

# New National Seismic Hazard Model for New Zealand: Changes to Estimated Long-Term Hazard

M.W. Stirling, G. H. McVerry, & M. Gerstenberger

*GNS Science, Lower Hutt, New Zealand.*



2012 NZSEE  
Conference

**ABSTRACT:** We compare site-specific response spectra and hazard maps from the recently-updated national seismic hazard model (2010 NSHM) and predecessor NSHM of 2002. The new model incorporates over 200 new onshore and offshore fault sources, and utilises newly-developed New Zealand-based scaling relationships and methods for the parameterisation of the fault and subduction interface sources. The distributed seismicity model has also been updated to include new seismicity data, a new seismicity regionalisation, and improved methodology for calculation of the seismicity parameters. The new spectra and maps show some significant reductions to estimated hazard in areas dominated by the distributed seismicity model (e.g. Auckland and Northland), increases in the Wellington region due to the new Hikurangi subduction zone model, and some reductions along some major faults in the South Island. Future improvements to the NSHM will include the treatment of epistemic uncertainties (source models and ground motion prediction equations), incorporation of GPS data into the distributed seismicity model, nationally-based integration of time-dependent seismicity modelling methodologies, and inclusion of formal testing methodologies in the model.

## 1 INTRODUCTION

A major update of the national seismic hazard model (NSHM) was completed in 2010, and will shortly be published (Stirling et al. in press). The update supersedes the earlier NSHM of 2002 (Stirling et al. 2002) and has largely focussed on the source models, with addition of a large amount of new seismicity and fault data. A revamp of the methods used to model the fault and distributed seismicity parameters has also been achieved. In this paper we provide an overview of the main differences in estimated hazard between the two models. Note that the update is time-stamped 2010, so does not incorporate the more recent seismicity modelling associated with the 2010-2011 Christchurch earthquakes (e.g. McVerry 2012). The Greendale Fault, source of the M7.1 4 September 2010 Darfield earthquake has been included in the 2010 NSHM

## 2 COMPARISONS OF HAZARD MAPS AND SPECTRA

Examples of hazard estimates from both new and earlier NSHMs are shown in map form (Figs. 1 and 2), and in the form of spectra for major centres (Fig. 3). All hazard maps and spectra are based on Class C (Shallow Soil) site conditions (see McVerry et al., 2006 for definition of site classes). For each of the maps shown, we calculate the hazard with the McVerry *et al.* ground motion prediction equation (GMPE), and with the GMPE uncertainty set to three standard deviations.

The 475 year peak ground acceleration (PGA) maps show a now-familiar pattern of hazard that is highest from the southwestern South Island to the eastern North Island (the northeast-trending zone of  $PGA \geq 0.5g$ ). Hazard in this northeast-trending zone reflects the greatest concentration of active fault sources and seismicity in the model. In particular, the Fiordland (southwestern-most South Island), Alpine fault (western-central South Island) and Hope fault (northern-central South Island) sources are most responsible for this zone of high hazard in the South Island. The crustal and Hikurangi

subduction zone sources show a strong influence on hazard in the eastern North Island. Comparison of Figure 1 to the equivalent map from the earlier NSHM (Fig. 2) shows that the biggest change in hazard is in the southeast of the North Island. The new Hikurangi subduction interface model (see earlier) has an obvious impact on the hazard in this area, and highlights the importance of the new subduction interface modelling. The new subduction interface modelling more than counteracts the 50% reduction in Wellington fault (Wellington-Hutt Valley source) hazard from the Poissonian-based estimates used in the earlier NSHM. High hazard anomalies seen in the earlier NSHM maps (Fig. 2) have been eliminated along the Alpine and Hope Fault sources by improved modelling at fault source boundaries (Fig. 1). Lastly, the hazard estimates for Auckland and Northland are reduced in the new NSHM, reflecting the impact of the new distributed seismicity model and associated b-value (see below).

The graphs of site specific response spectra for Class C (Shallow soil) sites show hazard for 150, 475, 1,000 and 2,500 year return periods, and the spectra are compared to the corresponding spectra from the earlier NSHM (Fig. 3). For Auckland, the spectra have reduced significantly from the earlier NSHM, again reflecting the influence of the new distributed seismicity model on the hazard estimates. The increased b-value in the new model (about 1.1 for the new model versus less than 1 for the earlier NSHM) is the primary reason for the reduced spectral accelerations in Auckland. The new NSHM uses the method of Aki (1965) to develop distributed seismicity parameters, whereas the earlier NSHM used the method of Weichert (1980). For Wellington, the only significant change to the spectra from the earlier NSHM is a slight increase in hazard at spectral periods of 0.4 seconds and greater. This increase in longer period hazard is due to the changes to the Hikurangi subduction interface sources. For Christchurch, hazard has increased for periods less than about 0.6 seconds, reflecting the decreased b-value in the new NSHM (less than 1 in the new NSHM, and close to 1.2 in the older NSHM). Lastly, spectra for the city of Dunedin generally show a slight increase in hazard for the new NSHM. This reflects a slightly decreased b-value in the new NSHM (less than 1 in the new NSHM and greater than 1 in the earlier NSHM).

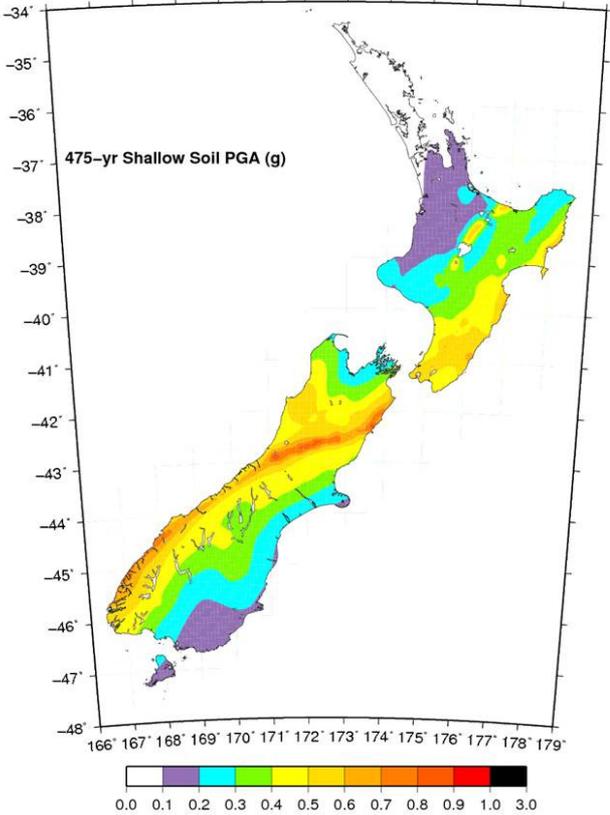


Figure 1. Map derived from the 2010 NSHM, showing peak ground acceleration expected with a 475 year return period on Class C sites. Hazard estimates are in units of g.

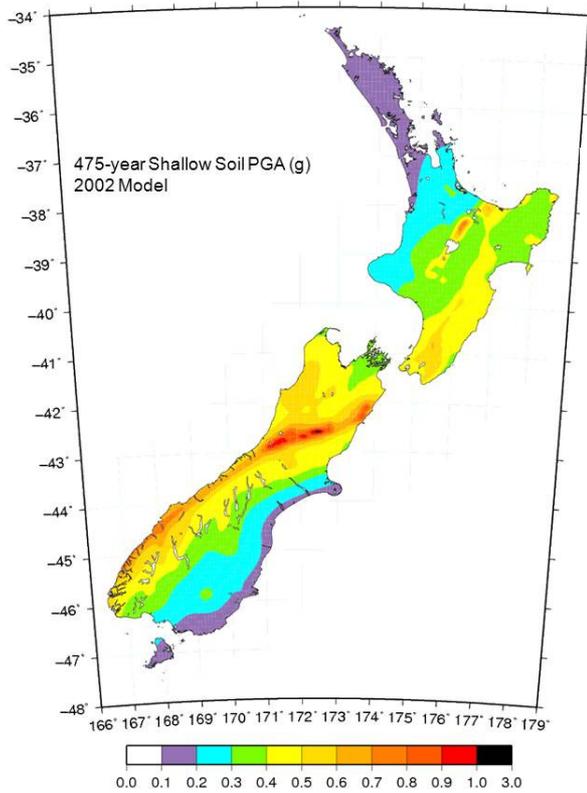
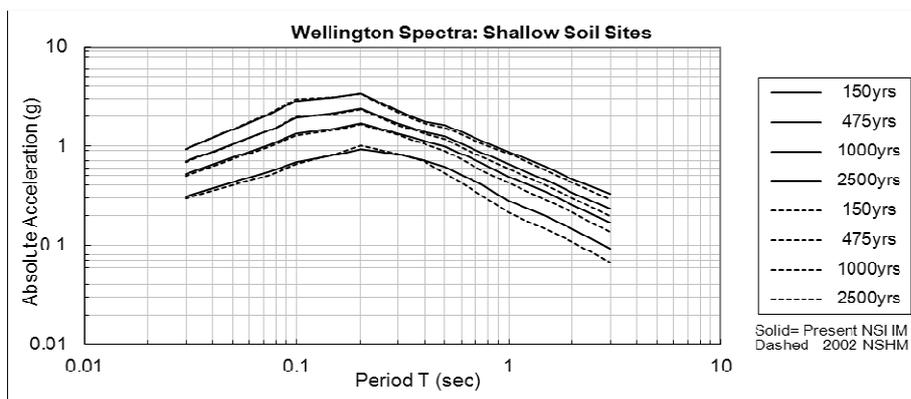
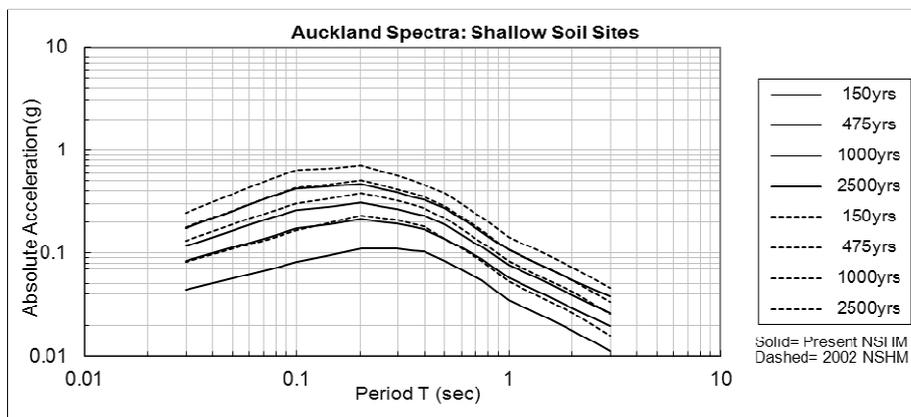


Figure 2. Map derived from the 2002 NSHM, again showing peak ground acceleration expected with a 475 year return period on Class C sites.



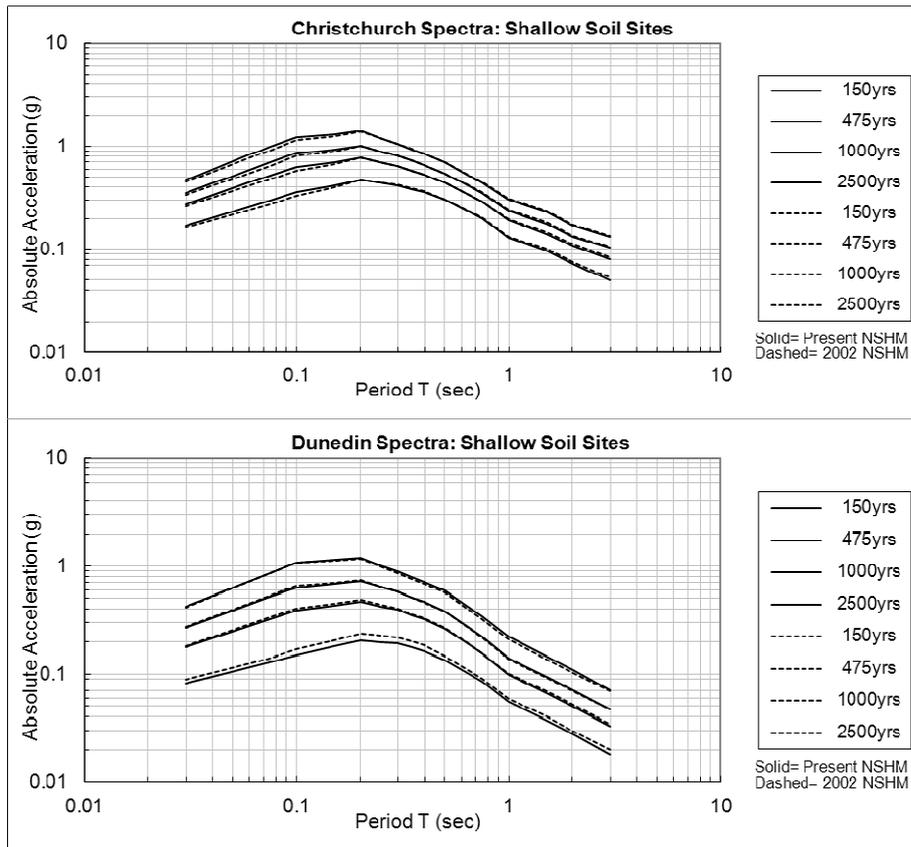


Figure 3. Response spectra for the four main centres, for Class C sites.

### 3 CONCLUSIONS AND FUTURE DIRECTIONS

Comparison of site-specific response spectra and hazard maps from the recently-updated national seismic hazard model (2010 NSHM) and predecessor NSHM of 2002 reveal show some significant reductions to estimated hazard in areas dominated by the distributed seismicity model (e.g. Auckland and Northland), increases in the Wellington region due to the new Hikurangi subduction zone model, and some reductions along some major faults in the South Island. Future improvements to the NSHM will include the treatment of epistemic uncertainties (source models and ground motion prediction equations), incorporation of GPS data into the distributed seismicity model, nationally-based integration of time-dependent seismicity modelling methodologies, and inclusion of formal testing methodologies in the model.

#### REFERENCES:

- Aki, K. 1965. Maximum likelihood estimates of  $b$  in the formula  $\text{Log } N = a - b M$  and its confidence limits. *Bulletin of the Earthquake Research Institute* 43, 237-239
- McVerry, G. H., J. X. Zhao, N. A. Abrahamson, and P. G. Somerville 2006. Response spectral attenuation relations for crustal and subduction zone earthquakes, *Bull. New Zeal. Soc. Earthquake Eng.* 39, 1-58.
- McVerry, G. H. 2012. Spectra and pgas for the assessment and reconstruction of Christchurch. *Proceedings of the 2012 Annual Conference of the New Zealand Society of Earthquake Engineering.*

Stirling, M. W., G. H. McVerry, and K. R. Berryman 2002. A new seismic hazard model of New Zealand. *Bull. Seis. Soc. Am.* 92, 1878-1903.

Stirling, M.W., McVerry, G.H., Gerstenberger, M., Litchfield, N.J., Van Dissen, R., Berryman, K.R., Langridge, R.M., Nicol, A., Smith, W.D., Villamor, P., Wallace, L., Clark, K., Reyners, M., Barnes, P., Lamarche, G., Nodder, S., Pettinga, J., Bradley, B., Rhoades, D., Jacobs, K. National Seismic Hazard Model for New Zealand: 2010 Update. *Bulletin of the Seismological Society of America* (in press)

Weichert, D.H., (1980), Estimation of the earthquake recurrence parameters fro unequal observation periods for different magnitudes: *Bulletin of the Seismological Society of America*, 70, 1337-1346.