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Natural Hazards and Earth System Sciences Discussions

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

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Dear Referee #2

I revised the manuscript along the line which I described in the previous reply. I change the "Method" almost totally. I place the base of the discussion on the tsunami magnitude by Abe (1981). As the result, the method section was simplified substantially. I considered the possibility of application to slow events. But I had to conclude that it is difficult using low-resolution sensors such as MEMS. High sensitive sensor would overcome the difficulty. Whereas I change the base of the method, the resultant threshold was not changed very much (8.9 cm -> 8.1 cm).

I tried to upload the tentatively revised manuscript. However I failed to include the PDF in this comment. So I put the method section as text in this comment.

I wish you could review the methodology again.

Printer-friendly version

Discussion paper

Akio Katsumata

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Method

We aim at distinguish events with tsunami potential from seismic data obtained at a single station. Abe (1981) presented empirical relationship among magnitude, distance, and tsunami height as

$M_t = \log_{10} H + a \log R + D$, (1)

where M_t is tsunami magnitude, H is the maximum amplitude of tsunami wave in meters measured by tide gauge, R is the distance in km from the epicenter to the tide station along the shortest oceanic path, and a and D are constants (a = 1.0, D = 5.80). This relationship was obtained with an assumption of $M_t = M_w$. M_w denotes the moment magnitude. When M_t and H are assumed, R is approximately specified.

Katsumata et al. (2013) proposed magnitude M estimation method with peak ground displacement A obtained at local distance as

$M = a \log_{10} A + b \log_{10} R_h + c$, (2)

where a, b, and c are constants, and R_h is the hypocentral distance (km). a, b, and c were adjusted with an assumption of $M = M_w$. Katsumata et al. (2013) presented a, b, and c in Equation (2) for various cutoff periods. If M_t and R of Equation (1) are substituted into M and R_h of Equation (2), it is possible to convert the tsunami height H to seismic wave amplitude A. When M_t and H are assumed at 8.0 and 2 m, R and A become 79 km and 0.11 m for the case of 20-s cutoff. The tsunami height of 2 m is assumed as that could cause serious damages. The value of 0.11 m is considered to be used as the threshold. If the observed amplitude is larger than this value and magnitude is 8.0, the event would be close enough to cause tsunami damage at the observation point. If the observed amplitude is larger than this value and the epicentral distance is 79 km, the magnitude should be greater than 8.0. The line in Fig. 2 presents the upper limit of the distance from the event for a given magnitude. The Equation (1) by Abe (1981) is valid in the epicentral distance range no less than 100 km. Since the distance of about 80 km is out of range, this deriving is an very approximate estimation. Although these are approximate values with relatively large standard deviations, they gives rough estimation of possible risk. When M t and H are assumed at 8.5 and at 2 m, R and A become 250 km and 0.07 m for the case of 20-second cutoff. Considering the possibility of larger earthquake, it is better to lower the threshold. Considering such matters, we set the threshold value as 0.11/10 σ M /a = 0.081 m, where σ M is the standard deviation of magnitude estimation of 20-s cutoff.

For 50-s cutoff, the value of A becomes 0.12 m for H = 2 m. Longer period is considered to be better to cope with lager events with longer source duration. However, there is instrumental limitations in any observation systems. For the case of MEMS sensor, the instrumental noise is considerably high compared with feed-back type accelerometers. The noise level of MEMS accelerometer is assumed to be 0.002 m/s 2 in this study, which level is easily available, and is slightly lower than the human-noticeable tremor level. The 0.002 m/s 2 of a 20-s period corresponds to 0.02 m in displacement. For the case of a 50-s period, it corresponds to 0.13 m, which is almost the same as the threshold amplitude level of A. Since some margin is required for the seismic observation, the case of 50-s cutoff is not appropriate. And the magnitude of 20-s cutoff of Katsumata et al. (2013) often agreed well with that of 100-s cutoff. 20-s cutoff is considered to be enough for ordinary earthquakes of M 8. However, spectrum level of the seismic wave of 22-s period is lower than that of ordinary earthquake for slow earthquakes (Polet and Kanamori (2000)). 20-s may be too short for typical slow events. If a low-noise feed-back type accelerometer is used, longer period such as 50-s or 100-s is possible to be used. Longer period is considered to be better for size estimation of slow events.

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