Adaptive tsunami waveform inversion for estimating coseismic vertical displacements and slip distribution

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We developed an advanced two-step tsunami source inversion method with adaptive Green's functions by applying an optimization and a reciprocity principle (Mulia et al., 2018 JGR). In the first step, the method reconstructs the sea surface displacement from observed tsunami waveforms based on a superposition of Gaussian-shaped unit sources. Here, we optimize the unit source locations that give the best fit of waveforms to observations. This leads to non-equidistantly distributed unit sources, in which the synthetic waveforms from such sources to the observation points are generated using the reciprocity principle to save computational efforts of Green's functions. In the second step, the reconstructed sea surface displacement is used to estimate the slip on a finite fault plane. We also optimize the fault parameters that produce the closest displacement pattern to the first step result. Therefore, our method provides best fitting of waveforms and optimum fault parameters with automation for the process. The current method improves our previous studies, in terms of the construction of tsunami Green's functions using the reciprocity principle and determination of fault parameters through the optimizations.

We tested the proposed method using tsunami data of the 2004 Kii Peninsula, Japan event generated by an M_w 7.4 intraplate earthquake. Our result revealed a maximum initial displacement of approximately 0.5 m with the uplift region extended northwest to the epicenter. This value is slightly higher than that of most source models by the previous studies (e.g. Baba et al., 2005 EPS, Satake et al., 2005 EPS), but yields more accurate tsunami waveforms, particularly at the later phase of waveform recorded at a Global Positioning System buoy station off Cape Muroto. In terms of fault slip distribution, our model produced a maximum slip of 2.1 m, located at the uplift region of the coseismic displacement. Furthermore, the shallow fault depth resulted from our simulation is consistent with the more reliably relocated aftershock distribution by Bai et al. (2006 EPS).

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