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3-D FEM derived elastic Green's functions for the coseismic deformation of the 2005 Mw 8.7 Nias-Simeulue, Sumatra earthquake

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Using finite element models, we first examine the sensitivity of surface displacements to the location of fault slip, topography, and three-dimensional variations in elastic moduli in the context of a 2-D infinite thrust fault. We then evaluate the impact of these factors and fault geometry on surface displacements and estimates of the distribution of coseismic slip associated with the 2005 Mw 8.7 Nias-Simeulue, Sumatra earthquake. Topographic effects can be significant near the trench, where bathymetric gradients are highest and the fault is closest to the free surface. Variations in Young's modulus can significantly alter predicted deformation. Surface displacements are relatively insensitive to perturbations in Poisson's ratio for shear sources, but may play a stronger role when the source has a dilatational component. If we generate synthetic displacements using a heterogeneous elastic model and then use an elastic half-space or layered earth model to estimate the slip distribution and fault geometry, we find systematic residuals of surface displacements and different slip patterns compared to the input fault slip model. The coseismic slip distributions of the 2005 earthquake derived from the same fault geometry and different material models show that the rupture areas are narrower in all tested heterogeneous elastic models compared to that obtained using half-space models. This difference can be understood by the tendency to infer additional sources in elastic half space models to account for effects that are intrinsically due to the presence of rheological gradients. Although the fit to surface observations in our preferred 3-D FEM model is similar to that from a simple half-space model, the resulting slip distribution may be a more accurate reflection the true fault slip behavior.