Explicit uncertainty incorporation in ground motion simulations and their use in NZ probabilistic seismic hazard and loss analysis
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1 Executive Summary

Earthquake-induced ground motion prediction is presently under-going a paradigm shift from the empirical prediction of ground motion intensity measures based on regression analysis of observations from past earthquakes, toward the use of physics-based simulation methods that directly predict the ground motion time series. This research has examined several aspects that are necessary to progress ground motion simulation methods toward application for seismic hazard and loss analysis. Specifically, validation against observations including uncertainties, application of simulation methods to forecast future earthquake hazards, and consideration of ground motion simulation methods in seismic loss analysis.

Validation results illustrate that the present ground motion simulations can perform comparably against conventional empirical alternatives. Commonly considered uncertainties in simulations are insufficient to explain the deviation of observations from mean simulations. More exhaustive treatment of uncertainties is a multi-year topic that requires on-going research. Ground motion simulations used in multiple versions of seismic hazard maps for New Zealand compare similarly to conventional results from empirical models, but with a sharper spatial variation, and provide an alternative prediction result that will increasingly be included in ensemble predictions.

2 Technical Abstract

This abstract provides a summary of (published) research outcomes that have been undertaken to examine aspects necessary to progress ground motion simulation methods toward application for seismic hazard and loss analysis. Specifically: (i) validation of ground motion simulations against observations; (ii) explicit consideration of modelling uncertainties, including application to validation; (iii) simulation-based probabilistic seismic hazard analysis for New Zealand; (iv) application to loss analysis.

Simulation validation Lee and Bradley provides a summary of the work undertaken in this project associated with validation of ground motion simulation using 609 earthquakes in New Zealand. A journal publication of this work has been submitted to Earthquake Spectra. As part of this work, we also developed the automated visualization of simulations, as published in Polak and Zhu M.

Simulation modelling uncertainties Neill et al. [b] provides an overview of the consideration of several ground motion simulation uncertainties for the 22 February 2011 Christchurch earthquake, building on our prior work published in Razafindrakoto and Bradley. Neill et al. [a] further extends the consideration of modelling uncertainties to validation of 148 earthquakes in the Canterbury region. This work is on-going, as the consideration of modelling uncertainties for ground motion simulation validation will continue to evolve as the modelling methods themselves advance over the coming years.

Simulation-based probabilistic seismic hazard analysis Four publications (Tarbali et al.) provide an overview of the multiple iterations of simulation-based probabilistic seismic hazard analysis that have been undertaken with partial support from this project. As seen in the authorship list, this research outcome has required a large team, but has resulted in the first series of simulation-based seismic hazard maps for New Zealand. A journal publication for this work is in the final stages of preparation for submission.

3 Acknowledgements

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References

R.L. Lee and B.A. Bradley. Progress toward new zealand-wide hybrid broadband ground motion simulation validation. page 8.

S. Neill, R.L. Lee, and B.A. Bradley. Ground motion simulation validation with explicit uncertainty incorporation for small magnitude earthquakes in the canterbury region. a.

S Neill, R.L Lee, and B.A. Bradley. Preliminary examination of kinematic rupture parameter variability in simulated ground motions. page 8, b.

V. Polak and Motha J Bradley BA Razafindrakoto HNT. Zhu M, Bae S. GmSimViz: Automated 3d visualization of ground motion simulation with generic mapping tools (GMT). 4(35):808.

Hoby N. T. Razafindrakoto and B.A. Bradley. Examination of ground motion simulation uncertainties for the 2010 mw7.1 darfield and 2011 mw6.2 christchurch, new zealand earthquakes.