Title
Revealing micro-asperity rupture through finite source inversion

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ABSTRACT: Laboratory studies of acoustic emission events with seismic signatures have used the point source assumption. Given the millimeter-scale size and clustering of the asperities and the centimeter-scale distances to the sensors, the records can convey information about the source complexity that is not fully revealed in a point source inversion. We develop a finite source inversion technique following Hartzell and Heaton, 1983 to compute the spatiotemporal distribution of slip during rupture of asperities and asperity clusters. First inversions of purely synthetic signals reveal some of the applicability and limitations of the algorithm. A preliminary inversion of one recorded event is included for demonstration. With much further sensitivity analysis and modeling improvements, the resulting slip profiles will provide a new tool for understanding the frictional strength and rupture behaviors of self-similar rough-rough interfaces at any scale.

1. INTRODUCTION

Laboratory studies of controlled shear faults have been shown to exhibit earthquake-like acoustic emissions (AE) events in a variety of rock and polymer materials (e.g. McLaskey and Glaser, 2011). When conducted on rock materials these experiments typically produce hundreds to thousands of AE events, providing for a statistical study of fault properties such as variations in stress state (Goebel et al., 2013) and type of seismicity (McLaskey and
Yamashita, 2017). Some experimental combinations of materials and constraints—including our direct-shear experiment in Poly(methyl-methacrylate) (PMMA)—instead produce only tens of AE events. While the resulting catalog is insufficient for aggregate study of events, it presents the opportunity to focus on analysis and modeling of individual sources.

Source study in strong motion seismology quickly becomes a problem of inversion. Stable inversions of full moment tensors, as described by Minson and Dreger, 2008, are computed at the laboratory scale with increasing frequency (e.g. Kwiatek et al., 2014; Stierle et al., 2016). Further information about the kinematics of an earthquake source can be inferred from a finite source inversion following Hartzell and Heaton, 1983. As the quality of laboratory AE data and accuracy of system models continues to improve, finite source inversion is reaching the verge of feasibility at the laboratory scale. We seek to investigate the demands and sensitivity of a finite source inversion algorithm adapted for the laboratory and then apply it to state-of-the-art, absolutely calibrated acoustic emissions records from our PMMA shear fault.