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Rupture process of the 2014 Iquique, Chile earthquake estimated from tsunami waveforms, teleseismic, and GPS data

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We applied a new method to compute tsunami Green's functions for slip inversion of the 1 April 2014 Iquique earthquake using both near-field and far-field tsunami waveforms. Inclusion of the effects of the elastic loading of seafloor, compressibility of seawater, and the geopotential variation in the computed Green's functions reproduced the tsunami travel-time delay relative to long-wave simulation, and allowed us to use far-field records in tsunami waveform inversion. Multiple time window inversion (Satake et al., BSSA, 2013) was applied to tsunami waveforms iteratively until the result resembles the stable moment-rate function from teleseismic inversion. We also used GPS data to perform a joint inversion of tsunami waveforms and co-seismic crustal deformation (Gusman et al., EPSL, 2012). According to results, the major slip region with a size of 100 km $\times$ 40 km is located down-dip the epicenter at depth ˜28 km, regardless of assumed rupture velocities. The total seismic moment from the slip distribution estimated by the joint inversion is 1.24×10^{21} Nm (Mw 8.0) (Gusman et al., GRL, 2015). This seismic moment is slightly smaller than 1.88×10^{21} Nm (Mw 8.1) from a teleseismic waveform inversion.

The tsunami arrival time and polarity reversal observed at far-field DART stations can be accurately reproduced by solving shallow water equations and applying the phase velocity correction to the simulated waveforms (Watada et al., JGR, 2014). The slip distribution of the 2014 Iquique earthquake from our joint inversion method can accurately explain the tsunami waveform in the near-field as well as in the far-field. We propose the tsunami phase velocity correction to be included as a standard procedure in inversion methods when using far-field tsunami waveforms.

The teleseismic inversion with different rupture velocities (1.5, 2.0, and 2.5 km/s) yielded similar moment rate functions which all peaked at ˜35 s, but their spatial slip distributions are different. On the contrary, the joint inversion gives a stable spatial slip distribution for different rupture velocities. Among the slip distributions from the teleseismic inversions with the three different rupture velocities, the one for 1.5 km/s is most similar to the slip distribution from the joint inversion of tsunami waveforms and GPS data in terms of large slip area. Thus, the velocity of 1.5 km/s may better represent the rupture process of the 2014 Iquique earthquake (Gusman et al., GRL, 2015).

Keywords: Rupture process, Tsunami waveforms, GPS data, Teleseismic body waves, Tsunami dispersion, Joint inversion