Numerical simulations of mainshock and aftershock sequences on geometrically complex fault zones

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A large earthquake triggers many smaller aftershocks, while its physical mechanism is still debated. Recent observation provides us very high-resolution aftershock catalogs (e.g, Yukutake & Iio, 2017). To be able to constrain the physical mechanism of aftershocks utilizing these catalogs, a forward model that relates fault structures and aftershock distributions would be necessary.

In this study, we aim to reproduce aftershocks originated from complex fault geometry in the framework of earthquake sequence simulations (Rice, 1993; Erickson et al. 2020). More specifically, we examine the hypothesis that a significant portion of aftershocks is ruptures of faults surrounding mainshock fault (Yukutake & Iio, 2017). We explicitly model both of the mainshock fault and hundreds of small surrounding faults, all of which have fractally rough geometries. This is motivated from the observation that natural faults show deviation from planar geometry at all scales (e.g. Candela et al. 2012). Using HACApK, a highly scalable H-matrix library, we simulate slip evolution on a complex fault system with O(10^5) degrees of freedom.

In the preliminary results, we successfully reproduced (1) tens of aftershocks which roughly follow Omori-like power-law temporal decay, (2) aftershocks occurring inside the "stress shadow" of mainshock, and (3) diverse focal mechanisms of aftershocks, all of which are universally seen in natural aftershock sequences. Furthermore, we seek physical insights on the relationship between aftershock distributions and the mainshock fault geometry.

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