INVESTIGATING THE BACK-PROJECTION METHOD USING SYNTHETIC RUPTURE MODELS: FAULT HETEROGENEITY, ARRAY DISTRIBUTIONS AND FREQUENCY DEPENDENCE

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The back-projection (BP) method has been widely used to image the rupture process of many large and moderate earthquakes since its first application to the 2004 Mw 9.2 Sumatra earthquake. However, some critical questions – relevant to the interpretation of BP results – remain unanswered. Some of the important ones are – why different arrays often capture different rupture features for the same earthquake? What physical properties of the fault can we infer from the BP results? Here we use kinematic earthquake rupture models, in which we exactly know the spatiotemporal evolution of the rupture process. Those models are set up with various rupture velocities, slip rates, fault orientations, and unilateral or bilateral ruptures. We compare BP results generated from a range of synthetic arrays with the prescribed rupture models. Results suggest the BP can only track heterogeneous ruptures. In a certain frequency band, the BP is sensitive to rupture heterogeneity in a limited size range, which explains the frequency dependent ruptures usually observed in subduction zones. When ruptures propagate in multiple directions simultaneously, the frequency of source energy recorded in the arrays are changed due to the Doppler effect of rupture directivity. The BP tends to track the rupture in a direction that produces dominant seismic energy in the array within a certain frequency bands used. In a next step, dynamic rupture models will be set up to examine the direct relation between BP results and earthquake dynamics. Understanding the physical implications of BP characteristics helps integrating modern observational techniques into dynamic rupture modeling, specifically with respect to the size and distribution of heterogeneities across faults.