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Discussions

Interactive comment on "Stand-Alone Tsunami Alarm Equipment" *by* Akio Katsumata et al.

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I received a comments from one of co-authors. Since it is helpful to understand the motivation and points of this work, I would like to show it here.

> The comment by Referee #1 seems to be involved in confusion of (a) "official warning", which is sometimes late, and (b) "precautionary guideline", which is not a replacement of (a) but a supplemental information.

> The comment suggests that we have to clarify our motivation : being based on the fact that people who did not utilize "the quick and low-quality information" had been killed in past tsunami events; and this lesson from the 2011 Tohoku tsunami has been shared among tsunami research community.

> From this reason, I also thought that we had better to insist that there is no doubt that seismograph-based or seismic-intensity-based decisions is essential as the 'only'

possible approach to be quick enough to encourage people living near a source area to start evacuation; and we probably should say that such decision is preferable to be available without using any remote information because of unreliability of the telecommunication immediately after major earthquake.

And I have not shown the revised introduction yet. So show it in this entry.

Introduction

Early-stage tsunami warnings are usually issued by governmental organizations, based on the estimated hypocenter and magnitude. Magnitude, a crucial factor for tsunami forecasting, is estimated based on amplitude of the seismic wave (Katsumata et al. , 2013), rapid estimation of seismic moment (Tsuboi et al. , 1995), or high-frequency energy radiations (Hara , 2007).

If earthquake magnitude can be estimated using ground motion at a single site, residents can be alerted to evacuate due to a possible tsunami. Whereas strong ground motion indicates relatively large magnitude, it does not always mean possibility of tsunami hazard. Smaller events can make the same level of ground motion as those by larger events with tsunami potential, and frequency of strong motion is far more than that of disastrous tsunami. High possibility of tsunami incursion can not be 20 aware of only by strong ground motion. Furthermore some people will not evacuate even after hearing tsunami warning by governmental organizations or mass media sometimes. Many people were killed by tsunami after hearing official tsunami alert at the time of the 2011 off the Pacific coast of Tohoku earthquake. We think that multiple and precautionary information of tsunami alert will help people become aware of coming tsunami risk. The information by mass media is often unavailable after strong ground motion due to power failure. And there may be the cases in which official tsunami alarm is temporally unavailable by communication problem, or not established. A single site processor could become another information source of possible tsunami.

Development of low-cost micro electro mechanical systems (MEMS) accelerometers enables equipping an ordinary house with such a single-station tsunami alarm. Some single-site processing methods have been proposed for earthquake early warning. Odaka et al. (2003) developed a method to estimate epicentral distance using single-site seismic data. Magnitude can be estimated based on epicentral distance and amplitude at the station. Allen and Kanamori (2003) used the P-wave predominant period to estimate earthquake magnitude. With tsunami, it is not necessary to focus on the P-wave part of the seismic wave, because it is better to wait for completion of the fault rupture to estimate earthquake magnitude. Moreover the high noise level of a MEMS sensor may result in considerable difference in the estimated value based on P-wave onset. Figure 1 presents examples of epicentral distance estimation from the onset of the P-wave using the method of Odaka et al. (2003), in which sharpness of the onset is used for epicentral-distance estimation. For example, with the 2003 Tokachi-oki earthquake (Fig. 1 (a)), the difference in sharpness of onset estimated with assumption of different noise levels corresponds to 1.6 times the difference in distance. For the 2011 off the Pacific coast of Tohoku earthquake (Fig. 1 (b)), the difference in onset earthquake (Fig. 1 (b)), the difference in onset corresponds to 5 times the difference in distance. It is possible to use the whole seismic wave trace for tsunami evacuation purposes. Amplitude is directly related to earthquake magnitude. Strong-motion duration, which is related to earthquake magnitude (Trifunac and Brady , 1975; Dobry et al. , 1978; Izutani and Hirasawa , 1987), is a candidate for single-site magnitude estimation. Although duration is a possible candidate, amplitude is used in this study.

Table 1 lists earthquakes that involved ten or more casualties due to tsunamis around the Japanese islands in the past 100 years. This table indicates earthquakes with a magnitude of 8 (M8) or greater caused serious disasters. Here we seek to differentiate earthquakes greater than M8 from others. We discuss single-station seismic wave

processing, focusing on possible application to stand-alone tsunami alarm equipment.

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