UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

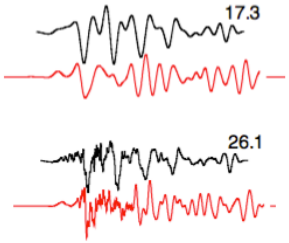
Initiation of simulation-based PSHA (Cybershake) for the Canterbury region

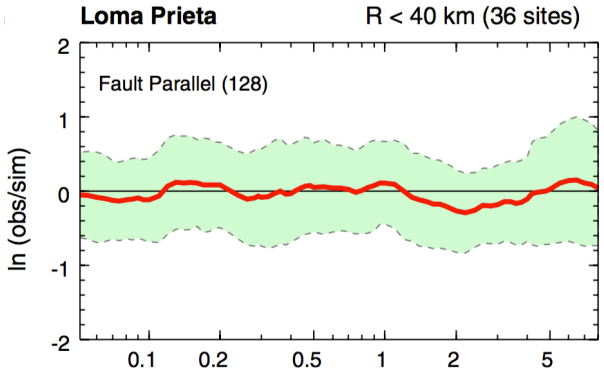
University of Canterbury

Karim Tarbali and Brendon Bradley

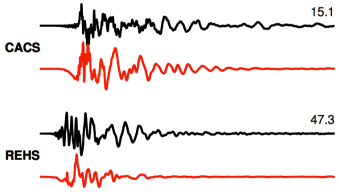
Motivation— capabilities of simulations

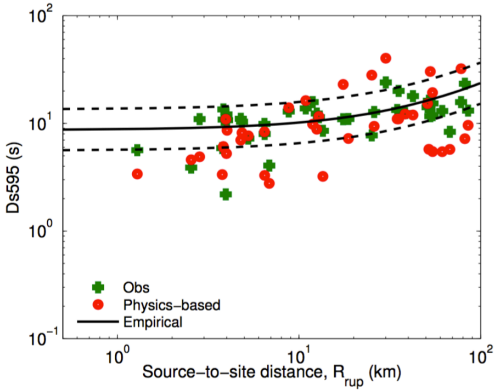
- Validation of simulated ground motions for past events demonstrates the capabilities of simulations for seismic hazard assessment

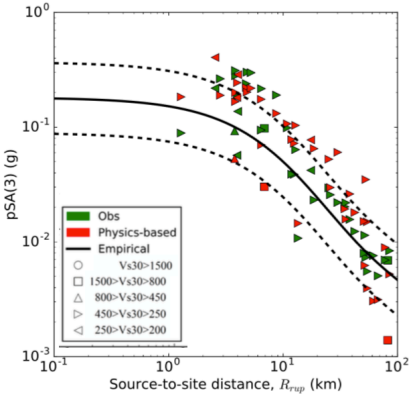




Graves and Pitarka (2010), BBSA







Razafindrakoto, Bradley, Graves (2017)

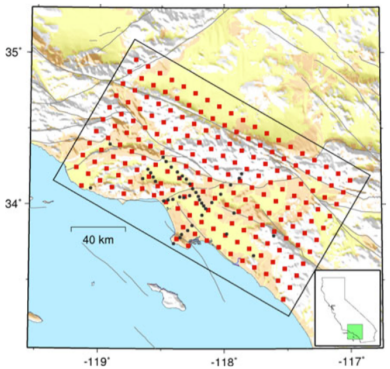
Motivation— shortcomings of the empirical models

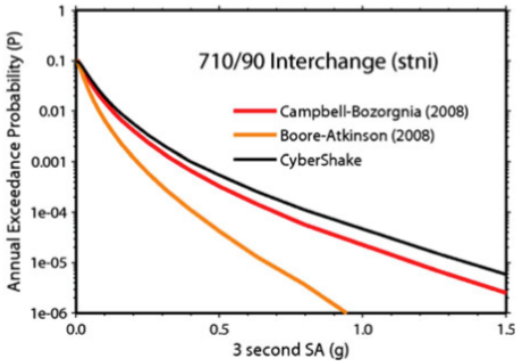
Explicit consideration of

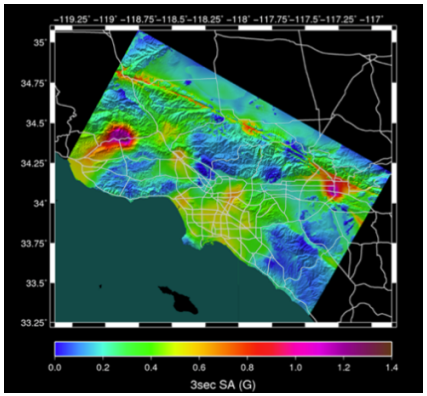
- Directivity effects
- Basin generated waves
- Nonlinear site effects
- Hypocenter location
- Stress drop
- Slip heterogeneity
- Rupture velocity

SCEC cybershake— First attempt

- Region: Southern California
- Earthquake rupture forecast: UCERF 2.0
- Simulation approach: Graves and Pitarka (2010)







Key aspects:

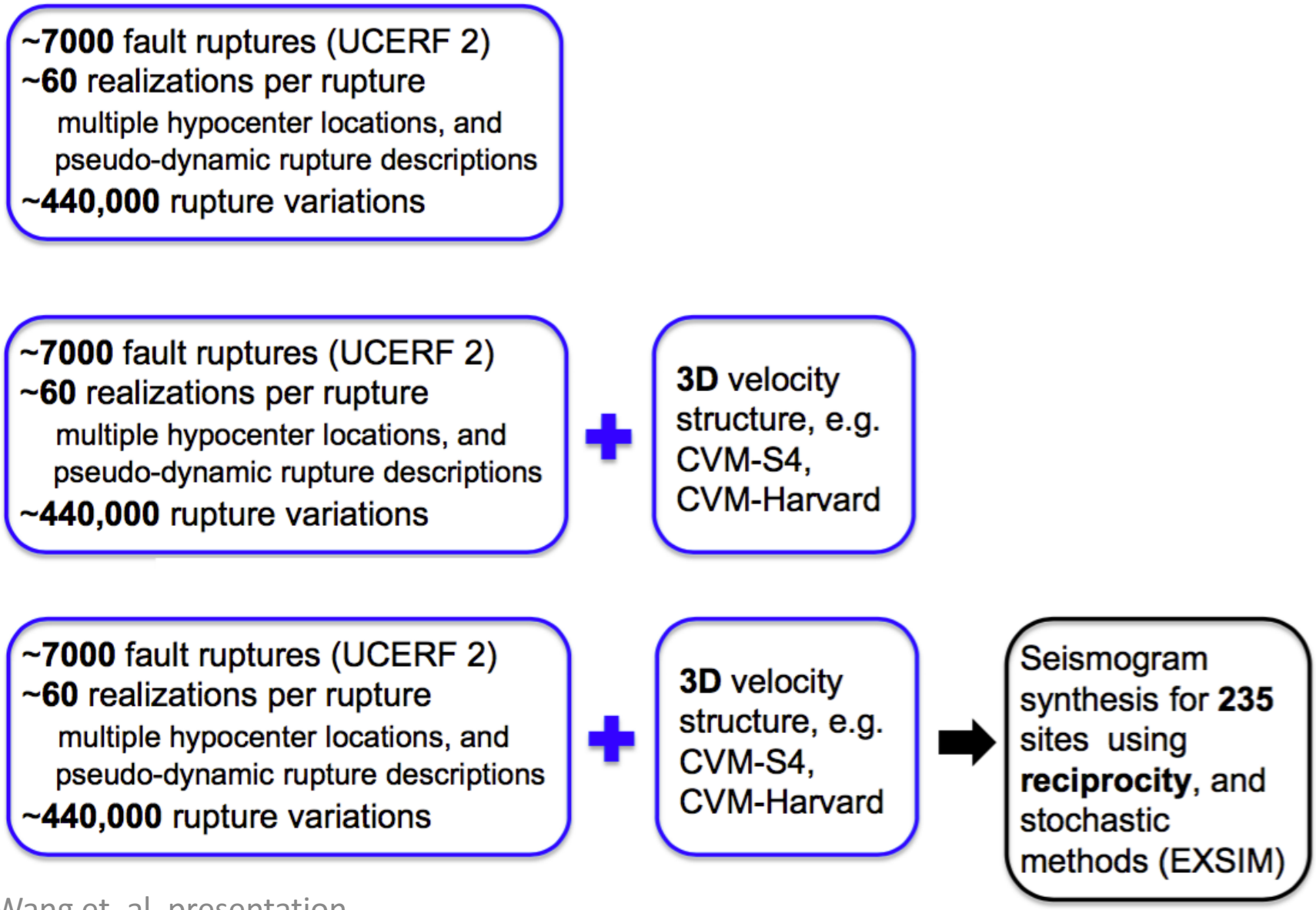
- Reciprocity
- No local site effects
- No high frequency

Data and CPU requirements for the CyberShake computational components, per site of interest

Component	Data	CPU hours
Mesh generation	15 GB	150
SGT simulation	40 GB	10,000
SGT extraction	680 GB	250
Seismogram synthesis	10 GB	6,000
PSHA calculation	90 MB	100
Total	755 GB	17,000

Graves et. al. (2010), Pure Appl. Geophys.

SCEC Cybershake – Evolution



New Zealand Cybershake— Planned first iteration

First attempt:

- Region: Canterbury
- Crustal model: NZVM v1.64 (Thomson et al. 2017)
- Earthquake rupture forecast: Stirling et al (2012)
- Simulation approach: Graves and Pitarka (2010, 2015)

Aspects different compared to the first SCEC Cybershake

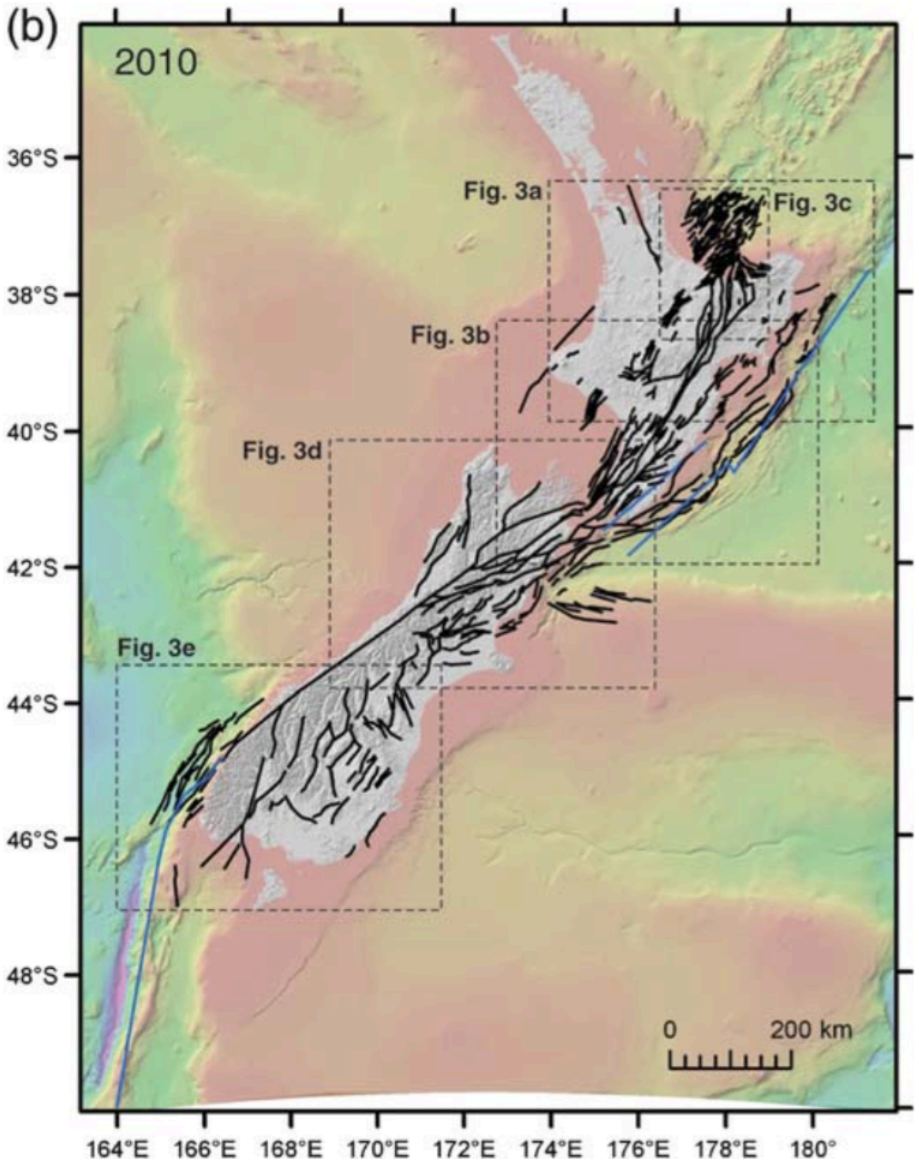
- Forward simulation, i.e., no reciprocity
- Local site effects, i.e., empirical and/or simulation-based site response
- Broad band simulation
- Utilizing empirical PSHA to identify dominant scenarios

New Zealand Cybershake – Aspects

- Transition freq = 0.25Hz; Minimum Vs=500m/s; grid spacing=0.4km
- Slip distribution: 5 realizations
- Hypocenter location: every 20 km along the strike direction; and one row of hypocenter along the dip directions
- Empirical ground motion prediction used for (i) background seismicity; and (ii) fault-based seismic sources which provide a small contribution to the hazard
- Different computational domains used for each simulation based on rupture magnitude; integration of all plausible ruptures in PSHA calculation occurs through the use of a co-located grid of surface stations for storing simulation outputs

New Zealand Cybershake – Aspects

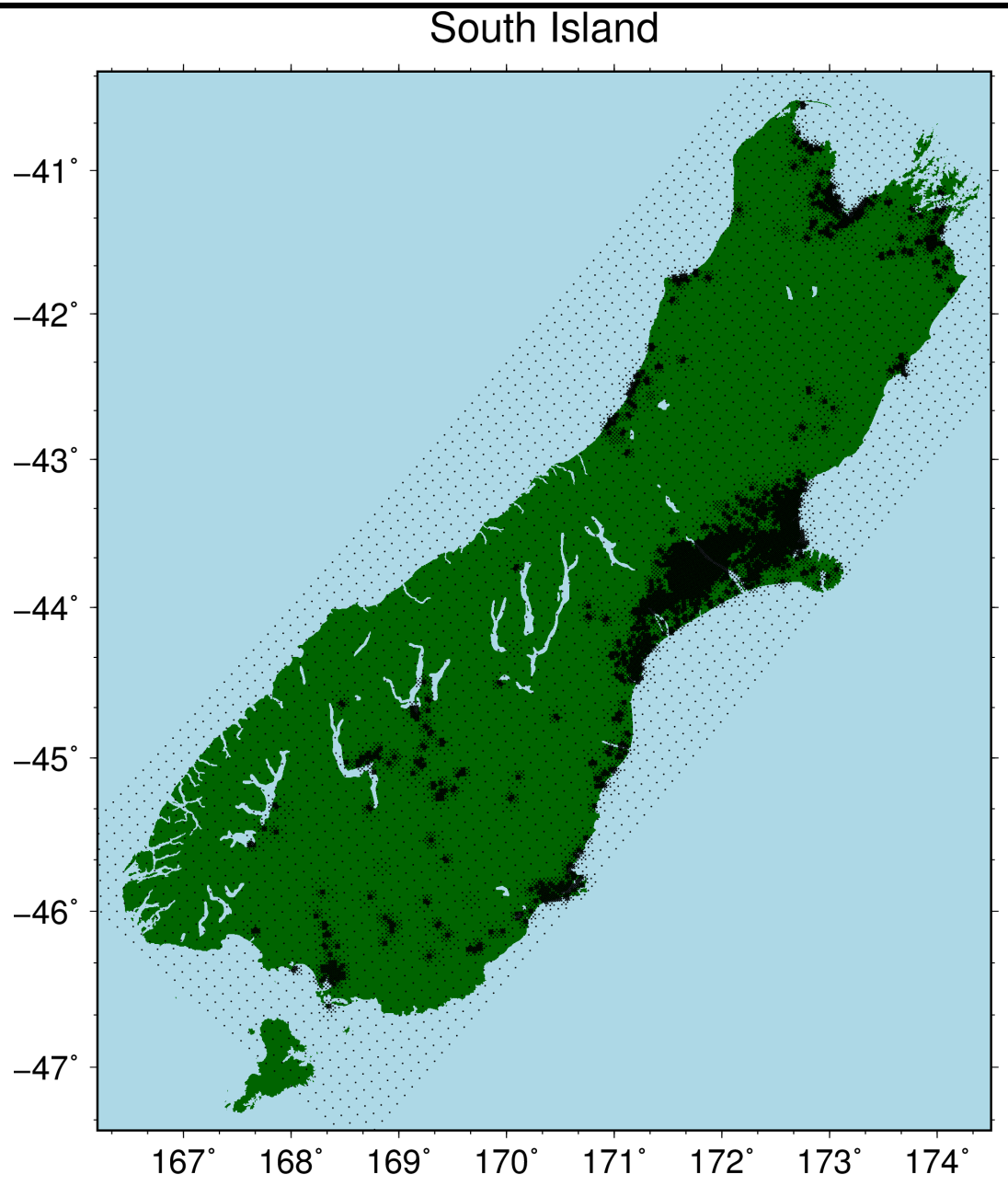
~500 characteristic faults



Stirling et al (2012)

New Zealand Cybershake – Aspects

- Using non-uniform grid as a function of population density and soil shear wave velocity for storing simulation results

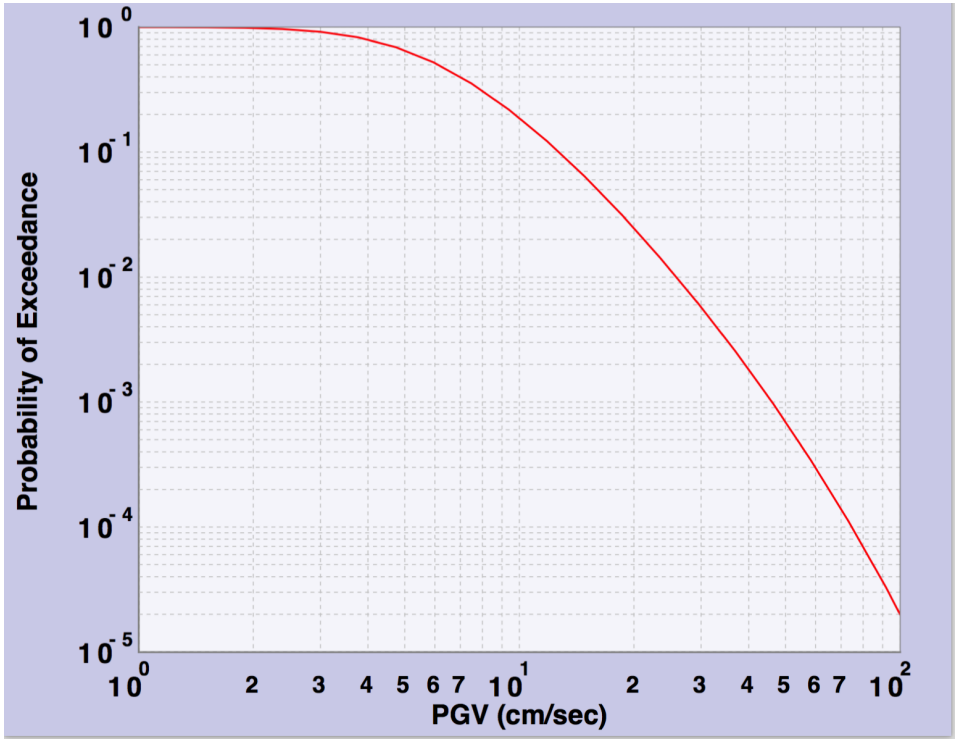


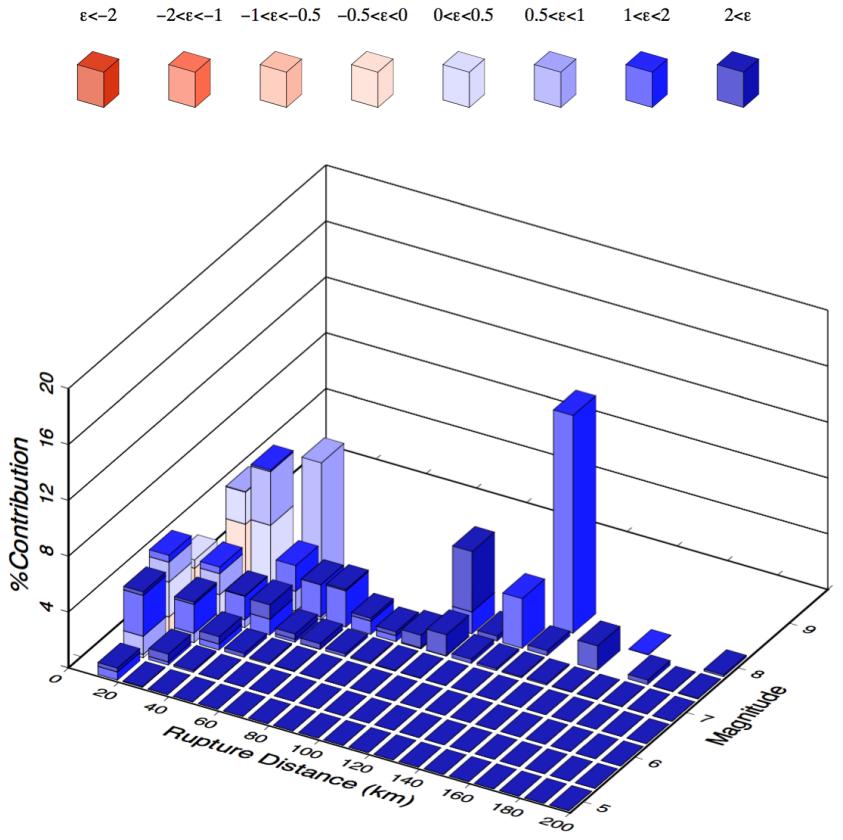
Canterbury region – Dominan scenarios

Empirical PSHA:

Ground motion model: Bradley (2013)

Earthquake rupture forecast: Stirling et al (2012)





Canterbury region – Dominan scenarios

Computational effort:
~ 50,000 core hours

CHCH_Deagg_PGV_10in50yrs.txt

Source#	% Contribution	TotExceedRate	SourceName	DistRup	DistX	DistSeis	DistJB
000017	15.60	0.016568292	AlpineF2K	134.12	134.30	134.12	133.57
000335	07.44	0.007904454	Port2GreyS	44.21	-44.21	44.31	44.21
000025	04.28	0.0045436528	Ashley	31.05	-30.91	36.08	31.05
000324	03.30	0.0035086423	Pegasus1nw	21.66	18.87	21.66	17.69
005460	02.99	0.0031732747	NSHMP Point Source	12.53	07.97	11.01	04.61
000018	02.83	0.003000976	AlpineK2T	120.70	127.05	120.70	120.09
000126	02.65	0.0028171192	HopeConway	106.17	-97.42	106.86	106.17
005461	02.13	0.0022597075	NSHMP Point Source	13.80	09.62	11.80	06.26
005459	01.71	0.0018115453	NSHMP Point Source	17.85	14.90	15.28	11.55
000336	01.68	0.0017879123	Port2GreyL	44.21	-44.21	44.31	44.21
000390	01.60	0.0016970133	Springbank	28.31	-28.29	30.33	28.29
000127	01.56	0.001658803	HopeConwayOS	106.43	-96.42	107.11	106.43
005524	01.55	0.0016496767	NSHMP Point Source	15.20	11.45	12.87	08.09
000145	01.45	0.0015368208	JorKekNeed	159.20	-36.54	159.59	159.20
000159	01.43	0.0015149664	Kelly	109.66	-105.61	109.70	109.66
005396	01.26	0.001342691	NSHMP Point Source	20.47	18.33	18.01	14.98
000074	01.25	0.0013298484	Cust	32.98	-32.50	34.99	32.96
005525	01.15	0.0012239655	NSHMP Point Source	16.00	12.49	13.54	09.13
000169	01.08	0.0011507465	LeesV	45.83	54.42	45.83	44.16
000174	01.03	0.0010971716	Lowry	64.79	55.99	64.79	63.62
005395	01.02	0.0010865381	NSHMP Point Source	23.08	21.70	20.89	18.35
005523	01.02	0.0010861646	NSHMP Point Source	19.20	16.68	16.66	13.32
005397	01.00	0.0010625711	NSHMP Point Source	20.92	18.92	18.50	15.57
012474	00.98	0.0010426964	NSHMP Point Source	12.53	-08.81	30.35	04.61
012475	00.87	9.2503073E-4	NSHMP Point Source	13.80	-07.16	30.65	06.26
000132	00.84	8.880124E-4	Hororata	37.80	-25.10	39.54	37.80
005458	00.83	8.8511454E-4	NSHMP Point Source	23.91	22.73	21.81	19.38
000285	00.81	8.5746974E-4	Omihi	49.11	35.83	49.11	47.55
005462	00.75	7.976643E-4	NSHMP Point Source	19.48	17.04	16.95	13.68
000250	00.73	7.792569E-4	NorthCant1	32.66	34.02	32.66	29.14
000072	00.73	7.783802E-4	ClarenceNE	126.51	-106.64	127.66	126.51
000152	00.71	7.509002E-4	KaiwaraS	56.74	57.43	56.74	55.39
000125	00.69	7.3753716E-4	Hope1888	104.53	-104.53	105.29	104.53
005394	00.65	6.897206E-4	NSHMP Point Source	27.84	27.42	26.06	24.07
000347	00.57	6.006092E-4	Rakaia	41.52	-21.43	42.68	41.52
000391	00.56	5.95308E-4	Springfield	55.85	-45.18	57.92	55.85
005522	00.54	5.701563E-4	NSHMP Point Source	24.80	23.83	22.79	20.47
005398	00.53	5.6426116E-4	NSHMP Point Source	24.22	23.12	22.15	19.76
012536	00.52	5.557121E-4	NSHMP Point Source	15.20	-05.33	31.07	08.09
000128	00.52	5.498353E-4	HopeCW	105.05	-105.05	105.82	105.05
012537	00.51	5.4362154E-4	NSHMP Point Source	16.00	-04.29	31.36	09.13
005526	00.47	5.0422695E-4	NSHMP Point Source	20.65	18.56	18.20	15.20
012476	00.44	4.698161E-4	NSHMP Point Source	19.48	00.26	32.97	13.68
012473	00.43	4.583456E-4	NSHMP Point Source	17.85	-01.88	32.15	11.55

Time Line

- Aug 2017: Simulations for 50 sources considered
- Oct 2017: Cybershake PSHA results for Canterbury based on f=0.25Hz transition frequency

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- Dec 2017: Cybershake PSHA results for South Island based on f=0.25Hz
- ~ Jan 2018: New NESI HPC resources

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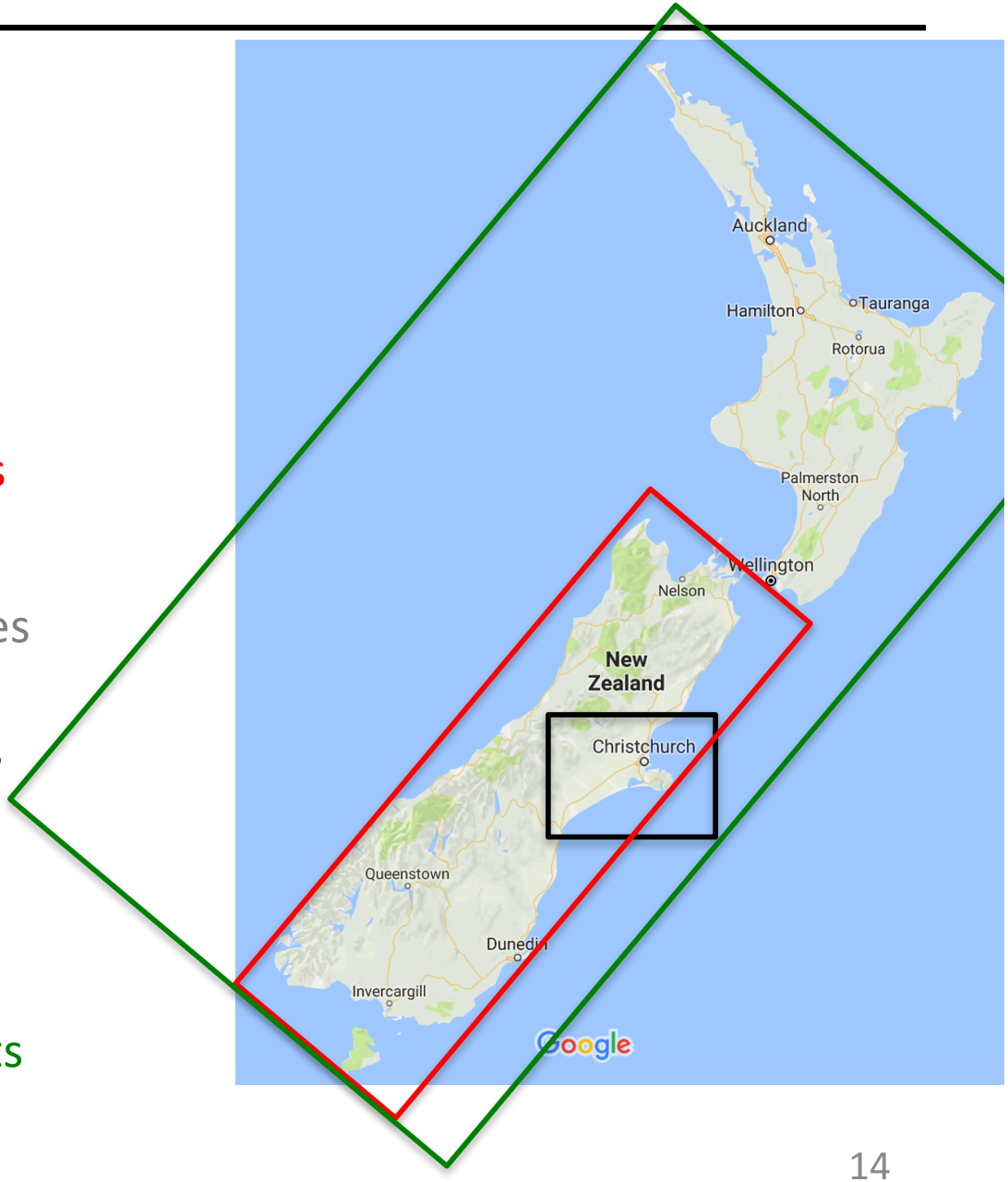
- ~ Jan 2018: New NESI HPC resources
- Feb 2018: Cybershake PSHA results for Canterbury based on f=0.5Hz
- March 2018: Cybershake PSHA results for NZ based on f=0.25Hz
- June 2018: Cybershake PSHA results for NZ based on f=0.5Hz



Thanks for your attention

Discussion …