Generous to a fault: How including both seismic and geodetic datasets improves earthquake slip characterization

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Following an earthquake of interest, deciphering the spatiotemporal details of the rupture help to inform shaking predictions, loss estimates, and damage assessments. Shaking is related to a location's distance from slip asperities; however, rupture directivity can result in variable shaking and damage at different azimuths, despite similar distances from the rupture. The U.S. Geological Survey National Earthquake Information Center (NEIC) produces a slip model (known as a finite fault model, FFM) within hours of a significant earthquake. In the past, these models have been produced with broadband teleseismic data, for which it is generally feasible to model earthquakes of magnitude 7 and larger globally. Peer-reviewed research products have demonstrated that incorporating regional-distance seismic and geodetic observations, where available, can improve model quality and the accuracy of downstream impact products. In addition, these high-quality research products contribute to general knowledge of the earthquake rupture process, including magnitude-dependent qualities of rupture (i.e., earthquake scaling laws) and specific attributes of well-instrumented fault systems (e.g., rupture propagation speeds).

In this talk, I will demonstrate recent updates to NEIC operations that move us toward producing these joint regional/teleseismic seismo-geodetic FFMs in a response time frame (hours). Including regional seismic and geodetic datasets enhances our ability to model smaller magnitude earthquakes than NEIC previously considered for rapid slip characterization and improves model resolution for earthquakes of any size. I will highlight results from the 2021 M7.2 Nippes, Haiti, earthquake, for which teleseismic waveforms included interference from an earlier M6.9 earthquake offshore Alaska. This interference limited the quality of NEIC's initial teleseismic FFM (top figures). The slip model was later improved through integration of regional seismic and geodetic data (bottom figures) clarifying the rupture's westward directivity and confirming the benefit of including any available observations in NEIC response models.

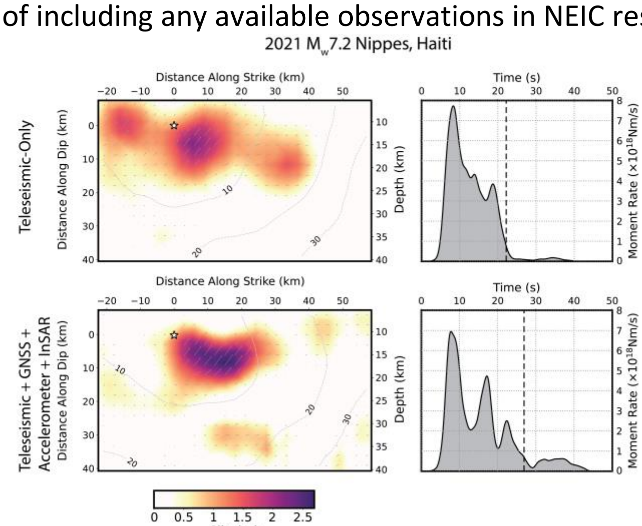

Figure 1. Slip models of the 2021 M7.2 Nippes, Haiti, earthquake. Top: model using only teleseismic data. Slip on fault plane (left) and moment rate function (right). Bottom: model using teleseismic, GNSS, accelerometer, and InSAR observations. Slip on fault plane (left) and moment rate function (right).