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A phase coherence approach to estimating the spatial extent of earthquakes

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We present a new method for estimating the spatial extent of seismic sources. The approach takes advantage of an inter-station phase coherence computation that can identify co-located sources (Hawthorne and Ampuero, 2014). Here, however, we note that the phase coherence calculation can eliminate the Green's function and give high values only if both earthquakes are point sources—if their dimensions are much smaller than the wavelengths of the propagating seismic waves. By examining the decrease in coherence at higher frequencies (shorter wavelengths), we can estimate the spatial extents of the earthquake ruptures. The approach can to some extent be seen as a simple way of identifying directivity or variations in the apparent source time functions recorded at various stations.

We apply this method to a set of well-recorded earthquakes near Parkfield, CA. We show that when the signal to noise ratio is high, the phase coherence remains high well above 50 Hz for closely spaced M<1.5 earthquake. The high-frequency phase coherence is smaller for larger earthquakes, suggesting larger spatial extents. The implied radii scale roughly as expected from typical magnitude-corner frequency scalings.

We also examine a second source of high-frequency decoherence: spatial variation in the shape of the Green's functions. This spatial decoherence appears to occur on a similar wavelengths as the decoherence associated with the apparent source time functions. However, the variation in Green's functions can be normalized away to some extent by comparing observations at multiple components on a single station, which see the same apparent source time functions.