**REPORT**
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# History and activities of the European-Mediterranean Seismological Centre

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**Abstract** The European-Mediterranean Seismological Centre (EMSC) provides rapid information on earthquakes and their effects, but does not operate seismic stations. It collects and merges parametric earthquake data from seismological agencies and networks around the world and collects earthquake observations from global earthquake eyewitnesses. Since its creation in 1975, it has developed strategies to complement earthquake monitoring activities of national agencies and coordinated its activities in Europe with its sister organisations ORFEUS and EFEHR as well as with global actors, while being part of the transformative EPOS initiative. The purpose of this article is to give a brief history of the EMSC and describe its activities, services and coordination mechanisms.

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## Introduction

The European-Mediterranean Seismological Centre (EMSC) has become one of the most important global earthquake information centres in the world over the last decades. While some of its activities are well known in the seismological community, the organisation itself, its history, structure and governance, its links with other European and global bodies, the way its services are organised and the basic principles that guide them have never been described in a single and open document and thus remain unclear to many actors in seismology and users of its services. The aim of this paper is to describe these different aspects of the EMSC and to illustrate how a regional non-profit non-governmental organisation can complement rapid public earthquake information in coordination with national actors thanks to a well-established and community-agreed policy. We also outline the current evolution of EMSC activities and the major overhaul of its processing system, and call for new networks to contribute data, as well as potential sponsors whose contributions are needed to maintain and further develop our activities and services.

## EMSC brief history

In 1975, the European Seismological Commission (ESC), considering the level of seismic risk in the Euro-Mediterranean region, recommended the creation of the Centre Sismologique Euro-Mediterranéen (CSEM, or Euro-Mediterranean Seismological Centre, EMSC) to "determine in near real time the epicenters of potentially damaging earthquakes" in this region, as well as the epicentral location of smaller magnitude earthquakes using data from existing monitoring networks (Mueller, 1980). This recommendation was supported by both IASPEI (International Association for Seismology and Physics of the Earth's Interior) and IUGG (International Union of Geodesy and Geophysics). In practice, it was a way of maintaining in Strasbourg the earthquake location activities of the Bureau Central International de Sismologie (BCIS, Rothé, 1981) which began publishing an instrumental catalogue in early 1900's and ceased to exist in 1975 in the Euro-Mediterranean region (Adams, 2002). EMSC practically started operating in 1976.

It may not be well known, but during the Cold War EMSC was instrumental in the global exchange of parametric data across the Iron Curtain. Direct telegraphic exchanges from some of the Warsaw Pact countries to the USA were restricted. The parametric data received at the EMSC by telex via the World Meteorological Organisation's Global Telecommunications System (WMO/GTS) were forwarded, still by telex, to the National Earthquake Information Center in Boulder, USA (NEIC was then part of the National Oceanic and Atmospheric Administration) and integrated into the Preliminary Determination of Epicenters (PDE) monthly bulletin, itself established in 1940. The Soviet bloc countries were aware of and pleased with this arrangement, which was seen as a way of solving a sensitive political problem (B. Presgrave, personal communication 2022).

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Data were usually sent to NEIC 2 to 3 times a week, thanks to Elie Peterschmitt and his staff at Louis Pasteur University in Strasbourg.

The EMSC, despite its lack of formal legal existence, continued to locate earthquakes in the Euro-Mediterranean region on an ad hoc basis until its founding meeting held in Strasbourg in December 1982 chaired by Jean Bonnin and attended by representatives from 8 countries (Belgium, Finland, France, Germany, Israel, Portugal, Switzerland, United-Kingdom) in addition to the ESC. Seismological institutes from 4 other countries (Albania, Italy, Spain, Yugoslavia) had expressed their support for this creation but did not attend the meeting. The statutes of the EMSC were presented in 1983 and officially registered in 1984 as a non-profit association under French law, a status that still exists today. The geographical area covered ranged from the Arctic in the north to the southern shores of the Mediterranean in the south, and from the Mid-Atlantic Ridge in the west to the Urals in the east. The aim was to rapidly locate earthquakes, improve data exchange, earthquake information and cooperation in the Euro-Mediterranean region.

In 1993, the agreement between the EMSC and its host Louis Pasteur University in Strasbourg was terminated and in 1994 the EMSC moved to the Laboratoire de Détection et de Géophysique (LDG) of the Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA) in Bruyères le Châtel, near Paris, its current location.

## EMSC among the scientific bodies and actors

The EMSC operates under the auspices of the ESC (European Seismological Commission), the oldest regional commission of IASPEI (Adams, 2002). It coordinates its activities with its sister organisations in Europe, ORFEUS (Observatories & Research Facilities for European Seismology), a non-profit foundation for the coordination and promotion of digital broadband seismology in the Euro-Mediterranean area (Strollo, 2021), and more recently EFHER (European Facilities for Earthquake Hazard and Risk, Haslinger et al., 2022). Schematically, although operations, roles and responsibilities are different, in terms of services, EMSC is the European-Mediterranean version of NEIC (Hayes et al., 2011; Masse and Needham, 1989), while ORFEUS is that of IRIS-DMC (Incorporated Research Institutions for Seismology; Data Management Center. Smith, 1987; Hutko et al., 2017) now Earthscope.

The coordination between these three European organisations has been developed through a series of European funded projects for research infrastructures (e.g. Giardini et al., 2008), which in turn led to the establishment of EPOS (European Plate Observing System) as a European infrastructure for solid Earth sciences (Cocco et al., 2022). EMSC, ORFEUS and EFHER are jointly responsible for the seismology services within EPOS (Haslinger et al., 2022).

The EMSC was also involved in the now defunct UNESCO programme RELEMR (Reducing Earthquake Losses in Extended Mediterranean Region, https://en.unesco.org/disaster-risk-reduction/science-technology-resillience/REL) from the late 1990s to the mid-2010s to improve collaboration and data exchange with institutes around the Mediterranean. The bulletin exchanges established thanks to RELEMR significantly improved the availability of parametric data, adding readings from several hundred stations and in turn, the images of the seismicity in the region (Godey et al., 2006, 2013).

## Membership, governance and funding

The EMSC has 3 types of membership, active members, key nodal members (a type of membership created in 1993 and introduced in 1994) and members by right. Active members are seismological institutes that participate in the activities of the EMSC and contribute to its objectives. Currently there are 66 of them from 54 countries (Table 1). Key Nodal Members are active members that provide specific support to the EMSC. Recognised Key Nodal Members are LDG (France) for hosting the EMSC, the GeoForschungsZentrum Potsdam (GFZ, Germany) for its key contribution to the EMSC services for global earthquake monitoring through its GEFON programme (Quinteros et al., 2021), the Istituto Nazionale di Geofisica e Vulcanologia (INGV, Italy) centres in Roma and Milan for thematic support on earthquake location methods and the AHEAD (Archive of Historical Earthquake Data) programme on European historical seismicity, respectively (Locati et al., 2014), and finally the Instituto Geografico Nacional (IGN, Spain) for maintaining a back-up website for EMSC members (www.ign.es/web/resources/sismologia/www/csem/fso.html). The ESC, the International Seismological Centre (ISC), NEIC/USGS and ORFEUS are members by right due to their international activities and cooperation with the EMSC.

The EMSC is governed by its annual General Assembly of members and advised by an Executive Council that consists of the President, three members elected by the General Assembly, representatives of the Key Nodal Members and the Secretary General. The Secretary General, who is responsible for day-to-day operations, administration, human resources and funding, is an employee of LDG, the host of the EMSC. The EMSC also benefits from the operational environment provided by LDG, which is responsible for informing the French authorities in case of earthquakes on the national mainland territory and operates the French Tsunami Warning Centre (Gailler et al., 2013; Roudil et al., 2013). LDG's support also includes the IT infrastructure of the EMSC and its maintenance.

Thanks to LDG hosting, the EMSC's expenses consist mainly of salaries and travel expenses of its staff, with minor allocations for other operational and administrative tasks. Funding comes from membership fees, participation in research projects (mainly European Union Framework Programmes), more recently EPOS, and sponsorship. A major challenge has been to maintain and improve services while being funded largely by soft money mainly dedicated to research. In 2020, the SCOR Foundation for Science offered a three-

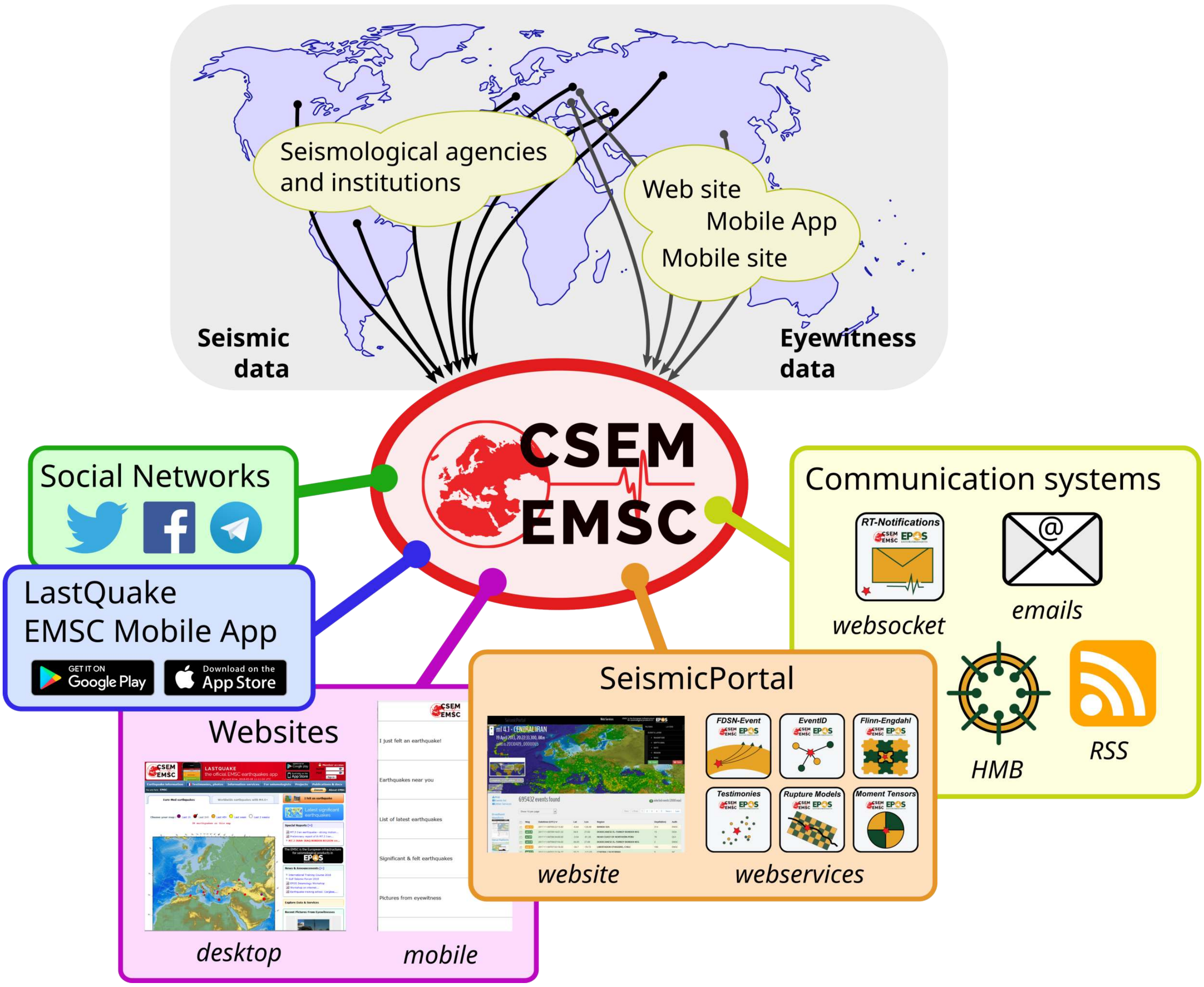


**Figure 1** Schematic of EMSC services. Parametric data is collected from seismic networks to derive earthquake parameters, and eyewitness observations are collected through websites and the LastQuake smartphone app. Information is disseminated through various channels, including social networks and webservices.

year sponsorship to initiate a long overdue major upgrade of the service - the first in the last two decades - completed in June 2023. Sponsorship and financial donations remain an essential element of the EMSC's financial sustainability plan.

In addition to the Secretary General, there are currently 8 EMSC staff members comprising seismologists, IT experts, software developers and a sociologist. The size of the team has not changed recently and is unlikely to increase significantly due to the funding structure.

## Roles and operation principles

The EMSC provides rapid information on earthquakes and their effects. It does not operate seismic stations. It merges seismic data, mainly parametric data (earthquake parameters, amplitudes, arrival times and CMTs) collected by network operators and crowdsourced ground truth data from eyewitnesses to provide services on a global scale with a focus on the Euro-Mediterranean region. (Figure 1; Table 2).

In contrast to many national seismological institutes, the EMSC has no legal mandate for earthquake information. Its scientific role is to provide redundancy and back-up to the authoritative national earthquake information services and to complement them, especially for earthquakes felt in several countries. Experience shows that redundancy and back-up may be needed after major earthquakes, as heavy traffic can bring down national earthquake information websites, hampering public communication and international data and information exchange. Merging seismic data can also improve earthquake information in border regions if bilateral exchange between neighboring countries is not optimal, or for offshore earthquakes. Complementarity of services is best illustrated by the online collection of macroseismic data, where collection at the national level optimizes the volume of data collected within national territories, but does not provide a complete picture when an earthquake is felt across borders. While methods exist to merge such geographically fragmented datasets (e.g., Van Noten et al., 2016), global-scale col-

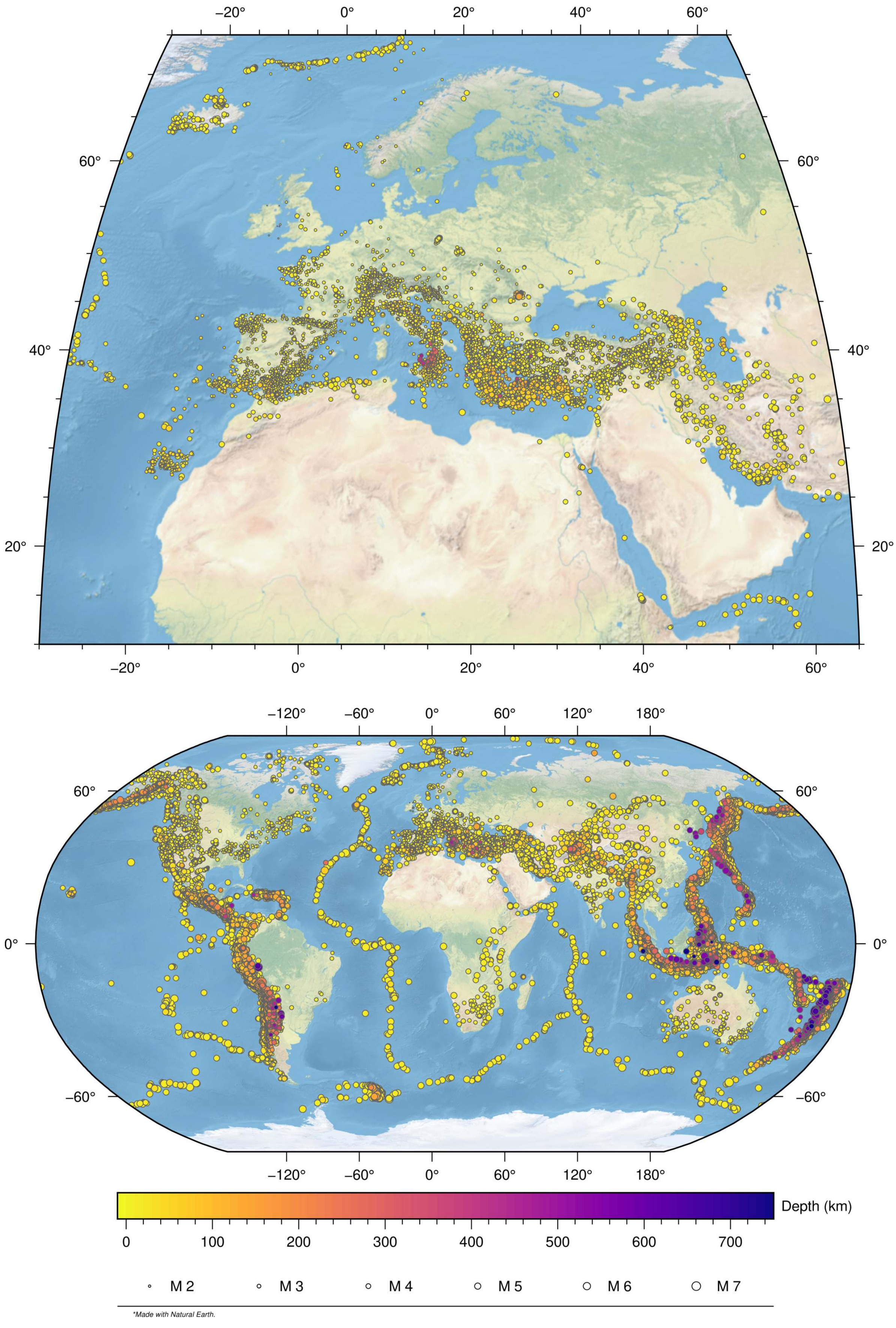


**Figure 2** Geographical distribution of earthquakes reported in 2022: 22 148 earthquakes in the Euro-Mediterranean region (top) and 89 529 earthquakes on a global scale (bottom). Low-magnitude earthquakes are mainly reported in the Euro-Mediterranean region.

lection, like the one of the EMSC remains the fastest way to capture the full spatial distribution of impacts for such earthquakes.

One practical consequence of the lack of a legal mandate is that EMSC does not get involved in matters of national interest. In practice, it does not contact or develop projects with national civil protection services and media interviews on earthquake-related-issues are refused if they come from journalists in the affected countries. However, through its participation in the ARISTOTLE consortium, EMSC services contribute to the rapid earthquake impact assessment sent within 3 hours to the 24/7 Emergency Response Coordination Centre (ERCC), which is part of the EU Civil Protection Mechanism and coordinates the delivery of assistance to disaster-stricken countries (Michelini et al., 2020).

There are two basic principles for earthquake location at the EMSC, which were officially approved by the General Assembly in 2010 and described in Bossu and Mazet-Roux (2012). First, a provider can generally be trusted for earthquake information in the geographical area covered by its network, but its locations outside that area should not be reported unless they are consistently confirmed by another network. Application of this first principle implies that earthquake information can be maintained, at least for earthquakes large enough to be reported by several networks, even when information from the local network is not available. Second principle, relocations by the EMSC (obtained by merging the collected parametric data from the different contributors) should be limited to cases where a significant improvement in quality can be expected, or in other words, locations provided by data providers that are both reliable and accurate should be considered authoritative and published without change. In practice, a location is considered reliable if it can be reproduced with the associated data set of arrival times within its uncertainty range. It is considered accurate if it meets criteria related to the geometry and azimuthal distribution of reporting stations at short distances (up to 250 km, see details in Bossu and Mazet-Roux, 2012).

The implementation of these principles is more complex than described here, firstly because the system is fully dynamic, with new data constantly flowing in and manual observations replacing automatic ones. The implementation must also take into account the heterogeneity of network density and performance, and ensure the quality of information while avoiding missing significant earthquakes. For example, in a number of cases a moderate earthquake (M>4.5) was only reported by a local network within the boundaries of its network, while such an earthquake, given its magnitude, should have been reported by other networks, especially neighbouring ones. To cover such cases, a maximum magnitude is set for the network, above which an earthquake in its area of coverage will not be reported by the EMSC, unless confirmed by another network.

The presented approach of limiting the number of relocations performed by the EMSC is essential for public communication, where even slight discrepancies in earthquake locations between international organisations and national institutes can lead to misunderstandings and endanger public trust. It also implicitly recognises that the locations provided by national institutes are likely to be more accurate than those calculated by the EMSC using a similar dataset, thanks to their local knowledge and experience. By 2022, 85% of the 90,000 earthquake locations in the Euro-Mediterranean region publicly reported by the EMSC had been determined by data providers (Figure 2).

The situation for magnitude is more complex and magnitudes are not homogeneously determined. For small earthquakes, reported only by the local network, the magnitude is reported unchanged. For large earthquakes, the Mw provided notably by GFZ and NEIC is favoured. The main difficulty is for earthquakes 3<M<4.5, where available magnitude estimates are generally limited to ML (local magnitude) and often show large differences between different institutions. Whenever possible, the magnitude is recalculated using available amplitude measurements - if the definition and units are clearly defined - or using the EMSC instance of the SeisComp system (Weber et al., 2007). The final choice is then left to the seismologist performing the manual review.

## Data contributors, data policy and data access

In 2022 there were 100 parametric data contributors, many of them EMSC members, representing a total of 8,130 seismic stations (Figure 3). The preferred data exchange tools are messaging systems, but despite our efforts to phase out email, it is still widely used because of its ease of setup. For 26 of these 100 contributors, earthquake location and magnitude are scanned from the institute's website when attempts to establish data exchange fail. In 2022, 4,871 focal mechanism and moment tensor solutions for 1,596 earthquakes were also collected from 12 different institutes. Finally, 249 000 felt reports representing the local level of shaking or damage were collected from earthquake eyewitnesses worldwide in 2022. The number varies as a function of seismicity and 250 000 have already been collected in the first 3 months of 2023 due to the earthquakes in Turkey.

All data collected is open, but no formal licensing of data and products has been finalised at this stage. This is a time-consuming process as it requires unanimity, certified by a signed document from each contributor. Thanks to the EPOS push, the aim is to apply the CC BY 4 licence (https://creativecommons.org) and eventually to meet the FAIR (Findability, Accessibility, Interoperability, and Reuse) principles.

Data can be accessed via the website (www.emsc-csem.org) or the earthquake portal. The website serves multiple audiences (public, scientists...) and provides fast information on earthquakes. It is more suitable for exploring individual events and recent activity, while the earthquake portal is aimed at researchers and provides access to larger datasets via web services (https://www.seismicportal.eu/webservices.html). Hosting the web services separately from the website limits the risk of slowdowns due to high traffic on the main site after

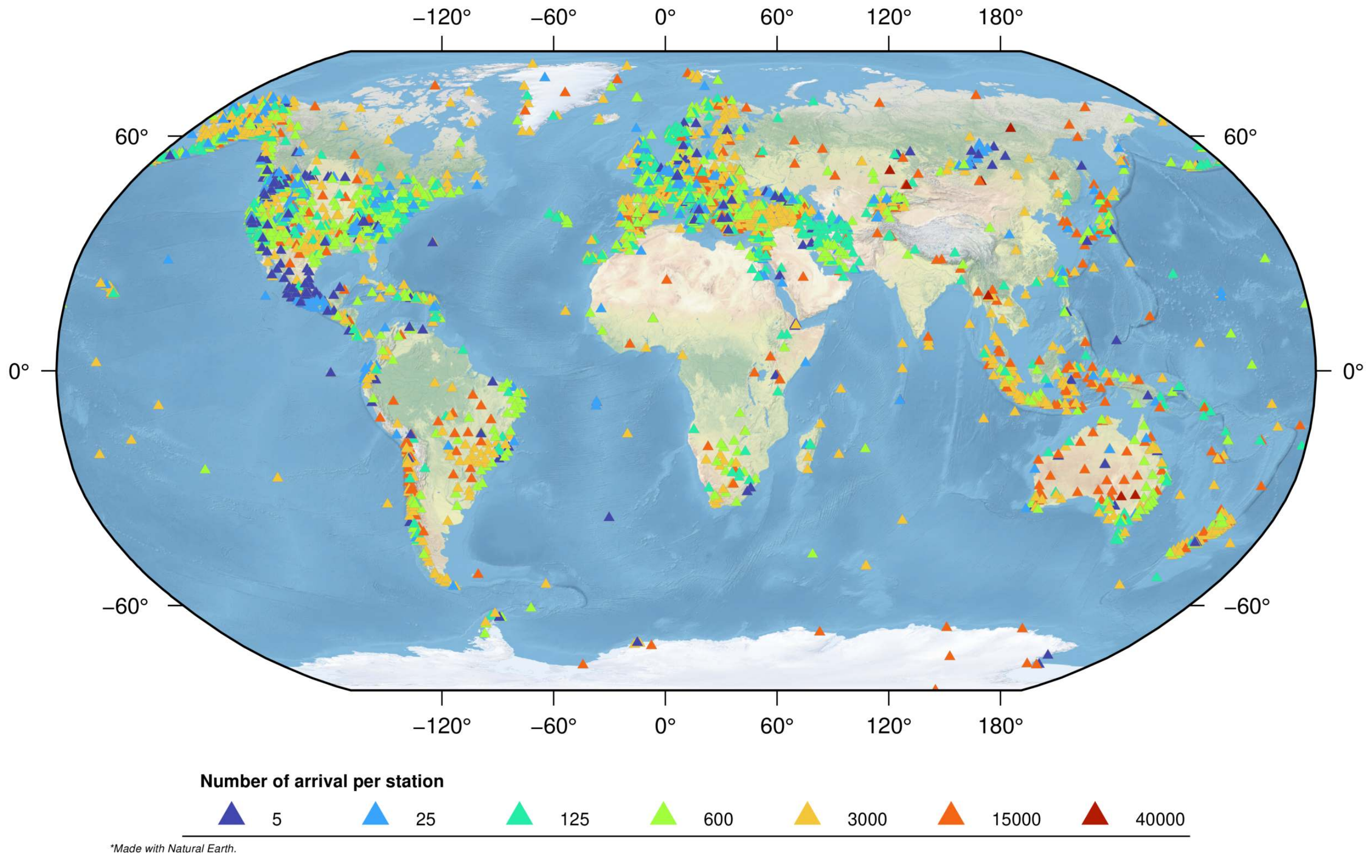


**Figure 3** Locations of stations with reported arrival times in 2022, color depending on number of reported arrival times. Different organisations can pick phases from the same station due to open real-time waveform exchange. This means that EMSC can receive the same phase data for a station from multiple sources even if there is no parametric exchange between the station operator and the EMSC. However, parametric data exchange is essential for properly monitoring low magnitude local seismicity.

widely felt earthquakes. The FDSN event webservice (https://www.fdsn.org/webservices/fdsnws-event-1.2.pdf) is heavily used (average of 250 000 requests/day from 4 600 daily unique visitors). It was upgraded in 2023 and now has a limit of 20 000 events per request. The FDSN event service only publishes earthquake parameters once they have stabilised and so there is a typical delay before publication of a few to 20 minutes.

## EMSC services

Although they are somewhat intertwined, the EMSC services can be schematically divided into 2 groups, one for the public and earthquake eyewitnesses, and one for the seismological community. The group of public activities, called LastQuake, aims to provide information about felt earthquakes and their effects. As it has been described in several publications, it is only outlined here.

LastQuake is a multi-component information and crowdsourcing system consisting of a smartphone application, a website for mobile devices and a Twitter bot (Bossu et al., 2018a, 2023). The eyewitness engagement strategy is based on crowdsourced detection, where felt earthquakes are detected not by seismic data, but by the online behavior of eyewitnesses immediately after they feel the shaking. Three types of crowdsourced detections are implemented at EMSC. Two of them reveal information-seeking behaviour, either by visiting our websites (Bossu et al., 2008, 2012, 2014) or by launching the LastQuake app (Bossu et al., 2018b), which generates a detectable and localizable change in the spatio-temporal characteristics of the traffic. The third, originally developed by Earle et al. (2012), monitors the rate of tweets (messages published on the microblogging site Twitter) containing the keyword "earthquake" in different languages, a rate that increases after a felt earthquake in a region where Twitter is popular, as eyewitnesses share their experiences.

Crowdsourced detections generally precede seismic locations and are typically available within 15 to 90 seconds of the earthquake. To be comprehensive, in 2022 these crowdsourced detections were supplemented by those independently performed by the Earthquake Network app, the first smartphone-based earthquake early warning (Finazzi, 2016). It detects felt earthquakes (Bossu et al., 2021) using the internal motion sensor of its users' smartphones. Crowdsourced detections are immediately published on the various components of the LastQuake system, and users are invited to confirm the existence of an earthquake by reporting their experience using a series of cartoons representing the 12 levels of the EMS 98 macroseismic scale (Grunthal, 1998). It initiates a rapid and massive collection of these re-

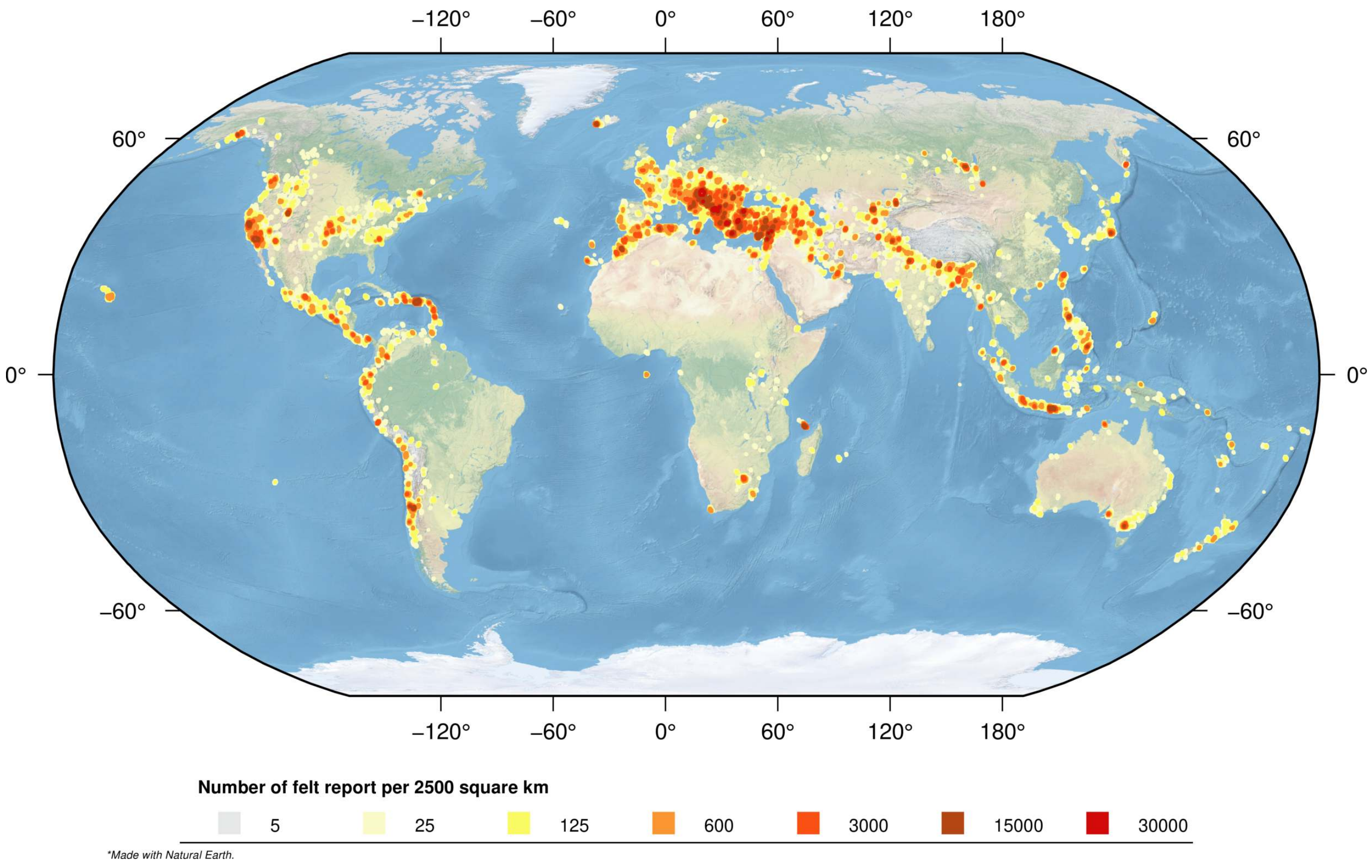


**Figure 4** Geographical distribution of the density of the 2M felt reports crowdsourced up to April 18h 2023. The Europe-Mediterranean region is characterised by a high rate of crowdsourcing.

ports, called felt reports, with a median collection time of 10 minutes in 2022 (Figure 4). For example, more than 2,000 were collected within the first 15 minutes of the M7.8 2023, Kahramanmaras, Turkey earthquake. Felt reports are consistent with well calibrated "Did You Feel it?" (DYFI) responses (especially after a small correction of the bias for the high intensities, Wald et al., 1999; Quitoriano and Wald, 2020) as well as with independently and manually derived macroseismic datasets (Hough et al., 2016; Kouskouna et al., 2021; Bossu et al., 2015, 2017).

The determination and sharing of earthquake parameters have always been, and still is, the core service provided to the seismological community. Today, it deals exclusively with rapid determinations. However, a bulletin covering the European-Mediterranean region was produced for the period January 1998 to July 2012, which included data from 78 contributing networks from 53 countries and a total of 3,400 seismic stations. At the time, it significantly improved data availability in the region (Godey et al., 2006, 2013). However, due to funding difficulties and to avoid duplication with ISC activities, this activity has been discontinued. The bulletin is hosted at the ISC (https://doi.org/10.31905/EC1TT8WX) and data, metadata and local contacts have been transferred to the ISC to ensure long-term ingestion in its global bulletin. During this period, coordination with the ISC and NEIC was particularly close on issues such as the International Seismic Station Registry. The "For seismologists only" web page publishes the data sent by each contributor (earthquake parameters, moment tensors) as well as the parameters recalculated by the EMSC. It may contain several tens of locations for the same large earthquake, as determined by the different reporting networks. To limit misuse of the data, it contains a disclaimer pointing out the uncertain quality of the information, as many locations are fully automatic and outside the reporting networks. It is a popular webpage with network operators (20,000 accesses per day). The general public is invited to use the main page, which displays one set of parameters per earthquake. In the EMSC procedures, the data from the different networks are automatically merged. They are manually validated by EMSC staff during working hours, at least once a day during weekends and holidays, and for larger earthquakes in a more or less concentric scheme (M>5 in the Euro-Mediterranean region, M>6 in continental Asia and M>7 worldwide) by an on-call seismologist from our host institute in typically 20 minutes. Since July 2022, the Crowdseeded Seismic Location (CsLoc) method, which combines crowdsourced detections and seismic data analysis for fast (60-90s) and reliable locations of felt earthquakes (Steed et al., 2019; Bondár et al., 2020), has been fully implemented.

The only service restricted to members and accessible by login is the results of rapid impact assessment by the tool named EQIA (Earthquake Qualitative Impact Assessment, Julien-Laferrière, 2019; Guérin-Marthe et al., 2021). It offers heads-up on the scale of damage. However, such result is considered vulnerable to misinterpretation and over-interpretation by laypersons and journalists due to the inherent uncertainties of

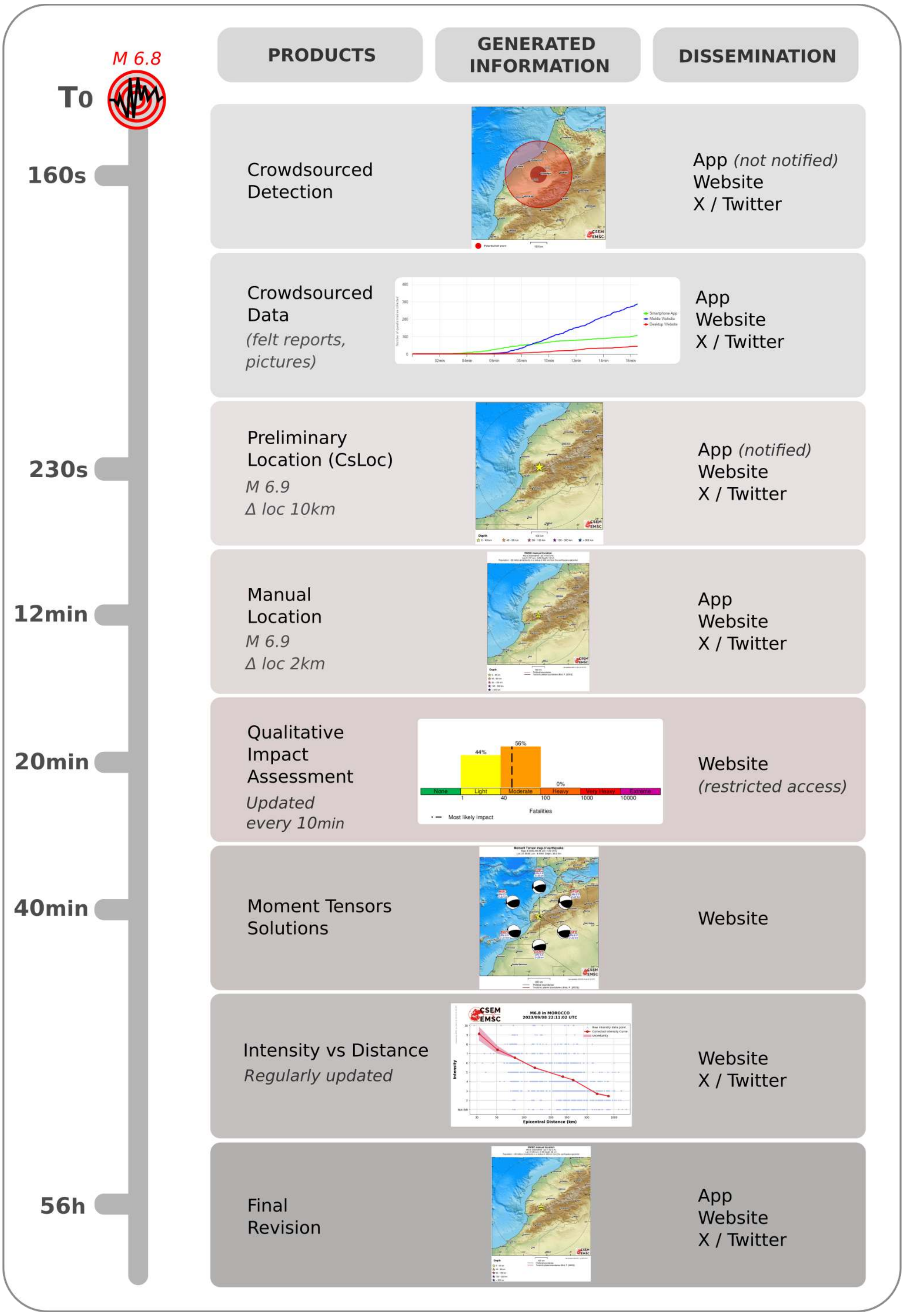


**Figure 5** Abbreviated timeline -relative to origin time- of the main EMSC product releases and updates as well as their distribution channels for the 8 September 2023 M 6.8 Morocco earthquake.

such estimates and access is restricted to identified end-users (Bossu et al., 2015). Figure 5 shows an abbreviated timeline -relative to origin time- of the main EMSC product releases and updates as well as their distribution channels for the 8 September 2023 M 6.8 Morocco earthquake.

## Current evolutions

There have been 2 major developments over the last few years. The first is the complete refactoring of both the back-end (processing part) and front-end (websites, smartphone app, etc.) systems, made possible thanks to the support of the SCOR for Science Foundation. The second concerns new methods related to rapid impact

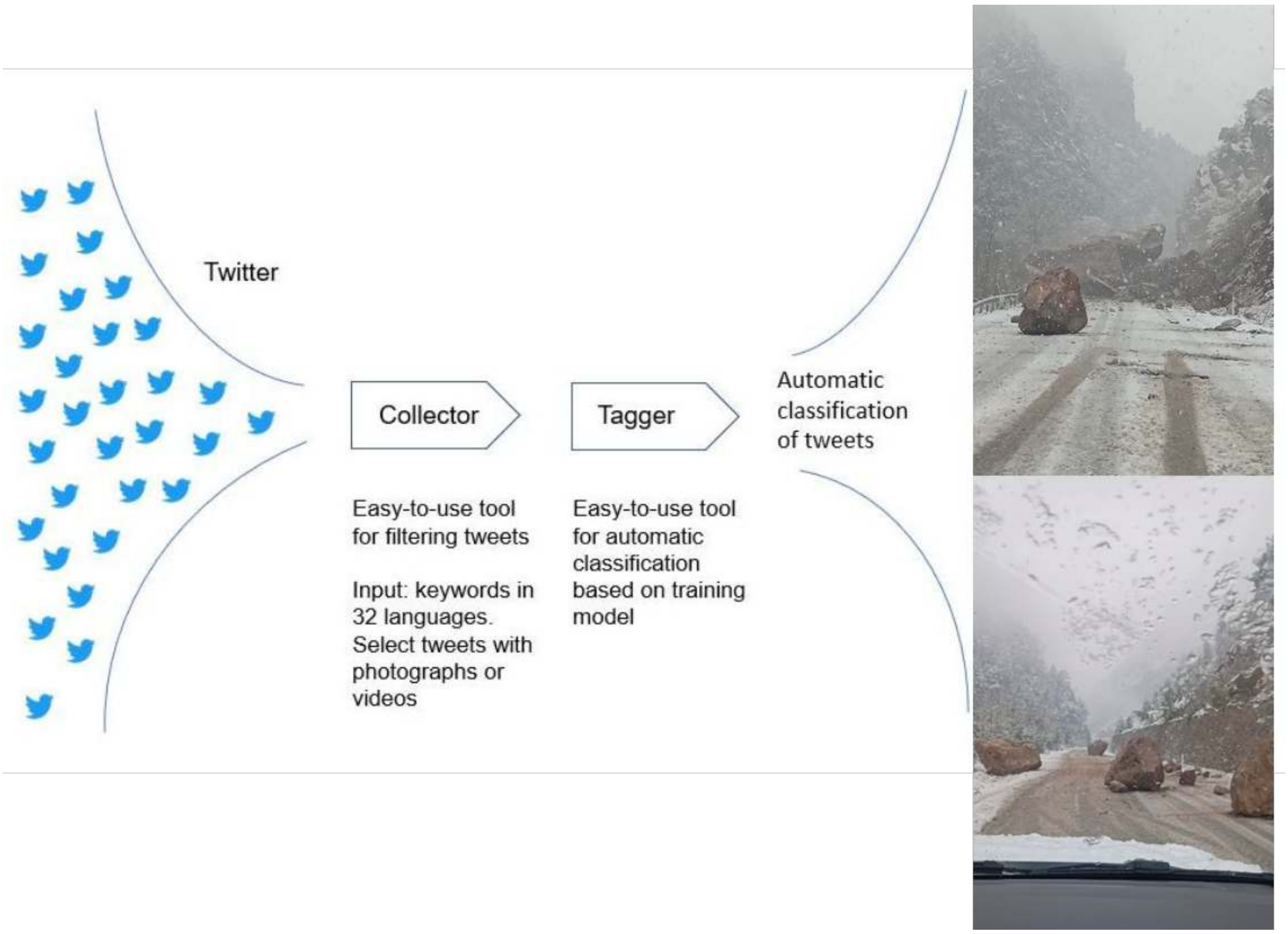


**Figure 6** Schematic of the Global Landslide Detector (GLD), developed in collaboration with the Qatar Computing Research Institute and the British Geological Survey Landslide Team. Tweets containing both an image and a landslide-related word in different languages are collected. Images not related to landslides are automatically rejected. The 2 images on the right were collected 12 hours after the M7.8 Kahramanmaras earthquake in Turkey.

assessment, some of which optimise the use of felt reports for the calculation of shaking maps and damage assessment, and other harvesting of information from social media for the detection of landslides.

The refactoring of the systems is the first of its kind and was long overdue. It started with a new mobile website in 2020, followed by a new version of the Twitter bot (Twitter is now called X) in February 2022 (Bossu et al., 2023). The new version of the smartphone app is currently being tested and a new desktop website was launched at the end of June 2023. The main change concerns the backend and the processing of the seismic data, including in particular a new data model, a modular structure and the implementation of the iLoc location algorithm, particularly suitable for unbalanced networks and with more accurate formal uncertainty estimates (Bondár et al., 2018). It was originally developed at the ISC, where its implementation has resulted in consistent locations improvements (Bondár and Storchak, 2011). The new system and associated website for desktops allow better crediting of data contributors and different types of contributions (e.g. phase picking, station operators...). By adding a third digit to the earthquake locations, the grid patterns visible on the highly zoomed map of the earthquake sequence accompanying the Cumbia Vieja volcano on the island of La Palma in 2021, which led to rumours and conspiracy theories, will not be repeated (Fallou et al., 2022). Only minor adjustments have been made to the new seismic data processing system since its release in June 2023. So far, the main use of the felt reports has been limited to purely data-driven products such as earthquake impact maps and intensity vs distance curves. This is now evolving rapidly. Quitoriano and Wald (2022) developed a methodology to incorporate them into ShakeMap products, resulting in a lower level of uncertainty. Böse et al. (2021) apply the Finite-Fault Rupture Detector (FinDer) algorithm, which typically requires real-time ground motion observations from a dense seismic network operated in the vicinity of the earthquake (Böse et al., 2012), to felt reports to compute line-source models. The system has been in operation for the last 18 months and the results already appear promising when using the first 10 or 20 min of felt reports, but they still need to be fully evaluated. The inclusion of both felt reports and, for larger earthquakes, an early finite rupture model, could significantly speed up the production of reliable Shakemaps for global earthquakes, and in turn reduce the uncertainties of the impact models derived from ShakeMap. Recently, Lilienkamp et al. (2023) developed a data-driven approach that bypasses the computation of ShakeMap and is completely independent of seismic data to discriminate high-impact from low-impact earthquakes globally based only on felt reports available within the first 10 minutes. It is a first step and could evolve into a traffic light system by adding additional crowdsourced data. However, it can already correctly classify a significant proportion (39%) of low-impact events with high confidence and then quickly and reliably rule out the need for emergency response. Still related to the use of crowdsourced data, Contreras et al. (2022) performed a sentiment and topic analysis on the comments of users providing felt reports. As hypothesised, negative polarity in the comments is associated with higher intensities, while positive polarity prevails in those associated with the lowest intensities.

Finally, a prototype called the "Global Landslide Detector" is available online (https://landslide-aidr.qcri.org/service.php#home). It collects tweets (messages published on Twitter) containing both the keyword "landslide" and related words in different languages, as well as an image. A trained AI engine rejects the images not related to landslides (more than 99% of the collected tweets, Pennington et al., 2022; Ofli et al., 2022, Figure 6). Initiated by the EMSC to detect triggered landslides, which can significantly hamper rescue operations by blocking roads, the project was expanded to detect and document all types of landslides. A landslide was detected 12 hours after the M7.8 earthquake in Kahramanmaraş, Turkey (Figure 6). GLD's operations are currently affected by Twitter's data access restrictions. These developments aim to improve the ability to quickly and reliably assess the impact of global earthquakes.

## Concluding remarks

The EMSC is a non-profit organisation created by the seismological community to provide it with rapid information on earthquakes and their effects, with a portfolio of services complementary to those of the national institutes. It has benefited from numerous European research projects to fund the development of its services and to pioneer citizen seismology, and is now implementing a sustainability plan thanks to its participation in long-term initiatives such as EPOS or ARISTOTLE, but also thanks to private donations and sponsorships. It has an open data policy and aims to improve its dissemination services in the coming years. Finally, this paper is also an opportunity to call on network operators to consider sharing their parametric data.

## Acknowledgments

The EMSC as an organisation and its services are the result of the long-term support and cooperation of many people and institutions over the last 20 years. Firstly, the members for their support and active participation in setting policy, past and present members of the Executive Council for their guidance, with a special mention to past EMSC President Chris Browitt, and without forgetting the data contributors. They are all warmly thanked and should be given credit for the achievements of the EMSC. The services have been developed thanks to the dedicated work of past and present staff. The authors would like to thank Michel Cara and Bruce Presgrave for their insightful discussions on the history of the EMSC as well as the SCOR Foundation for Science for enabling the technical upgrading of the services. Reviews by A. Michelini, J. Schweitzer and 2 anonymous reviewers have helped to improve the quality of the manuscript.

## Competing interests

The authors declare no competing interests

**Table 1** (continued)

| **Key Nodal Members** | |
|---|---|
| Laboratoire de Détection et de Géophysique (LDG) | France |
| GeoForschungsZentrum (GFZ) | Germany |
| Istituto Nazionale di Geofisica e Vulcanologia (INGV) | Italy, Roma |
| Istituto Nazionale di Geofisica e Vulcanologia (INGV) | Italy, Milano |
| Instituto Geografico Nacional (IGN) | Spain |
| **Active Members** | |
| Institute of Geosciences, Polytechnic University of Tirana (IGEO) | Albania |
| Centre de Recherche en Astronomie, Astrophysique et Geophysique (CRAAG) | Algeria |
| National Survey for Seismic Protection (NSSP) | Armenia |
| GeoSphere Austria | Austria |
| Republican Seismic Survey Center of Azerbaijan National Academy of Sciences (RSSC) | Azerbaijan |
| Center of Geophysical Monitoring (CGM) | Belarus |
| Royal Observatory of Belgium (ORB/ROB) | Belgium |
| Republic Hydrometeorological Institute (RHI) | Bosnia-Herzegovina |
| Federal Meteorological Institute (FMI) | Bosnia-Herzegovina |
| National Institute in Geophysics, Geodesy and Geography - BAS | Bulgaria |
| Croatian Seismological Survey (CSS) | Croatia |
| Geological Survey Department (GSD) | Cyprus |
| Institute of Physics of the Earth, Brno (IPE) | Czech Republic |
| Geophysical Institute of the Academy of Sciences (GFU) | Czech Republic |
| Geological Survey of Denmark and Greenland (GEUS) | Denmark |
| Observatoire Geophysique d'Arta (CERD) | Djibouti |
| National Research Institute of Astronomy and Geophysics (NRIAG) | Egypt |
| Institute of Seismology, University of Helsinki (ISUH) | Finland |
| Bureau Central Sismologique Francais (BCSF) | France |
| ISTerre, Institut des Sciences de la Terre | France |
| Seismic Monitoring Centre of Georgia (SMC) | Georgia |
| Federal Institute for Geosciences and Natural Resources (BGR) | Germany |
| National Observatory of Athens (NOA) | Greece |
| University of Thessaloniki (AUTH) | Greece |
| Institute of Engineering Seismology and Earthquake Engineering (ITSAK) | Greece |
| Laboratory of Seismology, University of Patras | Greece |
| Kövesligethy Radó Seismological Observatory | Hungary |
| Icelandic Meteorological Office (IMO) | Iceland |
| Dublin Institute for Advanced Studies (DIAS) | Ireland |
| Geological Survey of Israel (GSI) | Israel |
| National Data Center (NDC) of Israel, Soreq Nuclear Research Center | Israel |
| Istituto Nazionale di Oceanografia e Geofisica Sperimentale (OGS) | Italy |
| Jordan Seismological Observatory | Jordan |
| Seismological Institute of Kosovo | Kosovo |
| Geophysics Centre at Bhannes (SGB) | Lebanon |
| Libyan Center for Remote Sensing and Space Science (LCRSSS) | Libya |
| European Center for Geodynamics and Seismology (ECGS) | Luxembourg |
| Seismological Observatory | North Macedonia |
| Department, University of Malta (UM) | Malta |
| Institute of Geology and Seismology | Moldova |
| Direction de l'Environnement | Monaco |
| Institute of Hydrometeorology and Seismology (MSO) | Montenegro |
| Centre National pour la Recherche Scientifique et Technique (CNRST) | Morocco |
| Département des Sciences de la Terre | Morocco |
| University of Bergen (BER) | Norway |

| | |
|---|---|
| NORSAR | Norway |
| Institute of Geophysics, Polish Academy of Sciences (IGPAS) | Poland |
| Instituto de Meteorologia (IMP) | Portugal |
| Universidade de Evora | Portugal |
| Faculdade de Ciências da Universidade de Lisboa | Portugal |
| National Institute for Earth Physics (NIEP) | Romania |
| Geophysical Survey of the Russian Academy of Sciences (GSRAS) | Russia |
| Seismological Survey of Serbia (SSS) | Serbia |
| Earth Science Institute, SAS, Department of Seismology | Slovakia |
| Agencija Republike Slovenije za okolje (ARSO) | Slovenia |
| Institut Cartografic i Geologic de Catalunya (ICGC) | Spain |
| Swedish National Seismic Network (SNSN) | Sweden |
| Schweizerischer Erdbebendienst (ETH) | Switzerland |
| Royal Netherlands Meteorological Institute (KNMI) | The Netherlands |
| Institut National de la Météorologie (INMT) | Tunisia |
| Disaster and Emergency Management Presidency, Earthquake Department (ERD) | Turkey |
| Kandilli Observatory and Earthquake Research Institute (KOERI) | Turkey |
| Main Centre for Special Monitoring (MCSM) | Ukraine |
| Dubai Municipality Seismic Network | United Arab Emirates |
| British Geological Survey (BGS) | United Kingdom |
| National Seismological Observatory Centre (NSOC) | Yemen |
| **Members by right** | |
| European Seismological Commission (ESC) | |
| Observatories and Research Facilities for EUropean Seismology (ORFEUS) | |
| International Seismological centre (ISC) | |
| U.S. Geological Survey (USGS) | United States |

**Table 1** List of member institutions in January 2023.

**Table 2** (continued)

| Institute | Country/Region | Exchange tool | Parametric data | MT |
|---|---|---|---|---|
| Institute of Geosciences, Polytechnic University of Tirana (IGEO) | Albania | Email | L P A | MT |
| Centre de Recherche en Astronomie, Astrophysique et Géophysique (CRAAG) | Algeria | Web | L | |
| Instituto Nacional de Prevencion Sismica (INPRES) (NSNA) | Argentina | Web | L | |
| National Survey of Seismic Protection (NSSP) | Armenia | Email | L P A | |
| Geoscience Australia, Canberra, ACT, Australia (AUST) | Australia | Mail | L P A | |
| Geosphere Austria (GBA) | Austria | Email | L P | |
| Republican Seismic Survey Center or Azerbaijan National Academy of Sciences (RSSC) | Azerbaijan | Email | L P A | |
| Royal Observatory of Belgium (UCC) | Belgium | Email | L P A | |
| Rede Sismografica Brasileira (RSBR) | Brazil | Web | L P A | |
| National Institute in Geophysics, Geodesy and Geography - BAS (SOF) | Bulgaria | Email | L P A | |
| Canadian National Seismic Network (CNSN) BB stations (CN) | Canada | Web | L | |
| Departamento de Geofisica, Universidad de Chile (CSN) | Chile | Email | L | |
| Seccion de Sismologia, Univ. de Costa Rica, San Jose, Costa Rica (UCR) | Costa Rica | Web | L | |
| Seismological Survey,University of Zagreb (ZAG) | Croatia | Email | L P | |
| Servicio Sismologico Nacional de Cuba (CENAIS) (SSNC) | Cuba | Web | L | |
| Geological Survey Department (GSD) | Cyprus | Email | L P A | |
| Geophysical Institute of the Academy of Sciences (GFU) | Czech Rep. | Email | L P | |
| Institute of Physics of the Earth (IPEC) | Czech Rep. | Email | L P A | |

**Table 2** (continued)

| | | | | |
|---|---|---|---|---|
| Universidad Autonoma de Santo Domingo (UASD) | Dominican Rep. | Web | L | |
| Escuela Politecnica Nacional, Quito, Ecuador (QUI) | Ecuador | Web | L | |
| National Research Institute of Astronomy and Geophysics (NRIAG) | Egypt | Email | L P A | |
| Servicio Nacional de Estudios Territoriales (SNET) | El Salvador | Web | L | |
| Laboratoire de Detection et de Geophysique (LDG) | France | Email | L P A | |
| Institut de Physique du Globe de Paris (IPGP) | France | Email | | DC |
| Géoazur (Université Cote d'Azur, IRD, CNRS, Observatoire de la Cote d'Azur) (OCA) | France | Email | L P A | DC |
| Réseau National de Surveillance Sismique (ReNaSS) | France | Web | L P A | |
| Seismic Monitoring Centre of Georgia (TIF) | Georgia | Email | L P | |
| Bundesanstalt fur Geowissenschaften und Rohstoffe, German Regional Seismograph Network (BGR) | Germany | Email | L P A | |
| GeoForschungsZentrum (GFZ) | Germany | HMB | L P A | MT |
| Landsamt fur Geologie, Rohstoffe und Bergbau (LED) | Germany | Email | L P | |
| National Observatory of Athens, Geodynamic Institute (NOA) | Greece | Email | L P A | MT |
| Aristotle University of Thessaloniki, Department of Geophysics (THE) | Greece | Email | L P A | |
| University Of Athens (UOA) | Greece | Email | | MT |
| University of Patras Seismological Laboratory (UPSL) | Greece | Email | | MT |
| Observatoire Volcanologique et Sismologique de Guadeloupe (OVSG - IPGP) (OVSG) | Guadeloupe | Web | L P A | |
| URGeo, Geoazur (Universite Cote d'Azur, IRD, CNRS, Observatoire de la Cote d'Azur) (AYIT) | Haiti | Email | L P A | |
| MTA CSFK GGI Kovesligethy Rado Seismological Observatory (BUD) | Hungary | Email | L P A | |
| Department of Geophysics, Icelandic Meteorological Office (IMO) | Iceland | Web | L | |
| India Meteorological Department, New Delhi, India (NDI) | India | Web | L | |
| Badan Meteorologi, Klimatologi dan Geofisika (BMKG) | Indonesia | Web | L | |
| Institute of Geophysics, University of Tehran (IGUT) | Iran | Email | L P A | |
| International Institute for Earthquake Engineering and Seismology (IIEES) | Iran | Email | L | |
| Irish National Seismic Network (INSN) | Ireland | Email | L P A | |
| Geological Survey of Israel, Seismology Division (GSI) | Israel | Email | L P | |
| Instituto Nazionale di Geofisica e Vulcanologia (INGV) | Italy | Email | L P A | MT |
| Instituto Nazionale di Oceanografia e Geofisica Sperimentale - OGS (OGS) | Italy | Email | L P A | |
| Kazakhstan National Data Center (KNDC) | Kazakhstan | Email | L P A | |
| Korean Meteorological Administration (SEO) | S. Korea | Web | L | |
| Kyrgyz Institute of Seismology (KIS) | Kyrgyzstan | Email | L P A | |
| National Center for Geophysical Research (GRAL) | Lebanon | Email | L P A | |
| Malaysian Meteorological Department (MMD) | Malaysia | HMB | L P A | |
| Malta Seismic Network, Seismic Monitoring and Research Unit (SMRU), University of Malta (MLT) | Malta | Email | L P A | |
| Observatoire Volcanologique et Sismologique de Martinique (OVSM - IPGP) (OVSM) | Martinique | Web | L P | |
| Servicio Sismologico Nacional, Instituto de Geofisica, UNAM (UNM) | Mexico | Web | L | |
| Institute of Geophysics and Geology (MOLD) | Moldova | Email | L P A | |
| Montenegro Seismological Observatory (MSO) | Montenegro | Email | L P A | |
| Centre National de la Recherche Scientifique et Technique (CNRST) | Morocco | Email | L P | |
| National Seismological Centre, Department of Mines and Geology (NSC) | Nepal | Web | L | |
| Koninklijk Nederlands Meteorologish Instituut (KNMI) | Netherlands | Web | L | |
| Geonet, GNS science (GNS) | New Zealand | Web | L P | |

**Table 2** (continued)

| | | | | |
|---|---|---|---|---|
| Instituto Nicaraguense de Estudios Territoriales (INET) | Nicaragua | Web | L | |
| Seismological Observatory (SKO) | N. Macedonia | Email | L P A | |
| University of Bergen (BER) | Norway | Email | L P A | |
| NORSAR | Norway | Email | L P A | |
| Centre Polynésien de Préventions des Tsunamis (CPPT) | Pamatai | Email | | MT |
| Universidad de Panama (IGC) | Panama | Web | L | |
| Instituto Geofisico del Peru (LIM) | Peru | Web | L | |
| Philippine Inst. of Volcanology and Seismology, Quezon City, Philippines (PIVS) | Philippines | Web | L | |
| Instituto Portugues do Mar e da Atmosfera (IPMA) | Portugal | Email | L P A | |
| Instituto Portugues do Mar e Atmosfera (PDA) | Portugal | Email | L P A | |
| Puerto Rico Seismic Network (PRSN) and Puerto Rico Strong Motion Program (PRSMP), University of Puerto Rico at Mayaguez (PR) | Puerto Rico | PDL | L P A | |
| National Institute for Earth Physics (NIEP) | Romania | Email | L P | |
| Geophysical Survey of the Russian Academy of Sciences (GSRAS) | Russia | Email | L P | |
| Seismological Survey of Serbia (SSS) | Serbia | Email | L P A | |
| Agencija Republike Slovenije za okolje, Seismological Office (LJU) | Slovenia | Email | L P | |
| South African Seismological Network (SASN) | South Africa | Web | L | |
| Instituto Cartografic i Geologic de Catalunya (ICGC) | Spain | Email | L P A | |
| Instituto Geografico Nacional (IGN) | Spain | Email | L P A | |
| Swiss Seismological Service (ETHZ) | Switzerland | Email | L P A | |
| Central Weather Bureau (CWB) | Taiwan | Email | L P | |
| Thailand Seismological Bureau (TSB) | Thailand | Web | L | |
| University of the West Indies, St. Augustine, Trinidad (TRN) | Trinidad and Tobago | Email | L | |
| Institut National de Meteorologie (INMT) | Tunisia | Email | L P A | |
| Disaster and Emergency Management Presidency, Earthquake Department (AFAD) | Turkey | Email | L P A | MT |
| Kandilli Observatory and Earthquake Research Institute (KOERI) | Turkey | Email | L P | MT |
| Carpathian Seismological Department, Ukraine Academy of Science (LVV) | Ukraine | Email | L P | |
| Ukrainian NDC, Main Center of Special Monitoring (MCSM) | Ukraine | Email | L P A | |
| British Geological Survey (BGS) | United Kingdom | Email | L P A | |
| Alaska Regional Network, University of Alaska-Fairbanks (AK) | US | PDL | L P A | |
| Alaska Tsunami Warning Seismic System, West Coast and Alaska Tsunami Warning Center (AT) | US | PDL | L P A | |
| Alaska Volcano Observatory, USGS - Anchorage, University of Alaska, Geophysical Institute (AV) | US | PDL | L P A | |
| 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 | |
| Montana Regional Seismic Network, Montana Bureau of Mines and Geology (MB) | US | PDL | L P A | |
| 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 |
| Cooperative New Madrid Seismic Network, St. Louis University and University of Memphis (NM) | US | PDL | L P A | |
| Western Great Basin/Eastern Sierra Nevada, University of Nevada, Reno (NN) | US | PDL | L P A | |
| Oklahoma Seismic Network, University of Oklahoma (OK) | US | PDL | L P A | |
| Pacific Tsunami Warning Seismic System, Pacific Tsunami Warning Center, Ewa Beach, Hawaii (PT) | US | PDL | L P A | |

**Table 2** (continued)

| | | | | |
|---|---|---|---|---|
| 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 |

**Table 2** List of data contributors in 2022 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 contains at least locations and magnitude (L). They generally contains picks (P) and amplitudes (A).

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