Communicating Geohazards

Delivering Information in Crisis and Calm

A handbook developed from the short course of the same name in Portland, Oregon, October 6-8, 2019

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Image credit:

Front page, pages 9 and 12 (Mount St. Helens) and page 15 (Kīlauea): Courtesy of the U.S. Geological Survey

Page 17: Aerial photograph of the 2014 Oso landslide in northwest Washington (Mark Reid/USGS)

This handbook was designed by Maïté Agopian, 2020

Introduction

This handbook is the product of a two-day short course with three remote follow-on sessions led by social scientists and professional science communicators in October 2019. Participants included eight geoscience graduate students and six journalists of various career stages. The course covered responsible communication of geohazards, with a focus on earthquakes and volcanoes of the Pacific Northwest. While the handbook includes basic background information on Cascadia, the best practices are applicable to communicating about geohazards of all types, anywhere in the world.

This course was motivated by the recognition that geoscientists and journalists are both called on to communicate about hazards, while often neither group receives training in the best practices in how to do so. Also, while working with the news media is important for sharing science broadly, many scientists are reluctant to do so, and journalists often have trouble accessing scientists. Yet the two professions share traits such as curiosity and skepticism, a desire for truth, and a drive to learn. By creating a cohort to recognize these similarities and understand the conflicting needs (for example, science usually moves slowly, journalism often moves quickly) we hoped to improve hazards communication to the public through more effective communication and better relationships. More on the course at Communicating Geohazards: Delivering Information in Crisis and Calm.

The course and this handbook were funded by an AGU Celebrate 100 Grant with in-kind support from UNAVCO, the Incorporated Research Institutions for Seismology (IRIS), the U.S. Geological Survey Volcano Hazards Program, and Portland State University.

We would also like to acknowledge the USGS Cascades Volcano Observatory for hosting us for half a day, and in particular Carolyn Driedger for speaking and Elizabeth Westby for leading a mock press conference activity based on real data from the 2018 eruption crisis of Kīlauea, Hawaii. Wes Thelan, Ben Pauk, and Aaron Rinehart led participants on a tour of the facility.

Cascadia

The driving forces

People living in or visiting the Pacific Northwest are well aware of the region's iconic mountains, but may not be aware of the forces responsible for them. The same forces that made these mountains also result in earthquakes, tsunamis, and volcanic eruptions, and other geologic hazards like landslides and liquefaction.

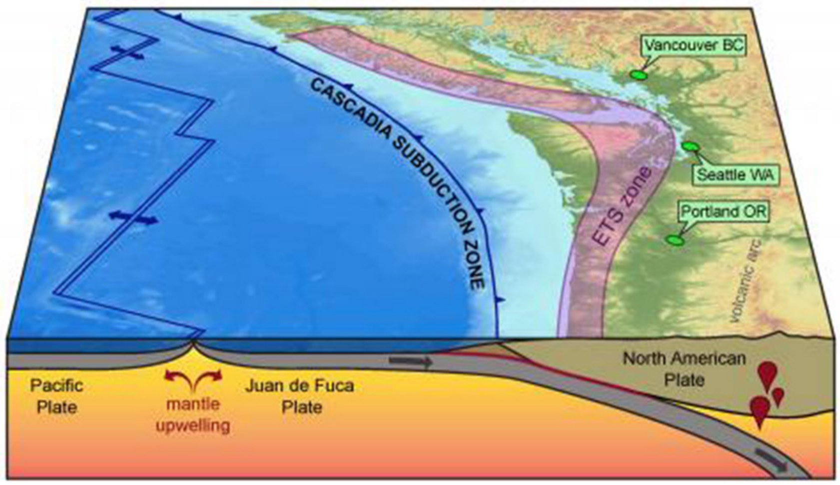


Figure 1: Tectonic setting of the Pacific Northwest. (Image/USGS)

Where plates meet

Most of these hazards are driven by two tectonic plates colliding. **The Juan de Fuca plate**, a plate formed under the ocean and shown as the thin gray slab above, is diving (subducting) eastward beneath the thicker and more buoyant **North American plate**. This area is referred to as the **Cascadia Subduction Zone**. The entire region, from western British Columbia to northern California and from the coast to the Cascade Mountains, is referred to simply as **Cascadia**. The contact between the two plates is shown in this image by the black line with "teeth" (at the earth's surface) and the red line (within the earth).

One thing that makes understanding subduction zones challenging is that much of the action happens offshore, deep underwater. There are efforts to improve seafloor instrumentation; this is something to keep an eye on.

Bending before breaking

As the Juan de Fuca plate marches eastward, it pulls the North American plate along with it. Much of the boundary between the two plates is locked by friction, which prevents the plates from sliding past each other--until the stress becomes too great and is released in an earthquake. Researchers are still working to understand what triggers earthquakes and determines how much of a fault will rupture.

In between earthquakes, the North American plate buckles with the pressure of collision. The western edge of the North American Plate--the part under the Pacific ocean--is pulled down, while the area inland from the coast is pushed upward (Figure 2). Over hundreds of years, this changes the shape of the coast in significant ways. Researchers study these ongoing motions in the Pacific Northwest with tools like high-precision GPS.

Making a tsunami

Along subduction zones like Cascadia, the frictional forces built up along plate boundaries are massive. During an earthquake, land that has been pulled down with the subducting plate springs upward and outward in a matter of minutes, displacing the seawater above it. Subduction zone earthquakes in Alaska and Cascadia have generated waves that traveled across the Pacific ocean, devastating coastal areas thousands of miles away from the tsunami's source. These tsunamis also leave behind important evidence of past earthquakes.

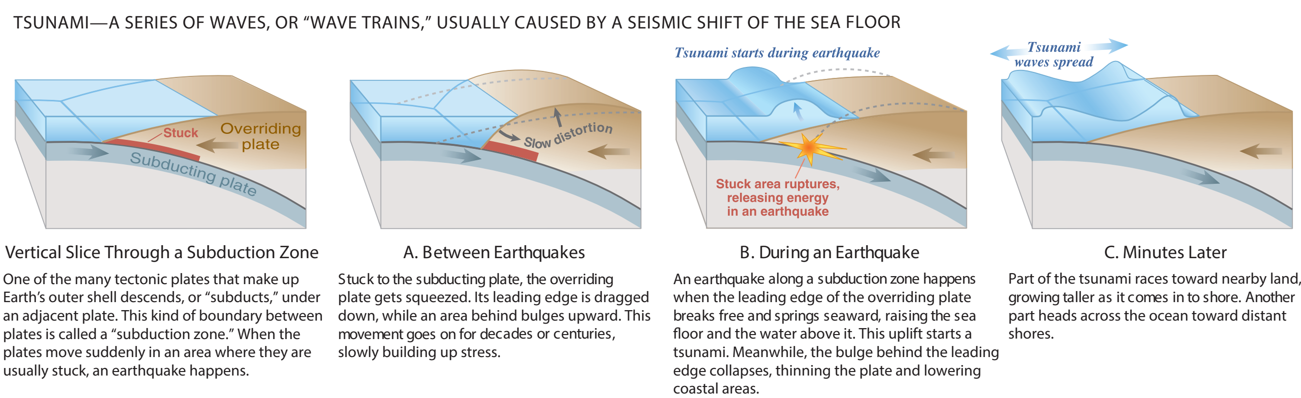


Figure 2: How large subduction zone earthquakes cause tsunamis. (Image/USGS Circular 1187)

The biggest quakes

The last major earthquake on the Cascadia subduction boundary was on January 26, 1700. There were no modern seismometers to measure the earthquake, and no written records in the Pacific Northwest. There were, however, Native American stories referring to the earthquake and subsequent tsunami, and researchers found datable evidence of sunken forests (from the shore dropping down) and tsunami deposits (from those waves rushing in). The exact date was nailed down through written records of an "orphan" tsunami in Japan--a tsunami with no associated earthquake. Researchers estimate the magnitude of that earthquake to be about a magnitude 9.

At least 40 earthquakes of magnitudes greater than 7.5 have been identified in the last 10,000 years in Cascadia. The average time between earthquakes on the Cascadia interface is 246 years. However, the current understanding is that time between earthquakes has varied from as little as 27 years to as much as 577 years. Additionally, studies indicate that earthquake magnitudes have varied from an estimated 7.5 (with a rupture length of 138 miles) to 9.1 (with a rupture length of 621 miles), as the entire subduction zone does not always rupture in each earthquake. This variability is why the term "overdue" is misleading. Also, these estimates are constantly being revised with new data and improved methodologies. See 10,000 years of Cascadia earthquakes.

"Silent" earthquakes?

A phenomenon called *episodic tremor and slip* (ETS) was first discovered by geophysicists in Cascadia, and then was recognized at other major faults around the world. ETS is essentially a slow earthquake, where the motion along a fault happens so slowly that it doesn't generate felt seismic waves, even if the event releases the energy of a magnitude 6 earthquake. In Cascadia, deep on the subduction zone--deeper than where earthquakes occur--the Juan de Fuca plate slides for several weeks about every 12-14 months, depending on where along Cascadia you are. The image above shows the projection of the **ETS zone** up onto the land surface. Scientists are still working to understand the relationship between slip and major earthquakes. More on ETS, including current activity, at the Pacific Northwest Seismic Network's Tremor Overview page.

All the other places for earthquakes

Earthquakes in the Pacific Northwest don't only occur on the boundary between the Juan de Fuca and North American plates. Damaging earthquakes can also happen within the downgoing Juan de Fuca plate as it bends into the mantle, or in the overriding North American plate as it is compressed by the convergence of the plates. The magnitude 6.8 Nisqually earthquake of February 28, 2001 is an example of a deep earthquake in the downgoing Juan de Fuca plate. Even at a depth of about 52 km, this earthquake caused about $4 billion in damages. The Seattle Fault is an example of a fault within the North American plate that threatens the inland population of the Pacific Northwest. There are plenty more to explore.

The volcanoes above

The subduction zone is a volcano-maker. As the downgoing Juan de Fuca plate sinks deeper into the mantle, seawater that was trapped in rocks heats up and sweats off. The water causes small amounts of the nearby mantle to melt and rise in blobs into and through the overriding North American plate. This melt collects in magma storage regions below a 1,300- km- (800-mi-) long chain of volcanoes along the west coast of North America - The Cascade Range. This rich volcanic zone contains prominent snow-clad peaks of stratovolcanoes and approximately 2,900 other known volcanic features ranging from small cinder cones to substantial shield volcanoes. You can get background information and the latest updates on the Cascade volcanoes from the USGS Cascades Volcano Observatory website.

Monitoring networks

The U.S. Geological Survey (USGS) is responsible for monitoring and reporting on volcanic and earthquake activity in the United States. The work of the USGS Cascade Volcano Observatory in the Pacific Northwest is supported by many academic and research institutions, such as the Pacific Northwest Seismic Network and UNAVCO.

Magnitude vs. intensity

Every earthquake has one magnitude but many different intensities. Magnitude is a number that describes the relative size of an earthquake; it is calculated using data from seismometers. The magnitude scale is logarithmic which means that for every number increase in magnitude there is a ten-fold increase in energy released during that earthquake. For more information watch IRIS's short animation on Magnitude Explained: Moment Magnitude vs. Richter Scale.

Intensity is a number that describes the shaking that was experienced during an earthquake; it can be calculated using seismic instruments, looking at damage to structures, and/or assessing the experiences of people who experienced the shaking. Each earthquake will produce different intensities of shaking in different locations. The amount of earthquake shaking is influenced by the size of the earthquake, the distance away from the earthquake, and the local rock and soil conditions. For more information on the difference between magnitude and intensity watch IRIS's short animation on Earthquake Intensity. Earthquake intensity is important to emphasize in communicating about an earthquake because it is the intensity, not the magnitude, that describes how areas are impacted.

Stories to tell

All of the above topics are active areas of research, and some of the leading researchers on these issues in Cascadia and around the world are in the Pacific Northwest.

- What is the status of earthquake and tsunami early warning, and how does it work?
- How much is the land deforming and where are the earthquakes, and what does that tell us about what's going on deep below--whether at a fault or a volcano?
- How are communities preparing?
- What policy is addressing seismic, volcanic, and landslide hazards?
- How do scientists study these hazards?
- What are the local, rather than regional, hazards?
- What are the "hidden hazards" of an area, like liquefaction (when sandy ground destabilizes during an earthquake) or landslides?
- What are the "cascading hazards" that could be associated with a local or regional event and what planning has been done to identify and address these hazards?

The content of the remainder of this handbook is a summary of information presented and resulting discussions in the October 2019 Communicating Geohazards short course.

Communicating Hazards Effectively and Responsibly

Our communication has an impact. When we are communicating about hazards--which can affect people's lives, livelihoods, and mental health--we need to be particularly cognizant of the impact of our words, tone, and images.

Course activity: Brainstorm on white board as a large group:

Positive : What are potential positive impacts of hazard communication?

Negative: What are potential negative impacts of hazard communication?

There are many, many positive impacts of communicating hazards. This is why we do it. Positive impacts include:

- Encouraging personal and household preparedness
- Educating the community
- Encouraging infrastructure preparedness, e.g., for schools, hospitals, and workplaces
- Informing policy related to hazard resilience, e.g., building codes
- Increasing the efficacy of individuals (the ability for individuals to make and act on their own decisions) by providing information and context
- Decreasing anxiety through decreasing the uncertainty and misinformation around what a particular hazard or series of events might bring

Unfortunately, we can also do harm with our communication. Possible negative impacts include:

- Economic damage, e.g. through unnecessary tourist avoidance of an area or property depreciation if threats are overstated
- Improper preparatory actions for a particular hazard, potentially resulting in harm to people or property
- Inhibiting sensible action if threats or an individual's ability to deal with them are understated
- Increased work for agencies to correct misinformation
- Decreased trust in official sources, or scientists' knowledge of the hazards in question
- Unnecessarily inducing anxiety

These potential negative impacts are why we communicate about hazards responsibly.

In this section, we summarize some of the practices that promote positive responses to hazards and how to avoid missteps.

Crisis vs. Calm

In "blue sky" times, science is deliberate and iterative. Success is measured through peer-reviewed publications and funded grants. During crisis, however, science is rapid and decisive, based on limited information; success is measured through lives saved, injuries reduced, and infrastructure saved or restored (Colwell and Machlis, 2019).

Communication in "blue sky" times focuses on education, preparation, resilience, building trust, and sharing the excitement of science. During a crisis, however, communication needs to be rapid, clear, informative, actionable, and empathetic, sensitive to those whose lives are affected. Success is measured in lives saved, injuries reduced, and anxiety reduced.

Communication During a Crisis Depends on the Crisis

Different events will require different communications. For example, earthquakes can affect a large area, and impact a large swath of population simultaneously. The response is short in duration and the communication needs are mainly pre- and post-event. Volcanic unrest can have a local, regional, or international impact, with various communities impacted in different ways (e.g., by flows, ashfall, or gases). It can be a long duration event with changes needed in messaging throughout the activity. Communication needs are pre-, during-, and post-activity.

Recommended best practices

- Lay communications strategy groundwork in "blue sky time" (e.g., Bartel and Bohon, 2019). Define and distribute duties, roles, and responsibilities amongst personnel if you are part of an agency or organization.
- Understand your own role, if you're outside an agency and need to define it for yourself. (See Who Speaks for Hazards Science?, below.)
- Establish relationships between scientists and journalists, and with other partners.
- Prepare a list of facts and figures for the hazard you expect to be communicating about to use as background.

Communication Pitfalls

Most scientists and journalists are not trained in hazard communication. Many academic and unaffiliated scientists step in to communicate during a crisis, which comes with some benefits and some challenges. Scientists often aren't trained in communication, resulting at times in inappropriate framing of the problem, unnecessary or improper discussion of uncertainty, overly technical (jargon-laden) responses, unintended and seemingly contradictory media narratives, and/or interviews that are seen as cold, callous, or unfeeling.

Consistent messaging is difficult without a coordinated media response. Also, communicators external to the agencies responsible for issuing official hazard responses may unintentionally undermine the agencies; the public may turn to high-profile individual scientists rather than heeding the advice coming from official channels.

Journalists have to be able to cover a range of topics, and may report on hazards with no previous experience and no recent knowledge of earth science. This can result in reporting focused on misconceptions, with mistakes, or with omissions of important information.

Recommended best practices

- Train in hazards communication. For scientists, general science communication training is now available at most large scientific meetings.
- Foster interdisciplinary collaborations, e.g., between physical and social scientists.
- Steer away from interpreting data, unless you are authorized to do so as part of an agency responsible for crisis event response. Speculation can undermine the word of authoritative sources. Refrain from sharing preliminary results without permission of theresponding science agency.
- Refer to appropriate and official sources.
- Do not share photos like selfies that could be construed as insensitive to people who are affected, photos within restricted areas, photos without appropriate personal protective equipment, or, at least for scientists, photos of destruction of property and/or life without permission.

Scientists:

- Be prepared with the most important information, and offer it to journalists who may be at a loss for what to ask.

Who Speaks for Hazards Science?

Hazards science is a broad field that includes experts from many different branches of science, research, emergency management and communication. So how do we decide who speaks for hazards science? Who is considered an expert and in what context? Where are the boundaries of an individual's expertise and when should they step forward or step back, i.e. "stay in their lane"?

Course activity for scientists: The Knowledge Pyramid

Draw a pyramid, like the one shown here in Figure 3. Consider three categories: **Place**, **Process**, and **Methods**.

At the bottom of the pyramid, write down your foundational knowledge in these areas--the broadest subject areas you feel you can speak to. This bottom foundation indicates what you know more about than the general public related to your field, and are comfortable speaking about in general terms and concepts. For geoscientists, think about what you've learned through coursework, teaching, or background research.

As you move up the pyramid, get more specific in what you write. Your middle level should be more specialized. Once you moved beyond the basics, what did you learn or explore?

our top level indicates what you are most uniquely equipped to talk about--your expertise. This is likely based on original research and/or direct experience.

It's okay to leave one or more categories blank. If you have not participated in original research, you will probably not have anything at the top yet.

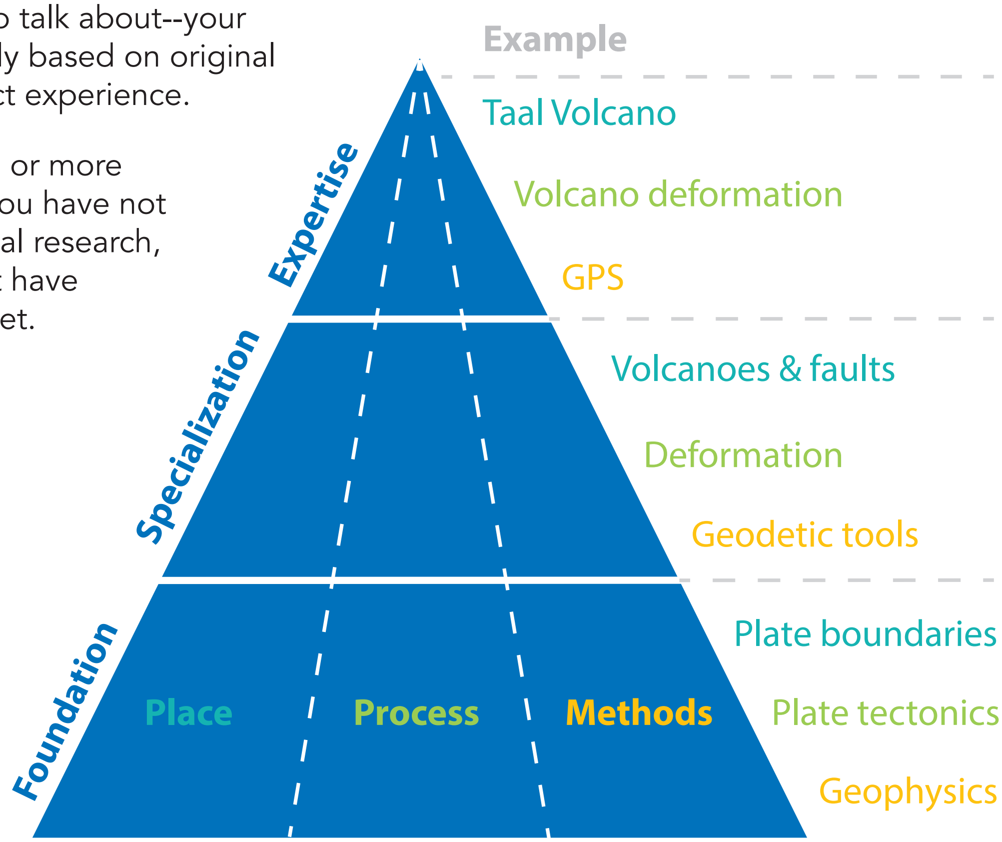


Figure 3: Example of a Knowledge Pyramid (Beth Bartel/UNAVCO).

Recommended best practices for scientists

Ask When you are approached for an interview, ask the journalist what the scope of the piece is and what they would like you to speak to. Then ask yourself what you are able and willing to address. Do not diminish your knowledge and expertise! Do recognize and indicate to the journalist ahead of time where your boundaries are.

Defer If the inquiries are about specifics that fall outside your area of expertise, consider deferring to someone else with that expertise. This is a gift to both the journalist and the other scientist. The journalists in this course indicated that they are very grateful for scientists who can refer them to the appropriate sources; sources are not always easy to find. Other scientists, meanwhile, will benefit from the exposure. If the journalist is on a tight timeline, stick to what you are comfortable speaking about.

Refer Point to expert and official sources, especially when the subject falls outside your area of expertise. Even if it is within your area of expertise, be conscientious of acknowledging that there are others working in these areas and on these problems, when and where appropriate. This will gain the trust and respect of your peers, as well as highlighting the collective efforts of the scientific community. Note that most of what you say however, if not a live interview, will be cut!

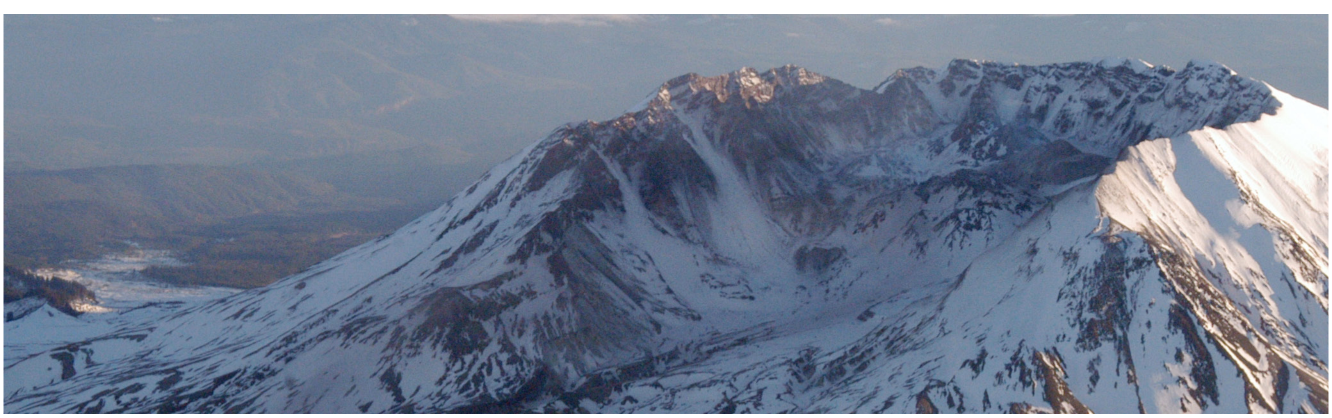
Recommended best practices for journalists

- Always solicit comments from official sources. If they don't get back to you in time, consider noting that you reached out to them as you would for a political story. This will at least indicate who the official source is, and that you have tried contacting them.

- Using a variety of sources will highlight the diversity within the science community.

- The loudest voice is not always the most credible source, nor the expert in a particular subject. Check affiliations and backgrounds. When possible, ask another trusted source in the field about a new source.

- Avoid using the same source repeatedly, unless they are an official source or a local expert; try to find experts in the particular subject matter, whether the expertise needed is regarding the place, process, or method.



The Role of Trust

Trust is critical in hazard communication (e.g. Petty and Wegener, 1998). Trust of the messengers and message is key to ensuring audiences will take information into account when forming opinions, making decisions, and taking action. Trust between scientists and journalists is vital to enable sharing accurate information broadly and accessibly.

Discussions during the short course revealed that journalists were more concerned about the trust of the public than of their peers. This concern for public trust rang especially true for local journalists, who are beholden to specific communities.

In contrast, geoscientists are particularly concerned with the trust and respect of scientific peers. This results in the reluctance of many geoscientists to speak broadly about science, either with the press or over social media, for fear of peer judgement (Bartel and Bohon, 2019).

Course activity: In groups of 3-4, mixed with scientists and journalists, participants discussed: What is the definition of trust? What does trust look like?

Discussions resulted in definitions of trust centered around the themes of **reliability**, **transparency**, **intentions**, **accuracy**, and **competence**.

What the experts say

Hovland et al. (1953) found that source credibility is based on expertise, trustworthiness, and goodwill or good intentions. Petty and Wegner (1998) describe communicator credibility as dependent on perceived expertise and trust, where trust is considered the inferred motivation to be truthful. Trust was further described by Fiske and Dupree (2014) as having two components: warmth and competence. While these are just three examples, they help to show that many definitions of credibility and/or trust touch on both intent and competence, in some way. Basically, do you know what you're talking about, and why do you do what you do?

Who does the public trust?

According to the Pew Research Center, scientists are some of the most trusted sources, with 86% of US adult respondents having a great deal of confidence (35%) or a fair amount of confidence (51%) in scientists in 2019. The work also shows that trust in scientists varies based on the type of science, as well as the respondent's familiarity with the topic, political affiliation, and other factors. The numbers were much lower for news media, at 47% in 2019. However, these are very general groupings. For more, see Trust and Mistrust in Americans' Views of Scientific Experts (2019).

A study from Haynes et al. (2008) during the ongoing eruption of Soufriere Hills volcano, Montserratt, found trust amongst the island's population was highest in friends, then scientists, and then local media sources. Trust was lowest in the government and the world press. This is a good reminder that news media is a very broad category, which varies by audience, medium, and philosophy.

Multiple studies show that during a hazard, people become especially dependent on the media as a source for information. They also look to verify information with multiple sources. Coordinated messaging is important to ensure trust in the information and recommendations, and to avoid confusion.

Building trust

In best case scenarios, trust is built in "blue-sky" times, before an event has people on edge. But it's also important to know how trust is assessed in a crisis situation: Perceptions of credibility and trust are established quickly, so introducing caring and expertise early in communicating is essential. Covello (2008) describes that both competence and honesty/openness (transparency) are major factors when people assess whether a source is trustworthy. However, the largest factor by far is listening/caring/empathy/compassion, at 50% (Figure 4). What's more, this factor is evaluated in the first 9-30 seconds. Because of this, how we deliver our communication is critical.

It's worth nothing that Fiske and Dupree (2014) found that scientists rate high with the public on competence but only average on warmth.

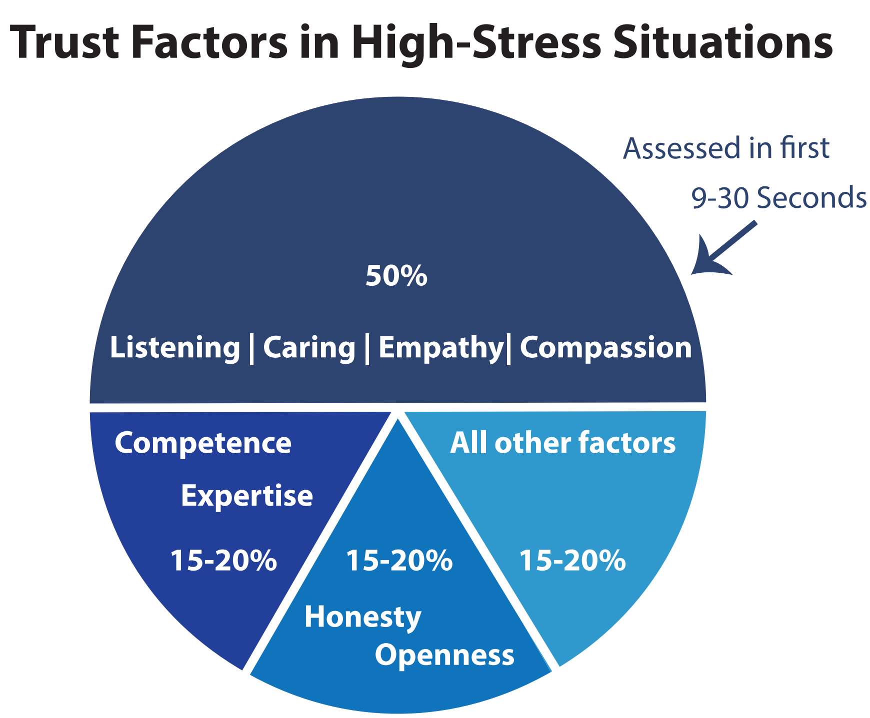


Figure 4: Trust factors in high-stress situations, redrawn from Covello (2010), p.147.

Recommended best practices

Communication should be:

Quick and frequent Don't let rumor gaps form or give space for people to speculate you have something to hide. This is especially important for agencies (both government and news). Be prepared to address the following questions:

- What happened
- Why it happened
- What will happen next
- What to do

Consistent Coordinate messaging across organizations and channels to avoid confusion over which messages and sources to trust and what action to take. Support partners to indicate to the public where there is collaboration and who has what role.

Direct Indicate what the hazards and risks are as we understand them, without exaggerating or underplaying them.

Transparent Make information open and accessible, for example by sharing data publicly and showing what work is being done behind the scenes. According to Pew Research Center findings, "Open public access to data and independent committee reviews inspire the most confidence in scientists and boost their trust in research findings." Communicate methods: Show what work scientists and others are doing to assess and otherwise respond to hazards, including field activities, operations center work, and instrumentation.

Empathetic Use personal pronouns like we and our. Acknowledge hardship. Point out commonalities, e.g., if you live in the area affected or have experienced similar events in the past.

Respectful Answer questions in earnest, assuming that questioners are asking in earnest (tone is often difficult to assess, especially online), aware that others are listening. Remember we are representing ourselves, our institutions, and our field(s), and the tone of our responses may affect trust in each.

Humble Communicating with humility can make us more relatable and accessible, and allow room for error. Listen to your audience; use or create opportunities for two-way communication. Learn about and respond to audience knowledge and needs

Motivating People to Action

People have different reasons for their choices when responding to a geohazard. Key ideas that can help both scientists and journalists relate to audiences are empathy and understanding that people's choices are reasoned. Choices can be based in an individual's values system or previous experiences, as well as in religious and political beliefs (Drummond & Fischhoff, 2017).

Witte (1994) developed the extended parallel processing model (EPPM) as a means to understand how audiences respond to threatening messages. In response to a message, audiences perceive some ratio of threat and efficacy. Their perceived threat is based on how severe they expect the hazard to be and how personally susceptible they feel to it. According to the EPPM, if an audience does not feel threatened, then they will not respond. If they do perceive a threat, then their self-efficacy (feeling that they can accomplish an appropriate response) and response efficacy (feeling that actions they take will be effective in reducing the threat) determine what kind of response they take. If efficacy is low, then audiences will take maladaptive responses in which they downplay the fear. If audiences have high efficacy, then they will take adaptive responses to reduce the threat.

This has implications for communication about geohazards. A certain level of fear of the threat is necessary to motivate behavior. However, too much threat without an effective response is debilitating. When giving information, include a clear call to action with appropriate steps that can reduce the threat. Good ways to increase self-efficacy through communication include having role models demonstrate how to take action and encouraging through persuasion (Bandura, 2004).

Recommended best practices

- When giving information, include a clear call to action with appropriate steps that can reduce the threat. Direct people to sources of more information.
- Understand the barriers to taking action and provide messaging that addresses these barriers when possible, for example emphasizing the availability of shelters equipped with medical resources. See the NPR article "Why Stay During A Hurricane? Because It's Not As Simple As 'Get Out'."
- Empathize with your audience and recognize that their concerns and experiences are valid to them.

Figure 5: Brian Bartlett from the South Florida Search and Rescue team checks in on Tom Garcia, who stayed in his home through Hurricane Michael. (Joe Raedle/Getty Images)

Understanding Risk, Hazard, and Uncertainty

People's choices during a hazard are based on their perceptions of risks, not just on scientific assessments of risk magnitude. Risks are often misperceived. Risks are seen as especially problematic when they are out of our control, unfamiliar, or unfair.

In times of crisis, negative information is especially salient. It becomes hard for people to process. Thus, communicators should use simple language with clear instructions.

In common language, uncertainty is not about technical constraints or boundary conditions. Instead, it is not knowing what will happen or how it will affect oneself. Most people find uncertainty to be a negative feeling and will work to reduce uncertainty. If information is not available, they may misperceive a higher level of certainty than exists to reduce that uncomfortable feeling. Metaphors and visual aids can help people to better understand uncertainty.

Recommended best practices

- Again, communicate quickly and frequently, even where there is no new information. Agencies should consider regular updates, letting the press (for government agencies) and the public (for news media) know when to expect the next update.
- Counter the spread of misinformation, which often offers an illusion of certainty, by dispelling myths and providing updated, accurate information.
- Use simple language with clear instructions.
- Use metaphors and visual aids to help people better understand uncertainty.
- Share general background information on the hazard (what it is, putting it in context) so people have a better understanding of what is happening.
- Emphasize what we know but also share the uncertainty involved. Share what we know, what we don't, why, and what we're doing about it.

Focusing the Story

Journalists understand that certain elements make a story newsworthy. Scientists should ask themselves how the following elements may apply to their work when speaking with journalists, particularly in "blue sky" times.

What makes a story newsworthy?

- Timeliness - why now?
- Proximity - is it close to me?
- Conflict and Controversy - is there disagreement?
- Human Interest - are there interesting people involved?
- Relevance - does it affect me?
- Significance - is it important?
- Prominence - does it involve someone noteworthy?
- Novelty - is it weird, different, new, or unusual?

Most of these elements apply naturally to hazards stories, especially during a crisis. However, highlighting conflict and controversy can distract from the information the public most needs to know, cause confusion, undermine the credibility of authorities, harm response efforts, and unnecessarily induce anxiety. Reporting on conflict and controversy can be crucial, for example if policy makers are neglecting to fund resilience initiatives. However, especially during a crisis, we must be careful about how and when we portray hazards-related conflicts, be particularly careful to not sensationalize, and, as with all topics, present stories that appropriately weigh different views as opposed to giving equal time to unequally represented opinions or findings.

Recommended best practices

- Focus on what people most need to know. Ask hazards professionals (or yourself) what the most important thing to understand is.
- Emphasize or include most-likely scenario(s) rather than focusing on the worst-case scenario.
- Do not play up conflict or controversy related to hazards unless it is in the public's best interest to do so, especially during a crisis. Avoid sensationalizing, including using words like "overdue."
- Where possible, bringing in a local angle. A story about a large earthquake elsewhere can be a good opportunity to talk about local earthquake hazards.
- Focus on the information that pertains to impact, e.g. earthquake intensity (degree

of shaking) rather than magnitude (size). The intensity is most relevant, as it is related to human impact.

- Put the cause of damage in perspective. McClure and Velluppillai (2013) point out the difference between attributing damage to an earthquake's magnitude (uncontrollable cause) vs. to human design (a relatively controllable cause).

Losing Control of the Narrative

Information can be lifted from one media story to the next. Often local print news sources and news agencies like the Associated Press generate original content that is then repeated in other media outlets, which don't talk to the original information sources. This, plus the tendency of certain media outlets to sensationalize, can result in an anxiety-inducing, misleading, and/or inaccurate game of telephone, where the information is corrupted from one messenger to the next.

Additionally, individual scientists or pseudoscientists may muddy the waters with misinformation, misleading information, or genuinely false information like predictions.

To complicate our communication efforts, the first thing people hear or see is often what sticks.There are a few things we can do, both as scientists and journalists, to curb the flow of misinformation when this happens.

Recommended best practices

- To avoid propagating misinformation, contact an original source to ensure you are interpreting the information and implications correctly, especially if you are changing the wording and potentially the meaning of the original story.
- When information gets skewed, contact the news outlet to request a correction. Conscientious news outlets will be responsive. Promote accurate information by pitching another media story or generating your own content on social media or the web. See, for example, Dr. Christy Till's Yellowstone Fact vs. Fiction website.
- In correcting misinformation, lead with the correct information. Avoid restating incorrect information directly.
- If not involved in the research or response, you can still correct misinformation by commenting on it directly, if on a social media feed, or commenting about it, on a social media feed or otherwise.

Scientists:

- Contact your institution's public information officer (PIO) or communications office before publication or presentation of what could be attention-grabbing findings. Recognize your time may be distributed differently than you have budgeted or are used to, if you will be spending a lot of time talking with the press. Leverage the exposure to share your process, the process of science, and the hazards you are communicating.

The Economics and Politics of Hazard Communication

Our communication goes global. With digital media, information about hazards is communicated by and accessed by people around the world--and quickly. Many of these people make decisions about where to travel based on what they see or hear in the news media, and overblown coverage can dramatically hurt local economies. On the other hand, businesses or politicians may pressure reporters or scientists to underplay hazards. Reporting the actual extent of the hazard is crucial to both safety and economic well-being.

Misleading imagery can be a major source of misinformation or misunderstanding. The use of non-representative images, such as a photo of an erupting volcano in a story about a volcano that is not yet erupting, can cause unnecessary anxiety among non-local friends and family of residents as well as deter potential tourists. See Out-of-context photos are a powerful low-tech form of misinformation, by Lisa Fazio for The Conversation, for more on how influential photos can be.

Recommended best practices

- Report not only the extent of the affected areas but also what areas are safe and open to residents (especially for local communication) and tourism (especially for regional or global communication).
- Use situation-appropriate images, preferably from the location of focus. Ask: Is this image misleading? Use imagery to represent overall effects, not only the worst damage.

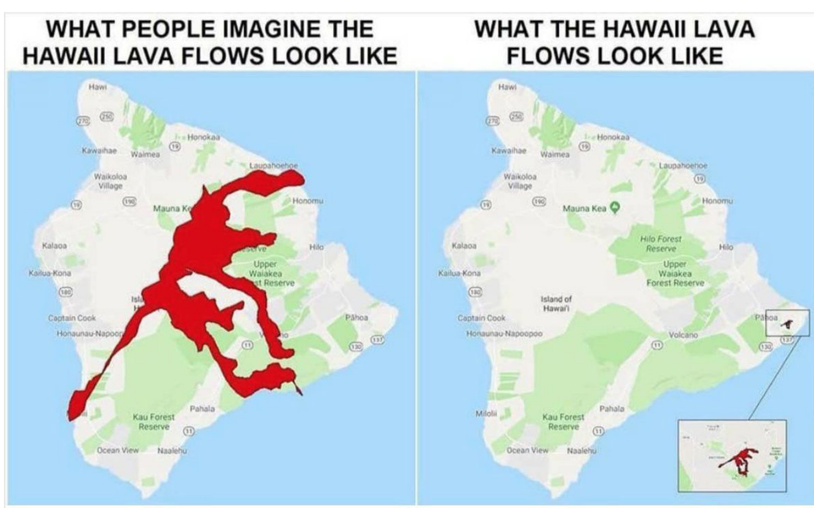


Figure 6: A meme from 2018 pointing out that, despite what people outside Hawaii might think, the 2018 Kilauea lava flows were affecting a very small area of the Big Island. (Source: MEME)

New Media Era

The proliferation of digital media technologies, including the internet, social media, and mobile devices, has changed the way we communicate. Digital media has a global and immediate reach through channels that are broadly and freely accessible; it has both increased our available communication pathways and changed audience expectations.

Social media, in particular, has transformed the information landscape. News breaks on social media, and many people use it as their primary news source. As opposed to traditional media outlets, anyone can share information on social media, including agencies, individual scientists, journalists, and citizens who may have information relevant to a hazard. Because of this, media outlets use citizen, expert, and official posts to obtain information and sources. Therefore, it is important to remember that any post may be reproduced by mass media.

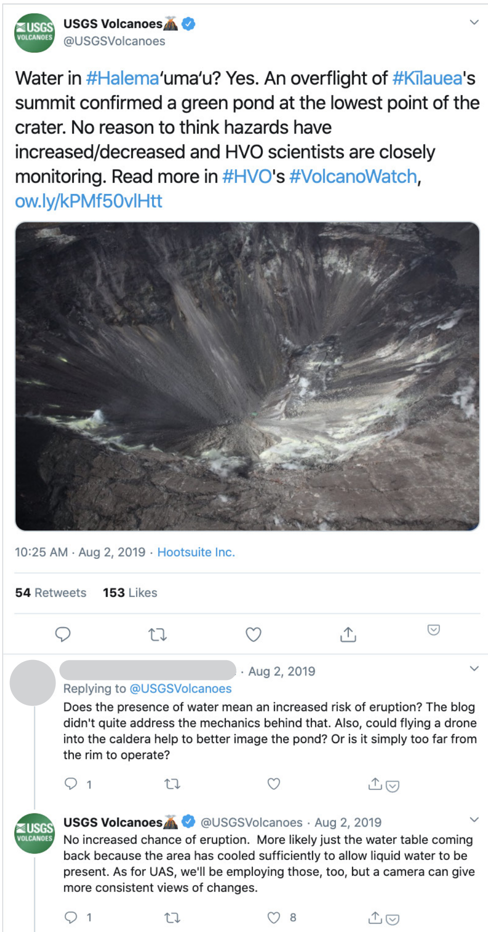
In the pre-digital media era, consumers expected information within hours of an event, but the age of social media has shifted expectations. Users expect information to be shared immediately, within minutes as opposed to hours, and with real-time updates. Most agencies are not able to issue information this rapidly because of their emphasis on accuracy over speed; this creates an information void.

The gatekeepers of information have also changed. Whereas all information and reporting came from the media before the digital age, digital dissemination methods offer direct pathways from information producers, such as scientists and agencies, to a public audience. This open access to media platforms and lack of information gatekeepers means anyone can present themselves as an expert. Unfortunately, expertise can be difficult for the public to determine, leading to the spread of misinformation, speculation, and bad advice.

Recommended best practices

- Incorporate social media into your communication plan.
- Follow relevant sources on social media.
- Not everyone is on social media, so be sure to share information on other communication channels if you are trying to reach an entire community.
- Use #hashtags, tag @partners, and direct people to @OfficialAccounts. Amplify the messages from official accounts by reposting them.
- Use hashtags that are being promoted by official sources only if you are adding new information that will be helpful for the public. This permits impacted communities to search for official guidance more easily.
- When there is a question you can't answer, call out @SomeoneWhoCan.
- Use precaution when posting during a crisis; follow all recommendations throughout the rest of this handbook.
- Beware of amplifying or using sources that you are not confident are credible; check bio and affiliation, and go to official sources when possible.

- Remember that some of the best sources may not be on social media. Ask around on social media for recommendations and/or check the Request A Scientist platform or SciLine. Leverage your network of scientists to ask around for you!



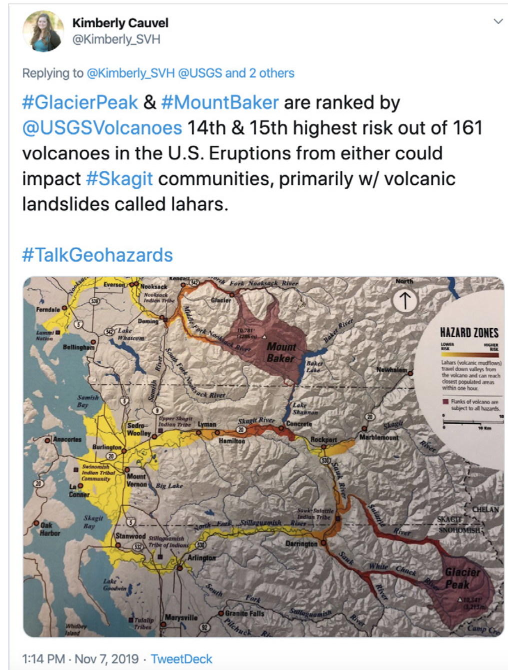


Figure 7: Being active on social media helps keep information gaps from forming, and addressing questions can calm nerves and prevent the spread of misinformation. Referring to official sources indicates to the public where to go for information. (Screenshots/Twitter)

Unprepared: An Evening with Ed Jahn, Oregon Public Broadcasting

In an informal discussion and Q&A, Ed Jahn of Oregon Public Broadcasting shared lessons learned and applied in Unprepared, a multimedia OPB project centered on a 56-minute documentary about Oregon's earthquake risk.

Here are some thoughts from that discussion.

On working with journalists

A communications specialist at an organization's training is very different than the ideas of what a journalist wants from you. An organizational communicator will be trained to think about the needs and messages of the organization. Instead, understand your audience first and stop thinking about yourself.

Understand the medium. For breaking news, reporters will want to know who, what, when, where, why, and how. Speak quickly, concisely, and to the point. For a documentary, expect long questions and long answers, and the same question in different ways. Reporters are not just looking for information; they're looking for information to be communicated, usually without getting into the weeds. Radio reporters need good sound. Video journalists want to go somewhere to do something. Both of these media are focused on experience. Take them somewhere while you're doing research, even if the research isn't done; think about this in the early stages of your research while there is still work going on outside the lab.

Speak your audience's language. Be relatable.

Tell people what they need to know, not what you think they ought to know.

Research the person who is doing the interview. Prepare based upon what types of interviews the person conducts.

Scientists don't always have to say yes to reporters. You can also ask for a commitment from a reporter to fact check prior to publication. Note that reporting needs to be fair and accurate but does not need semantic mirroring.

If reports include inaccurate information, call reporters and be specific about the corrections needed and the requests for them to be done. Note that sometimes people are reporting straight to the web without any editorial control.

For journalists

Identify the gaps in knowledge and report on that. What's the new angle?

Figure 8: Video journalist Ed Jahn of Oregon Public Broadcasting shares his expertise with participants of the Communicating Geohazards short course in Portland, Oregon, 2020. (Beth Bartel/UNAVCO)

A Few More Notes for Scientists on Working with Journalists

When we asked the journalists what scientists can do to be helpful in the reporting process, this is what we heard:

- Get experience talking to a lay audience
- Prepare with resources, visuals, and a bulleted list of ideas to get across
- Use analogies
- Provide photographs and/or infographics to support the story; photographs of the scientist doing their work can be especially compelling.

Figure 9: Geoscience PhD Student Jordan Caylor and environmental journalist Julia-Grace Sanders review scientific jargon and identify lay-friendly alternatives at the short course. (Beth Bartel/UNAVCO)

Reading and Watching List

The following readings and videos are a collection of pieces on Cascadia hazards, the role of science journalism, and hazards communication as reported in the popular media, as well as several peer-review publications on the topic of communicating about hazards.

We asked participants to consider the following as they watched or read each piece:

- Write down emotions/feelings/reactions as you notice them.
- How and when is science incorporated into the popular media pieces? How much science is presented?
- What kind of vocabulary is used to convey the science?
- What are the elements or topics of the stories aside from science? What else is covered and considered?
- Is there a character, or characters? (Note: A character does not have to be human.)
- Is there a story arc (beginning, middle, and end)?
- Were any analogies used?
- Did the author(s) communicate or comment on uncertainty, and if so, how?

Popular press

Unprepared - Oregon Public Broadcasting project led by Ed Jahn - watch the 50 minute doc and peruse the other content to see what's there

We're Barely Listening to the U.S.'s Most Dangerous Volcanoes - Shannon Hall, in the New York Times

The Really Big One - Kathryn Shultz, in The New Yorker

Revisiting the Role of the Science Journalist - Teresa Carr, in Undark

Kathryn Schulz Paints a Chilling Picture of "The Really Big One" - Michelle Nijhuis, in The Open Notebook

These 3 Hurricane Misconceptions Can Be Dangerous. Scientists Want to Clear Them Up. - Kendra Pierre-Louis, in New York Times

Why Stay During A Hurricane? Because It's Not As Simple As 'Get Out' - Adrian Florido, in NPR

Out-of-context photos are a powerful low-tech form of misinformation, Lisa Fazio for The Conversation

Scientific publications

Communicating Uncertainties in Natural Hazard Forecasts - Stein & Geller, 2014, in Eos
Seismic Risk: The Biases of Earthquake Media Coverage - Deves et al., 2017, in Geoscience Communication

Short Course Participants and Projects

Short course participants completed hazard communication projects individually or in partners, ranging from articles to social media campaigns, and from cartoons to paper art.

Figure 10: The 2019 Communicating Geohazards cohort, including instructors, at Portland State University. (Melissa Weber/UNAVCO)

Kimberly Cauvel

@Kimberly_SVH

Kimberly Cauvel is an environmental journalist in Washington state on staff at the Skagit Valley Herald. Her beat includes telling stories about the region's active geography, from volcanoes in the mountainous east of Skagit County to sea level rise along marine shorelines in the west -- and frequent flooding along the Skagit River that connects the two.

Project: Experts agree more tools are needed to monitor local volcanoes - Skagit Valley Herald, front page, with associated Twitter teasers using hashtag #TalkGeohazards.

Jordan Caylor

Jordan Caylor is a PhD student in geophysics at the University of El Paso, Texas with a background in elementary education.

Project: Two experiments for 4th-5th grade audiences to teach them about the processes involved in tsunamis and earthquakes.

Jeng Hann Chong | Casey Smith

Jeng Hann is a geophysics graduate student at California State University Northridge. He was born and raised in Kuala Lumpur, the capital of Malaysia. His current research involves understanding the effects of the Cascadia subduction zone towards earthquakes in the Pacific Northwest.

Casey Smith reports on the intersections between science + the environment and government + politics, particularly in regard to how elected representatives and government agencies address and respond to our changing planet. She writes for the Berkeley Science Review, an independent, graduate-run research magazine. She is a journalism graduate student at the University of California, Berkeley.

Joint project: The Geo-Info Facebook page to dispel common hazards myths about earthquakes, volcanoes, and tsunamis.

Elizabeth Davis

Elizabeth Davis' work consists of evaluating evidence for the effects of prehistoric earthquakes and historic landslides in population centers like Seattle, Washington. She is a geoscience PhD student at the University of Washington.

Project: Seattle Fault audio tour for a Washington State ferry route.

Audrey Dunham

Audrey Dunham is an earthquake seismologist, with research interests centered around understanding natural hazards, investigating earth structure through seismic imaging in the Cascadia Subduction Zone and the Teton Fault, and using simulations from the 2015 Gorkha earthquake in Nepal to relate seismic shaking to the coseismic landslide distribution. She is a geoscience graduate student at the University of Arizona.

Project: Social media campaign featuring the research of female geoscience graduate students at the University of Arizona and how it relates to geohazards. @Arizona_AWG on Twitter, hashtag #TalkGeohazards.

Robby Goldman | Camille Nava

@RTG047

Robby is a volcano geologist (or volcanologist) who studies how forces acting within volcanoes affect the underground movement of magma and whether that magma will erupt at the surface. He uses computer simulations to study the inner workings of volcanoes in both New Zealand and Hawai'i. Robby also studies how scientists and scientific agencies communicate with the public during natural crisis events such as volcanic eruptions. He is a PhD student at the University of Illinois Urbana - Champaign.

Camille is an early-career journalist who also writes creative nonfiction. She focuses on issues with a lens on social and education justice, and science and environment communication. She has called the Pacific coast region home for many years.

Joint Project: Discussing Geohazards and the Importance of Diversity in STEM, a conversation with geoscientists.

Catherine Hudson

Catherine Hudson is a freelance earth science journalist and works as a seasonal environmental educator at Tualatin River National Wildlife Refuge. She has always had a passion for communicating science, and regularly presents environmental education materials at the Refuge to groups of students.

Project: Pull-tab art for kids on earthquake and tsunami hazards.

Ellen Lamont

Ellen Lamont is a geoscience graduate student at Oregon State University working to understand the development of young mountain ranges like the Himalayas or the Cascades, which naturally lends itself to discussions about natural and seismically-induced hazards. She is interested to help at-risk individuals balance consideration for personal and communal preparedness with their other basic life needs.

Project: Clearinghouse website of information on natural hazards of the Cascadia region.

Carol Morton

@carolmorton

Carol Morton is a science writer who recently returned to Oregon after 20 years in the Boston area. There, she covered mostly biomedical sciences for research institutions and for newspapers and magazines. In Oregon, she recognizes the importance of geophysics stories, which live at the intersection of science and society, where citizens need good information to make decisions affecting their lives and futures.

Project: A written piece on the story behind the story of Shannon Hall's New York Time article "We're Barely Listening to the U.S.'s Most Dangerous Volcanoes."

Julia-Grace Sanders

@sanders_julia

Julia-Grace Sanders is a journalist passionate about equity and the environment and chases stories at the intersection of those issues. She currently covers local government, science and environment in the Seattle area for The Daily Herald. In the past, she's reported on women's health in Cambodia, homelessness and immigration in Seattle, labor and industry issues in a rural Washington county and edited the University of Washington's student newspaper.

Project: A written piece for The Daily Herald on the local impact of The South Whidbey Island Fault.

Joshua Wiejaczka

@joshwiejaczka

Joshua Wiejaczka is a PhD candidate in volcanology at the University of Oregon. His research focuses on explosive volcanism with particular interest in the transition of eruption styles from explosive to effusive, large caldera-forming eruptions and volcanic hazards mitigation.

Project: Social media campaign on the Cascadia earthquake hazard, starting with the 2019 ShakeOut drill. @joshwiejaczka on Instagram and Twitter, hashtag #TalkGeohazards.

Mel Zhang

As a graduate student at the University of Colorado, Boulder, Mel Zhang researches the relationship between slow slip and damaging earthquakes at shallow, tsunami-generating subduction zones. She believes that the biggest role scientists can play in making a difference for underprivileged parts of society is to appropriately communicate about hazards research. As a circus artist, she has learned to concisely lay out foundational knowledge as context upon which she can build the deeper story. In circus, this is a practice which can prevent serious injury; in science it is a practice which can prevent miseducation and mis-action regarding Earth's processes.

Project: Cartoons dispelling common geohazards myths.

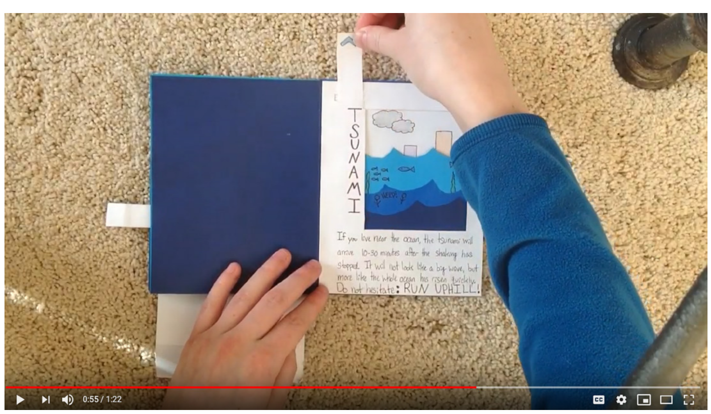


Figure 11: Catherine Hudson presents her pull-tab project in a video. (Screenshot)

Short Course Instructors

Beth Bartel

@EatTheCrust

Beth Bartel is the science communication and outreach specialist at UNAVCO, with a background in volcano geophysics and journalism. In addition to sharing geoscience and hazards with a broad public, she regularly collaborates with colleagues to identify and share communication best practices as well.

Wendy Bohon

@DrWendyRocks

Dr. Wendy Bohon is an earthquake geologist and the science communication specialist for the Incorporated Research Institutions for Seismology (IRIS). Her work focuses on earthquake education and improving the communication of hazard and risk before, during and after rapid onset geologic hazards.

Wendy Stovall

@RocksRock

Dr. Wendy Stovall is the Deputy Scientist-in-Charge of the Yellowstone Volcano Observatory (YVO) and a science communicator with the USGS Volcano Hazards Program. Her work focuses on providing current, accurate, and accessible information on the science behind volcanoes and their impacts.

Lauren Frank

Dr. Lauren Frank is an Associate Professor of Communication at Portland State University. She specializes in public health communication, mass media research, and risk and strategic communication.

Michael Poland

Dr. Michael Poland is the Scientist-in-Charge of the Yellowstone Volcano Observatory at the USGS Volcano Hazards Program. In this role, he utilizes his expertise in volcano deformation but also must understand the full spectrum of volcano science and communicate broadly with an often-concerned public.

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