Exploring How Operational Earthquake Forecasts Are Communicated in Italy, Japan, New Zealand, and the United States

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About this talk

- About earthquake forecasts
- How Japan, New Zealand, Italy and U.S.A. communicate their forecasts
- What experience/research has taught us and how we have implemented those lessons
About Operational Earthquake Forecasting

Operational Earthquake Forecasting (OEF) “is the dissemination of authoritative information about these time-dependent probabilities to help communities prepare for potentially destructive earthquakes” (Jordan et al., 2014).
Communication is social and cultural

- Alberts et al. (2007) defined communication as a transactional process in which people create meaning, from both verbal and non-verbal messages, which are also influenced by society and culture.
- What works in one culture may not be successful in another.
- Informative study not comparison.
OEF Communication across four countries

- What terminology is used to describe OEF in different countries?
- What are the latest versions of communication regarding earthquakes (as of May 2018)?
- Does your agency have a communication plan or strategy to communicate forecasts?
- What channels most frequently used?
- Examples from media coverage?
- Lessons learned about providing OEF to various publics?
Terminology

- “Aftershock Forecast” U.S.G.S.
- “Earthquake Forecast” New Zealand
- “Operational Earthquake Forecast” Italy
- “Information on prospective of seismic activity after large earthquakes” OR “Information on the Nankai Trough Earthquake”
JAPAN: Three types of forecasts

- Information on the Nankai Trough Earthquake
  - Frequency: monthly and during an emergency (one week)

- Information of the prospect of seismic activity after large earthquakes.
  - Frequency: forecasts are issued one week after the main shock if seismicity is ongoing.
  - “In the area suffered strong motion, please be careful for large earthquake with JMA seismic intensity 5 lower for one week after the first event. Also, there is a possibility that larger earthquake than the first event would occur, so be careful. Especially, there are many cases of occurrence of earthquakes with strong motion in 2-3 days after the first large earthquake.”

- Information on prospect of seismic activity in the eastern Izu District (not yet released but likely)

- Note: JMA does not use the term aftershock since August 2016 due to language confusion over the term.
What the forecast in Japan looks like

Media release format
New Zealand: Ongoing forecasts


- Forecasts of variable length from 1-day to 1-year, with the length increasing as the sequence decays.
How OEF is communicated in N.Z

- OEF is communicated using tables, location, scenarios, narrative, use of terminology like “chance” and in percentages using ranges.
- Forecasts are given as the expected range in number of earthquakes in a time frame, as percentages, and using a probability translation table.

<table>
<thead>
<tr>
<th>Verbal likelihood term</th>
<th>Probability of outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely likely</td>
<td>Greater than 99%</td>
</tr>
<tr>
<td>Very likely</td>
<td>80% and greater</td>
</tr>
<tr>
<td>Likely</td>
<td>60% and greater</td>
</tr>
<tr>
<td>About as likely as not</td>
<td>40% to 60%</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Less than 40%</td>
</tr>
<tr>
<td>Very unlikely</td>
<td>Less than 15%</td>
</tr>
<tr>
<td>Extremely unlikely</td>
<td>Less than 1%</td>
</tr>
</tbody>
</table>

GeoNet Probability Translation Table 2, v. 2.0, used from 1 September 2015.
Scenarios

There are very different probabilities for each scenario; some of these may be more unsettling to you than others. We recognise that while these scenarios may increase anxiety the best thing is to be prepared. Remember: To drop, cover and hold in an earthquake. If you feel a long or strong earthquake and you are on the coast, evacuate immediately.

Scenario One: Extremely likely (>99% within the next 30 days)

The most likely scenario is that aftershocks will continue to decrease in frequency (and in line with forecasts) over the next 30 days. Felt aftershocks (e.g. over M5) would occur in the area from North Canterbury to Cape Palliser/Wellington. This includes the potential for aftershocks of between 6.0 and 6.9 (77% within the next 30 days). Scenario one will continue to play out, even if either scenario two or three also occurs.

Scenario Two: Unlikely (approximately 20% within the next 30 days)

An earthquake smaller than the mainshock and between M7.0 to M7.8 would occur. There are numerous mapped faults in the North Canterbury, Marlborough and Cook Strait areas capable of such an earthquake. It may also occur on an unmapped fault. This earthquake may be onshore or offshore but close enough to cause severe shaking on land. This scenario includes the possibility of an earthquake in the Hikurangi Subduction Zone. Earthquakes here or in the Cook Strait have the potential to generate localised tsunami. The Hawke’s Bay earthquake sequence in 1931 provides an analogy to scenario two, as a M7.3 aftershock occurred approximately 2 weeks after the initial M7.8 earthquake.

Scenario Three: Extremely unlikely (<1% within the next 30 days)

A much less likely scenario than the previous two scenarios is that recent earthquake activity will trigger an earthquake larger than the M7.8 mainshock. This includes the possibility for an earthquake of greater than M9.0, which could be on the ‘plate interface’ (where the Pacific Plate meets the Australian Plate). Although it is still very unlikely, the chances of this occurring have increased since before the M7.8 earthquake.

Take care of yourselves and others – physically and mentally

Earthquakes can be very upsetting. Our scientists have also been pretty shaken up and have felt many aftershocks.

Please follow our friends at the Ministry of Civil Defence & Emergency Management on Twitter and Facebook for the latest in preparedness and tsunami information. Also, keep updated with your local and regional Civil Defence and Emergency Management Groups.

Beyond physical preparedness is the emotional and psychological support for these earthquakes. There is nothing wrong with being upset about the earthquake, it is a perfectly normal feeling. The All Right? Hotline (0800-777-846) is a great resource where you can talk about any anxieties or concerns that you have regarding the earthquakes.

Further, two lives were lost due to this earthquake. Our thoughts go out to the family and friends of those people.
A template has been developed for rapid release (within two hours) post major event as part of the suite of products on the earthquake event page.

Simple earthquake information and safety messages first.

U.S.A Release only; release will be in August 2018.

Tables, narrative approaches used in early template.

Areas for exploration: maps and graphical tools to contextualize information.
M 7.9 - 280km SE of Kodiak, Alaska

Aftershock forecast

Be ready for more earthquakes
- More earthquakes than usual (called aftershocks) will continue to occur near the mainshock.
- When there are more earthquakes, the chance of a large earthquake is greater which means that the chance of damage is greater.
- The USGS advises everyone to be aware of the possibility of aftershocks, especially when in or around vulnerable structures such as unreinforced masonry buildings.
- This earthquake could be part of a sequence. An earthquake sequence may have larger and potentially damaging earthquakes in the future, so remember to: Drop, Cover, and Hold on.

What we think will happen next
According to our forecast, over the next week there is a >99% chance of one or more aftershocks that are larger than magnitude 3. It is likely that there will be smaller earthquakes over the next week, with 480 to 1200 magnitude 3 or higher aftershocks. Magnitude 3 and above are large enough to be felt near the epicenter. The number of aftershocks will drop off over time, but a large aftershock can increase the numbers again, temporarily.

More details about the earthquake forecast is provided in the section “Our detailed aftershock forecast” below.

About this earthquake
So far in this sequence there have been 31 magnitude 3 or higher earthquakes, which are large enough to be felt, and 2 magnitude 5 or higher earthquakes, which are large enough to do damage.

Our detailed aftershock forecast
The USGS estimates the chance of more aftershocks as follows:
- Within the next week until 2018-1-30:
  - the chance of an earthquake of magnitude 3 or higher is >99%, and it is most likely that as few as 480 or as many as 1200 such earthquakes may occur in the case that the sequence is re-invigorated by a larger aftershock.
  - the chance of an earthquake of magnitude 5 or higher is >99%, and it is most likely that as few as 3 or as many as 16 such earthquakes may occur.
  - the chance of an earthquake of magnitude 6 or higher is >55%, and it is most likely that as few as 0 or as many as 4 such earthquakes may occur.
  - the chance of an earthquake of magnitude 7 or higher is >8%, and it is most likely that as few as 0 or as many as 2 such earthquakes may occur.

About our earthquake forecasts
No one can predict the exact time or place of any earthquake, including aftershocks. Our earthquake forecasts give us an understanding of the chances of having more earthquakes within a given time period in the affected area. We calculate this earthquake forecast using a statistical analysis based on past earthquakes.
Our forecast changes as time passes due to decline in the frequency of aftershocks, larger aftershocks that may trigger further earthquakes, and changes in forecast modeling based on the data collected for this earthquake sequence.

This forecast was issued: 2018-1-23.
This forecast will be updated on or before 2018-1-30.
M5.3 2017 Soda Springs, Idaho Sequence

- last updated September 18, 2017 3:05 PST

On September 2, 2017, there was a M5.3 earthquake east of Soda Springs, Idaho. It caused moderate shaking over a broad area of southeastern Idaho, northern Utah, and western Wyoming.

The earthquake has been followed by a sustained and highly active sequence of smaller earthquakes (aftershocks), more than we would typically observe for earthquakes of this size. Because of this, we are providing earthquake forecast scenarios, below, that we’ll update regularly as long as the sequence continues.

About the M5.3 Mainshock

The M5.3 earthquake occurred as the result of normal faulting within the shallow crust on a fault dipping at an intermediate angle either to the west or to the east. This faulting style is typical of earthquakes located in the Intermountain Seismic Belt, a prominent NS-trending zone of seismicity in the Intermountain West, and a region of moderate-to-high seismicity.
Here are the three scenarios or possibilities for the week starting Sept. 19, 2017, based on earthquake forecast models:

1. **Scenario #1 (most likely: 90-95% chance):**
   The sequence will continue to decay over the next week, which means there will be fewer earthquakes. Earthquakes above M3 may be felt by those in the area, and occasional spikes in activity may be accompanied by additional M4 or larger earthquakes, but with none larger than the M5.3 mainshock. While all earthquake sequences decay over time, there are several other possible outcomes, which are listed next.

2. **Scenario #2 (less likely than Scenario #1 but possible with 5-10% chance):**
   A similar sized or larger earthquake than the M5.3 mainshock may occur. This situation is often referred to as a “doublet” when a similar sized earthquake follows the original earthquake that kicked off the sequence. Doublets have occurred in places around the world, but they are not very common.

3. **Scenario #3 (the least likely scenario but still possible with less than 1% chance):**
   A much larger earthquake than M5.3 could occur, up to and including the M7.0 range, in which case we would call what has happened prior to any larger earthquake a foreshock sequence. We have seen this happen in other places around the world, with the most notable being L’Aquila, Italy in 2009. It is important to understand that this is a highly unlikely scenario, but we cannot ignore the possibility of this occurring.
Future directions for U.S.A.: visualization of OEF
Italy: Emerging OEF

- Plans are ongoing to release OEF to emergency managers and various publics via a dedicated website.

- OEF is communicated using maps, graphs, and a searchable database.
Communication plans and strategies

- None of the four countries have a comprehensive communication plan.
- U.S.A./U.S.G.S has a draft Operational Earthquake Forecasting Products and Standards which includes elements of social science research and communication best-practice.
- Japan is developing templates as part of their ongoing development of a communication plan.
Channels: broadcast media, social media, and websites

- All four countries utilize or plan to utilize a webpage for the forecasts.
- Broadcast media is an important part of communication of OEF in all four countries.
  - Press conferences will be held in Japan.
- Social media is utilized in New Zealand and U.S.A. through official Twitter and Facebook feeds.
- All groups have varying levels of interactions with a variety of end users. New Zealand, in particular, has direct communication with a range of users: businesses, governments, emergency managers, and building engineers.
Lessons Learned - Reporting

- New Zealand has an ongoing social science study on how forecasts were interpreted and used for the various earthquake sequences from 2010 – present. This research is used to develop the U.S.A and New Zealand forecasts.

- In Japan, since August 2016, no forecasts have been provided that required a “lessons learned” report.

- Italy has yet to release OEF so no lessons formally learned.
Lessons Learned: Social Science Research in New Zealand

- People liked the combination of maps, tables, numbers but also wanted more context and “the story” of what the OEF means.
- While people may not fully grasp what probabilities are, people expressed to us that they liked having all the information available.
- People cope differently. Some people find information helps with coping, while others do not.

McBride (2016) PhD Dissertation:

- Empathetic messaging
- Reflective communication practice
- Scientific echo chambers hamper communication (objective is not to impress peers but connect with publics)
- Two-way, conversational approaches are more successful and persuasive than one-way (relational theories)
- Multiple agencies = more trustworthy
- The use of acronyms, jargon, and gobbledygook is the language of exclusion. This was found in publications pre-Canterbury earthquake sequence and there is evidence of this occurring afterwards.
Legal considerations

- U.S.G.S. has federal legal protections for producing OEF.
- Japan has a different legal framework, however no litigation insurance.
- Italy and New Zealand do not.
Conclusion

- The four countries have diverse terminology, narrative, and graphical approaches to communicating OEF.
- Written communication plans and strategies do not exist for OEF presently.
- Channels are consistent overall, with social media in New Zealand and U.S.A.
- Research into lessons learned is either ongoing or at the beginning stages.
- Continuous improvement is important.
- Templates are becoming more frequent, with exploration into spacial formats.
- Future collaborations and sharing of research is vital to progress the successful communication of OEF.
Thank you. Questions?

Social science.... It's like normal science, only more talkative.
REFERENCES


