Supplemental Material for

"A method to generate initial fault stresses for physics-based ground motion prediction consistent with regional seismicity"

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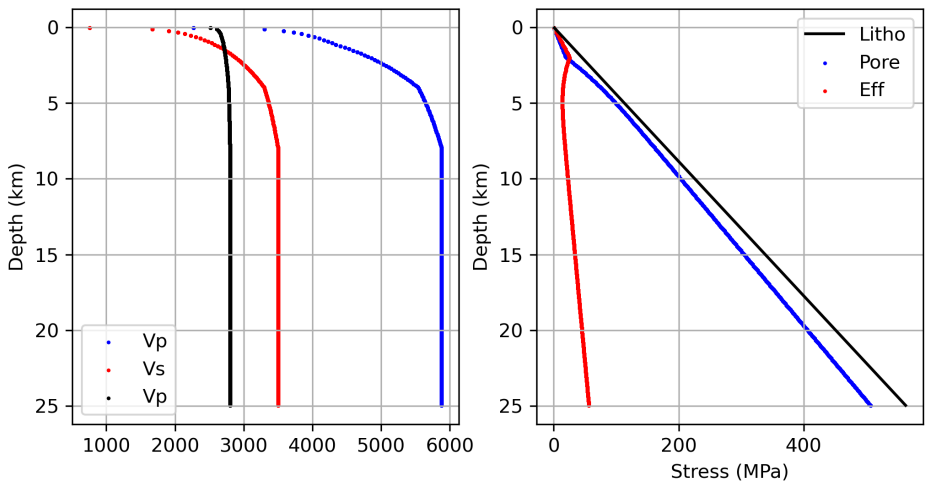

Figure S1: Soil and stress profile. P- and S-wave velocities, and density by depth (left), and lithospheric (or total) stress, pore pressure, and effective stress by depth (right). Velocities and density are shown in units of m/s and kg/m^3, respectively.

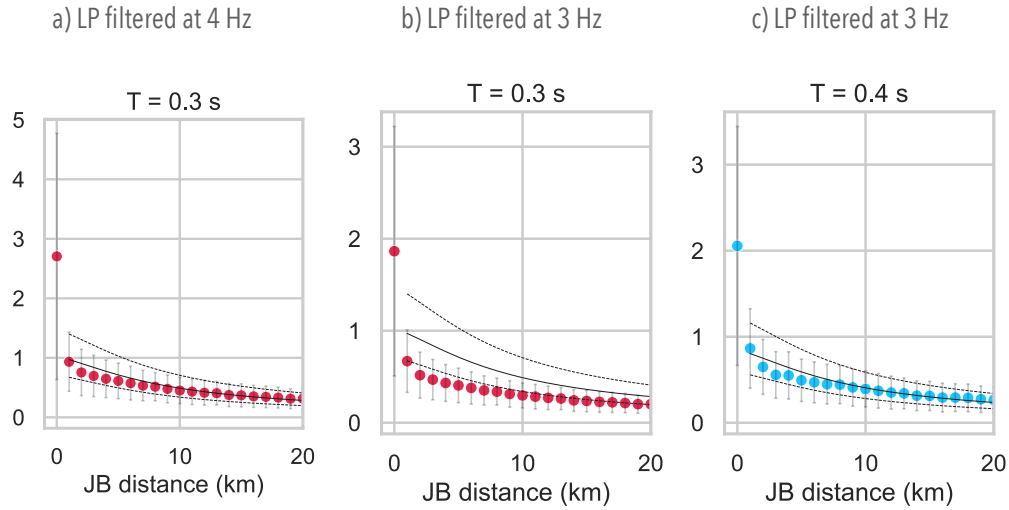

Figure S2: Same as Figure 4 for periods of 0.3 s after low-pass filtering at 4 Hz (a), 0.3 s after low-pass filtering at 3 Hz (b) and 0.4 s after low-pass filtering at 3 Hz (c). The GMPE fit is preserved for T=0.4 s. Since we low-pass filtered our synthetics at 3 Hz, the output ground motion approaches the lower limit of GMPEs at T=0.3 s that we only show for comparison.

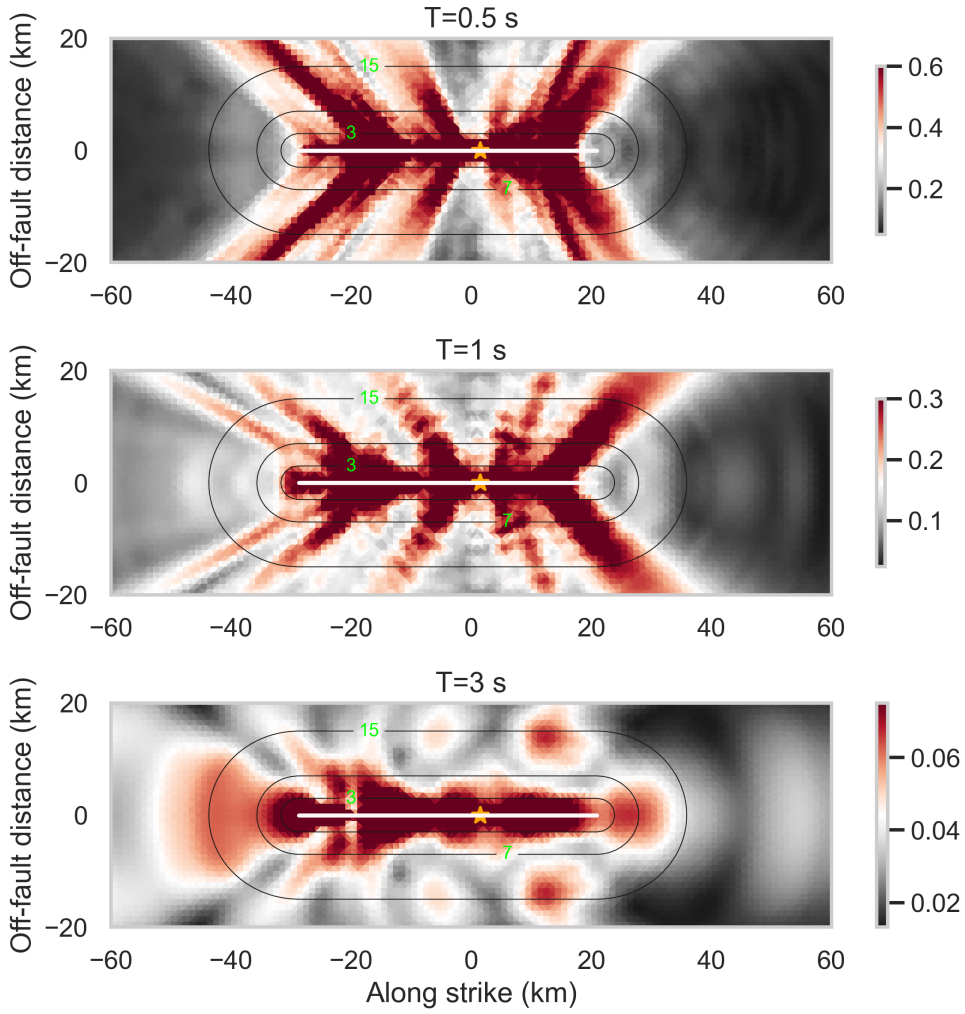

Figure S3: Spatial distribution (top view) of synthetic spectral accelerations in Model I. Shown for periods of 0.5 (top), 1 (middle), and 3 s (bottom). Surface rupture is shown by solid line in white. The contours stand for equidistant stations for different Joyner-Boore distances as denoted in green. Epicenter is shown by a star.

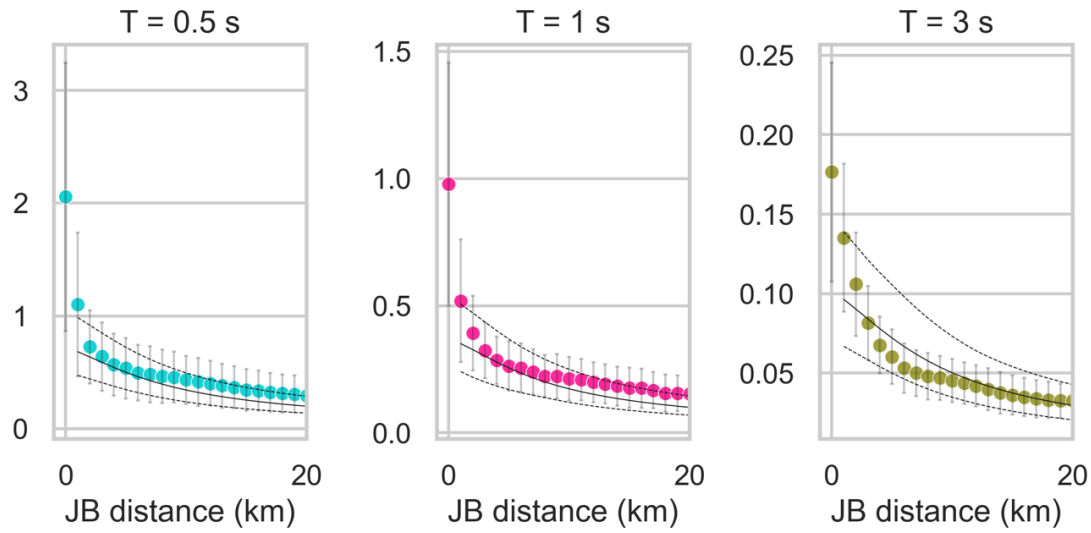

Figure S4: Same as Figure 4 for Model II. Amplitudes are linearly scaled for Mw 7.05. Heterogeneous model satisfactorily captures the GMPE trend above 10 km.

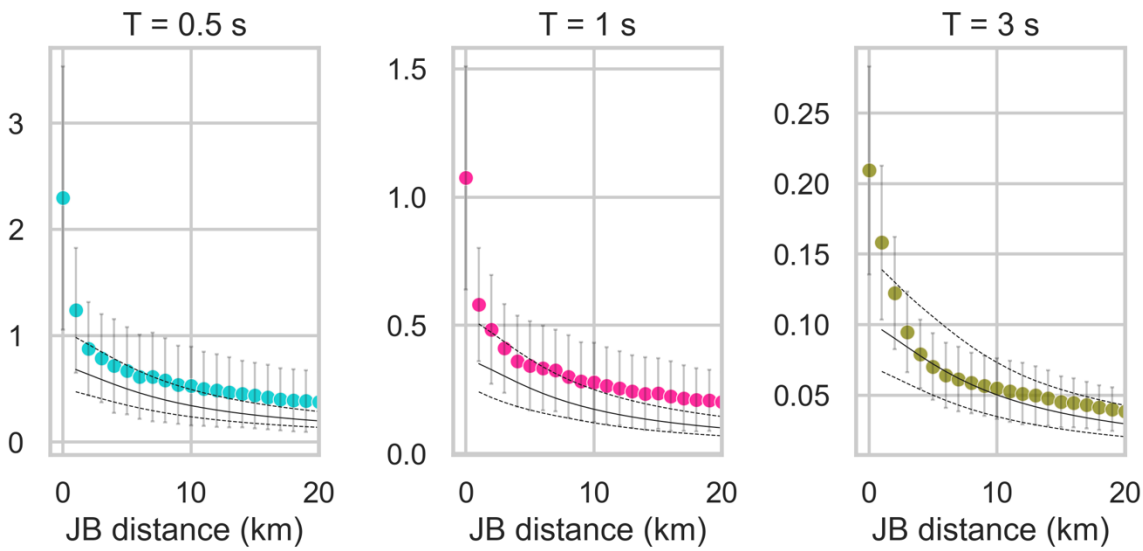

Figure S5: Same as Figure 4 for Model III. Amplitudes are linearly scaled for Mw 7.12. Since the average stress drop increases in this model, the synthetics are amplified at all distances and especially at periods of 0.5 and 1 s overestimate the GMPEs. The decay with distance is similar to other heterogeneous models.

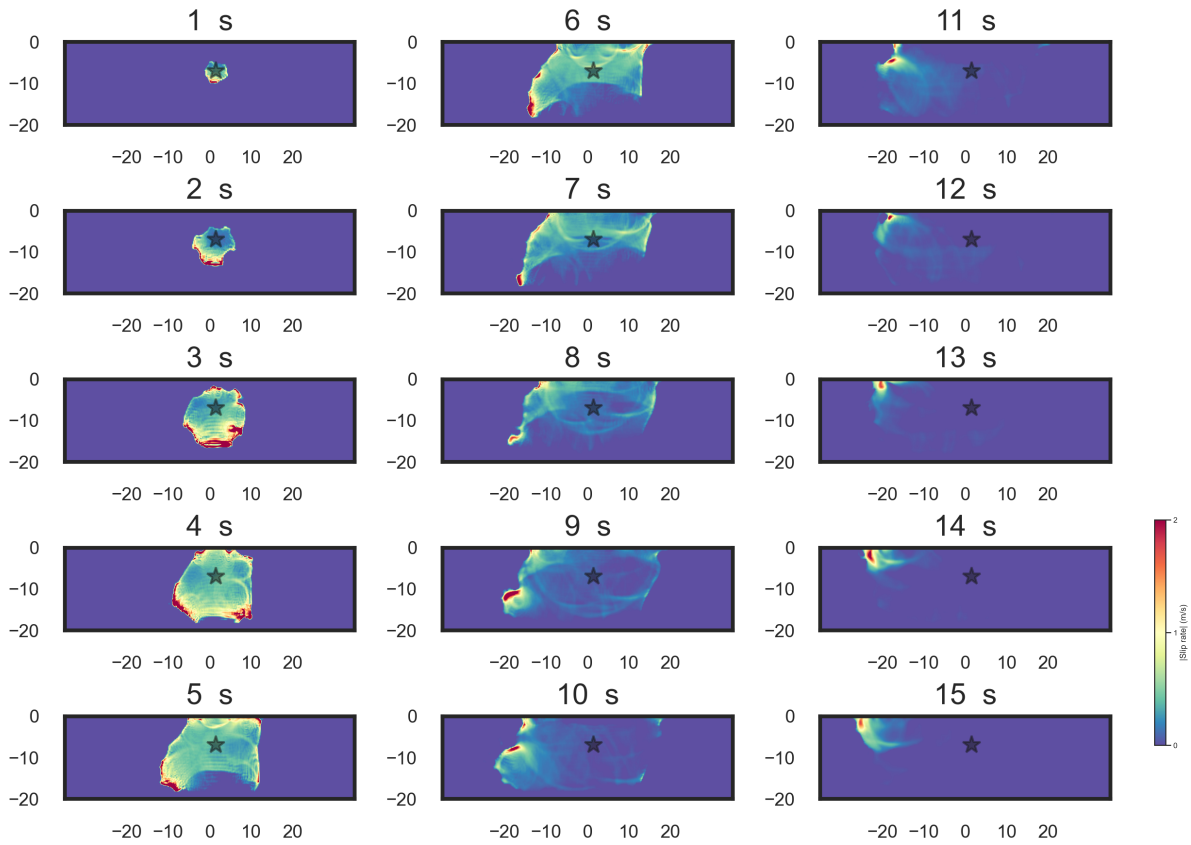

Figure S6: Snapshots of slip velocity at different instants. Shown for Model I.

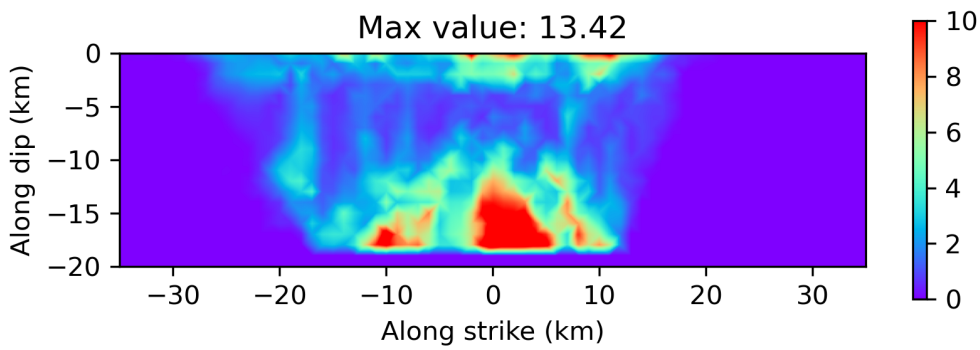

Figure S7: Peak slip velocity (in m/s) for Model I.

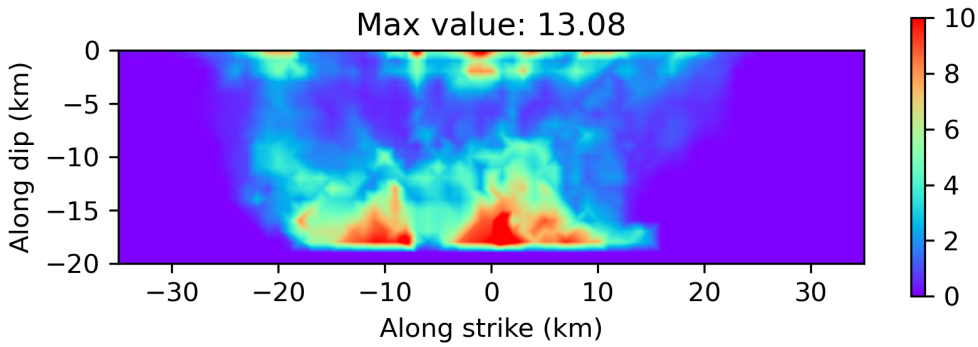

Figure S8: Peak slip velocity (in m/s) for Model II.

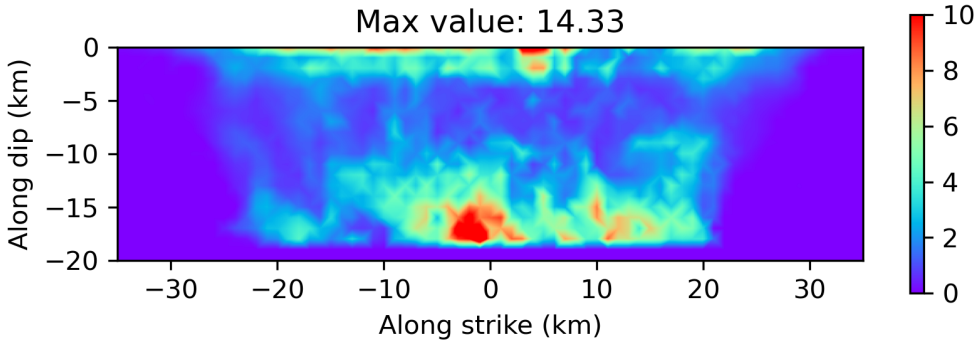

Figure S9: Peak slip velocity (in m/s) for Model III.

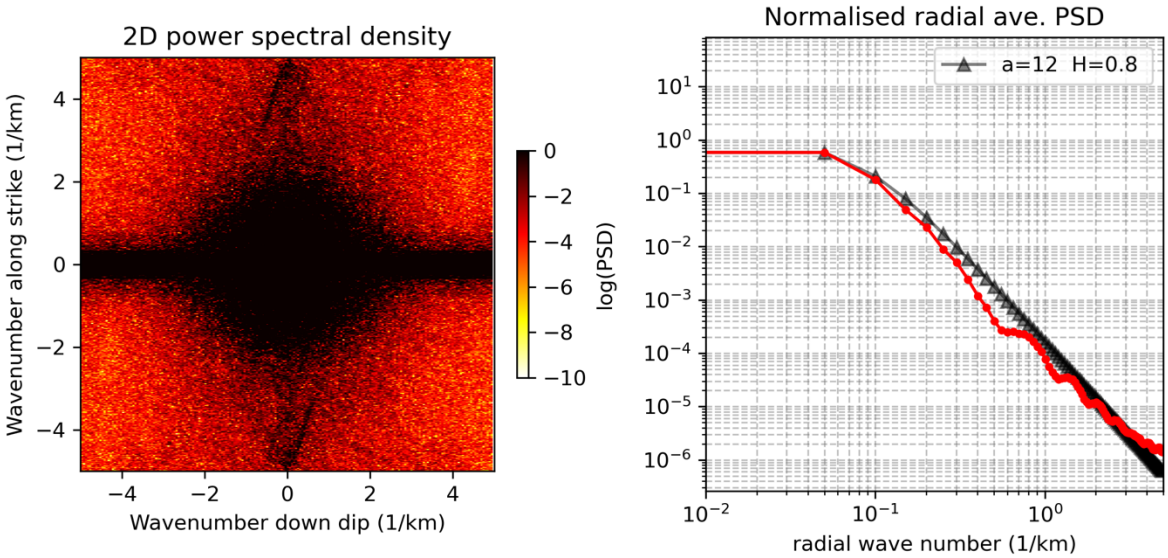

Figure S10: 2D (left) and 1D (right) slip spectra for Model I. Synthetic slip and fitted Van Karman function are shown in red and black, respectively, in the right diagram. Function coefficients are provided in-plot legend box.

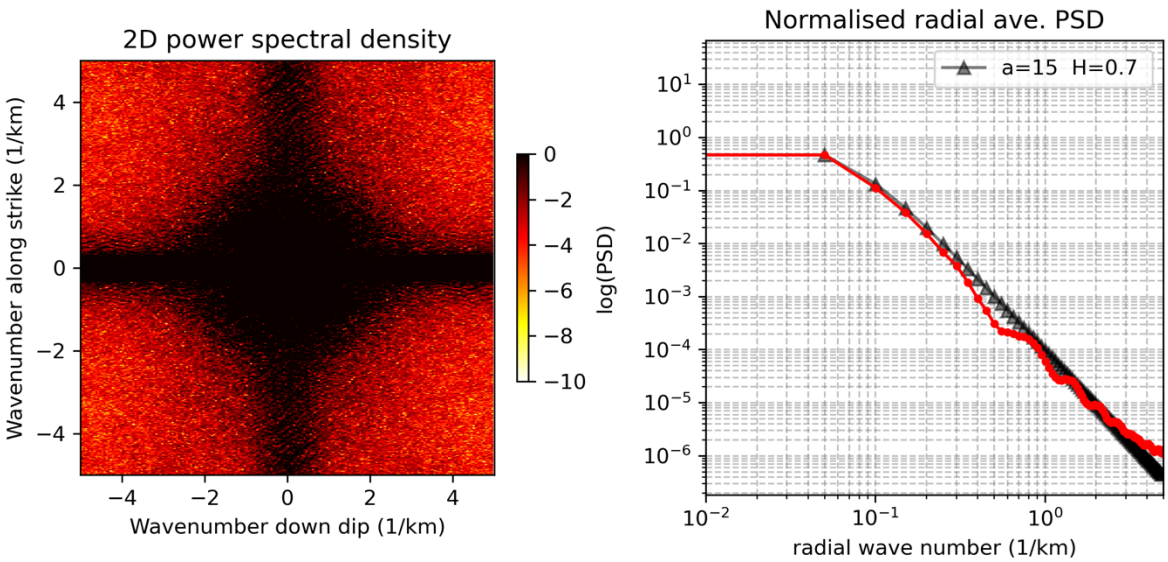

Figure S11: 2D (left) and 1D (right) slip spectra for Model II. Synthetic slip and fitted Van Karman function are shown in red and black, respectively, in the right diagram. Function coefficients are provided in-plot legend box.

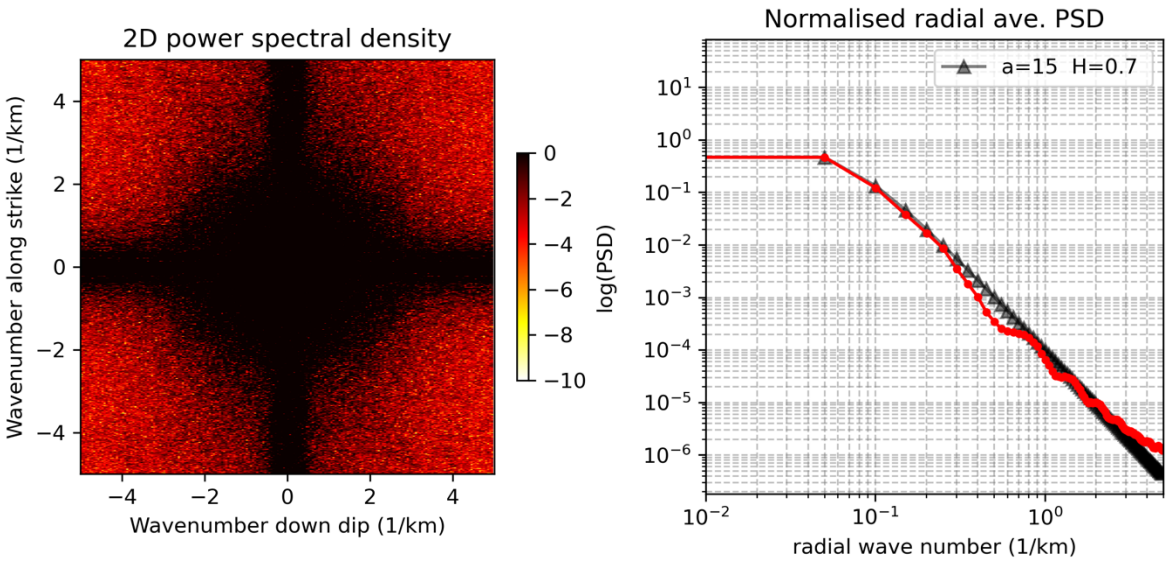

Figure S12: 2D (left) and 1D (right) slip spectra for Model III. Synthetic slip and fitted Van Karman function are shown in red and black, respectively, in the right diagram. Function coefficients are provided in-plot legend box.

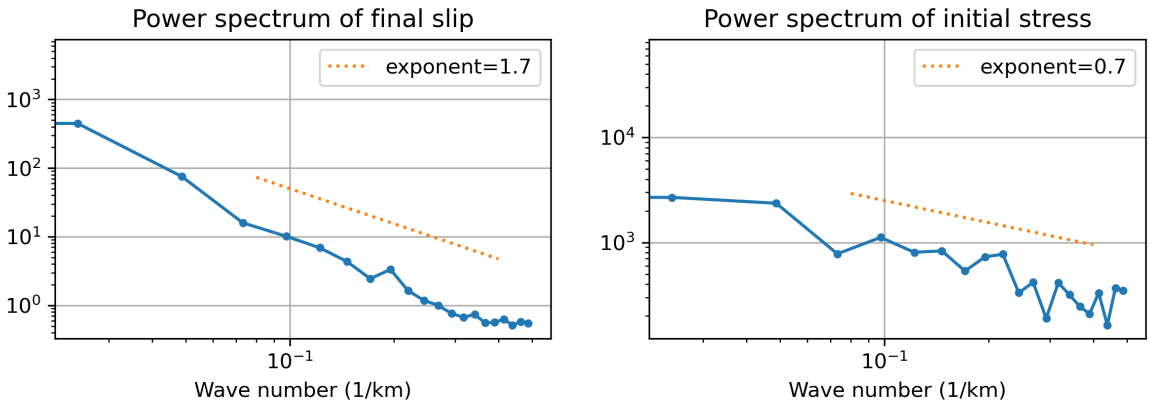

Figure S13: Slip and initial stress spectra. Power spectrum of final slip (left) and initial stress (right). We used the depth averaged 1D Fourier amplitudes when computing the power spectra, similar to Lavallée and Archuleta (2003).

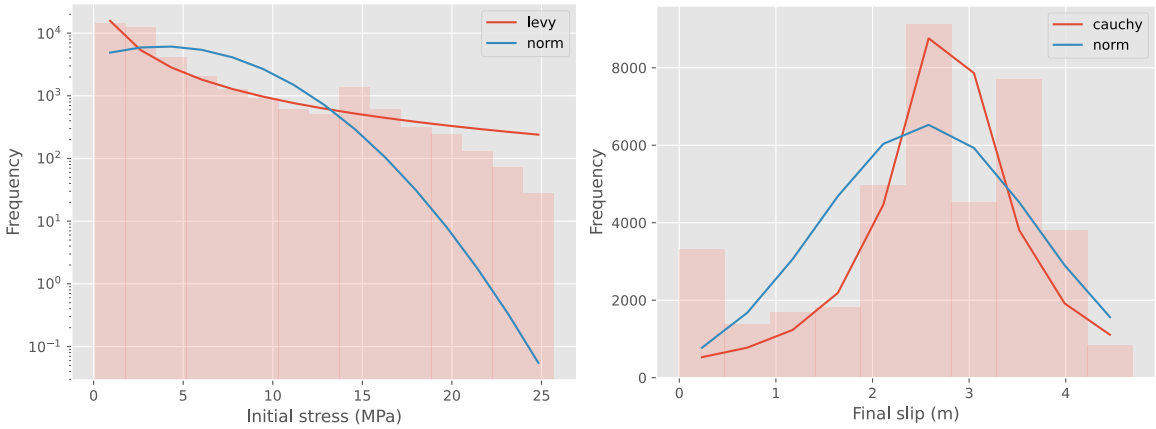

Figure S14: Slip and initial stress distributions. Histograms, fitted Gaussian (norm) and non-Gaussian distributions shown for initial stress (left) and final slip (right). Best-fitting non-gaussian distribution is Levy and Cauchy for initial stress and final slip, respectively.

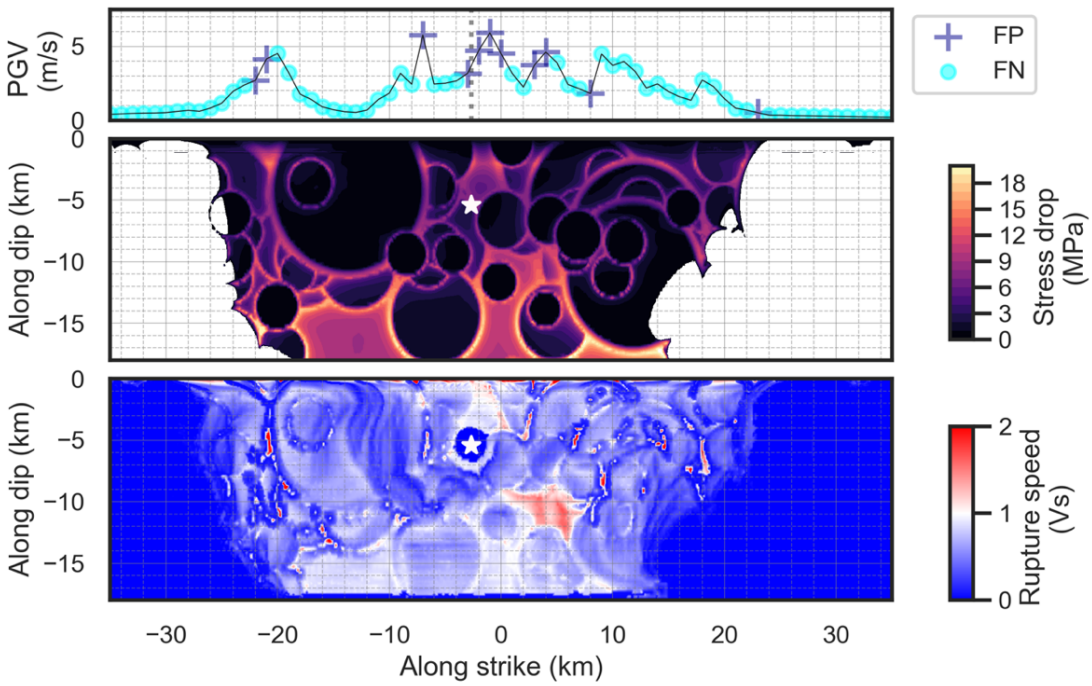

Figure S15: Same as Figure 7 for Model II.

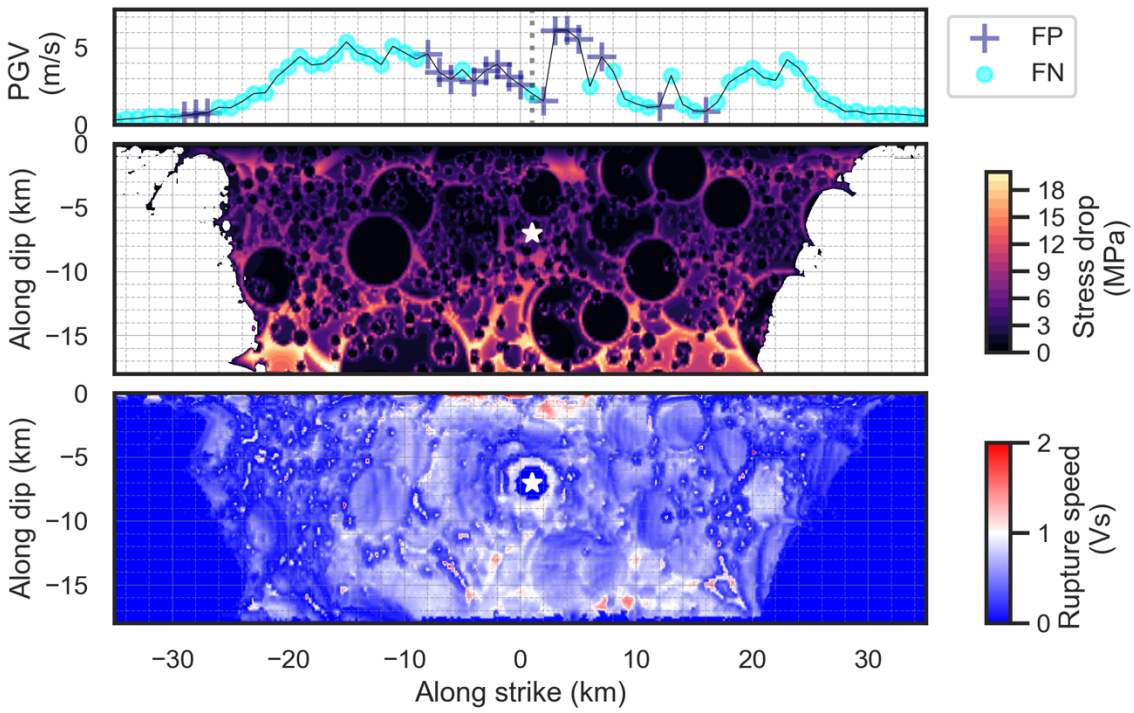

Figure S16: Same as Figure 7 for Model III.

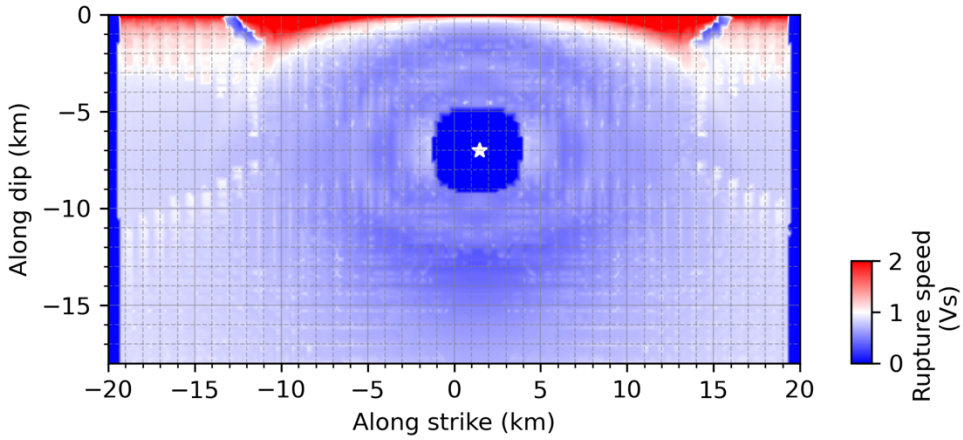

Figure S17: Rupture speed in unit of S-wave speed for homogenous stress model without stratigraphy. Rupture speed reaches supershear values at shallow depth upon free-surface effects.

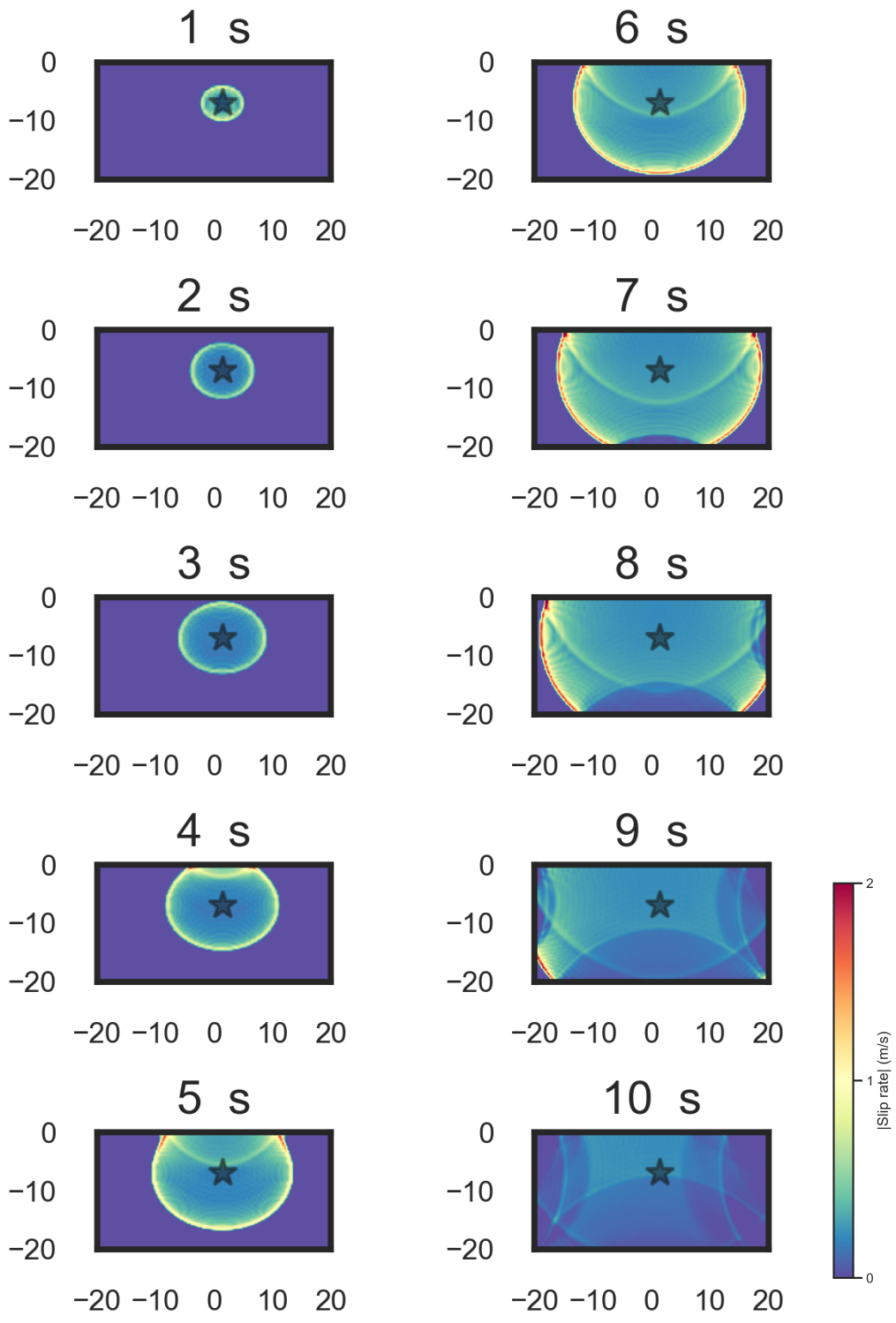

Figure S18: Same as Fig. S6 for homogeneous model without medium stratigraphy.

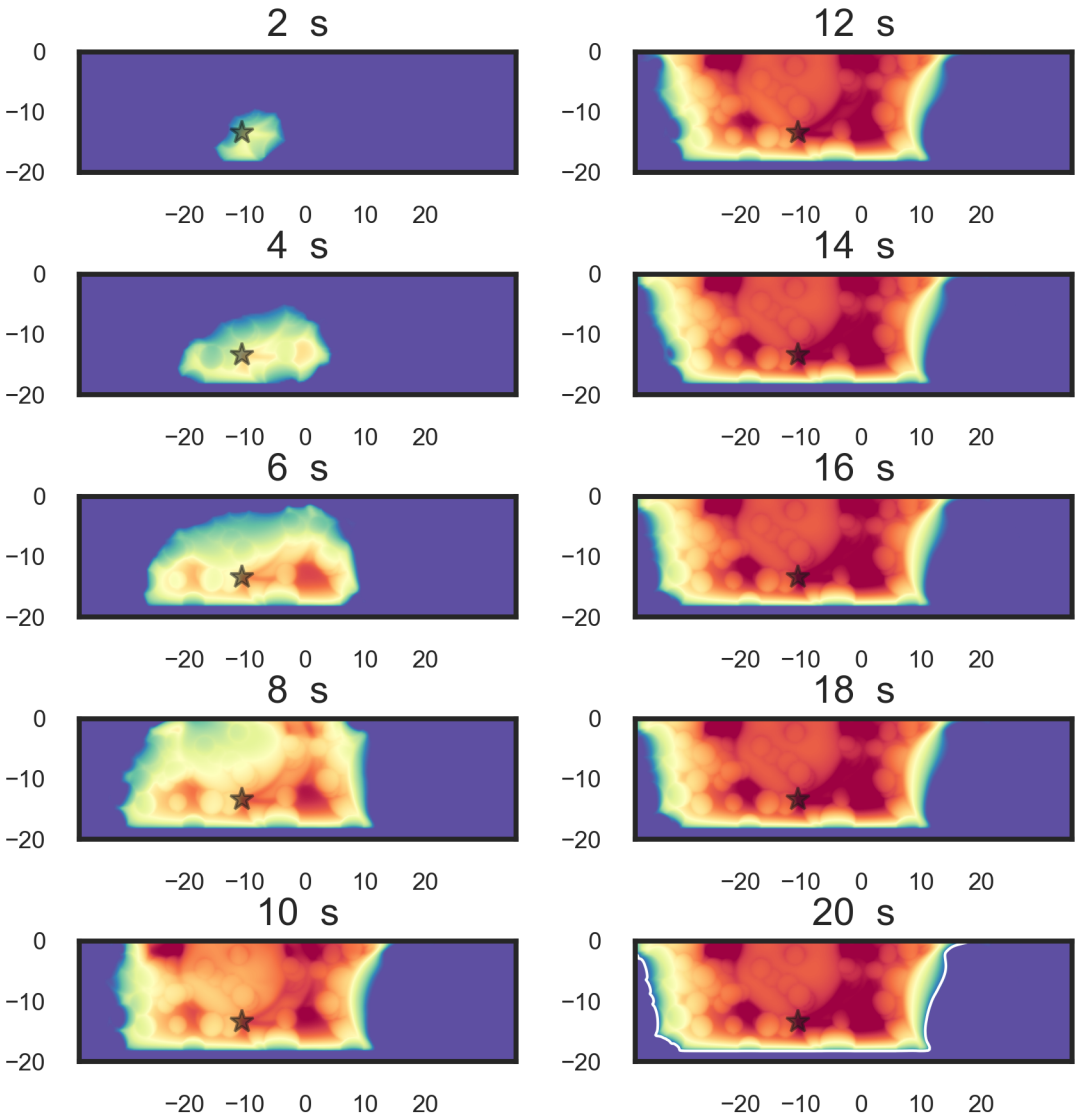

Figure S19: Same as Fig. 5, shown for a different hypocenter location for Model I. Hypocenter is set at (-10.5, -13.4) km. Resultant magnitude equals 7.11.

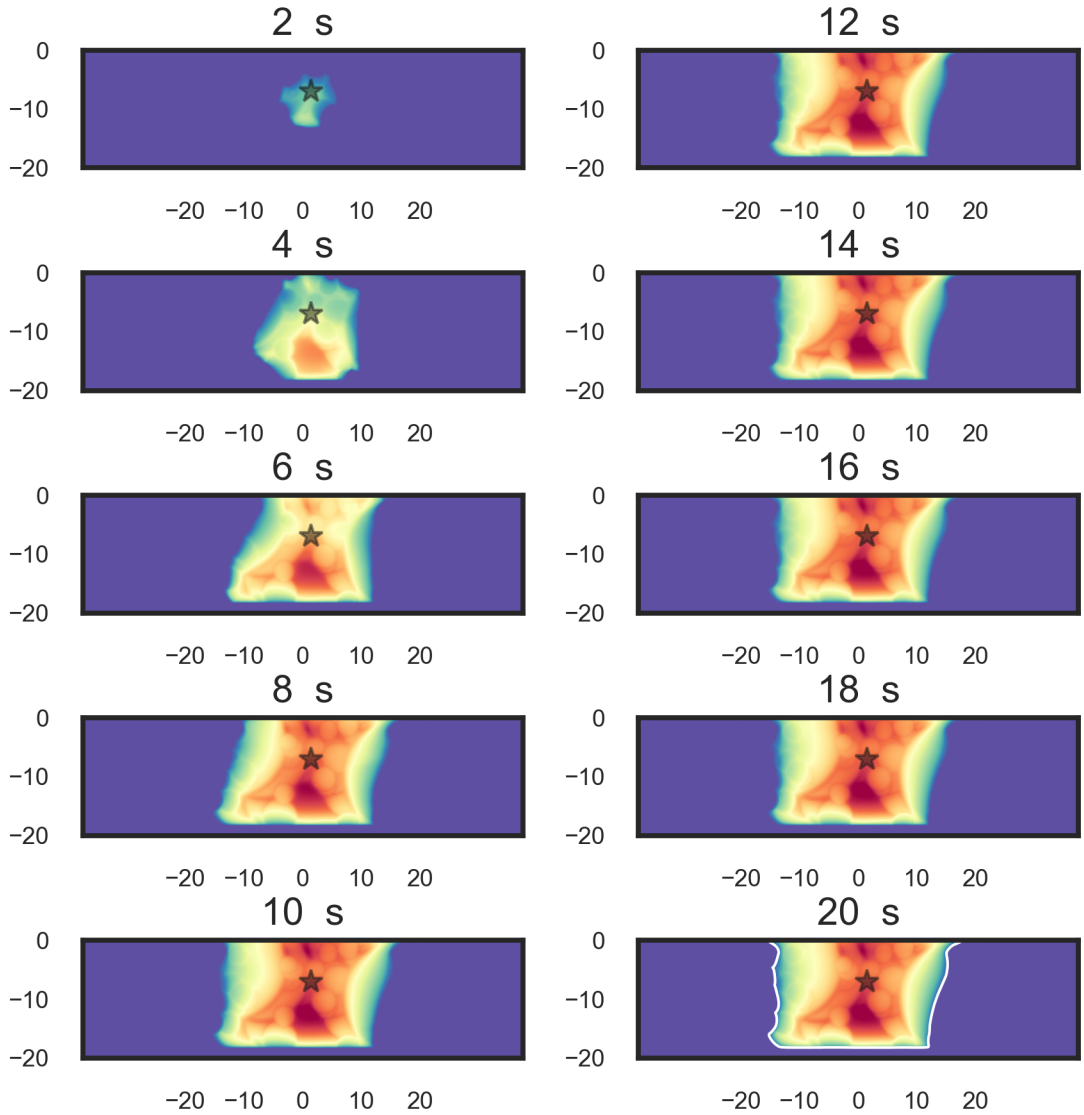

Figure S20: Same as Fig. 5, shown for a smaller L value for Model I. We set L=15. Resultant magnitude equals 6.88.

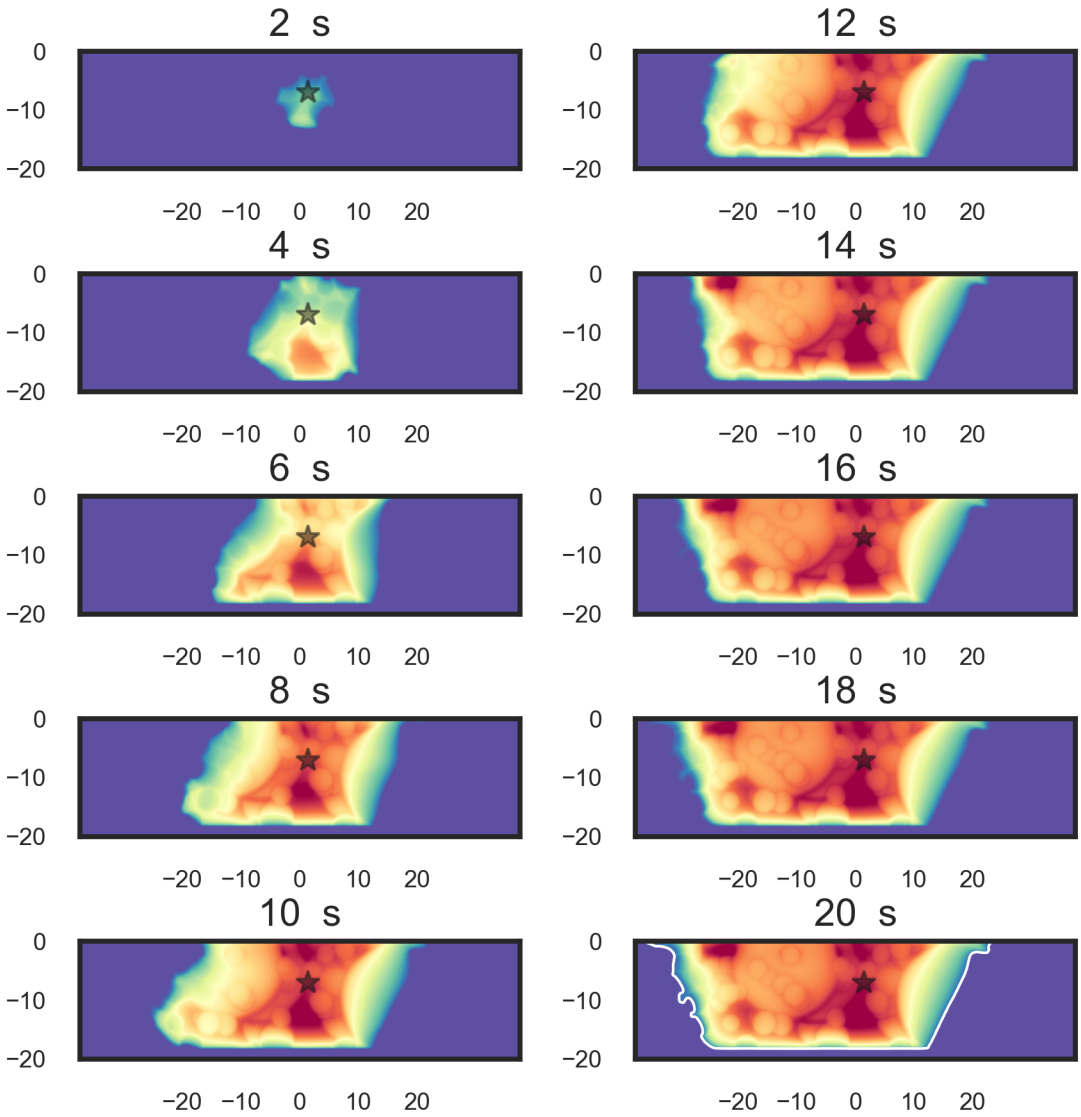

Figure S21: Same as Fig. 5, shown for a larger L value for Model I. We set L=25. Resultant magnitude equals 7.07.

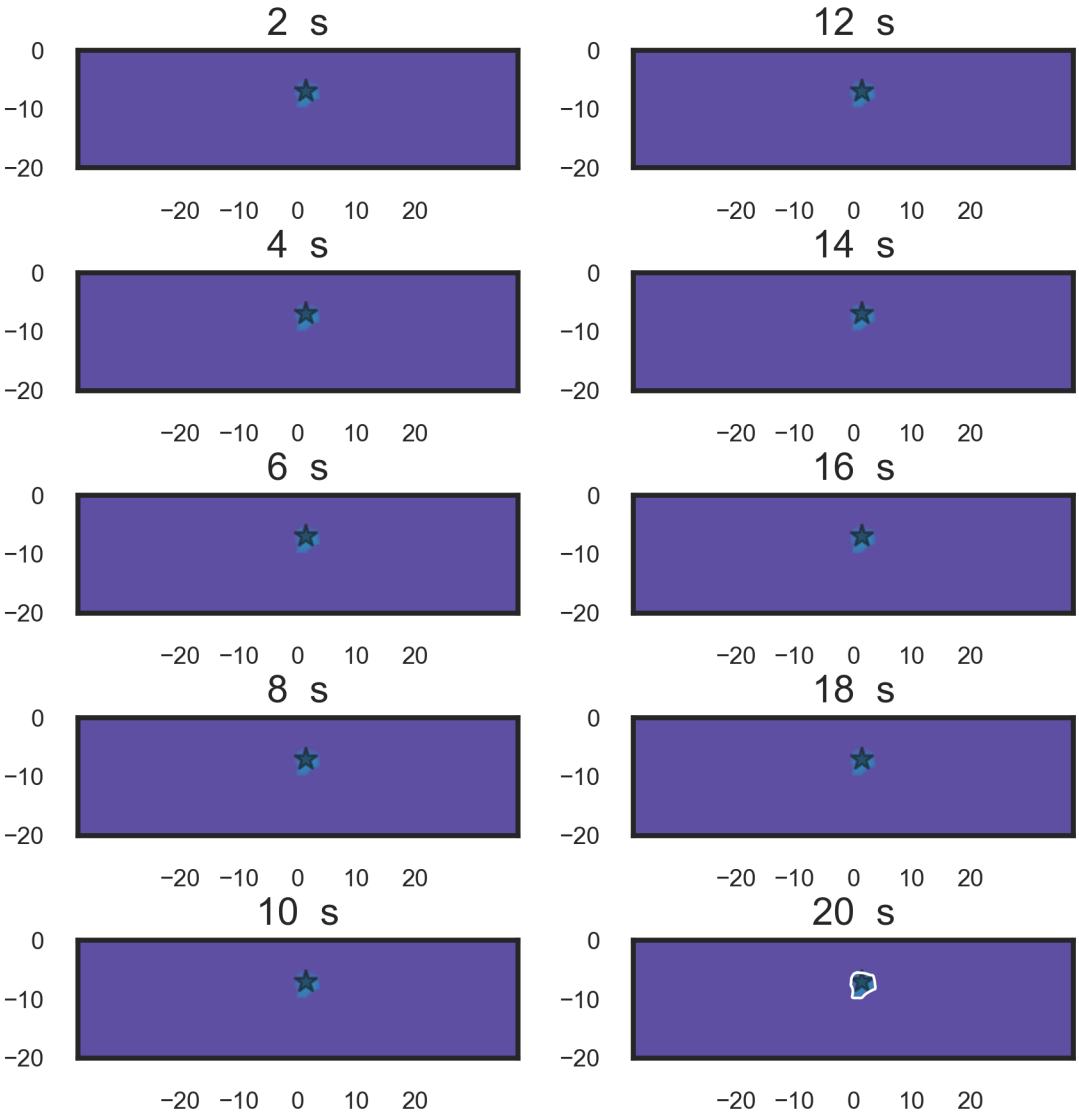

Figure S22: Same as Fig. 5, shown for a larger S value for Model I. We set S=4.

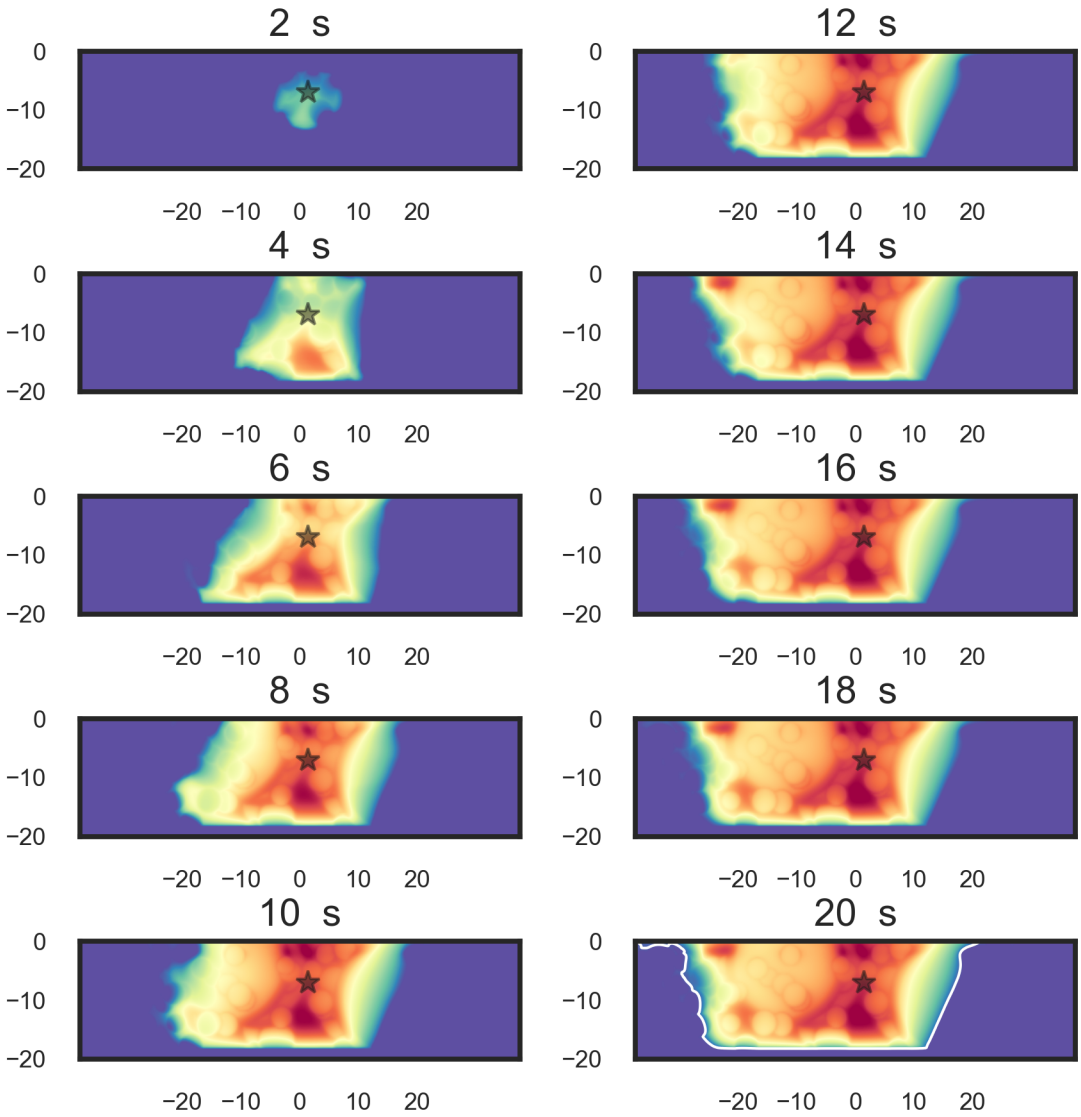

Figure S23: Same as Fig. 5, shown for a smaller S value for Model I. We set S=1.5. Resultant magnitude equals 7.02.

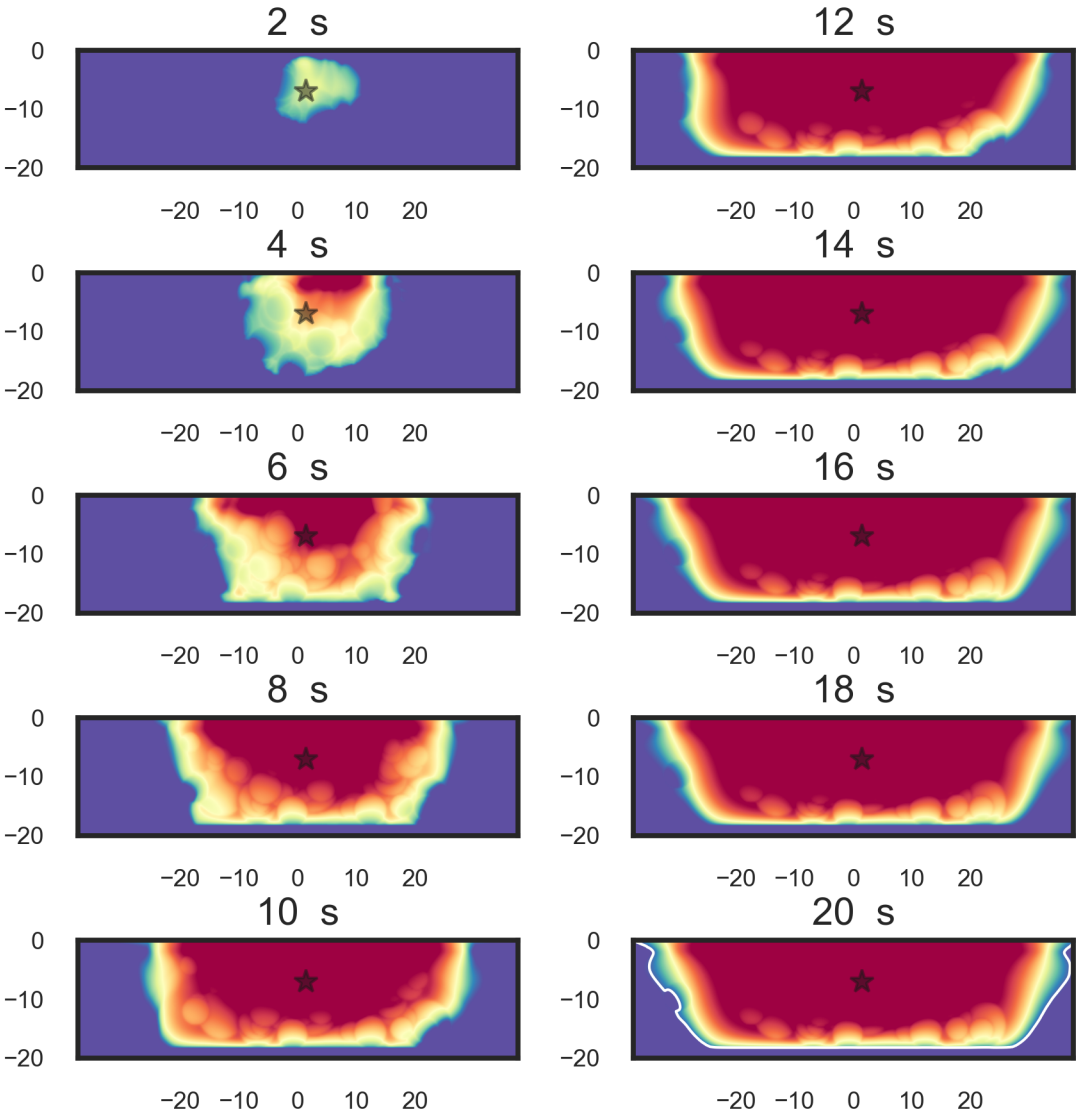

Figure S24: Same as Fig. 5, shown for a different occurrence order of past seismicity. We search for the next event in relatively large stress areas (above 75 percent of maximum allowed stress). Resultant magnitude equals 7.3.

Homogeneous models with and without medium stratigraphy

For comparison purposes, we created homogeneous models with and without medium stratigraphy: the first model assumes a uniform half space, and the second model uses the same velocity profile as the heterogeneous models. In these two additional models, we used the a fault length of 40 km and width of 20 km, and we set dynamic and static friction coefficients as 0.2829 and 0.36, respectively. Initial shear stress (along strike) and normal stress equal 31 and 100 MPa, respectively. We determined these values to get a magnitude 7 event in the homogeneous model without stratigraphy. The resultant magnitude equals 7.03 in the model without stratigraphy, and 7.04 in the one without stratigraphy. Below we show how ground motion of these two cases compare to GMPEs — with no purpose of fitting. Homogeneous model without stratigraphy underestimates the GMPEs at all periods (Fig. S25); the medium stratigraphy in the second model notably amplifies the ground motion again at all periods (Fig. S26). We also provide the rupture speed and slip rate variation for the latter (Figures S27-30).

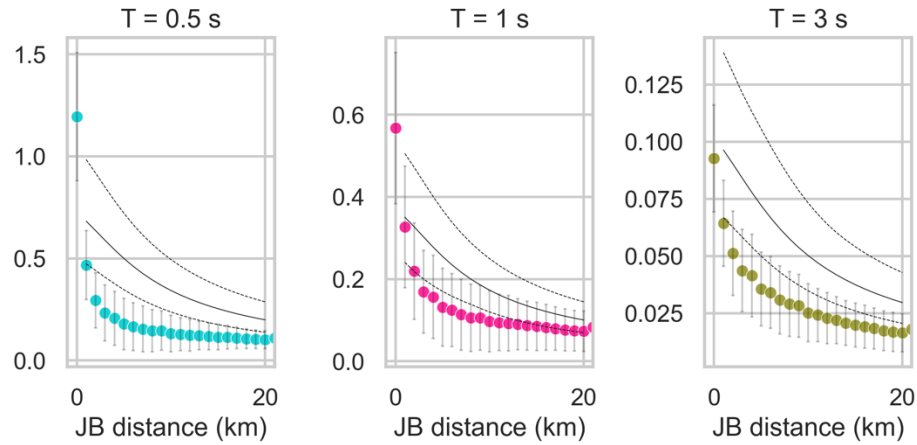

Figure S25: Same as Figure 4 for homogeneous model without medium stratigraphy. Synthetics underestimate ground motion at all periods.

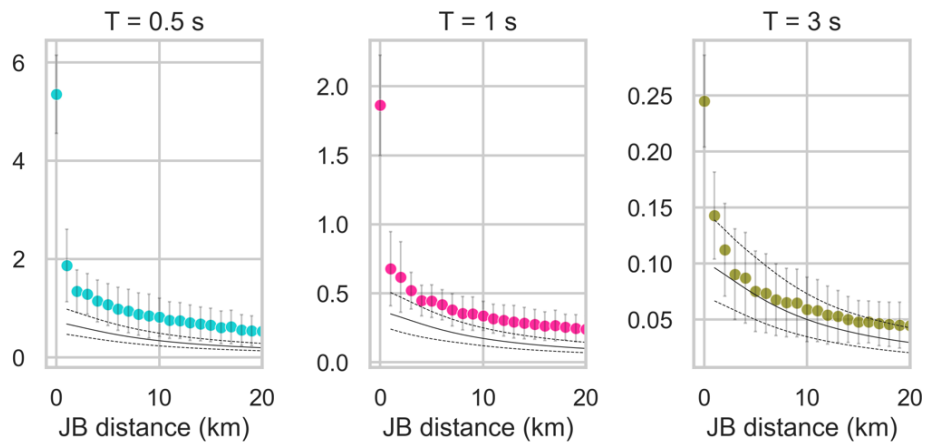

Figure S26: Same as Figure 4 for homogeneous model with medium stratigraphy.

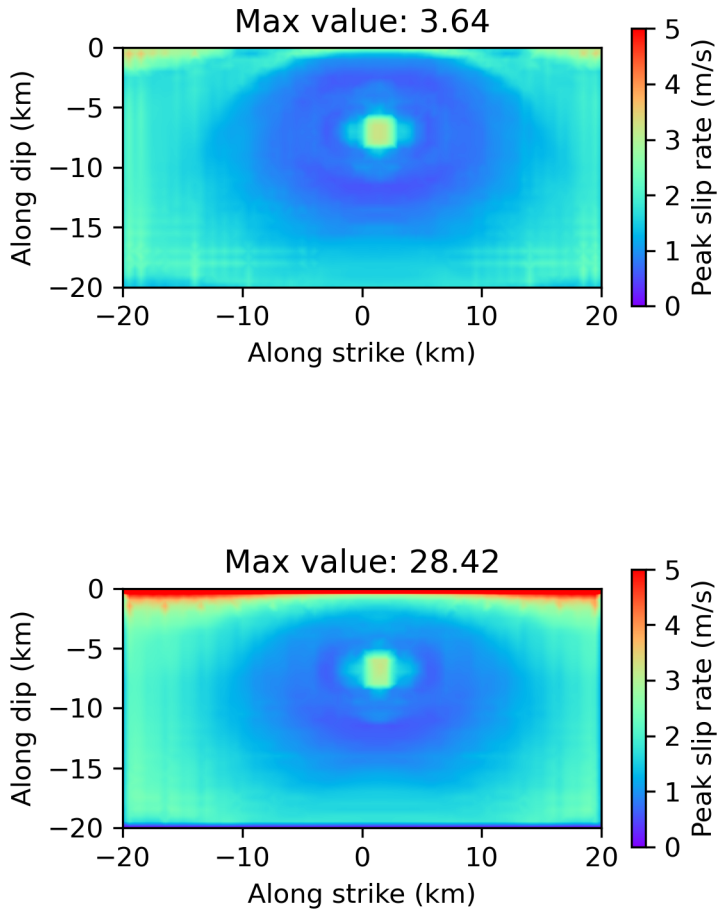

Figure S27: Peak slip rate for homogeneous model without stratigraphy (top) and with stratigraphy (bottom).

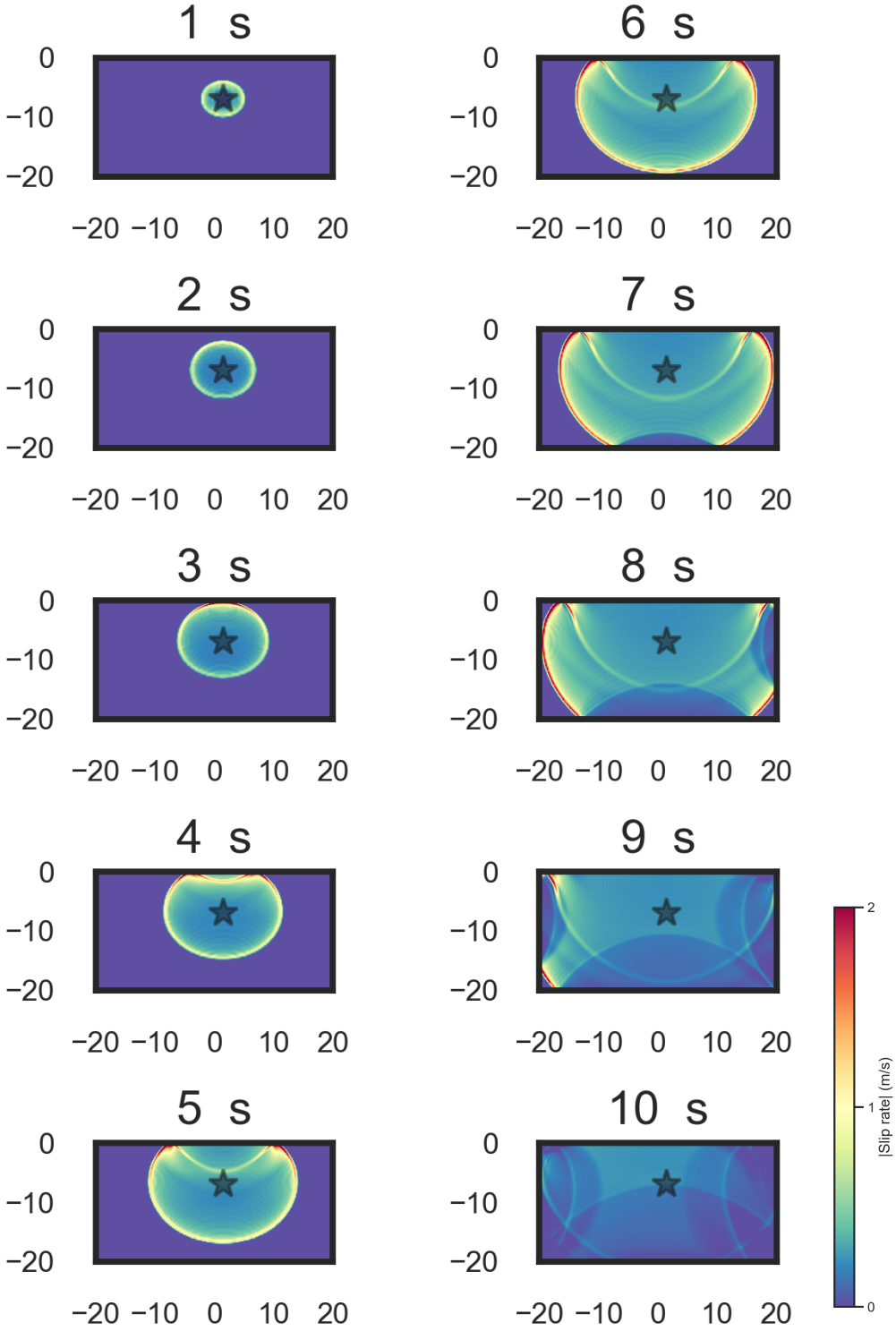

Figure S28: Same as Fig. S6 for homogeneous model with stratigraphy.

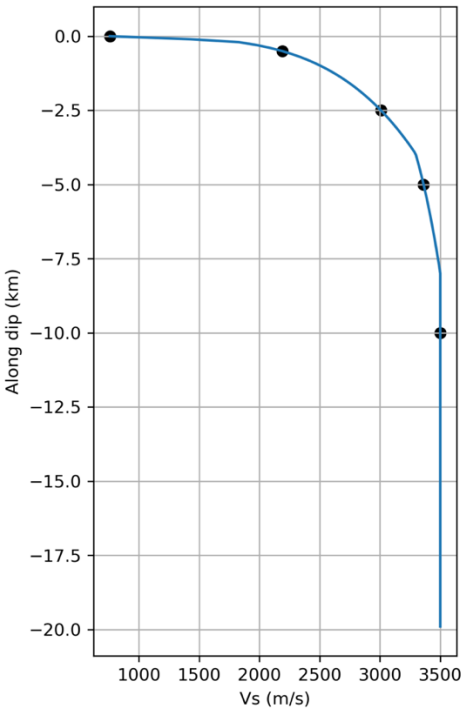

Figure S29: S-wave speed variation by depth shown with four chosen depth levels. Slip rates at these locations are shown for the two homogeneous models in Fig. S30.

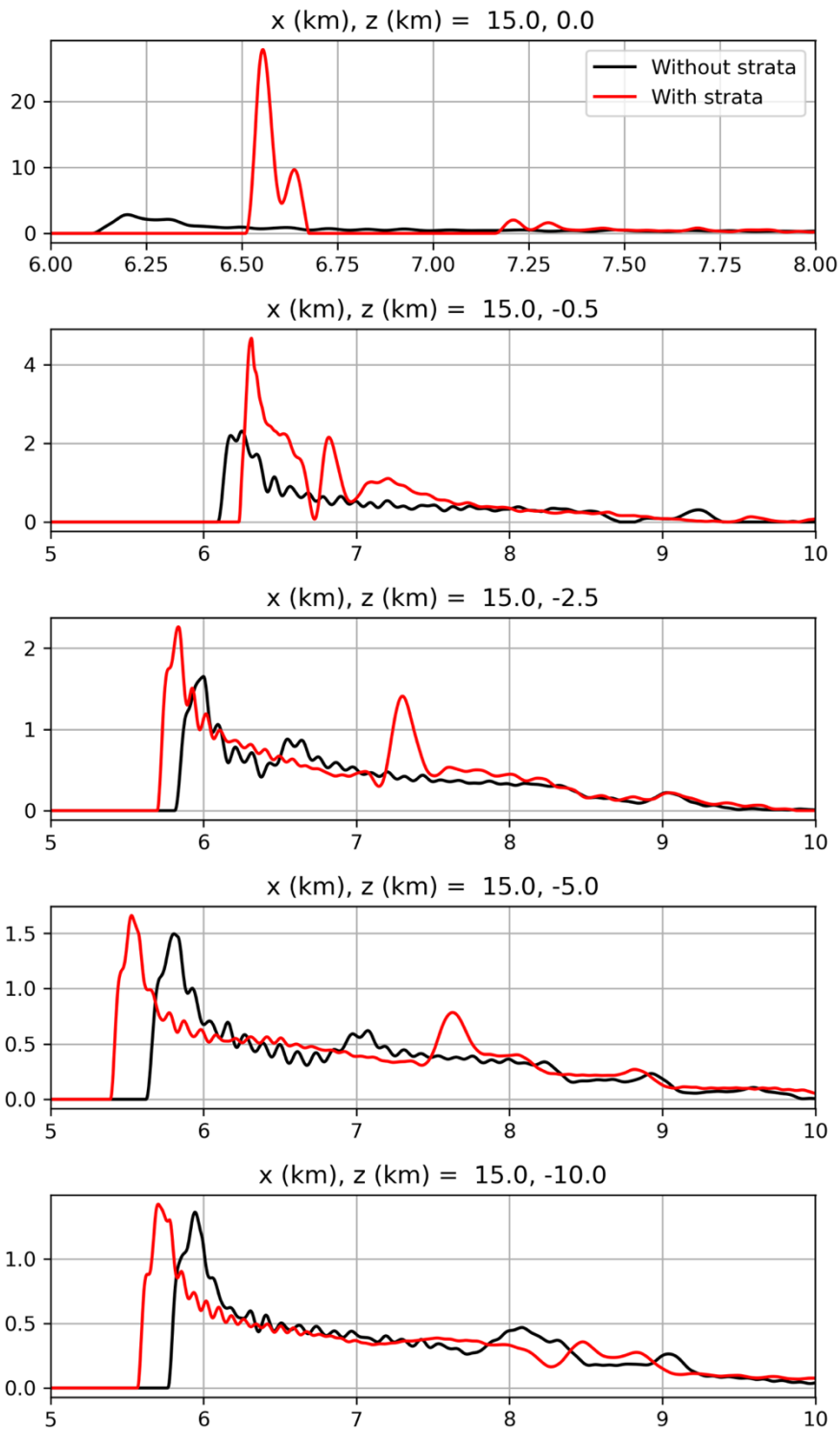

Figure S30: Comparison of slip rates between the homogeneous model without stratigraphy (in black) and with stratigraphy (in red) at four different depth levels. Chosen coordinates are provided in subplot titles. The second originates from free surface effects and propagates downwards. Both first and second slip rates peaks are larger at shallower depths in the presence of stratification.