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Feasibility of near-real-time imaging of the rupture of megathrust earthquakes by normalized short-period envelopes

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1. Introduction

After a great earthquake, real-time estimations of rupture area and locations of asperities are important to assess hazards due to tsunami and ground shaking. However, it takes long time to analyze source process by the waveform inversion. Aoki et al. (2010, 2011) developed a method for near-real-time imaging of earthquake rupture by normalized short-period envelopes, and succeeded in depicting rough image of rupture processes of the 2003 Off Tokachi Eq. and the 1994 Far E off Sanriku Eq.

When Tonankai and Nankai Eqs. occur simultaneously in near future, the fault length will be 500km long, and the magnitude will be about M8.5 [ERC, 2001]. The megathrust earthquakes would have a lot of asperities on the fault. It is supposed that the rupture will start at off the Kii peninsula and will propagate bilaterally. We have applied our method to the earthquakes of M8.0 or smaller with unilateral rupture. Thus it is very important for us to evaluate the applicability of the method to a great earthquake with complex ruptures. In this study, we discuss the resolving power and application technique based on the simulated envelopes of the presumed Tonankai and Nankai Eqs.

2. Method

Our method is based on the Source-Scanning Algorithm [Kao & Shan, 2007]. It is applied for identifying the rupture plane. The brightness of a grid point is calculated by summing the amplitudes of normalized short-period envelopes with the correction of the S-wave travel times at all stations. The grid points are arranged not on the prescribed fault plane, but in the 3D source volume. The composite image of the brightness at all grid points illuminates the locations and timings of seismic rupture (e.g. asperity).

We used fixed stations to image the brightness for all grid points because the analyzed earthquakes had the fault length no more than 150km. However, in the case of the Tonankai and Nankai Eqs., the capability of our method is still unknown. In this study, we compare two cases. Case 1: imaging all grid points with the all stations. Case 2: dividing the grid points into some local sub-volumes, and imaging gird points in a sub-volume with limited stations near the sub-volume.

A simulated envelope was calculated by convolving the time series of the energy radiations with a synthetic envelope on the basis of the scattering theory including the effect of intrinsic absorption [Saito et al., 2002, 2005]. The energy radiation was estimated on the basis of the distribution of 9 asperities by the CDPC (2005).

3. Feasibility study for the Tonankai and Nankai Eqs.

In the case 1, the grid points were arranged in and around the presumed focal region (1000km (along the trough axis) x 200km (orthogonal to the axis) x 95km (depth)) at 4km interval. In the case 2, we divided the volume of the case 1 into 9 sub-volumes (200km x 200km x 95km) with an overlap of 100km along the axis. The brightness of each grid was calculated for 180 sec after the initial rupture. Simulated envelopes were evaluated at the locations of the JMA inland accelerometers and the cable-type OBSs installed by the JMA and JAMSTEC.

In the case 1, we used 84 stations within 500km from the epicenter. Consequently, we can roughly image only the nearest asperity from the epicenter in the side of Tonankai area, and cannot image the other asperities as the peak of the brightness more than 0.7.

In the case 2, we used 20 to 37 stations within 250km from a reference point in each sub-volume. As a result, we can image 7 asperities as the neighboring peaks of the brightness with 0.7 or greater. The two smallest asperities cannot be depicted. Though the ghost peaks tend to appear in the edge of the sub-volume, we can evaluate the reliance of the image due to the overlap of the sub-volumes.

We conclude that the case 2 is preferable for great earthquakes with complex ruptures. We plan to investigate the proper volume of the grid points for suppressing the ghost image and getting high resolution.

Keywords: Near-real-time processing, Source process, Simulation, The Tonankai and Nankai Earthquakes