S012-0011 - Rupture and traffic tracking with six degree-of-freedom ground motion observations: a proof of concept

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Abstract

With the availability of new instrumentation for more complete ground motion measurements, as rotation or strain measurements using optical technology, novel application opportunities in seismology arise. Back azimuth (BAz) information can be determined from combined measurements of rotations and translations at a single site. Such six degree-of-freedom (6-DoF) measurements are reasonably stable in delivering similar information compared to a small-scale array of three-component seismometers. Here we investigate whether a 6-DoF approach is applicable for imaging earthquake rupture propagation and other seismic sources. While common approaches determining the timing and location of energy sources generating seismic waves rely on the information of P-waves, here we take S-waves into account.

We analyze 2-D and 3-D synthetic cases of unilateral but complex rupture propagation. The back azimuths of directly arriving SH-waves in the 2-D case, and P-converted SV-waves, direct SV- and SH-waves in the 3-D case are tracked. For data analysis in terms of wave polarity we compare a cross-correlation approach using a grid-search optimization algorithm with a polarization analysis method. We successfully recover rupture path and rupture velocity with only one station, under the assumption of an approximately known fault location. Using more than one station, rupture imaging in space and time is possible without a priori assumptions. We show robustness of the approach in resolving relatively small variations of rupture velocity, and rupture jumping across off set fault segments. We discuss the effects of rupture directivity, supershear rupture velocity, source-receiver geometry, wavefield interference as well as other potential and challenges for the method.

We verify our approach with the analysis of moving traffic noise sources using 6-DoF observations. The collocated classic seismometer and newly-built ring laser gyroscope ROMY near Munich, Germany, allow us to record high-fidelity, broadband 6-DoF (particle velocity and rotational rate) ground motions. We

successfully track from the estimated BAz as a function of time vehicles and their speed while traveling along a nearby highway.

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