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The seismic alert system in Mexico City: an example of a successful Early Warning System (EWS)

The Problem

The rapid technological and scientific development in the fields of instrumentation, telecommunications, computer hardware and specialized software has promoted the research, design and installation of Early Warning Systems (EWS) of geological phenomena. The need to rapidly assess the imminent presence of a potentially damaging geological phenomena and the immediate broadcast of an alert to the interested government institutions and to the general population has been made possible by many of these technological advances. Today, EWSs are operating worldwide routinely in a routine manner and broadcasting alerts of earthquakes, tsunamis, volcanic eruptions and landslides.

The basic principle behind all EWSs is the time of opportunity. This time is the period between the observations of a certain phenomenon assessed as being potentially dangerous and the arrival of the first damaging effects to the locations and cities of interest. In the case of regional tsunami warning systems, for example, the time of opportunity is measured in hours. In the case of earthquakes, however, the damaging seismic waves have an impact in only the first few tens of kilometres from the epicentre; at longer distances, seismic waves are attenuated and no longer pose a threat to urban constructions and infrastructure.
Thus, the challenge of seismic alert systems is to attain the capability to record the occurrence of an earthquake and to determine within a few seconds whether its magnitude is sufficiently large to warrant the emission of an alert to the population. The relatively large velocity at which seismic waves travel in the Earth limits the time of opportunity to only a few seconds. This has hindered the routine use of seismic EWSs. The capital city of Mexico is an exception to this principle, as it is located at a distance of about 350 kilometres from the Pacific coast, where the larger earthquakes take place in the Mexican subduction zone. Under normal conditions, seismic waves at this distance would be already too attenuated to represent any danger. In Mexico City, however, the incoming seismic waves are amplified up to one hundred times, as it is built on the soft clay deposits of an ancient lake (Ordaz and Singh, 1992). These unusual soil conditions are responsible for the high amplification of seismic waves in the city.

Even though Mexico City is located away from the main seismic sources along the coast, the unique soil in the central part of the city is the cause of its very high seismic hazard. On the other hand, this distance translates into a time of opportunity of approximately 60 seconds. The challenge remains, however, to discriminate within only a few seconds whether it is an earthquake of moderate magnitude or a large earthquake, which could potentially damage Mexico City. This unusual combination of geological conditions of the subsoil and of the geographic location of Mexico City -today home to more than 20 million people- has encouraged the development of the technological and scientific tools to implement a seismic EWS in Mexico City (Espinosa-Aranda et al, 1995).

The Science

On 19 September 1985, an earthquake with magnitude 8.1 occurred on the Pacific coast of Mexico (UNAN Seismology Group, 1986). This earthquake caused unprecedented damage in Mexico City and the human losses due to this relatively distant earthquake in Mexico City, accentuated the need to develop a EWS as a tool to mitigate the loss of human lives during future seismic events (Meli, 1987). In 1987, the government of Mexico City requested the development of a EWS to cover the so-called Guerrero seismic gap, a region that has not experienced earthquakes greater than magnitude 7 since the early XX[th] century (Nishenko and Singh, 1987). Twelve sensors located in the coast of the state of Guerrero originally formed the system; to date, the system is composed of over 100 sensors distributed in southern Mexico and covering the whole Pacific coast (Figure 1). Seismic alerts are emitted using a diversity of redundant telecommunication means and the end user, in Mexico City, is alerted using low cost receivers. These low cost receivers have been installed in practically all the public schools located in the vulnerable regions of soft soils in the city. In total, there are over 90,000 users of the system in Mexico City receiving the seismic alerts today.

Figure 1. The solid black circles represent the distribution of sensing stations used in the Mexican Seismic Alert System. (source: CIRES, Mexico)

Application to policy and practice

Although the Mexico City EWS has experienced great technological and seismological advances, there is still a missing assignment in the establishment of clear public policies and protocols for the distribution and use of the alert, something that social scientists involved in this initiative have always demanded from the beginning. The use of beepers and cell phones to receive alerts is a relatively new technological option to enhance the distribution of the alert. Nevertheless, who may issue alerts and under what conditions has not been regulated. Also, what exactly should the recipient of the alert do, has not been established and regulated. This is particularly important given that low-cost receivers are being widely distributed by the local and federal government. However, this distribution is not accompanied by policies on its use. For example, is it feasible to evacuate a 20 story building within the 50 seconds allowed by the time of opportunity? What should hospitals do in the 60-second time of opportunity available? In summary, the EWS in Mexico City offers an unprecedented possibility to save lives in the event of a major earthquake. Nevertheless, clear public policies and protocol for its use are urgently needed to guarantee its correct application and to make use of all of its potential benefits, by exploring lessons learnt in similar cases. A good analogy of how technical and scientific advances have made an impact in protecting the population from natural hazards is the Tsunami Warning System of the Pacific. Communities in several Hawaiian cities, for example, receive an alert when an impending tsunami may reach the shores of their communities. Contingency plans and protocols exist to allow the population to vacate the zones of highest exposure. Specific evacuation plans and protocols accompanying the seismic alert system probably will save many lives when a large earthquake strikes Mexico City and schools and buildings are evacuated in an orderly and structured manner. In establishing these policies and protocols to react to the emission of a seismic alert, it is crucial to understand how people in Mexico City perceive the hazard posed by earthquakes and how they would react to an alert in specific locations (e.g., Eiser et al, 2012).

Does it make a difference?

To date, the system has generated a total of 34 public alerts and 72 preventive warnings from a total of 2,200 earthquakes detected (Cuellar et al., 2013). The difference between the two is based on the predicted magnitude of the earthquake. Since its inception, the system issued only one false public alert. This took place during the development stages of the EWS, which was put in place prematurely based on political pressure to

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implement the system. More notably, it is important to emphasize that all large earthquakes that have occurred since the initiation of the system have been identified and warned.

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