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

Science Questions and Answers

GNS 29.9.22

About the National Seismic Hazard Model

WHY DO WE NEED TO KNOW ABOUT SEISMIC HAZARD?

Knowing how earthquakes might affect different parts of the country helps us to understand the impact of those earthquakes on communities, and helps New Zealanders to prepare for earthquake events, make good decisions, and increase our earthquake resilience.

WHAT IS THE NSHM?

The National Seismic Hazard Model (NHSM) provides an estimate of the likelihood and strength of earthquake shaking that might occur at any given site in New Zealand. The model helps deliver science-based estimates that are essential for Aotearoa New Zealand to build risk assessments and manage risks to safety, security and the economy from seismic events.

The NSHM is a part of Aotearoa New Zealand's science 'infrastructure', helping to inform technical standards for earthquake engineering design as well as providing critical information for earthquake risk management relevant to insurance, infrastructure management and emergency planning and response.

WHO USES THE MODEL AND WHAT IS IT USED FOR?

The model is used broadly by organisations and decision makers that need to estimate the likely impact of earthquakes on Aotearoa New Zealand's land, buildings, and infrastructure.

The model is used to guide seismic risk communication for civil defence planning and community resilience, for road and rail infrastructure planning, and to help insurance companies assess risk. It helps in the management of government owned assets and in determining how buildings and structures need to be designed and built so they inform the risk settings of our building regulations requirements in relation to earthquake loadings.

WHY DOES THE NSHM NEED TO BE REVISED NOW?

It is critical to have an up-to-date understanding of the seismic hazards facing New Zealand to ensure we can appropriately manage risks from earthquakes to the built environment. First developed in the 1980's and last updated in 2010, our previous model was out of date. This 2022 revision reflects international best practice and the learning from Aotearoa New Zealand's recent significant seismic activity. The Canterbury earthquake sequence and the Kaikōura earthquake showed the vulnerability of our society, for example. How these regions were impacted by the earthquakes helps us know that we need to make changes to the way we

design for and prepare Aotearoa New Zealand in future, so we can reduce the risks we face from new earthquake hazard events

WHY HAS IT BEEN SO LONG SINCE THE LAST REVISION?

Earthquake science is complex and seismic hazard modelling takes a long time to complete.
Significant global advances in seismic science have been made in recent years, and Aotearoa New Zealand's earthquake activity in the past decade has added to our knowledge base. Some short-term funding was made available for a minor revision after the Christchurch earthquakes. A small data update was made to the previous model in 2010, but the last big review of the science in the model was undertaken 20 years ago, in 2002.
The NSHM requires sustainable funding to ensure that it is kept up to date using best possible science. The complexity of seismic hazard modelling has increased, so the resource required to revise and continue to update the national model so that it continues to be at international best practice has also grown.
An international review was undertaken and a business case was developed to articulate the benefits and understand the costs of developing the NSHM, and this was approved in late 2019.

HOW DO WE KNOW THE SCIENCE IS ACCURATE – CAN WE TRUST THE MODEL?

The NSHM is world leading science that has been developed and reviewed by many national and international experts. Building the model is complex, a little like building a million-piece puzzle. The scientists study hundreds of thousands of models, almost a million in fact, which all contribute to the final model.

To use the term "accurate" in its true sense would possibly require the earthquakes to happen – like the weather forecast is tested by the weather event itself - but, notwithstanding that, we have very high faith in the science and the model. It has been internationally peer reviewed by a large panel of experts, and we test the forecasts against past earthquakes, long term data sets and global science. Through our advanced understanding of how earthquakes work, we do know that the model is very reliable.

WHAT SORT OF RESEARCH IS INVOLVED?

The NSHM incorporates scientific understanding of earthquakes acquired from diverse research fields, ranging from paleoseismology (study of historic earthquakes), geodesy (study of the Earth's shape and gravity field) and geophysics (study of the physics properties and processes of the Earth), through to engineering seismology (study of earth science and civil engineering to understand seismic hazard).

WHO IS DOING THE WORK?

MBIE, GNS Science, Toka Tū Ake EQC, engineers, universities and other Crown Research Institutes worked together closely on the revision of the model. Many local and international scientists and academics have been involved in its development.

HAS THE MODEL BEEN REVIEWED BY EXPERTS?

Throughout the revision project, technical advice on the development of the NSHM has been provided by a 17-member panel of international scientists and engineers using a participatory review process. An additional 5-member international panel then undertook an assurance review of the science process.

DO OTHER COUNTRIES HAVE (NATIONAL) SEISMIC HAZARD MODELS OR IS THIS UNIQUE TO NZ?

Most seismically active countries have seismic hazard models.

HOW MUCH HAS THE REVISION OF THIS MODEL COST?

MBIE and Toka Tu Ake EQC have together invested about $5M per year to do this revision of the NSHM. This has involved over 50 scientists, engineers and stakeholders from New Zealand and in several other countries globally over 2.5 years.

HOW LONG DID IT TAKE TO CALCULATE THE RESULTS? HOW MUCH DATA IS IN THE MODEL?

The calculation of the final model took nine days on a 'supercomputer'.
The final result is approximately 35GB, however if all the intermediate products of the model's development (including the individual realisation hazard curves of the calculation) were included it would be somewhere around 2 Petabytes of data (2,000 Terrabytes or 2,000,000 GB).

WHERE IS THE MODEL AVAILABLE?

The model results are free and accessible online, via a web app hosted on the GNS Science website.

How does the model impact me?

DOES THIS REVIEW OF THE MODEL MEAN WE MAY NOT BE SAFE IN OUR HOMES AND BUILDINGS?

The NSHM only provides an assessment of the ground shaking hazard. It does not consider the likely performance of a building and doesn't fully capture the risk to that building and its occupants.
The science doesn't make decisions about changes that are required, but it does help the decision makers to determine what those changes could be.
The Ministry of Business, Innovation and Employment can assist with queries relating to homes and buildings.

WHO DECIDES HOW THE MODEL WILL DETERMINE ANY CHANGES?

The NSHM is a tool that government and industry use to help them understand seismic hazard in New Zealand better, and to help with decision making.
How hazard risk is applied to regulatory policies is determined by the government agency responsible for the specific regulation, usually in consultation with the New Zealand public.
The agencies responsible for the engineering, building and insurance industries will all be considering the NSHM data and using it to help inform any changes that may be required.

HOW WILL CHANGES IN POLICY AND PRACTICE AFFECT NEW ZEALANDERS?

Time will be required to determine how the revised hazard information will be applied. For example, if changes to building regulations or standards are necessary, they will be considered by the Ministry of Business, Innovation and Employment.

WHEN WILL CHANGES AFFECT NEW ZEALANDERS?

No changes will be immediate.
Industry leaders will communicate any required changes from the model directly. Enquiries about likely changes should be directed to the responsible agency.

About earthquakes

WHAT ARE FAULTS?

Earthquakes occur on faults. A fault is a rupture in the Earth's crust that enables the land to move independently on either side. Faults can be as short as a few metres or up to 1000kms long and they can cause a variety of different land movements. Shaking from ruptures can affect areas a long way away.
Repeated earthquakes and their associated fault movements have formed the major mountain ranges of New Zealand.
There are nearly 1000 faults that we know of in Aotearoa New Zealand, and these are found both on and offshore. There will be others that we don't know about yet.

HOW IS MAGNITUDE DETERMINED?

We describe an earthquake as happening at a place (the epicentre), at a distance below the Earth's surface (depth), and having a size (magnitude).
Magnitude is an estimate of the energy released in the earthquake, and there are different ways of calculating magnitude, so it is quite common to see slightly different magnitude values attributed to the same earthquake.

WHAT IS GROUND SHAKING

If an earthquake causes strong ground shaking our built infrastructure (like buildings and dams) and lifelines (like our power and water networks) can be affected.
Ground shaking will vary due to the near-surface ground conditions as well as the location and orientation of the earthquake fault rupture. These all affect the way the seismic waves travel through the ground.
Peak ground acceleration (PGA) is a measure of earthquake shaking. It measures the *maximum acceleration* of the ground that occurred during shaking at a particular location. Frequency of shaking (how many times the ground moves up or down, or back or forth during a set time) is also important.
Typically, we expect that high frequency (rapid) ground shaking might mostly affect shorter buildings, and low frequency (slow) ground shaking might mostly affect tall buildings

HOW DO SCIENTISTS MONITOR EARTHQUAKES?

Scientists monitor earthquakes by measuring the seismic waves they generate, using a seismometer.
GNS Science, through the GeoNet programme, owns and operates the national seismograph network and there are hundreds of broadband seismometers located across New Zealand to help rapidly identify and measure our earthquakes.
Seismic waves are caused by the two sides of a fault moving past each other. Measuring these waves help us determine the type of earthquake, its origin, and its strength/intensity.

WHAT DOES PROBABILITY OF EXCEEDANCE MEAN?

We cannot predict earthquakes, but we can forecast them, and then forecast the ground shaking that might occur from those earthquakes.
An earthquake forecast provides a probability or chance. It says *how likely it is* that an earthquake of a given magnitude range, within a given area, over a given time frame, *will* happen.

The NSHM provides a hazard forecast. This is an estimate of the level of ground motion that might happen at any one location with a specified *probability of exceedance.*
For example, we might determine a level of ground shaking that has a 10% chance of being exceeded within the next 50 years. In other words, it is 10% likely we will experience this level of shaking, or greater, within 50 years.
The NSHM calculates multiple probabilities of exceedance (Such as 2% and 10%), so we can explore a range of potential hazard scenarios.

An explanation of PoE is available on the NSHM webpage on the GNS website.

WILL WE GET MORE EARTHQUAKES IN MY REGION IN FUTURE? WHEN WILL THEY HAPPEN?

No one can predict when earthquakes will happen, but we know they will keep happening because of how the Earth is formed. We can expect to experience earthquakes in every part of New Zealand, and they might happen any time. That is why there is so much scientific work going into understanding as much as we can about earthquakes, and ensuring our decision makers can access and use that science to help with planning and policy.

We can't stop earthquakes, and we can't predict when they will happen, but we can prepare for them by making sure our infrastructure, our buildings, and our regional planning takes earthquake risk into account. Being as safe and as resilient as we can, including preparing our homes and protected our whanau, helps us manage during earthquake events.

IS AOTEAROA NEW ZEALAND GOING TO KEEP GETTING DAMAGED FROM LANDSLIDES AND EARTHQUAKES? WHAT CAN WE DO TO PROTECT THE LAND?

We can't stop faults from moving and we can expect that our land will change over time.
Research has described the considerable geological changes that have happened on Earth over many thousands of years, and we can expect these changes to continue.

Knowing all we can about seismic risk is really helpful, as it means we can use that information to know where and how to design and construct our homes and buildings, and our critical infrastructure like dams and roads and bridges.

Making sure we build on and use land in ways that is safest, will make sure these structures are best placed to fare as well as possible in an earthquake event.

WHAT CAN WE DO TO PREVENT EARTHQUAKES HAPPENING?

There is nothing we can do to prevent earthquakes happening, and we can't predict when they will occur. But as science continues to advance and we grow our understanding of earthquakes, our monitoring and risk mitigation measures will also continue to develop.

What do the results tell us?

GROUND SHAKING HAZARD, NOT IMPACT (RISK)

The NSHM forecasts the shaking hazard across New Zealand over set time periods, such as within the next 50 or 100 years. The NSHM does not forecast the impact of that shaking on communities. This is often referred to as the seismic risk. The NSHM is the instrument used by others to estimate risk and to then make risk-based decisions.

HAS HAZARD INCREASED? WHERE?

The 2022 revision of the NSHM shows that seismic hazard has increased almost everywhere throughout Aotearoa New Zealand compared to what we knew previously. This is not unexpected, because:

- We now know a lot more about earthquake behaviour due to better global understanding, more sophisticated science, and more than a decade of advancements in technical computing.

- We now have an improved model of the variability in shaking from potential earthquakes that could rupture in any single location. One significant contributor is the Hikurangi Subduction Zone, another is the Alpine Fault. These are important sources, but we also model the likelihood for earthquakes on unknown (hidden) faults and how shaking can affect regions far from the epicentre.

- We can model low probability but potentially high impact events affecting New Zealand, by understanding how faults can link together.

HOW MUCH HAS THE HAZARD INCREASED?

Hazard increase ranges from approximately no change in some areas to more than doubling in others, with an average increase of around 50% or more. This does not necessarily translate to an equivalent increase in impact as impact does not always increase proportionally to the hazard.
In addition, when interpreting how the hazard has changed, it is important to understand what they are changing from. For example, if there has been a doubling in a region with previously very low modeled hazard, the update of the modeled hazard will still be low.

WHY IS THERE DIFFERENT GROUND SHAKING HAZARDS IDENTIFIED IN MY REGION?

The NSHM provides multiple outputs for each location, and they must be considered together to fully understand the hazard. A single aspect of the results considered on its own cannot reflect the level of hazard for a location. For example, the NSHM tells us the likelihood of different kinds of ground shaking occurring. This ranges from short sharp movements to longer or rolling movements, and multiple other kinds of movement in-between. Different kinds of shaking may incur different hazard. To understand the hazard of a specific location, it is important to understand the collection of the kinds of ground shaking that are likely to occur there.

HAS THE EFFECT ON THE WELLINGTON BASIN BEEN CONSIDERED IN THE NSHM?

The effect on the Wellington basin is not explicitly included in the NSHM, however the amplification effect of soils (including in basins) is included broadly across the whole of New Zealand by considering the Vs30* of a site.

This approach is common for seismic hazard models globally. To capture more complex basin amplification effects, we need detailed and sophisticated models tailored to the specific basin of interest. We are using a case study of the Wellington Basin to explore these models for potential future application in seismic hazard. This is a global scientific challenge, but one that is promising for both increasing the accuracy and reducing uncertainty in our national seismic hazard model in the future.
Further work will be undertaken in the next phase of the NSHM. Our knowledge of faults, earthquakes, and shaking continues to evolve and we can anticipate further changes to seismic hazard estimates in the future as this knowledge develops.

**a measure of the behaviour of the ground soils at the near surface, which can impact shaking.*

IS THERE A SUMMARY OF MY REGIONS HAZARD RESULTS?

Regional fact sheets have been provided on the NSHM page on the GNS website that outline the hazard results for different regions. Go to www.gns.cri.nz/nshm

What will this mean for building and engineering?

For more information about how MBIE uses the National Seismic Hazard Model to help inform the risk settings in our building regulations and to improve the safety of buildings across New Zealand, visit building.govt.nz.

What will this mean for insurances?

For information about how the NSHM will be considered by insurers, go to Toka Tū Ake EQC.

How can I prepare my whānau for earthquakes?

For information about how you can prepare and protect your whānau from earthquakes, go to the National Emergency Management Agency (NEMA) Get Ready webpage.

How can I make our home and buildings safer?

For information about how you can help protect your home, workplace, schools and the places you spend time in from earthquakes, go to Toka Tū Ake EQC Be Prepared webpage.