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EDITORIAL

Introduction to ocean floor networks and their scientific application

Yoshiyuki Kaneda

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This special issue is focused on ocean floor networks and their applications. Moreover, many papers relate to the applications and analyses of crustal activities and mega thrust earthquakes using real time data from underwater cable systems.

In the history of optical ocean floor cable developments, the first commercial cable was deployed in Japan in 1986 (Momma et al. 1997; Ogasawara and Kojima 2007). Since the 1990s, advanced ocean floor cables with optical amplification technologies and multi-wave length transmission systems have developed rapidly. Accordingly, scientific interest in using real time monitoring systems has expanded.

In seismology-related fields, real time monitoring is required to detect earthquakes and tsunamis as part of early warning systems (Hayashi 2010; Hoshiba and Ozaki 2012), and monitoring of crustal activity helps to better understand the mechanism of mega-thrust earthquakes (Kaneda et al. 2009a, b). To date, some advanced ocean floor network systems have been developed and deployed off the west coast of Canada/USA, Southwestern Japan and northeastern Taiwan (Chiang et al. 2010). In Japan, DONET (Dense Ocean floor Network system for Earthquakes and Tsunamis) has been developed. DONET1 was deployed around the Tonankai seismogenic zone in the Nankai Trough, while DONET2 is under deployment around the Nankai seismogenic zone, to the west of DONET1 (Fig. 1).

When the Mw 9 Great Earthquake occurred in East Japan on March 11 2011, the importance of real-time monitoring using ocean floor networks was recognized (Ide et al. 2011; Kido et al. 2011; Hoshiba and Ozaki 2012). Previously, tsunami experts had developed Early Warning Systems, but unfortunately they lacked enough offshore real-time monitoring data to adequately assess the magnitude of the threat (Baba et al. 2004; Tsushima et al. 2009). However, Hino and colleagues analyzed the pre-slip conditions of the 2011 Tohoku earthquake using data from pressure gauges near the epicenter (Ohta et al. 2012). The results proved to have important implications for the predictability of mega-thrust earthquakes as in the case of the Nankai Trough seismogenic zone off southwestern Japan.

Leblond et al. investigated the feasibility of estimating the volumetric flow rates of gas emissions using seafloor sensors and modeling (Greinert and Nützel 2004; Géli 2008), the results led to the high sensitivities for monitoring gas emission using advanced modeling. Kanazawa and Shinohara (2009) developed a compact ocean bottom cabled seismometer system deployed in the Japan Sea for the monitoring of seismicity. On the other hand, Takahashi et al. (2014, This special Issue) developed a new buoy observation system for tsunami and crustal deformation for EEW (Earthquake Early Warning) and its prediction, a system which is being tested as well as the quality of its produced data (Percival et al. 2011; Ohta et al. 2012). If this system proves to be of practically use, it will become a useful real time monitoring system for crustal deformations and tsunamis (Tsushima et al. 2009).

In the field of modeling and simulation research, Nakamura et al. (2011, This Special Issue) analyzed the anomalously large seismic amplification using ocean floor

Y. Kaneda (✉)
Disaster Mitigation Research Center Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8601, Japan
e-mail: kaneda.yoshiyuki@i.mbox.nagoya-u.ac.jp

Y. Kaneda
Japan Agency of Marine Science and Technology Center, 2-15 Natsushima-cho Yokosuka 237-0061, Japan

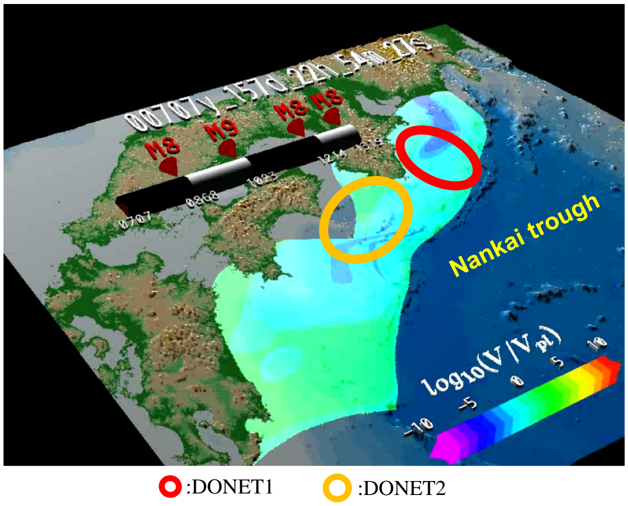

Fig. 1 The Nankai Trough seismogenic zone and ocean floor network system (Hyodo and Hori JAMSTEC) *Red circle*: DONET1, *yellow circle:* DONET2

network data from DONET1 deployed off the Eastern Kii peninsula, southwestern Japan, leading to the precise estimation of seismic magnitudes using Ocean floor network data (Park et al. 2003; Nakanishi et al. 2008; Nakamura et al. 2011).

As part of the seismological research, Nakano et al. (2012) investigated the seismicity in the Tonankai seismogenic zone off the Kii peninsula in south western Japan, detecting high seismicity and clustered seismicity for the first time in the Tonankai seismogenic zone.

Hori et al. (2013), using ocean bottom cable network data, developed a simulation geared towards the numerical forecasting of time intervals between successive M8 earthquakes along the Nankai Trough, southwestern Japan, (Ishibashi 2004; Hori 2006; Furumura 2011; Hyodo and Hori 2010, 2013; Murakami et al. 2012). This numerical experiment will also lead to the testing of numerical forecasting of mega-thrust earthquakes around the Nankai Trough seismogenic zone (Fig. 1).

Ariyoshi et al. (2009, 2012) investigated the detectability of shallow slow earthquakes by means of the Dense Ocean floor Network system for Earthquakes and Tsunamis (DONET1) in the Tonankai district, Japan (Nakatani 2001; Ampere and Rubin 2008). The seismicity of shallow slow earthquakes happens to be one of the indicators of the next mega-thrust earthquake recurrence on the Nankai trough seismongenic zones (Obara and Ito 2005; Nakano et al. 2012; Sugioka et al. 2012). Based on the simulation studies, it was found that the shallow part of seismicity on the mega thrust earthquake seismogenic zones will increase in the pre-seismic stage of the forthcoming recurrence of mega-thrust earthquake.

Baba et al. studied Near-field Tsunami Amplification Factors in the Kii Peninsula, using the Dense Ocean floor Network for Earthquakes and Tsunamis (DONET), contributing to the precise early estimation of tsunami scale, which is useful for disaster mitigation (Baba et al. 2004; Baba and Cummins 2005).

Hsiao et al. conducted on site analyses based on seismological observations using the Marine Cable Hosted Observatory (MACHO) off NE Taiwan (Liu et al. 1998; Lin et al. 2007; Hsu et al. 2013). The MACHO Observatory system is very similar to DONET and is used to detect the high seismicity off northeastern Taiwan;. MACHO will be extended in the near future to further improve the Early Warning System on Earthquakes and Tsunamis. Furthermore, the MACHO system will lead to the understanding of micro-seismicity and the complex tectonics off eastern Taiwan using long-term monitoring data.

Likewise, in this special issue, many experts have discussed the East Japan earthquake in 2011, which generated a large tsunami and damaged many coastal cities along the Pacific Ocean, and the possibilities of the Nankai Trough megathrust earthquake in southwestern Japan.

Previously, around the Tohoku megathrust earthquake seismogenic zone, the ratio of plate coupling appeared to be about 30 %, while the relative plate motion corresponding to the remaining 70 % was thought to be accommodated by stable slip. As it happens, the coupling ratio has been estimated as a stable slip zone therefore, the strain accumulation has not been specifically evaluated (Fujiwara et al. 2011) even though it slowly accumulated in the estimated stable slip zones. In this particular seismogenic zone, there are only several real time monitoring systems such as the off Kamaishi small ocean floor cable system and GPS Sea level gauge buoys, which could detect the large earthquake and tsunami of the Tohoku Earthquake 2011, Nonetheless, the advanced inline cable system off Tohoku seismogenic zone is under construction which in turn will monitor the area off Tohoku and Kanto seismogenic zones for the mitigation on large earthquakes and tsunamis disasters.

It is important to highlight and to better understand crustal activities including crustal deformation, as well as for detecting earthquakes and tsunamis around submarine seismogenic zones. Extended real time monitoring systems equipped with a variety of seismometers, pressure gauges and thermometers are required in ocean seismogenic zones is most important, particularly in the circum-Pacific (Mazzotti et al. 2002; Kodaira et al. 2006; Park et al. 2003) and Indian Ocean areas as well as other locations (Pollitz et al. 2006). Furthermore, real time monitoring of ocean floor environments and processes such as gas emissions and volcanism, and monitoring systems which include chemical sensors and magnetometers and other equipment are also required in offshore areas around the world.

In the development of future ocean floor network plans, there is a need to also develop advanced ocean floor network cable technologies, new buoys systems and data analyses/simulation studies using real time data from ocean floor networks.

Last but not least, in this special issue, many significant and important research results based on ocean observing data are also presented.

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