**The M7 2016 Kumamoto, Japan, Earthquake: Surface Strain in the Damage Zone And Fault Slip Revealed By Differencing Near-Field Geodetic Imagery**

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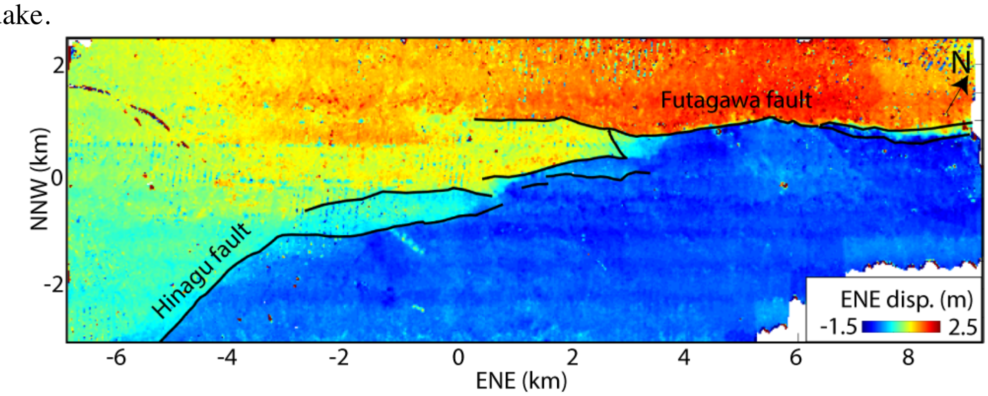
The differencing of high-resolution topography acquired before and after an earthquake measures the 3D deformation field along and adjacent to the surface rupture and fills a near-fault gap in geodetic observations of deformation. Observations of the fresh surface rupture, along-fault slip, and distributed off-fault deformation in the shallow crust facilitate understanding of how processes active in a single earthquake influence fault zone structure over multiple earthquake cycles. Earthquake slip inversions constrained with near- *and* far-field displacements quantify coseismic slip throughout the seismogenic zone and indicate mechanical controls on slip propagation.

Our work on the April 2016 M7 Kumamoto, Japan, earthquake addresses these topics. The earthquake ruptured the Hinagu and Futagawa faults on the Kyushu Island with an oblique strike-slip mechanism and surface slip exceeding 2 m. By applying the Iterative Closest Point algorithm to airborne lidar point cloud imagery collected before and after the earthquake mainshock, we measure the 3D surface displacement field at a 50 m spatial resolution. 36 ± 29% and 62 ± 32% of the horizontal and vertical deformation, respectively, was accommodated off the main fault trace. Horizontal strains of up to 0.03 suggest that the approximate elastic strain limit was exceeded over a 250 m width along the rupture. These observations measure the permanent damage accumulated during the single earthquake.

We developed a lidar topography-optical-InSAR distributed-slip earthquake source inversion. The maximum slip of 5.9 m occurs at 4.5 km depth. The missing shallow slip along the primary fault likely reflects shallow distributed and inelastic deformation. We show how datasets with varying spatial resolution constrain the distributed fault slip. As geodetic inversions ingest more data types, this type of calculation becomes critical for comparing inversion results and derived products (e.g., stress drop). Ultimately, slip models that include the complexity in the fault geometry and crustal rheology observed in near-fault imagery will advance our understanding of shallow fault zones.

Topographic differencing is an emerging technique that measures change to natural and anthropogenic landscapes by comparing multi-temporal high-resolution topography datasets. We are working with the NSF-funded facility OpenTopography to implement on-demand vertical and 3D topographic differencing for overlapping datasets. This tool will allow individuals with varying geospatial expertise and needs to perform topographic differencing, for example, for the 2016 M7 Kumamoto earthquake.




ENE displacement for the 2016 M7 Kumamoto, Japan, earthquake calculated by applying the Iterative Closest Point algorithm to pre- and post-earthquake high resolution topographic imagery.