Updates to the Somerville et al. (2009) Ground Motion Model for Australia Using Broadband Ground-Motion Simulations

Australian Earthquake Engineering Society

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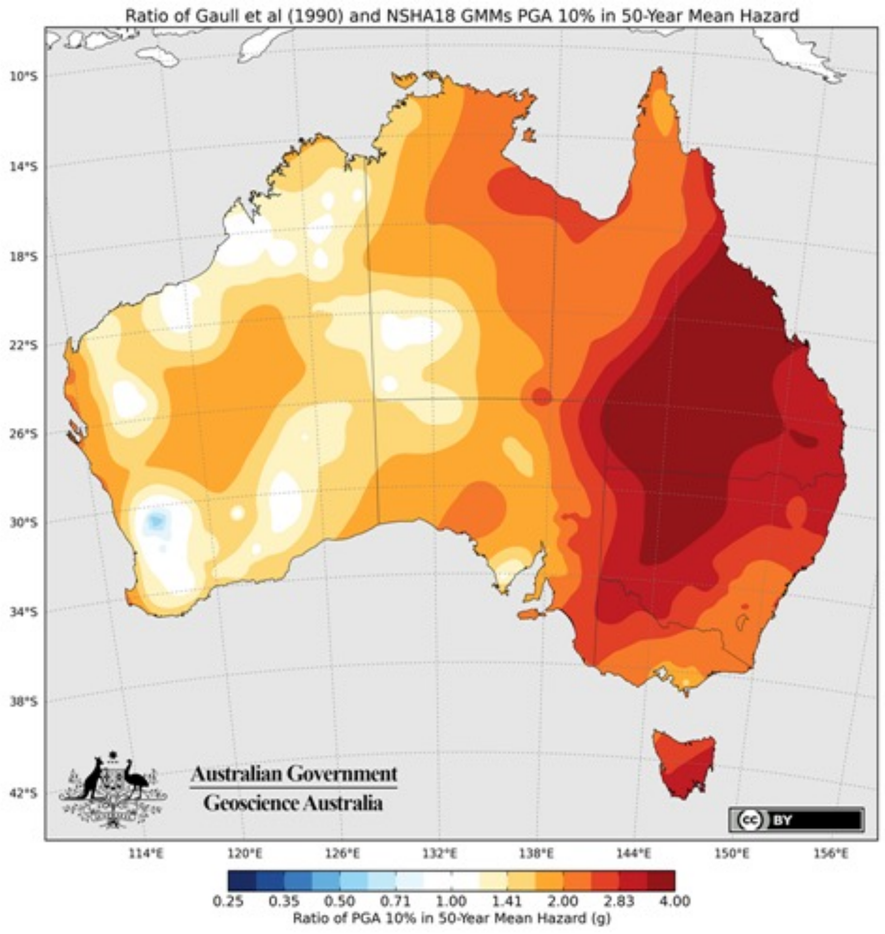
Introduction

- Seismic Hazard results are sensitive to the selection of ground motion models (GMMs)

- Use of modern GMMs, including Somerville et al (2009; Sea09), was one of the key factors contributing to the reduction of NSHA18 seismic hazard relative to the 1991 national map

- Sea09 are due for improvement by taking advantage of the ground motions recorded in Australia in the past decade-plus



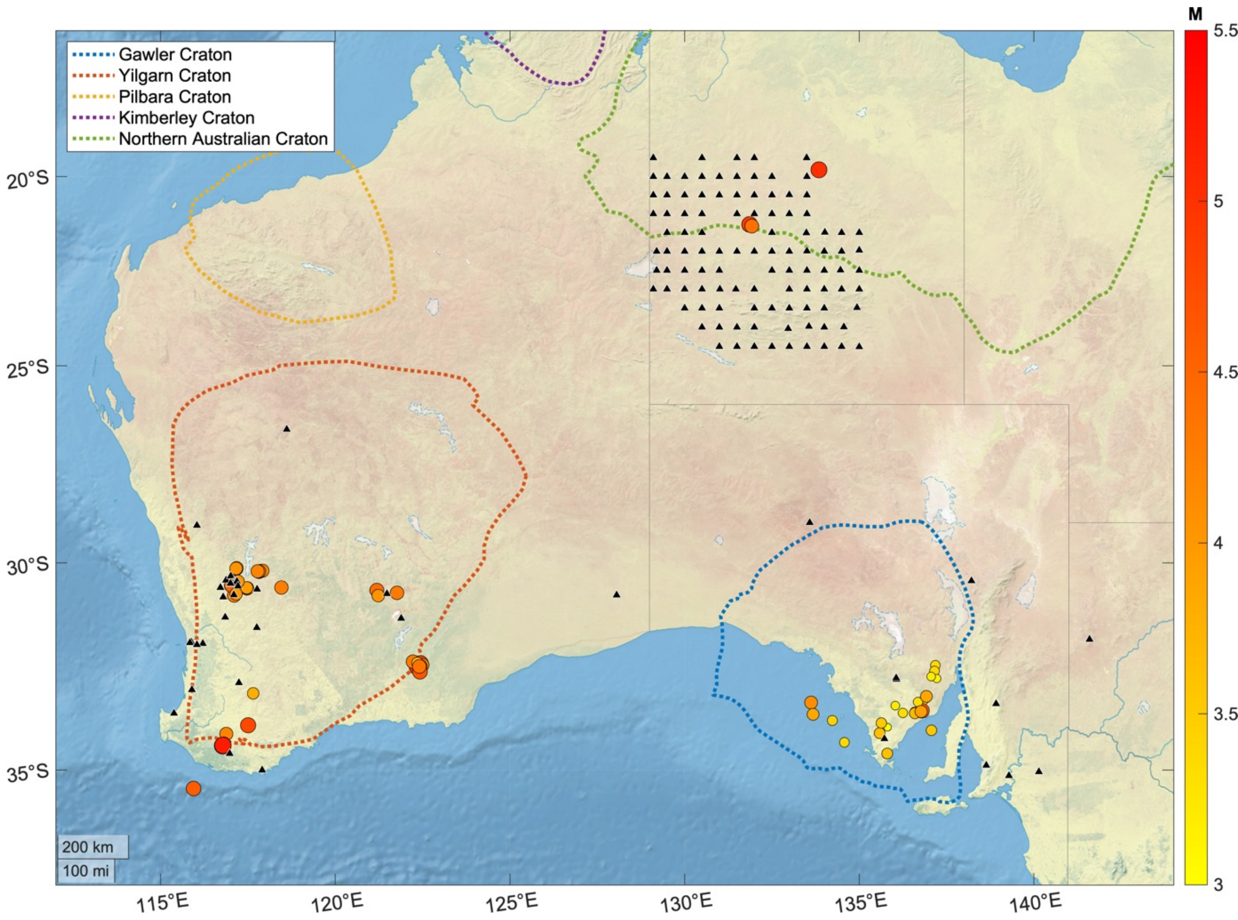
Source: Ghasemi and Allen (2023)

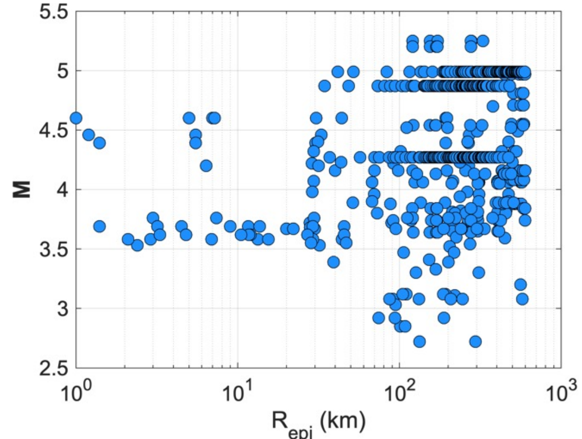
Earthquake Catalogue and Ground Motion Database

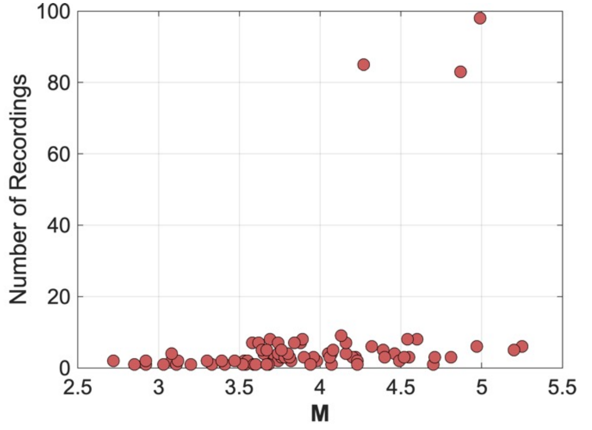
– Geoscience Australia is revising the earthquake catalogue for NSHA23

Ghasemi, H., and T. Allen (2021). Engineering ground-motion database for western and central Australia, Australian Earthquake Engineering Society 2021 Virtual Conference.

– We compiled a Cratonic earthquake ground motion database including waveform data from Ghasemi and Allen (2021) and from IRIS

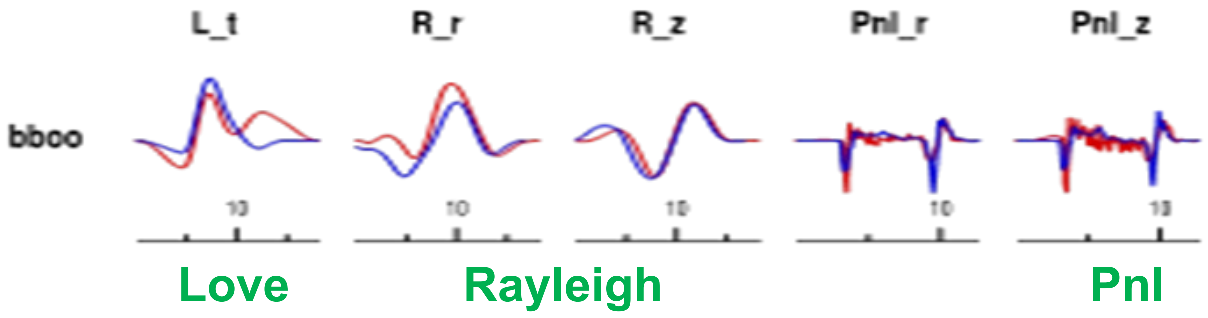






Earthquake Source Inversion for Seismic Moment, Focal Mechanism and Depth using Regional Seismograms

– “Cut & Paste” method breaks waveforms into Pnl (intermediate period shear coupled P wave propagation in the crustal waveguide); and surface wave (Love and Rayleigh wave) segments and inverts them independently for seismic moment, focal mechanism, and focal depth of the source



– Improved source parameter estimates for the earthquake catalogue used to update the GMM

Sommville, O. (1930). A propos d’une onde longue dans la première phase de quelques séismogrammes. Gerlands Beitraege zur Geophysik, 27, 437–442.

Zhao, L.S. and Don Helmberger (1994). Source inversion from broadband regional seismograms. BSSA 84, 92-104.

Zhu, Lupei and Don Helmberger (1996). Advanced source estimation techniques using broadband regional seismograms. BSSA 86, 1634-1641.

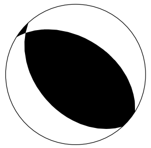
North Australian Craton event, 2019 08 01, Mw 4.96

2019/08/01 01:22:16.999

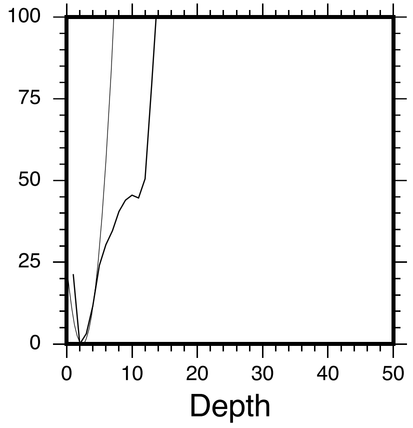
Lon: 133.916 Lat: -19.7647

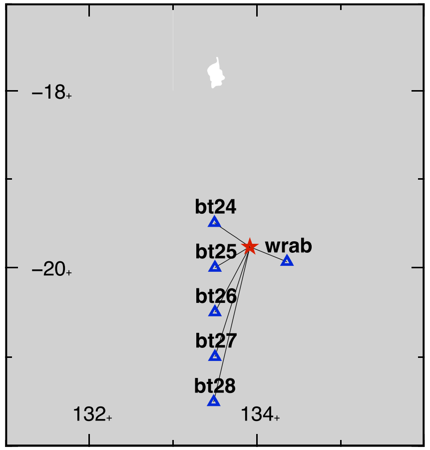
Depth: 02

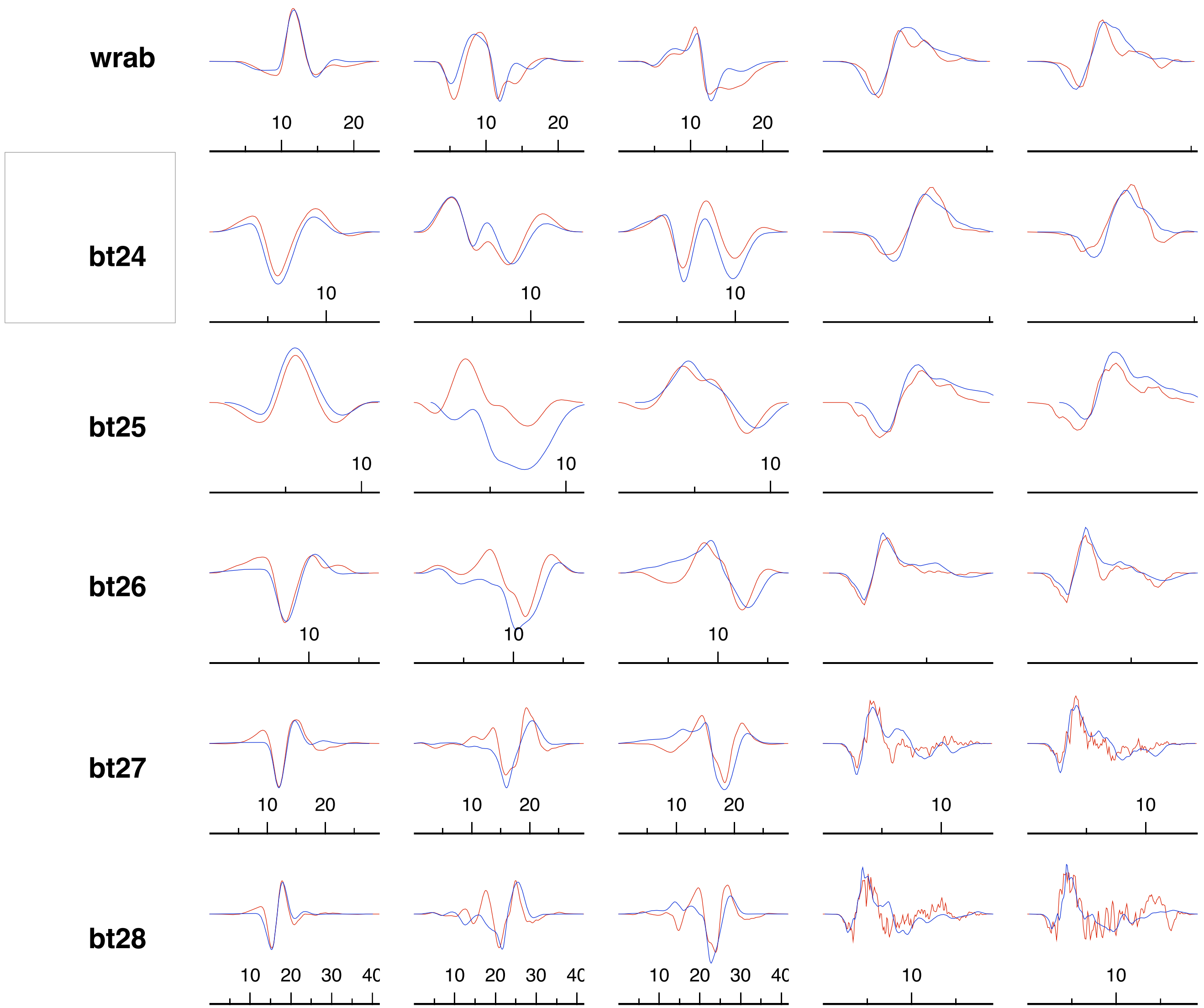
Mw: 4.96



Strike/dip/rake 302/47/79



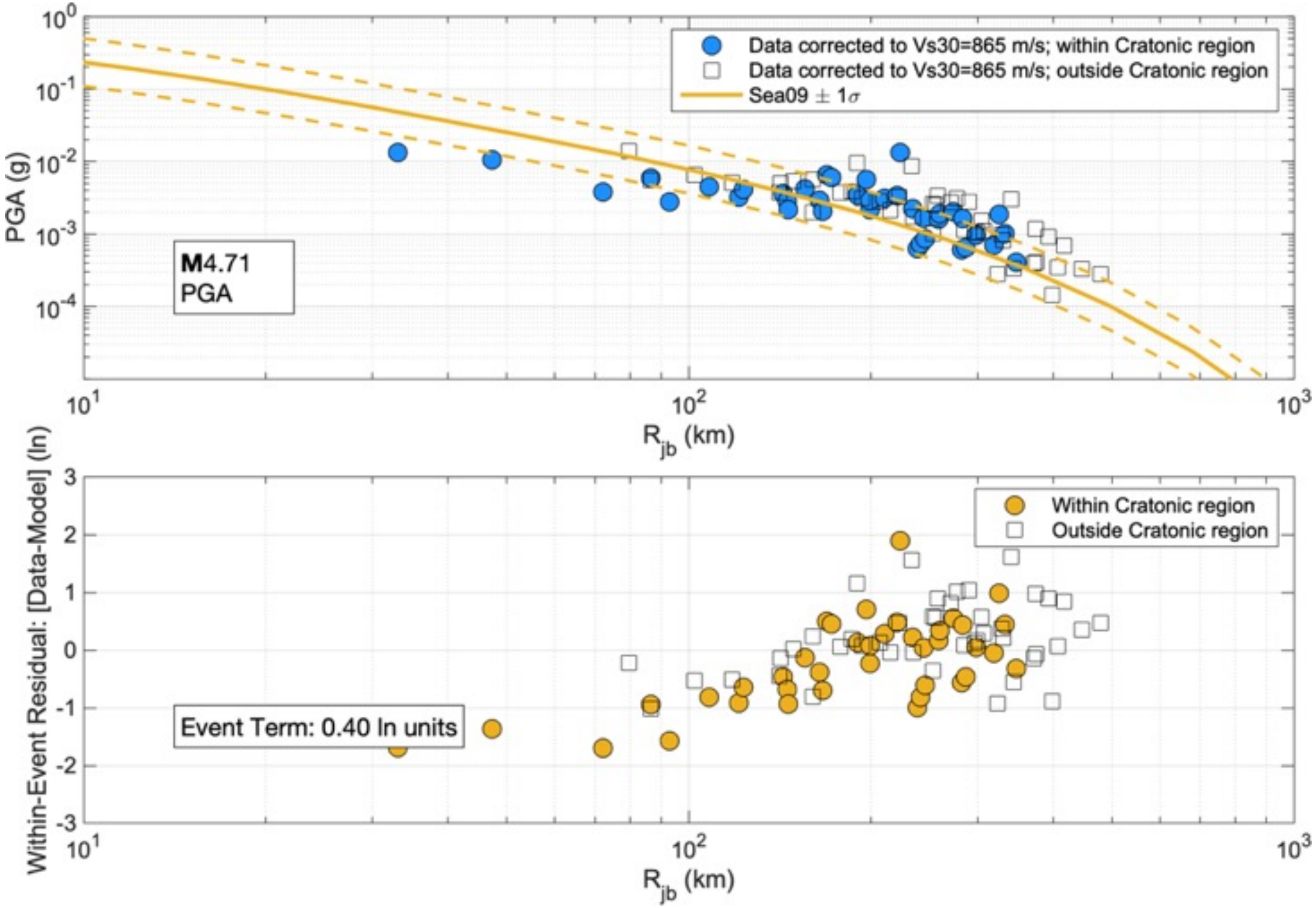




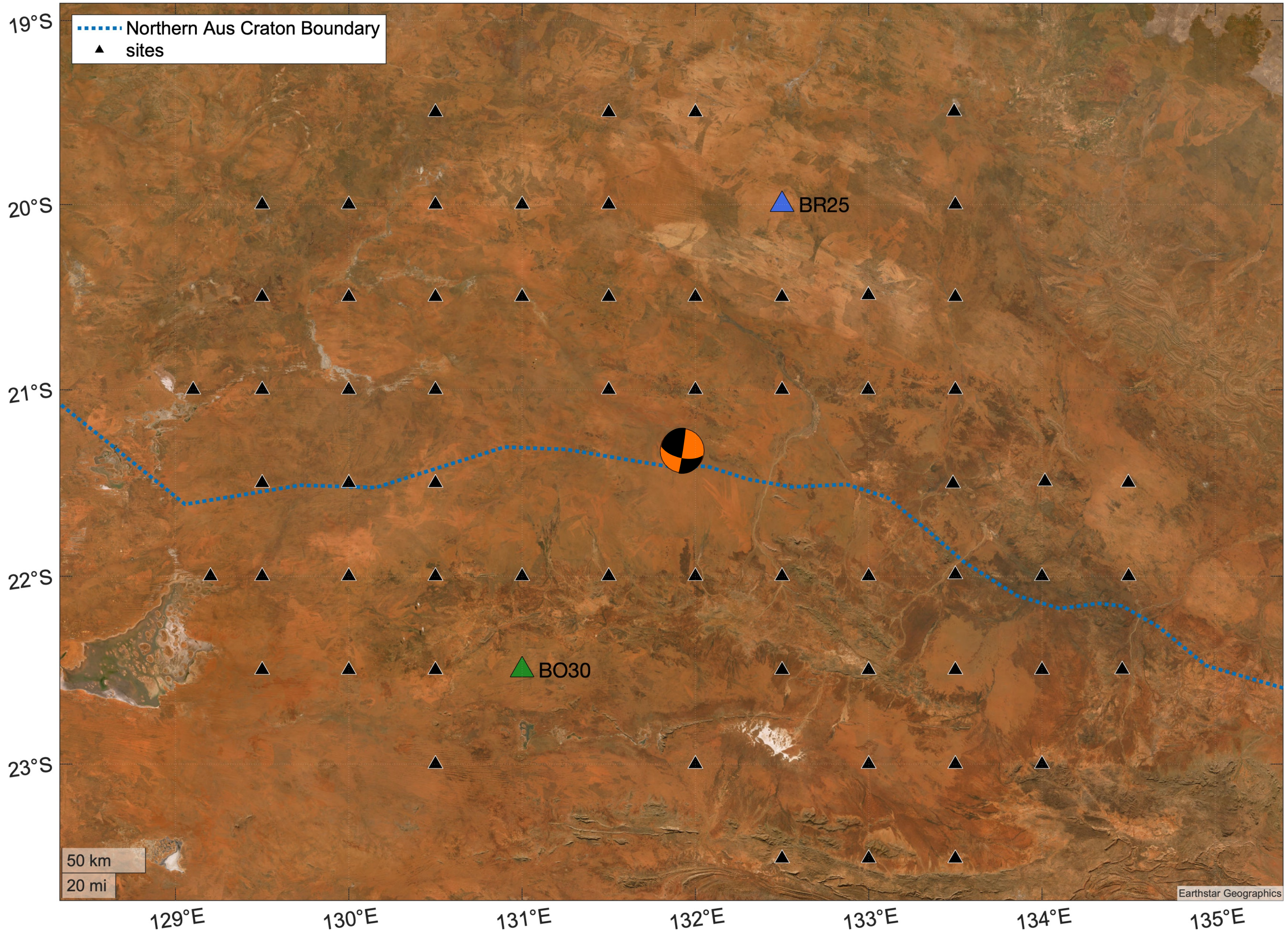
Empirical Calibration
Using the Catalogue with Revised Source Parameters

- Sea09 tends to overpredict at close distances and underpredict at large distances

- We updated the Sea09 Cratonic model coefficients which control the decay with distance:
  geometric spreading and anelastic attenuation terms



North Australian Craton Earthquake on May 30, 2019



The epicentre is located on the NSHA18 boundary (blue line) between the craton to the north and the reactivated Proterozoic crust to the south

One of the nodal planes of the focal mechanism is sub parallel to the boundary

The record at **BR25 (blue triangle)** is in the craton and the record at **BO30 (green triangle)** is at a similar distance outside the craton

The next slide shows that the response spectra have correspondingly different shapes (both adjusted to Vs30 = 865 m/s)

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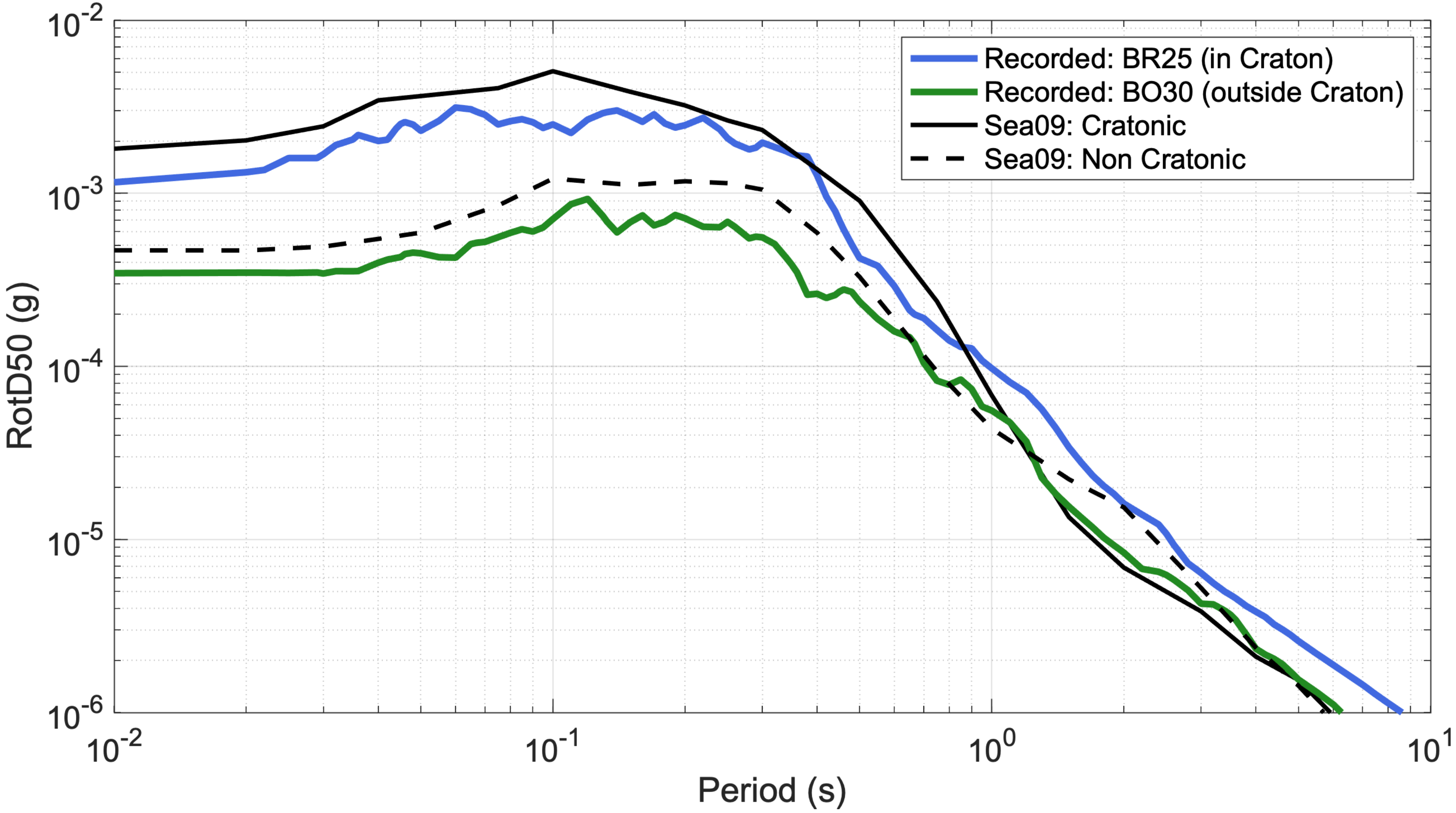
North Australian Craton Earthquake on May 30, 2019



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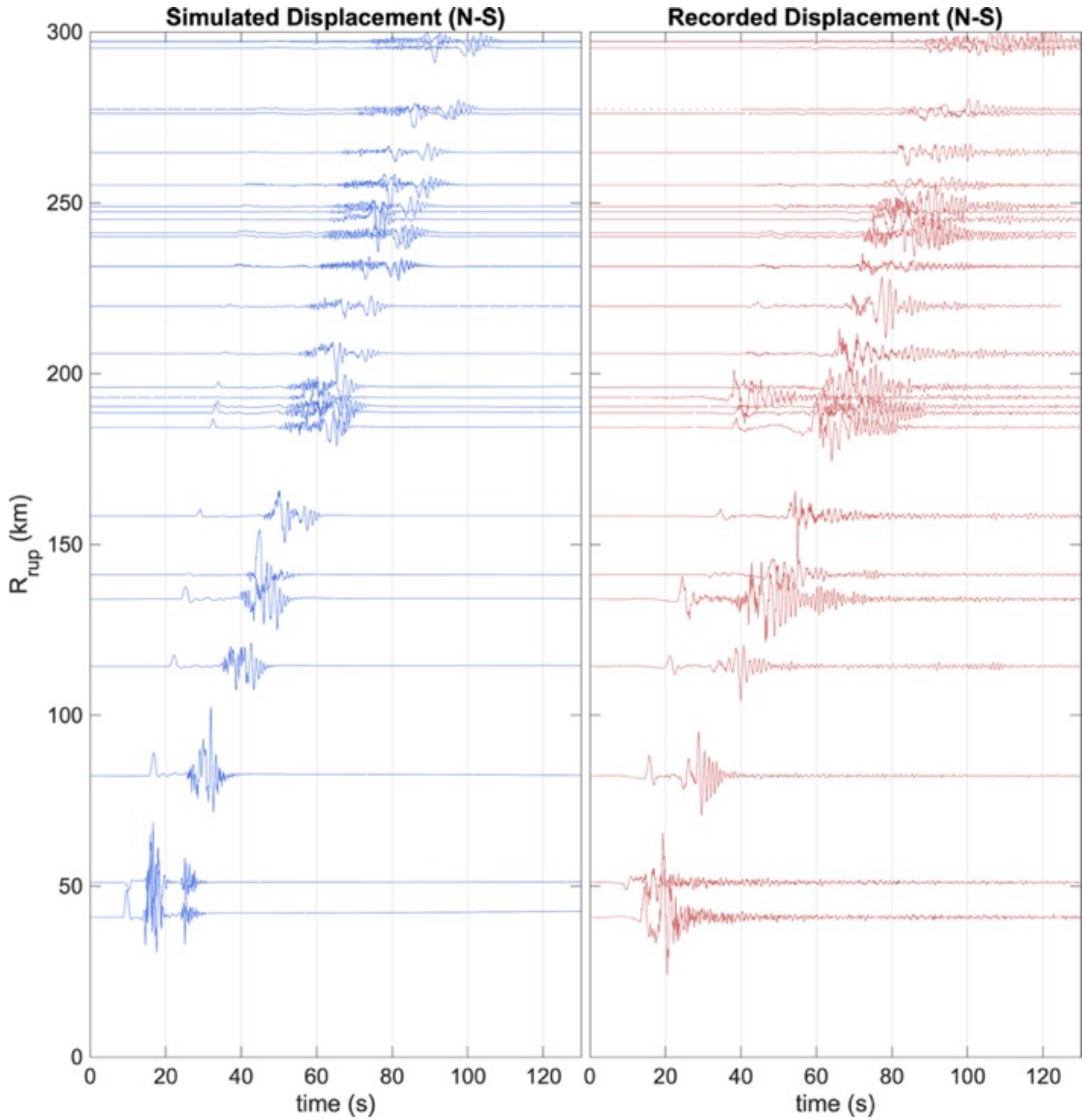
Earthquake Ground Motion Simulations

- Ground motion simulations are used to extrapolate the model to larger earthquake magnitudes that typically control design ground motions but for which no Australian data are available
- The earthquake ground motion simulations are validated using the recorded ground motion data.
- This portion of the Sea09 update is ongoing.



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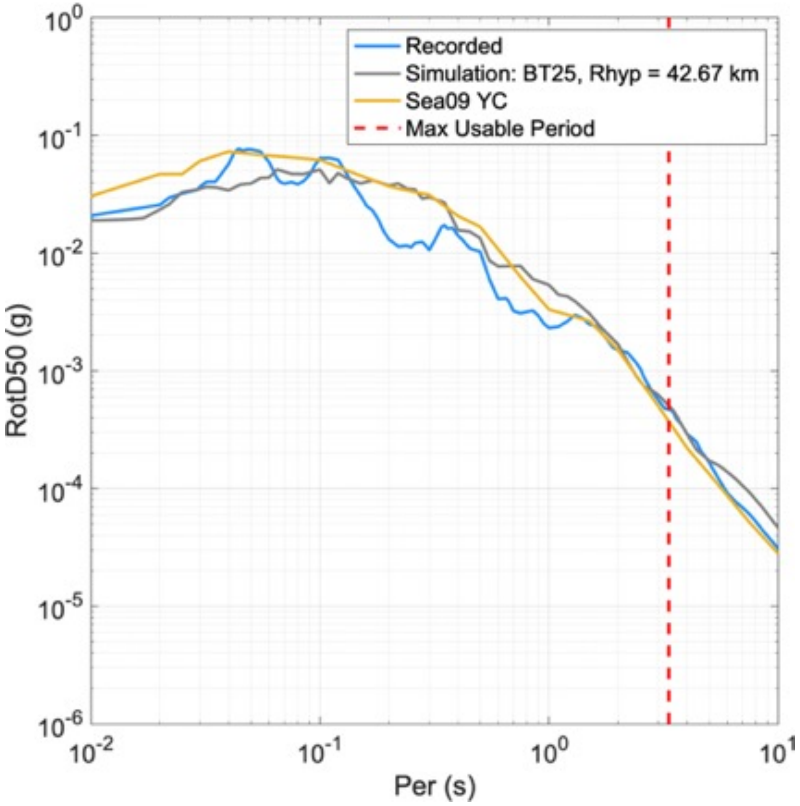
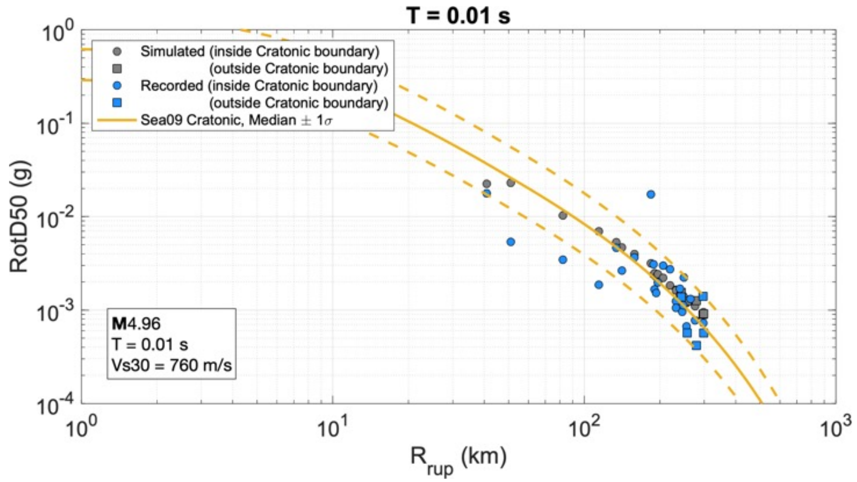
Recorded, Simulated and Model Response Spectra

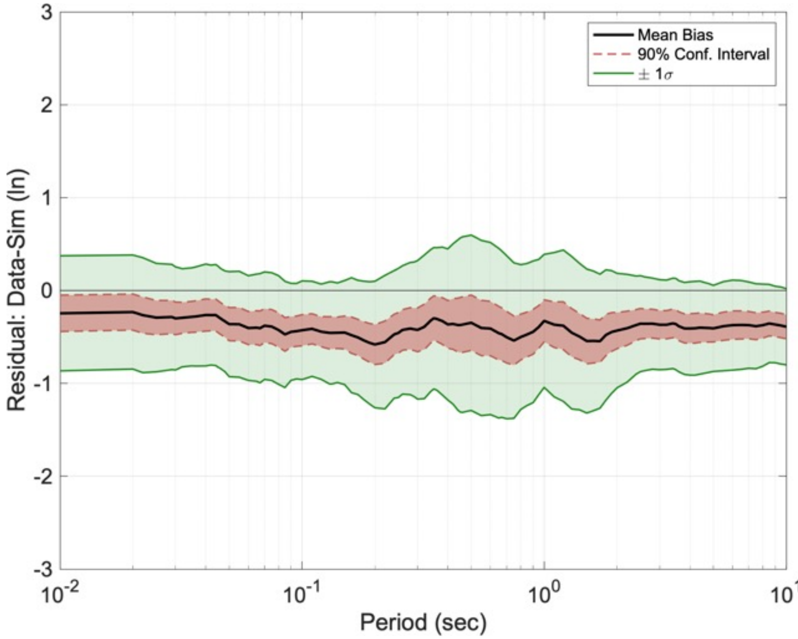
Response Spectral Shape



Distance Scaling

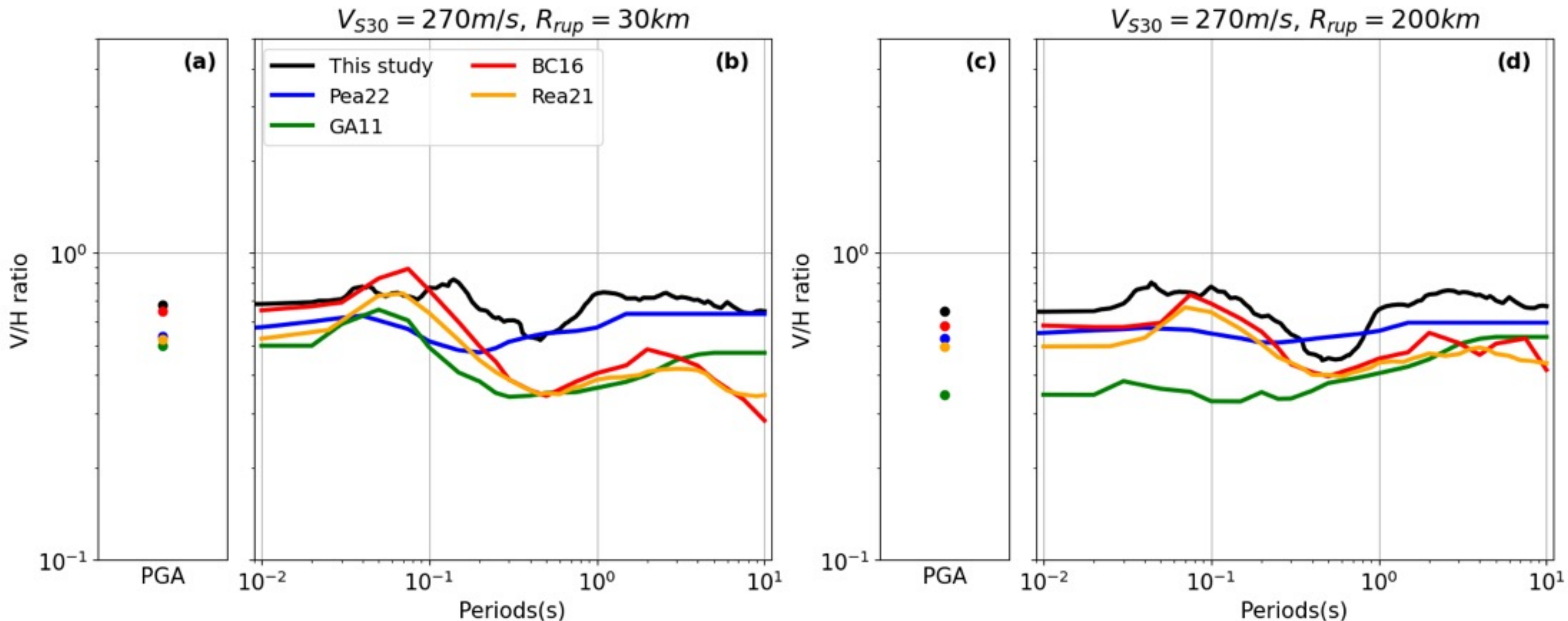


Mean bias and 90% confidence



Vertical to Horizontal (V/H) Spectral Ratios

- We developed a V/H model from the recorded database
- Observe (and model) generally larger V/H ratios than the other models



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Conclusions

- Comparisons with recently recorded ground motions in Australia have revealed that refinements to the distance and depth scaling components of the Sea09 model provide a better fit to those data.

- The updated Sea09 model incorporates the earthquake depth; accounting for the effects of Rg waves (from shallow events, impacting longer periods) and for energetic buried ruptures (impacting short periods).

- Ground motion simulations provide a good fit to recorded ground motions in the dense Northern Territory array. The remaining Sea09 updates will be finalized once the validation phase is complete.

- These conclusions have been enabled by the high quality and volume of the seismograms and geological information made available by Geoscience Australia and University of Melbourne.

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