Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

HDS26-P05 Room:Convention Hall Time:May 21 17:15-18:30

Issues specific to offshore tsunami observation in near-field

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The March 11 Tohoku earthquake (M9.0) destroyed vast costal zone of the northern Japan together with many coastal tide gauges. It also did offshore tsunami observation stations off Tohoku. A part of them, like GPS tsunami buoys, was already recovered but the others are not. In 2011, JMA and MEXT started their plans to construct new offshore tsunami observation networks off Tohoku. When these networks will be built up once, it is possible that the offshore data, which will be transmitted to the land on real-time base, may improve the reliability of the regional forecast for near-field tsunamis. However, there seem be issues to be overcome for achieving precise near-field tsunami forecast. We would like to discuss two of them below.

First issue is pressure resolution in ocean-bottom pressure gauge (OBPG). When a large earthquake occurs, offshore ocean-bottom pressure gauges (OBPG) usually record tsunami and preceding pressure fluctuations with frequencies much shorter than the period of the tsunami. The pressure fluctuations are primarily attributed to seismic Rayleigh waves traveling through oceanic lithosphere from a distant earthquake (Fillioux, 1982). In some cases, such pressure fluctuation masks tsunami signals for nearby earthquakes (Okada, 1995; Tsushima et al.,2009). In the 2003 Tokachi-oki earthquake (Mw8.0), however, a pressure signal with an amplitude of a few hundreds of kPa (equivalent to several tens of meters H2O) was observed with the near-field OBPGs, while tsunami amplitude was estimated only an order of a few kPa (equivalent to only a few tens of centimeters H2O). The period of the main energy of the observed pressure signals was several seconds that are much shorter than tsunami period. In addition, the tsunami and pressure signals were completely overlapped. The large pressure signals observed is considered mostly low-frequency hydroacoustic waves reverberating between the sea surface and ocean bottom through water layer, which was theoretically predicted by Kajiura (1970), and these are closely related to ocean-bottom vertical motion due to an earthquake (Matsumoto and Mikada, 2005; Nosov et al., 2007) and remain mostly in the source region (Nosov, 2000). The near-field experience in 2003 suggests that to extract tsunami information precisely from OBPG records for coastal tsunami forecast, we will have to observe ocean-bottom pressure in much wider range of amplitude from an order of millimeters H2O to an order of, at least, several tens of meters H2O and in much broader frequency range from an order of 0.1 seconds to an hour. Pressure resolution of OBPGs attached on the existing Japanese cabled observatories is not so fine to satisfy the above conditions. In near-future, near-field OBPG measurement will require finer pressure resolution than the present.

Second issue is sudden temperature change on deep ocean floor. In the 2003 Tokachi-oki earthquake, we found that the temperature within OBPGs in the source region suddenly decreased by an order of 0.1 degree C per ten minutes, which was much rapid change in the deep ocean floor environment off Tokachi (Hirata et al., 2003). Such sudden change in temperature caused artificial pressure signal that distort tsunami waveforms owing to a transient thermal response of OBPGs (Takahasi, 1983; Hirata and Baba, 2006). The mechanism of such sudden temperature change remains unresolved so that we cannot decide whether this is local phenomena or not. Any near-field tsunami forecast based on records monitored with OBPGs, experienced a sudden temperature change, may include not small prediction error unless the transient thermal effect of OBPGs is properly corrected.

Keywords: tsunami, offshore, observation, tsunami forecast