Seismic intensity and JMA magnitude estimation for ‘slow tsunami earthquakes’ based on moment rate spectrum

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INTRODUCTION

The ‘slow tsunami earthquakes’ radiate relatively low seismic energies in the period range 1-20s and generate great tsunamis (Polet and Kanamori,2000). It is considered that the 1896 Sanriku earthquake, which occurred east off Tohoku district and generated huge tsunami, was one of typical ‘slow tsunami earthquakes’. And it killed over 20,000 people. JMA basically issues 1st tsunami warning immediately after hazardous tsunami is anticipated based on the estimated hypocenter and magnitude (M_J) from local seismic wave data so that people could have time to evacuate from tsunami (JMA,2011). JMA magnitude is determined from seismic records of natural period of 6s. Therefore seismic signals from ‘slow tsunami earthquakes’ would be weak compared with normal earthquakes, and would lead to underestimation of M_J.

It is desired to analyze local seismic data of ‘slow tsunami earthquakes’ for study on those earthquakes, but such data is almost not available. The 1992 Nicaragua earthquake (M_w7.6, GlobalCMT) was one of ‘slow tsunami earthquakes’ which occurred at a plate boundary. We estimated moment rate spectrum of the 1992 Nicaragua earthquake with tele-seismic data, and discuss its appearance at local distance.

DATA and METHOD

Houston and Kanamori(1986) got moment rate spectrum from vertical displacement of tele-seismic wave in P-phase (not involving PP) at stations in the epicentral distance range of 30-100 degrees. In Kikuchi et al.(1993), transverse displacement of tele-seismic wave in S-phase (not involving SS) are also used for source process analysis. So we estimate spectra in lower frequency range from P- or S-phase STS-1 wave data in 70-90 degrees, and those in higher frequency range from in 35-55 degrees.

We got wave data from web-site of IRIS. We also got each parameter (dip, strike etc.) and CMT moment from Global CMT Project. To estimate spectrum with taking various factors (attenuation, radiation pattern, etc.), we used IASP91 and crust2.0 as velocity structure, also used subroutines of “Teleseismic Body-Wave Inversion Program” constructed by Kikuchi and Kanamori.

We got moment rate spectrum of the 1992 Nicaragua earthquake. We also estimate those of several other earthquakes at plate boundary east off Tohoku district to characterize the 1992 Nicaragua earthquake.

RESULT

We obtained moment rate spectrum of the 1992 Nicaragua earthquake in the period range 1-200s. At first, to confirm our result we compared it with the results of Polet and Kanamori(2000). Our result was consistent with that of Polet and Kanamori(2000). Corner frequency of a normal event of M_w7.6 is estimated at 0.039Hz (26s in the period) with an assumption of ω^2-model. It seems that the corner frequency of the 1992 Nicaragua earthquake is 0.005Hz or lower (200s or over). And the obtained amplitude of moment rate all over the range is lower than that of a normal M_w7.6 earthquake. It was confirmed that the 1992 Nicaragua earthquake had character of ‘slow tsunami earthquakes’ in our analysis.

JMA seismic intensity is related to seismic wave in the period of 1-2s. We compared amplitude of moment rate spectrum in the 1-2s range of the 1992 Nicaragua earthquake with those of earthquakes east off Tohoku district. It was found that spectra of 1-2s range of the 1992 Nicaragua earthquake is almost the same as that of a M_J 6.6 earthquake. Maximum seismic intensity of this earthquake was 3. So if an earthquake that has the same characteristics as those of the 1992 Nicaragua occurs east off Tohoku district, its maximum seismic intensity would be about 3 or lower.
Also, we compared spectra of 3-6s range, because JMA magnitude M_J would reflect spectrum level of 3-6 s. It was found that amplitude of moment rate spectrum in these range and M_J have a good correlation. Spectrum level in 3-6s range of the 1992 Nicaragua corresponded to M_J 6.9 of the plate-boundary events east off Tohoku district. It is much lower than M_w7.6, and it means underestimation of magnitude.

Keywords: spectrum, tsunami earthquake, seismic intensity, magnitude