# Update of the National Seismic hazard Model for New Zealand: *The old working on the new*

*Hundalee Fault section of the M7.8 2016 Kaikoura earthquake rupture, NZ*


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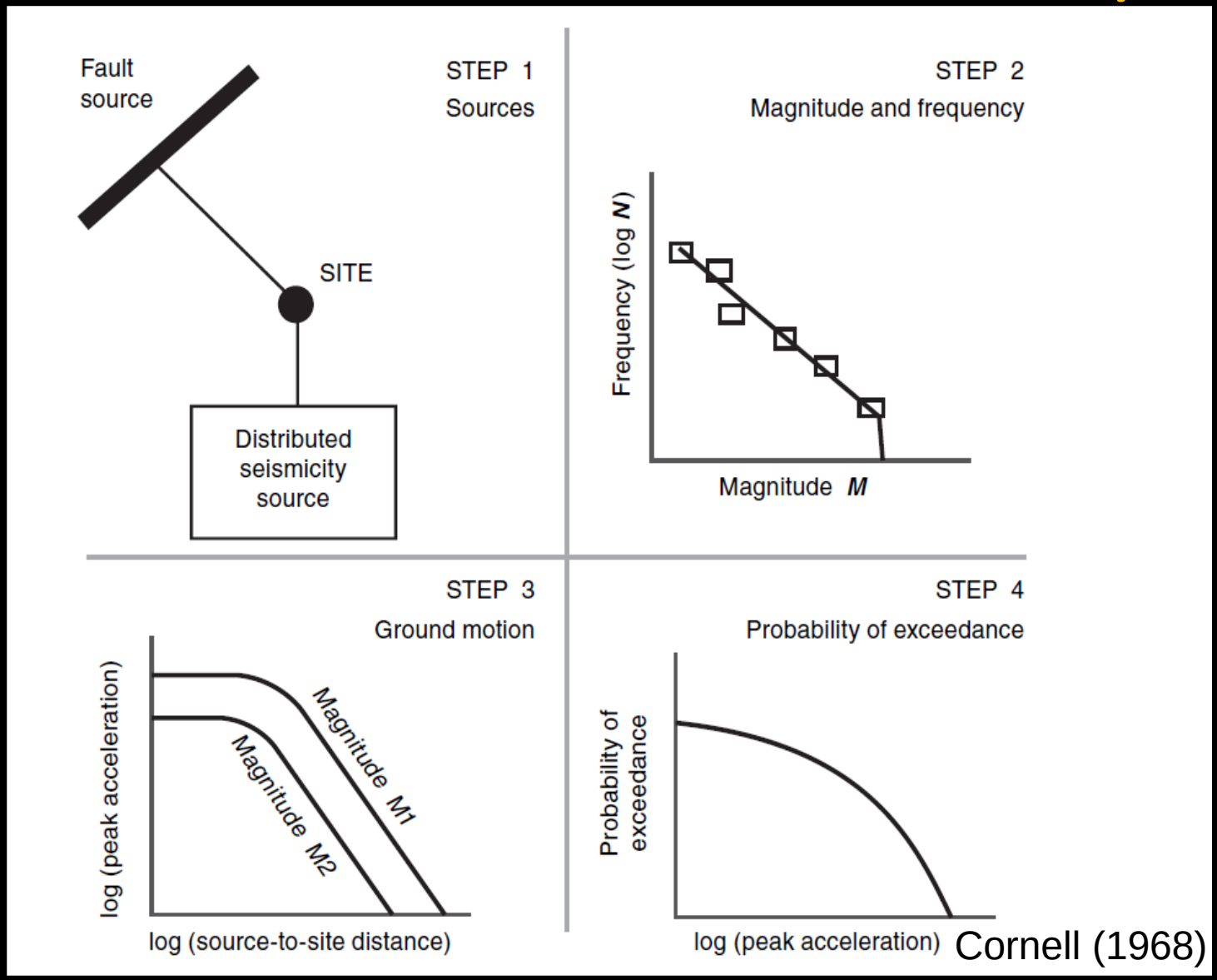
# Introduction

1. Probabilistic seismic hazard analysis (PSHA)

2. History of the national seismic hazard model (NSHM)

3. Present NSHM update

# Probabilistic Seismic Hazard Analysis




Cornell (1968)

*A solid & reliable framework for seismic hazard analysis*

# Solid and reliable: My BMW R80

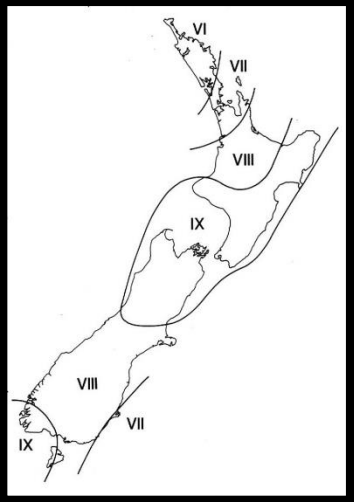
**23 May 1999**
The day I purchased my BMW R80.
Mileage 42,000 km

**23 May 2019**
Still with the same bike 20 yrs later.
Mileage 180,000 km

# New Zealand National Seismic Hazard Model (NSHM)

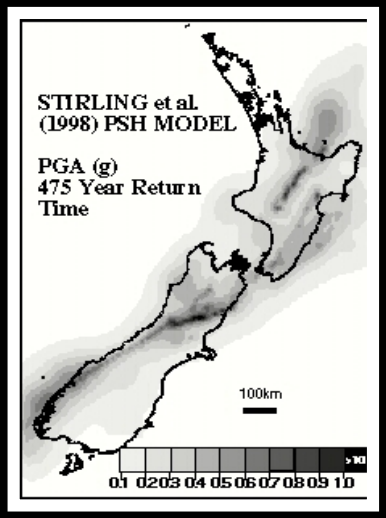
*Introduction of fault sources transformed New Zealand's seismic hazardscape*

**1983**



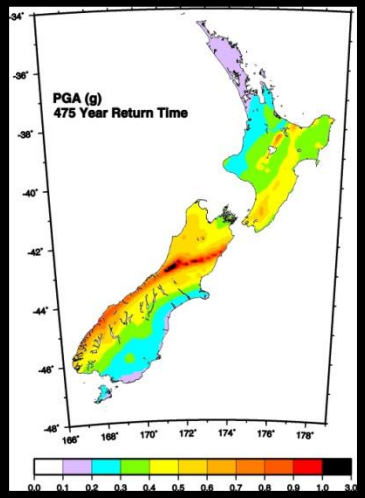

**Smith & Berryman (1983)**

**1998**



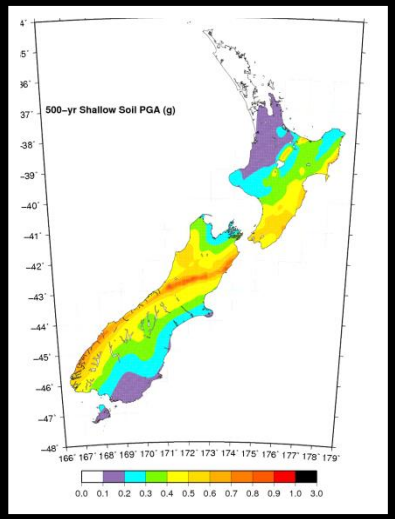

**Stirling et al (1998)**

**2002**




**Stirling et al (2002)**

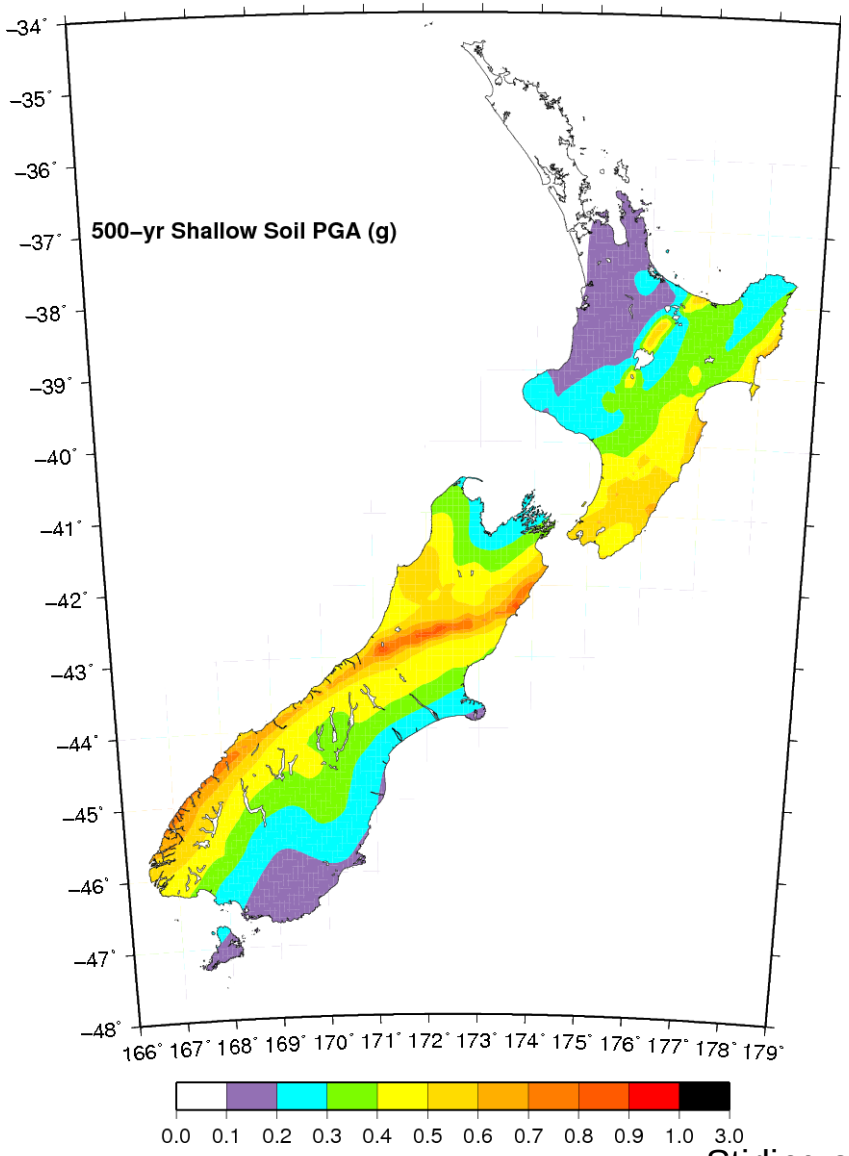
**2012**

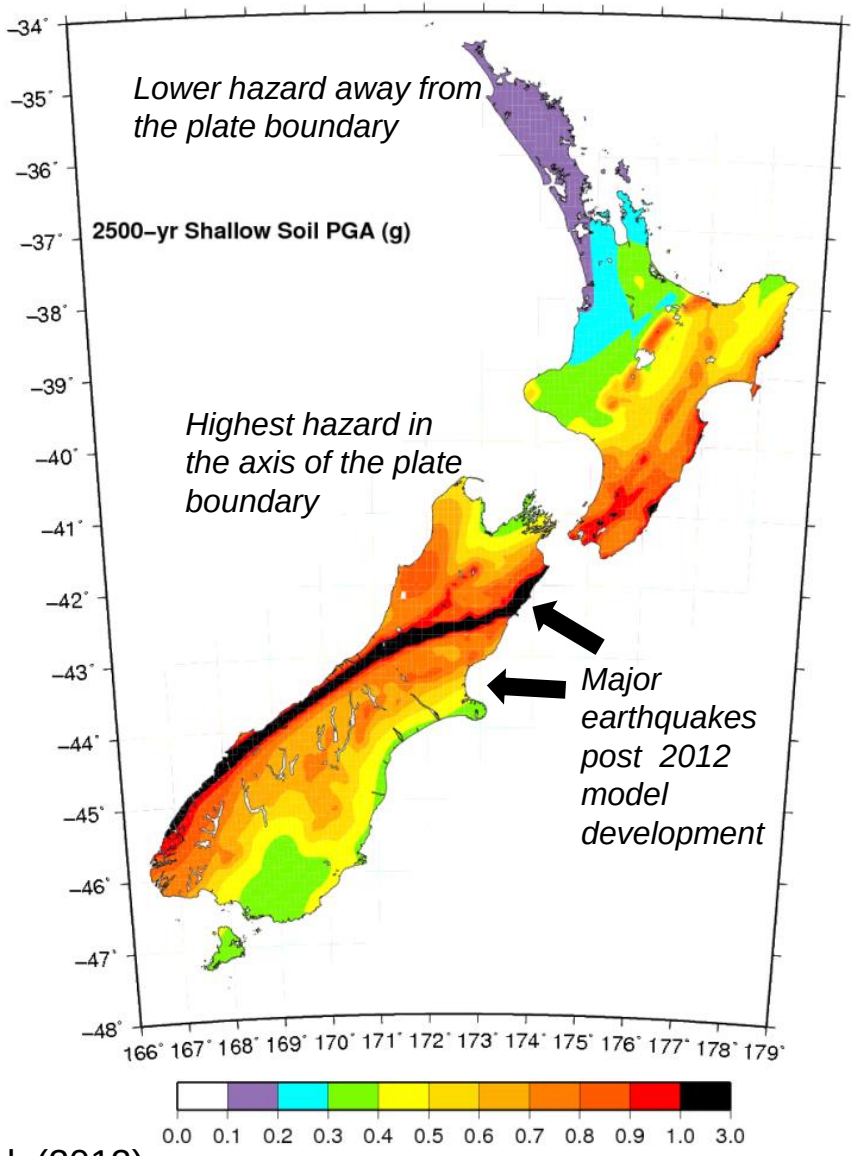



**Stirling et al (2012)**

*All maps show PGA for a 500 yr return period on soft rock/hard soil*

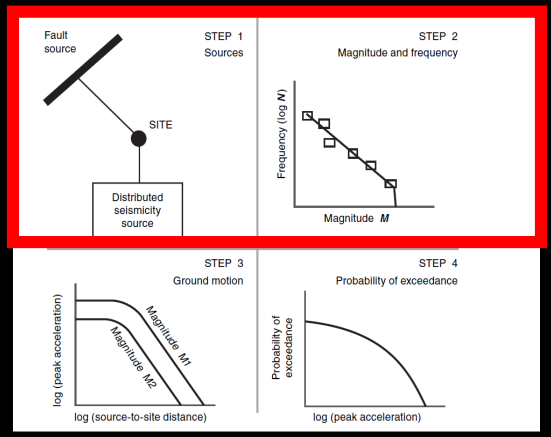
# Examples of Hazard Maps




Stirling et al. (2012)

# NSHM update



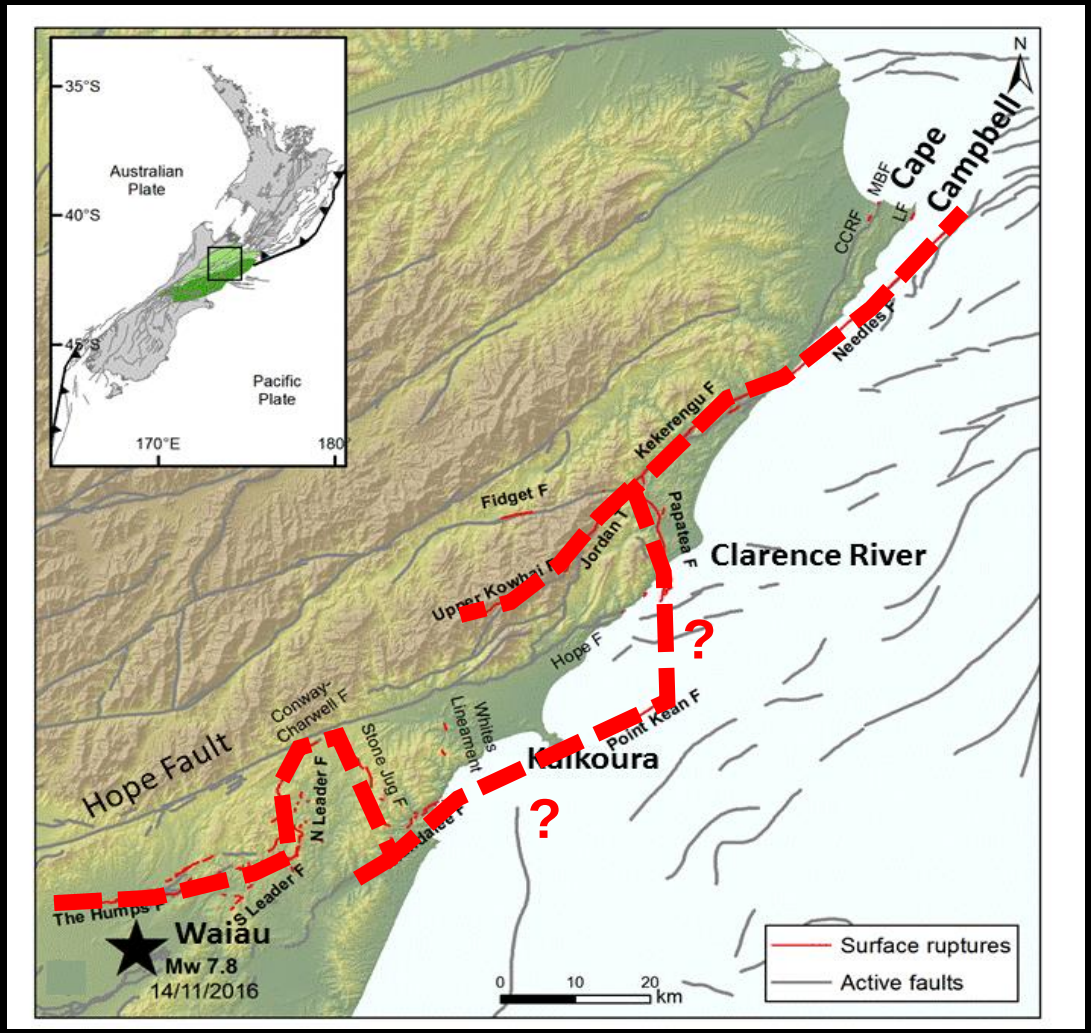

*Source*

- *Fault source modelling:* rupture complexity (geometry and recurrence), recurrence, earthquake scaling, fault source completeness, geodetic data inclusion, and major subduction zone focus

- *Seismicity modelling:* Catalogue homogenisation, geodetic data inclusion, and hybrid modelling of time-dependent earthquake probabilities

- Comprehensive treatment of epistemic uncertainty

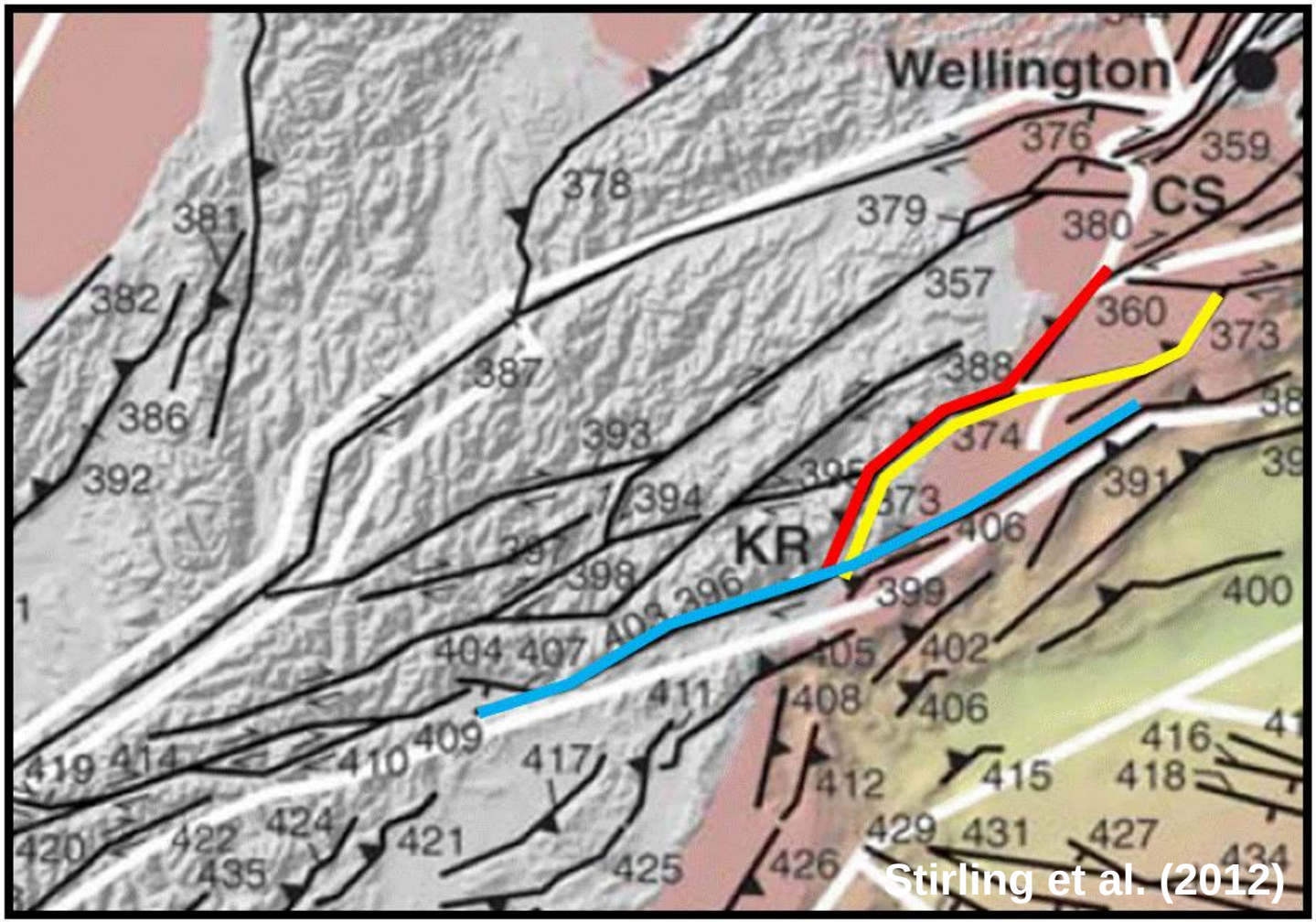
# M7.8 2016 Kaikoura earthquake




How repeatable is the complex Kaikoura event?

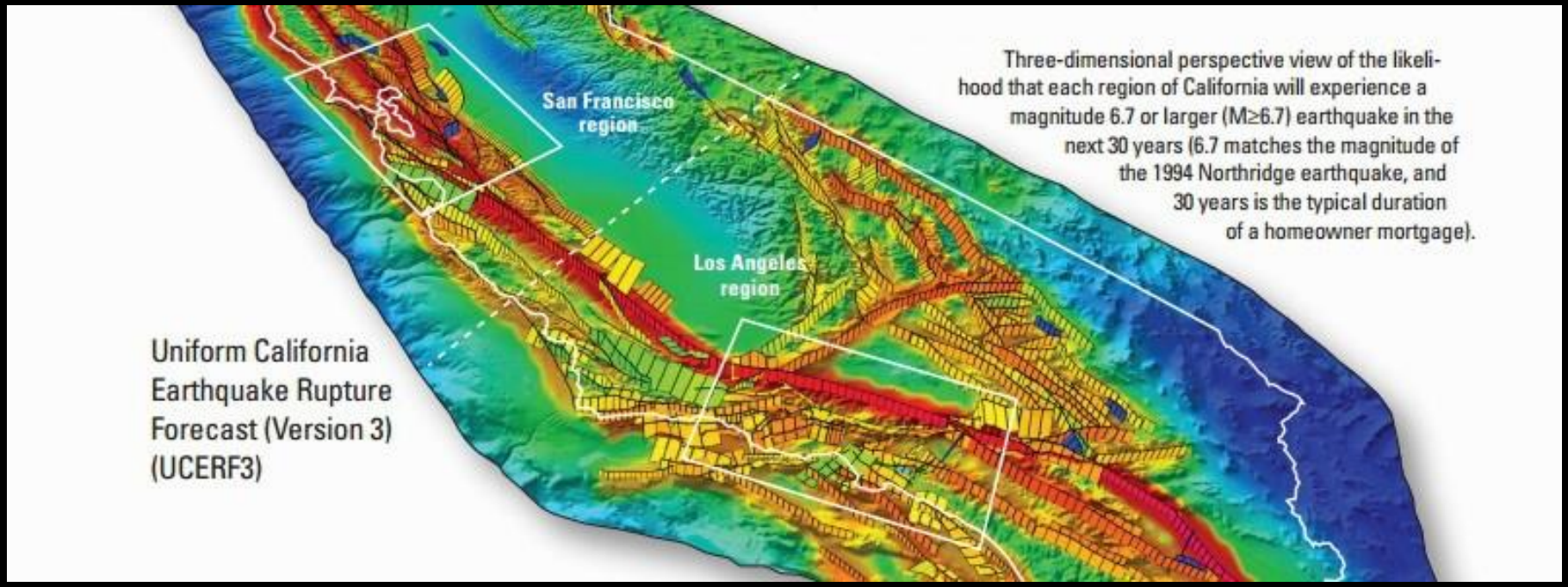
Complex rupture modelling, and examination of paleoearthquakes on the participating faults

# 2012 NSHM multi-fault sources, NE Sth Island



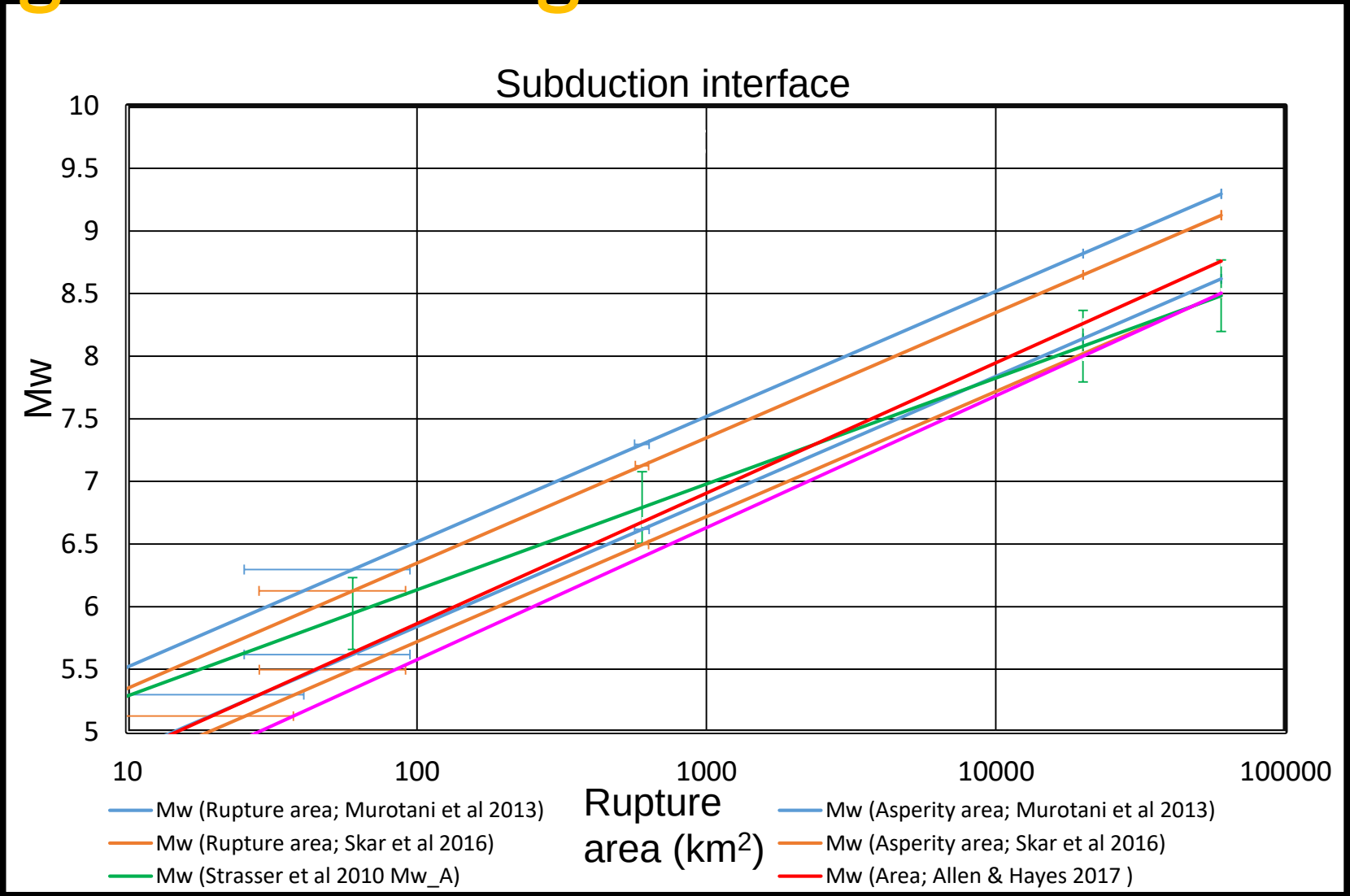

Acknowledged displacement-length ratios & continuity of plate motion rates, but not as complex as 2016 Kaikoura event

# UCERF3: complex fault source modelling



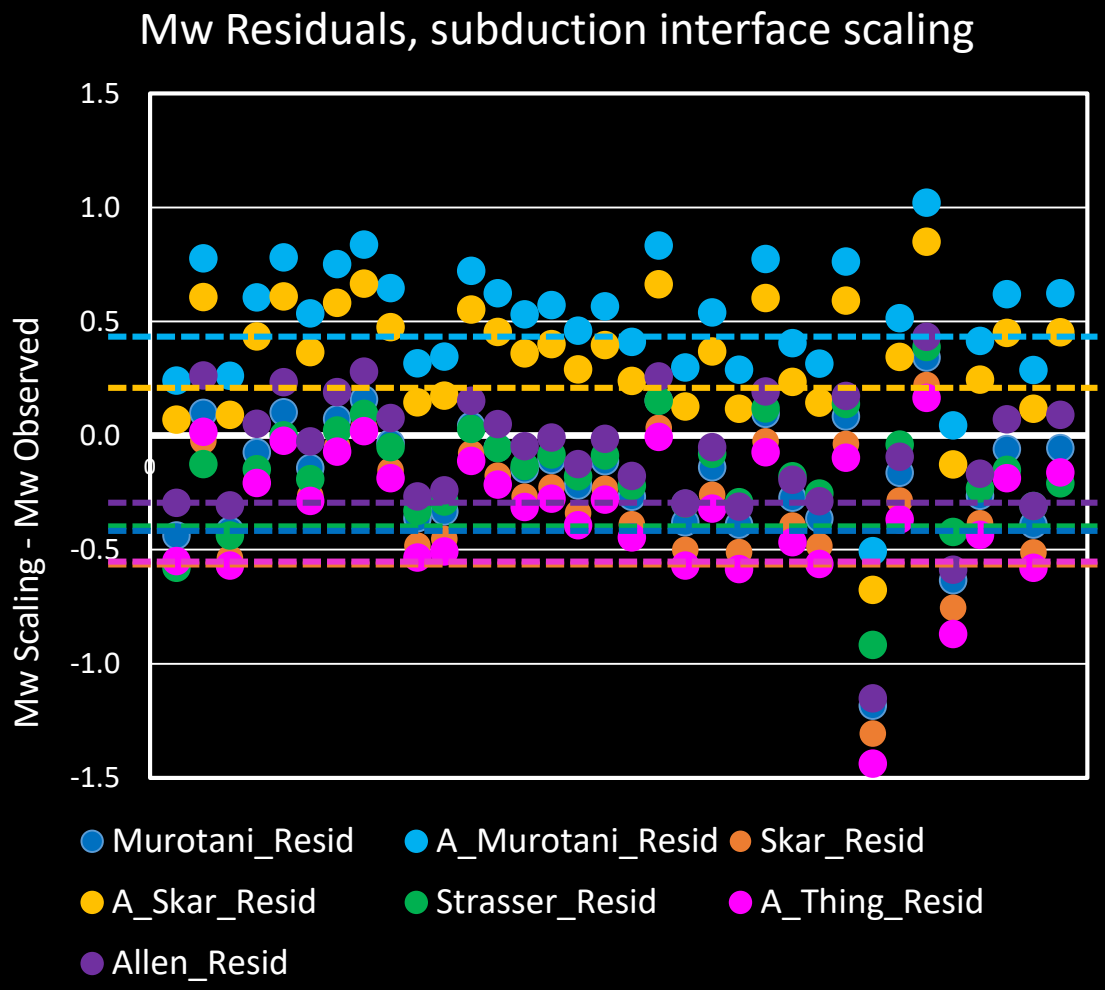

- Relaxation of fault rupture segmentation
- Plausibility filters to stop “runaway” ruptures
- Magnitude-frequency and earthquake scaling considerations
- Grand inversion: inverting rupture rates to solve for slip rate at a point

# Magnitude scaling relations

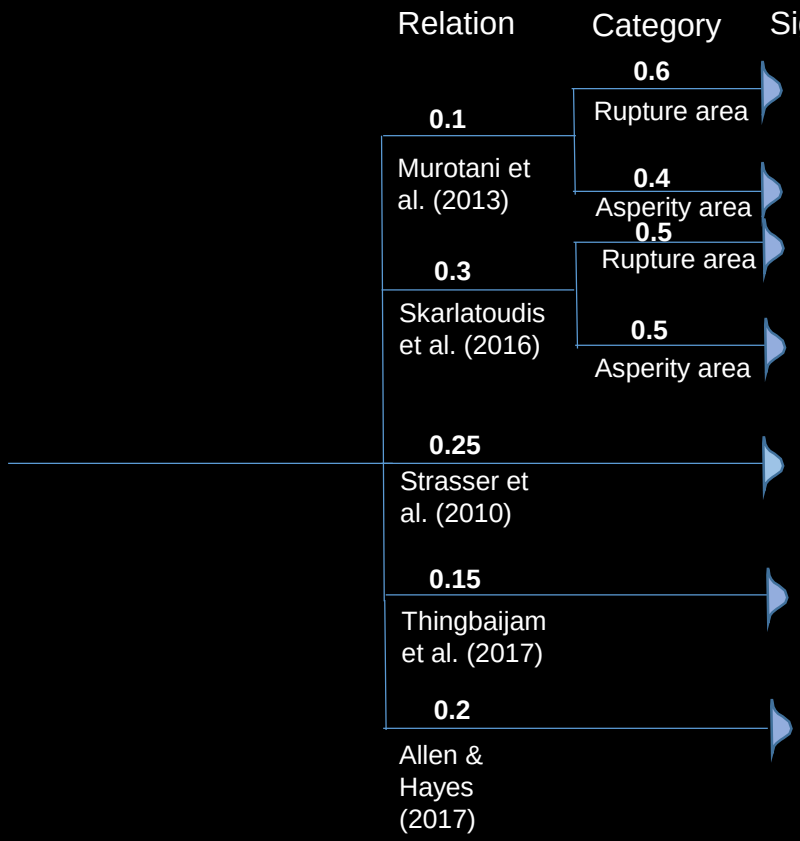



- Large range of regressions to choose from
- Selection based on tectonic environment, recency, data quality/quantity, and residual analysis

# Magnitude scaling relations



# Magnitude scaling relations




**Weighting justifications**

"Relation" and "Category" weights reflect performance in residual analysis

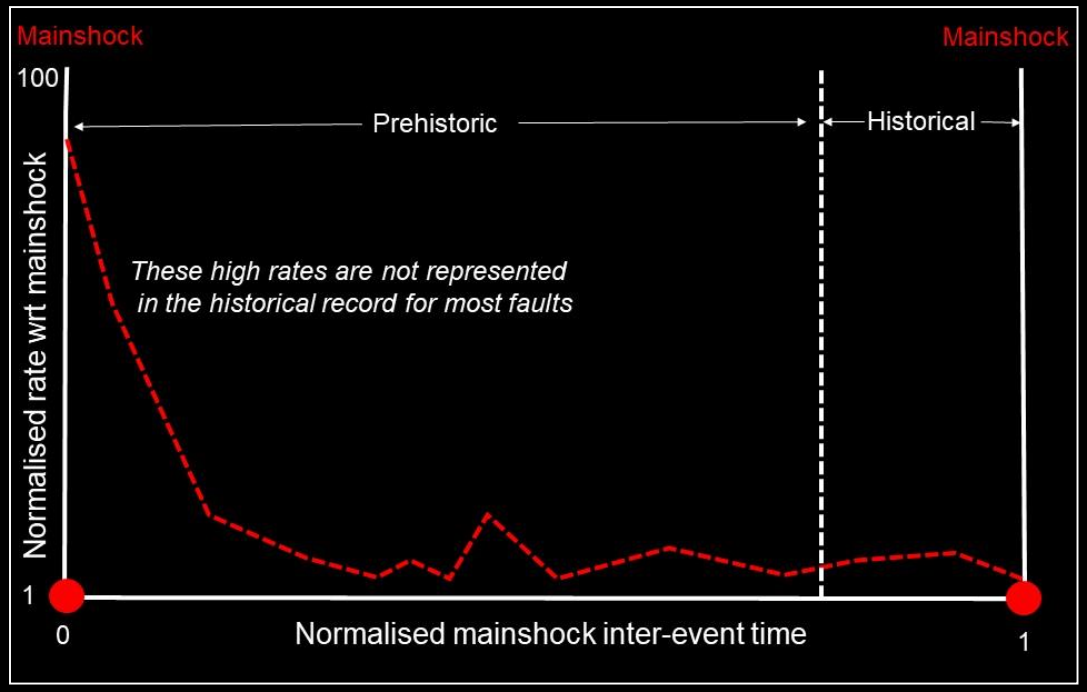
# Recurrence

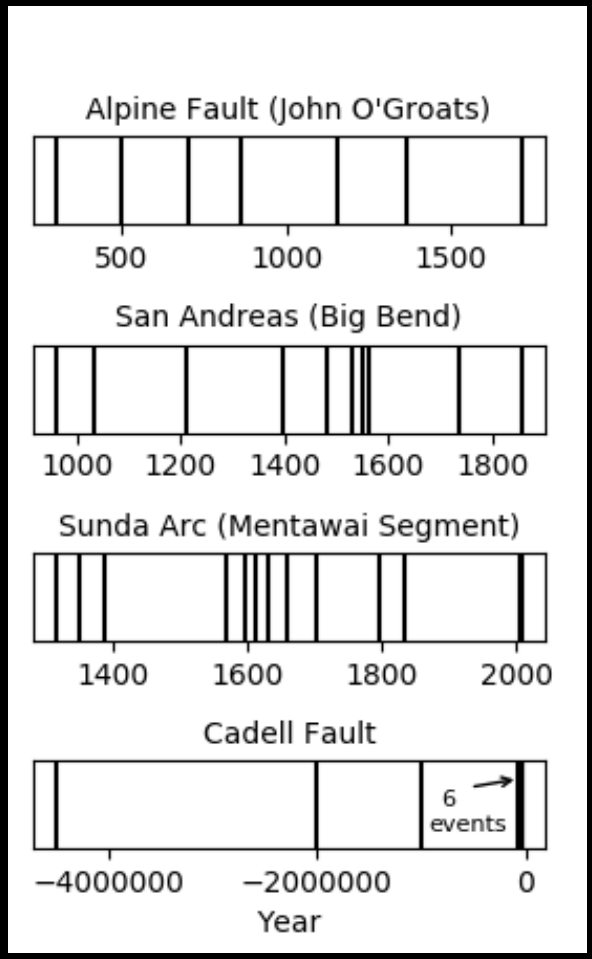
- Earthquake recurrence aperiodicity

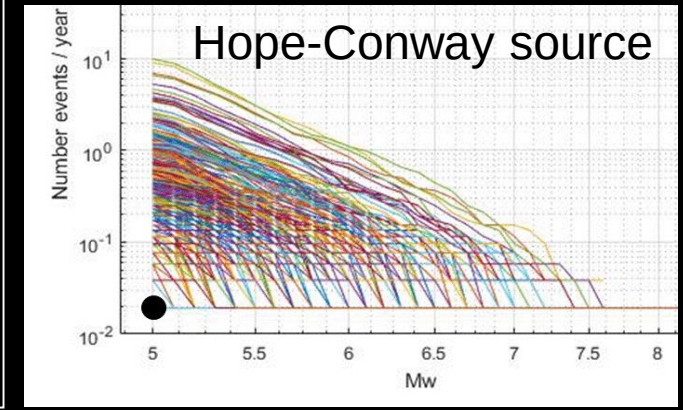
*Jonathan Griffin's PhD*

- Magnitude-frequency distributions

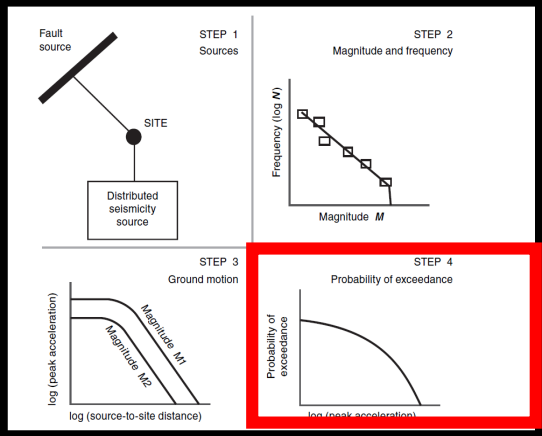
*Time-dependence*

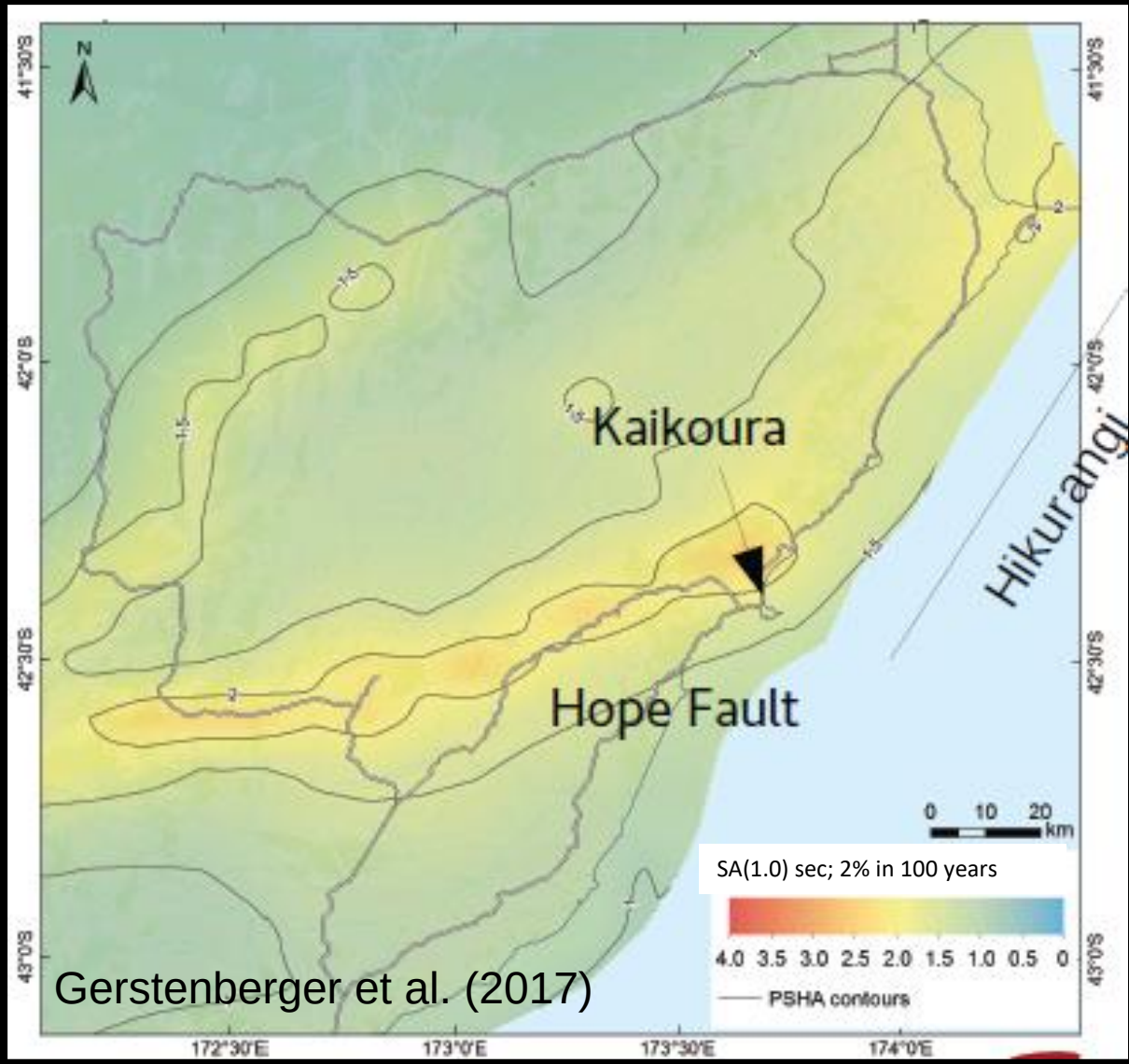


# NSHM Update



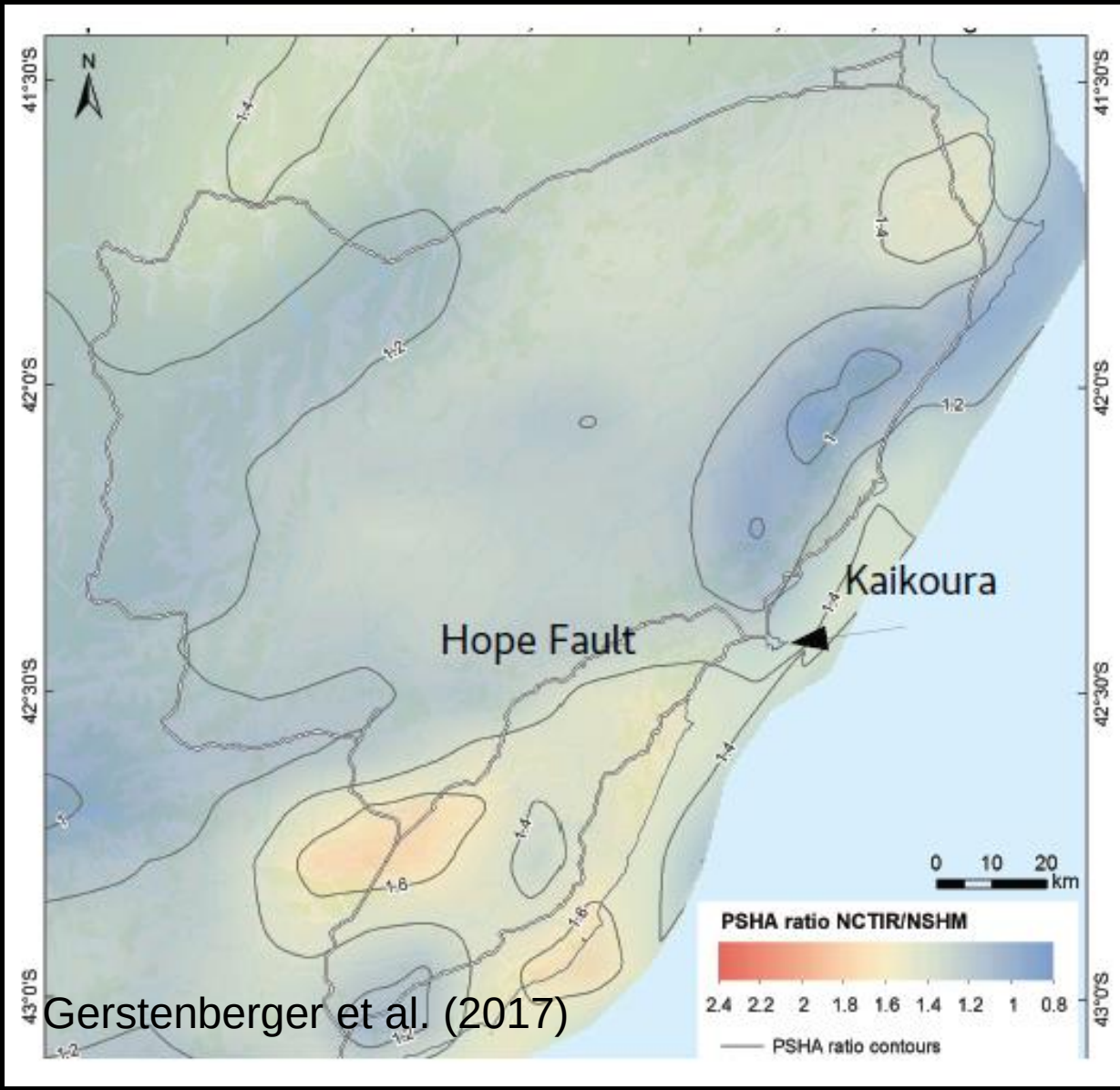




*Incorporates*

- OpenQuake software
- Multi-fault ruptures
- Time-dependence of mainshocks and aftershocks
- Range of ground motion models

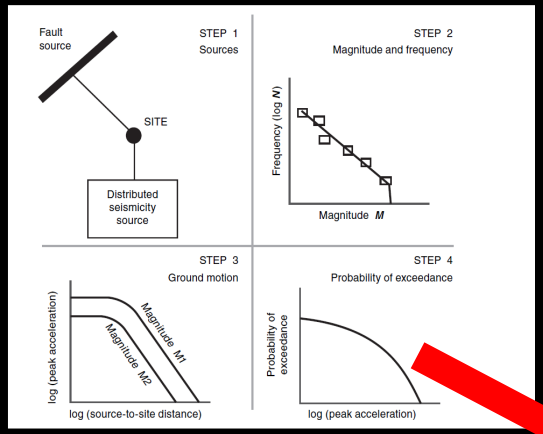
# Kaikoura PSH model

Ratio New/Old NSHM
2% in 100 years




Some increases and decreases in hazard: influence of many factors, including time-dependence

# NSHM update



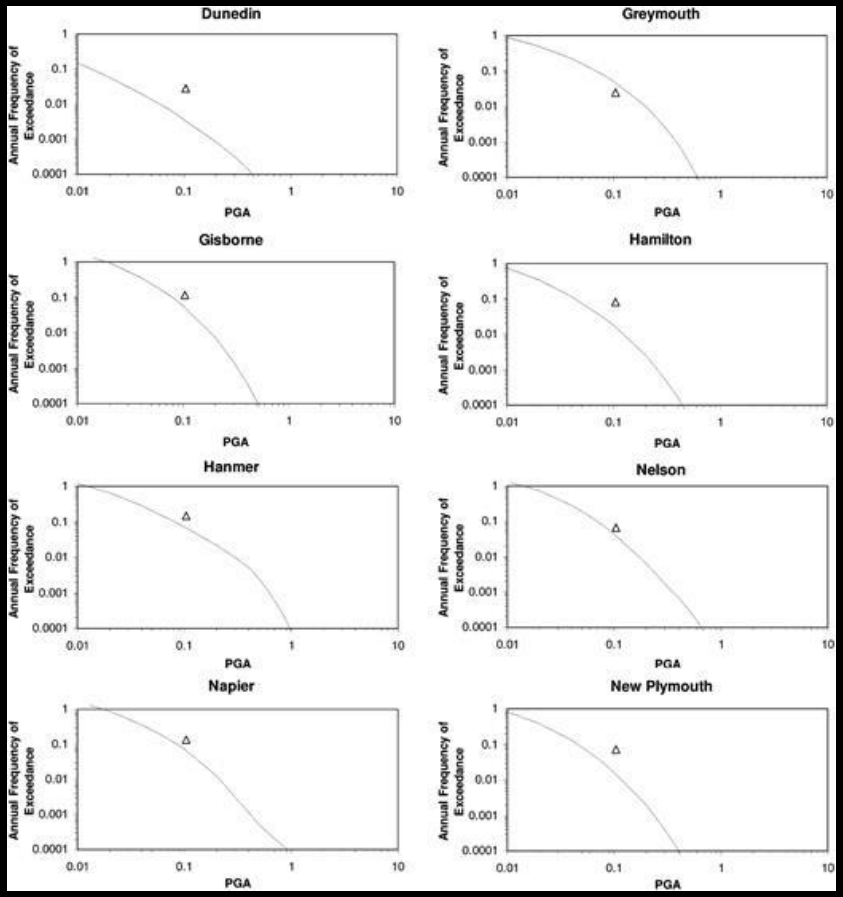

Testing and evaluation

*Testing and evaluation*

- Predicted vs observed ground motion exceedances across NZ from instrumental and felt-intensity data

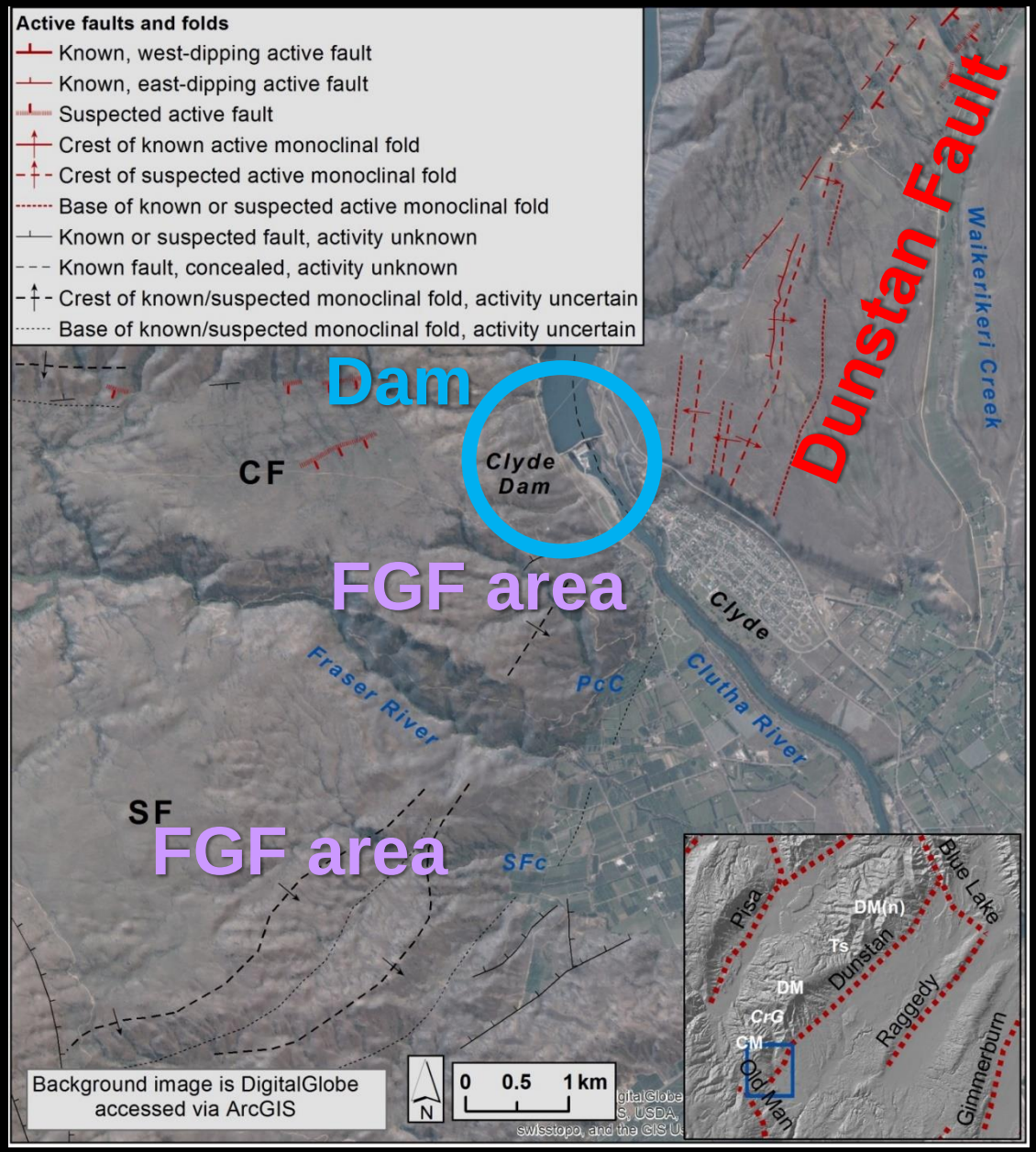
- Ground motion non-exceedance from fragile geologic features

# Accelerograph stations

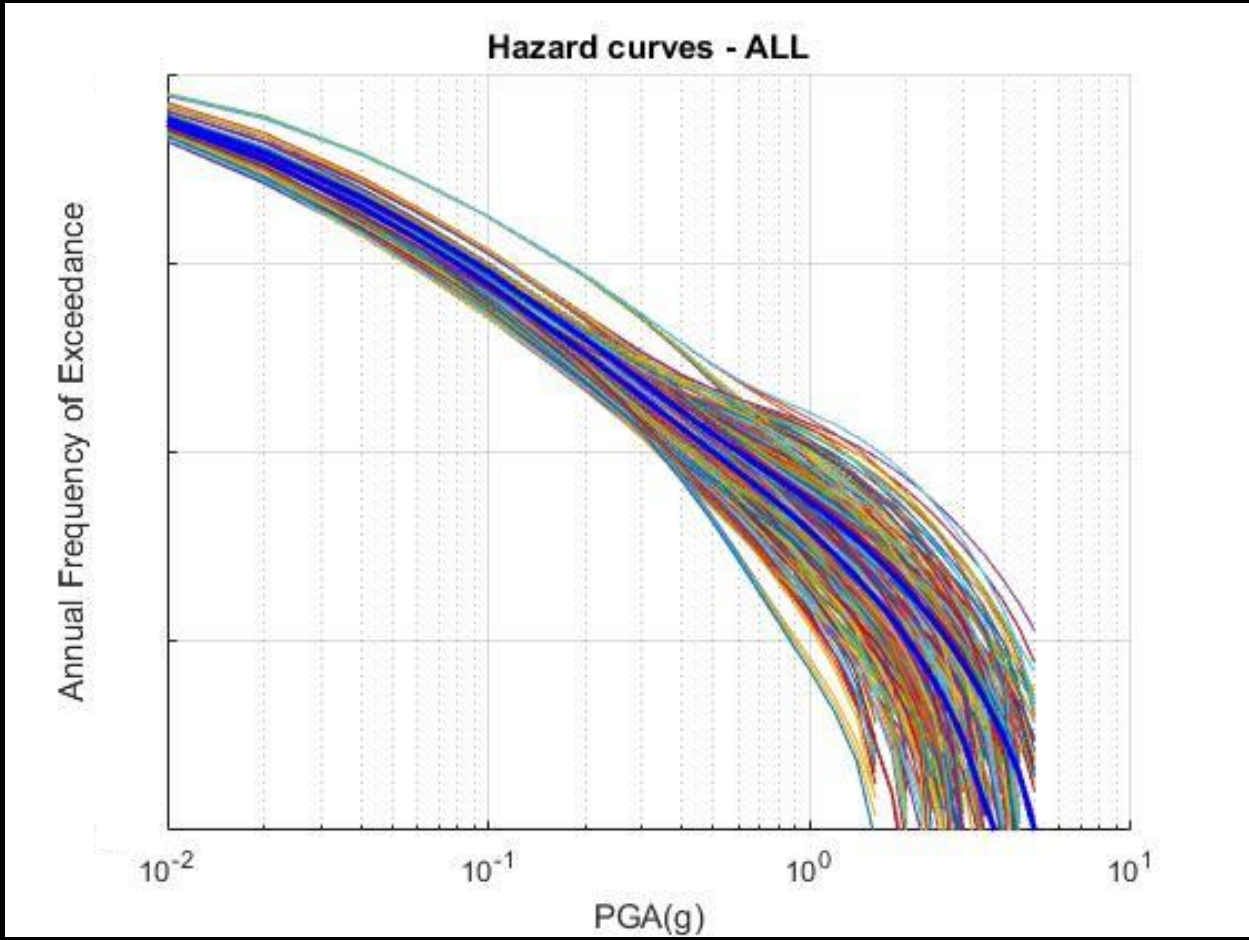

*Predicted vs observed exceedances of specific ground motion levels*

# Clyde Dam, Otago

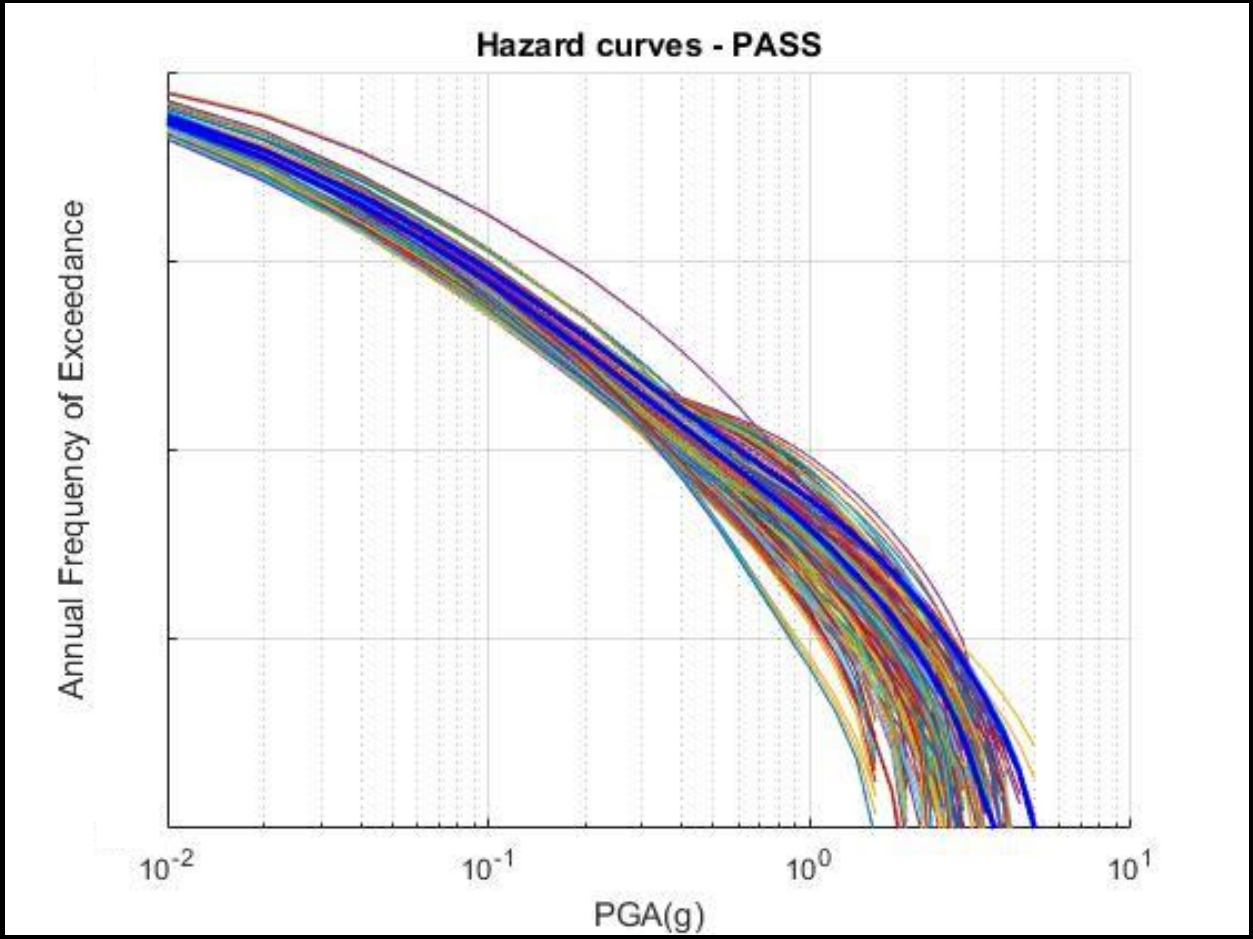



≥50 FGFs within c. 4km of the dam site

# All hazard curves



# Passed hazard curves




PASS = Hazard curves that allow a FGF survival probability of ≥5% in 24,000 years

# Conclusions

- Major update of the NSHM, incorporating a decade of R&D
- Increased awareness and support for NSHM work
- Update across the spectrum of source model, ground motion model, software, hazard outputs, and testing and evaluation
- Otago contributions at the Core NSHM group level, and within the source model and testing and evaluation workflows

# The End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