

Supplementary information for:

“The Energetic 2010 M_W 7.1 Solomon Islands Tsunami Earthquake”

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Details of tsunami impact:

Variations in tsunami impact were observed across the New Georgia Group. The tsunami impact peaked with a maximum flow depth of 7.5 m as measured on trees at Retavo, and a maximum run-up of 7 m was identified in an uninhabited jungle to the east of Endotori Point. Tsunami run-up remained sustained in the 5 to 7 m range from Mbaniata to Ndoro Point along a 12 km stretch of Rendova’s south coast. The tsunami run-up remained below 2 m from Hofovo Point (Rendova’s westernmost point) to the north and along Rendova and Tetepare’s coastlines inside the Blanche Channel. The 2010 tsunami exceeded the 2007 tsunami from Havila to the east. More than a meter tsunami run-up was documented on South Island (Marovo Lagoon) and Simbo Island at Magela. The residents of Tapurai on Simbo Island relocated to Magela based on a unanimous decision after the 2007 tsunami given the total destruction and massive land loss due to subsidence. The “old” Tapurai now serves as plantation. Sub-meter tsunami waves were observed throughout the New Georgia group including along the south shores of Ranongga and Ghizo Islands.

Deformation Model Optimization:

Optimal model parameters including locking depth and distance from the trench are determined for both the shallow megathrust TsE and high-angle intraslab models initially using

uniform slip models. For each model we constrain the strike and dip using the fault and auxiliary planes of the gCMT focal solution. For the shallow megathrust model, the updip edge is constrained by the trench. The downdip extent of slip (locking depth) is best fit at 5.2 km depth (**Figure S5a**), corresponding to a down-dip width of 13.3 km. Substantial deeper slip would require upward motion on the most proximal coastal points. For the high-angle intraslab model, we tested both locking depth and distance from the trench. For this model neither the locking-depth nor position are well constrained (**Figures S5b,c**), and can only be described as deeper than about 8 km, and seaward of the nearest coastal measurement (near 15km from the trench). Our choice of 20 km locking depth and near-trench rupture are feasible.

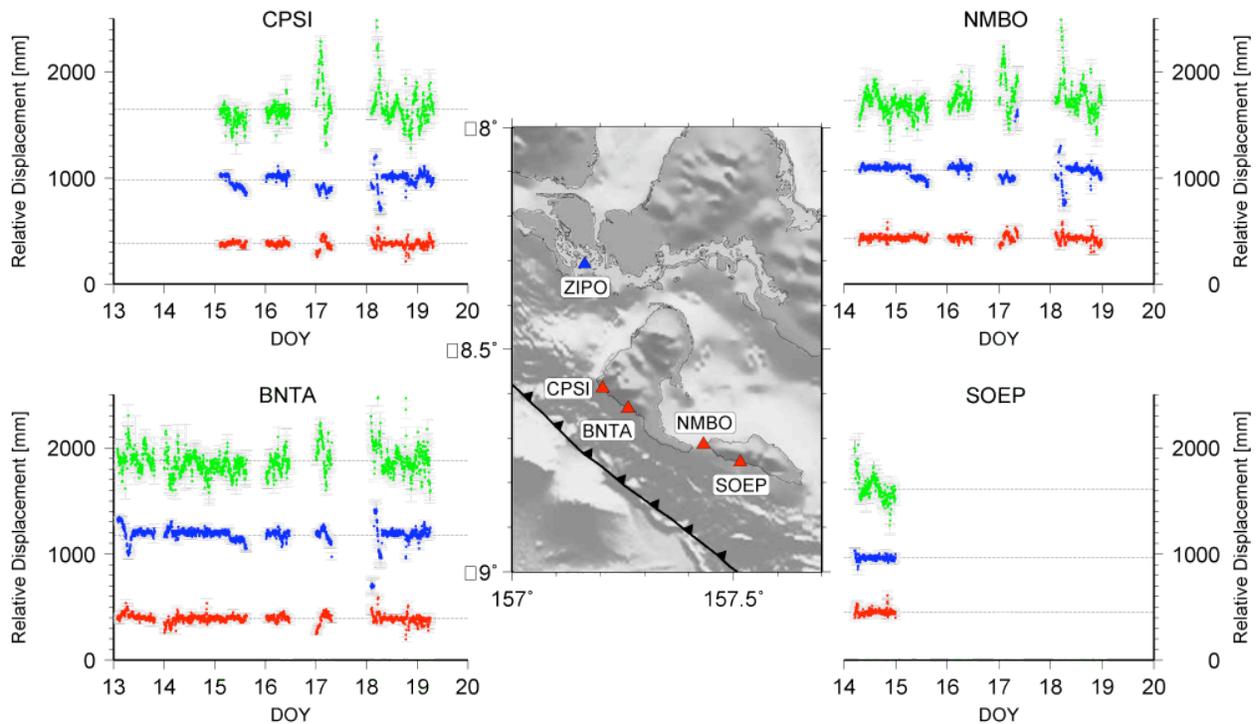


Figure S1: 15-second kinematic GAMIT-TRACK (Herring *et al.*, 2008) solutions (plotted as 5-minute averages) of the post-seismic GPS survey relative to base-station ZIPO show no discernable deformation in the near-trench environment.

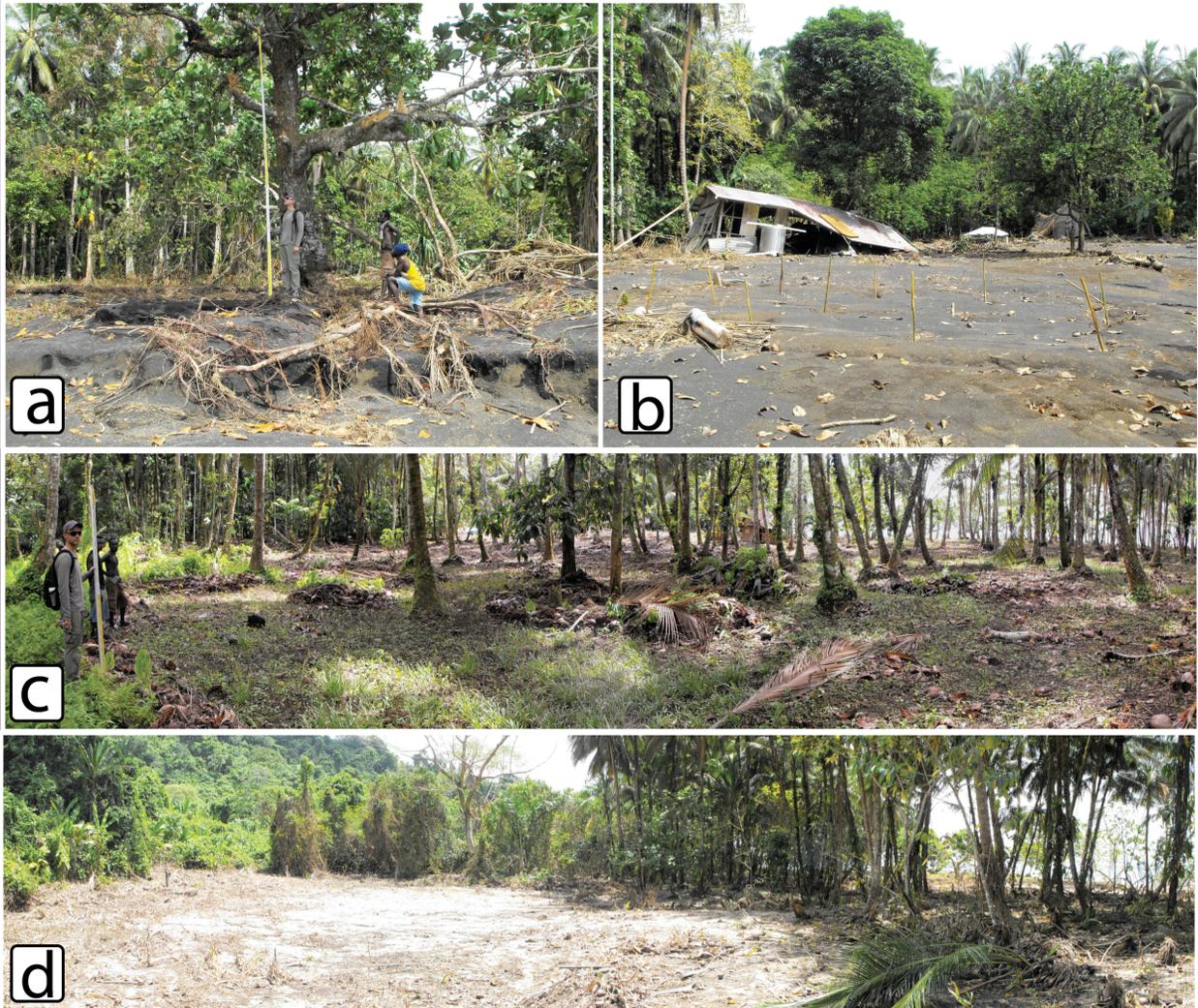


Figure S2: Tsunami impact on Rendova Island: [a] Maximum flow depth of 7.5 m at Retavo (based on bark damage and rafted debris on a tree 4.7 m above terrain 2.8 m above sea level at tsunami arrival); [b] Remnants of floated houses deposited 30 to 50 m away from their original foundations marked with sticks at Retavo; [c] Wrackline marking the maximum inundation of 150 m in a forest at Retavo; [d] Wrackline and sand deposit marking almost 7 m run-up and 130 m inundation at uninhabited (besides crocodiles) Ngoro Point.

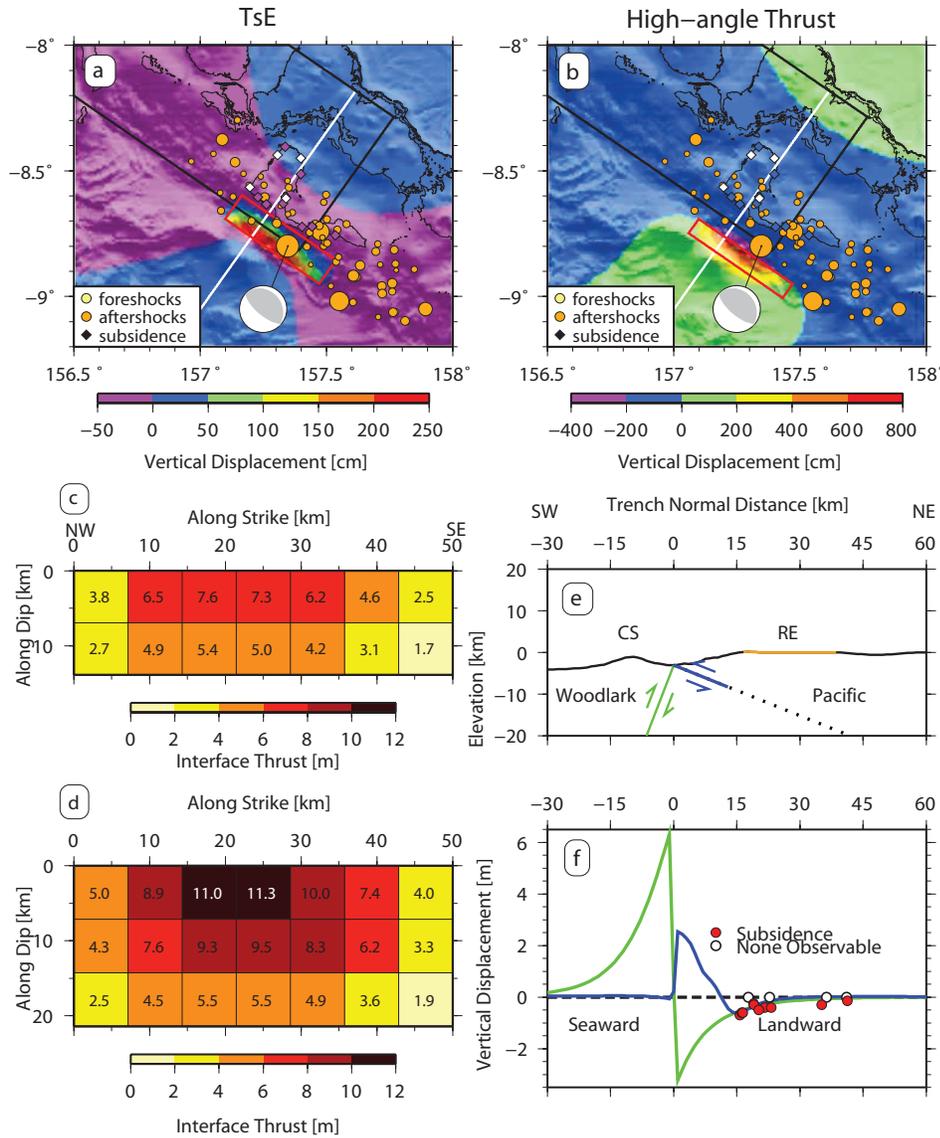


Figure S3: [a, b] Predicted vertical surface deformation and [c, d] modeled slip differences are shown for the 3 January 2010 M_W 7.1 Solomon Islands earthquake between the best-estimate megathrust tsunami earthquake (TsE) and intra-slab event, respectively (similar to **Fig. 3**). Model parameters for both follow the gCMT solution (Ekström *et al.* 2005) with strike = 125° and [e] dip = 22° or 69° . [f] The predicted deformation along the profile in [a,b] is also shown (white line). Megathrust model has a mean slip=4.67 m corresponding to an M_W 7.2 (detailed in **Fig. S5**), while the intraslab model [e] has smoothed variable slip corresponding to an M_W 7.4.

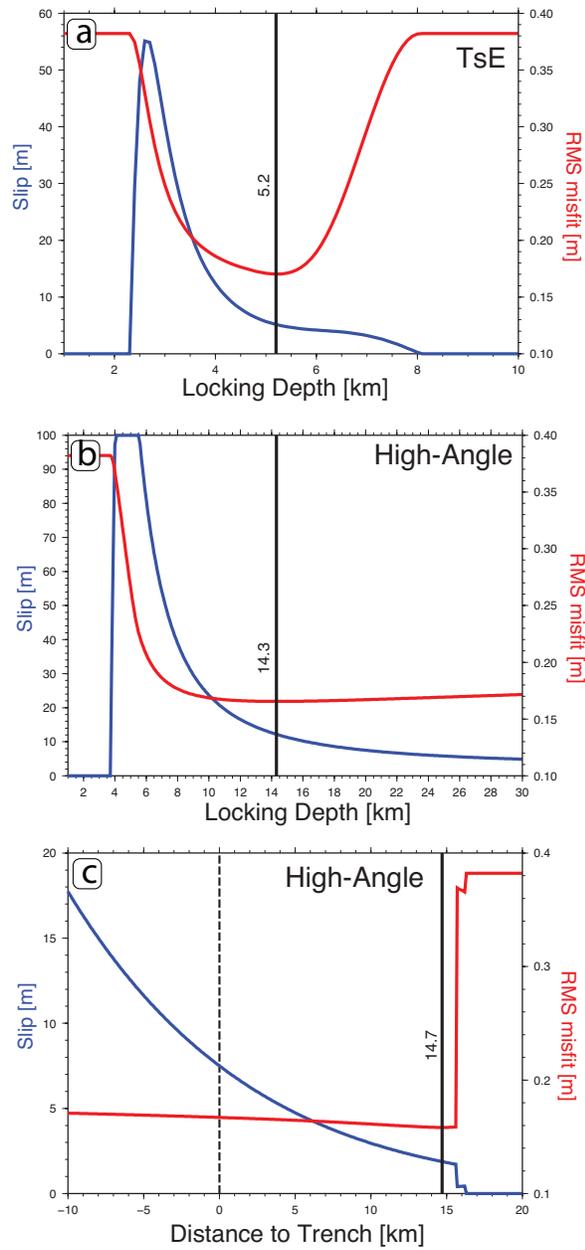


Figure S4: [a,b] Tests for optimal locking depth (base of slip) for the shallow megathrust tsunami earthquake (TsE) and high-angle models. For the TsE model optimal locking depth is determined to be 5.2 km depth. [c] Trench-normal distance is additionally tested for the high-angle model. For each, the lowest RMS misfit models are denoted by black vertical line; however neither the locking-depth nor the trench-normal position well constrained for the high-angle model.

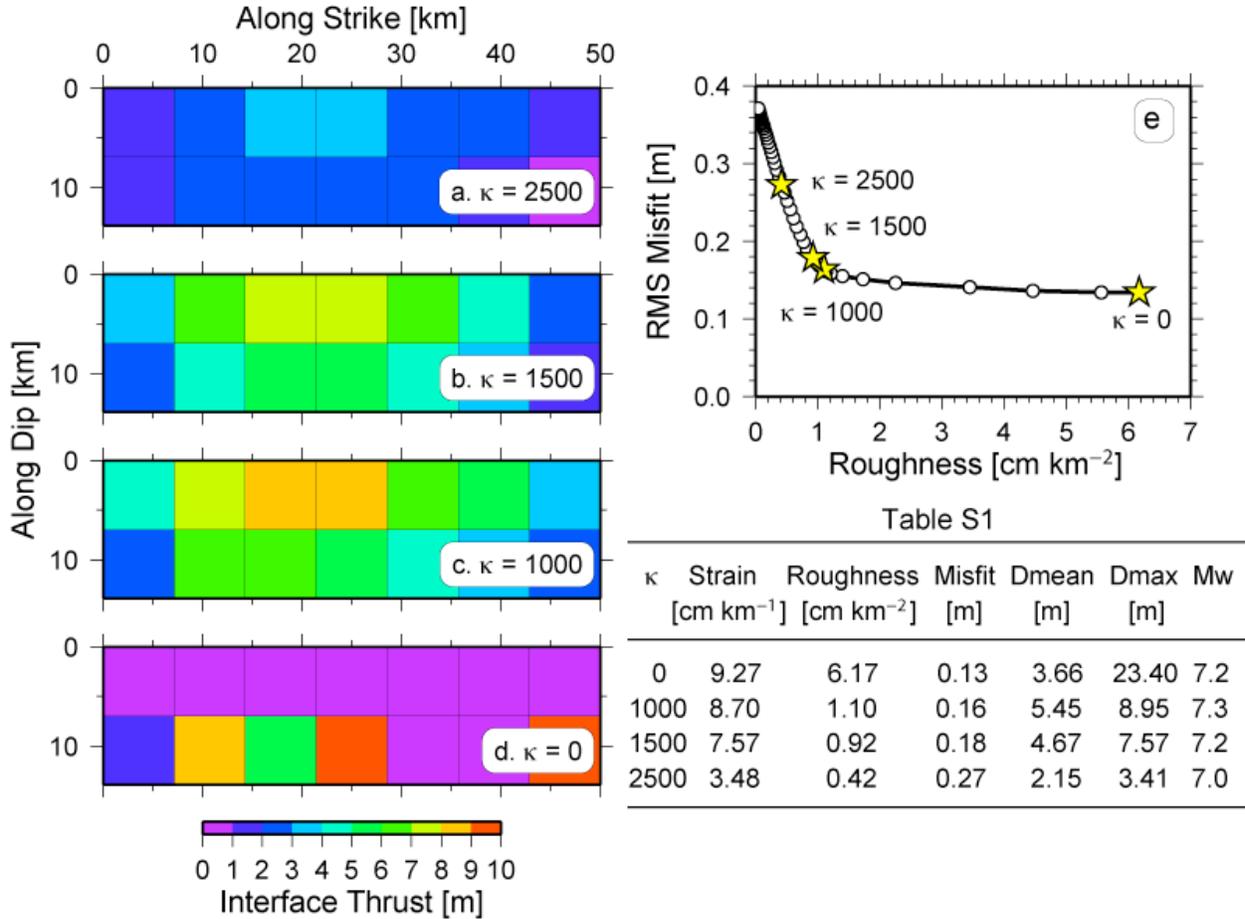


Figure S5: [a-d] Model results are shown for a range of smoothing parameters. Because independent determination of individual patches in the 7x2 grid slip model is impossible given the scarcity and location of data, smoothing is applied (Jónsson *et al.*, 2002; Chen *et al.*, 2009). The smoothing parameter κ controls the smoothness of the modeled interface, where the preferred and somewhat subjective solution is determined at the point with the [e] trade-off between decreased roughness and increased misfit becomes too great. Our preferred model, $\kappa = 1500$, is preferred over 1000 because the cumulative slip yields an estimated M_w closer to the observed value of $M_w = 7.1$ (Table S1).

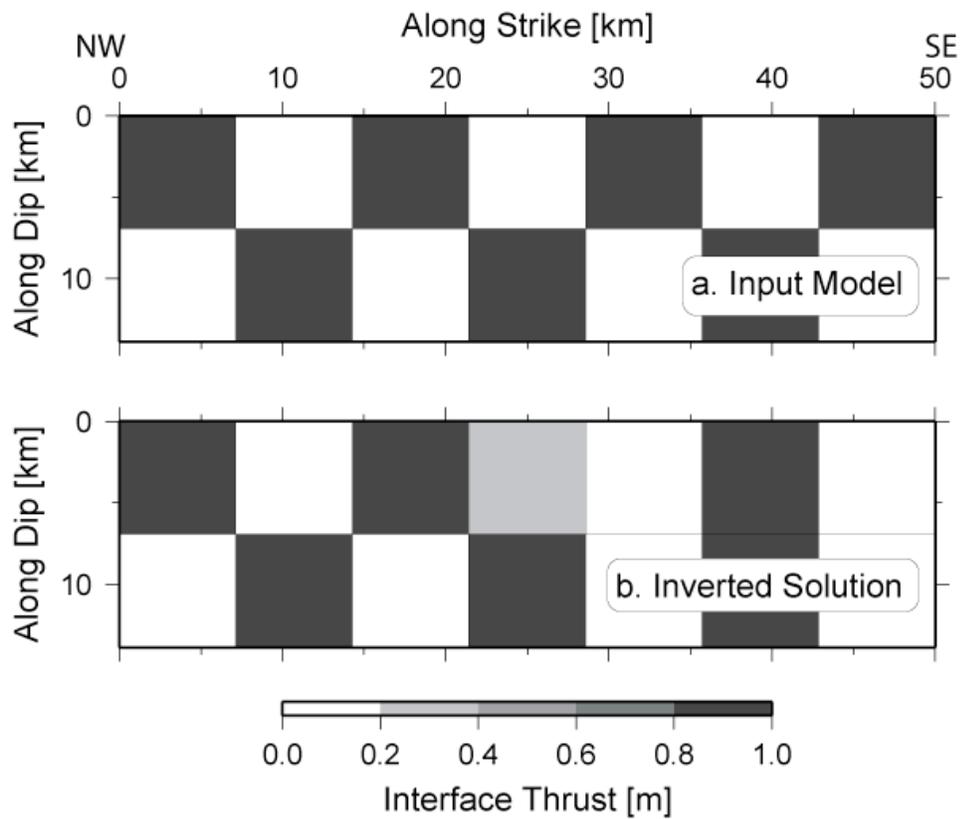


Figure S6: Checkerboard test identifying the resolvability of individual patches of slip given an alternating [a] input model of 0's and 1's. [b] The inverted result shows that while the subsidence data is sufficient to recover the deeper slip and upper 30 km in the west, resolution falls-off in the shallow southeastern segment due to lack of subsidence data in southeastern Tetepare Island.

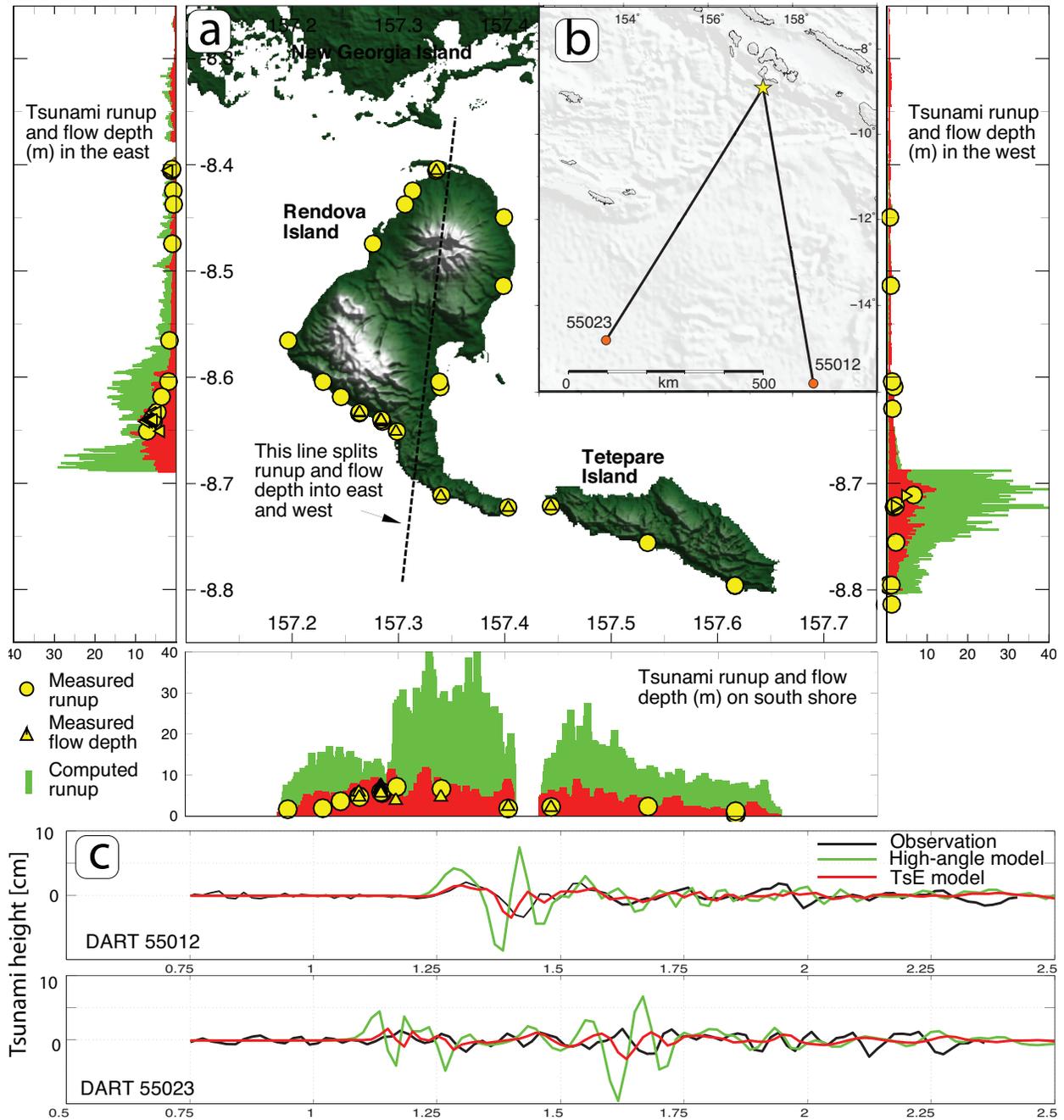


Figure S7: Alternative predicted [a] tsunami inundation (green bars) and open-ocean [c] tsunami wave heights at [c] dart buoys 1000 km to the south (locations shown in [b]) compared to the preferred model (red bars, repeated from **Figure 5**), but includes both TsE (red) and high-angle fault (green) model predictions for open-ocean tsunami waves without a time-correction.

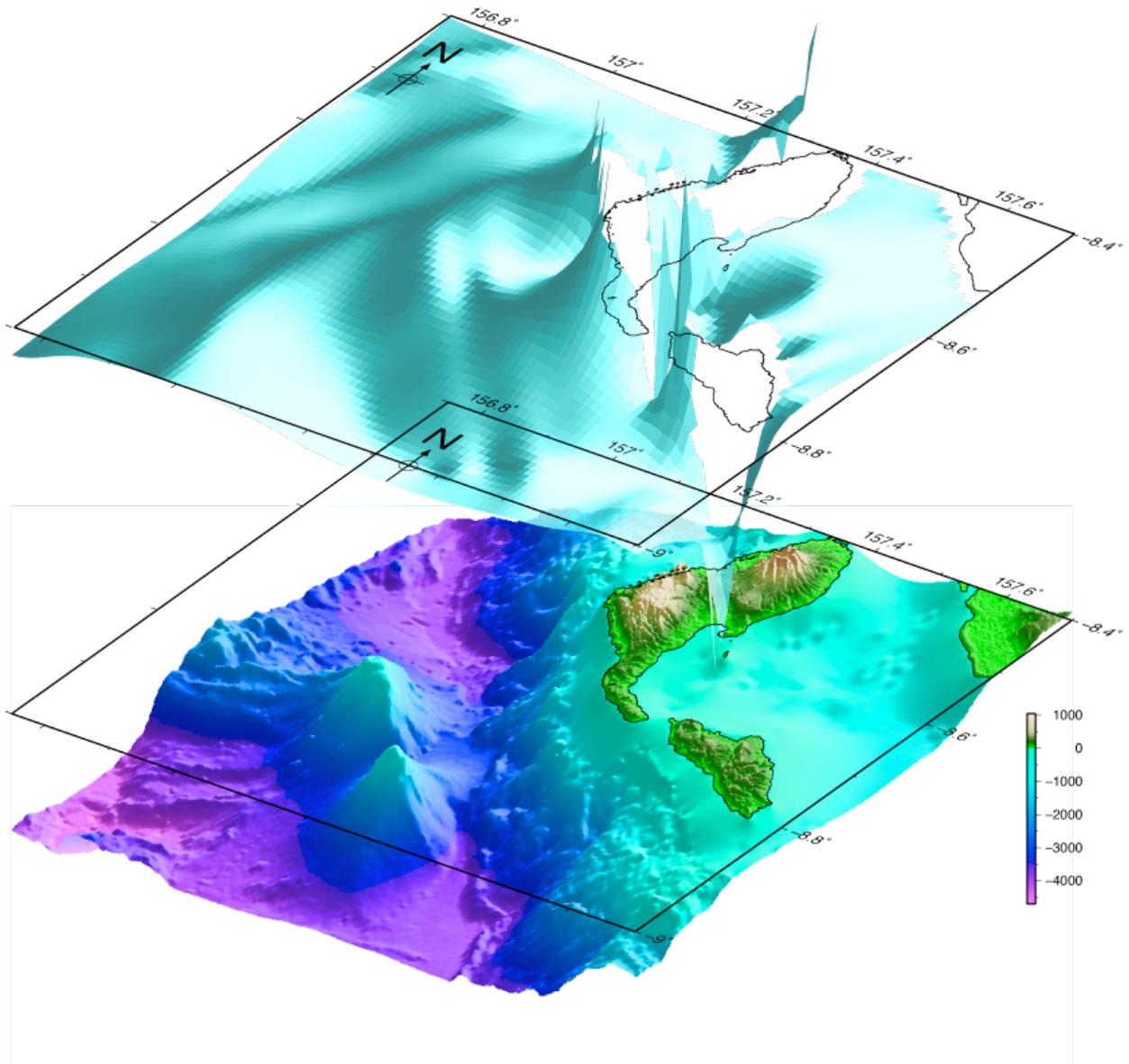


Figure S8: Perspective view of the earthquake source region and predicted tsunami wave heights 10 minutes after rupture (maximum amplitudes 1.4 m). This view highlights the impingement of the Coleman and Kana Keoki seamounts at the trench causing a near 1-km local elevation change in trench depth.