Rapid seismic source characterizations: from large to small magnitudes

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Rapid and accurate characterization of earthquake sources directly benefits ground shaking prediction and hazard assessment and also enhances our understanding of earthquake source physics. However, inversions for large earthquake rupture complexities are typically computationally consuming, posing challenges to systematic analysis of large earthquake source properties in a consistent framework. On the other hand, efforts to resolve small earthquake details are hampered by the limited coherence of seismic waves at high frequencies. In this study, we consider a suite of new approaches to overcome these limitations. For large earthquakes, we develop an algorithm to resolve source complexity by inverting moderate-to-long-period seismic waves (T>8s) for multiple centroid moment tensors (CMTs) in a semi-linear framework. A sparsity constraint is imposed, based on the physical understanding that earthquake moments are often mainly released at only a few spots for a given time window. Using our algorithm, we build a large catalog of source models, including all global Mw>7 deep earthquakes since 1990. Our models suggest that the rupture complexity of deep earthquakes may be influenced by subducting slab temperature and slab geometry. For small earthquakes, we develop a novel deconvolution approach that uses energy envelopes to remove path effects and extract source information, as the energy envelopes are more coherent at high frequencies where the waveforms are typically incoherent. We validate our energy deconvolution analysis using a well-studied Mw 5.4 Ridgecrest earthquake, and apply the algorithm to determine rupture directivities of over 100 Mw>3.5 aftershocks during the 2019 Ridgecrest sequence. Our results show that many of the earthquakes ruptured orthogonal interlocking faults during the Ridgecrest sequence, showing the potential of the approach in mapping fault networks in high resolution.