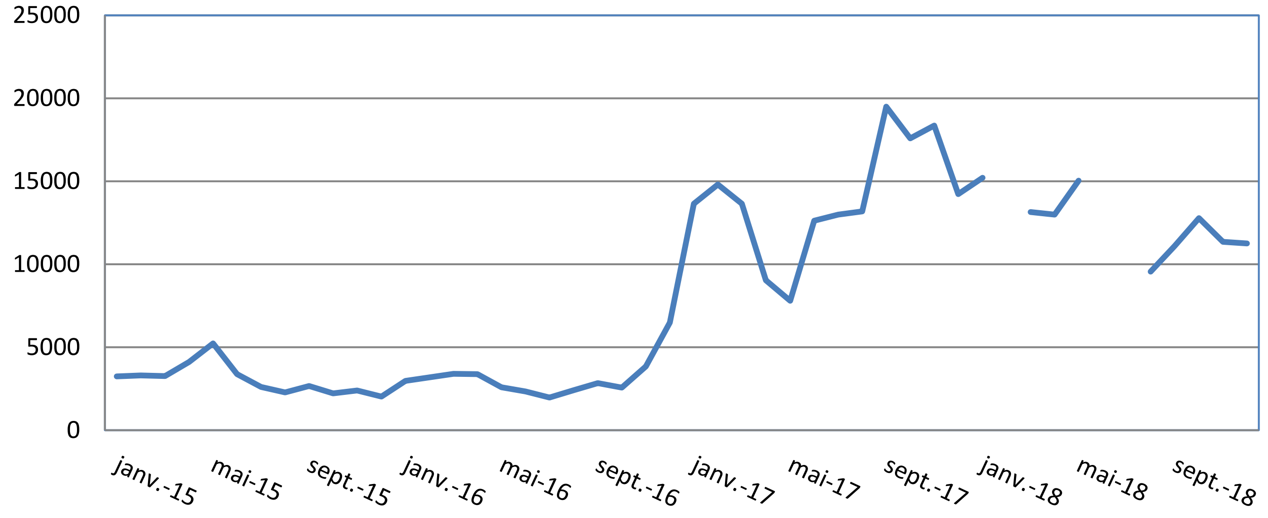


Figure 24 : Unique IP address per month of FDSN-event service since 2010

- **All other services** were released at the end of 2017 and their traffic is 2 orders of magnitude less important (Figure 25) and we have between 10 and 100 unique users per day. We can easily explain this observation: these services are new and they concern only the community of seismologists. Whereas the FDSN-event service is more useful for general purposes and is probably used by other mobile applications.

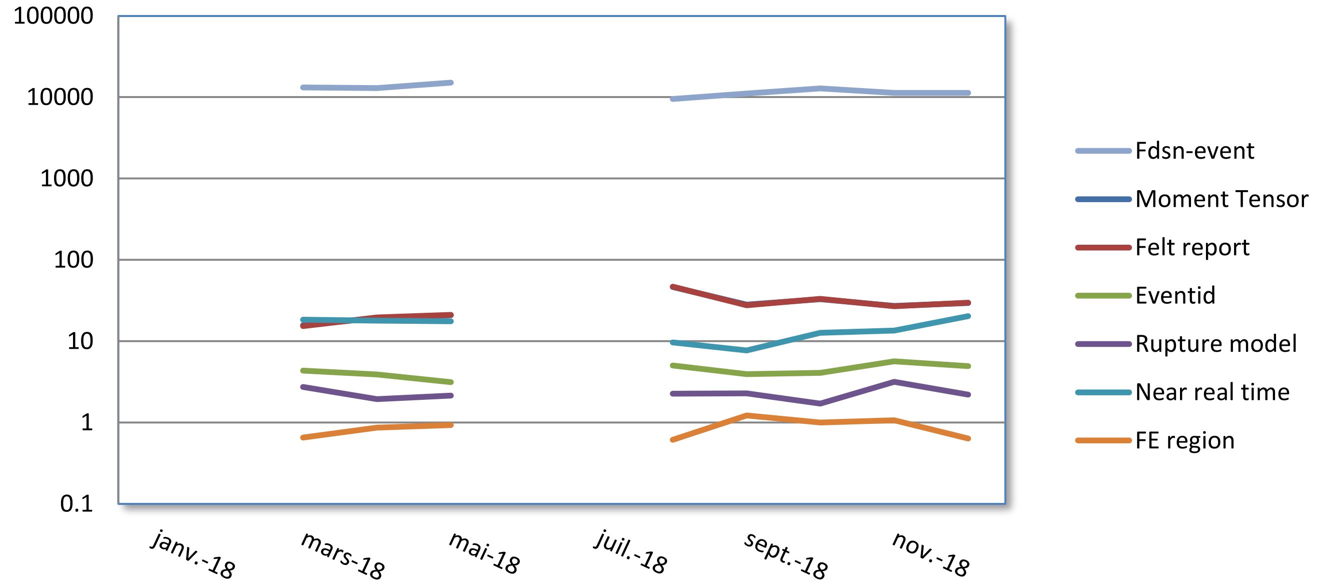


Figure 25: Traffic of Seismic Portal web services. The traffic is measured by counting unique IP address of users.

II.6.3 HMB COMMUNICATION SYSTEM

Within the EPOS project, the EMSC is testing and using a new communication system called HMB. HMB is the acronym for HttpMsgBus which is a general-purpose http-based message bus developed by GFZ[9]. This messaging service uses the classical TCP port 80, widely open on networked computers (Figure 26).

[9] http://doi.org/10.5880/GFZ.2.4.2016.001

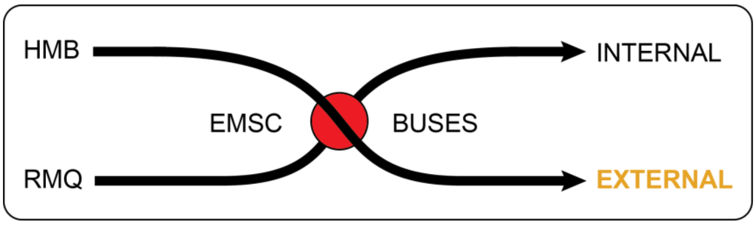


Figure 26: EMSC use two buses for its real-time activities. The RabbitMQ bus for internal communication and the HMB messaging service to communicate to the external.

One current challenge for the EMSC is to modernize data exchange with its members. Email exchange is being progressively removed in favor of new technologies such as HMB bus communication (faster and more robust). Simultaneously, the EMSC has started to disseminate real-time QuakeML files produced by the EMSC data centre through the HMB channel. This new standardized way of exchanging data offers the possibility to deliver the same information, at the same time, to all Seismological Institutes.

Since 2017, HMB has been used in the EMSC data collection system with the GFZ, KAN and NOA institutes. We encourage others to use this system but it has not yet replaced emails… It is also being integrated into Seiscomp3 although this is not yet completely documented.

II.6.4 TRAFFIC SUMMARY

Daily unique users												
Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**year-year change**
Desktop website	11,440	16,856	32,043	46,406	47,452	37,502	35,862	32,551	34,552	35,289	33,600	-5%
Mobile website	*NA*	*NA*	*NA*	3,084	5,581	5,915	9,161	13,999	20,672	21,000	18,000	-14%
***LastQuake* App**	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	1,296	4,573	7,964	11,323	13,941	+23%
Twitter (followers)	*NA*	*NA*	*NA*	*NA*	*2,701*	*3,485*	0	18,541	41,550	74,600	90,000	+37%
Add-ons	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	950	727	743	824	+11%
FDSN webservice	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	3,180	3,057	3,172	4,900	5,000	+2%
Other services (RSS…)	212	615	1,917	2,670	4,173	5,669	2,031	271	205	4,850	3,400	-30%
Total	11,652	17,471	33,960	52,160	59,907	52,571	51,530	73,942	108,842	152,705	176,765	+16%

Table 11: Change in the number of daily unique users of EMSC real time services over the last 10 years. We choose to count separately Twitter views. Red percentage is a decrease and blue an increase from last year.

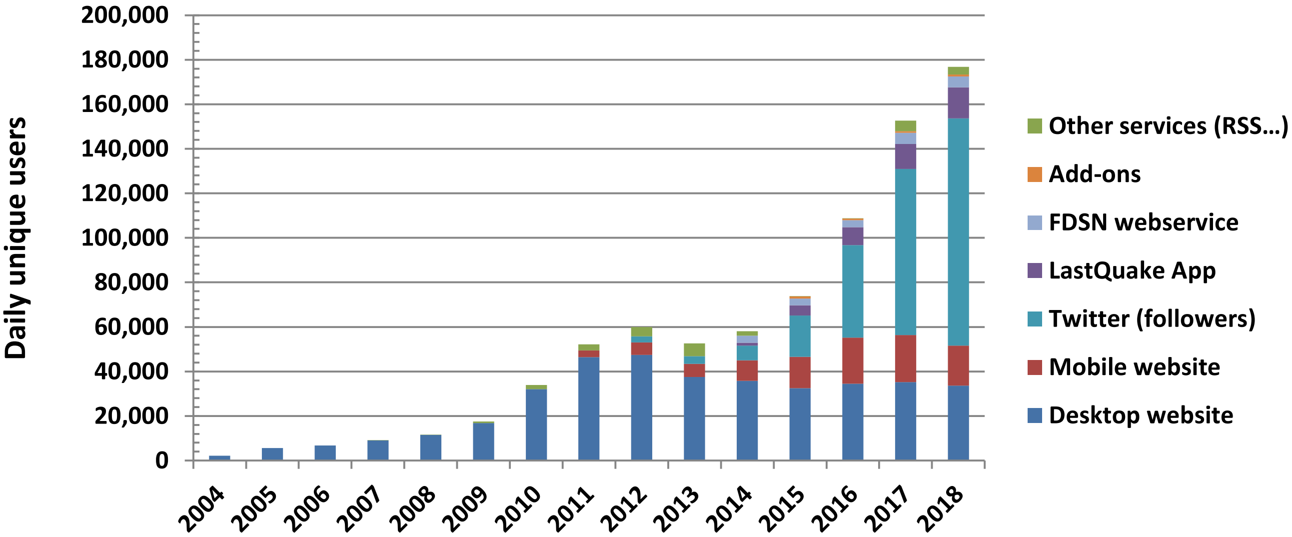


Figure 27: Change in the daily use of EMSC real time services since 2004. "*Other services*" stands for RSS feeds, Search and export data, etc.

Total number of users								
Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**year-year change**
Active Apps (Android)	*NA*	*NA*	11,129	58,888	141,318	168261	216232	+29%
Active Apps (iOS)	*NA*	*NA*	4,563	27,081	50,175	97293	138664	+43%
Total active Apps	*NA*	*NA*	**15,692**	**85,969**	**191,493**	**265,554**	**354,896**	+34%
Twitter @LastQuake	*2,701*	*3,485*	5,877	15,898	34,878	63,200	88,000	+39%
Twitter AllQuakes (@emsc)	*NA*	*NA*	697	2,643	6,672	11,400	14,000	+23%
Add-ons (LastQuake+ AllQuakes)	*NA*	*NA*	*NA*	950	730	743	824	+11%
Facebook fans	*NA*	10,971	14,246	17,077	21,000	24432	27000	+11%
Total	**2,701**	**14,456**	**36,512**	**122,537**	**254,773**	**365,329**	**484,720**	+33%

Table 12: Total numbers of users of LastQuake smartphone App, browser add-ons, Twitter and Facebook.

III CITIZEN SEISMOLOGY IN MAYOTTE

Since 10th May 2018, a series of earthquakes has hit Mayotte Island, and they have not yet stopped. This seismic activity is very unusual in the area and has left not only the citizens, but also the authorities and the scientific community puzzled. Due to the bad seismic station coverage in the region, events of smaller magnitudes (M<4) are not collected in real time by EMSC and were not diffused by any other seismological center.

Among the population, seismic risk culture was very low as people were not used to earthquakes. Since the seismic sequence is close to the island, the population feels many events, even small ones, yet they had difficulties to find information due to the lack of seismic data and communication failures from both scientific institutions and local authorities. In addition to the information shortage, the socio-cultural context (including religious beleifs and political situation) led to the rise of a distrustful atmosphere and of conspiracy theories in Mayotte. This appeared clearly through the local newspapers, comments on social media and reports from eyewitnesses.

Since the beginning of the sequence, we have collected 144 seismic events and 15 of them have a magnitude greater than M5 (Figure 28). However since the origins were not diffused automatically, we could only report main events even though the BRGM did detect a lot of small events (<M4). In June 2018, there were 2991 local users of LastQuake which represented 1% of the local population. The high number of reports (14800 felt reports and 5731 comments) expresses the overall anxiety of the population regarding this seismic sequence (Figure 29 and Figure 30).

For more details on the sociological study of this case, you can read the article on the EGU blogs :

https://blogs.egu.eu/divisions/sm/2019/03/08/taking-into-account-the-cultural-context-to-improve-scientific-communication-lessons-learned-from-earthquakes-in-mayotte/

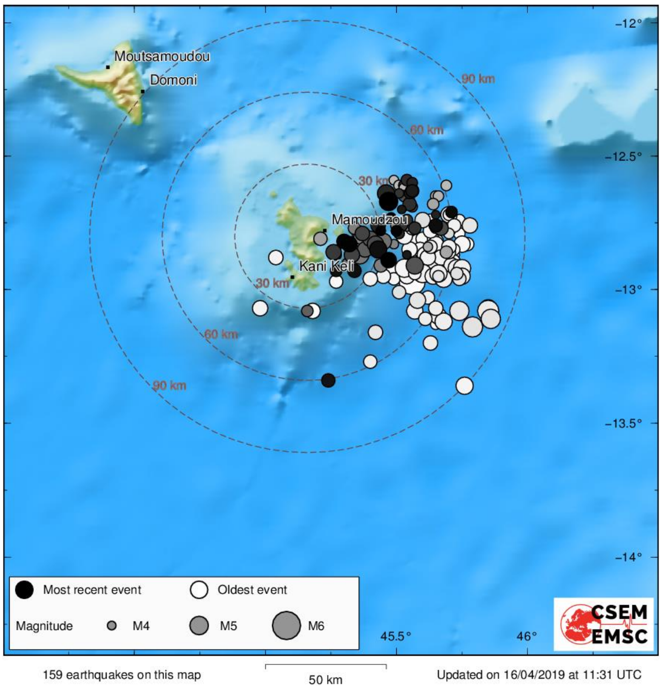


Figure 28: Spatial distribution of earthquakes near Mayotte between May 2018 and April 2019.

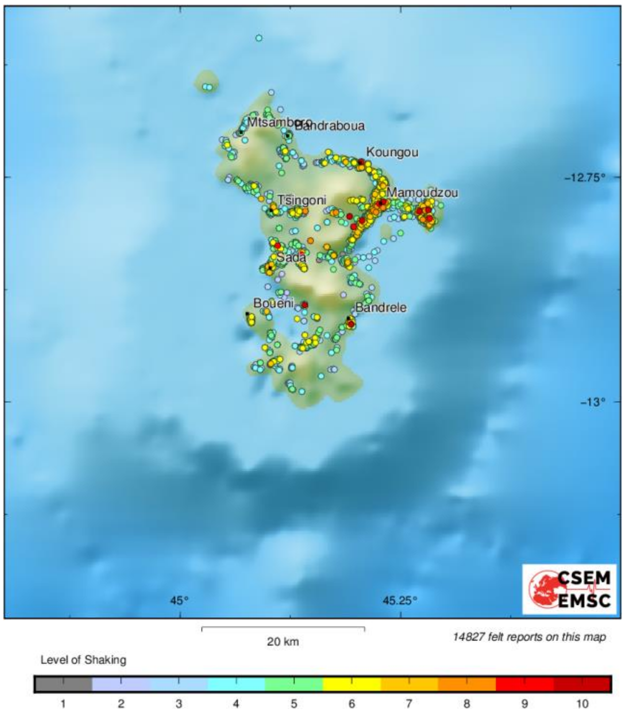


Figure 29: Distribution of 14827 felt reports collected in Mayotte main island since the beginning of the sequence.

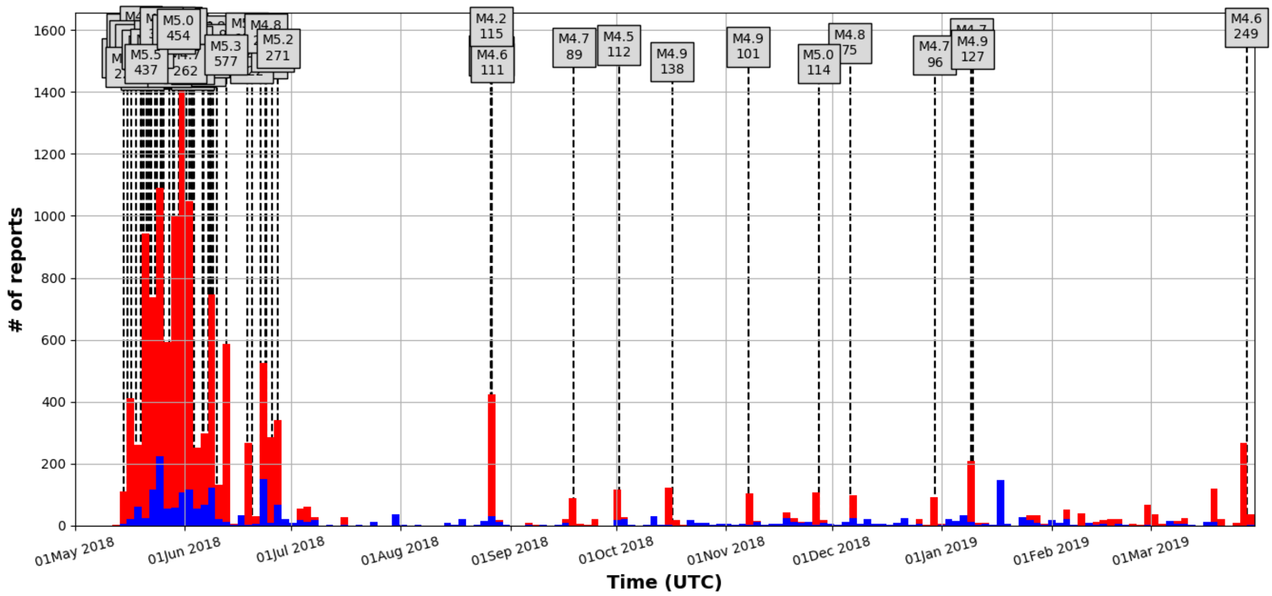


Figure 30: Time distribution of the felt reports collected in Mayotte between May 2018 and April 2019. One bin represents 50 hours. **Red bars** correspond to felt reports associated to a seismic events collected at EMSC. **Blue bars** are non-associated felt reports.

IV Recent developments

IV.1 Noid : felt event without seismic confirmation

The objective of this task was to integrate into LastQuake felt seismic events without requiring seismic confirmation. In particular, we wanted these events to be display in the event list on our LastQuake app while avoiding misinterpretation by the public.

The evolutions of the EMSC system have considerably accelerated the detection of felt seismic events thanks to traffic monitoring. These detections have become faster than the arrival of the actual seismic information, and this is true everywhere in the world. In some areas of the world where the EMSC is popular, we are in a position to detect low magnitude seismic events that may even be below the detection thresholds of sensor networks. Hence it can happen that earthquakes are detected by our system that are never confirmed by seismic data. With the priority to publish only events that were seismically confirmed, the EMSC did not publish any info on these events, except on the Twitter account or on a banner that was temporarily shown on the websites. This choice to avoid publication of any information, even if felt reports has been collected, proved to be problematic particularly in the case of Mayotte and led to rumors of hidden information (see in Mayotte, section 0).

To fulfill the needs of citizens, the EMSC has now incorporated these felt seismic events not confirmed by seismic data into its publication system, including the LastQuake application. Since this new system, called NOID, is at the frontier between the traffic monitoring system, the Felt report collection system and the real-time seismic system, it was a challenging development (Figure 31).

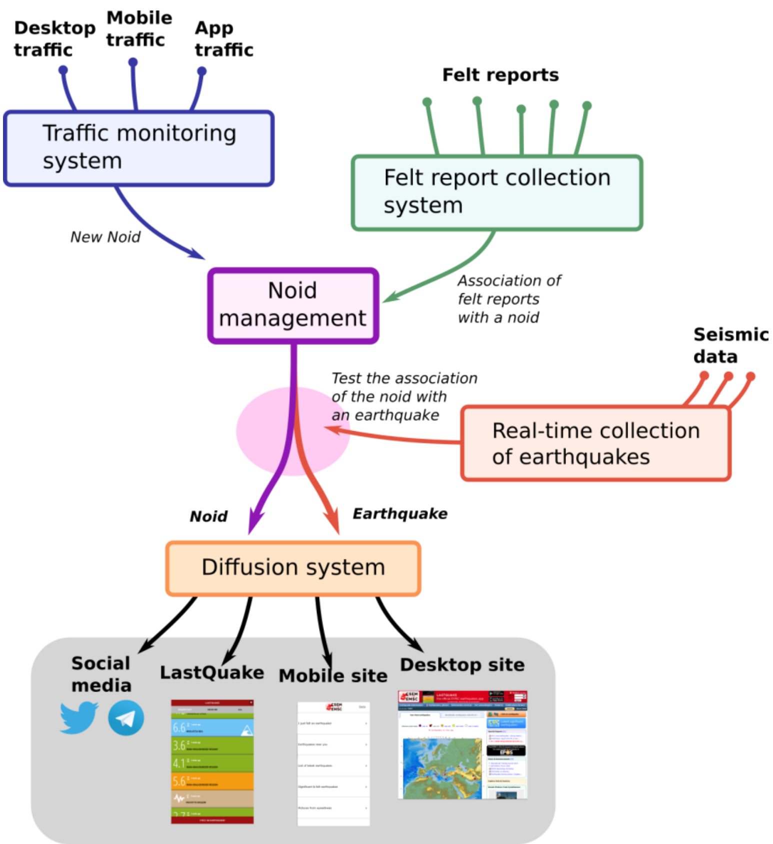


Figure 31: Integration of the NOID into EMSC systems

The creation of NOID is triggered by a traffic peak.

- At the very beginning there is a **banner** to inform EMSC users that something has happened.
- Then, with the collection of felt reports, the NOID is promoted to **significant** status and appears in the list of significant events in LastQuake.
- Once this NOID has been **associated** to seismic data, it becomes a normal felt and confirmed seismic event.

Figure 32 summarises these steps.

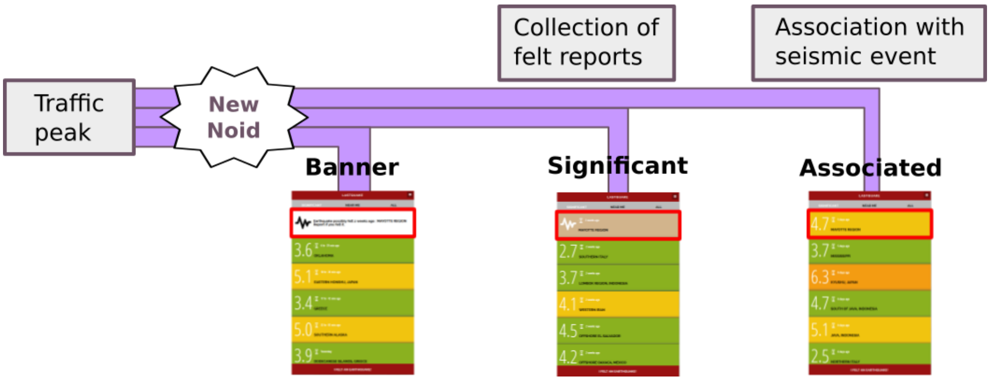
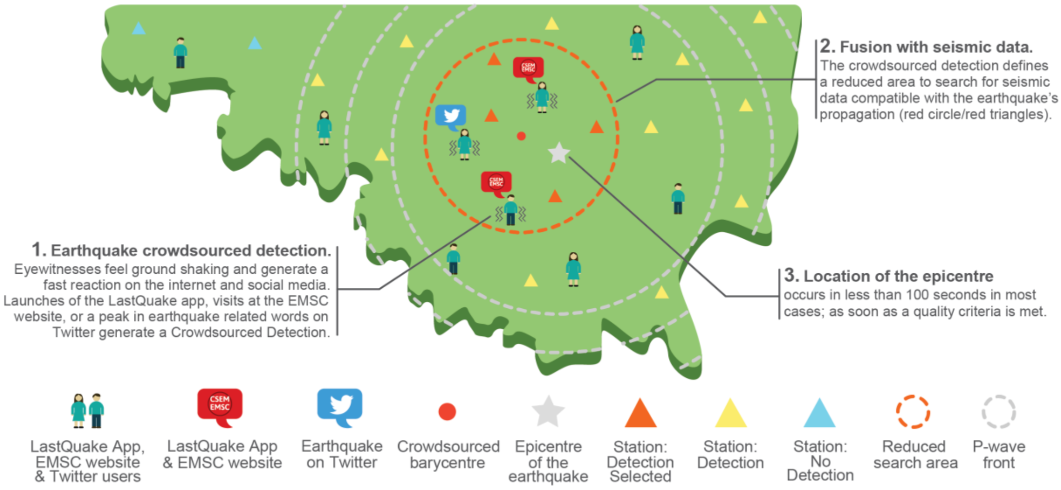


Figure 32: NOID history. From a banner to an associated status.

IV.2 CsLoc



In 2018, the EMSC developed a "Crowdseeded seismic Location" system in collaboration with Istvan Bondar and colleagues at GFZ. The system relies on the traffic peak detections of eyewitness activity on the internet (section II5.2) and the observation that they very often occur several minutes before the EMSC receives any earthquake parameters. Hence the CsLoc system makes its own analysis using the crowdsourced peak as a starting point to perform an analysis within seismic arrivals data from the GEOFON network. The system runs in real time but was tested retroactively on 2016 and 2017 datasets and shown to accelerate the availability of preliminary earthquake epicenters by several minutes (for these felt earthquakes). This research has been published in Science Advances (DOI: 10.1126/sciadv.aau9824) and was subsequently covered by articles in the Technology Review, Le Monde, Le Figaro, Spiegel and Le Temps newspapers! CsLoc is currently being further developed and should be put into production in 2019.

IV.3 UPDATE OF THE CORE REAL TIME SYSTEM

The Core Real Time System (RTS) is the IT software infrastructure that processes the seismological data received from contributors. It includes the reception, identification and parsing of the data. Then, the system determines if it's a new event or an update, merges the data and then updates the app, the website, twitter. The RTS is also in charge of determining whether or not the seismologist on call needs to be alerted.

In recent months, the EMSC has initiated an upgrade of the Real Time System software along with an upgrade of its servers to face the constant increase in data received. Our backup system, in Madrid, will be also updated.

The current RTS represent more than 1100 scripts, configuration files and binaries developed in the past 30 years. It used the languages C, C++, Pro/C, Fortran, GMT, shell scripts (csh, bash, ksh), java, and python languages, and both Oracle and postgresql databases which makes the system very hard to maintain.

So far:

- New python libraries have been developed to ease the data processing.
- The new version of the RTS has been placed on a private GitLab (a computer code version control system) which helps us to collaborate and to keep track of all our development. It is also very useful if we need to reinstall the system on a new machine.
- An update of all contributors is undergoing (contact list, format, moment tensor available…).
- A supervisor control system is under development to improve system reliability.

V CONCLUSIONS

- Within EPOS, EMSC has developed extensively the availability of data access via webservices. In addition to the FDSN-event web service, 6 other services have been released that give Real-Time notification, Moment tensors, Felt reports, Flinn-Engdhal region, EventID mapping and rupture models. These are new and haven't found extensive adoption yet but they are operational. Moreover they are integrated with the EPOS portal and should gain visibility over the coming months. HMB is also integrated with the EMSC core system and is transferring data to this system from GFZ, NOA and KAN. We hope other institutes to follow their lead.

- To improve user experience, we are going to release a new mobile website in order to facilitate better collection of felt reports. The design will be very similar to that of the LastQuake app since that has been a success and in order to improve consistency between our publication channels.

- We have a future plan to extend our diagrammatic thumbnails to request building floor position information from eyewitness. The aim will be to improve our collection of macroseismic information.

- A large task initiated at the end of 2018 is an update to the EMSC core system used to collect and process seismic data. This is an important project whose main goals are to allow the deployment of a new and up-to-date system at IGN and to enhance future development of our systems.

- The EMSC is entering a period of consolidation for all aspects of our systems, from hardware to data collection. Thanks to the funding of the LDG/CEA: an update of our production servers and our network infrastructure is ongoing. This will lead to improved redundancy, optimization of data collection and more efficient data processing. Allowing us to focus our attention on data quality and operation oversight.

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VII Annexes

VII.1 Annex : Contributor Agencies

Network	Institut	Data types	Country
AUST	Geoscience Australia	O	Australia
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 (EarlyBird system), Edinburgh	OP	United-Kingdom
BRGM	Bureau de Recherches Géologiques et Minières	O	France
BUC	National Institute for Earth Physics, Bucharest	OP	Romania
BUD	MTA CSFK GGI Kövesligethy Radó Seismological Observatory	OP	Hungary
CN	Canadian National Seismic Network (CNSN) BB stations	O	Canada
CNRM	Centre National de la Recherche Scientifique et Technique	OP	Morocco
CPPT	Centre Polynésien de Prévention des Tsunamis	M	France
CRAA	Centre de Recherche en Astronomie, Astrophysique et Géophysique, Algiers	OP	Algeria
CWB	Central Weather Bureau	OP	Chinese Taipei
CYP	Geological Survey Department, Nicosia	OP	Cyprus
DDA	Disaster and Emergency Management Presidency, Earthquake Department, Ankara	OPM	Turkey
DJA	Badan Meteorologi, Klimatologi dan Geofisika	O	Indonesia
DJI	Observatoire Géophysique d'Arta, Arta	OP	Djibouti
GFU	Geophysical Institute of Academy of Sciences, Prague	OP	Czech Republic
GFZ	GeoForschungsZentrum (GEOFON), Potsdam	OPAM	Germany
GII	Seismology Division, Geophysical Institute of Israel, Tel Aviv	OP	Israel
GNS	GeoNet, GNS Science	OP	New Zealand
GRAL	National Center for Geophysical Research, Beirut	OP	Lebanon
GSRC	Geophysical Survey. Russian Academy of Sciences, Obninsk	OP	Russia
GUC	Departamento de Geofisica, Universidad de Chile, Santiago	OP	Chile
GCMT	Seismological group of Harvard University	M	USA
HSNC	Technological Educational Institute of Crete, Seismological Network of Crete	P	Greece
ICC	Institut Cartogràfic i Geològic 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	OPAM	Italy
INMT	Institut National de la Météorologie, Tunis	OP	Tunisia
INSN	Irish National Seismic Network	OP	Ireland
IPEC	Institute of Physics of the Earth, Brno	OP	Czech Republic
IPGP	Institut de Physique du Globe de Paris	M	France
ISN	Iraqi Meteorological Organization and Seismology, Bagdad	OP	Iraq
KAN	Kandilli Observatory and Earthquake Research Institute, Istanbul	OPM	Turkey
KIS	Kyrgyz Institute of Seismology, KIS (KIS)	OPA	Kyrgyzstan
KNMI	Koninklijk Nederlands Meteorologish Instituut	O	The Netherlands
LDG	Laboratoire de Détection et de Géophysique, Bruyères-le-Châtel	OPA	France
LED	Landsamt für Geologie, Rohstoffe und Bergbau, Baden Württemberg	OP	Germany
LIM	Instituto Geofisico del Peru	O	Peru
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	OPAM	Spain

MCSM	Ukrainian NDC, Main Center of Special Monitoring, Kiev	P	Ukraine
MLT	Malta Seismic Network, Seismic Monitoring and Research Unit (SMRU), University of Malta	OPA	Malta
MNSN	Malaysian Meteorological Department, Petaling Jaya, Selangor	O	Malaysia
MOLD	Institute of Geophysics and Geology, Chisinau	P	Moldova
MON	Direction de l'Environnement, de l'Urbanisme et de la Construction	O	Monaco
MSO	Montenegro Seismological Observatory, Podgorica	OPA	Montenegro
NCMS	National Center of Meteorology and Seismology, Abu Dhabi	O	United Arab Emirates
NDI	India Meteorological Department, New Delhi	O	India
NEIC	USGS/NEIC, Golden, Colorado	OPAM	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	OPM	Greece
NRIA	National Research Institute of Astronomy and Geophysics, Cairo	OPM	Egypt
NSC	National Seismological Centre, Department of Mines and Geology, Kathmandu	O	Nepal
NSNA	Instituto Nacional de Prevención Sísmica (INPRES)	O	Argentina
NSSP	National Survey of Seismic Protection, Yerevan	OP	Armenia
OCA	GeoAzur, Universite de Nice Sophia-Antipolis, Valbonne	OPA	France
OGS	Osservatorio Geofisico Sperimentale, Trieste	OP	Italy
PDA	Instituto de Meteorologia, Azores University, Ponta Delgada, Azores	OP	Portugal
PIVS	Philippine Inst. of Volcanology and Seismology, Quezon City	O	Philippines
QUI	Escuela Politecnica Nacional, Quito	O	Ecuador
RNS	Réseau National de Surveillance Sismique, Strasbourg	OP	France
RSNC	Red Sísmica Nacional de Colombia, INGEOMINAS, Bogotá	O	Colombia
RSSC	Azerbaijan National Academy of Sciences, Baku	OP	Azerbaijan
SASN	South African Seismological Network	OP	South Africa
SED	Swiss Seismological Service, Zurich	OPM	Switzerland
SEO	Korean Meteorological Administration	O	South Korea
SIK	Seismological Institute of Kosovo	OP	Kosovo
SKO	Seismological Observatory of Skopje, Skopje	OPA	FYROM
SNET	Servicio Nacional de Estudios Territoriales (SNET El Salvador)	O	El Salvador
SOF	Bulgarian Academy of Science, Bulgarian Academy of Sciences, Sofia	OP	Bulgaria
SORS	Republic Hydrometeorological Institute, Banja Luka	OP	Bosnia & Herzegov.
THE	Department of Geophysics, University of Thessaloniki, Thessaloniki	OPAM	Greece
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
TRN	University of the West Indies, St. Augustine, Trinidad	OP	Trinidad and Tobago
TSB	Thailand Seismological Bureau	O	Thailand
UASD	Universidad Autonoma de Santo Domingo	O	Santo domingo
UCC	Royal Observatory of Belgium, Brussels	OP	Belgium
UCR	Seccion de Sismología, Universidad de Costa Rica, San José	O	Costa Rica
UNM	Servicio Sismologico Nacional, Instituto de Geofisica, UNAM	O	Mexico
UPSL	University of Patras, Seismological Laboratory, Patras	OPM	Greece
VEN	Fundación Venezolana de Investigaciones Sismológicas	O	Venezuela
VAO	Instituto de Astronomia, Geofisica e Ciências Atmosféricas, Univ. de São Paulo	OPA	Brazil
ZAG	Seismological Survey, University of Zagreb, Zagreb	OP	Croatia
ZAMG	ZentralAnstalt für Meteorologie und Geodynamik, Vienna	OP	Austria

Table 13: Real time data providers in 2018. Seismological networks that have provided real time parametric data to EMSC. Legends: Data type: O: Source parameters; P: Phase pickings; A: Amplitudes; M:Moment tensors.

VII.2 ANNEX : AGENCIES PROVIDING MOMENT TENSORS SOLUTIONS

The following agencies have been providing moment tensors solutions to the EMSC in 2018:

AUTH: Department of Geophysics, University of Thessaloniki, Thessaloniki, Greece

CPPT: Centre Polynésien de Prévention des Tsunamis, French Polynesia

ERD: Earthquake Research Department, Ankara, Turkey

GFZ: Potsdam, Germany

GCMT: Seismological group of Columbia University.

IGN: Instituto Geografico Nacional, Madrid, Spain

INGV: Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy

IPGP: Institut de Physique du Globe de 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

VII.3 ANNEX : SPECIAL WEB PAGES IN 2018

In 2018, the following special web pages have been published:

- Earthquake sequence in Mayotte since May the 13th 2018
- Report on the M6.8 Greece earthquake
- Preliminary report on the M7.5 Palu earthquake
- Preliminary report one the 2018 Lombok region earthquakes

VII.4 ANNEX : THE REAL TIME INFORMATION SERVICES IN FIGURES

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Earthquake data									
Real time data contributors	64	60	63	66	70	75	88	86	96
Origins received	60,628	78,756	81,828	84,060	92,421	89,954	103,495	122,702	151,276
Contributing Euro-Med stations	1,896	1,996	2,100	2,236	2,415	2,459	2,431	2,603	2,653
Moment tensors solution received	1,303	2,488	2,886	3,024	3,972	3,557	3,438	3,868	3,703
Earthquakes with moment tensors	701	1,037	1,198	1,230	2,052	1,910	1,612	1,348	1,299
Worldwide earthquakes	17,540	24,237	32,944	36,181	42,530	39,471	49,731	52,459	75,776
Euro-Med earthquakes	12,189	18,049	24,771	24,908	22,168	18,674	18,800	23,278	14,533
Earthquake Notification Service (ENS)									
Users	8,644	9,667	10,862	11,461	11,628	11,888	11,881	11,862	12,020
Disseminated notifications	122	137	152	156	208	119	131	151	170
Median prelim. publication time (Euro-Med)	9.1	7.6	7	7	6	4.2	4.3	4	6
Median alert triggering time (Euro-Med)	7.5	7	7	6	6	3.5	3.7	3	3
Median dissemination time (Euro-Med)	18	18	17	16	16	14.5	18.1	15	15
Average daily unique users									
Desktop website	32,043	46,406	47,452	37,502	35,862	32,551	34,552	35,289	33,600
Mobile website	*NA*	3,084	5,581	5,915	9,161	13,999	20,672	21,000	18,000
***LastQuake* App**	*NA*	*NA*	*NA*	*NA*	1,296	4,573	7,963	11,323	13,941
Twitter services (LastQuake & AllQuakes)	*NA*	*NA*	*NA*	3,485	6,028	18,541	41,550	74,600	102,000
Browser add-ons (LastQuake & AllQuakes)	*NA*	*NA*	*NA*	*NA*	948	950	727	743	824
FDSN webservice	*NA*	*NA*	*NA*	*NA*	3180	3,057	3,172	4,900	5,000
Other services (ex: RSS)	1,917	620	2,086	3,655	3,043	271	205	4,850	3,400
TOTAL	**33,960**	**50,110**	**55,119**	**50,557**	**59,518**	**73,942**	**108,841**	**152,705**	**176,765**
Significant earthquakes detected	*NA*	57	104	288	998	1,411	1,910	2,223	2051
Collected testimonies									
Via the desktop website	2,400	3,831	11,909	14,909	16,056	16,506	15,366	8782	12332
Via the mobile website	*NA*	783	2,235	2,991	6,491	16,581	23,134	22562	27818
Via LastQuake application	*NA*	*NA*	*NA*	*NA*	3,314	22,927	53,138	65293	80324
TOTAL	**2,400**	**4,614**	**14,144**	**17,900**	**25,861**	**56,014**	**91,638**	**96637**	**120474**
Collected comments									
Via the desktop website	547	1,299	3,187	3,897	4,905	5,304	4,522	2,533	3,609
Via the mobile website	*NA*	315	813	1,197	2,818	7,425	9,871	7,847	9,094
Via LastQuake application	*NA*	*NA*	*NA*	*NA*	1,536	12,322	25,412	27,554	37,434
TOTAL	**547**	**1,614**	**4,000**	**5,094**	**9,259**	**25,051**	**39,805**	**37,934**	**50,137**
Testimonies with an associated comment	22.8%	35.0%	28.3%	28.5%	35.8%	44.7%	43.4%	39.3%	41.6%
Collected pictures/videos									
Pictures/videos received and published	118	17	156	96	62	145	150	248	229
Earthquakes with associated pictures/videos	6	9	15	12	14	15	28	26	48
***LastQuake* App users**									
Android	*NA*	*NA*	*NA*	*NA*	11,129	58,888	141,318	168261	211947
iOS	*NA*	*NA*	*NA*	*NA*	4,563	27,081	50,175	97293	136124
TOTAL	*NA*	*NA*	*NA*	*NA*	**15,692**	**85,969**	**191,493**	**265,554**	**348,071**
Activity on social networks									
Facebook fans	*NA*	*NA*	*NA*	10,971	14,246	17,077	21,875	24432	26000
Twitter views (per year in million)	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	29.42	48.7	68.1

VII.5 ANNEX : *LASTQUAKE* AND *ALLQUAKES*