Hybrid Broadband Ground Motion Simulation Validation of Small Magnitude NZ Earthquakes using NZVM 2.0

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Motivation

- Validation is important to quantify predictive capability of physics-based simulations.
- When advancements are made to simulations, need to re-validate.

Previous work

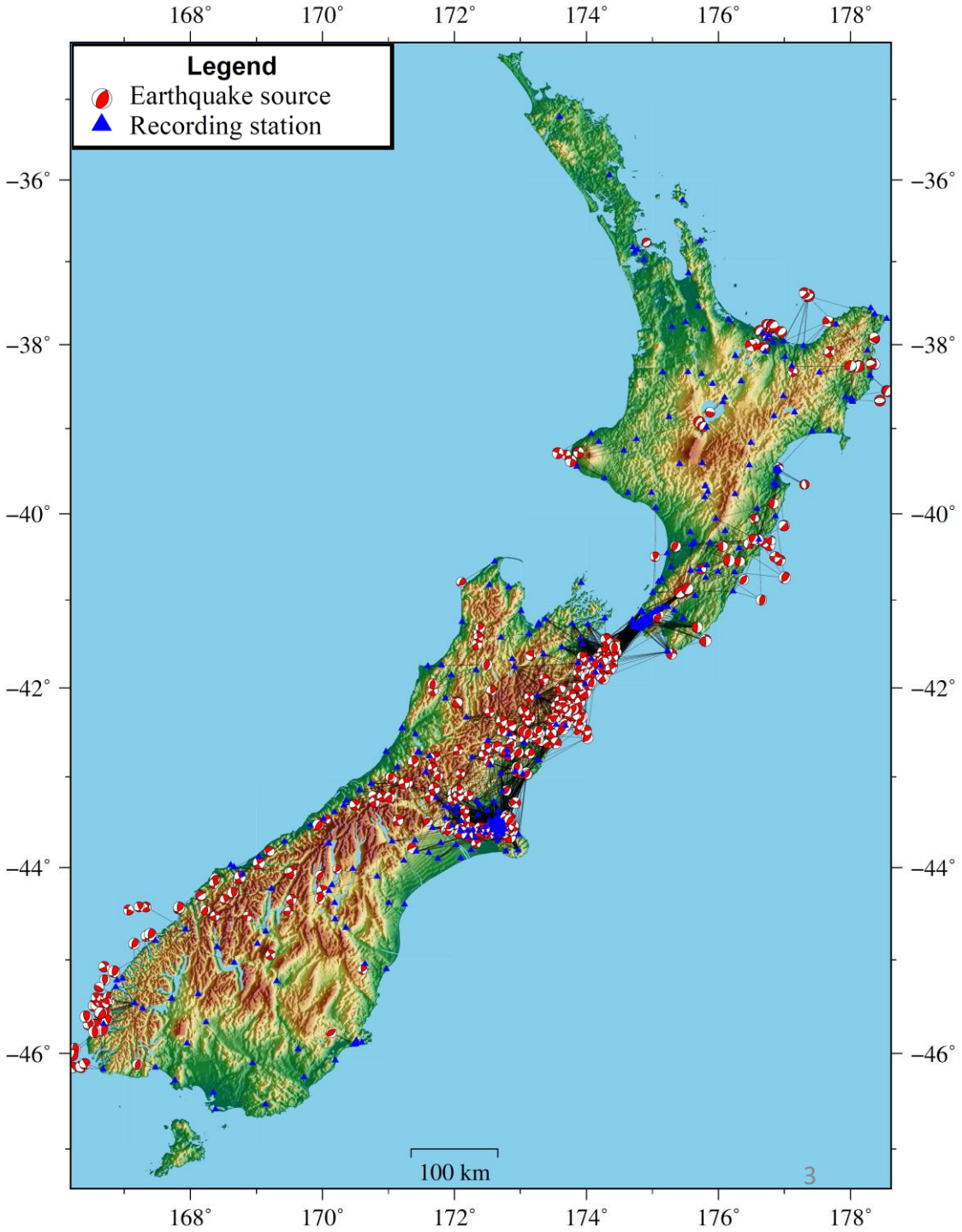
Region	Velocity Model	Simulation Versions
• Canterbury	• v1.66	• v17.5 • v18.5

Current work

• NZ	• v1.66 • v2.02	• v17.5 • v18.5

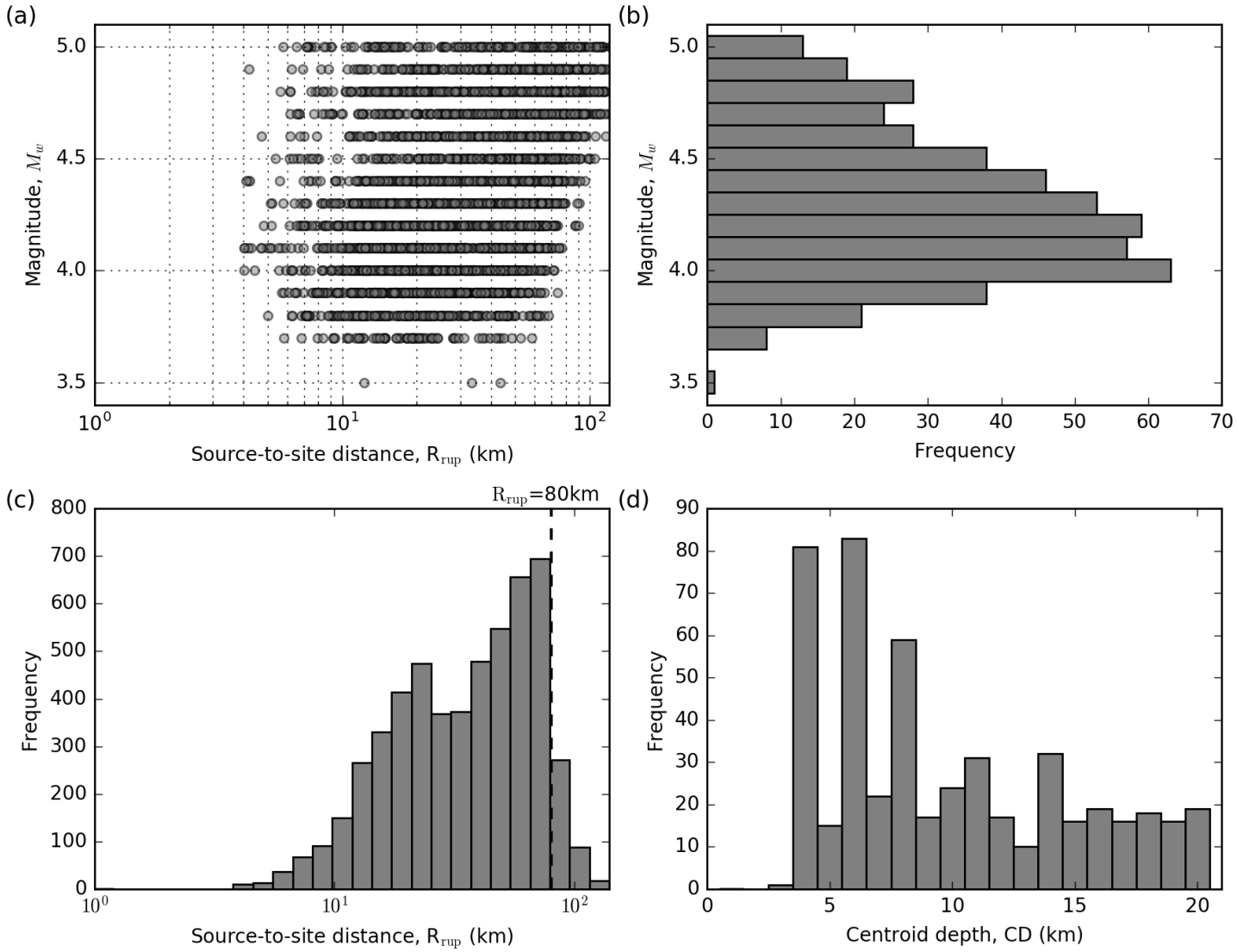
Events and Stations

- 498 earthquake events from initial set of 2268.
- Magnitudes between 3.5≤Mw ≤ 5.0.
- Minimum of 3 high-quality ground motions required per event.
- Earthquake source data obtained from GeoNet centroid moment tensor catalogue.
- 282 recording stations.



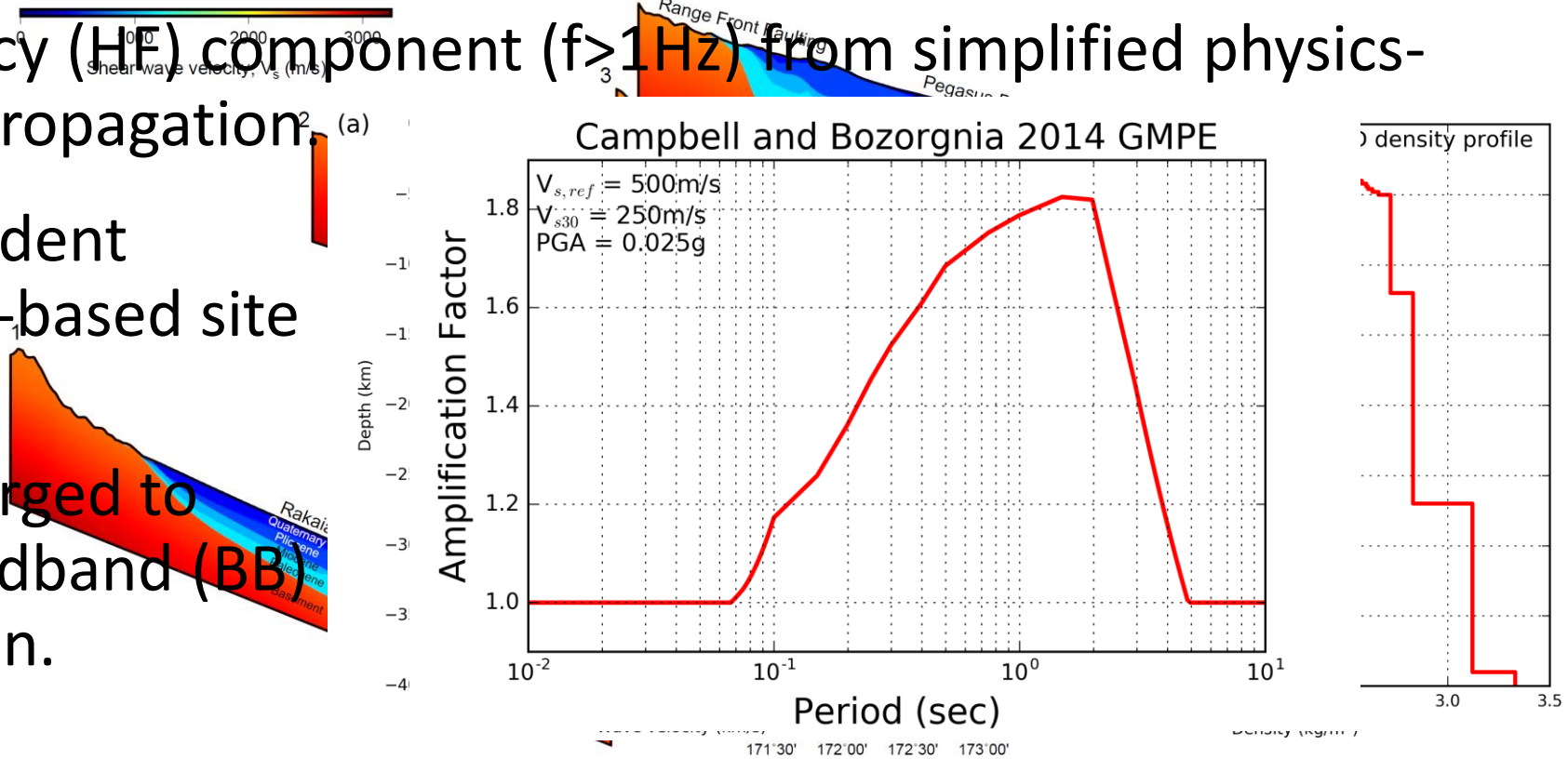
Events and Stations

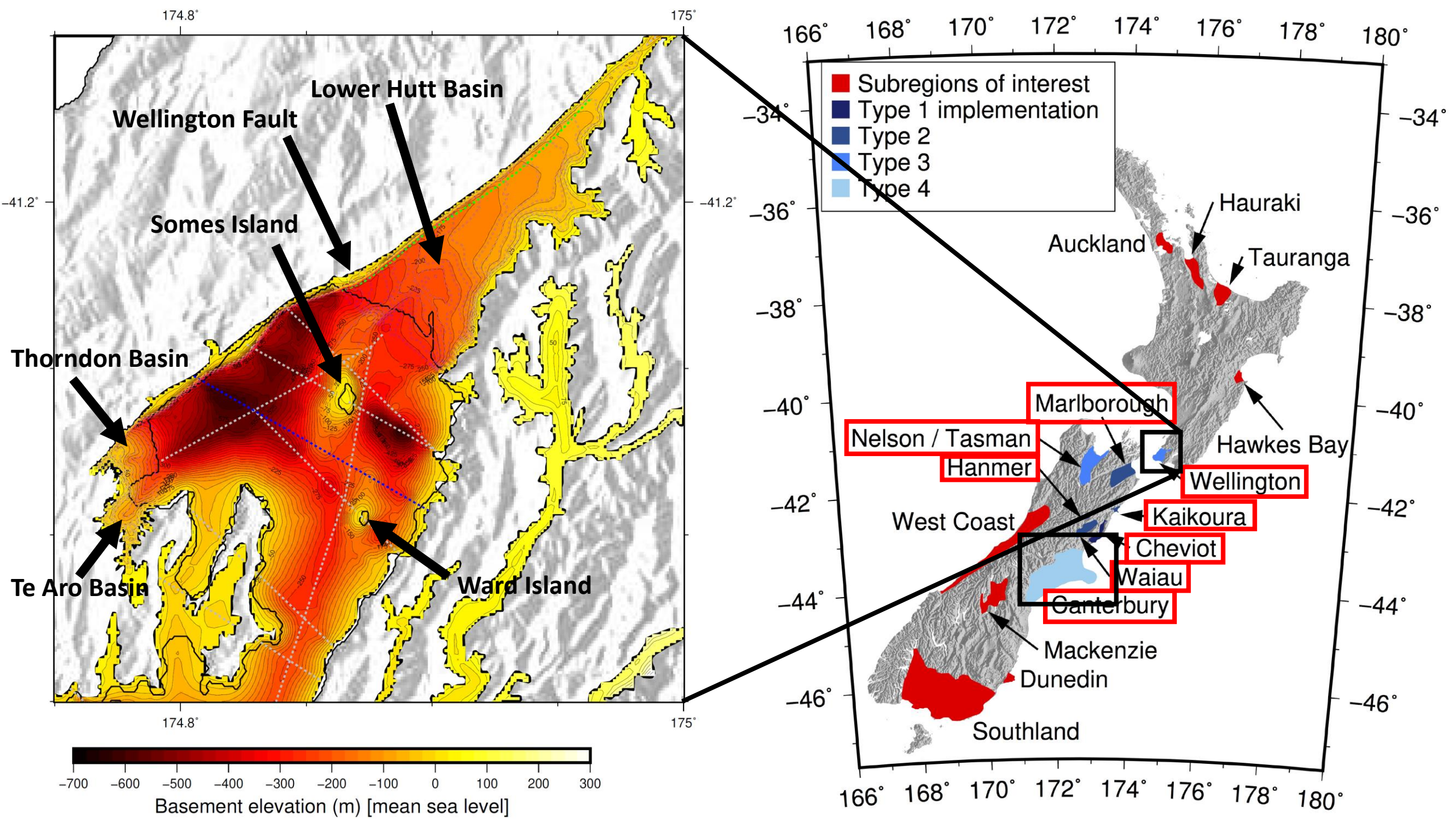
- Good distribution of Mw-Rrup.
- Most earthquakes are Mw≥4.0.
- Most records have Rrup≤80km.
- Limited to earthquakes with centroid depth≤20km.



Simulation Methodology

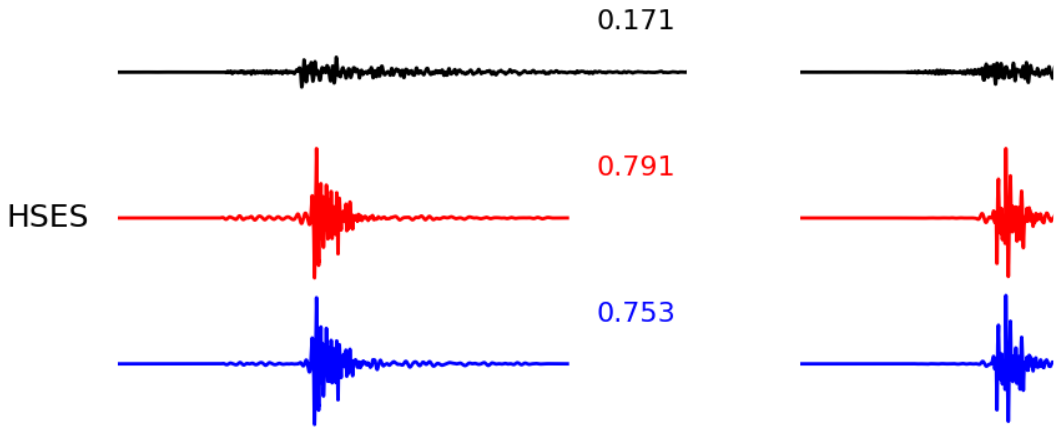
- Widely-used Graves and Pitarka (2010,2015) hybrid approach.
- Low-frequency (LF) component (f<1Hz) from comprehensive physics-based wave propagation.
- High-frequency (HF) component (f>1Hz) from simplified physics-based wave propagation.
- Period-dependent empirical V_{s30}-based site amplification.
- LF and HF merged to produce broadband (BB) ground motion.

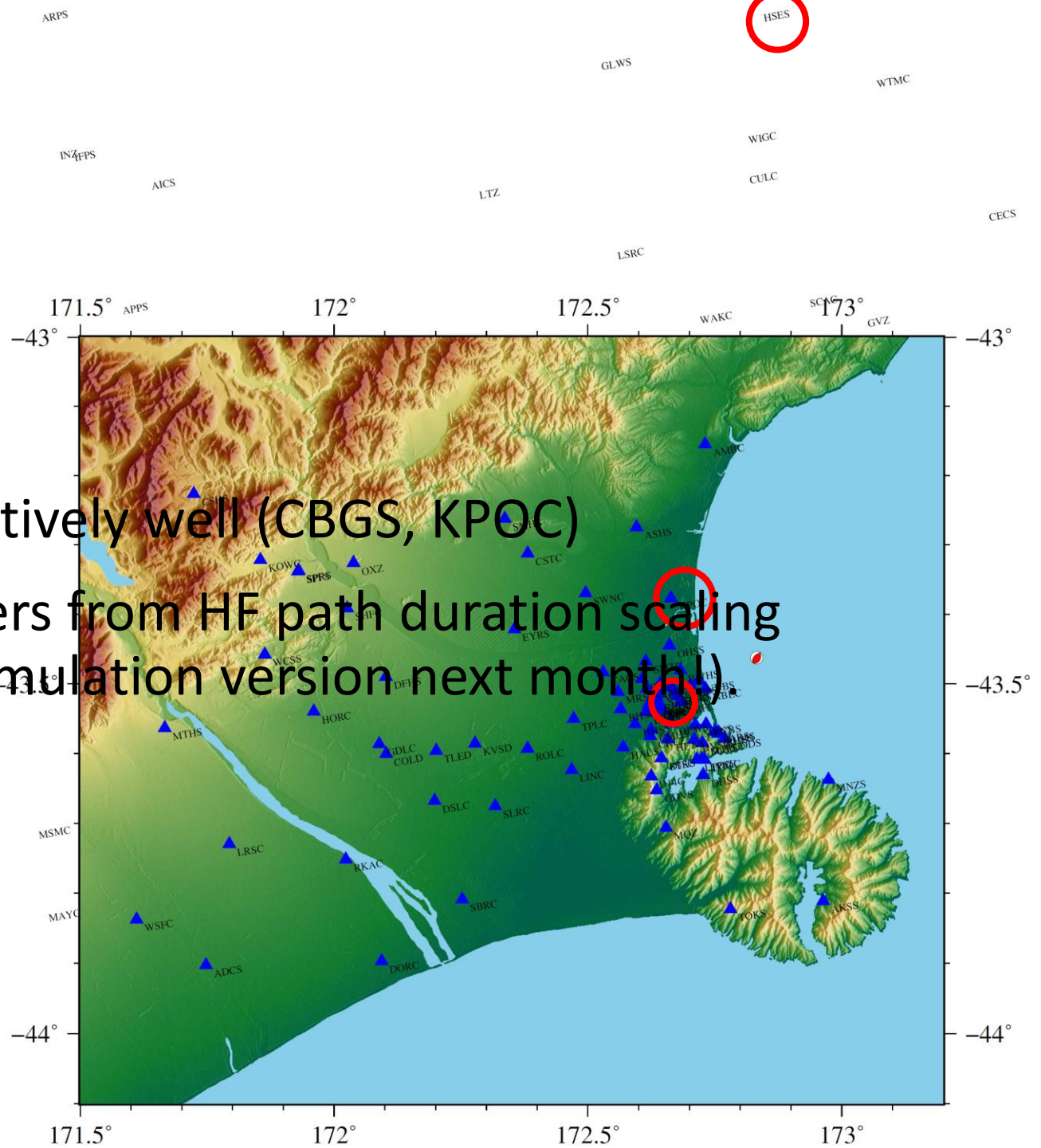



Lower Hutt Basin
Wellington Fault
Somes Island
Thorndon Basin
Te Aro Basin
Ward Island
174.8°
175°
-41.2°
−700 −600 −500 −400 −300 −200 −100 0 100 200 300
Basement elevation (m) [mean sea level]
Subregions of interest
Type 1 implementation
Type 2
Type 3
Type 4
166° 168° 170° 172° 174° 176° 178° 180°
-34° -36° -38° -40° -42° -44° -46°
Hauraki
Auckland
Tauranga
Marlborough
Nelson / Tasman
Hanmer
Hawkes Bay
Wellington
West Coast
Kaikoura
Cheviot
Waiau
Canterbury
Mackenzie
Dunedin
Southland

Individual event result

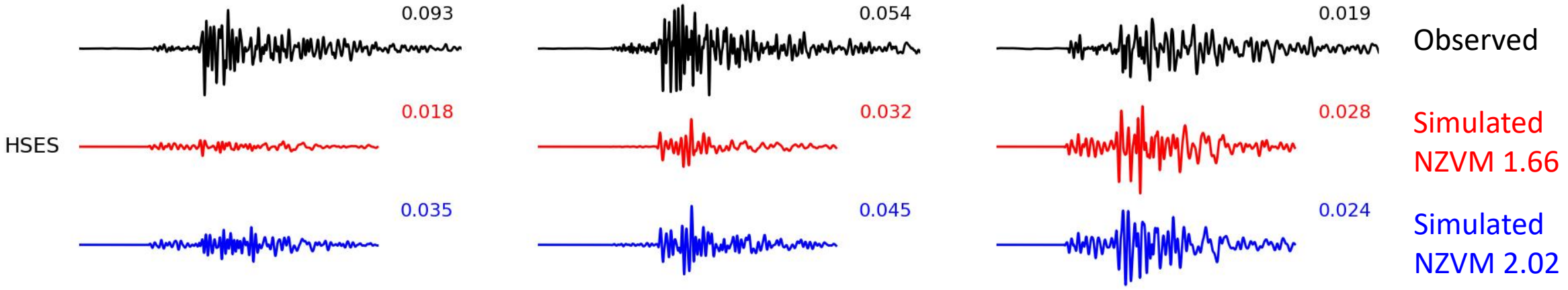
- Christchurch event 2012p001403
- Mw 4.8 located in the offshore ea
- Canterbury Basin sites match relatively well (CBGS, KPOC)
- HSES is located far away and suffers from HF path duration scaling problems (addressed with new simulation version next month!)





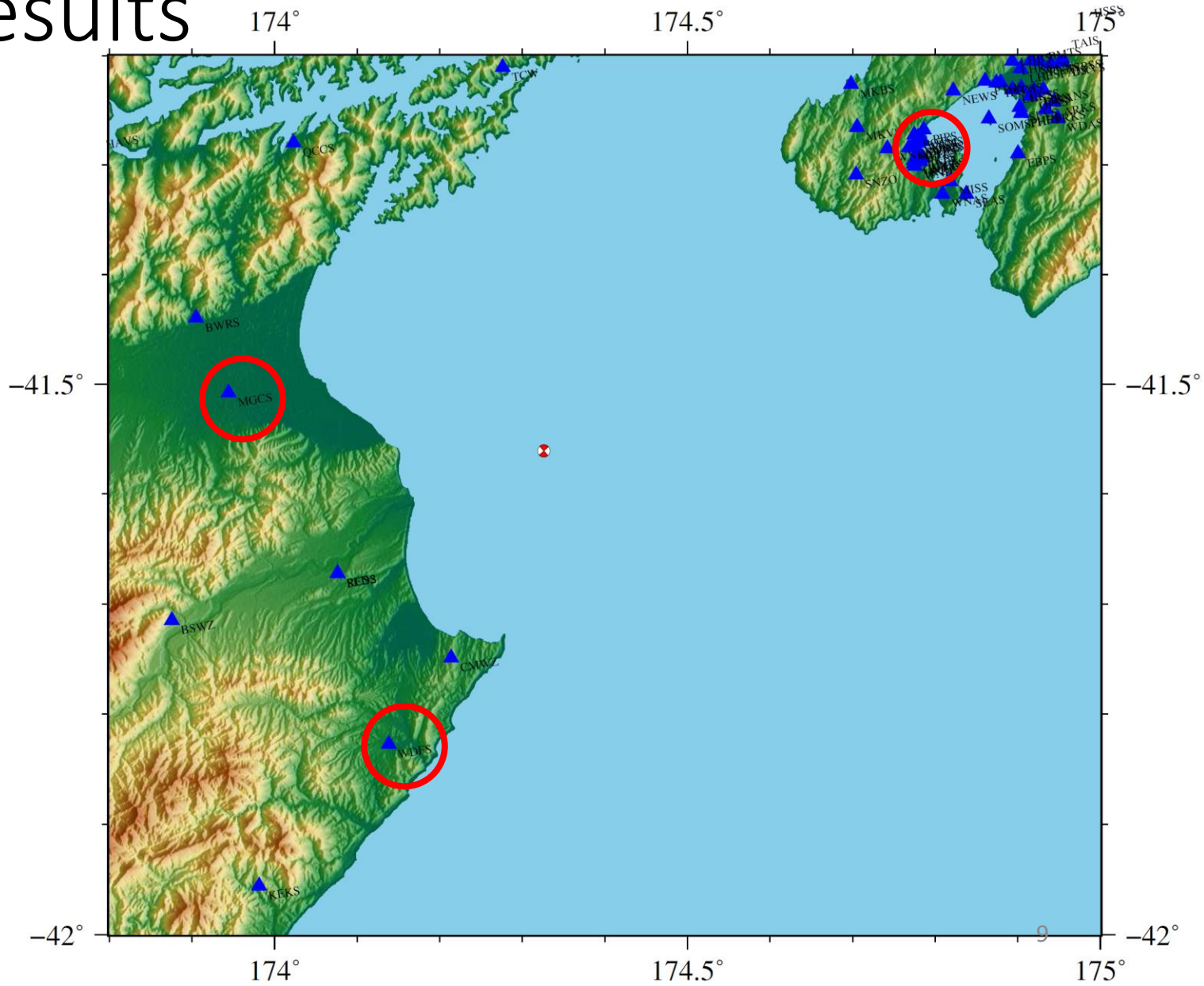
Individual event results – Low Frequency

- Canterbury Basin sites practically no change (e.g. CBGS, KPOC).
- Hanmer Springs site HSES larger amplitudes.
- No other “new basin” site with observation but comparing the two simulations shows the same trends (larger amplitudes and basin-generated waves).



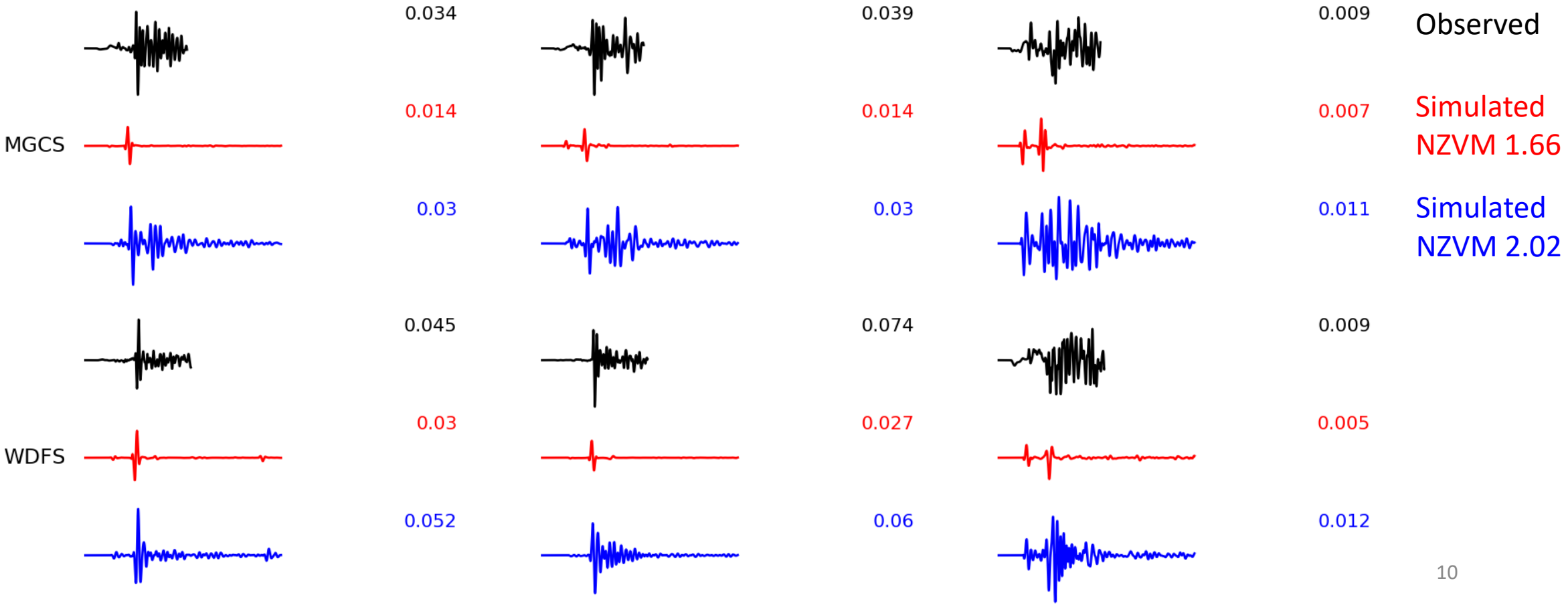
Individual event results

- Wellington event 2013p546148:
- Mw 4.2 located in Cook Strait between South Island and North Island.
- Show movie of simulation for NZVM 1.66 and 2.02.



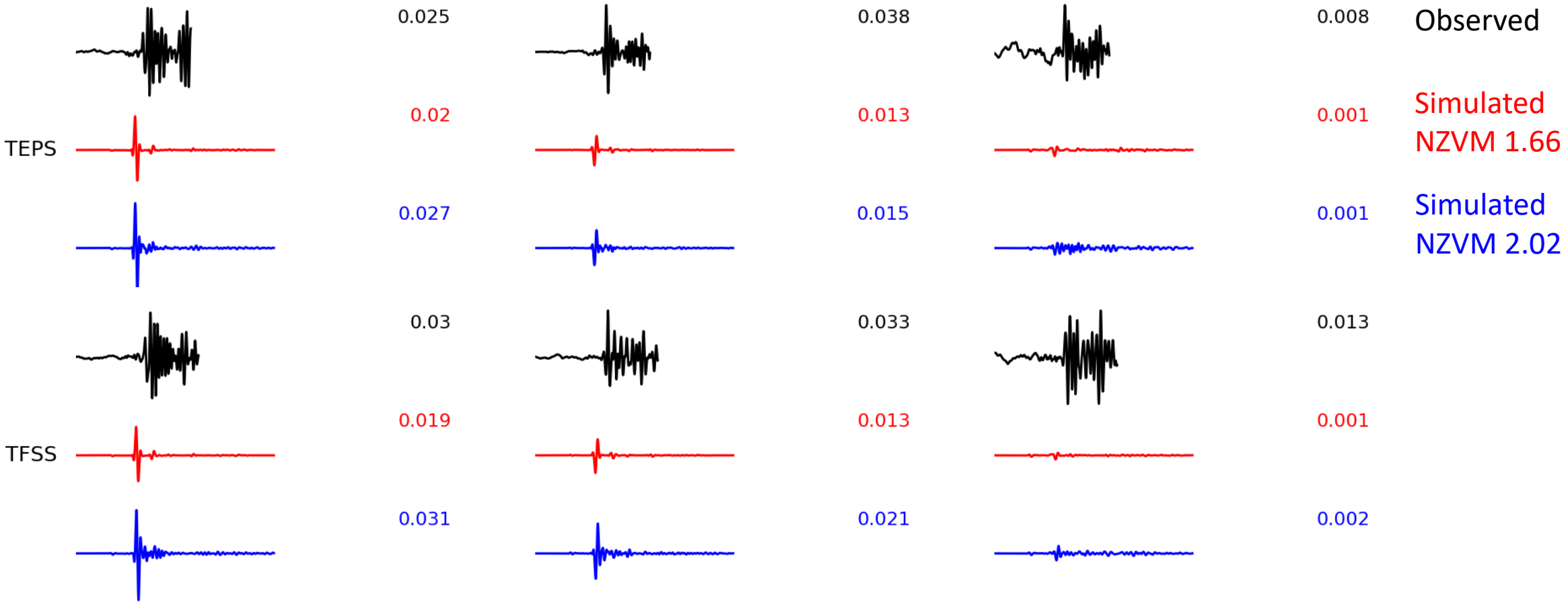
Individual event results – Low Frequency

- Marlborough basin sites:



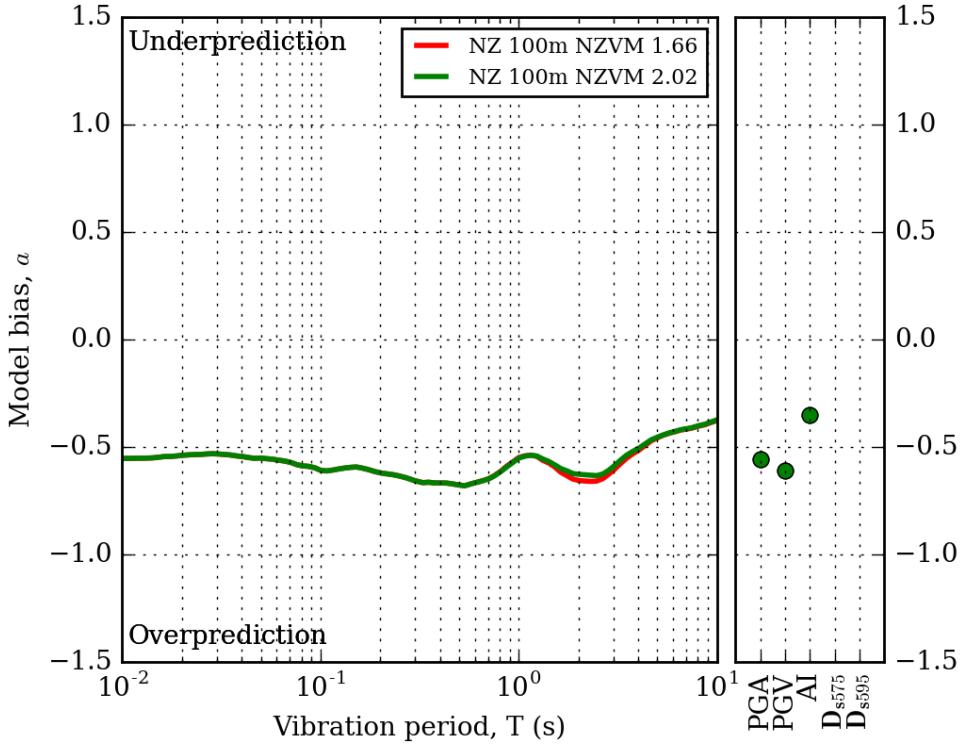
Individual event results – Low Frequency

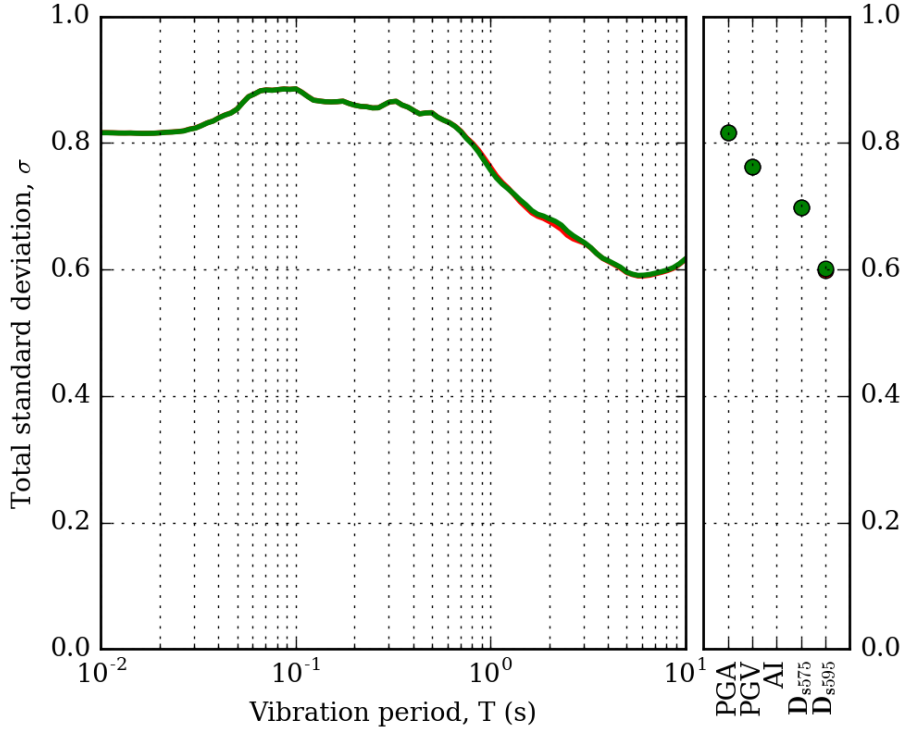
- Wellington basin sites:



Results across all events and stations

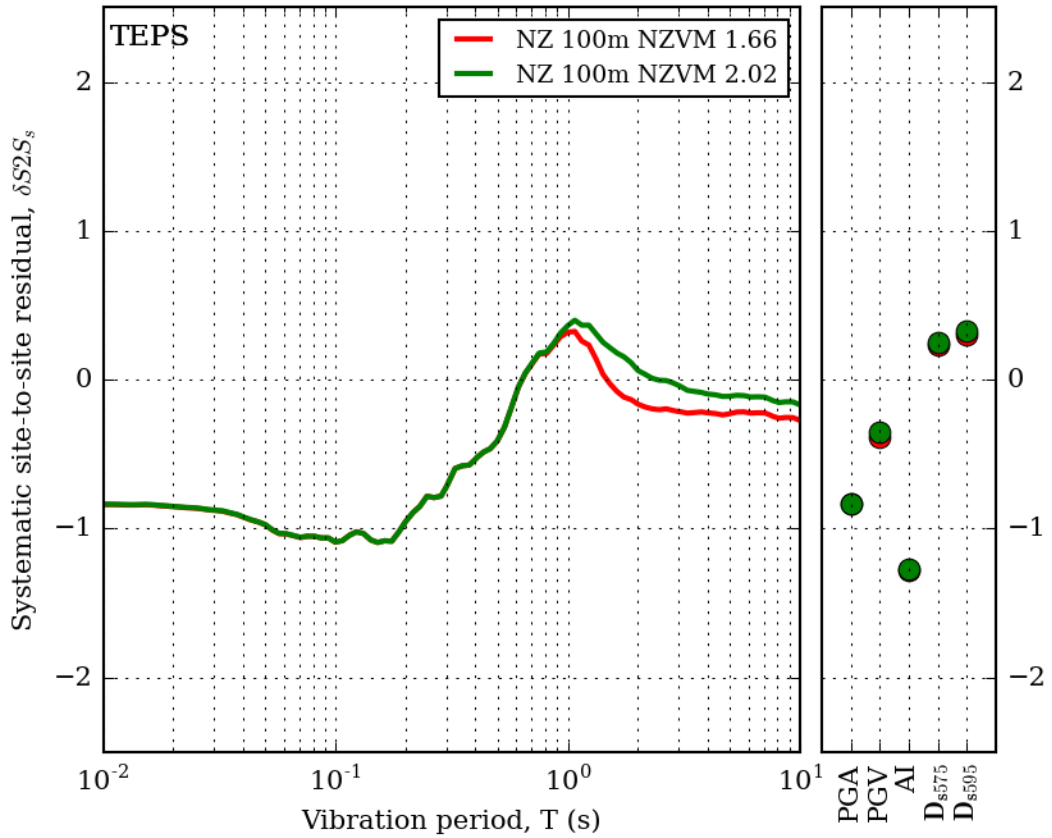
- Small changes as a relatively small number of stations are in newly modelled basins.
- Also there is an ambiguous trade-off between modelling the basin and the empirical site amplification.

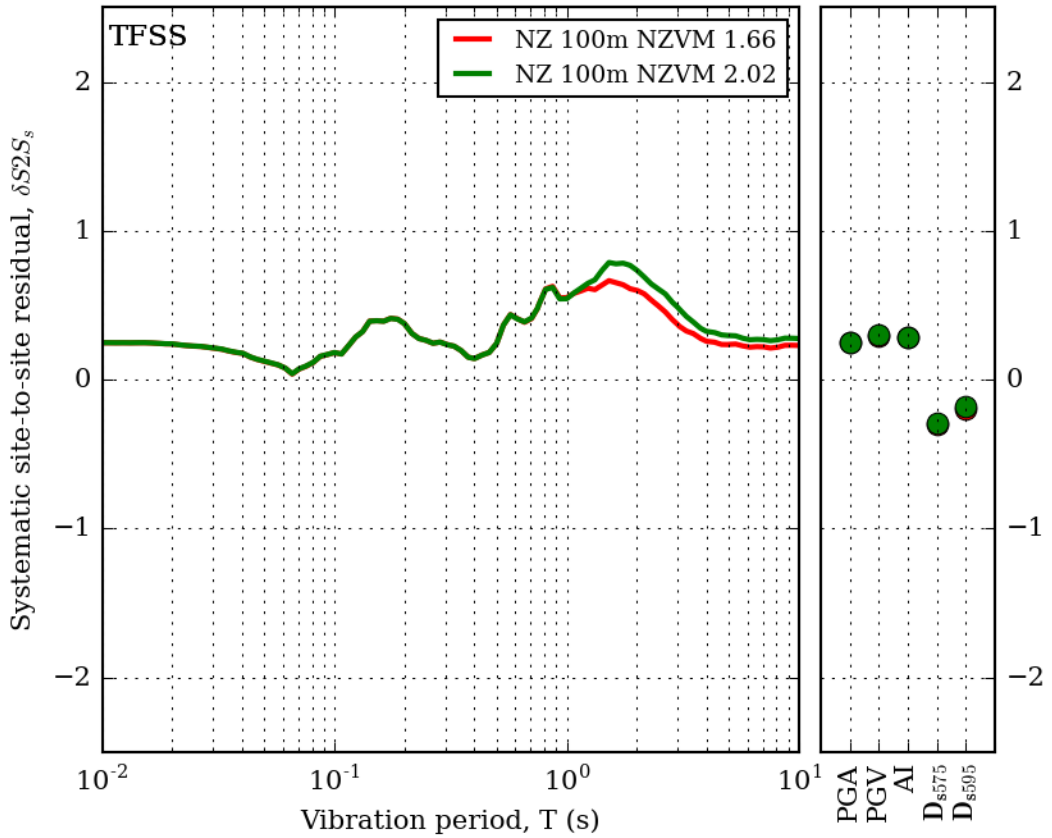




Systematic Site-to-site Residual

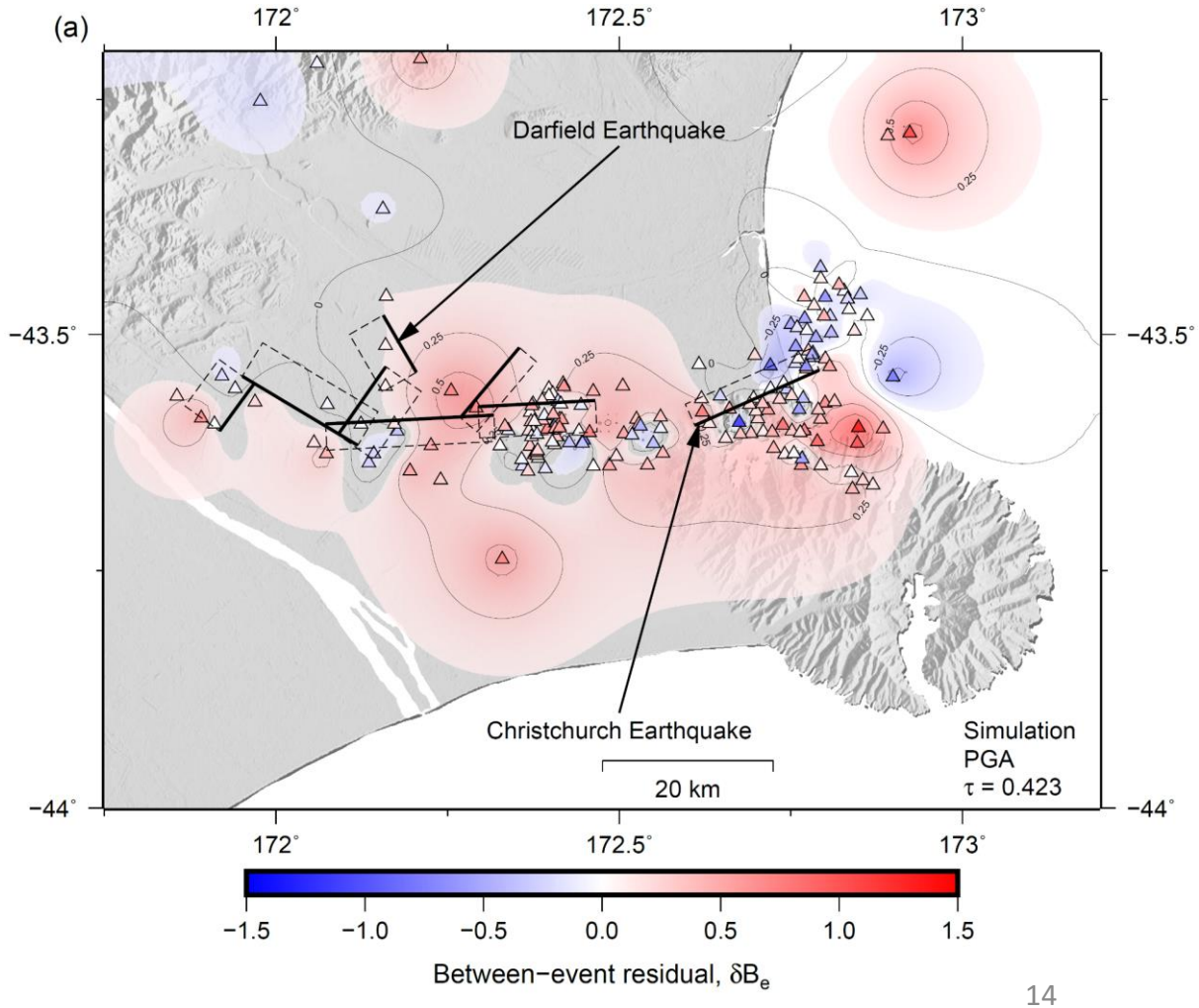
- Despite larger amplitudes arising from the finite difference LF simulation, application of empirical site amplification can result in larger LF amplitudes in the broadband ground motion.





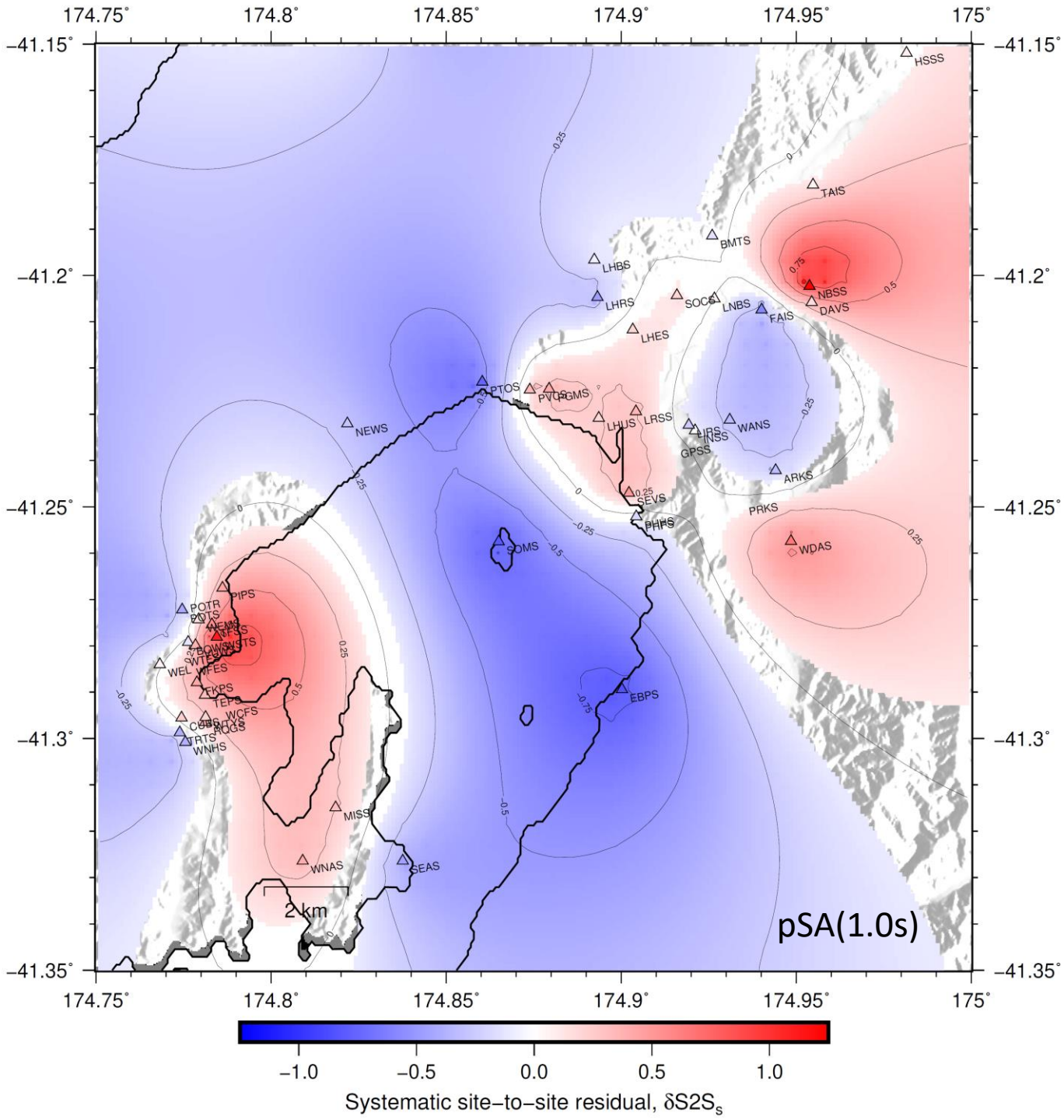
Between-event residual

- Spatial variability in between-event residual suggests spatial variation in source characteristics not being captured.
- E.g. Spatially variable stress drop.



Systematic site-to-site residual

- Spatial variability in systematic site-to-site residual suggests site characteristics can be modelled better.
- E.g. Better velocity characterisation and treatment of site effects.
- NZVM1.66 and NZVM2.02 results similar due to basin modelling and empirical site amplification trade-off.



Further work

- More and better sedimentary basin models.
  - Geometry of basins.
  - Velocity variations within basins.
- Improved ground motion simulation version.
  - Improved HF path duration.
  - Reduce LF site amp.
  - STAY TUNED, COMING AT NEXT MONTH’s FLAGSHIP 1 MEETING.
- Consider more earthquake events, i.e. M_w 5.0-6.0.