Analytical modeling of the long-period velocity pulse observed in the 2016 Kumamoto earthquake

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In the 2016 Kumamoto earthquake (M_{JMA}7.3), Nishihara village are registered to be 7 on JMA seismic intensities. The station at Nishihara village (Kumamoto Prefecture’s Instrumental Intensity Seismometer) observed the long-period velocity pulse (EW and UD component) whose width is 3 seconds and quasi-static deformations whose horizontal and vertical components are about 2 m (Asano & Iwata, 2016). Previous studies on slip inversion of the Kumamoto mainshock reported that rupture front of the large slip area (asperity) just under Nishihara village propagated from deep part of Futagawa fault to ground surface. Therefore, we have discussed whether the long-period velocity pulse is caused by the effect of forward directivity by far-field S wave or static displacements whose cause is near-field term and intermediate terms (near-field term + intermediate terms : near-field terms). Here we investigated the causes of the long-period velocity pulse by simply modeling the 2016 Kumamoto mainshock and using analytical solutions of near-field term, intermediate terms, far-field terms due to rectangular fault.

Fig.1 shows the simplest fault model in this study and the station which is simulated Nishihara village. Considering dip angle of Futagawa fault, we set the station a little under top of fault. This model considered the only asperity’s contribution and model asperity as a reference to Asano & Iwata (2016). Numerical calculation setting is P-wave velocity:6.0 km/s, S-wave velocity:3.5 km/s, Length of asperity:10 km, Width of asperity:14 km, slip amount:3.3m, risetime:1.5 s, slip angle:-135°, rupture velocity:2.5 km/s. Rupture front propagates from bottom of asperity to ground surface. Calculation results are doubled due to the effect of free surface.

Fig.2 shows results of ground motion and velocity. We were able to reproduce displacement and velocity records by using simple model (Fig.1). Fig.2 also shows near-filed terms and far-field terms. In EW component, both near-field terms and far-field terms contribute to long-period velocity pulse. In UD component, near-field terms mainly contribute to long-period velocity pulse. Above that, the long-period velocity pulse observed in the 2016 Kumamoto mainshock attributes to near-field terms in EW and UD components and forward directivity in EW component. However, numerical results of our simplest model underestimate the amplitude of velocity pulse in EW component. Later, we need to minutely model slip angle of asperity and the complexity of source mechanisms.

Keywords: Kumamoto earthquake, near-field term, forward directivity, permanent displacement, near-fault region

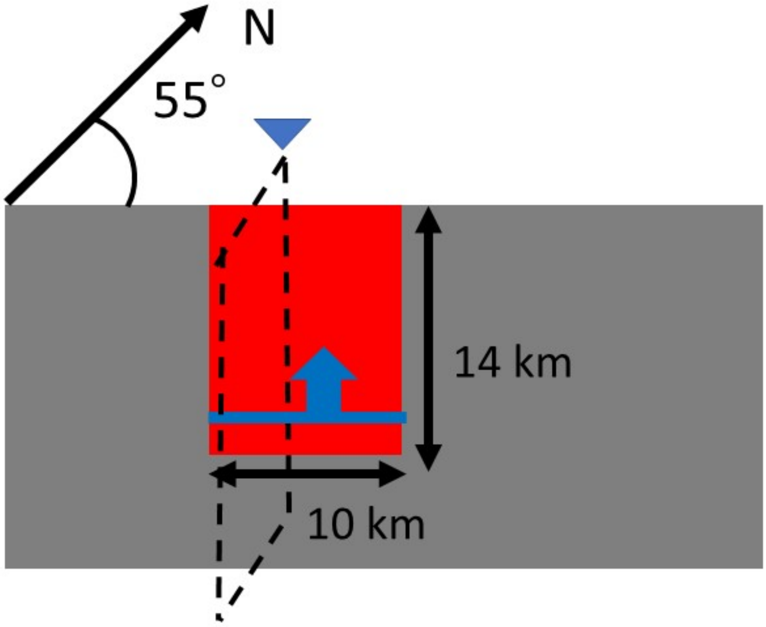

Fig.1 Simple asperity model in this study. Gray region is whole fault plane and red region is a large slip area (asperity). Blue triangle is the station which is simulated Nishihara village. Blue line and vector show rupture front and forward direction of that.

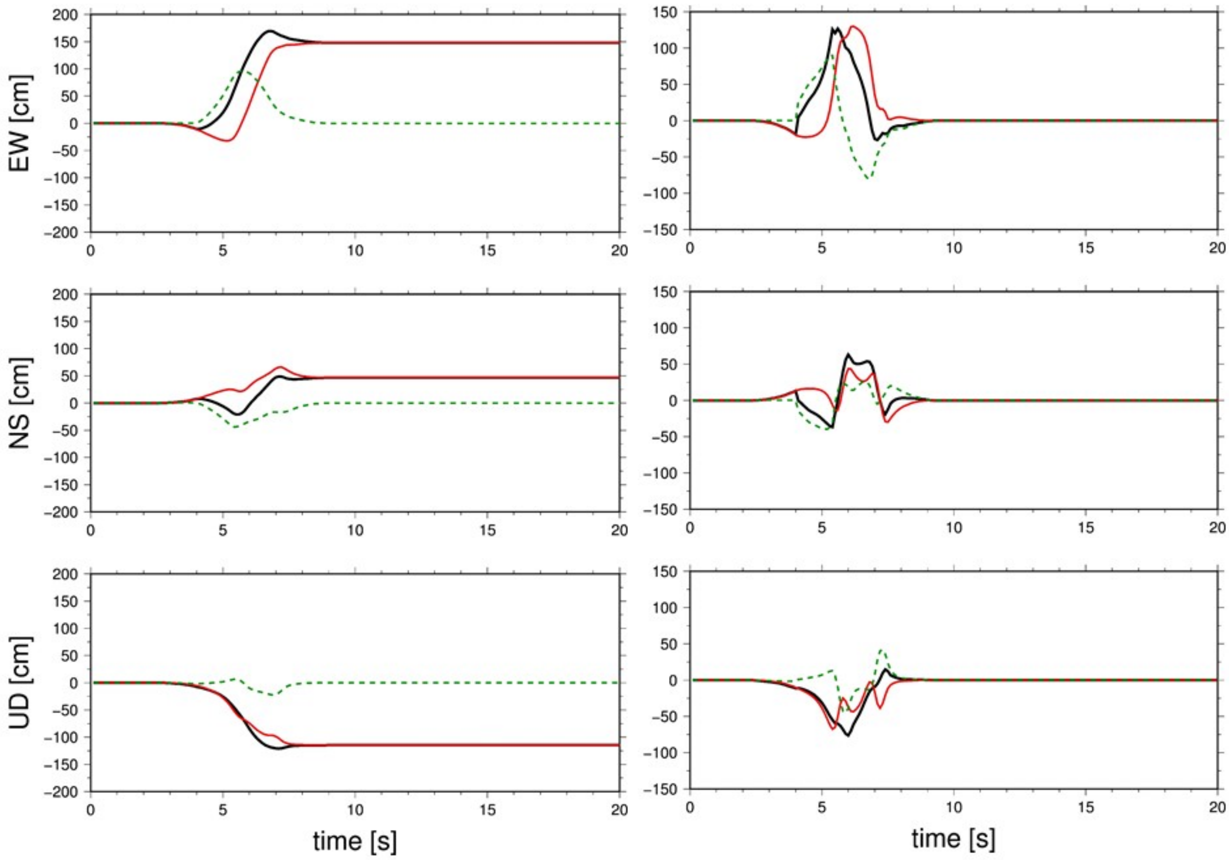

Fig.2 Results of displacement and velocity. Black line indicates ground motion. Red and green dashed line show near-field terms and far-field terms.