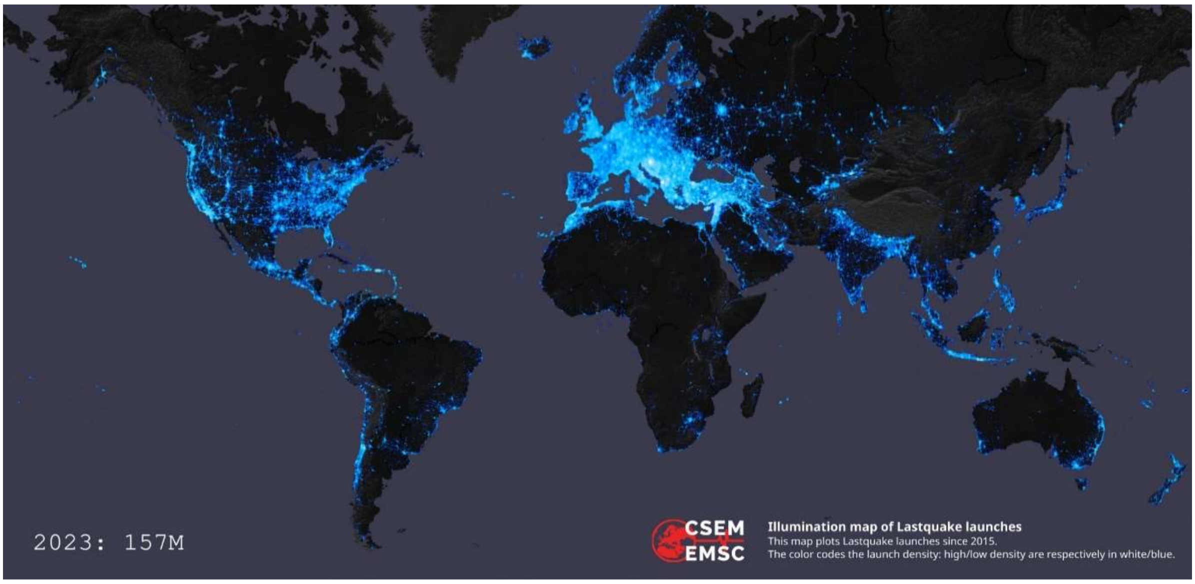
European-Mediterranean Seismological Centre

EMSC 2023 Activity Report



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EMSC is the pillar for seismological products within the European Plate Observing System

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1 Preambule

This is our first annual activity report since 2018. The reason for this long interruption was the renovation of the Real Time Information System (RTS), i.e. the parametric data’s processing system and the renovation of the desktop website, which was released in June 2023. This included, among other things, a new data model, a new location algorithm (iLoc), a change of database system and a more modular and easier to maintain structure. We can also add the upgrade of the FDSN webservice, the development of a new version of LastQuake app, as well as our eponymous bot on X (formerly Twitter), a bot on the Telegram messaging application, not forgetting the time-consuming adaptation of all our tools on X (following the changes to the API access policy) and our search for alternatives (Mastodon, T2, BlueSky...).

With this long overdue upgrade, which has consumed a significant proportion of EMSC's manpower over the last 3-4 years, behind us, it is time to resume the production of our Annual Activity Report. The purpose of this document is not to describe the work carried out, but to illustrate how the data provided by our members and contributors is used, and to define a set of Key Performance Indicators (KPIs) that are useful for monitoring the evolution of service performance over the years, identifying any weaknesses and ensuring that they are addressed. 2023 was a transition year, with two different RTSs operating consecutively. As a result, the KPI may not fully reflect the true impact of the new system. Nevertheless, they will be used as a benchmark in future years.

Please note that the purpose of the report is not to describe how the services work, as their operation is described in the articles in the references, but only to provide as concise an assessment of performance as possible. Therefore, YOUR feedback is essential to ensure that we have not overlooked any aspect and to enable this report to become a standard EMSC product in the future.

2 List of projects and Partners for 2023

In addition to the membership fees and the data shared by contributors (see page 36), the activities of the EMSC have been made possible in 2023 thanks to the support of the following partners and projects.

3 Executive summary

The EMSC's services are based on the data shared by the monitoring networks. The number of data contributors continues to increase, rising from 86 in 2017 to 110, with the result that the number of reported earthquakes rise to more than 100,000 by 2023. Although the location software has been modified to iLoc during the switch to the new Real-Time System (RTS) in June 2023, the principle of not relocating reliable and accurate locations remains unchanged, with 86% of published locations coming directly from a contributor. The first location is published in less than 14 minutes, with a location uncertainty of 2km and a magnitude uncertainty of 0.1 (median values).

The number of felt reports collected in 2023 was 470k with a median collection time of 8 min 30s. A number of studies have recently demonstrated the value of this crowdsourced data for constraining ShakeMaps and rapid impact estimates.

The Earthquake Qualitative Impact Assessment's (EQIA) performance in 2023 confirms the results of previous assessments: that is efficient in identifying damaging and non-damaging earthquakes (99.2% success rate) but that the true extent of damage of large impact earthquakes may not be correctly estimated. The contribution of felt reports to rapid impact assessment (see page 33) seems to outline a clear strategy to address this shortcoming in EQIA.

Visibility to the public was high, with a global number of visits of 10M/month from all seismically active regions of the world and a strong presence on social networks (400k total number of followers, 14.4M views/month). The same applied to our web services for scientists, with an average of 530k requests per day - the vast majority of which were for the FDSN events webservice – consisting of a total of 1.6M users from 221 countries.

4 Introduction

The European-Mediterranean Seismological Centre (EMSC) is a non-profit, non-governmental organisation, hosted by the CEA/LDG (Commissariat à l'Energie Atomique/Laboratoire de Détection Géophysique) with 75 member institutes from 56 countries, that provides rapid information on global earthquakes and their effects thanks to seismic data shared by 110 institutes around the world (Figure 1). Without this sharing of data (mainly parametric data), no services would be possible. The support of the LDG in maintaining operational conditions is essential, as is that of the IGN (Madrid, Spain), which maintains a redundant web page for seismology institutes in the event of technical difficulties at the EMSC (http://www.ign.es/web/resources/sismologia/www/csem/fso.html). These services are yours and we thank you for your support.

These services were created at the request of the seismological community to provide redundancy and back-up for national monitoring services and to overcome their geographical fragmentation. From this point of view, the EMSC's services were in some ways a precursor to the objectives of EPOS (European Plate Observing System), the European research infrastructure for the Solid Earth in which the EMSC acts as the earthquake products pillar of the Thematic Core Service (TCS) "seismology".

The services are used not only by the seismological community but also by the general public (through our websites, LastQuake app and bots on social media). This openness has its disadvantages, in particular the difficulty for the IT infrastructure to manage the violent peaks in traffic generated by widely felt earthquakes, but it also allows for the massive collection of witness observations (felt reports, geo-located imagery), which are themselves becoming essential for rapidly estimating the impact of earthquakes (Figure 1). The list of scientific publications shows that this is a promising area of research.

This report begins with a presentation of the seismic data collected and the characteristics of the seismicity reported, before going on to present the crowdsourced detections, the collection of felt reports, performances of the Earthquake Qualitative Impact Assessment (EQIA) and ending with an analysis of the use of the various services.

All uncertainties are median values.

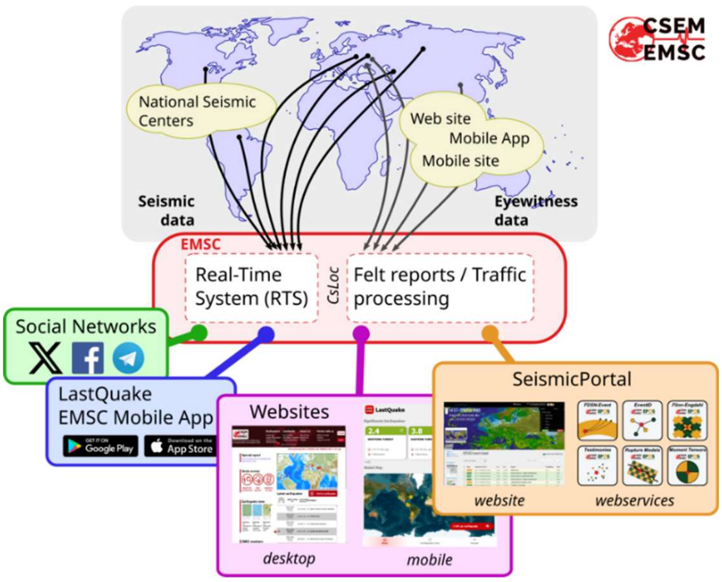

Figure 1 : Schematic representation of the collection and processing of data and the distribution of information and services. The EMSC does not operate any seismological stations; its services are based on seismic data provided by monitoring networks and crowdsourced data from witnesses.

5 Seismic data collection

The values below characterise the parametric data received during 2023 (https://www.emsc-csem.org/Earthquake_data/).

- Number of contributing networks: 110 (see page 36 and https://www.emsc-csem.org/Earthquake_data/contributors.php)
- Number of stations reporting data: 9 282 (Figure 2, Table 1)
- Number of Euro-Med stations 3 672 (Figure 3)
- Number of earthquake origins: 221 540 (Figure 4)
- Number of arrival times: 4.7M
- Moment Tensor solutions: 4 211 for 1 893 earthquakes (Figure 5)

In addition to the parametric data from these 110 data contributors, EMSC has its own implementation of the SeisComp4 monitoring system and a CsLoc implementation (see page 20).

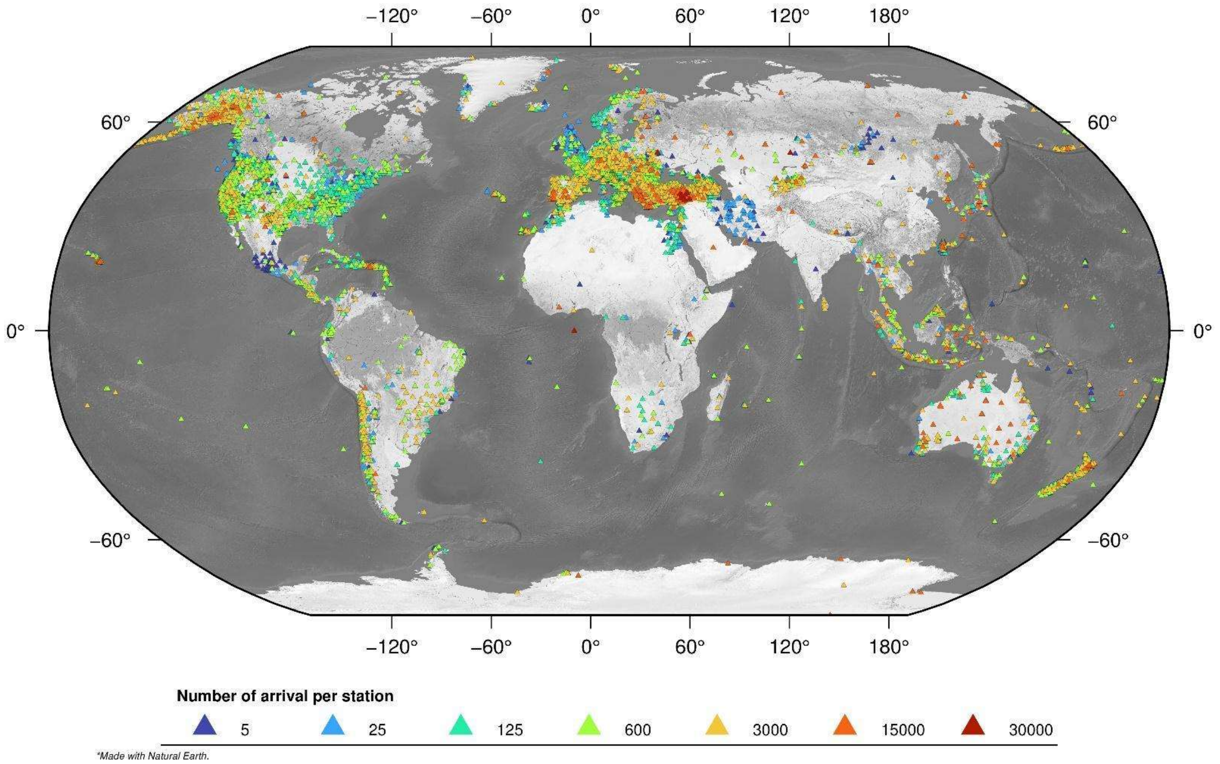

Figure 2 : Map of the 9 282 stations reporting data in 2023. The colour indicates the number of arrival times reported. Six stations, all located in Türkiye, reported more than 20, 000 phases (maximum 24, 000), this number being of course linked to the aftershocks of M 7.8 and M 7.5 in February 2023.

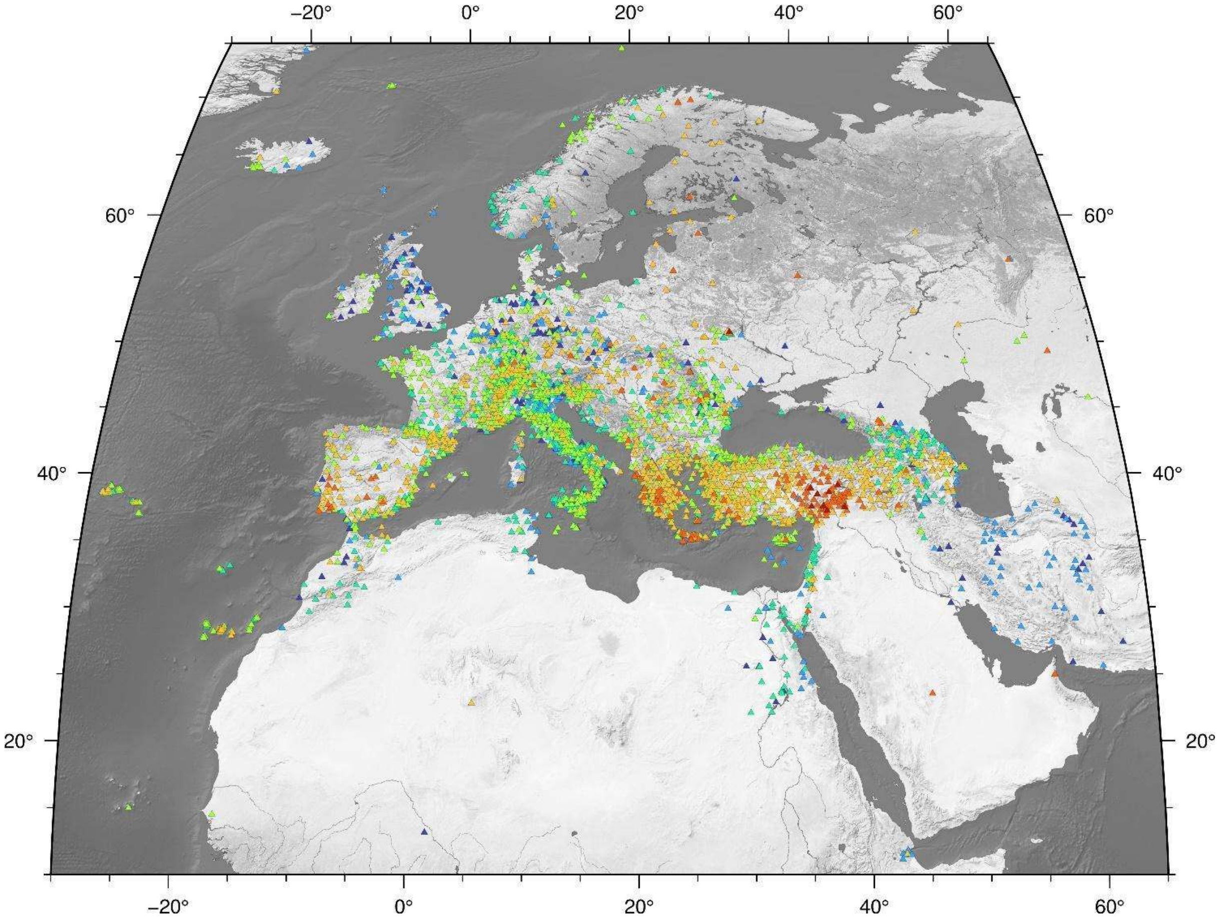

Figure 3 : Map of the 3 672 stations in the Euro-Mediterranean region reporting data in 2023. The colour indicates the number of arrival times reported. Six stations, all located in Türkiye, reported more than 20 000 phases (maximum 24 000), this number being of course linked to the aftershocks of M 7.8 and M 7.5 in February 2023.

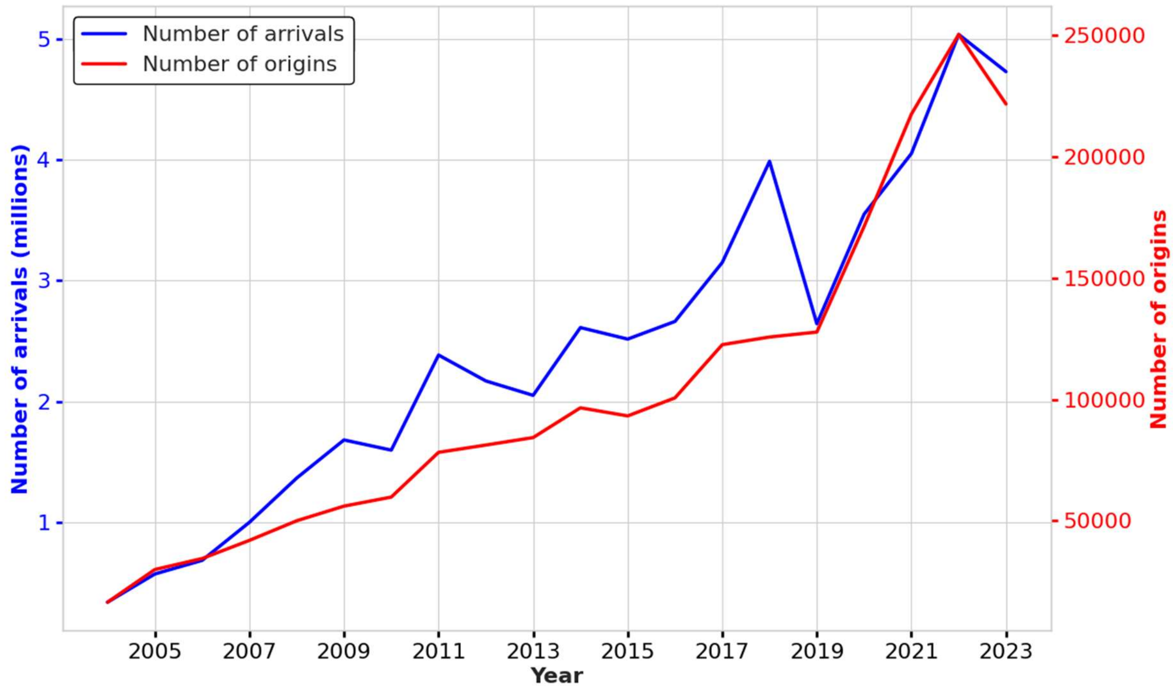

Figure 4 : Temporal evolution of parametric data contributions since 2005. The volume of contributions has doubled since 2018, the date of our last activity report.

Year	2004	2006	2008	2010	2012	2014	2016	2018	2020	2022	2023
Origins (x1k)	16.54	34.51	50.04	59.79	81.20	96.52	100.61	125.66	171.19	250.15	221.54
Arrival times (x1M)	3.41	6.87	13.68	15.98	2.17	2.61	2.66	3.99	3.55	5.03	4.73
Stations	2 923	4 015	3 050	3 468	4 695	6 412	7 162	7 260	8 448	8 771	9 282
Moment Tensor solutions	1 013	1 105	1 328	1 303	2 869	3 972	3 235	2 908	2 889	3 470	4 211
Earthquake with Moment Tensor solution	181	622	725	701	1 198	2 052	1 612	1 610	1 339	1 601	1 893

Table 1 : Temporal evolution of parametric data contributions since 2005. The volume of contributions has doubled since 2018, the date of our last activity report.

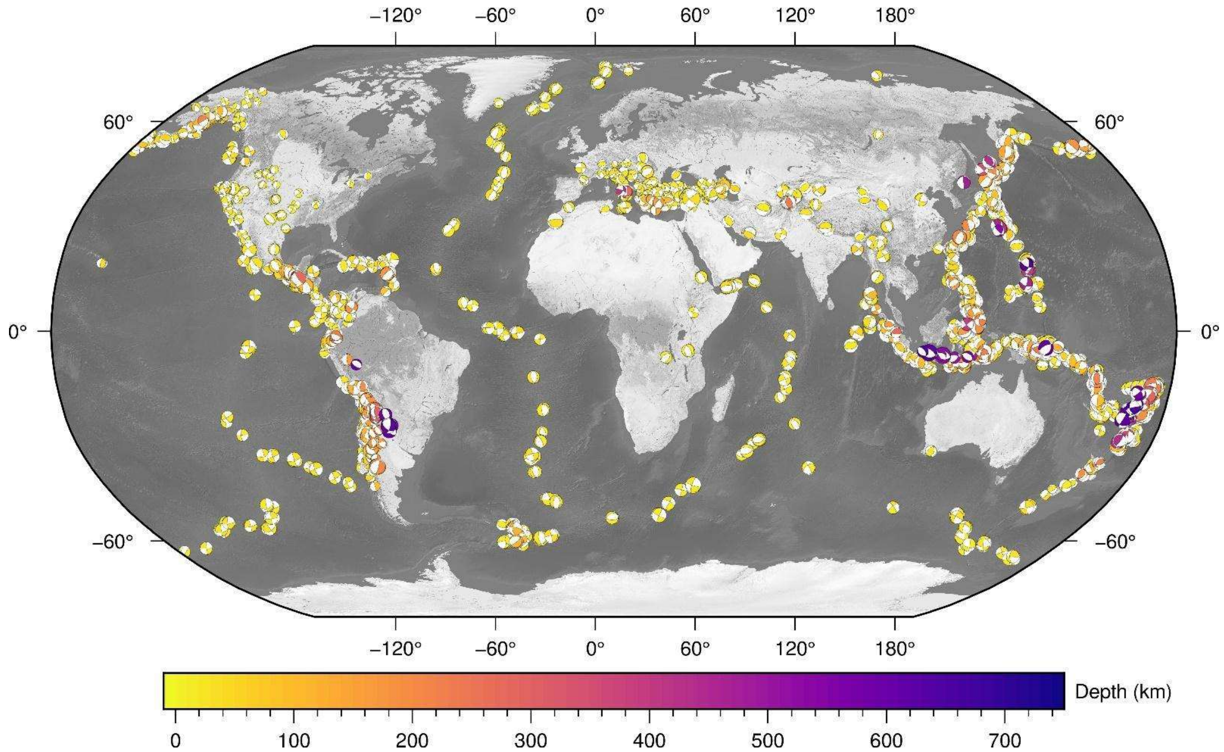

Figure 5 : Map of the 1 893 earthquakes with a Moment Tensor solution.

6 2023 Seismicity characteristics

This paragraph presents the seismicity published for the year 2023.

- 108 522 earthquakes (Figure 6)
- 40 356 earthquakes in the European-Mediterranean region (Figure 7)

There are 4 types of earthquakes locations (Table 2):

- **Reported locations**: earthquake location coming directly from a contributor which is judged to be reliable and accurate (generally small magnitude earthquakes) and is not authoritative.
- **Authoritative locations**: A location which meets the "authoritative" quality criteria – based on the azimuthal coverage within 250km epicentral distance- (Bossu and Mazet-Roux, 2012[1]). Like reported locations, authoritative ones are generally that of the local institute.
- **Data Selected Locations**: Earthquake reported by several institutions. None of the reported locations meets the authoritative criteria. However, the criteria are met by merging data from several contributors.
- **Merged locations**: Earthquake reported by several institutions, none of which are authoritative and no "data selected location" is available. Location is recomputed by the EMSC using iLoc software using available data

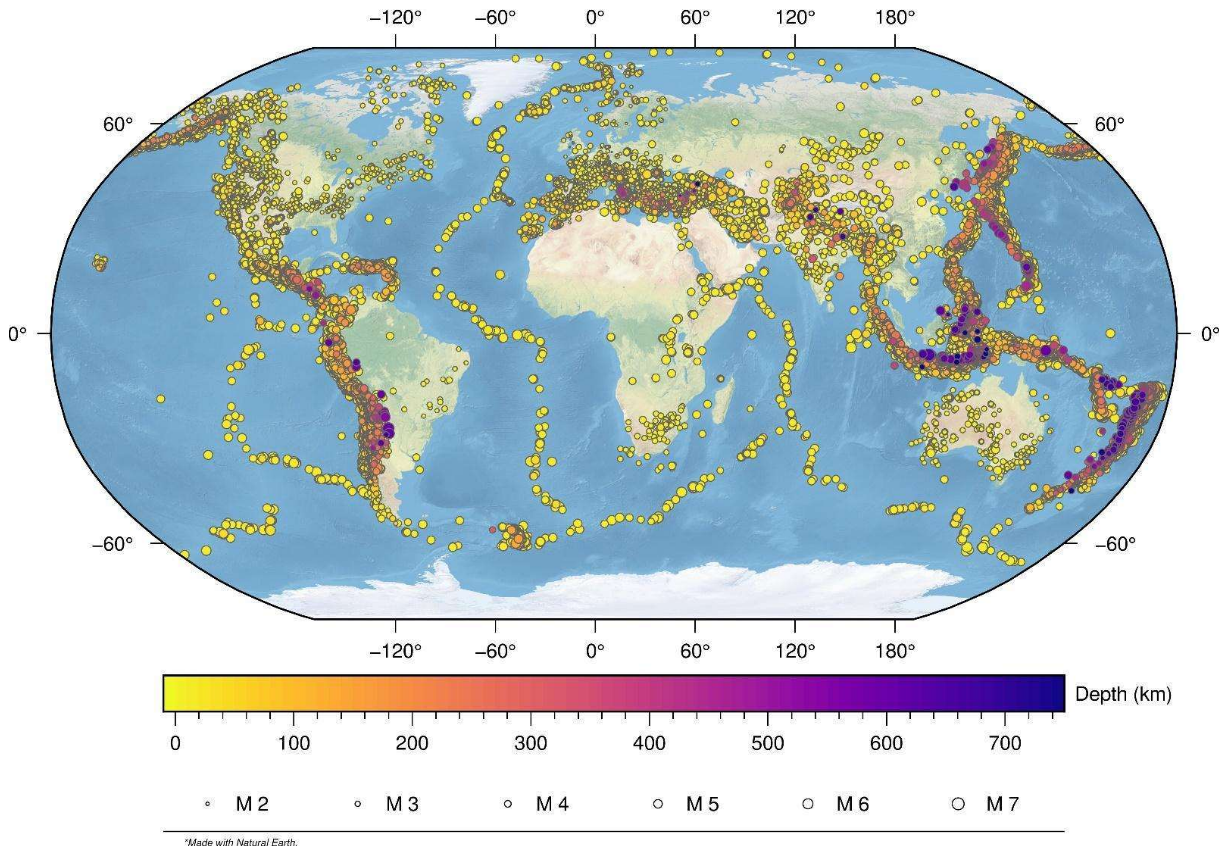

Figure 6 : Map of the 108 522 earthquakes located in 2023

[1] Bossu, R., & Mazet-Roux, G. (2012). An operational authoritative location scheme. In *New Manual of Seismological Observatory Practice 2 (NMSOP-2)* (pp. 1-8). Deutsches GeoForschungsZentrum GFZ.

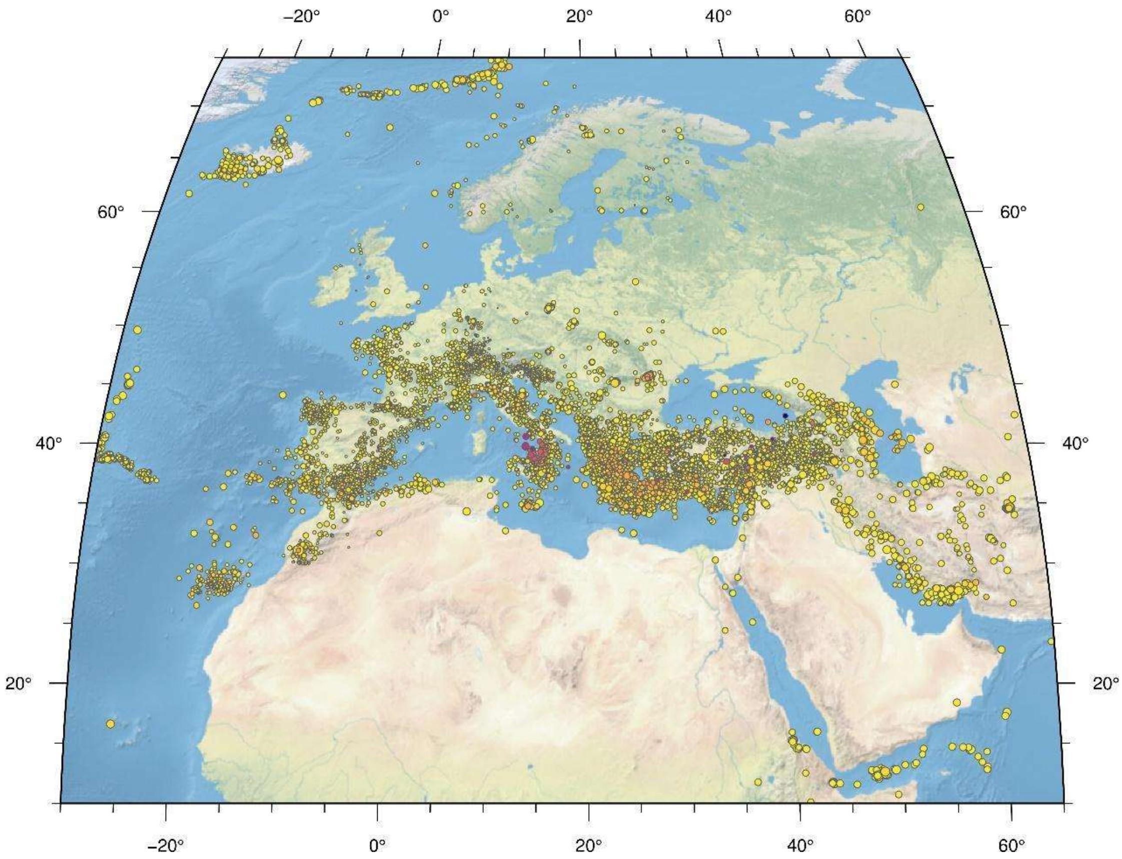

Figure 7 : Map of the 40 536 earthquakes located in 2023 in the European-Mediterranean region.

Only merged and data selected locations are actually computed by the EMSC, they represent only 16% of the locations only (Table 2). In other words, 84% of the earthquake locations published by the EMSC come directly from a data contributor and are published without modification.

Type of locations	Worldwide EQ	Euro-Med EQ
Reported locations	74 353 (68.5%)	19 131 (47.2%)
Authoritative locations	16 385 (15.1%)	9 947 (24.5%)
Data Selected Locations	564 (0.5%)	413 (1%)
Merged locations	17 220 (15.8%)	11 045 (27.3%)

Table 2 : Distribution of the type of location for all earthquake locations published by the EMSC at global level and in the Euro-Mediterranean region. The vast majority of locations published by the CSEM (84%) are not recalculated but verified before publication.

The majority of the authoritative locations are in Europe (including Türkiye), the US and New Zealand (Figure 8, Figure 9).

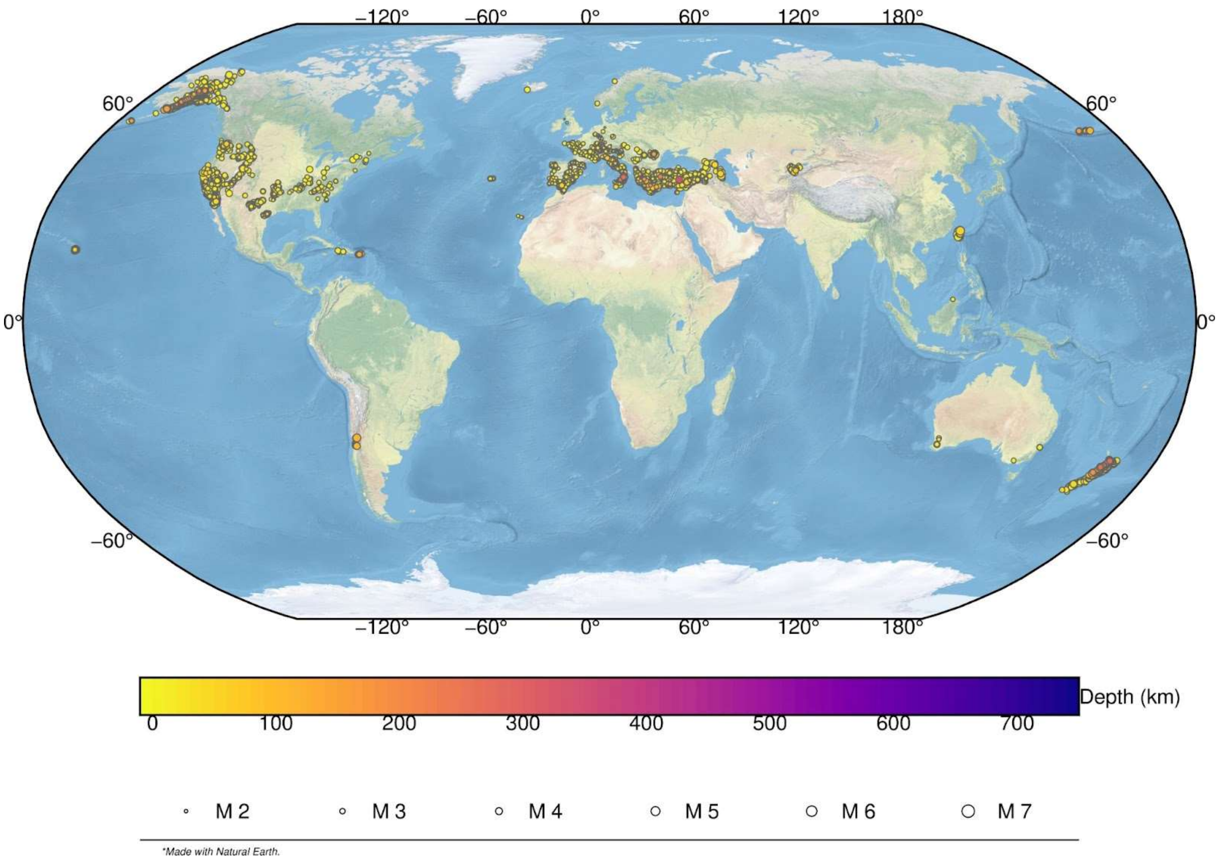

Figure 8 : Spatial distribution of the 2023 authoritative locations.

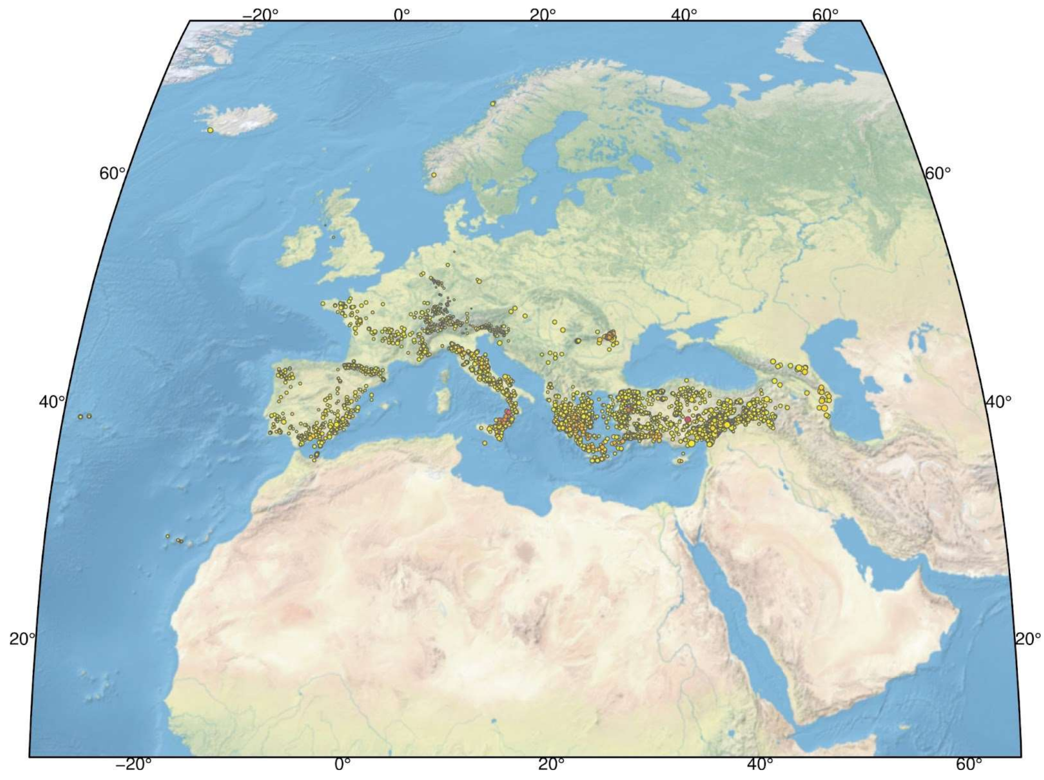

Figure 9 : Spatial distribution of the 2023 authoritative locations in the European-Mediterranean region.

7 Accuracy and speed of first location and magnitude estimates

The first location is published within **13.9 minutes** of the earthquake and its accuracy (defined as the difference between the first and last published location) for earthquakes having at least one update (42 035 earthquakes) is **2.3 km** and its magnitude uncertainty (also defined as the absolute difference between first and final values) is of 0.1. However, as the majority of events are 'reported' (Table 2), this value of location and magnitude accuracy mainly characterize the average performance of the reporting agencies.

It is also possible to evaluate the location and magnitude accuracy for the earthquakes reported by at least 2 agencies (30 497 earthquakes), in this case **the location accuracy is 3.4 km** and **magnitude accuracy of 0.1**.

8 Crowdsourced detections

Crowdsourced detections are detections of felt earthquakes independent of seismic data and based on the online reactions of eyewitnesses, more precisely their online information-seeking behaviour immediately after the shaking. Crowdsourced detections are typically in the range of 10 to 90 seconds of the earthquake and they usually precede seismic detections.

The crowdsourced detections are based on the traffic to the EMSC websites, the LastQuake app, the rate of tweets containing the keyword "earthquake" on Twitter (TED) and the detections of the EQN smartphone app, which is shared with us in real time by its operator, the University of Bergamo (Italy).

In 2023, there were 3 141 crowdsourced detections related to 1 678 earthquakes. The detections methods are complementary with 2/3 of the earthquakes being detected by a single method (Figure 10).

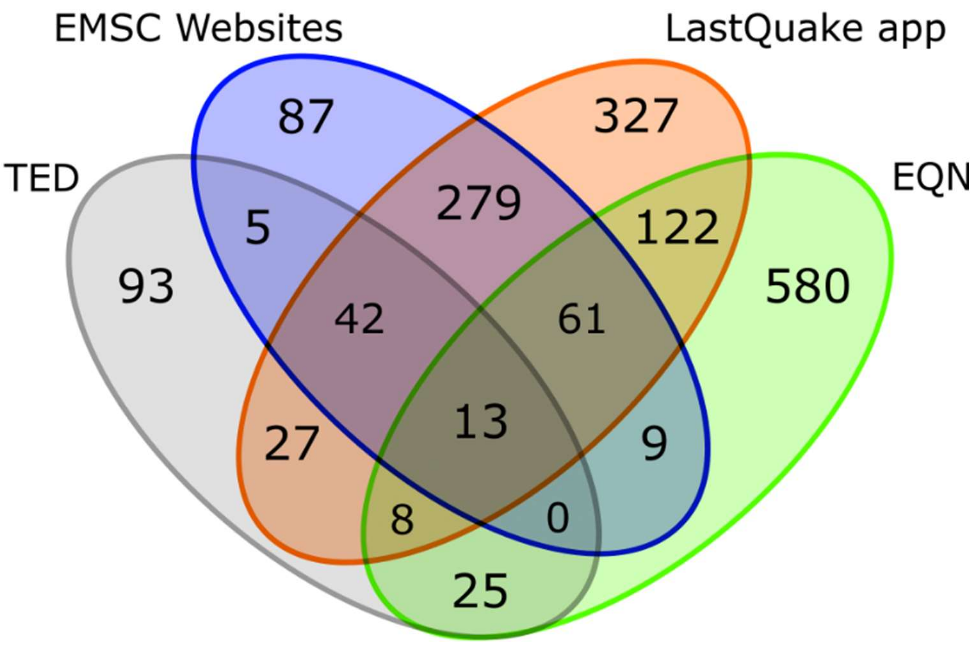

Figure 10 : Venn diagram showing the distribution of earthquakes detected by different types of crowdsourced detections. The complementarity of the different detections is strong, with 2/3 of earthquakes detected by a single method and less than 1% detected by all 5 methods.

8.1 CsLoc (Crowdseeded Seismic Locations)

CsLoc[2] are the combined analysis of crowdsourced detections and seismic data for rapid and reliable location of felt earthquakes. CsLoc require real-time waveform availability, the spatial distribution of the CsLoc reflect the regions where such data is available (Figure 11). CsLoc went live in July 2022 after more than 2 years of testing. We present here the first performance evaluations.

For the sake of completeness, since 14/09/2022, the Cyprus Geological Survey Department, which due to its size is unable to provide rapid information outside working hours, has made waveforms from 10 stations available to the EMSC in real time in order to publish CsLoc for felt earthquakes, even of those of low magnitude.

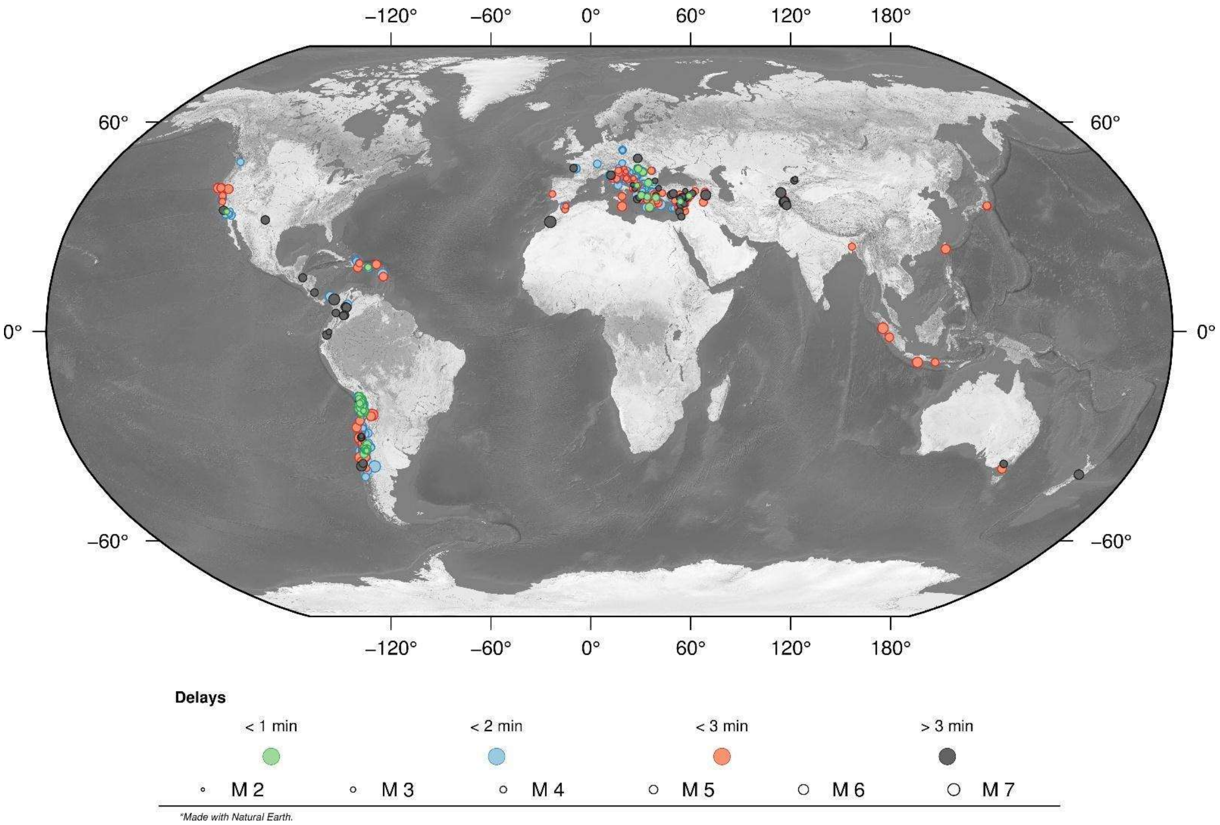

Figure 11 : Spatial distribution of 624 *CsLoc. The colour indicates how quickly the location was published.*

CsLoc are published 116s (median time) after the earthquake, and the first magnitude estimate (which is more time-consuming because it requires amplitude measurements), is published in 198s, when available (79% of cases, for 491 over 624 earthquakes). The type of triggers has an effect on the speed of the CsLoc with EQN and LastQuake being the fastest (Figure 12).

The locations have an uncertainty of 11km and an on the magnitude of 0.2.

[2] Steed, R. J., Fuenzalida, A., Bossu, R., Bondár, I., Heinloo, A., Dupont, A., ... & Strollo, A. (2019). Crowdsourcing triggers rapid, reliable earthquake locations. *Science advances*, *5*(4), eaau9824.
Bondár, I., Steed, R., Roch, J., Bossu, R., Heinloo, A., Saul, J., & Strollo, A. (2020). Accurate locations of felt earthquakes using crowdsource detections. Frontiers in Earth Science, 8, 532958.

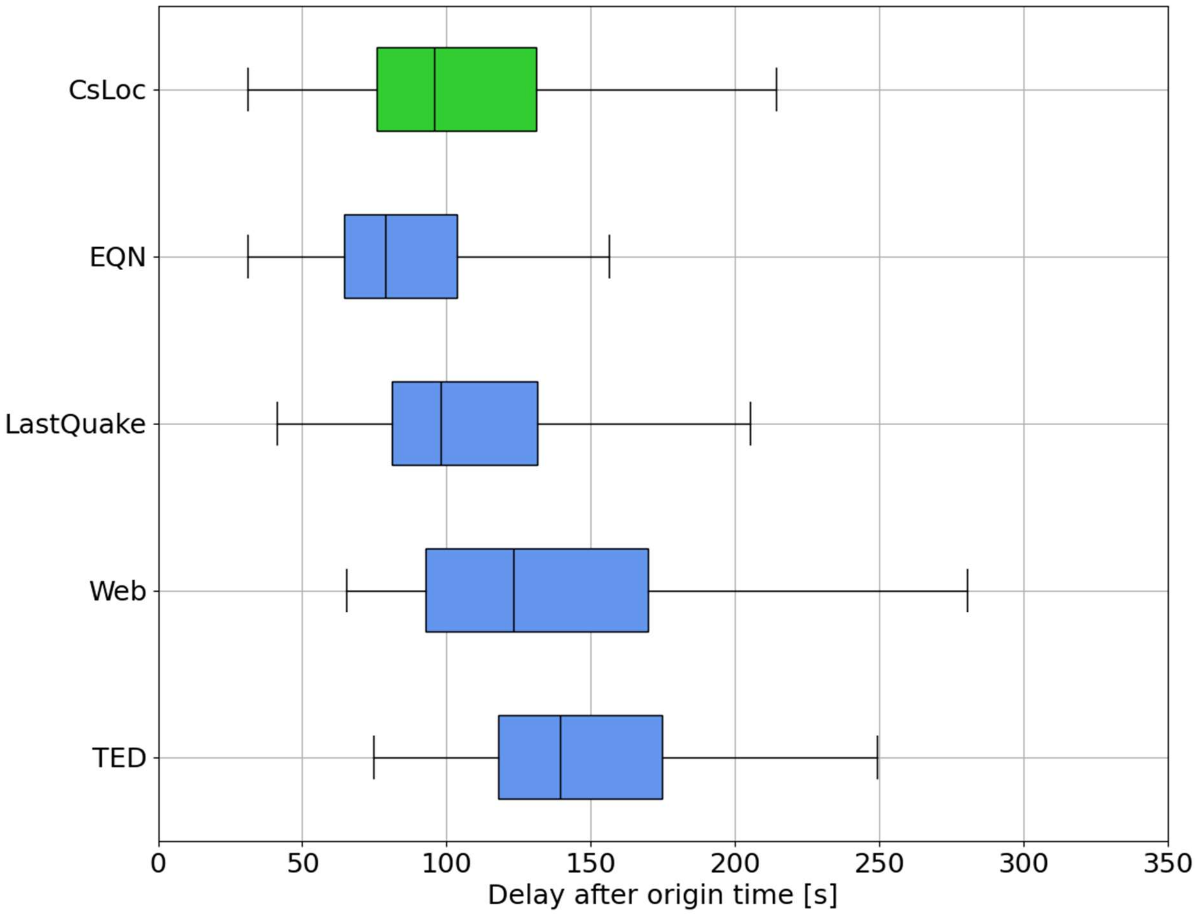

Figure 12 : Box-and-whisker plot of publication delay for each crowdsource trigger types (blue) and all CsLoc (green) locations. The EQN and LastQuake triggers produce the fastest CsLoc results

9 Felt reports collection

In 2023, 469 249 felt reports associated with 5 186 earthquakes were collected (unassociated ones are disregarded), with a median collection time of 8.5 minutes (Table 3, Figure 13). 1/3 of them are accompanied by a comment and 80% the felt reports are associated with earthquakes that have been "crowdsource detected". Felt reports are collected in all seismically active regions, and in greater numbers in the Euro-Mediterranean region (Figure 15, Figure 16).

	2012	2014	2016	2018	2020	2022	2023
# of felt reports	12 388	24 490	78 945	106 462	502 676	248 809	469 249
Desktop	85%	62 %	18 %	10%	1%	2%	1%
Mobile	15%	26 %	27 %	25%	11%	37%	29 %
App	0%	12%	55%	65 %	88%	61%	70 %
# reports associated to crowdsource detected earthquake	6 909	19 007	68 546	91 749	448 123	211 348	376 334
Median time	41min 17s	29min 39s	17min 10s	12min 59s	9min 45s	7min 57s	8min 30s
% with comments	28.1%	35.1%	44.2%	42.1%	33.3%	32.5%	33.2%
# validated pictures	126	64	151	229	912	249	674
# felt events	479	809	1 629	1 940	4 164	2 863	5 186

Table 3 : Trends over time in the main statistics relating to crowdsourced data (felt reports and images). The # symbol indicates "the number of".

The LastQuake application is by far the most effective method of crowdsourcing (70%), followed by the website for mobile devices (29%) and then the website for desktops (1%) (Table 3). A Telegram robot, which went online at the end of the year, has only collected a few dozen reports.

Felt reports are collected over longer periods of time during destructive earthquakes, when many users discover the LastQuake application or websites. The median collection time was 30 minutes for the devastating M7.8 earthquake in Türkiye in February 2023 and over 3 hours for the M6.8 earthquake in Morocco in September 2023 (Figure 14). The difference between these two examples illustrates the fact that unlike Türkiye, where LastQuake was already known before the earthquake, the number of users in Morocco was close to zero.

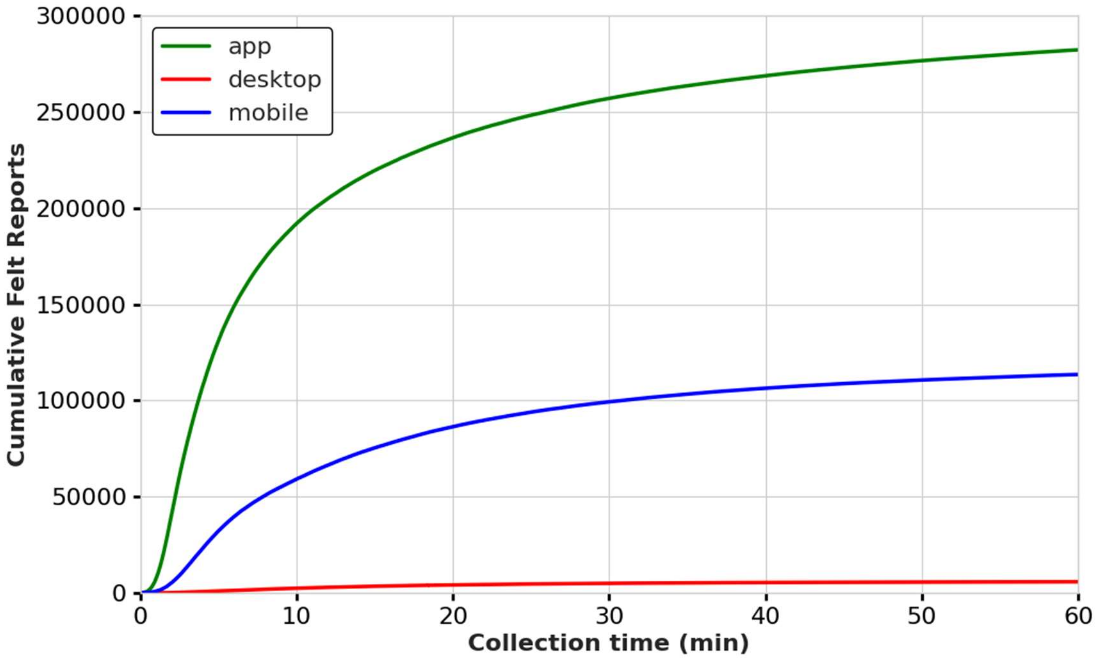

Figure 13 : Cumulative number of felt reports collected as a function of time and collection tool. The LastQuake app is the most efficient crowdsourcing tool on average.

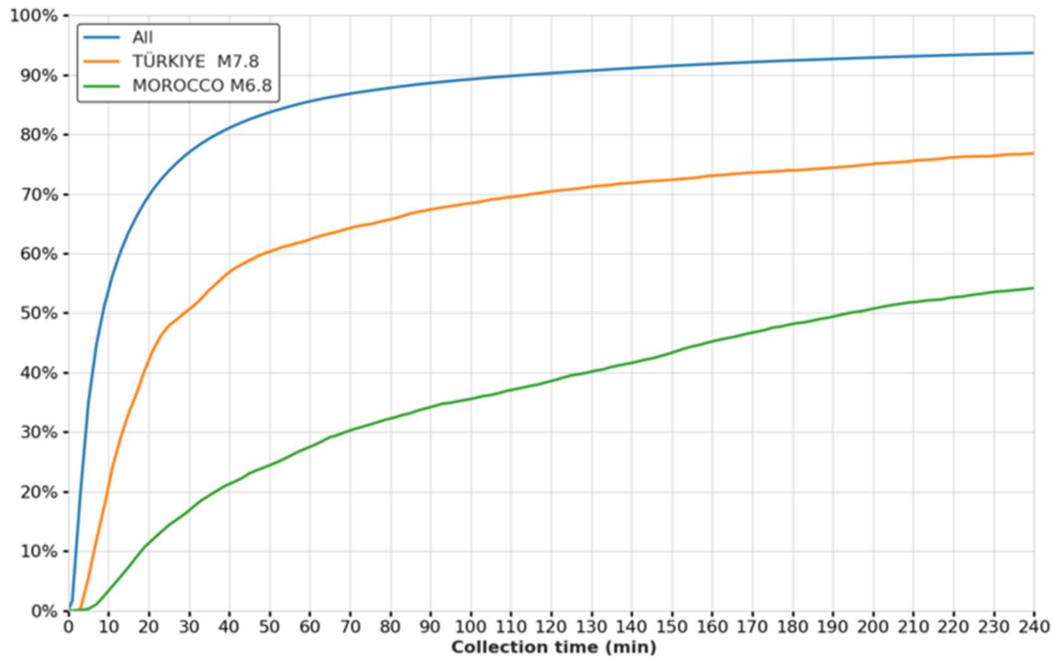

Figure 14: Cumulative number of felt reports collected as a function of time for all earthquakes and specifically for two destructive earthquakes in 2023: The M7.8 Tukey and M6.6 Morocco earthquakes. Collection extends to longer time periods for damaging earthquakes.

Although the number depends on the scale of destruction caused by earthquakes over the past year, the collection of geo-localised images seems to be gradually increasing over the years (674 images were validated and published in 2023).

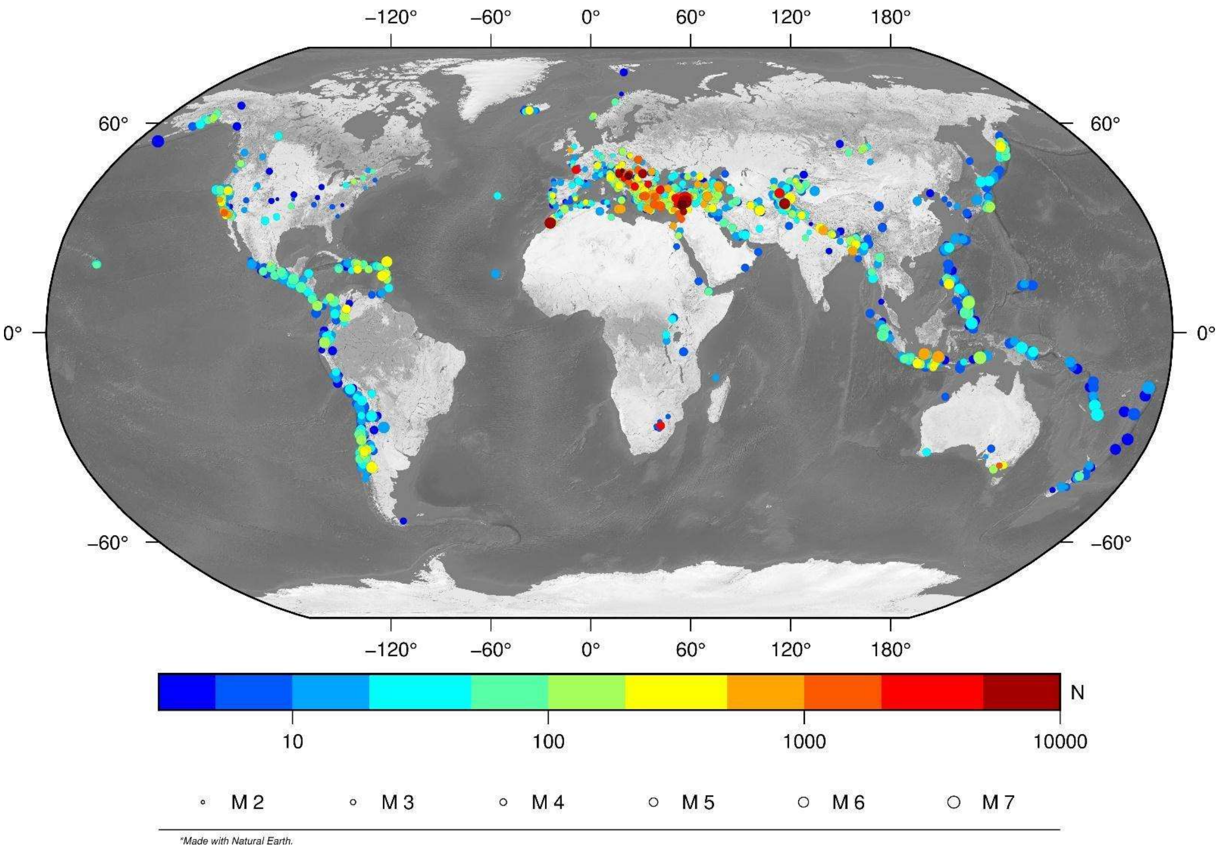

Figure 15 : Map of earthquakes for which felt reports have been collected. The colour depends on the number of felt reports.

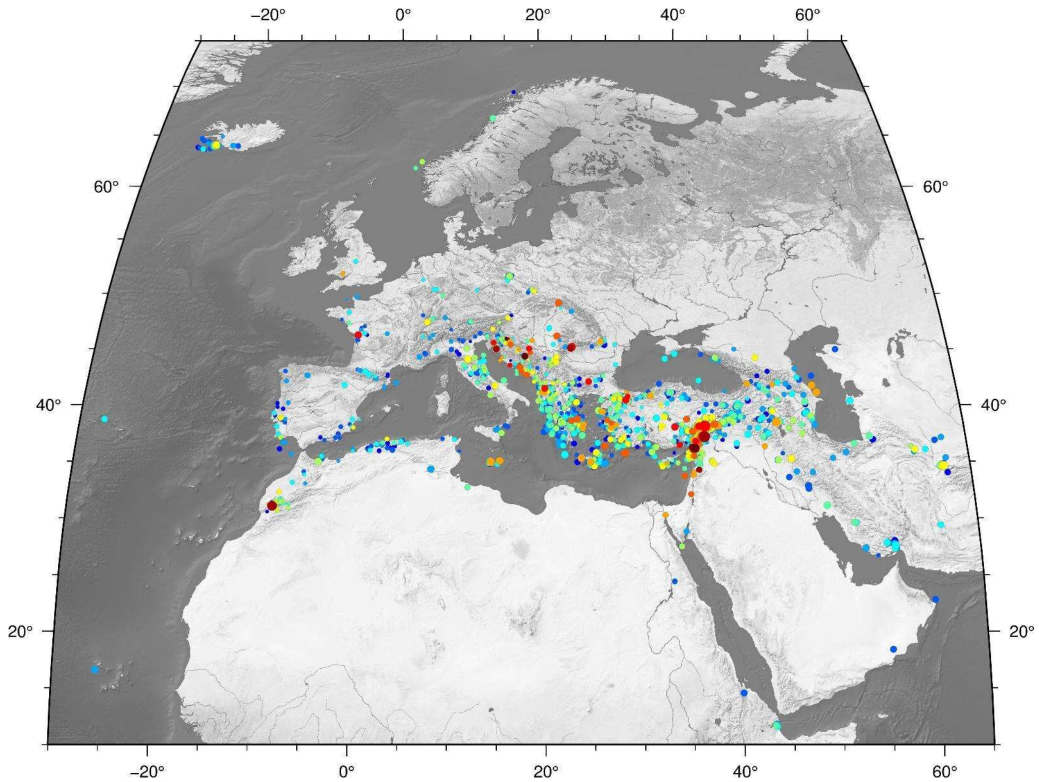

Figure 16 : Map of European-Mediterranean earthquakes for which felt reports have been collected. The colour depends on the number of felt reports.

10 Earthquake Qualitative Impact Assessment (EQIA)

EQIA is an automatic rapid earthquake impact assessment tool, the results of which are restricted to EMSC members (they are available on the members section of the website and soon via an SMS service). Although the results are expressed in terms of expected fatalities (with mean value and uncertainty range), the aim is not to provide a quantitative estimate of the human impact, but only a rapid indication (between 10 and 45 minutes) of the potential level of damage. Up to magnitude 7, EQIA is based on a point-source approximation. Beyond M7, 6 scenarios are calculated, 3 for each nodal plane of the moment tensor, 2 unilateral ruptures and one bilateral. Depending on the type of mechanism and the spatial distribution of the population, these different rupture scenarios can give highly variable impact estimates. In the performance estimates presented here, for the 3 damaging earthquakes with M>7 only the scenario closest to the actual outcome was taken into account.

An impact estimate is carried out for all earthquakes of magnitude 5 or more, with a hypocentral depth of less than 150 km and for which a non-negligible part of the population was exposed to a shaking level of at least 0.05g, an estimate based on a Ground Motion Predictive Equation. In 2023, there were 1096 such earthquakes, of which 19 are damaging according to the NOAA database.

The performances presented in this report relate to the last assessment for each event, typically available 20 to 30 minutes after earthquakes of magnitude less than 7 or after 50 minutes for earthquakes with magnitudes greater than 7 for which it is necessary to wait for the moment tensor solution.

- The EQIA gave a **correct estimate** (i.e. a best estimate of 0 fatalities) for 1,014 of the 1,077 **non-damaging earthquakes** (94% success rate) and the estimate of 0 fatalities falls within the uncertainty range for 57 others[3] (**99.4% success rate**).
- There are 6 **false positives** (**0.6% rate**) including the M 6.7 aftershock of the February 2023 Turkish sequence and 4 earthquakes in continental Asia between M 5.2 and M 5.5. However in this range of magnitudes the smallest uncertainties in the earthquake parameters (location, magnitude) and in the spatial distribution of the population can lead to very different impact scenarios.
- For the **19 earthquakes reported as damaging** by NOAA, 17 of them had the actual death toll in the uncertainty range of the EQIA predictions (**89.5% success rate**). Among them, 7 had correct estimates (i.e. a best estimate in agreement with the actual death toll) (**36.8% rate**). The 2 false negatives (**10.5% rate**) had 1 and 11 deaths respectively, i.e. cases where the impact can be often driven by specific individual accidents, i.e. beyond a statistical approach such as EQIA.

In conclusion, EQIA is efficient in identifying damaging and non-damaging earthquakes (**99.2% success rate**). Although the majority of failures are associated with moderate earthquakes, where uncertainties play a large role, and earthquakes with limited impact, where a statistical approach is not relevant, it is still possible that the true extent of damage of large impact earthquakes may not be correctly estimated (Figure 17).

[3] One of these is the M 7.5 Turkish earthquake of February 2023, which followed the M 7.8 earthquake and for which no death toll was given

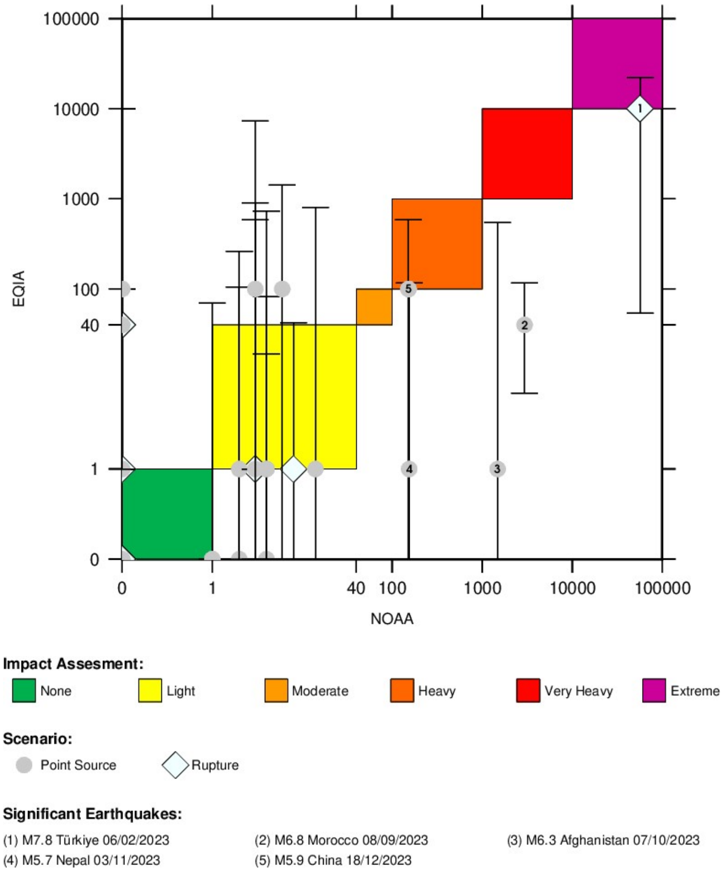

Figure 17 : Summary of EQIA results for 2023: EQIA estimate - including error bars - versus actual number of deaths. The coloured squares represent the effect categories used in EQIA.

11 EMSC product distribution services

Distribution services can roughly be divided into 2 categories: those aimed primarily at the public and those aimed more specifically at the scientific community. The first category includes websites, social networks and the LastQuake smartphone application, while the second includes web services, although this separation is somewhat arbitrary, as many institutes regularly consult the page (19k daily views) presenting the data collected (https://www.emsc-csem.org/Earthquake_data).

11.1 Services targeting the public

The total public visibility of the services can be estimated by adding together the average monthly visits to our websites and LastQuake smartphone app. It yields **10M visits/month** (Website (desktop): 1.3M/m; Website (mobile): 3.1M/m; LastQuake App: 5.5M/m).

The cumulative number of the LastQuake app launches on the front page of this document shows that the services are accessed from most of the seismically active regions of the world.

The audiences for earthquake information on the social networks are:

• X (formally Twitter):	@lastquake	310k followers 14.4M views/month
	@emsc	51k followers
• Mastodon :	@lastquake@masto.ai	2.3k Followers
	@emsc@masto.ai	1k followers
• Bluesky:	lastquake.bsky.social	0.5k followers

The total number of views on @LastQuake (14.4M/month) represents a 250% increase since 2018. A significant part of this increase is linked to the sequence of destructive earthquakes in Turkey, a country where Twitter is particularly popular.

An information and crowdsourcing LastQuake bot was also released on the messaging app Telegram in 2023 which has 1.5k users.

Corporate communication:

• LinkedIn:	1k followers
• Facebook:	43k followers

11.2 Email Notification Service

The email notification service (ENS) provides manually validated earthquake parameters for magnitude 5 in the Euro-Mediterranean region and, through more or less concentric circles of increasing magnitude, for earthquakes greater than magnitude 7 on a global scale (Figure 18). Parameters are manually validated on 24/7 basis by seismologists on call from our host CEA/LDG.

In 2023, 248 earthquakes triggered the ENS, a higher number than in previous years due to the two 2023 aftershock sequences in Morocco and Türkiye.

- Number of notifications: 248
- Median dissemination time: 16 min
- Location accuracy: 4.5 km
- Magnitude accuracy: 0.1
- Number of users: 8 409

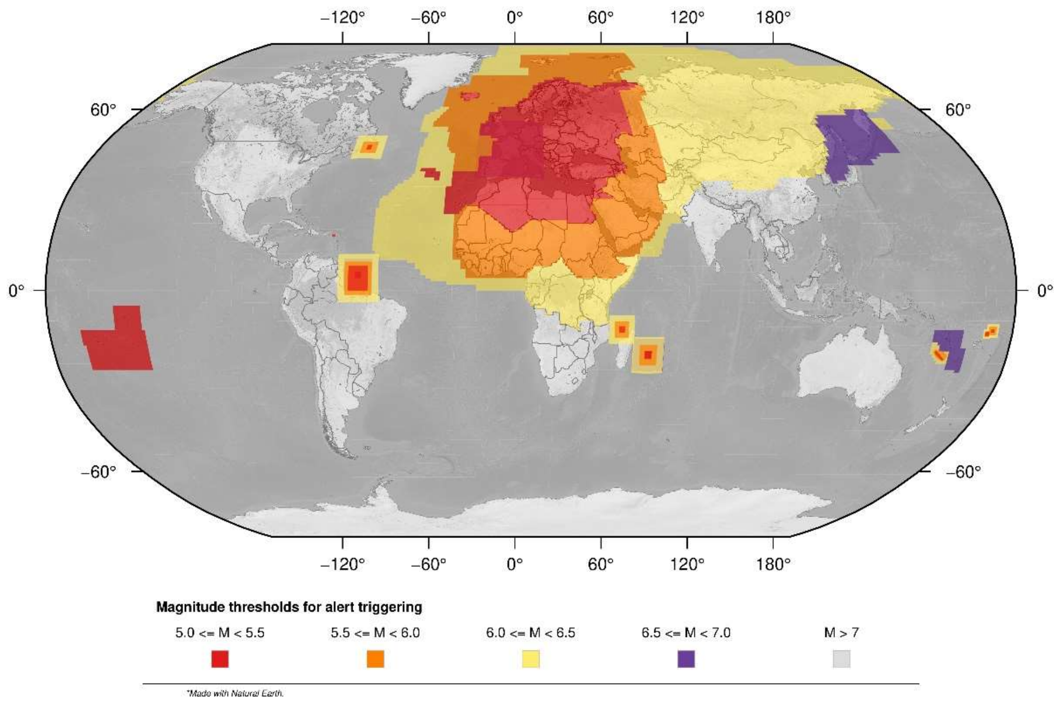

Figure 18 : Magnitude threshold for the e-mail notification service. For earthquakes above the threshold, manually validated earthquake parameters are distributed thanks to on-call seismologists from our host CEA/LDG.

11.3 Webservices

The EMSC provides the following 7 webservices to the scientific community (including a service based on websockets), see https://seismicportal.eu/webservices.html

- **EventID** dynamically maps between event identifiers to allow the identification of the same event in different seismological institutions.
- **FDSN EVENT** conforms to the FDSN-Event standard and distributes all of the EMSC event data available. Event information can include all origins and all arrivals if desired.
- **Flinn-Engdahl Lookup** identifies the Flinn-Engdahl region for a latitude/longitude coordinate.
- **Moment Tensors** provides access to moment tensor solutions collected at EMSC
- **Rupture models** allows someone to retrieve all rupture models from Martin Mai's SRCMOD database (the database of finite-fault rupture models of past earthquakes).
- **Felt reports** gives access to the EMSC felt reports crowdsourced from eyewitnesses.
- **Near Real-time Notification** reports new and updated earthquake parameters using the WebSocket protocol.

Another service, the **WMS** (Web Map Service), developed for internal purposes - the automatic generation of maps for the Seismic Portal (www.seismicportal.eu) - proved to be externally accessible so it is included in the statistics. A study will be carried out to identify the users (e.g. seismologists, application developers), and assess whether this usage constitutes a significant burden on the IT infrastructure, in which case access will have to be blocked.

With a daily average of 500k requests, the FDSN service accounts for 95% of requests to EMSC webservices (Table 4). Users come from all over the world (Figure 19), but surprisingly users from Iran and the USA alone account for 45% of users (Table 5). The moment tensors and felt reports webservices have an equivalent volume of requests of around 4k per day.

Services	Unique IP	Ratio	Daily request (average)
Fdsn-event	1 565 197	95.22%	512 440
Felt reports	52 683	3.20%	4 714
Moment tensor	53 421	3.25%	3 918
Near Realtime Notification	11 312	0.69%	1 605
EventId	2 800	0.17%	5 278
Rupture models	2 595	0.16%	154
Flinn-Engdahl Lookup	838	0.05%	5 211
Wms	35 145	2.14%	37 831

Table 4 : Number of users (defined as the number of unique IP addresses) and the average number of daily requests for each web service. The total number of users, all services combined, is 1.6M originating from 221 different countries.

Country	Unique Ip	Ratio
Iran	411 124	25.01%
USA	325 655	19.81%
Türkiye	138 418	8.42%
Morocco	61 477	3.74%
Germany	52 400	3.19%
Italy	46 311	2.82%
India	40 218	2.45%
United Kingdom	31 776	1.93%
Syria	31 039	1.89%
Australia	26 218	1.59%

Table 5 : Breakdown of web services users by country. Iran and the United States alone account for 45% of users (identified by unique IP).

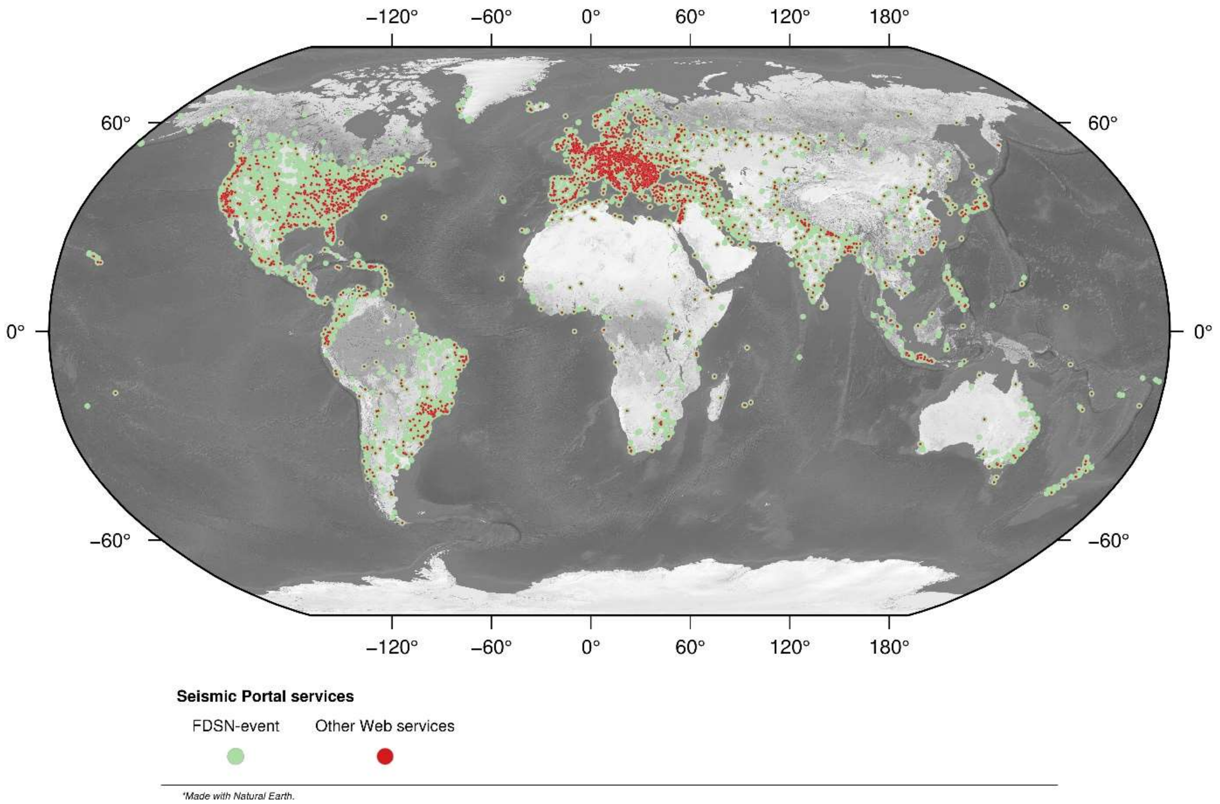

Figure 19 : Geographical distribution of the users of the FDSN webservice (green) and other services (red). Use of the latter is more concentrated in the Euro-Mediterranean region.

12 Current developments

The EMSC is constantly striving to improve its services, and to do this it carries out research, for the most part via external collaborations (see list of references page 33). Two main topics can currently be identified: the fight against misinformation - and in particular claims of earthquake predictions - and the use of felt reports to improve Shakemaps and rapid impact estimates.

The fight against disinformation has already been implemented in the @LastQuake X (Twitter) bot, and we are now trying to assess its effectiveness. With regard to the use of felt reports for ShakeMaps and rapid impact estimation (including the determination of rupture geometry for strong earthquakes), the added value has been demonstrated by several recent articles and 2024 should see the start of tests under operational conditions.

One failure worth mentioning is the discontinuation of the Global Landslide Detector. This original service based on harvesting information from X had attracted a great deal of interest, and follow-up projects were under discussion to link it to satellite imagery. Unfortunately, as access to the X API now has to be paid for, we are no longer able to offer this service.

Finally, considerable work has gone into a new version of the LastQuake application. As this is the central component for collecting felt reports, it is essential that this new version receives the approval of users. A phased roll-out will begin in spring 2024. Finally, we are continuing to explore Cloud technology in order to limit slowdowns to our services after widely-felt earthquakes and consequently optimise the collection of felt reports.

13 Concluding remarks

This report will not necessarily answer every questions relating to the services provided by the EMSC. We have tried to keep it as short as possible and to share the main characteristics and performance of the services that we have developed from the data shared with us by our contributors.

For the next annual report, we plan to go beyond simple averages or medians and look at identifying outliers and their causes. In addition, as the minimum magnitude of reported earthquakes continues to fall, particularly in the Euro-Mediterranean region, and as parameter revisions become more and more frequent, it is becoming difficult in some cases to differentiate between a simple revision of parameters and two earthquakes that are close in time and space. Discussions on this subject have been initiated with certain contributors.

We hope you find this report useful, and we look forward to receiving your comments and questions.

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Alaska Volcano Observatory, USGS - Anchorage, University of Alaska, Geophysical Institute (AV)	US	PDL	L P A		
Earthquake Early Warning System (ShakeAlert EW)	US	PDL	L		
Southern California Seismic Network, California Institute of Technology / USGS - Pasadena (SCSN)	US	PDL	L P A		
Hawaiian Volcano Observatory Network, Hawaiian Volcano Observatory (HV)	US	PDL	L P A		

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USGS Northern California Regional Network, USGS-Menlo Park, California (NC)	US	PDL	L P A		
National Earthquake Information Center, U.S. Geological Survey (NEIC)	US	PDL	L P A	MT	B.R.
Cooperative New Madrid Seismic Network, St. Louis University and University of Memphis (NM)	US	PDL	L P A		
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Puerto Rico Seismic Network (PRSN) and Puerto Rico Strong Motion Program (PRSMP), University of Puerto Rico at Mayaguez (PR)	US	PDL	LPA		
Pacific Tsunami Warning Seismic System, Pacific Tsunami Warning Center, Ewa Beach, Hawaii (PT)	US	PDL	L P A		
Southeastern Appalachian Cooperative Seismic Network, Virginia Tech, University of Memphis, Tennessee Valley Authority, and University of North Carolina (SE)	US	PDL	L P A		
Bureau of Economic Geology, The University of Texas at Austin (BEG UTEXAS) (TX)	US	PDL	L P A		
University of Utah Regional Network, University of Utah Seismograph Stations (UU)	US	PDL	L P A		
Pacific Northwest Regional Seismic Network, University of Washington, Seattle (UW)	US	PDL	L P A		
Global Centroid-Moment-Tensor (GCMT)	US	Email		MT	
National Seismological Observatory Centre (NSOC)	Yemen				A.

Table 6 : List of data contributors and members in 2023 for both earthquake parametric data and moment tensors. Contributions are sent via email or messaging systems (PDL or HMB). In some cases, they come from scrapping institutions' websites (Web). Parametric data includes at least locations and magnitudes (L). They generally contains picks (P) and amplitudes (A). On top of the list, one must add CsLoc and SC4 (EMSC SeisComP), which are provided by EMSC. EMSC members can be Key nodal member (K.N.), members by right (B.R.) and active member (A).

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Figure 20 : The EMSC team from left to right : Frédéric Roussel, Simon Issartel, Robert Steed, Camille de Carolis, Rémy Bossu, Jean-Marc Cheny, Matthieu Landès and Julien Roch. Guillaume Ucciani missing