*Seismica*

Supporting Information for

**Validation of tsunami earthquake ground-motion simulations using near-field observational data: Rupture parameter constraints from the 2010 Mentawai event**

T. A. Nye1,†, V. J. Sahakian1, D. Melgar1

1Department of Earth Sciences, University of Oregon, Eugene, Oregon, USA

†Now at the US Geological Survey, Moffett Field, California, USA

**Contents of this file**

Figures S1 to S9

**Introduction**

This electronic supplement contains the illustrations of the kinematic slip models used to generate synthetic waveforms for the 2010 Mentawai tsunami earthquake, a comparison between the original coarse slip model from Yue et al. (2014) and our finely discretized model, an illustration of the matched filter technique implemented, examples of observed ringing and effects of varying the shallow velocity structure, and an example of **M**PGA estimation. Rupture files and waveforms for the simulations can be accessed via the accompanying Zenodo dataset (Nye et al., 2024).

A screenshot of a computer screen

Description automatically generatedFigure S1. Slip models for all 30 initial stochastic ruptures (i.e., mentawai.000000, mentawai.000001, …, mentawai.000029, respectively).

**Figure S1.** Continued…A screenshot of a computer screen

Description automatically generated

**Figure S1.** Continued…A screenshot of a computer screen

Description automatically generated

**Figure S1.** Continued…

A screenshot of a computer screen

Description automatically generated

A screenshot of a computer

Description automatically generated**Figure S2.** (a) Coarsely discretized slip model from Yue et al. (2014). (b) Finely discretized version of the slip model from (a) used as the mean slip model for this study.

**A collage of different colored lines

Description automatically generatedFigure S3.** (a) Illustration of the simulation matched filter process using a common corner frequency (*f*c) for both the lowpass and highpass filters. (a) Normalized amplitudes of the individual low-frequency (yellow) and high-frequency (purple) waveforms in units of acceleration prior to any filtering. (c) Normalized amplitudes of the individual lowpass filtered low-frequency (yellow) and highpass filtered high-frequency (purple) waveforms, both with a filter *f*c of 1 Hz. (e) Normalized amplitude of the resulting broadband waveform after combing the waveforms in (c). (b,d,f) Fourier amplitude spectra of the waveforms in (a,c,e). The dashed line in (d) indicates the filter *f*c, and the black box in (f) highlights the artificial notch in the broadband spectrum.

**A collage of different colored lines

Description automatically generatedFigure S4.** Illustration of the matched filter process using a separate corner frequency (*f*c) for the lowpass and highpass filters. (a) Normalized amplitudes of the individual low-frequency (yellow) and high-frequency (purple) waveforms in units of acceleration prior to any filtering. (c) Normalized amplitudes of the individual low-frequency (yellow) waveform lowpass filtered with a filter *f*c of 1 Hz, and the high-frequency (purple) waveform highpass filtered with a filter *f*c of 0.1 Hz. (e) Normalized amplitude of the resulting broadband waveform after combing the waveforms in (c). (b,d,f) Fourier amplitude spectra of the waveforms in (a,c,e). The dashed and dotted lines in (d) indicate the lowpass and highpass filter *f*c, respectively, and the black box in (f) highlights the smoothed spectrum absent of an artificial notch.

**Figure S5.** Observed HR-GNSS displacement waveforms for the 2010 **M**7.8 Mentawai event.

*A group of blue lines

Description automatically generated*

**A screenshot of a graph

Description automatically generatedFigure S6.** Observed strong-motion acceleration waveforms for the 2010 **M**7.8 Mentawai event.

**Figure S7.** Fourier amplitude spectra of the ringing observed in the strong-motion and GNSS recordings of the 2010 Mentawai event. To capture the ringing, the records were trimmed to start at 2010–10–25T14:47:02Z. For both the seismic and geodetic data, the energy peaks around 0.1 Hz.**A graph of a graph showing different types of motion

Description automatically generated**

**Figure S8.** (left) Comparison between the original velocity model used for this study and three variations of the velocity model using softer layers in the shallow subsurface. (right) Binned displacement Fourier amplitude spectra for three example HR-GNSS stations using the different velocity models.

A graph of different types of data

Description automatically generated with medium confidence

**A graph of a graph of a number of numbers

Description automatically generated with medium confidenceFigure S9.** Example solvation for **M**PGA for one stochastic event with one set of parameters. (top) P-value for Kolgomorov–Smirnov (K–S) tests performed between simulated PGA values and GMM PGA predictions for trial magnitudes ranging **M**5.5-8.5. **M**PGD and **M**PGA for this event are indicated by the gold and red lines, respectively. (bottom) Statistic values for the K–S tests.

**Data and code availability**

Observed data for the 2010 Mentawai tsunami earthquake were obtained from Muzli Muzli of the Agency for Meteorology, Climatology, and Geophysics of Indonesia (BMKG) and from the Rhul et al. (2019) database. These data were recorded by HR-GNSS instruments operated by the Badan Informasi Geospasial (BIG) and strong-motion stations operated by the BMKG. Simulated data were generated using *FakeQuakes*, and the codes are available online at <https://github.com/dmelgarm/MudPy>. Inversion data used for simulating the Mentawai event were obtained from Yue et al. (2014). Rupture files and waveforms for the simulations can be accessed via our online Zenodo dataset (Nye et al., 2024). Maps were produced using the Generic Mapping Tools software (Wessel et al., 2019) with a digital elevation model downloaded from GMTSAR (Sandwell et al., 2011), and all analyses were completed with in-house code, available online at <https://github.com/taranye96/tsuquakes>. This includes a parameter configuration file for simulating data with *FakeQuakes*, and all major codes used for processing and analysis of the data.

**References**

Nye, T., Sahakian, V. J., & Melgar, D. (2024). 2010 Mentawai tsunami earthquake simulations [Dataset]. Zenodo. https://doi.org/10.5281/zenodo.10023345

Ruhl, C. J., Melgar, D., Chung, A. I., Grapenthin, R., & Allen, R. M. (2019). Quantifying the value of real‐time geodetic constraints for earthquake early warning using a global seismic and geodetic dataset. *Journal of Geophysical Research: Solid Earth*, 124(4), 3819–3837. https://doi.org/10.1029/2018JB016935

Sandwell, D., Mellors, R., Tong, X., Wei, M., & Wessel, P. (2011). Open radar interferometry software for mapping surface deformation. *Eos Transactions American Geophysical Union*, 92(28). https://doi.org/10.1029/2011EO280002

Wessel, P., Luis, J. F., Uieda, L., Scharroo, R., Wobbe, F., Smith, W. H. F., & Tian, D. (2019). The Generic Mapping Tools version 6. *Geochemistry, Geophysics, Geosystems*, 20(11), 5556–5564. https://doi.org/10.1029/2019GC008515

Yue, H., Lay, T., Rivera, L., Bai, Y., Yamazaki, Y., Cheung, K. F., Hill, E. M., Sieh, K., Kongko, W., & Muhari, A. (2014). Rupture process of the 2010 Mw 7.8 Mentawai tsunami earthquake from joint inversion of near-field HR-GPS and teleseismic body wave recordings constrained by tsunami observations. *Journal of Geophysical Research: Solid Earth*,119(7),5574–5593. https://doi.org/10.1002/2014JB011082