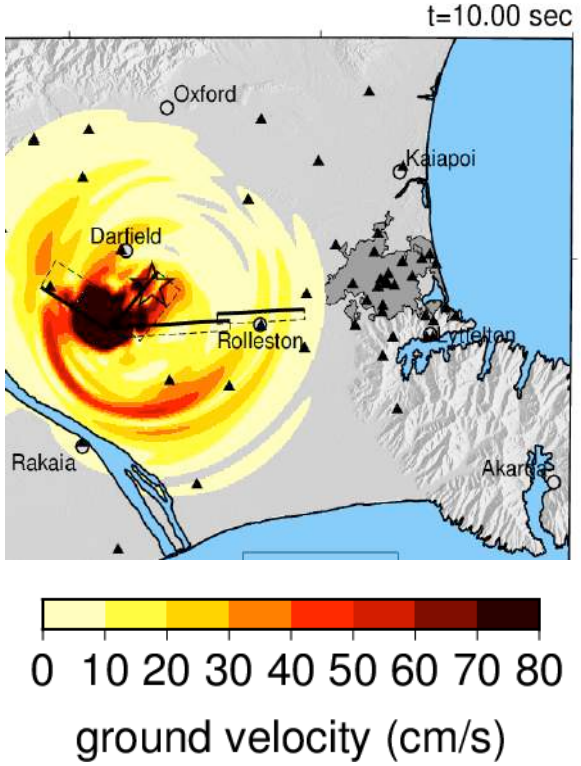
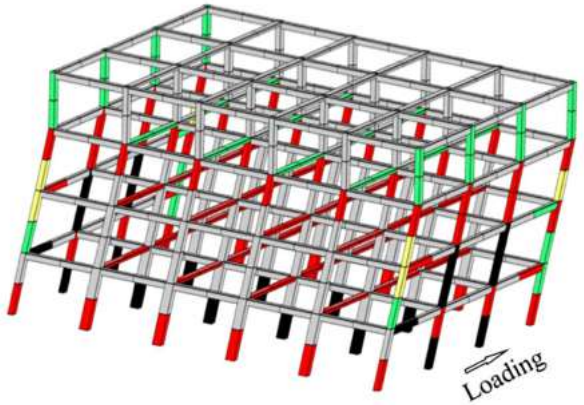
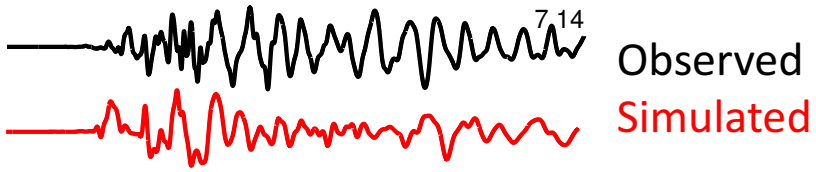
Flagship Project 1:
Ground motion simulation & validation







Brendon Bradley, Flagship Project Leader

Aim for today

27 September 2018 (9:00-10:30am NZT, web link: https://canterbury.zoom.us/j/374852384)

Purpose: To plan toward 2019-2020 QuakeCoRE GMSV research projects

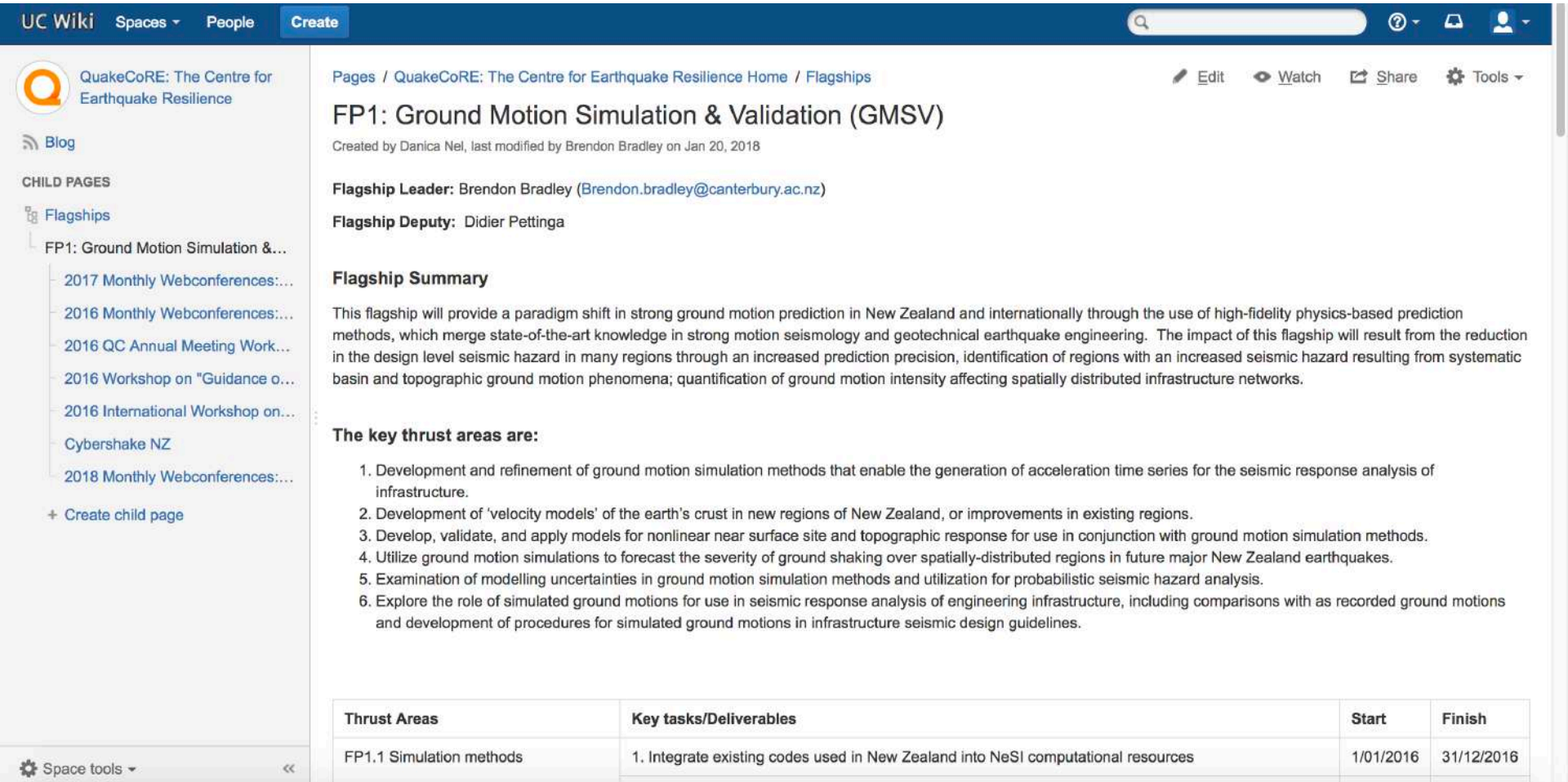
Agenda:

- "Summary of 2019-2020 QuakeCoRE FP1 plans" (Brendon Bradley, ~20 minutes)
- Initial Questions/Clarifications (All, ~10 minutes)
- Series of short discussions/presentations and Q&A: (~40 minutes)
    - Basin model development and site response (Seokho Jeong)
    - Approaches for examining Cybershake ground motion simulations in the context of utilization (Chris McGann)
    - Further research on subduction zone ground motion simulation (Paul Somerville)
    - The case for simulated ground motions for the Hikurangi Subduction Zone (James Dismuke and Jeff Fraser)
    - GM simulation: Steps into practice application (Didier Pettinga)
- Open discussion on weaknesses - what are we not adequately addressing? (20 minutes)
- Next steps: RfP submissions due on 19th October 2018

Summary of 2019-2020 FP1 plans

Wiki page:

https://wiki.canterbury.ac.nz/pages/viewpage.action?pageId=50626859



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QuakeCoRE: The Centre for Earthquake Resilience

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Flagships

FP1: Ground Motion Simulation &...

2017 Monthly Webconferences:...

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2016 QC Annual Meeting Work...

2016 Workshop on "Guidance o...

2016 International Workshop on...

Cybershake NZ

2018 Monthly Webconferences:...

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FP1: Ground Motion Simulation & Validation (GMSV)

Created by Danica Nel, last modified by Brendon Bradley on Jan 20, 2018

Flagship Leader: Brendon Bradley (Brendon.bradley@canterbury.ac.nz)

Flagship Deputy: Didier Pettinga

Flagship Summary

This flagship will provide a paradigm shift in strong ground motion prediction in New Zealand and internationally through the use of high-fidelity physics-based prediction methods, which merge state-of-the-art knowledge in strong motion seismology and geotechnical earthquake engineering. The impact of this flagship will result from the reduction in the design level seismic hazard in many regions through an increased prediction precision, identification of regions with an increased seismic hazard resulting from systematic basin and topographic ground motion phenomena; quantification of ground motion intensity affecting spatially distributed infrastructure networks.

The key thrust areas are:

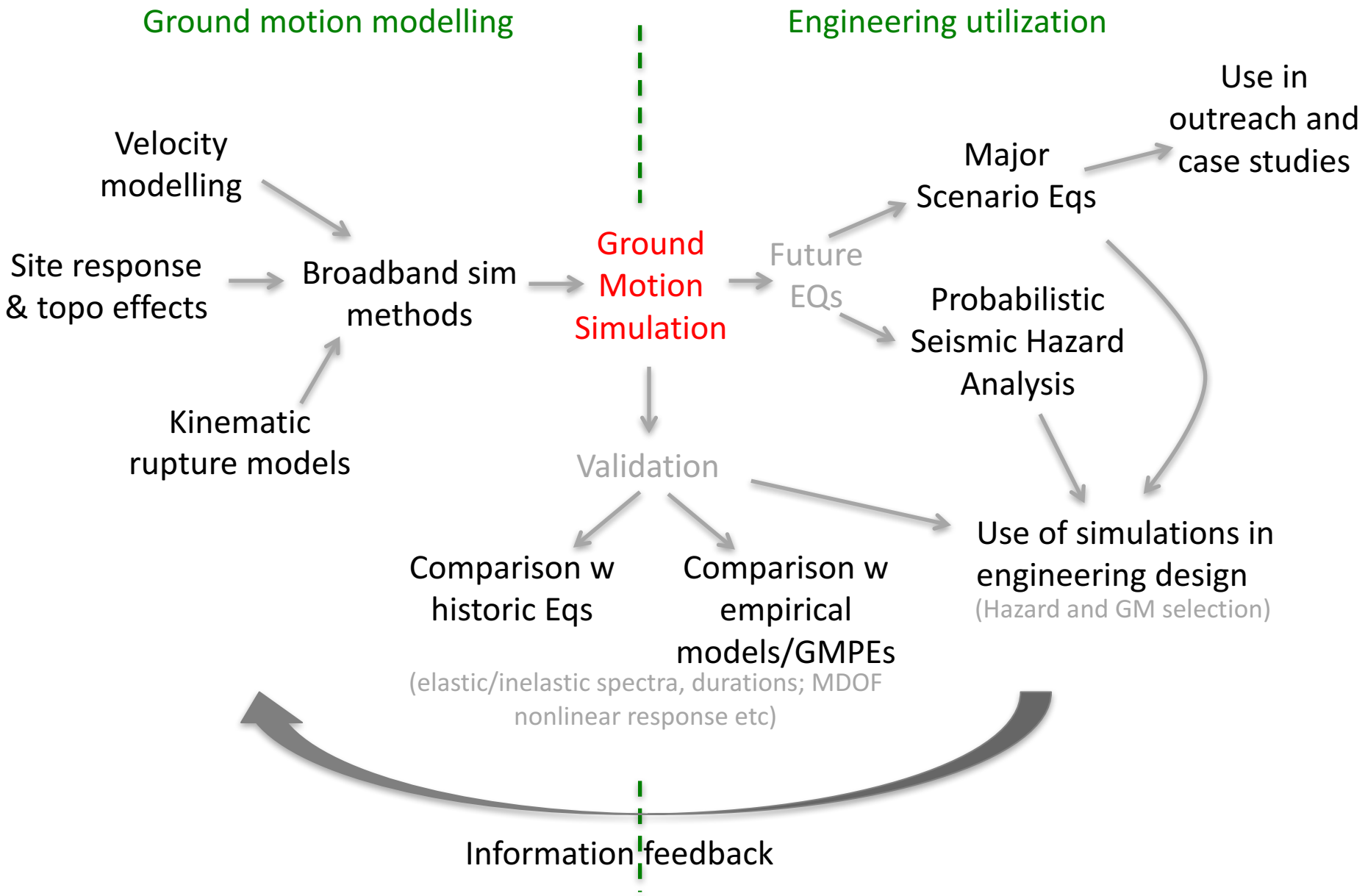
1. Development and refinement of ground motion simulation methods that enable the generation of acceleration time series for the seismic response analysis of infrastructure.
2. Development of 'velocity models' of the earth's crust in new regions of New Zealand, or improvements in existing regions.
3. Develop, validate, and apply models for nonlinear near surface site and topographic response for use in conjunction with ground motion simulation methods.
4. Utilize ground motion simulations to forecast the severity of ground shaking over spatially-distributed regions in future major New Zealand earthquakes.
5. Examination of modelling uncertainties in ground motion simulation methods and utilization for probabilistic seismic hazard analysis.
6. Explore the role of simulated ground motions for use in seismic response analysis of engineering infrastructure, including comparisons with as recorded ground motions and development of procedures for simulated ground motions in infrastructure seismic design guidelines.

Thrust Areas	Key tasks/Deliverables	Start	Finish
FP1.1 Simulation methods	1. Integrate existing codes used in New Zealand into NeSI computational resources	1/01/2016	31/12/2016

Contracted deliverables to funder

Thrust Areas	Key tasks/Deliverables	Start	Finish
FP1.1 Simulation methods	1. Integrate existing codes used in New Zealand into NeSI computational resources	1/01/2016	31/12/2016
	2. Validate simulations using historical New Zealand earthquakes	1/01/2016	31/12/2020
FP1.2 Velocity model development	1. Develop enhanced 3D velocity models in two regions of New Zealand	1/01/2016	31/12/2018
	2. Utilize full waveform tomography for high-resolution velocity modelling	1/01/2018	31/12/2020
FP1.3 Nonlinear site and topographic response	1. Directly integrate site response and topography into ground motion simulations vs. the use of Vs30. Examine the effects in Canterbury and Wellington	1/01/2016	31/12/2019
	2. Perform detailed analysis on when site-specific account for nonlinear and topographic effects is justified vs. simplified approaches	1/01/2018	31/12/2020
FP1.4 Application for major New Zealand scenarios	1. Perform ground motion simulation case studies for cross-flagship research and outreach and compare with empirical predictions	1/01/2016	31/12/2018
	2. Develop a 'Ground motion simulation atlas' illustrating seismic intensity over a region for 50 earthquake ruptures which are greatest risk to New Zealand	1/01/2017	31/12/2019
FP1.5 Uncertainties and PSHA	1. Develop advanced ground motion simulations with treatment of modelling uncertainties	1/01/2017	31/12/2020
	2. Perform 'Cybershake' simulations performed for T>1s in New Zealand. Compare with hazard from codes and GMPEs	1/01/2017	31/12/2020
FP1.6 Use of simulations in earthquake engineering analyses	1. Develop a co-created industry working document on the use of ground motion simulations in engineering design	1/01/2016	31/12/2018
	2. Compare and assess simulated vs. recorded ground motions with archetype engineering structures used to determine bias in simulation methods for feedback to developers	1/01/2017	31/12/2020

Spectrum of research



Current projects (wiki page)

Current Projects

Projects in 2018 include the flagship coordinated project, projects funded through the QuakeCoRE RfP, and students with QuakeCoRE or other university scholarships.

- 18FP1 - Flagship 1 coordinated project, containing the following sub-projects:
  - 1a. Validation of simulations for NZ-wide shallow crustal events (Lee, Bradley)
  - 1b. Ground motion simulations with multi-segment rupture (Vyas, Razafindrakoto, Bradley)
  - 2a. Development of basin models in Wellington and Auckland using 1st order methods (Wotherspoon, Bradley, Kaiser, Jeong, Cox, Foster, Lee)
  - 3a. Explicit site response analysis in simulations of the Kaikoura earthquake (Bradley, Wotherspoon, Cox, de la Torre, McGann, Dismuke)
  - 3b. Topographic modelling for Alpine Fault and Kaikoura earthquakes (Taborda, Asimaki, Jeong, Bradley, Wotherspoon)
  - 4a. Simulation of Wellington Fault earthquakes (Bradley, Tarbali, Lee)
  - 4b. Simulation of Hikurangi subduction zone earthquakes (Somerville, Bayless, Skarlatoudis)
  - 4c. Simulation of moderate magnitude earthquakes in the Auckland region (Dempsey, Riffault)
  - 5a. Analysis and propagation of modelling uncertainties in ground motion simulation (Bradley, Vyas, Lee, Tarbali)
  - 5b. Simulation-based seismic hazard analysis for New Zealand at 400m resolution (Tarbali, Bradley)
  - 6a. Application of code-compatible simulation vs. recorded ground motions for structural and geotechnical systems (McGann, Hayden, Chandramohan, Bradley, Pettinga, Tarbali, Loghman)
  - 6b. Guidance on the selection of simulated ground motions as an alternative method for use in NZ (Pettinga, Fraser, Bradley)
- 18AF8 - Ground motion simulation of Alpine Fault (incl Wairau as 'Northern AF') earthquakes (Tarbali, Bradley + AF8 project)
- 18QCS - Ground motion simulations for the Dunedin-Mosgiel urban area (Stirling, Kowal)
- 18207 - Soil-foundation-structure interaction analysis of an instrumented Wellington building (McGann, Chandramohan, Hayden, Pettinga, Jeong)
- 18213 - Incorporating the influence of ground motion duration and response spectral shape in NZ structural design and assessment practice (Chandramohan, Horspool, Bradley)
- 18KF - Development of a NZ-wide Vs30 model for use in regional ground motion simulations (Foster, Bradley)
- 18ET - Parametric models for velocity characterisation of inter-bedded sedimentary deposits in the Canterbury basin (Thomson, Bradley, Wotherspoon, Wood)

2019-2020 QuakeCoRE Coordinated Project Application Form

Title of proposed coordinated project: Flagship 1 Coordinated Project 2019-2020

Key Objective:

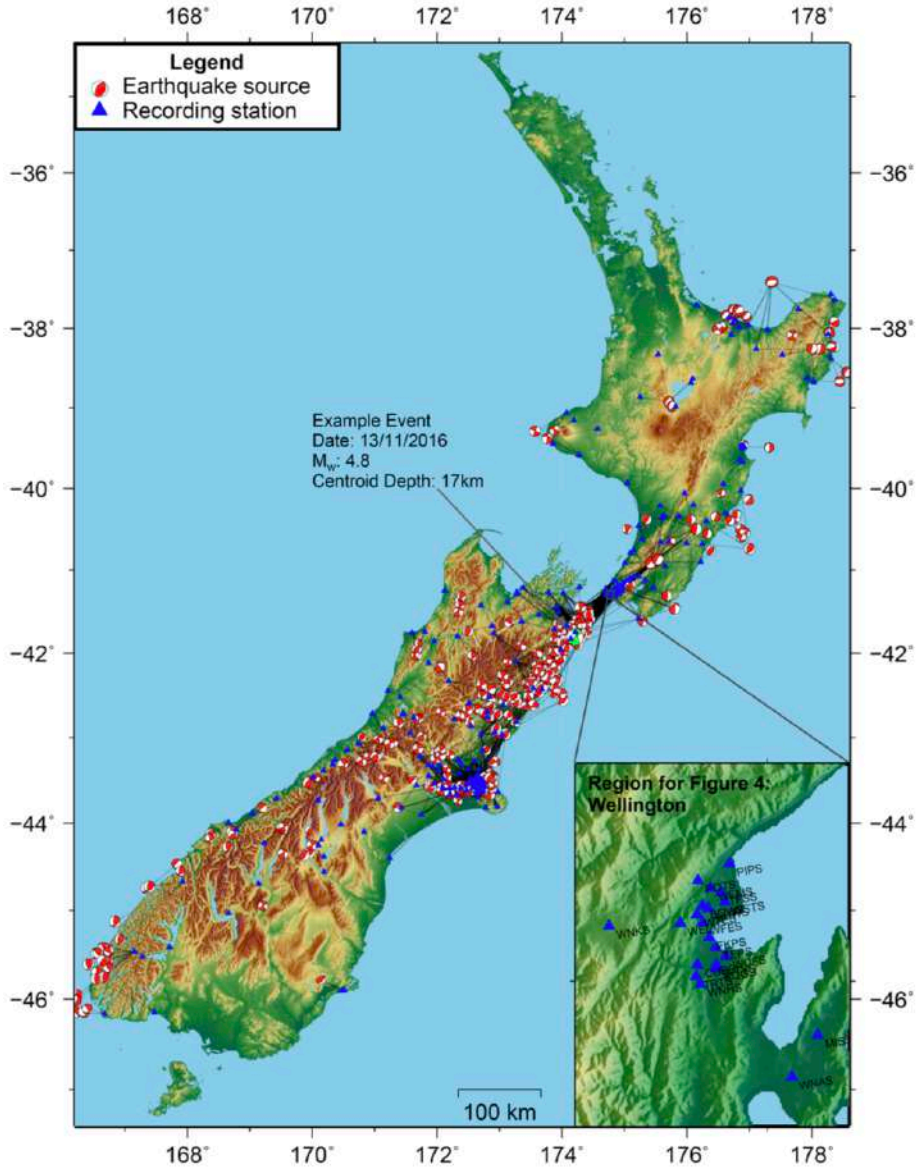
This coordinated project contains 6 over-arching objectives which correspond to those in the overall objectives of Flagship 1 in the 2018-2020 QuakeCoRE 3 year plan provided to TEC. Underneath each objective there are several sub-projects (where appropriate) which are based on a proposed body of work that will result in one or more publication outputs. In total there are 13 such sub-projects.

The list of projects under the objectives are:

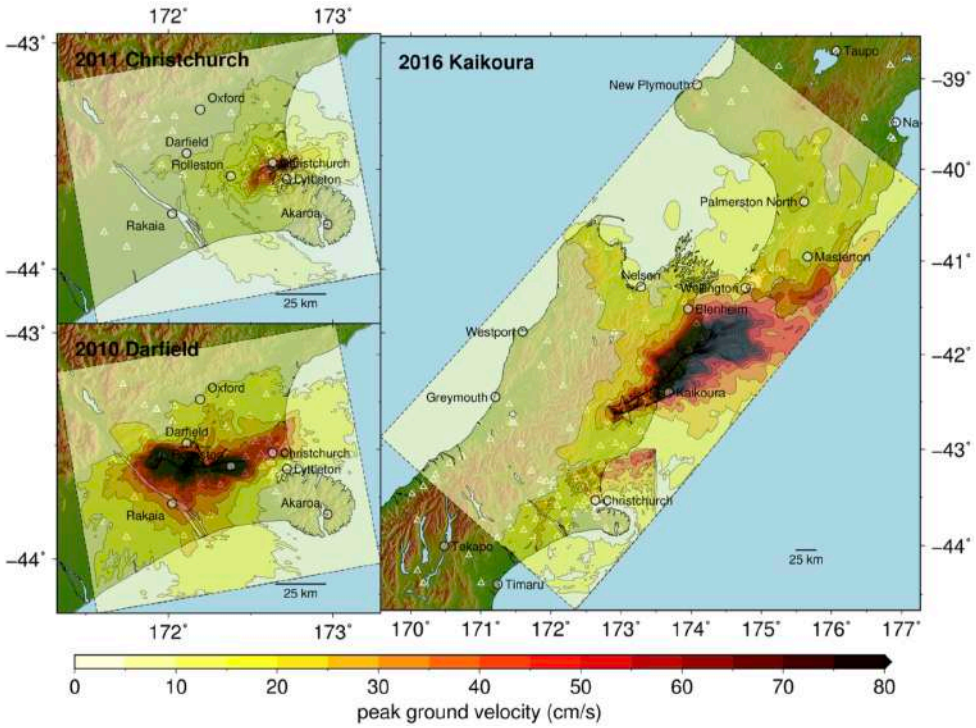
1. Simulation methods
    a. Validation of simulations for NZ-wide historical events
    b. Ground motion simulation with multi-segment rupture
2. Velocity model development
    a. Development of basin models in sedimentary basins using 1st order methods
    b. Full waveform tomography for velocity model improvement
3. Nonlinear site and topographic response
    a. Explicit site response analysis in simulations of the Kaikoura earthquake
    b. Topographic modelling for Alpine fault and Kaikoura earthquakes
4. Application for major NZ EQ scenarios
    a. Simulation of Wellington Fault earthquakes
    b. Simulation of Hikurangi subduction zone earthquakes
    c. Simulation of moderate magnitude earthquakes in the Auckland region
5. Uncertainties and PSHA
    a. Analysis and propagation of modelling uncertainties in ground motion simulation
    b. Simulation-based seismic hazard analysis for New Zealand at 200m resolution
6. Use of simulations in earthquake engineering analyses
    a. Application of code-compatible simulation vs recorded ground motions for structural and geotechnical systems
    b. b. Guidance on selection of simulated ground motions as an alternative method for use in NZ

Projects 1(a,b): Simulation methods

1a. Validation of simulations for NZ-wide historical events

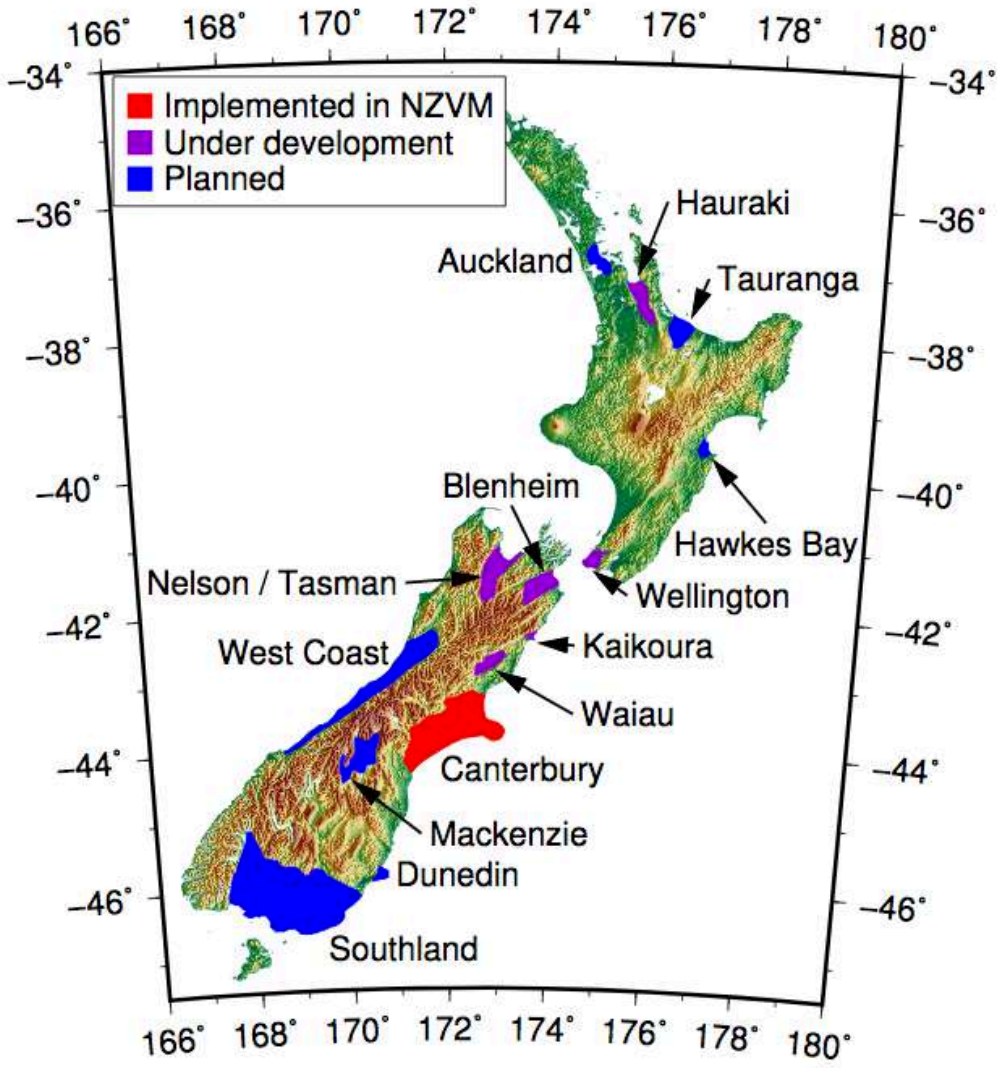


1b. Ground motion simulation with multi-segment rupture

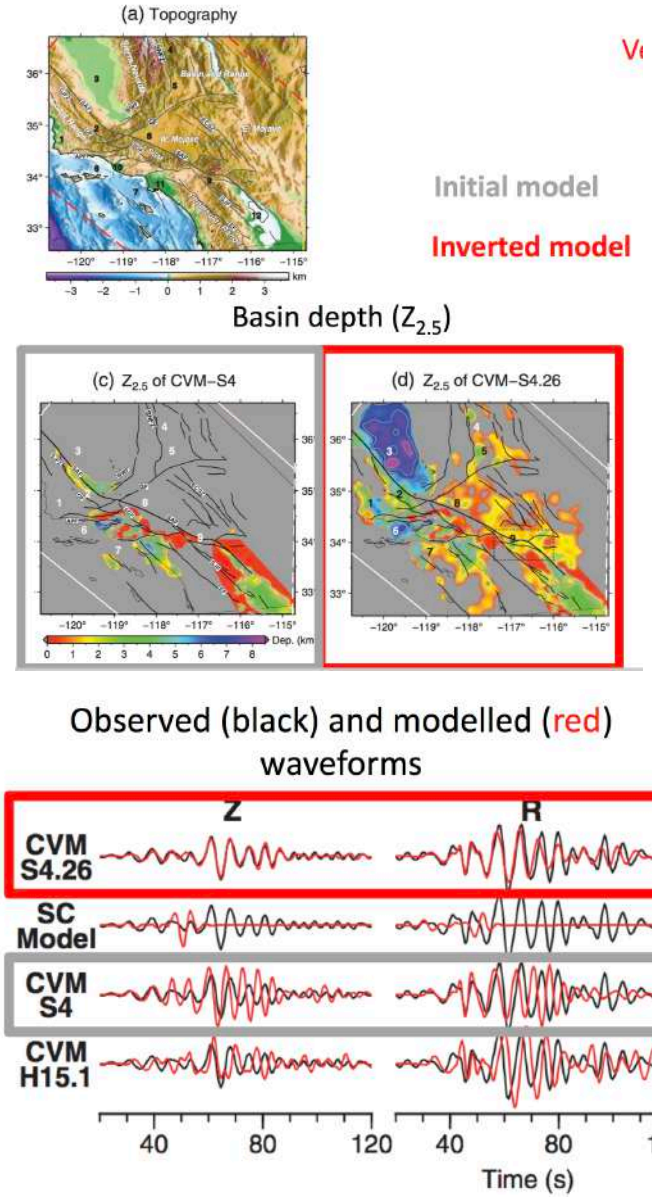


Projects 2(a,b): Velocity model development

2a. Dev. of basin models NZ-wide

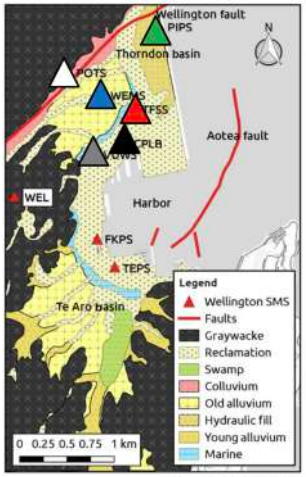


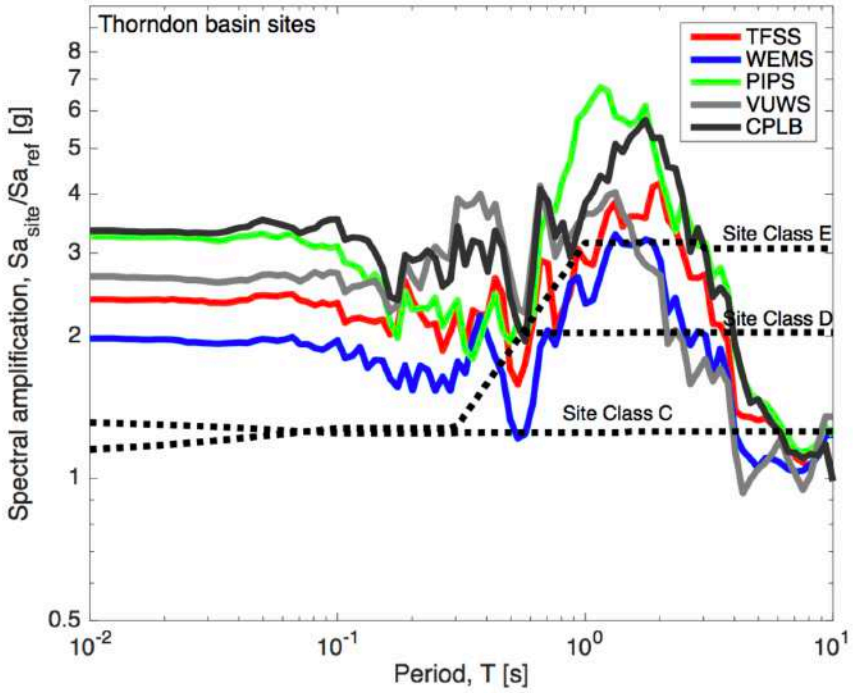
2b. Full-waveform tomography



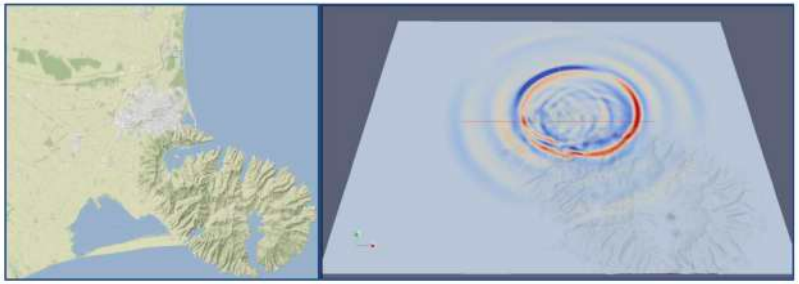
Projects 3(a,b): Nonlinear site and topographic response

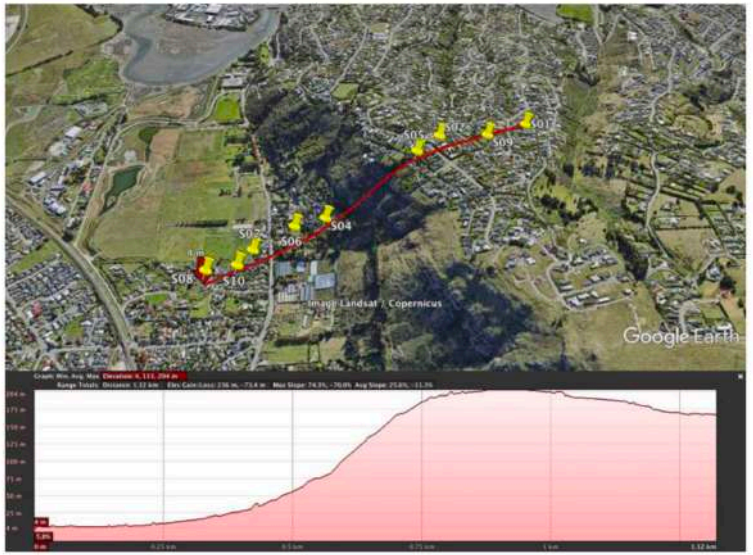
3a. Explicit site response analysis in simulations of the Kaikoura earthquake





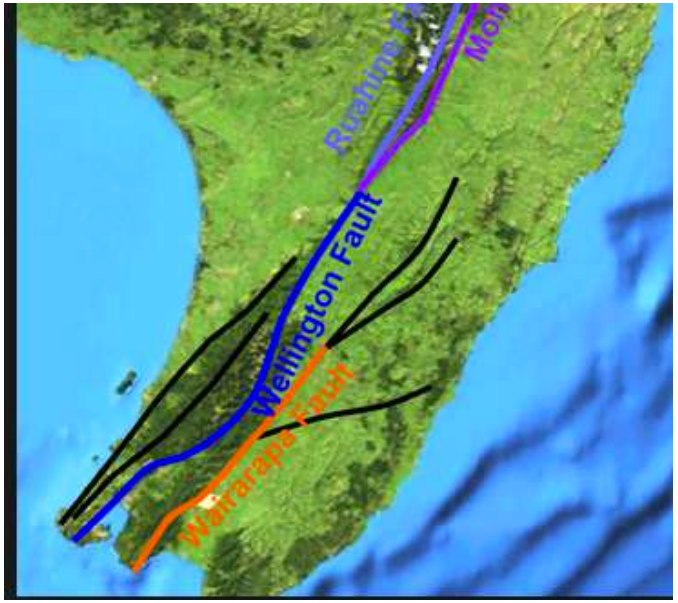
3b. Topographic modelling for Alpine fault and Kaikoura earthquakes (regional and local scale)



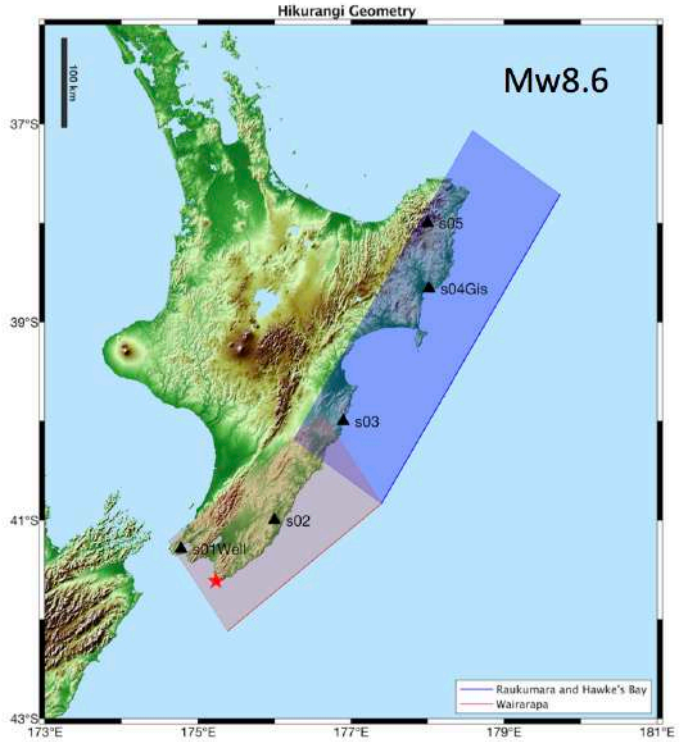


Projects 4(a-c): Application for major NZ EQ scenarios

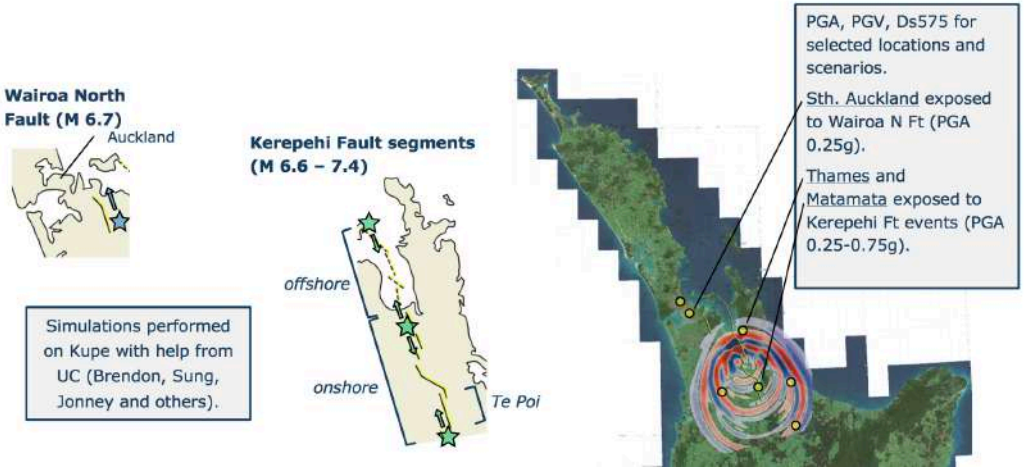
4a. Wellington



4b. Hikurangi

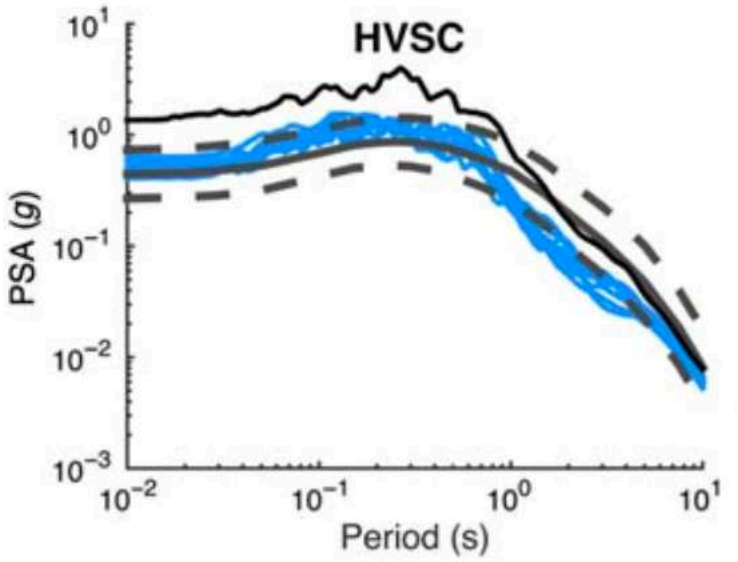


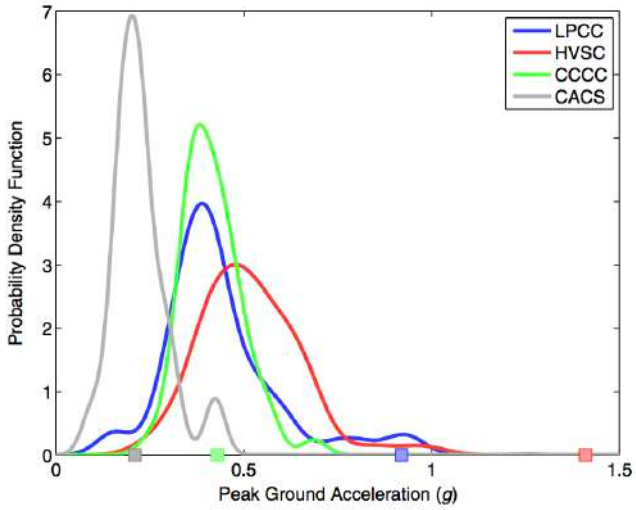
4c. Auckland



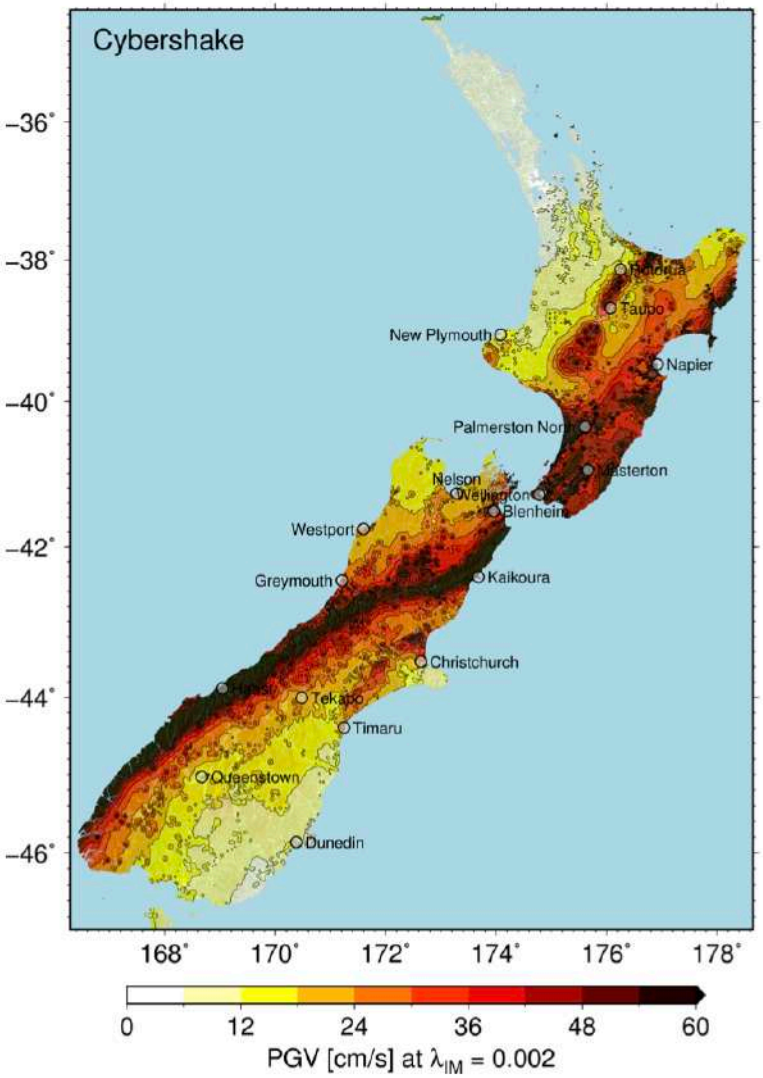
Projects 5(a,b):Uncertainties and PSHA

5a. Analysis and propagation of modelling uncertainties in ground motion simulation





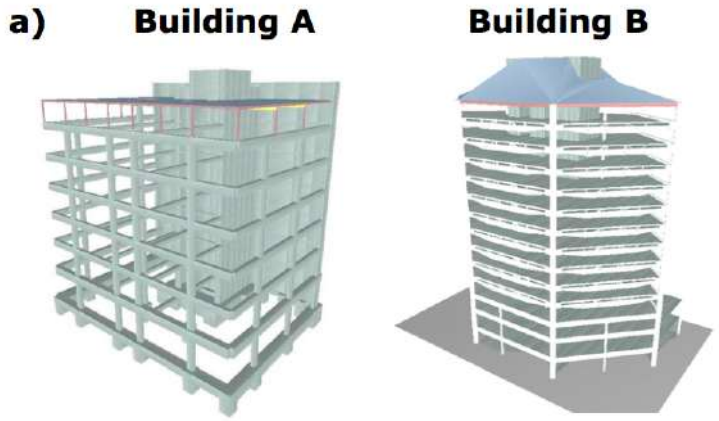
5b. Simulation-based seismic hazard analysis for New Zealand at 200m resolution

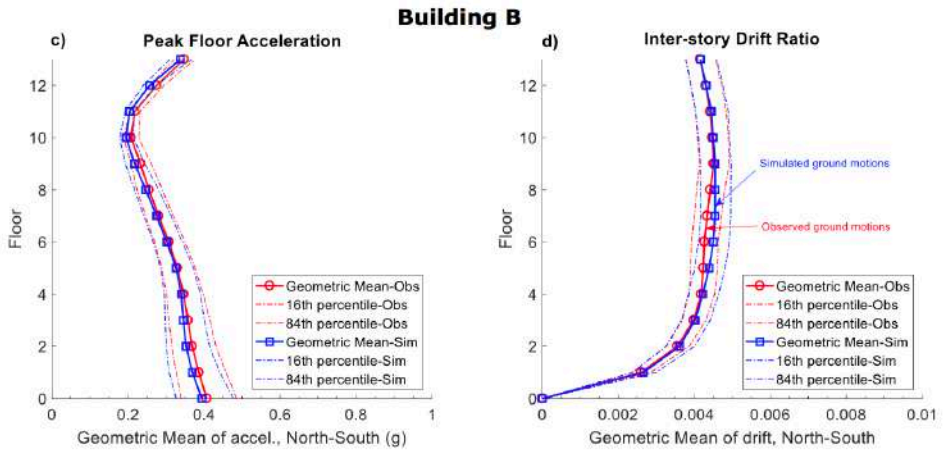


Projects 6(a,b): Use of simulations in Eq. Eng.

6a. Application of code-compatible simulation vs recorded ground motions for structural and geotechnical systems

6b. Guidance on selection of simulated ground motions as an alternative method for use in NZ





EARTHQUAKE ENGINEERING PRACTICE

Guidance on the Utilization of Earthquake-Induced Ground Motion Simulations in Engineering Practice

809

Earthquake Spectra, Volume 33, No. 3, pages 809–835, August 2017; © 2017, Earthquake Engineering Research Institute

Next step: Guidance on selection of simulated motions as alternative method for use in NZ