“Low risk does not equal no risk”: understanding barriers to earthquake risk reduction in low seismic hazard areas.

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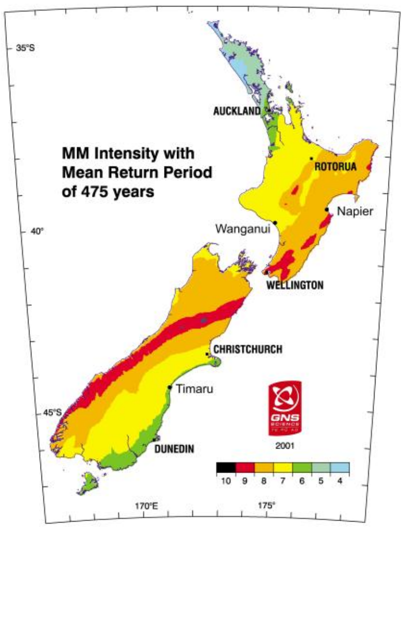
ABSTRACT: Over the past few decades considerable effort has been devoted to improving our knowledge of seismic risk. Much of this work has resulted in improved seismic risk models and hazard maps, delineating variations in relative risk. However, disparities are still common between these expert assessments and the manner in which the public and authorities interpret and act on seismic risk information. Public understanding of and response to earthquake risk is determined by a range of factors, including scientific information, and direct past experience of earthquakes, as well as the interaction of social, cultural, institutional and political processes. Many people in lower seismic hazard regions falsely interpret their relatively low seismic risk as a reason not to prepare. This phenomenon is common in many parts of the world, and it is a theme that will be explored in this paper within the context of Canterbury, New Zealand and eastern Washington, USA.

1 INTRODUCTION

Over the past few decades considerable global effort has been devoted to improving our knowledge of seismic risk. Much of this work has resulted in improved seismic risk models and hazard maps, delineating variations in relative risk (Stirling et al. 2002, Stirling & Petersen 2006). Public understanding of and response to earthquake risk is determined by a range of factors, including scientific information, and direct past experience of earthquakes, as well as the interaction of social, cultural, institutional and political processes (Eiser et al. 2012, Becker 2012, McClure et al. 2011, Paton et al. 2010a, 2000b). Geoscientists work hard to generate accurate assessments of seismic risk, which they acknowledge cannot be considered definitive. This information is then publically available and open to interpretation. Disparities are common between expert assessments and the manner in which emergency managers, policy-makers and the general population interpret and act on seismic risk information (Eiser et al. 2012, Becker 2012; 2010, Bostrom 1997). People residing in relatively low seismic hazard regions have been found to falsely interpret such seismic hazard assessments as a reason not to prepare. This is clearly illustrated by recent work in Canterbury, New Zealand (McClure et al. 2011) and eastern Washington (Johnston et al. 2012).

In New Zealand, the most recent seismic hazard assessment prior to the Christchurch earthquakes highlighted the high level of seismic risk associated with the plate boundary, particularly in the Wellington and the Southern Alps (Stirling et al. 2002, Figure 1). Christchurch was described as having *relatively* low risk in comparison, even though the city has a known historic record of damaging earthquakes, and a documented susceptibility to liquefaction (Clough 2006; MacKenzie 1999; Elder et al. 1999). When the earthquakes struck Christchurch, there was general shock that Christchurch had been hit so ferociously in what had been considered by many to be a low risk seismic region.

Figure 1. Map showing the distribution of MM intensity with a current Annual Exceedance Probability of 1/475 derived from the National Probabilistic Seismic Hazard Model (2001). Timaru is situated within MM6 (i.e. falling items, slight damage, e.g. cracked plaster), Wanganui within MM7 (i.e. buildings cracked, bricks and chimneys falling), and Napier within MM8 (i.e. damaged and partially or fully collapsed buildings), (Source: GNS Science).



McClure et al. (2011) examined changes in judgment of earthquake risk before and after the 2010 Darfield, Canterbury earthquake in three cities: Christchurch (Canterbury), Wellington and Palmerston North. The study found expectations of an earthquake occurring in Canterbury were low before the Darfield earthquake in each of the three locations and increased significantly after the earthquake occurred. Interestingly, the Christchurch earthquakes did not raise the risk perceptions of residents in Wellington in terms of future seismicity in their own city. Palmerston North residents however, did have a higher expectancy of a future seismic event. The authors concluded that there is a need for at-risk communities to understand that even if they are objectively at a lower risk than others in terms of probabilities, they should base their actions on the actual level of risk in their own region, even when that risk is judged lower in probabilistic terms than other regions.

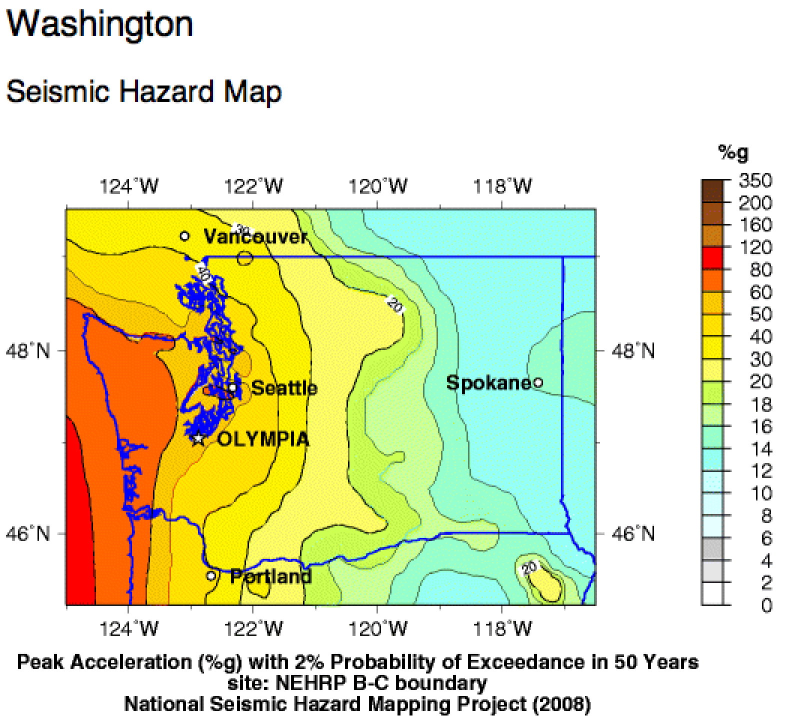
1.1 *Community understanding of earthquake risk in Eastern Washington*

Johnston et al. (2012) describes the results of a study investigating resident perceptions of natural hazard risk in eastern Washington. Field surveys were conducted at five county fairs in eastern Washington in 2010, probing respondents' attitudes toward multiple hazards and earthquakes (Johnston et al. 2012). Community meetings were then held to disseminate the results one year later, and to act as a forum for further discussion of the issues. The results highlighted an apparent disconnect between awareness of the possibility of future earthquakes and of the risk posed by these earthquakes. While the majority agree that Washington has seismic hazards and the awareness and understanding of the likelihood of future earthquakes was found to be relatively high, this did not translate into residents taking steps to get more prepared, with only a small proportion adopting basic mitigation measures other than owning a flashlight, fire extinguisher or first aid kit.

1.2 *Learning from Christchurch for United States communities*

For many cities in the United States (and other locations), the Christchurch experience and long-term recovery should be viewed as both a warning of what can happen, and as a sobering call to learn from this event to lessen these consequences. In particular, the Christchurch earthquakes struck areas of reasonable construction, with building codes not dissimilar to the United States codes, and orders of magnitude better than that in Haiti. The loss of life in Christchurch, concentrated in three collapsed structures, highlighted the importance of resilient building stock and the 'life safety' aspect of policy planning in this space. The state of Washington can be considered similar to New Zealand geologically, with a plate boundary off the western coastline representing an area of high seismic risk (like Wellington and the Southern Alps, Figure 2), with the risk reducing eastward with the distance from the plate boundary. Eastern Washington, therefore, is generally considered to have lower risk of being impacted by major subduction earthquakes than the western coast of the state.

Figure 2: Seismic hazard map for Washington, United States. The blue outlined is the state boundary.



Earthquake mitigation in the United States takes many forms. The one national effort is provided by the seismic provisions in the country's building codes which are updated every 6 years or so to reflect new scientific discoveries and improved engineering practice. Lessons learned from all major earthquakes are folded into the new codes, and thus over time, seismic safety slowly improves as the building stock is replaced with new structures. However, existing buildings, transportation systems, and other infrastructure usually are not subject to new codes, and over time, cities have a large population of deficient buildings. This is particularly true in areas such as the Pacific Northwest, where earthquake hazards are not completely understood. For example, great subduction zone earthquakes were unknown in the geologic record as recently as 25 years ago (Atwater & Hemphill-Haley 1997), and large crustal faults, capable of producing events in Puget Sound larger than those in Christchurch, were not yet discovered. Thus the effects of these earthquake sources are relatively recent in the seismic hazard maps that underlie the building codes (Frankel el al. 1996).

Over much of the United States, earthquake hazards are perceived by the general population to be lower risk than more frequent perils such as floods, tornados, or winter storms (Johnston et al. 2012). In addition, while emergency managers have access to current USGS seismic hazard assessments for their region, the low frequency of earthquake events in the region often results in earthquake mitigation and preparedness being prioritised below other types of hazards (such as storms and wildfire). As a result local authorities focus their limited resources on higher frequency (albeit lower consequence) hazards. As city, county, and state budgets constrict from the continuing recessionary times, it becomes harder for most localities to justify worrying much about "sustainability" and disaster-resistant communities. Opportunities to improve the seismic performance of a key bridge or an important city building get lost in the tough times.

There is also a tendency in areas outside of the high earthquake hazard zones of California and perhaps portions of western Washington and Oregon, for the population to overlook the consequences of a somewhat “ordinary” magnitude 6 to 7 earthquake. This societal attitude rests in part on national efforts that concentrate much of the earthquake science and mitigation effort in the highest hazard areas, and in part on human interpretations of short historical records, i.e. it hasn’t happened in the last 30 years, it probably won’t happen in the next 30 years. Christchurch, however, highlights the danger of not considering and acting on a city’s entire suite of known natural hazards. In this way, Christchurch is an ideal teaching opportunity for United States cities (and other regions) in lower earthquake hazard zones.

2 CONCLUSION

The lessons from Christchurch offer a very useful and timely opportunity for application in the Pacific Northwest of the United States. The cultural, economic, seismological, political and environmental aspects of the Christchurch events are sufficiently familiar and comparable to the Washington situation: stories and lsesons from Christchurch have an ability resonate with our emergency management counterparts in the state. For example, Christchurch and parts of eastern Washington have similar heritage building stock, with shared challenges and issues around building safety and the expense of retro-fitting these older buildings. Large parts of eastern Washington have an economy based on agriculture, and lessons can be learned from Canterbury with respect to recovery and resilience in the farming community. This research collaboration between USGS and GNS Science forms an important starting point for further work on effective communication of both new earthquake hazard results from the continuing USGS hazard assessment activities and how the Christchurch experiences can be parsed into manageable and actionable pieces.

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