How to fight misinformation about earthquakes? A Communication Guide

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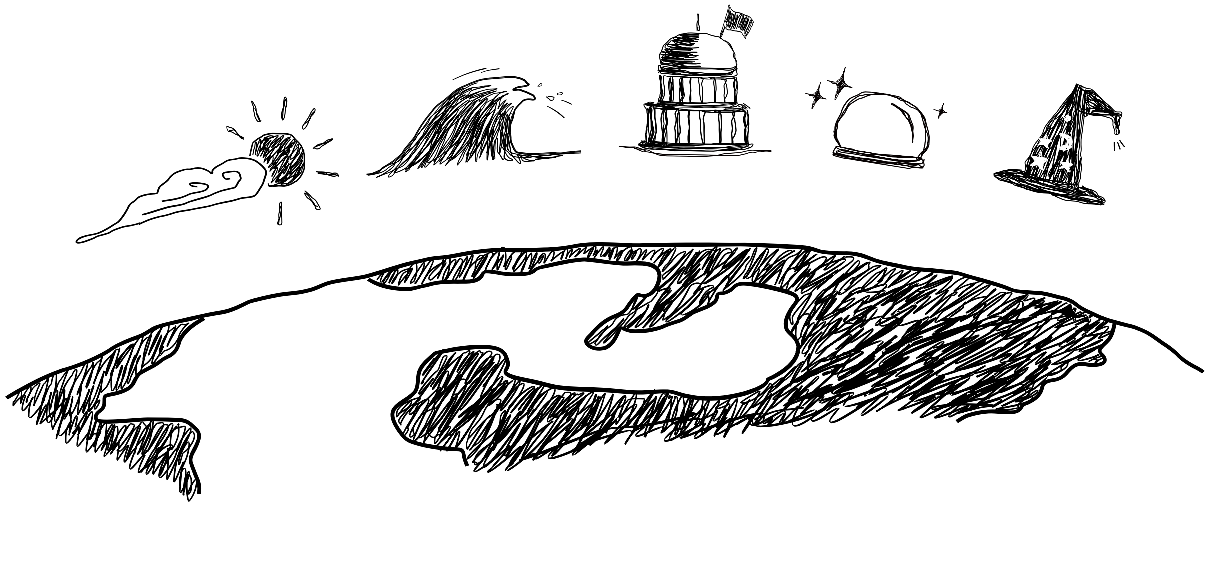
How to fight misinformation about earthquakes?

A communication guide

Evidence-based recommendations on how to fight misinformation before, during, and after seismic events.



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Note to the reader

This communication guide is intended to support institutions, scientists and practitioners who are communicating earthquake information to the public. The guide provides general recommendations on how to prevent and fight misinformation about earthquakes, an overview of when different types of earthquake information are available and a timeline that allows strategic planning of the communication during all phases of the seismic cycle. Further, we advise on how to deal with misinformation around commonly debated topics: how earthquakes are generated ("Creating earthquakes"), whether earthquakes can be predicted ("Predicting earthquakes"), and whether there is a link between earthquakes and climate ("Earthquakes and Climate").

Content

1 Earthquake misinformation: why does it matter?

When an emergency occurs, information is as critical to people as food or shelter. With the development of mobile and digital communication networks, the expectation to receive real-time, accurate information is high for a significant share of the world population. As a result of the rapid evolution of information and communication technologies, the majority of people around the world have access to online information [1] that can be shared quickly. Informing the people threatened by an imminent danger as soon as possible can save lives. Yet rapid, reliable, and efficient communication during an emergency situation comes with its own challenges due to information overload and lack of content moderation, which can lead to the spread of misinformation. This in turn can lead to unsuitable behaviour, with consequences for both human and economic losses.

Research shows that misinformation appears and is spread quickly because of both socio-psychological and technical reasons. At any one time, humans can store about three to four pieces of information in their minds [2],[3]. To help us manage the volume of information in the world, we have evolved to use shortcuts, or 'cognitive heuristics', that help us to focus on key pieces of information whilst ignoring those which are less relevant [4]. These typically aid us in making quick decisions, however such heuristic thinking can be susceptible to biases that result in irrational judgements compared to what would result from a slower, more deliberate process of thinking [5],[6].

During crises, when anxiety and stress are high, we are often even more limited in our mental capacity since stress uses mental resources [7]. This can lead us to rely more heavily on these heuristics, and increase the chance of biases occuring. In addition, time to check information is reduced during crises. These two things combined can cause people to believe and share misinformation that gives them certainty and helps the sense-making process [8]. This holds especially true when communication by formal institutions is lacking or the trust in the institutions communicating information is low. In addition, misinformation belief and spread can be linked to a lack of science and information literacy, and lack of communication from institutions setting expectations, which means that people may not know what information can be produced and at what time it can be available [9]. Therefore, in many cases misinformation, in contrast to disinformation (see Glossary), is spread with no malicious intent. Regarding the technical reasons, first, most social media, contrary to traditional ones, are unmoderated, which eases the dissemination of unverified information. Additionally, the sociotechnical design of these platforms prioritise content (e.g., algorithms, bots) that is likely to get users' engagement and that have already been liked, commented or shared by others, meaning that misinformation which is fulfilling a need in the audience for certain information, can be amplified [10]. As a result, misinformation is likely to be prioritised over more reliable content.

Since damaging earthquakes and their effects are rare and outside of most people's experience, they can generate anxiety, fear and even panic and hence are prone to give rise to the spread of misinformation. For instance, fake predictions about aftershocks flourish on social media after significant earthquakes, sometimes leading to hazardous behaviour. For example, following the M5.8 earthquake in Albania in 2019, fake news was spread about a M6.0 aftershock prediction, which led people to flee the city in panic [11]. However, earthquake misinformation is not limited to predictions: it also covers false information regarding earthquakes causes, or links between seismicity and other natural or manmade events. Despite often not being intentionally spread or created, misinformation should still be prevented or mitigated against where possible because of its effects.

To tackle this issue, we, an international group of social scientists, seismologists and statisticians, sought to address the questions i) what can be done generally to fight misinformation and ii) how can the most common myths related to earthquakes be individually addressed. To this end, we first elicited expert input from a group of seismologists and geologists to better understand the current research on the most common earthquake myths. Secondly, we conducted a survey with 167 earth scientists. In the survey, the scientists were asked to rate statements about potential earthquake myths on a scale from completely false to completely true. We discussed the survey results with a smaller group of seismologists to contextualise the scientific statements. Because communication is key to fight misinformation, we used these insights to compile this communication guide which should help institutions, scientists and practitioners working in the field of hazard and risk communication to combat earthquake misinformation.

The structure of the communication guide is as follows: First, we provide general recommendations and strategies on how to fight misinformation. Second, we introduce a communication timeline and situate the most common myths along this timeline. This communication timeline is needed to strategically plan your communication. Third, we summarise which information is actually available, where and when. Finally, we provide specific recommendations for the three most common myth topics - Creating earthquakes, Predicting earthquakes, and Earthquakes & Climate.

Glossary

Misinformation: information that is false or misleading according to the best available evidence at the time and that is communicated regardless of an intention to deceive [12]. We focus here on misinformation that is specific to earthquakes, their causes and consequences.

Disinformation: false information spread deliberately to deceive [12,13].

Pure disinformation: false information shared although both the original author and the propagator are aware of its false nature [12].

Fake news: type of disinformation. Fake news is the deliberate presentation of (typically) false or misleading claims as news, where the claims are misleading by design (e.g., the intention to deceive an audience, to manipulate public opinion) [14].

Prebunk: strategy consisting in "inoculating" people against misinformation before they are exposed to it. It includes a forewarning and preemptive refutations [15].

Debunk: strategy consisting in exposing a fact as being false or exaggerated [15].

2 What can you do to fight misinformation?

Sharing data and raw scientific knowledge is almost never sufficient to prevent and fight misinformation. Based on general theories of how to combat misinformation, we identified three key communication principles that can contribute to setting up a more efficient and effective communication process (Figure 1).

Understanding your audiences' perspectives and perceptions is crucial to design a communication that meets their needs and interests both in terms of what, how and when they receive information. This also includes trying to understand why and how the audiences could be exposed to misinformation. What could be the source and types of false information they may believe in and share, and why? What are the best communication methods to respond to that? To this end, adapting to the audiences' risk, scientific and information culture and considering the diversity of your audiencies is key.

To avoid the appearance of misinformation, we also identified specific methods to **refine messaging**. For instance, visuals and examples were found to help message comprehension, especially in cases of emergency. We have collected resources to help you develop these tips & tricks.

Finally, **trust** is essential when it comes to science and risk communication so make sure you establish a good relationship with your audience before the earthquake happens (e.g., engage in regular exchanges with authorities responsible for decision-making and communication who need information to make their decisions, engage in community events, work with local stakeholders to craft information products,...). Manage audiences' expectations beforehand so that they know what kind of information they can and cannot expect from you and from different authorities, when to expect it, and on which channel.

By following these general recommendations you will get ready to face earthquake myths and misinformation that you did not specifically prepare for.

Understand Your Audience

Know Your Audience

preparedness level
information needs
risk culture
expectations
beliefs
interest
science literacy
risk perception
psychology of risk

before the earthquake

Assess the needs of your audiences through, i.e., questionnaires or interviews and directly address them.

Ask public experts (first responders, sociologists, communicators) about the audience.

after the earthquake

Reflect on the experience: assess their effective behavior and level of knowledge during and after the event.

Tips & Tricks

probabilities & uncertainties

Use a combination of both numerical and verbal descriptions of probability and uncertainty. Verbal descriptions should not be used alone as they are often interpreted in different ways by different audience members.

format & wording

Use different formats so that people with different abilities can consult the ones they are most familiar with.

⚠ Icons and terminology can vary between cultures. Colour schemes can produce misperceptions & visual artifacts.

communication

Tailor your messages: different target audiences have different information needs and levels of expertise. Provide context and use comparisons. Test your communication material in advance.

Refine Messaging

acknowledge limitations & uncertainties
be inclusive
provide examples
avoid information overload
use visuals
be empathetic

How to Manage Expectations

Establish a Relationship

be clear and consistent
manage expectations
collaborate with all actors
build trust
be transparent

tell the public

What kind of information they can expect.

What is not possible to cover.

Why they cannot receive or access certain information.

Where they can find the information (i.e., which channel).

When the information will be available.

When they will receive the information.

Who is going to disseminate the information.

Figure 1: General recommendations on fighting misinformation.

3 How to best time your communication?

When it comes to seismic communication, the timing is critical. Information needs and expectations will evolve throughout the earthquake cycle (before an earthquake sequence, after a mainshock, during aftershock sequences,...), and so will the information available.

In order to combat misinformation efficiently, effective communication should be based on the seismic communication timeline. We thus developed a timeline summarising how to communicate and at what stage in the earthquake cycle the different myths are often shared. In addition, we explain in more detail when and what kind of earthquake information is available to be communicated.

The communication timeline

On the seismic communication timeline (Figure 2) we represent a typical example of when the most common myths and misinformation tend to appear during an earthquake sequence, which includes time before a major earthquake, right after a significant earthquake (crisis) and after, during the aftershock sequence. For instance, based on our expert experience working in earthquake risk communication, we observed that earthquake predictions often appear long before, or soon after a major shock, while content related to a potential link between earthquakes and climate and earthquake creation pop up a bit later, often after a series of aftershocks. Therefore, the content of communication and the communicators' attention must be drawn towards the most likely myths.

Earthquake information and its availability

Because misinformation belief and sharing can be linked to a lack of science literacy and a lack of understanding of what seismic information is available at what time during an earthquake sequence, we gathered this knowledge into the list below (see information box). We distinguish, for the three main information phases (Pre-earthquake, Earthquake, and Post-earthquake), what can scientifically be known about potential earthquakes. This aims to clarify what seismology can and cannot know, and is specifically relevant to clearing up the confusion between earthquake prediction, forecasting, early warning and rapid impact assessment.

However, because technologies, knowledge and resources are not the same for all countries and regions, this only represents what is theoretically known, and must be adapted to the local context. For instance, if in your region a public Earthquake Early Warning System is not in place, you will need to adapt your communication efforts accordingly and explain to your audiences why you do not have such a system and, thus, why they cannot expect this kind of information at the moment.

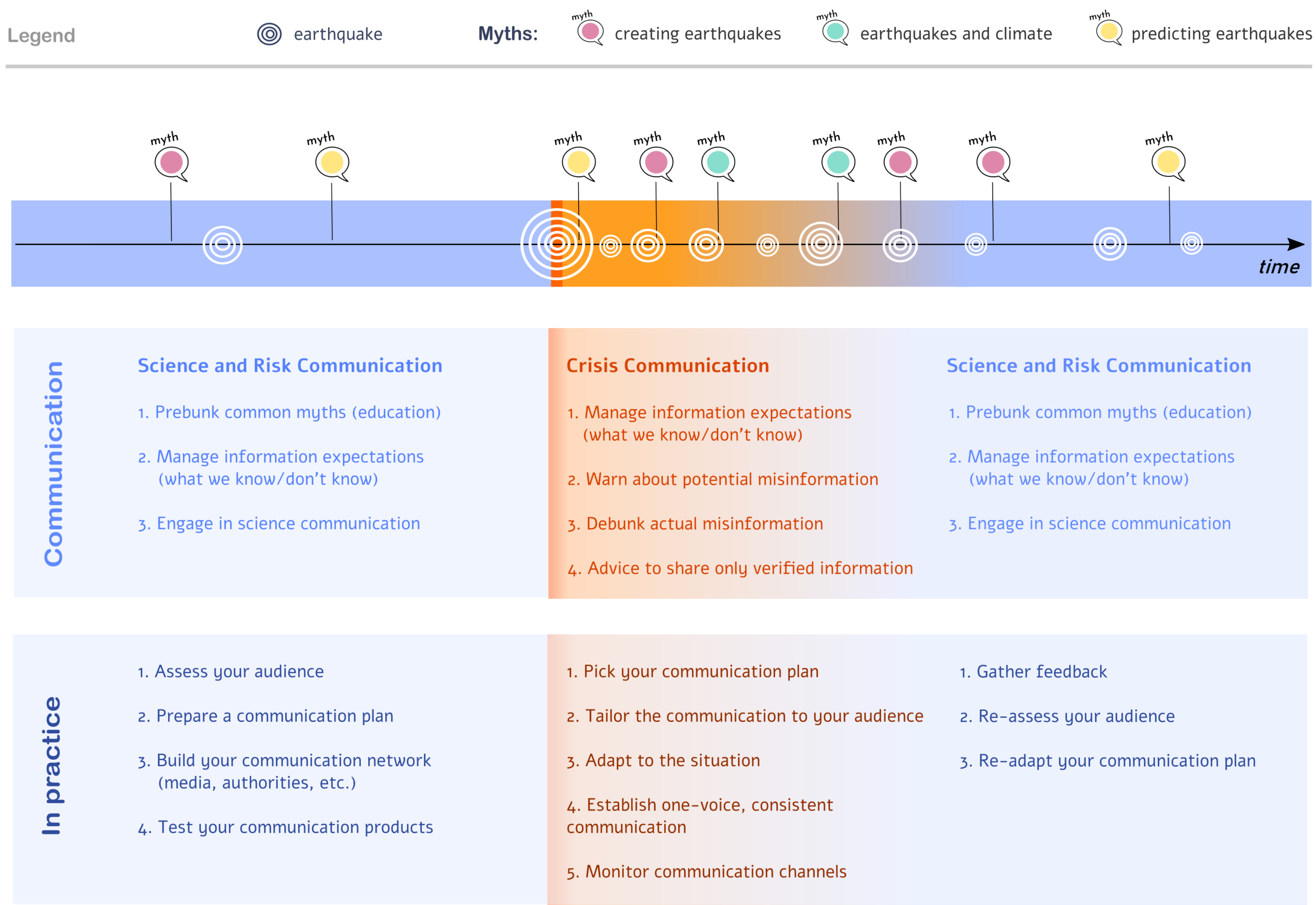

Figure 2: Communication timeline and associated communication strategies, based on an example of misinformation spread during an earthquake sequence.

Available earthquake information

1. Pre-earthquake

Seismic hazard: estimates the likelihood that an earthquake of a certain magnitude will happen in a certain area during a time window ranging from a few years (short-term) to a few decades (long-term). To obtain this estimate, seismologists review the historical seismicity of the area of interest and include detailed information on the local geological-tectonics factors.

2. Earthquake

Earthquake early warning: when an earthquake occurs, Secondary and Surface waves (S-waves) carry most of the energy and cause most of the damage, compared with the Primary waves (P-waves). The P-waves always travel faster than the S-waves, hence they are detected first by seismic instruments. A warning system based on P-wave arrivals can thus allow people in more distant areas to be alerted in advance and thus protect themselves from the imminent arrival of destructive shaking as soon as the earthquake originates. Thus, earthquake early warning is a very fast dissemination (a few seconds) of information after the occurrence of an earthquake, but before it strikes an area with damage.

Rapid earthquake information: a rapid message with general information about the earthquake, i.e. magnitude, epicenter, time and affected area, is available some seconds to a minute after the earthquake.

3. Post-earthquake

Aftershock forecasting: estimates the likelihood that, after a mainshock, following seismic events (aftershocks) of a certain magnitude will happen in the mainshock area within a time window of the order of some days or weeks. Aftershocks are unpredictable. However, their rate, occurrence, and magnitude tend to follow well-established empirical, statistical laws: i) there tend to be fewer aftershocks as time goes on, on average; ii) a larger earthquake tends to produce more aftershocks than a smaller earthquake; iii) a larger earthquake tends to produce aftershocks distributed over a larger area than a smaller earthquake; and iv) the magnitude of the largest aftershock is, on average, 1.2 units smaller than the magnitude of the mainshock.

Rapid impact assessment: involves the assessment of the distribution of ground shaking intensity (so-called ShakeMaps) and of the building damage, casualties and economic losses. Immediate post-event information is used to guide rescue and prioritize the emergency response effort to the areas most impacted. Efforts have been made in recent years in the attempt to find cost-effective alternatives and innovative strategies to rapidly assess the earthquake's impact in terms of felt shaking and observed damages. Examples are the USGS "Did You Feel It?" system or the EMSC "LastQuake" app.

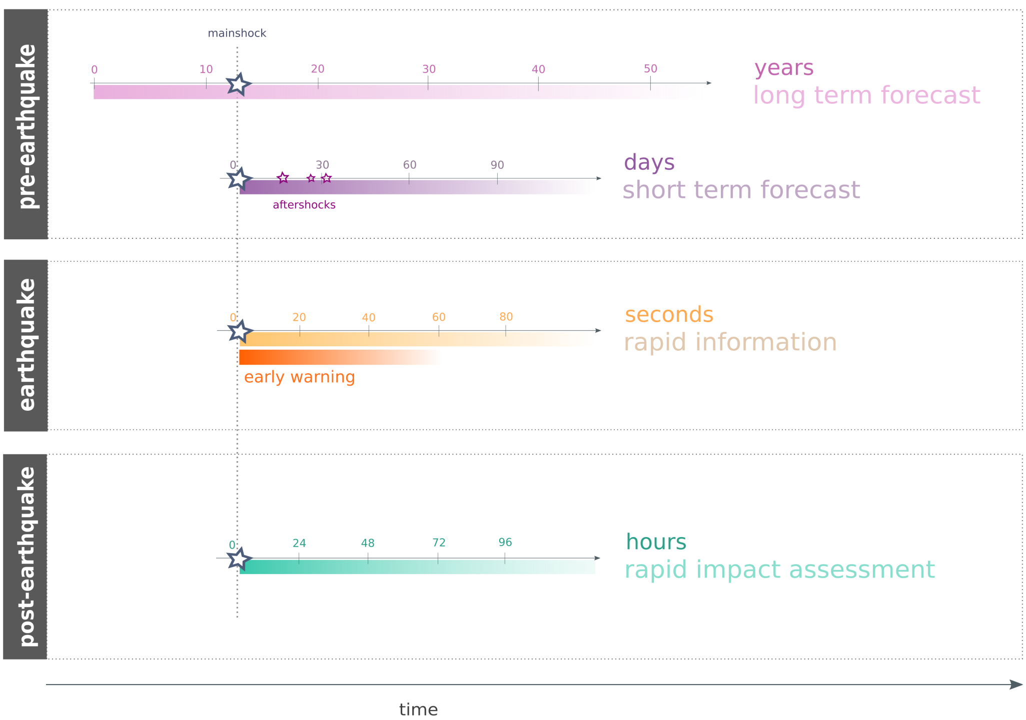

Figure 3: Available earthquake information before, during, and after the earthquake onset.

4 How can you fight the most common earthquake myths?

The most common myths about earthquakes can be classified into three themes: "Creating earthquakes", "Predicting earthquakes" and "Earthquakes and Climate". For each of these themes, we first list the questions that are commonly asked and then provide a general statement about the current scientific knowledge, which has been validated by various experts. Further, we describe the scientific knowledge in more detail and give explicit examples. Afterwards, we explain the reasons why these beliefs exist and provide specific recommendations on how to fight them. These specific recommendations complement the general recommendations provided in the section "What can you do to fight misinformation?" and do not replace them.

Creating earthquakes

Common questions

- Can earthquakes be created by human activities?
- Can earthquakes be created by governments?
- Can earthquakes be created by individuals with malicious intent?

Current scientific knowledge

Most of the time, human activities only cause earthquakes that are not felt or only slightly felt. Yet, in some cases, large technical interventions in the deep underground (e.g., geothermal heat exploitations, waste water disposal, oil and gas exploitation) can trigger felt or even damaging earthquakes. Individuals, operators, and the government cannot control the precise location, size and timing of these earthquakes.

Details

Human activities such as oil, gas or geothermal heat exploitation, extraction of groundwater, wastewater disposal, gas storage, carbon sequestration as well as mining activities can induce earthquakes [16, 17]. Whereas most of these earthquakes remain unnoticed, some are widely felt or even cause significant damage [18, 19].

Recent examples of large, damaging induced earthquakes include the magnitude 5.8 earthquake in Oklahoma (US) in 2016 likely caused by wastewater disposal [20] and the magnitude 5.5 earthquake in Pohang (South Korea) in 2017 induced by geothermal stimulation [21]. In Europe, a recent example is a sequence of induced earthquakes with magnitudes up to 3.5 near Strasbourg in 2019/2020, triggered by geothermal operations.

Reasons for misinformation & conspiracy theories

- Uncertain side effects: Seismologists themselves cannot always predict whether a certain operation will cause a small or a large earth tremor, or none at all. This uncertainty can make it impossible to communicate a precise risk level [22].
- Loss of control: People perceive induced earthquakes as worse (i.e., more worrying, damaging) compared to natural earthquakes [23] and a loss of control [24].
- Intervention in nature: People are generally critical of technologies that interfere with nature and thus are more likely to protest against it [25].
- Lack of immediately available information after an event: The physics of induced and natural earthquakes does not differ [26, 27]. Thus, it can take experts some time to analyse whether the earthquake has occurred naturally or was induced/triggered. Sometimes, operators initially deny responsibility, undermining trust.

Specific recommendations

- An independent institution should monitor seismic activity in the area the activities take place in before, during and after a project which has the potential to cause earthquakes.
- The responsible institution should communicate what can and should be expected as side effects of certain activities, including as low probability high-consequence events [19].
- The responsible institution should inform and establish a relationship with key stakeholders and the local population before starting any activity and continue informing, involving and updating them throughout the project [28, 29].
- The responsible institution should provide the interested audiences (e.g. media) with comprehensive yet understandable information on the technical aspects of projects and the economic, political and territorial objectives of the projects [30].
- Directly after an event, the responsible institution should communicate that seismologists/ scientific experts are evaluating the origin of the earthquake and will keep the public up to date. They should use the format: what we know; what we don't know; what we're doing to find out; what we can all do in the meantime; when and how we will come back with an update.
- A risk management approach is needed to define how to assess and handle the potential risk of induced seismicity to human activities [27, 31].
- As a policy recommendation, one should think about compensation mechanisms for public infrastructure degraded by seismicity and against other environmental damages [32].

Predicting earthquakes

Common questions

- Can earthquakes be predicted?
- Can aftershocks be predicted?
- Can small earthquakes prevent big ones from happening?
- Is seismicity increasing?

Current scientific knowledge

We can calculate probabilities which can provide a forecast of when and where earthquakes might occur, but we cannot predict precisely the magnitude, location and time of future earthquakes.

Details

There is a belief and hope among people that earthquakes can be predicted (e.g., by monitoring the seismicity over a given area or by studying animal behaviour, the moon cycle, etc). Conspiracy theories about earthquake prediction are present all over the world, especially on social media. However, scientists can only estimate the probability of experiencing a seismic event in a specific geographic location within a given time window. This is known as a forecast [33].

It is a commonly held misbelief that small magnitude earthquakes prevent big ones from happening. While minor earthquakes can relieve pressure from small faults or fault patches, this is only a tiny fraction of the plate-tectonically-stored energy available and is not enough to prevent a larger magnitude earthquake from happening on main faults. In fact, the smaller earthquakes can actually trigger bigger ones. From a hazard perspective, a region does not become safer after smaller events, and even after a large earthquake the seismic risk remains higher due to the high likelihood of numerous aftershocks. An illustrative example is the earthquake sequence in l'Aquila in Italy in 2009. Even though several smaller earthquakes occurred beforehand, there was a bigger event (M=5.9) afterwards causing severe damages and causing many fatalities [34].

So far *natural* seismicity has on average not been increasing globally since we have been able to monitor earthquakes (around 100 years). However, for certain time periods, the number of earthquakes can increase at a certain place, as seismicity is spatially and temporally clustered. In addition, due to denser seismic sensor networks, more earthquakes are registered by the seismological institutions worldwide. Earthquakes have only been registered instrumentally since 1900, and earlier in history, one can only consult media reports, books and pictures, which mainly refer to significant earthquakes in inhabited areas with written histories. In comparison, through human activities such as fracking or geothermal operations, *human-induced* earthquakes have increased in recent years and may increase in the future (see section "Creating earthquakes"). The seismic risk (as compared to the hazard) has also increased in recent years, because more and more people and buildings are exposed to seismic hazard due to population growth and urbanisation.

Reasons for misinformation & conspiracy theories

- Self-proclaimed experts: There are people who actively communicate on (social) media that they can predict earthquakes.
- Knowledge gap: People do not know what seismology can and cannot achieve.
- Not commonly-used terms: People do not know what the different terms seismologists use to communicate earthquake information mean, e.g. forecast vs. prediction.
- Technical misconceptions: People, for example, tend to believe that earthquake early warning systems can predict earthquakes because they give a warning (just) before the earthquake is felt in a particular region.
- Multi-hazard context: For all other natural hazards (e.g., hurricanes, tsunamis) forecasts some hours to days before the event are possible- because they can be seen from satellite imagery - which is not the case for earthquakes.
- Personal experience: After long-lasting earthquake sequences, affected people tend to believe that seismicity is increasing overall.

Specific recommendations

- Explain the specific terms (e.g. forecast) that are used to communicate earthquake information.
- Transparently communicate what seismology can do and what not.
- Plan the release of newly available information together with a communication team so that appropriate products/services tailored to the different target audiences can be offered.
- Continuously communicate throughout an earthquake sequence what is known about what happened and what can be expected in the short and long term.

Earthquakes and Climate

Common questions

- Are earthquakes more common during particular types of weather?
- Does climate change lead to more and larger earthquakes?
- Are earthquakes more common at particular times of the day (e.g. night) or of the year (e.g. spring)?
- Are earthquakes more common during certain tides?

Current scientific knowledge

Tectonics is by far the most common cause of earthquakes. However, there is evidence that in some cases, climate change-induced ice melting can cause (or often only prematurely trigger) earthquakes due to a reduced load on a bedrock. Increased seismicity has also been observed in relation to heavy rainfalls, which could occur at some locations more frequently due to climate change.

Details

'Earthquake weather', in the sense that more or larger earthquakes occur due to certain climatic or meteorological conditions, does not exist. However, heavy rainfall has been shown to lead to an increase in shallow seismic activity. There is evidence that, in specific cases, significant changes in climate and consequential alterations of meteorological phenomena can influence seismicity [35, 36].

Climate change has been causing significant temperature increases, which can trigger rapid deglaciations. Such changes in the load on a bedrock due to deglaciation can cause earthquakes [37]. Climate change also influences the atmosphere and in consequence can affect the frequency and intensity of major storms such as typhoons. Such storms in turn can initiate large pressure changes that activate episodes of slow slip resulting sometimes in significant earthquakes [38]. Slow slip events are fractures of the Earth's crust that propagate very slowly without generating considerable ground shaking. In addition, the frequency and the intensity of precipitation can be affected by climate change. There are a couple of documented cases of heavy rainfall [39] and hydrological loading (e.g., filling a dam) [40] inducing small, local earthquakes.

Some of these meteorological phenomena occur more often during certain seasons, e.g. deglaciation in spring. However, there is no evidence that significantly more earthquakes occur in certain seasons than in others, as tectonic causes remain the most common trigger of earthquakes. This is underpinned by the fact that the processes relevant for earthquakes usually take place in depths of the earth which are out of range for climatic influences [41]. In addition, there is also no evidence that earthquakes occur more often at particular times of the day. One of the reasons why some people believe that more earthquakes happen at night is due to the fact that there is less background noise/tremor (e.g. due to traffic) and so weak earthquakes are more felt during the night.

More debated is the influence of tides. Certain types of earthquakes have been linked to tidal activity. Specifically, earthquakes that occur in the middle of the ocean, at what scientists call "oceanic ridges", can be affected by the tides. At low tide, there is less water pressing on magma chambers at these oceanic ridges, allowing the chamber to expand. This causes strain on the surrounding rocks, which can cause the earth to move. This movement may result in earthquakes [42].

Overall, the effects of climate, rainfall and tides can be shown in very specific cases, but tectonic loading is by far the main driving force of seismic activity.

Reasons for misinformation & conspiracy theories

- Retrospective evidence: Climate change is a long-term process and its impacts often only become evident retrospectively, after some years or decades.

- Complex dynamics: The different natural processes are interconnected, complex and dynamic, which can lead to unexpected changes in the system (i.e. the butterfly effect).

- Emotions: The effects of climate change are often emotionally debated, which can lead to emotion-loaded conclusions, trying to support his/her own beliefs and concerns.

Specific recommendations

- Clearly communicate that science has shown that the weather on a particular day does not significantly affect seismicity.
- Clearly communicate that specific weather phenomena such as heavy rain or typhoons can occasionally trigger earthquakes.
- Stress that various, independent scientific groups are continuously monitoring the processes caused by climate change and its effects on earthquakes. Communicators should link through to the current independent sources of information, such as the IPCC.
- Communicate openly that the interactions between climate and seismicity are complex and currently only poorly understood.

5 In summary, what to consider for your fight against misinformation?

Misinformation has always existed in the form of rumours, conspiracies or malicious gossip. It can be found in all cultures and at all times in human history. Nonetheless, new communication channels have amplified misinformation to a new level allowing more people to share such information very easily and rapidly with a potentially enormous audience. Misinformation, as focused on in this communication guide, relates to misleading and false information about earthquakes, their causes, and consequences. This communication guide deals with the question of what institutions, scientists and practitioners who are communicating earthquake information to the public can do to fight, debunk, or counter misinformation. The short answer is, there is no simple solution. The longer answer is, when considering a set of different aspects, institutions can counter misinformation provided their engagement is long-lasting and constant.

Before taking any actions, it is important to eliminate a potential misconception. People who believe in or spread misinformation do not necessarily have malicious intentions nor are they stupid. Misbeliefs often arise due to the tremendous desire of humans to make sense of something. Particularly in situations with high uncertainties, misinformation often just fills the void. In other cases, the scientific facts are uncertain or complex and poorly understood. Understanding the nature and origins of misinformation, as well as the reasons for its spread, is at the basis of any counter or debunking strategy. It also involves establishing a relationship with different target audiences and building trust. Thereby, common misbeliefs should be taken seriously and addressed proactively. The aim should be to establish a dialogue of equals with the target audiences, also acknowledging the limits of scientific knowledge. To this end, one needs to know one's audiences. Only then can their needs be addressed, adequate communication materials designed, and suitable communication channels used. For example, a traditionally-rooted community, located in a rural area, with mostly elderly people holding misbeliefs about the earthquake hazard in their area will not be reached with a social media campaign.

As misinformation can spread at any stage of the earthquake cycle: before, during, and after an event, fighting it becomes a permanent task. Even though countering misinformation should not dominate all your communication activities, providing information that is relevant, understandable, and accessible for different target audiences at any time helps to stay on track. To reach this aim, we suggest regularly talking to different target audiences and testing potentially widely-used communication products before their dissemination. We believe that this can only be achieved via a transdisciplinary process with trained personnel and sufficient resources. This is of course challenging, and, for most institutions, a long-term process. However, this should not discourage you from communicating at all, because not speaking out is also a statement and even engaged individuals can make a difference.

Misinformation predominantly spreads during a crisis when resources are anyhow limited. Therefore, it is recommended to explicitly address communication issues in emergency plans helping you to guide your outreach activities in these times. In addition, a permanent issue monitoring helps to quickly detect rising misbeliefs and to define counter strategies. As mentioned beforehand, without engaged and trained personnel who are willing and keen to engage with different target audiences, these strategic measures remain worthless.

6 Do you want to learn more?

We list here some tools and references as an inspiration to dig deeper into how to best fight misinformation and to communicate hazard and risk information. The list is not exhaustive but considered as a good starting point.

1. To learn more about debunking techniques:
   Debunking Handbook

2. To learn more about why misinformation spreads and how to counter it:
   Countering misinformation in the information age

3. To learn more about automated tools to fight misinformation:
   A value-driven approach to addressing misinformation in social media

4. To choose adequate formats for uncertainty visualisation:

   Uncertainty Visualization

   Evaluating the effect of visually represented geodata uncertainty on decision-making: systematic review, lessons learned, and recommendations

   Visualizing Uncertainty in Natural Hazards

   Difficulties in explaining complex issues with maps: evaluating seismic hazard communication – the Swiss case

5. To choose adequate colours for your designs:

   The misuse of colour in science communication

   ColorBrewer

   Colour-gorical

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