Can we detect tsunami magnetic signals at on-land observatories prior to tsunami arrivals? : From the perspective of numerical experiments

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Tsunami flow crossing the geomagnetic field generates electric currents in the ocean and associated secondary magnetic fields due to the electromotive force. This tsunami-generated magnetic (TGM) variations are observable not only at the seafloor (e.g. Toh et al. 2011) but also at on-land magnetic observatories on islands or along coastlines (e.g. Tatehata et al. 2015). Most of the TGM data reported in previous studies are from the seafloor observations since TGM signals are much stronger at the seafloor, which implies that usage of off-shore seafloor magnetic observations is a sensible solution for tsunami early warning. On the other hand, much cheaper on-land magnetic observations may be useful because the vertical component of the TGM field precedes the tsunami arrival by approximately a quarter of the tsunami period in shallow oceans (< ~ 1000 m; Minami et al. 2015). Previous studies have never carefully investigated possibilities of using on-land magnetic data in tsunami early warning, because of the difficulty in evaluating the effect of realistic topography on the TGM variations at on-land observatories.

We conduct three-dimensional simulations of TGM signals to investigate feasibility of using on-land magnetic data for tsunami early warning, with the aid of the finite element simulation code by Minami et al. (2017). This study focuses on three devastating tsunami events in the past, the 1960 Chilean tsunami (Mw 9.5), the 2011 Tohoku tsunami (Mw 9.0), and the 1707 Hoei tsunami (Mw 8.7). For the three tsunamis, we adopt the source models of Ho et al. (2019), Satake et al. (2013), and Furumura et al. (2010), respectively. Although all the three large tsunamis did extensive damage, features of their topographies are distinct from each other. One of the features of coastlines in Tohoku is ria coast, while Nankai area of Japan includes capes and bays. As for Chilean coast for the 1960 event, a straight long coastline is present in the vicinity of Santiago, Chile. We set many virtual magnetic observatories and tide stations along the coastlines and investigate arrival times of tsunamis and TGM signals. In the presentation, we compare the arrival times of tsunamis and TGM signals at each virtual observatory and to discuss feasibility of using on-land TGM signals for tsunami hazard mitigation.

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