OPINION

September/October 2008

A Warning about Early Warning

Interest in the concept of "early warning" for earthquakes is increasing rapidly. The Japanese announced their version of a public system last fall. In the United States, algorithms are being developed and tests formulated to assess earthquake early warning systems in order to determine their relative merits and help improve their speed and reliability. At last fall's American Geophysical Union (AGU) meeting there were no fewer than 40 papers devoted to technical aspects of earthquake early warning. The simple concept of detecting a large earthquake soon enough after its origin to warn distant communities before strong shaking begins is easy to grasp. For the most part the basic scientific knowledge exists, and the technology to implement it is rapidly becoming a reality. But is the breakneck speed at which the technology is developing going to outstrip its real usefulness in a complex, multidimensional world?

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Earthquake early warning is not the first type of early warning to be used for natural hazards. It might be instructive to examine the track records for other early warning systems to help anticipate problems in their future use for earthquakes. Of course, the difference between prediction and early warning is very clear for earthquakes, but for slowly developing hazards such as hurricanes these grade into one another. For our purposes, once an event is underway, early warning in order to mitigate consequences is the relevant technology.

Unfortunately the success of prediction technology is inversely proportional to the speed of the damaging elements. Forecasters can warn us about storms more than a week in advance, yet they move only at cm/sec. We usually can anticipate volcanic eruptions hours to days ahead, and their eruptive products (ash clouds or lahars) move at meters/sec. But seismic waves travel at km/sec, and their source—earthquakes—are not predictable at all.

The successes of meteorological early warnings are well-known— from tornadoes to hurricanes to major blizzards and floods. The technology is mature and the science well-advanced. The linkages between the warning technology and its practical application by civil authorities and the public are usually well established and effective. We experience weather every day and are used to predictions and warnings related to it. Even so there are notable failures of the application of meteorologic early warning for the biggest events. The early warning for Hurricane Katrina was remarkably detailed and accurate and was available days ahead, and yet both local and national reaction to the warnings was very poor. The resulting disaster had nothing to do with the quality or timeliness of the early warning and everything to do with its interpretation and use by the civil authorities.

Less familiar to most people is volcano early warning. While volcanic unrest allows for crude predictions of the potential for imminent eruptions, once an explosion takes place there is little time before ash can impact air traffic corridors. After near disasters from aircraft flying into volcanic ash clouds in the 1980s (for example, in 1989 a 747 lost power in all engines for five minutes while on approach to Anchorage, Alaska, due to ash from Mount Redoubt), an international collaboration between volcano observatories and meteorological agencies now routinely generates both predictions and early warnings for ash. The number of aircraft-ash encounters in recent years has been very few (average of three per year versus eight per year in the 1980s and early 1990s), and these have been minor with no serious consequences. The success of this little-known early warning system may be leading to its degradation. Funding for the U.S. Geological Survey (USGS) part of this system was greatly reduced last year. The specific reasons lie buried in the intricacies of politics, but one can't help but wonder if the lack of recent ash-induced air disasters reduces its funding needs from a politician's point of view.

Another sort of volcano early warning that has been implemented in the United States is for lahars (volcanic mud flows) from Mount Rainier. However, I have serious reservations about the appropriateness of its use in this case. The realization in the 1980s that the town of Orting, Washington, was in a very precarious position in the direct path of likely lahars from Mount Rainier spurred a hazard mitigation effort. While land use planning was an obvious and effective solution to the problem, moving the 3,000-person village out of the valley, or even limiting further growth, was not considered a viable option. Better escape routes and a seismologically based early warning system were chosen as more politically acceptable alternatives. Unfortunately, with these options in place and no effective zoning for future land use, developers saw the now "protected," flat, 500-year-old lahar deposits as easy and cheap building sites for subdivisions. The town has more than doubled in size since the warning system was proposed. Even if the warning system actually works, it is unlikely that most of this larger population could be safely evacuated in the 30–45 minutes before a lahar reaches the town from the volcano. Thus, the technology-only solution may end up killing more people than if it were not available and if limiting growth were seen as the reasonable thing to do. If an inexpensive solution is perceived at the policy-maker level to provide adequate warning to save lives, other more effective mitigation may not be considered.

A case somewhat similar to an earthquake early warning is that for a tsunami. The damaging waves of a tsunami travel much more slowly than those for earthquakes, providing more time to evacuate hazardous locations. It stands to reason that the disaster of the 2004 Indian Ocean tsunami could have been greatly reduced by a tsunami warning system for the region; however, without good communications and education of the coastal people on how to react to a warning, a warning system alone might not have made much difference. Even in the United States where the communications infrastructure is very good and education levels are high, I have concerns about how effective our recently upgraded tsunami warning system really is. The public response to the M 7.2 earthquake off the coast of northern California in June 2005 provides a case in point. Technologically the early warning for this possible tsunami was nearly perfect. The warning was very timely (four minutes following earthquake origin time), but the immediate response was hugely variable. In the few "tsunami ready" towns where training, signing, and good plans had been made, more than 90% of those in potential inundation areas were properly evacuated. However, for most of the warning area the response varied from doing very little (even when the warnings were received) to not getting the warnings due to communications glitches. There was confusion over the meaning of the warning messages as well as ignorance of what to do on the part of emergency responders, the media, and the public.

Following the Indian Ocean tsunami disaster, Congress appropriated more than $30 million to upgrade our warning systems: most of it went to technological additions (ocean buoys and seismographs). I am told that much of the small amount designated for local-level education, communication, and coastal preparedness still is not available to the end user.

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My point in detailing the problems with other early warning systems is to emphasize that the science and technology parts of such systems seem to be way ahead of their effective application. Serious work is needed in the political and social sciences, education, and emergency management parts of the systems to realize the potential of early warning technology. As dedicated scientists, we are quick to advocate for more research and development to improve the speed and accuracy of warnings. But as responsible citizens should we not also strongly advocate for the rest of the system? Perhaps in some cases technology should not be the central focus. If so, we should be honest about its relative importance and encourage or advocate for a more comprehensive solution. However, we must be careful in taking this path, for once we step across the line to political advocacy, particularly outside our areas of expertise (zoning, for example), our objectivity as scientists to provide unbiased scientific information and advice is compromised. At the same time, when common sense says that a technological solution alone is not the answer, it is our responsibility as citizens to call public officials' attention to what may be a wasteful approach at best and, at worst, might lead to an increasingly dangerous situation. The United Nations International Strategy for Disaster Reduction report, Living with Risk: A Global Review of Disaster Reduction Initiatives (2004 version), recognizes the critical role of science and technology; however the report warns that "an over concentration on technical abilities at the expense of the human aspects … will provide disappointing results. In particular circumstances, science and technology can be misapplied, sometimes provoking or aggravating risks to a society."

Regarding earthquake early warning, while research into the technology is a worthy pursuit, I am increasingly concerned that its marketing to the public is disingenuous. Will the extra few seconds that another $20 million worth of seismograph stations in California might provide to some people for some types of earthquakes really make things better? Can we really say that seconds or even tens of seconds of warning will be useful when hours to days of warning for Katrina and other hazards seem to have been so ineffective? Perhaps the Japanese experiment will help to answer some of these questions, but will those answers be applicable to the very different political and social environment in the United States?

As the development of early warning technology for earthquakes continues, we must take into account the larger picture. Indeed, the Scientific Earthquake Studies Advisory Committee's 2007 annual report to the USGS director recommends that a "feasibility of earthquake alerting in the United States must include carrying out a comprehensive assessment of how such information would be used by end-users." We must step outside our ivory tower and try to anticipate the larger consequences of our developing tools and make sure that they will actually improve earthquake hazard reduction.

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Posted: *17 September 2008*