Intraslab rupture triggering megathrust rupture co-seismically in the December 17, 2016 Solomon Islands $M_w$ 7.9 earthquake

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Introduction

Supporting information includes 9 figures.
Figure S1. Global centroid moment tensor (GCMT) solutions for all events with $M_w \geq 5.0$ from 1976 to 2016 for the region near the junction of the New Britain and Solomon Islands trenches. The lower hemisphere focal mechanisms are plotted at the centroid locations and color-coded for centroid depth. The radius of each focal mechanism is proportional to $M_w$. The December 17, 2016 event is highlighted.
Figure S2. Summary of a planar rupture model that assumes the GCMT best double couple strike (313°) and dip (54°). A rupture velocity of 3 km/s is assumed and the subfaults have 6 2.5-s rise time triangles shifted by 2.5-s each, for total possible subfault durations of 17.5 s. The moment rate function is shown at the top left, with the centroid time (red tick) being $T_c = 41.6$ s. The slip distribution is shown on the bottom left, with the slip of the footwall shown by the red arrows with magnitude of the total slip in each subfault being color coded. The subfault source time functions are shown within each cell. The rupture fronts at 10 s intervals are shown by white dashed lines. The red star is the hypocenter location. The distribution of $P$-waves and $SH$-waves used in the inversion is shown in the lower hemisphere focal mechanism plots with corresponding radiation patterns color-coded. Constant $t^*$ values of 0.75 s and 3.0 s are used for $P$-wave and $SH$-wave modeling, respectively.
Figure S3. Map view and vertical cross section through the background seismicity (within the black quadrilateral) and the aftershock distribution for the December 17, 2016 Solomon Islands event. USGS-NEIC catalog events with magnitude ≥ 4.5 are shown with small grey circles scaled proportional to magnitude. Aftershocks are shown by circles scaled proportional to magnitude on a larger scale and color-coded with source depth. Large aftershocks are shown at their NEIC locations (with blue labeling of magnitude and hypocentral depth) and with corresponding GCMT mechanisms at the centroid location, (with black labeling of magnitude and centroid depth). Stars indicate the relocated positions of the intermediate depth aftershocks. The large green star surrounded by a dashed circle is the hypocenter of the December 17, 2016 event. In the cross-section, the black-dashed curves indicate the faulting geometries of the two faults in Figure 3, with the magenta curve indicating the dip of the alternate steeply dipping plane for the model in Figure S6. Aftershocks northwest of the reference line B-B’ are outlined in darker black than those to the southeast in the vertical profile.
Figure S4. Finite-fault inversion model for a single continuous plane with varying dip ranging from 10° at the up-dip end to 60° below 50 km. The model uses the GCMT best double couple strike (313°). A rupture velocity of 3 km/s is assumed and the subfaults have 6 2.5-s rise time triangles shifted by 2.5-s each, for total possible subfault durations of 17.5 s. The moment rate function is shown at the top, with the centroid time being $T_c = 41.3$ s. The slip distribution is shown on the bottom, with the slip of the footwall shown by the red arrows with magnitude of the total slip in each subfault being color-coded. The subfault source time functions are shown within each cell. The rupture front at 10 s intervals is shown by white dashed lines. The red star is the hypocenter location. Data sampling is the same as in Figure S2.
Figure S5. The two-fault finite source rupture model for the December 17, 2016 Solomon Islands earthquake. Fault E1 (shown in map view in Figure 3) is the first fault to fail, with rupture nucleating at 103.2 km depth on a fault dipping 30° toward the SW. The rupture expands at 3.0 km/s, and the first 35 s of the moment rate function in Figure 3 is from slip on E1. Fault E2 (shown in map view in Figure 3) is the second fault to fail, with rupture nucleating at 40 km depth on a fault dipping 35° toward the NE. The last 50 s of the moment rate function is dominated by energy release from Fault E2.
Figure S6. Comparison of observed (black) and computed (red) P-wave ground displacements (left panel) and SH-wave ground velocities (right panel) for the preferred two-fault rupture model for the December 17, 2016 $M_W$ 7.9 Solomon Islands earthquake shown in Figure 3.
Figure S7. A two-fault rupture model for the December 17, 2016 $M_W$ 7.9 Solomon Islands earthquake using the steeper dipping deep plane as an alternative to the shallow dipping plane used in Figure 3. The first fault to rupture is labeled E1, with the map view of the fault position (shallower edge is heavier line, red star is the hypocenter) and the slip distribution shown on the top left, and the moment rate function in red below. The second fault to rupture is labeled E2, with the map view of the fault position (shallower edge is heavier line, cyan star is the hypocenter) and the slip distribution shown on the top right, and the moment rate function in cyan below. The total moment rate function is shown by the black trace. The faulting geometry for E1 is shown by the red focal mechanism and the faulting geometry for E2 is shown by the cyan focal mechanism (fault planes are indicated by black lines), with the respective faulting parameters ($H_c$ is slip centroid depth) shown below. The one-week aftershocks from the USGS-NEIC are shown by circles with color-coded depths and size scaled proportional to magnitude. The relocated intermediate depth event hypocenters are shown by small stars. The magenta focal mechanism is the Global Centroid-Moment Tensor (GCMT) solution plotted at the centroid location. The forest green focal mechanism is the composite focal mechanism of the two-faulting slip model at the faulting centroid. Pink focal mechanisms are early GCMT solutions for larger aftershocks.
Figure S8. USGS-NEIC seismicity in the New Britain-Solomon Islands trench system with $m_b \geq 4.5$ for the time period 1973 to 2016. The top panel shows the seismicity in map view (area of the circles is scaled proportional to the seismic moment). The reference position at the junction of the trenches is along the epicenter of the December 17, 2016 $M_W$ 7.9 event. The time sequence of seismicity is shown below. Note the concentration of seismicity near the trench junction, the sparsity of seismicity in the central Solomon Islands to the east in the vicinity of the great April 1, 2007 $M_W$ 8.1 earthquake, and the concentration of activity in the southern Solomon Islands. Also note the regional tendency for large events to cluster spatially and temporally in 1974, 1975, 1977, 1995, 2000, and 2015.
Figure S9. The upper panel shows the first week of aftershocks for the September 9, 2005 $M_w$ 7.6 intraplate rupture with a hypocenter at 90 km (circles). The stars indicate the epicenters of the December 17, 2016 $M_w$ 7.9 earthquake (magenta) and its relocated aftershocks from Figure 2. Note how closely the extent of intermediate depth activity corresponds between the 2005 and 2016 events, and the almost total lack of aftershock activity on the shallow megathrust for 2005, in contrast to 2016 (Figure 2). The lower panel shows a vertical cross-section along the line B-B’, which is the same as in Figure 2, with the positions of the 2005 event and its aftershocks (triangles) shown. The dashed lines are the same planes as in the vertical section in Figure 2. The 2005 event may have activated both 60° and 30° dipping planes within the slab, with the shallow dipping plane parallel to, but 30 km deeper than the rupture plane in 2016.