Waveform inversion with empirical Green's functions for the source rupture process of the mainshock of the 2019 Ridgecrest earthquake sequence

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The 2019 Ridgecrest earthquake sequence with M_w 7.1 mainshock hit the Eastern California Shear Zone (ECSZ) in July 2019, which was the first event exceeding M_w 7.0 in California since the occurrence of the 1999 Hector Mine earthquake. The mainshock caused near-fault ground motions exceeding 0.5 G and 70 cm/s. It highly required clarification of the source rupture process and the generation mechanism of strong ground motions of the earthquake. In this study, the rupture process of the mainshock was investigated from waveform inversions of strong-motion data in the frequency range of 0.2-2.0 Hz. In the inversion scheme, the empirical Green’s functions (EGFs) were adopted to avoid possible uncertainties caused by the assumption of subsurface velocity structures, and to handle relatively higher frequency ranges of strong ground motions typically up to 2.0 Hz as well, which are of great importance from engineering points of view. Our preferred slip model suggested that the main rupture of the M_w 7.1 event was confined in a region approximately 40 km in length, within which two large slip regions were identified: the primary large slip region with a maximum slip of approximately 3.0 m was centered ~ 3 km NW of the hypocenter, which was slightly shallower than the hypocenter, and a secondary large slip region was centered ~ 23 km SE of the hypocenter. A relatively small rupture velocity of 2.2 km/s was identified. Then, the reliability and robustness of our preferred source model were examined by different combinations of EGF events, which resulted that the locations of the large slip regions are not significantly affected by the selection of the EGF events. Moreover, using the preferred source model, we synthesized ground motions at strong-motion stations that were not used in the inversion analyses. The synthetic waveforms could capture the main phases of the observed waveforms, indicating the validity of the major spatio-temporal characteristics of the slip model. Additionally, our preferred slip model is generally consistent with some of the other models based on different data sets focusing on a lower frequency range (generally lower than 0.5 Hz). In particular, our preferred model is consistent with the result of the subevent modeling of strong-motion and teleseismic data (Ross *et al.*, 2019). The results imply that the generation process of strong ground motions of the Ridgecrest mainshock did not involve significant frequency-dependent nature at least up to 2.0 Hz.

Keywords: the mainshock of the 2019 Ridgecrest earthquake sequence, waveform inversion, empirical Green’s function, strong ground motions, rupture process