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Kinematic Seismic Rupture Parameters from a Doppler Analysis

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The radiation emitted from extended seismic sources, mainly when the rupture spreads in preferred directions, presents spectral deviations as a function of the observation location. This aspect, unobserved to point sources, and named as directivity, are manifested by an increase in the frequency and amplitude of seismic waves when the rupture occurs in the direction of the seismic station and a decrease in the frequency and amplitude if it occurs in the opposite direction. The model of directivity that supports the method is a Doppler analysis based on a kinematic source model of rupture and wave propagation through a structural medium with spherical symmetry [1].
A unilateral rupture can be viewed as a sequence of shocks produced along certain paths on the fault. According this model, the seismic record at any point on the Earth's surface contains a signature of the rupture process that originated the recorded waveform.
Calculating the rupture direction and velocity by a general Doppler equation, - the goal of this work - using a dataset of common time-delays read from waveforms recorded at different distances around the epicenter, requires the normalization of measures to a standard value of slowness. This normalization involves a non-linear inversion that we solve numerically using an iterative least-squares approach.
The evaluation of the performance of this technique was done through a set of synthetic and real applications. We present the application of the method at four real case studies, the following earthquakes: Arequipa, Peru (Mw = 8.4, June 23, 2001); Denali, AK, USA (Mw = 7.8; November 3, 2002); Zemmouri–Boumerdes, Algeria (Mw = 6.8, May 21, 2003); and Sumatra, Indonesia (Mw = 9.3, December 26, 2004).
The results obtained from the dataset of the four earthquakes agreed, in general, with the values presented by other authors using different methods and data.

[1] Caldeira B., Bezzeghoud M, Borges JF, 2009; DIRDOP: a directivity approach to determining the seismic rupture velocity vector. J Seismology, DOI 10.1007/s10950-009-9183-x