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Rupture Tracking with Rotational Ground Motion 0bservations

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With the availability of new instrumentation for complete ground motion measurements (e.g., rotation sensing, strain measurements) the question on potential applications in seismology arises. From single-site combined measurements of rotations and translations (6 degrees of freedom) backazimuth information can be determined. Such measurements are reasonably stable, indicating the potential of a single point measurement returning similar information as a small-scale array of classic 3C seismometers. The S-wave field emitted during the shear failure of earthquake ruptures is inherently linked to rotational ground motions.

Here we investigate whether a 6 DoF approach is applicable for tracking a finite rupture in the P- and S-wave field. We analyse 2D and 3D synthetic cases of unilateral but complicated rupture propagation. The backazimuth of directly arriving SH-waves (in the 2D case) and converted SV-waves (in the 3D case) are tracked. We explore data analysis based on wave polarity. A new statistical approach for combining the backazimuth estimates of several stations is presented which shows a high resistance with respect to measurement outliers.

We successfully recover the rupture path and the rupture velocity with only one station in 2D and 3D, presupposed the fault position is known approximately a priori. Using more than one station, spatial rupture tracking is possible without any a priori assumptions. It is possible to correctly determine relatively small variations in rupture speed, and rupture jumping across off-set fault segments.

We discuss effects of rupture directivity, supershear propagation speeds, the geometry between source and receiver and shortcomings of the method.