Super-shear fault rupture propagation during the 2016 Kumamoto earthquake (Mw7.1); Numerical tests and resolution

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I investigated the rupture process of the April 16, 2016 Kumamoto earthquake, using a seismic back-projection methodology (Pulido et al. 2008, Pulido 2016), and a dense array of near-source strong motion records from the K-NET/KiKnet networks. The main target of this study is to understand the evolution of the rupture velocity during fault rupture propagation. I selected all the KNET/KiKnet records of the mainshock within 100 km around the Hinet epicenter (112 stations), and used the fault-parallel component rotated from the horizontal components. I bandbass filtered the data between 5 to 10 Hz and calculated the envelopes of velocity time series. Envelopes were stacked within a horizontal grid mesh covering the regions around the Hinagu and Futagawa fault traces and beyond, to obtain a temporal and spatial image of rupture propagation. My back-projection results show that significant grid energy was released in a region spanning 43km length along the Hinagu (16km) and Futagawa (27 km) fault zones. Back-projection results show a bilateral fault rupture propagation along the Hinagu and Futagawa faults, characterized by a slow sub-Rayleigh rupture velocity of 1.4 ~ 1.7 km/s, for the first 5.5 seconds of imaged rupture (4~9.5s from the origin time, OT). The rupture propagation towards the NE (along the Futagawa fault) experienced a very rapid increase in rupture velocity by reaching a value ~1.4 times larger than the average S-wave velocity (Vrup= 4.7 km/s) at 9.5s from OT, and remained super-shear for approximately 4.5 s (9.5 ~14s from OT) until fault rupture arrest. I also imaged a clear sub-Rayleigh rupture propagation towards the SW along the Hinagu fault zone (Vrup= 3.1 km/s), from 11 to 14 seconds after OT. I performed several numerical tests to analyze the effect of station distribution and the and the ability of my back-projection method to resolve the rupture process. I also performed multiple tests using actual records of aftershocks of the Kumamoto earthquake to test the accuracy of my results. All these tests indicate that the super-shear rupture propagation during the Kumamoto mainshock is a robust feature of my imaging results.

Keywords: 2016 Kumamoto earthquake, super-shear fault rupture, strong ground motion, seismic back-projection

