National Seismic Hazard Model

2022 Revision

Te Tauira Matapae Pūmate Rū i Aotearoa
NSHM
The New Zealand National Seismic Hazard Model
A GNS Science Led Research Programme

E mahi ana me
In collaboration with

Ngā hoa tuku pūtea
Funding partners

The science development and review process

NSHM includes scientific understanding from around the world

- Includes a broad range of scientific views
- More than 50 scientists from around New Zealand and around the world
- University of Canterbury, University of Otago, University of Auckland, NIWA and others
- United States, Canada, Italy, Germany, Australia, England

NSHM participatory peer review:

- Technical advice on the development of the NSHM has been provided by a 17-member panel of international scientists, engineers, insurance using a participatory review process.
- Scientifically detailed involvement from panel – weekly input
- Panel included key NSHM end-users

Assurance review:

- International review of processes: science, decision making and peer review, with positive outcomes

The NSHM produces probabilistic forecasts

What is the forecast for?

The NSHM provides a probabilistic forecast of earthquake shaking. The probabilities are determined from the scientifically credible range of shaking we might experience over the next 100 years. Often these probabilities are mapped using the average forecast.

PROBABILISTIC MODEL

Past earthquake events
+
applied statistical and physical science

Range of future possible shaking

What is our confidence in the forecast?

The confidence in the forecast is shown by looking at the range of possible futures and how likely they are. Each one of these can be expressed as a different map or different outputs for engineers

Testing the NSHM: The science is internationally peer reviewed by a large panel of experts, and we test the forecasts against past earthquakes, long term data sets and global science.

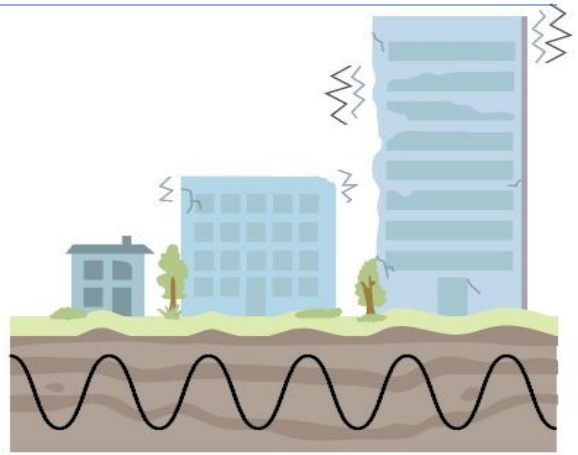
This process and our advanced understanding of how earthquakes work ensures that we are using the best available science.

The NSHM produces forecasts of shaking

The NSHM forecasts ground shaking. This is called the hazard.

The NSHM does not forecast the impact on society.

The impact on society is often called the risk.



The NSHM provides important input for making risk based decisions.

Making risk based decisions requires a community to understand their own risk tolerance.

The NSHM produces a wide range of results that model thousands of future earthquakes
Depending on a communities risk appetite they should look at the relevant results

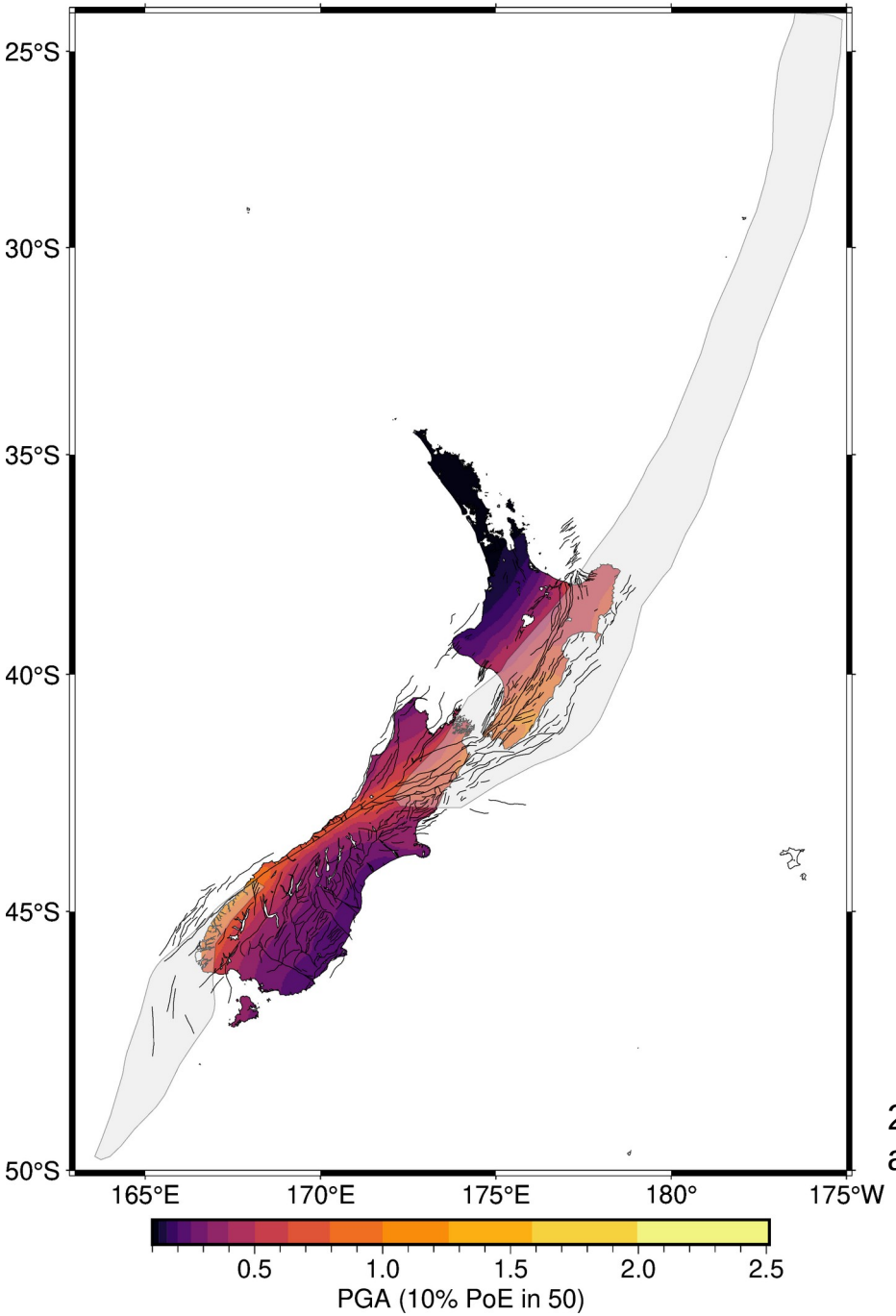
How do we make the NSHM?

Two Components of the NSHM

1 **Earthquake Ruptures** 2 Ground Shaking

1. Earthquake Ruptures: where, what frequency and what magnitudes

- Hundreds of thousands of modelled ruptures based on around 1,000 known faults and how they can rupture
- Many hundreds of thousands of random ruptures considered for faults that are unknown

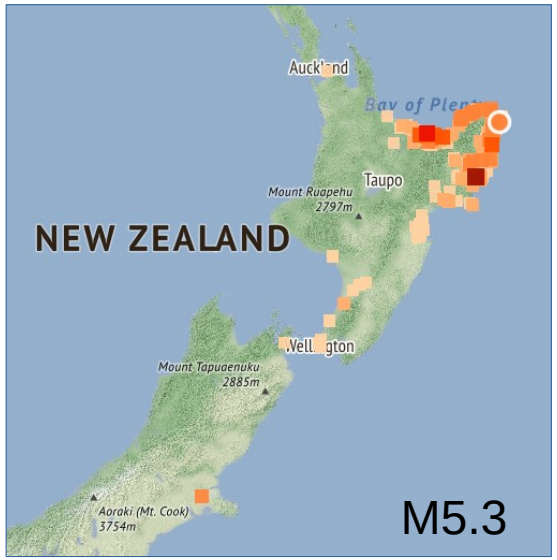


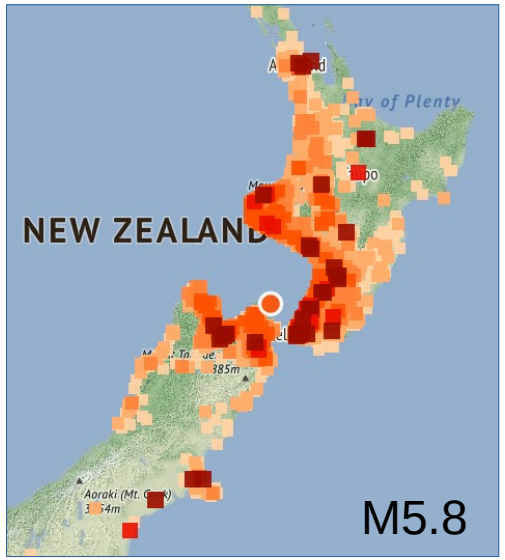
2022 NSHM faults including Hikurangi-Kermadec and Puysegur Subduction Interfaces

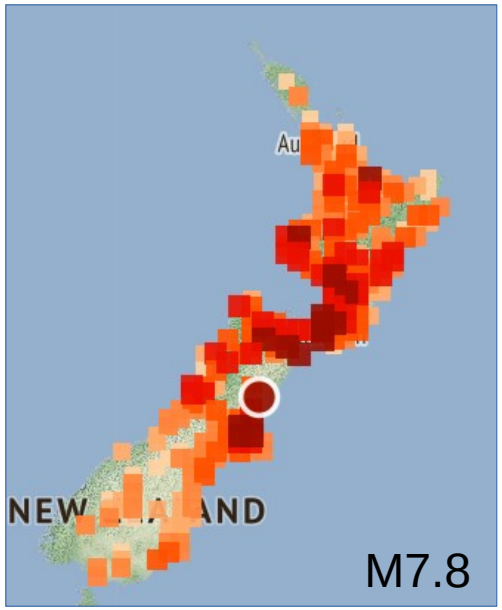
Two Components of the NSHM

1 Earthquake Ruptures

2 **Ground Shaking**







2. Ground shaking: what is the range of possible shaking when all ruptures are considered

- Use of many models, some internationally developed, some specifically optimised to New Zealand earthquakes
- Each model can give a different forecast for the same rupture
- Final shaking estimate includes all possible ruptures, and the range of shaking possible for each one of those

The shaking people felt in the Kaikoura M7.8 and two recent earthquakes

The NSHM brings together our most recent scientific understanding

The NSHM includes research from scientists from across New Zealand and across the globe

- Data and models of our many earthquake faults and their past ruptures
- Global advancements in complex fault ruptures and how to model them
- Improved statistical modelling of how often earthquakes occur
- Much additional shaking data from earthquakes in the last two decades
- Global advancements in the ability to model ground shaking
- High performance computing

Conceptual differences from previous NSHMs

Quantifying and modelling uncertainty is a critical part of the model	• Better includes our understanding of earthquakes • Communicates our confidence in the model results • Final result is a range of shaking, not a single estimate
Results include the influence of multiple data sets and scientific hypotheses	• A broader range of scientific understanding is included • Earthquake geology, seismology, geodesy, engineering seismology
Modelling of thousands of potential ruptures, rather than a few hundred	• Complex and multi-fault ruptures – more realistic hazard estimates • Variability in magnitude and rupture length • More high-impact low-probability earthquakes
100 year forecast	• Other shorter-term forecasts can be investigated
Use of many ground motions models rather than just one	• Internationally developed models • Models tuned to NZ data
Much more data is available	• Particularly for ground motion modelling • More realistic hazard estimates
How many earthquakes will occur?	• Improved range of future possible shaking included

Sample Example Hazard Results (full results available online)

Parameters used for displaying hazard

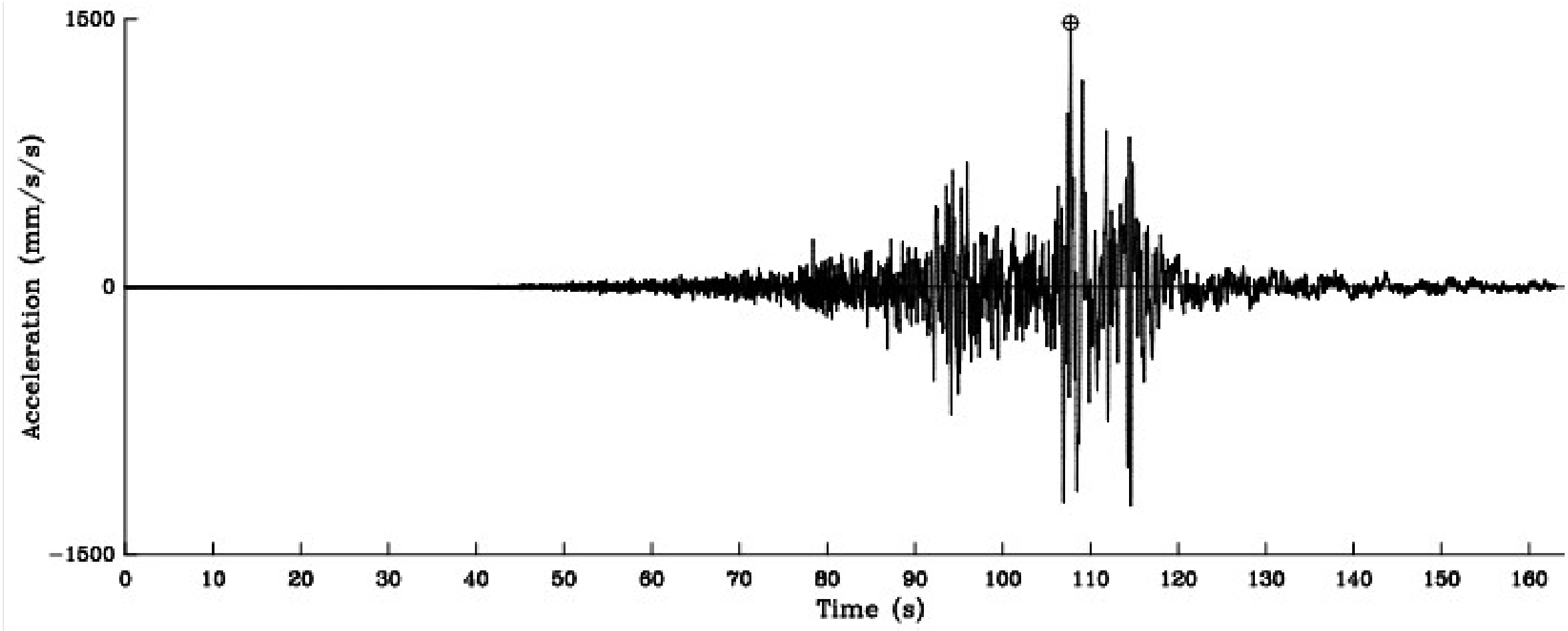
- Probability of Exceedance (PoE):
  How likely are we to experience this amount of shaking, *or more,* in a particular time period.
  For example: 10% Probability of Exceedance in 50 years or 2% Probability of Exceedance in 50 years.
  Lower probability means less likely, but higher shaking levels. **Risk Tolerance**

- Site conditions:
  The behaviour of the near ground surface (e.g., stiff or soft soils) can significantly impact shaking. How we measure this is very different than it was in the previous models, so we are not comparing apples to apples from previous models to now.

- Ground acceleration
  A single earthquake contains many frequencies of ground shaking. Land and structures respond differently to different frequencies of shaking

The NSHM produces thousands of results so its important to know what particular information is being shown. For example locations that are near each other but have different site conditions will have different shaking forecasts, and there are many different shaking forecasts for every location.

2016 M7.8 Kaikoura Earthquake in Wellington: every earthquake has many shaking frequencies



Kaikoura earthquake ground shaking recorded in Wellington

Earthquake is a mix of shaking frequencies, and each frequency has a different impact

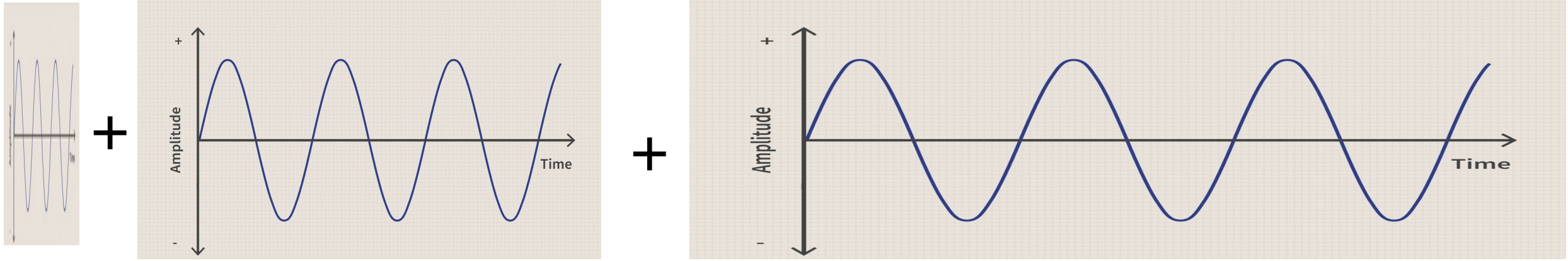
Land and shorter buildings are affected by high frequency shaking and taller buildings by lower frequency shaking

Land responds more to very high frequency (rapid) shaking, which can cause liquefaction

Low-rise (short) buildings respond more to high frequency (rapid) shaking

Mid-rise (medium height) buildings respond more to lower frequency (slower) shaking

High-rise (tall) buildings respond more to ever lower frequency (slow) shaking



PGA SA(0.5 seconds) SA(1.5 seconds) SA(3 seconds)

High Frequency/Short Period

Low Frequency/Long Period

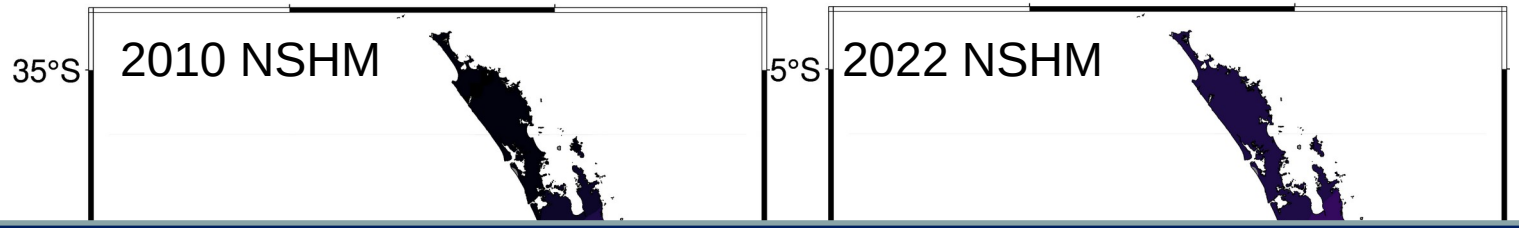
Hazard estimates and changes for different frequencies are different

Comparison of 2010 and 2022 PGA *Hazard* Maps

PGA: 10% Probability of Exceedance in 50 years

One of many possible comparisons – does not illustrate range of results.

Across all hazard parameters a range from no increase to more than double is seen. When considering site condition/Vs30 differences, the average increase is about 50% or more



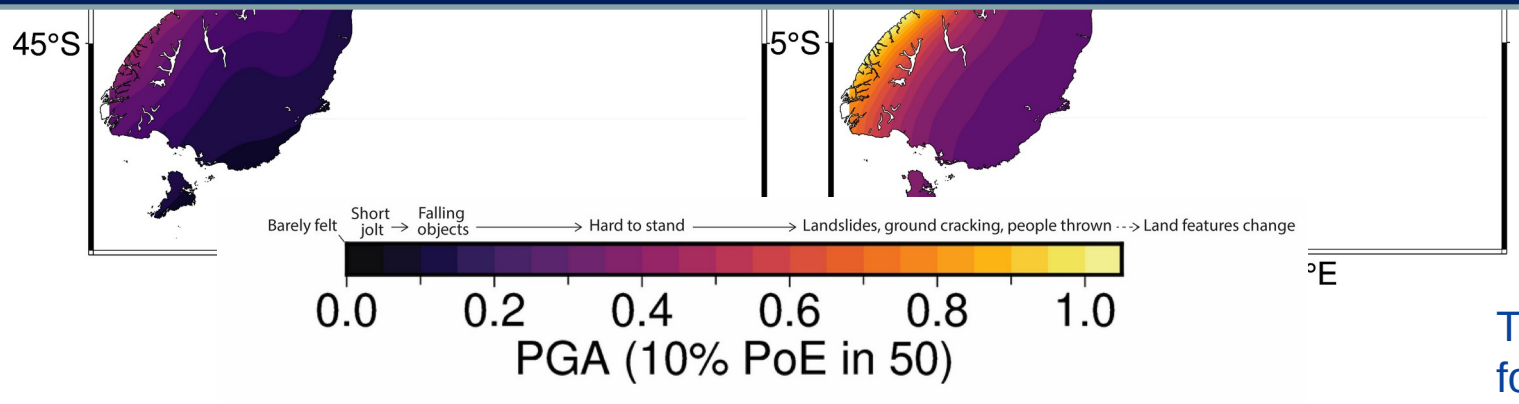
Example shaking for Vs30=250m/s

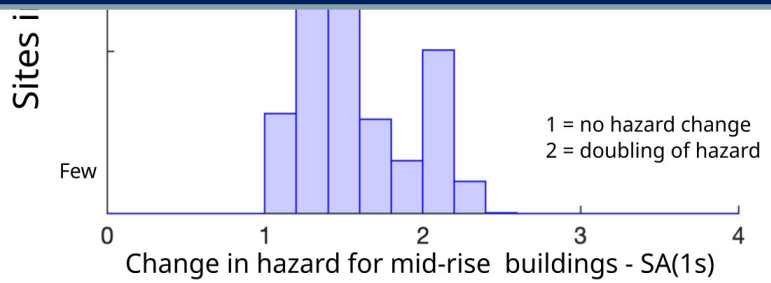
Location	2010 PGA(g)	2022 PGA(g)
Auckland	0.05	0.13

Increasing hazard does not necessarily translate to an

Shaking hazard increase across New Zealand ranges from approximately *no* change, to more than doubling. The <u>average</u> is an increase of about 50% or more.

Increases do not necessarily translate to an equivalent impact for buildings and other structures





The variability in hazard forecast for mid-rise buildings for an extensive range of sites across Wellington

Comparison of 2010 and 2022 PGA *Hazard* Maps

PGA: 10% Probability of Exceedance in 50 years

One of many possible comparisons – does not illustrate range of results.

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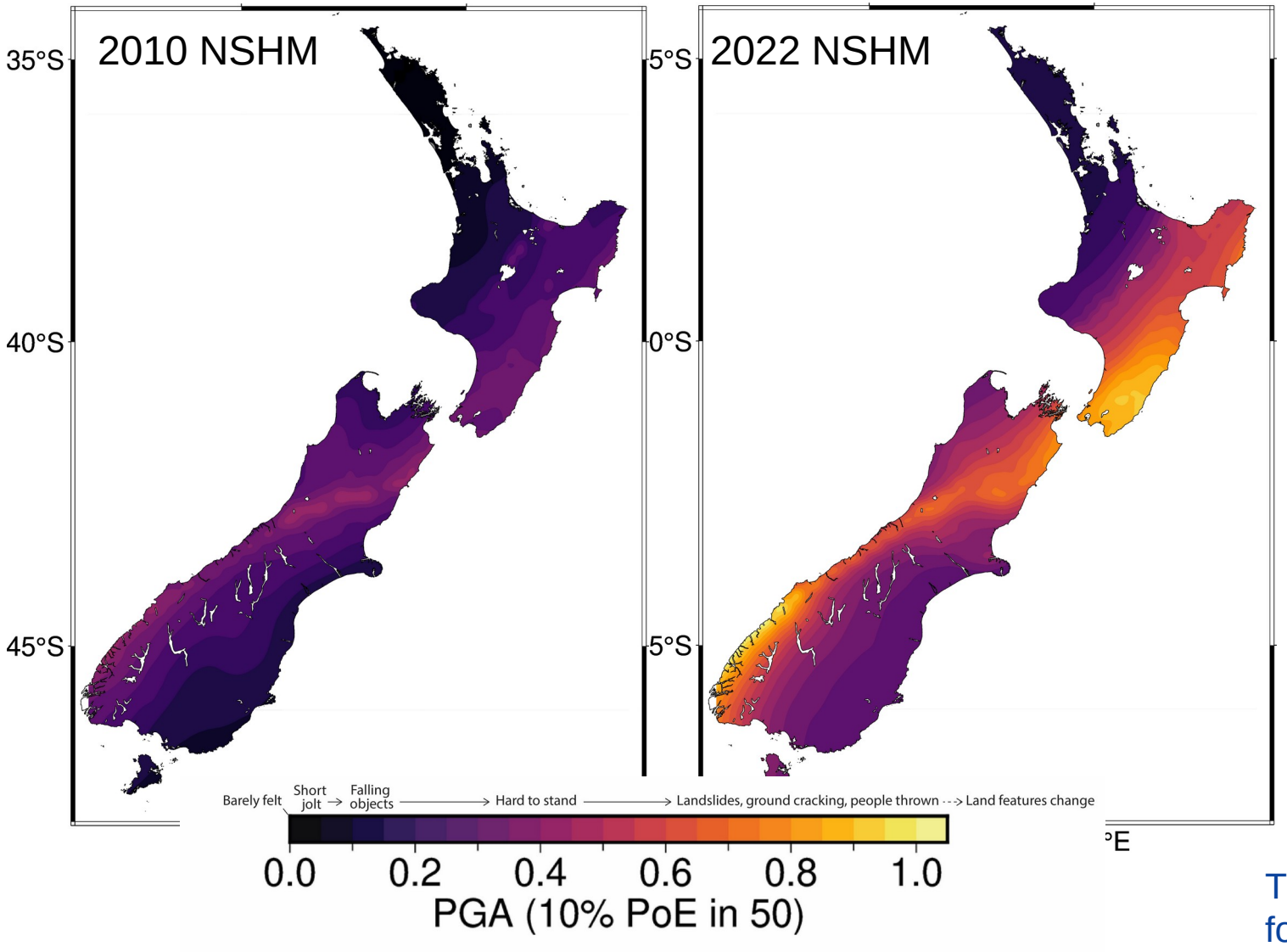
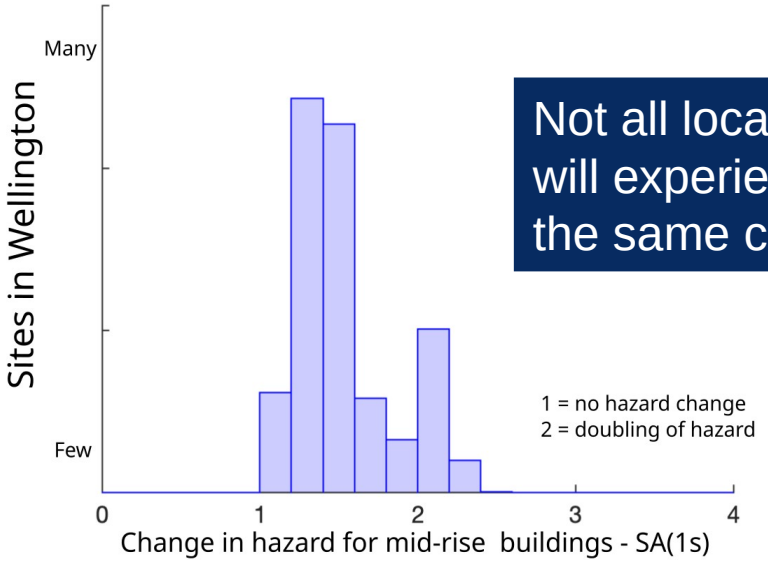


Example shaking for Vs30=250m/s

Location	2010 PGA(g)	2022 PGA(g)
Auckland	0.05	0.13
Wellington	0.32	0.82
Christchurch	0.17	0.42
Dunedin	0.1	0.26

Increasing hazard does not necessarily translate to an equivalent increase in impact, as impact does not always increase proportionally to the hazard.

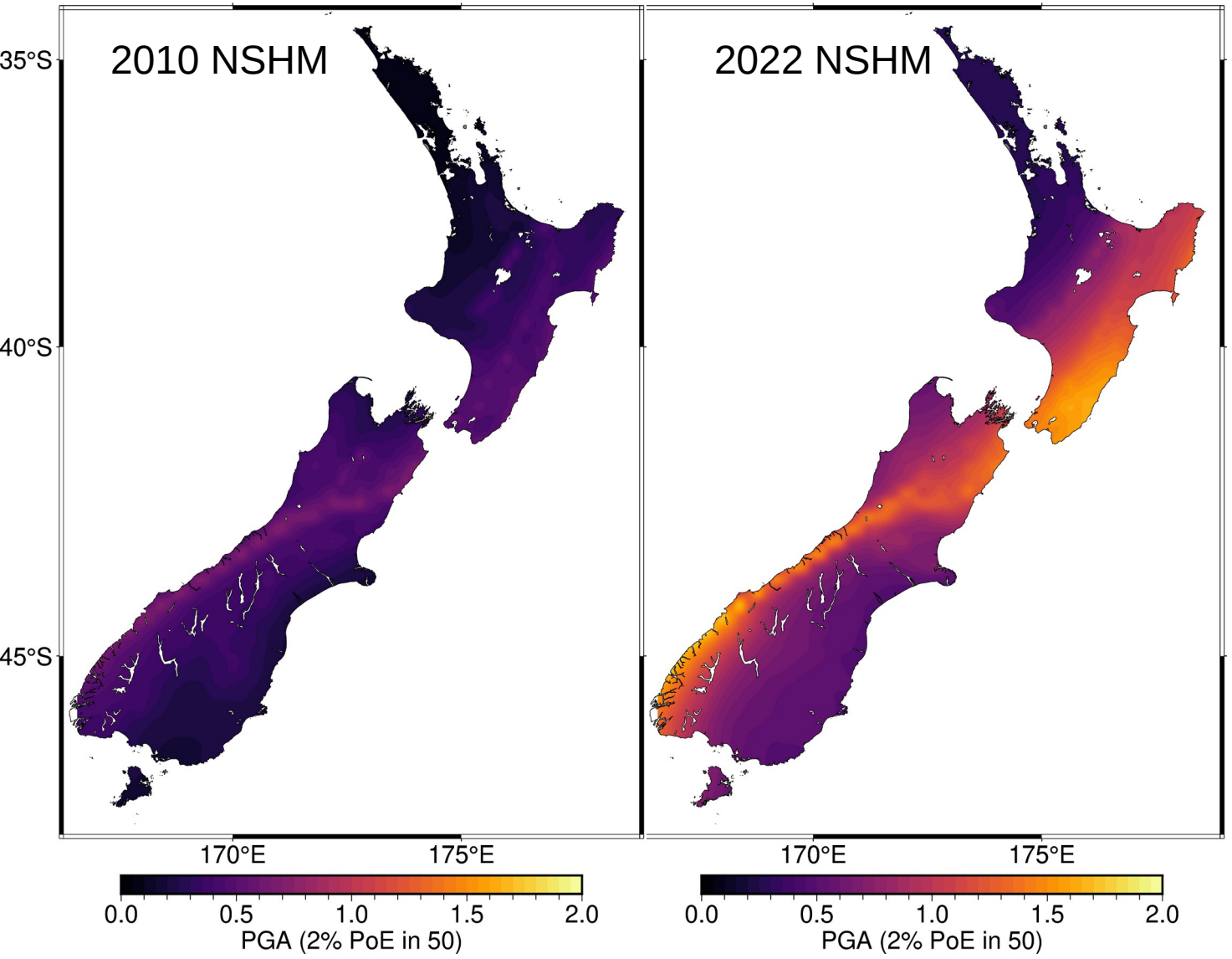


Not all locations will experience the same change

The variability in hazard forecast for mid-rise buildings for an extensive range of sites across Wellington

Comparison of 2010 and 2022 PGA *Hazard* Maps

PGA: 2% Probability of Exceedance in 50 years: lower risk tolerance



This set of maps shows the shaking with a 2% Probability of being exceeded in 50 years.

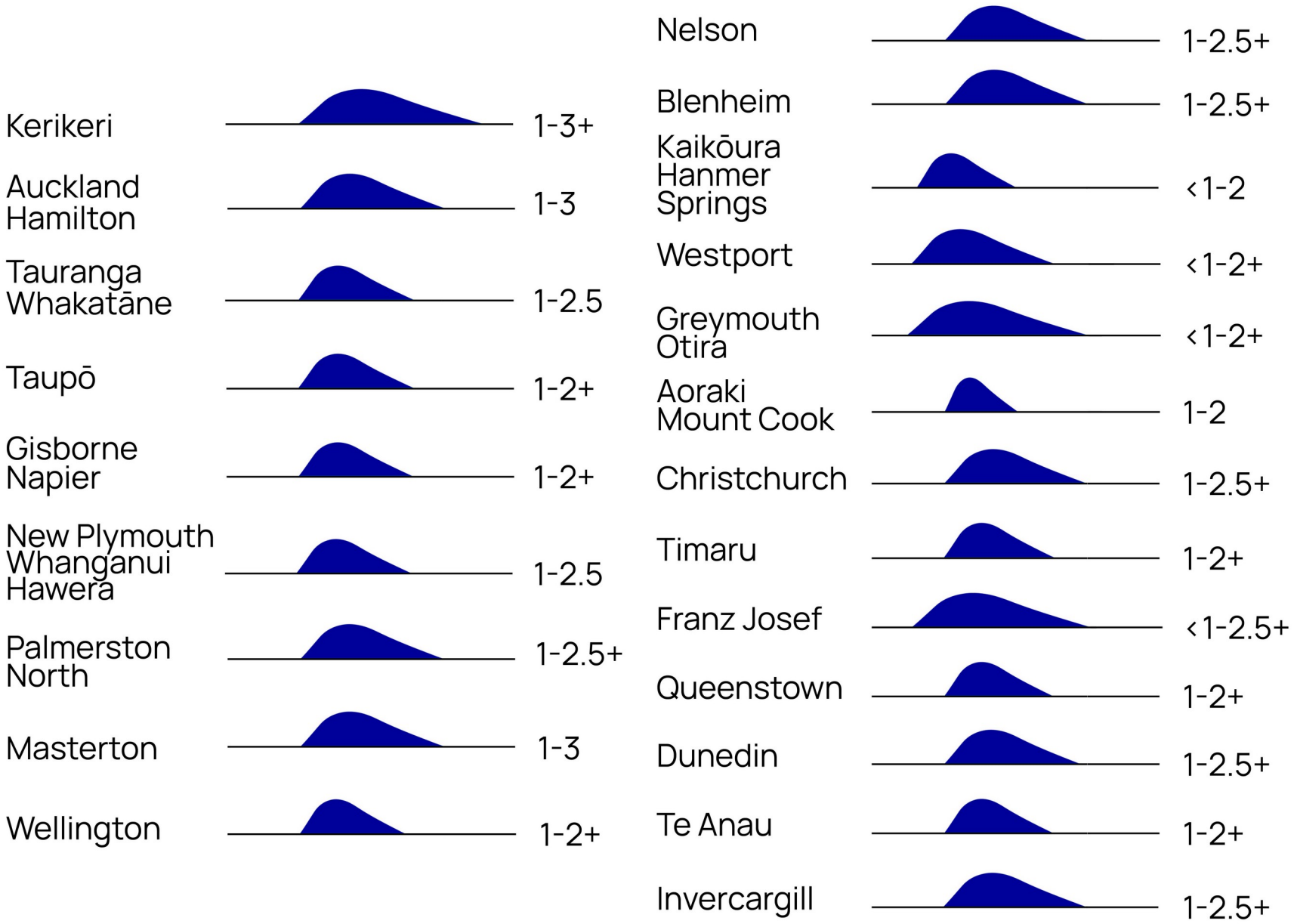
This shaking is higher than in the 10% PoE map but is less likely to occur.

These hazard maps show only one of many possible comparisons and do not illustrate the range of results

Example values for Vs30=250m/s

Schematic of hazard change when compared to previous estimates

This is figure is intended to give a general comparison and not precise values



1 = no change

Summary

- Forecast ground shaking hazard has increased across New Zealand with an average increase of about 50% or more.
  - In general the range is from no change to more than doubling
- The NSHM forecasts shaking hazard it does not forecast impact (risk).
- Increases in hazard do not necessarily correspond to equivalent increase in impact.

- The Hikurangi-Kermadec Subduction Zone represents a significant source of hazard for New Zealand and can affect much of the country.
- Our other well-known faults continue to be significant, such as the Wellington Fault, the Alpine Fault, and the faults that they connect with.
- Many other larger faults are also important to New Zealand's hazard landscape, and for each region there are smaller local faults that may cause significant shaking.
- The potential for events on unknown faults is also included in the model.

- What parts contribute the most to the hazard changes: ground motion modelling and total expected number of forecast earthquakes

Summary

- The NSHM is the best available science, globally, considering a huge amount of data and incorporating the most up to date understanding of earthquakes there is
- More than 50 experts, both locally and from around the world, have been involved - it is world leading science
- For a region, understanding the forecast includes considering a range of results – there is no simple number
- Naturally people can get anxious about earthquakes, but knowing everything we can about them helps us all to prepare. The NSHM tells us what we know about *shaking* - it is the earthquake forecasting data source that will help government and industry make good decisions about how we can plan well and be best protected.

What happens next?

The NSHM results will be used to:

- guide seismic risk communication for civil defence planning and community resilience
- Help in road and other infrastructure planning
- provide New Zealand's view of earthquake risk for insurance companies to use when assessing risk
- help in the management of government owned assets
- Provide input into determining how new buildings and structures need to be designed
  - *inform* the risk settings of our building regulations requirements.

The 2022 Aotearoa New Zealand NSHM Revision

Availability of NSHM details and full results

- 31 detailed reports publicly available online
- All models and science are available to anyone
- Full technical hazard results publicly available via the NSHM Web App

GNS Website

- Full range of explanatory material is available on the website

Embargo lifts at 6am tomorrow morning

www.gns.cri.nz/NSHM