



PSHA input model documentation for New Zealand (NZL)

GEM Hazard Team

Version history

Table 1 summarises version history for the NZL input model, named according to the versioning system described [here](#), and indicating which version was used in each of the global maps produced since 2018. Refer to the [GEM Products Page](#) for information on which model versions are available for various use cases. The changelog describes the changes between consecutive versions and are additive for all versions with the same model year.

Table 1 – Version history for the NZL input model.

| Version | 2018.1 | 2019.1 | 2022.1 | 2023.1 | Changelog |
|----------------|---------------|---------------|---------------|---------------|------------------------------------------------------------------------------------------------------------------------|
| v2010.0.0 | X | X | X | | First version of the model implemented in OpenQuake. |
| v2010.0.1 | | | | X | Mmin extended to M4 for crustal distributed seismicity. Source ids were revised to work with disaggregation by source. |
| v2022.0.0 | | | | | the 2022 National Seismic Hazard Model for New Zealand |

The following text describes v2022.0.0.

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This text was prepared by the GEM secretariat. For any queries about the model development or how to implement it, please contact GNS Science directly at: <https://nshm.gns.cri.nz/>

1 Summary

The development of the 2022 national seismic hazard model for New Zealand was led by GNS Science (Gerstenberger et al. 2022) who converted the model into [OpenQuake \(OQ\) engine](#) format. A summary of the 2022 model is provided below. The 2022 GNS model covers the North, South, and Stewart Islands.

2 Tectonic overview

New Zealand sits across the boundary between the Australian and Pacific plates, where relative plate motion is obliquely convergent across the plate boundary at rates of 48 to 40 mm/year from north to south (Wallace et al. 2007).

The plate boundary can be divided into three main components from north to south, namely: 1) the oblique westward subduction of the oceanic Pacific Plate beneath the continental Australian Plate east of the North Island (Hikurangi Margin); 2) the oblique continent-continent boundary in the South Island (South Island continental transpression zone) where the two plates collide and slip laterally; and 3) the northeastward subduction of the oceanic Australian Plate beneath the continental Pacific Plate southwest of the South Island (Puysegur Margin). These three major components of the plate boundary are further subdivided in tectonic regions (Litchfield et al. 2014).

3 Basic Datasets

See Gerstenberger et al. (2022) for a summary of the datasets used for developing the hazard model.

4 Hazard Model

4.1 Seismic Source Characterisation

The seismic source characterisation (SSC) consists of various seismic source typologies to describe earthquake occurrence in different tectonic settings. Distributed seismicity is used to model active shallow, subduction interface, and subduction intraslab seismicity, while fault sources are used to model seismicity occurring on shallow crustal faults and large subduction interface events.

The OQ implementation uses two OQ source typologies. The background (gridded) seismicity models are implemented as collections of **Point Sources**, while faults are modelled as **Multi Fault Sources**.

4.2 Ground Motion Characterisation

A GMC is applied for each tectonic region defined within the NZL 2022 seismic source Characterisation (*Active Shallow Crust, Subduction Interface and Subduction IntraSlab*). Each GMC below represents that summarised in Gerstenberger et al. 2022. The GMC for each tectonic region of the NZL 2022 model is reasonably complex and therefore the representations provided here only define the core "backbone" ground-motion models (GMMs) used within each of them. Each of these backbone GMMs is modified using adjustments which represent the epistemic uncertainty in the ground-motion. Bradley et al. 2024 should be consulted for a detailed overview of the adjustments made to each GMM.

| Active Shallow Crust | Weight |
|--------------------------------------------------------|---------------|
| Atkinson2022Crust | 0.28 |
| Stafford2022 | 0.39 |
| AbrahamsonEtAl2014 | 0.066 |
| BooreEtAl2014 | 0.066 |
| CampbellBozorgnia2014 | 0.066 |
| ChiouYoungs2014 | 0.066 |
| Bradley2013 | 0.066 |
| Subduction Interface | Weight |
| Atkinson2022SInter | 0.27 |
| NZNSHM2022_AbrahamsonGulerce2020SInter | 0.25 |
| NZNSHM2022_KuehnEtAl2020SInter | 0.24 |
| NZNSHM2022_ParkerEtAl2020SInter | 0.24 |
| Subduction Inslab | Weight |
| Atkinson2022SSlab | 0.27 |
| NZNSHM2022_AbrahamsonGulerce2020SSSlab | 0.25 |
| NZNSHM2022_KuehnEtAl2020SSlab | 0.24 |
| NZNSHM2022_ParkerEtAl2020SSlab | 0.24 |

Table 2 – Backbone GMPEs used in the NZL model

5 Results

Hazard curves were computed with the [OQ engine](#) for the following:

- Intensity measure types (IMTs): peak ground acceleration (PGA) and spectral acceleration (SA) at 0.2s, 0.3s, 0.6s, 1.0s, and 2s
- reference site conditions with shear wave velocity in the upper 30 meters (V_{s30}) of 760-800 m/s, as well as for V_{s30} derived from a topography proxy (Allen and Wald, 2009)

Hazard maps were generated for each reference site condition-IMT pair for 10% and 2% probabilities of exceedance (POEs) in 50 yrs. Additionally, disaggregation by magnitude, distance, and epsilon was computed for the following cities: Wellington. The results were produced as csv files and bar plots for each of the following combinations:

- hazard levels for 10% and 2% POE in 50 yrs
- PGA and SA at 0.2s, 0.3s, 0.6s, and 1.0s
- $V_{s30}=800$ m/s

All calculations used a ground motion sigma truncation of 5. Results were computed for sites with 6 km spacing

Visit the [GEM Interactive Viewer](#) to explore the Global Seismic Hazard Map values (PGA for $V_{s30}=800$ m/s, 10% poe in 50 years). For a comprehensive set of hazard and risk results, see the [GEM Products Page](#).

6 References

Allen, T. I., and Wald, D. J., 2009, On the use of high-resolution topographic data as a proxy for seismic site conditions V_{s30} , Bulletin of the Seismological Society of America, 99, no. 2A, 935-943

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Litchfield NJ, Van Dissen RJ, Sutherland R et al (2014). A model of active faulting in New Zealand. New Zeal J Geol Geop 57:32-5

Wallace LJ, Beavan RJ, McCaffrey R et al (2007). Balancing the plate motion budget in the South Island, New Zealand using GPS, geological and seismological data. *Geophys J Int* 168:332-351. doi: 10.1111/j.1365-246X.2006.03183.x

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