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Supporting Information for

Dynamic Rupture Scenarios of the Cascadia Megathrust based on Interseismic Locking Models

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Introduction

This supporting document explains the parameters used in the study and extends the results of the dynamic simulations. Specifically, Figure S1 shows the velocity models of the continental and oceanic blocks of Cascadia. Figure S2 is the comparison between dynamic simulations using bi-material (continental and oceanic) and 1D depth-dependent (only continental) material properties, illustrating the little difference between these two material assumptions. Figure S3 shows the dynamic simulation results assuming different thicknesses for the frontal prism. Figure S4 demonstrates the location of the sediment deposition at different depths, justifying our choice of the frontal prism depth range from 5 – 7 km. Figure S5 shows the moment magnitude of dynamic simulations initiated from different hypocenter locations with 10 km and 15 km radius nucleation zones, supporting our choice of 15 km radius nucleation zones. Figure S6 extends the Schmalzle-based dynamic simulations to a *dc* of 1 m.

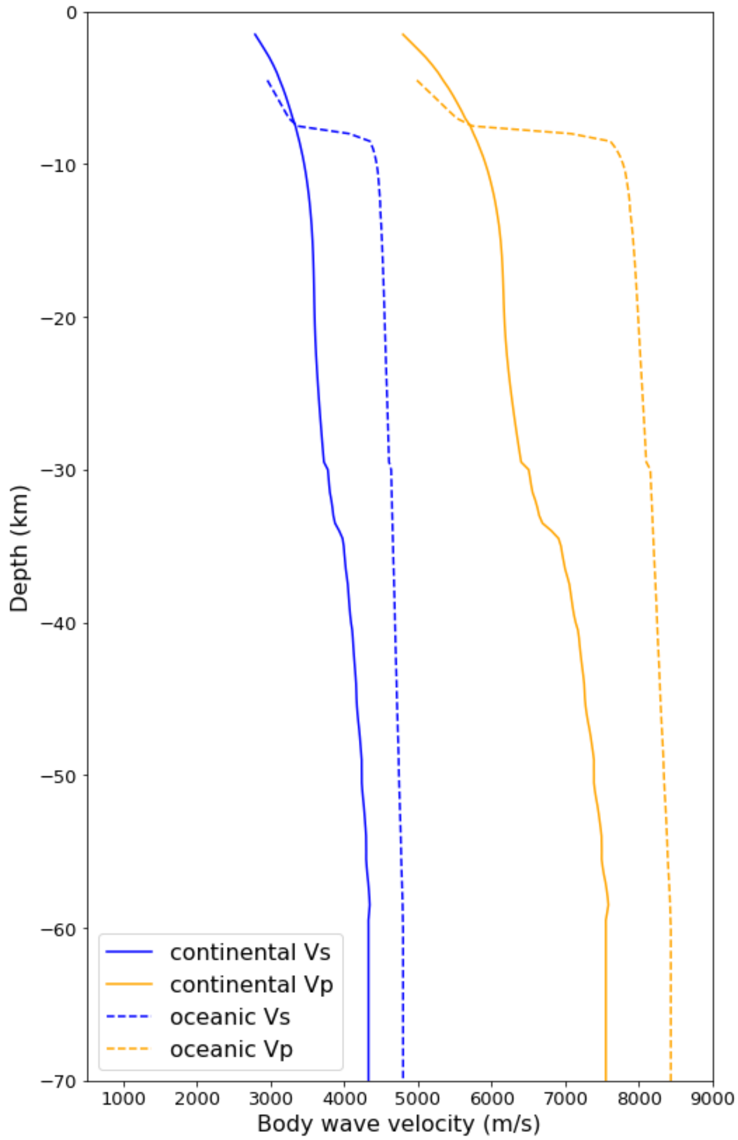

Figure S1. Velocity models of continental and oceanic blocks for Cascadia (Stephenson et al., 2017).

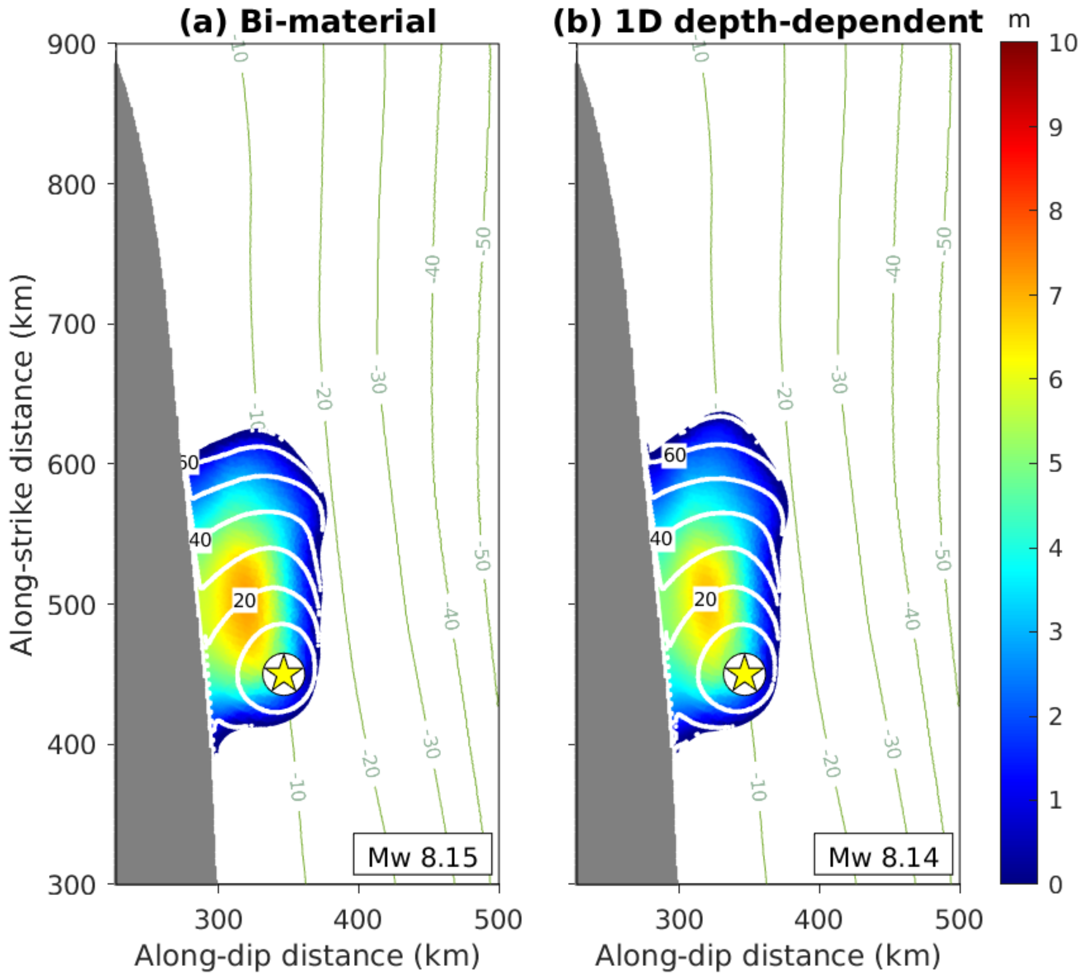

Figure S2. Final slip distribution of the same stress field utilizing (a) bi-material materials properties where the velocity contrast across two blocks is around 30%, and (a) 1D depth-dependent material properties (Figure 3a).

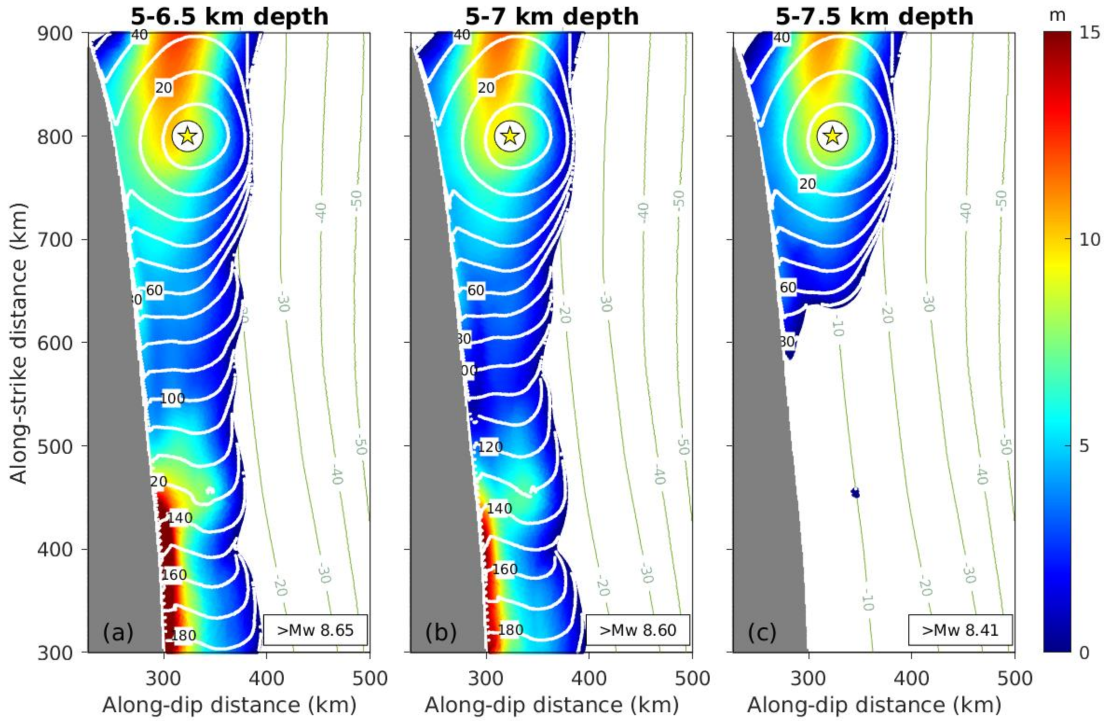

Figure S3. Final slip distribution derived from the Schmalzle model using a *dc* of 1 m assuming different thicknesses of the frontal prism. Stars: hypocenter locations. Olive-green contours: slab depth contours. Rupture fronts (white contours) are displayed every 10 seconds and numbered every 20 seconds. (a) Accretionary prism from 6.5 km depth to trench (5 km depth). Strong free-surface reflections are generated near the trench, causing an unphysical final slip that exceeds the slip deficit (b) From 5-7 km depth - our model assumption. (c) From 5 – 7.5 km depth.

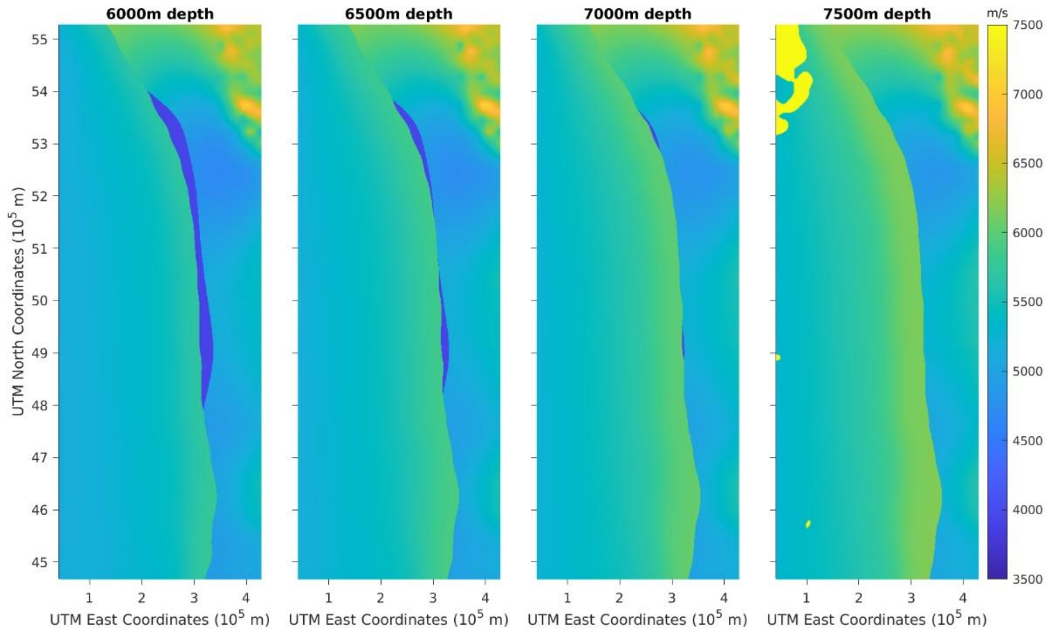

Figure S4. P wave velocity cross-sections of CSZ at different depths (Stephenson et al., 2017). The sediment deposition / accretionary prism is shown as the central gap with low velocity.

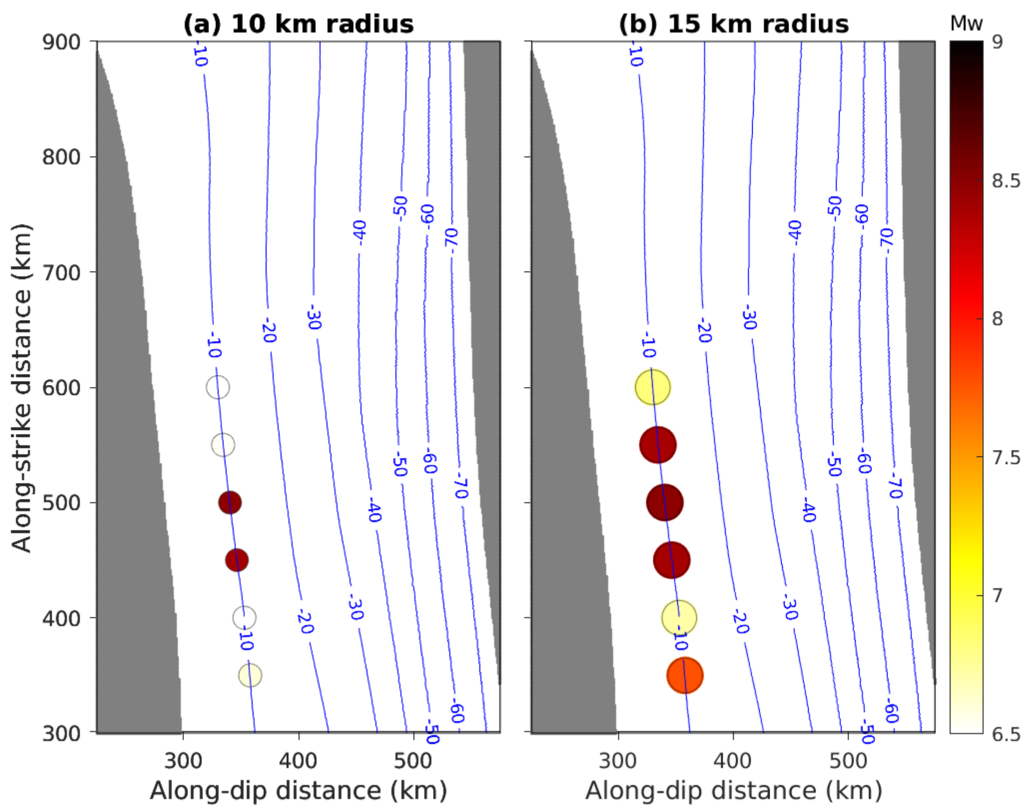

Figure S5. Map view of the moment magnitudes of rupture scenarios nucleated at each location (circles) using (a) 10 km radius and (b) 15 km radius nucleation zones.

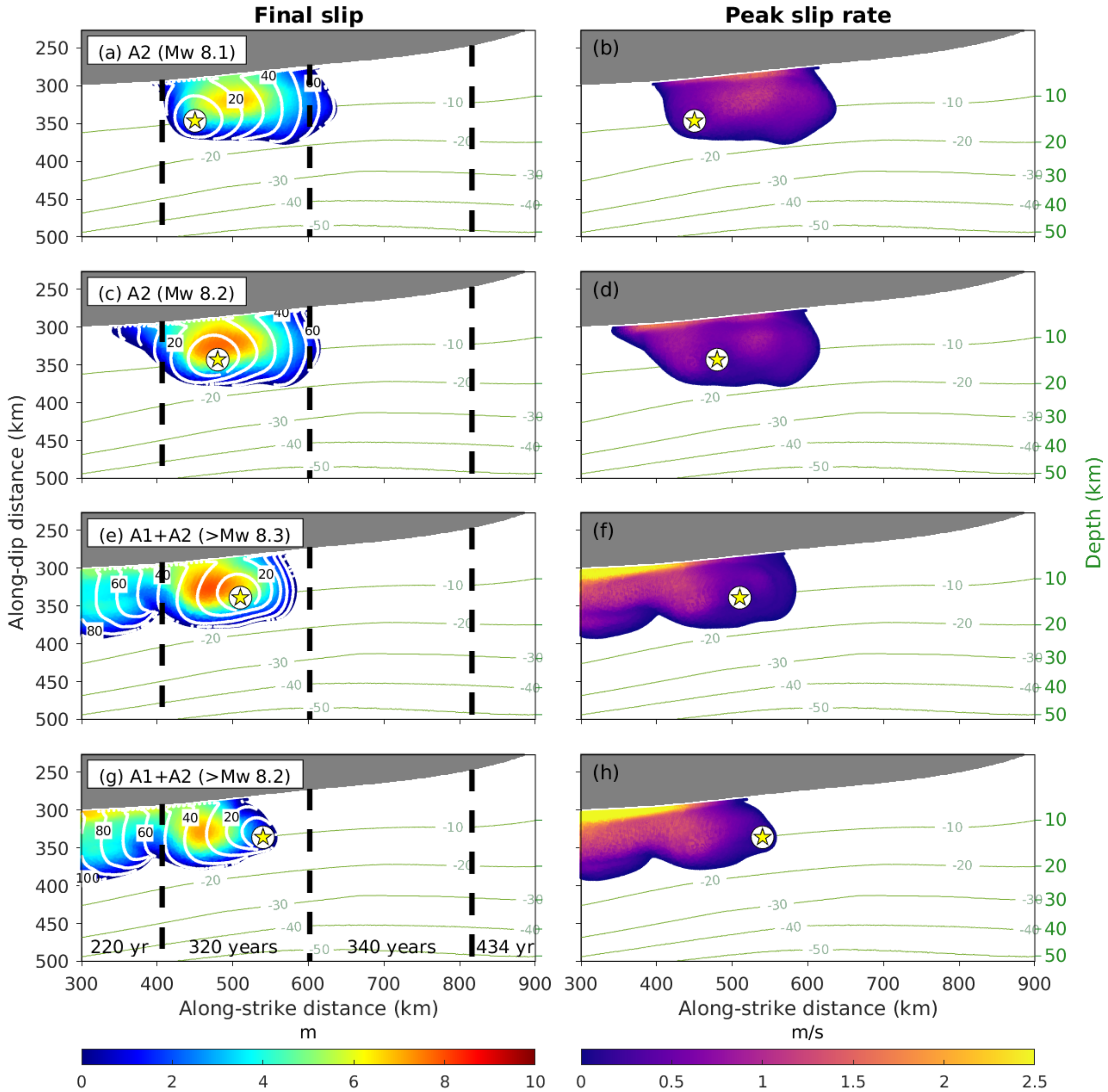

Figure S6. Same as Figure 6, except using a *dc* of 1 m. (a) & (b) Scenario rupturing the A1 asperity. (c) & (d) Scenario rupturing A1 and A2 asperities.

Supplementary Movies: Slip rate evolution in dynamic rupture scenarios

S1: Schmalzle model–FMR initiated fromA1(Figure 6e)

S2: Schmalzle model–FMR initiated from A2 (Figure 6g)

S3: Li model–FMR initiated at 15 km depth (Figure 7c)

S4: Li model–FMR initiated at 10 km depth (Figure 7e)

S5: Schmalzle model–A1+A2+C event (Figure 6c)

S6: Schmalzle model–A1 event (Figure 6a)

S7: Li model–segmented rupture (Figure 7a)