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2010 Chile earthquake tsunami observed by the seafloor geophysical observational network in the French Polynesia area

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The 2010 Chile earthquake (Mw = 8.8) occurred off the coast of Chile (35.846°S, 72.719°W) on February 27, 2010, at 06:34 UTC. The earthquake triggered a tsunami which spread all over the Pacific ocean, and reached the eastern coastal areas of Japan with the maximum height of about 1 m. At the time of the earthquake, a seafloor geophysical observational network was operating in the French Polynesia area, east to the Tahiti island (Suetsugu et al., 2011). The network consists of nine pairs of broadband ocean bottom seismometers (BBOBS) and ocean bottom electro-magnetometer (OBEM), and one of the BBOBS at the easternmost site (SOC8) is equipped with a Differential Pressure Gauge (DPG). The network apparatuses were installed in March 2009 and recovered in December 2010, the extent of which is about 400 km in east-west and north-south directions.
The tsunami from the 2010 Chile earthquake arrived at this region about 10 hours after the origin time of the earthquake, and the DPG recorded the bottom pressure change due to the passage of the tsunami wave. Simultaneously, all the OBEMs clearly recorded the electromagnetic (EM) signals due to the tsunami wave. The EM signals are evident in three components of magnetic field (Bx, By, Bz) and two horizontal components of electric field (Ex, Ey), and the variations of the tsunami signals lasted more than several hours after the passage of the tsunami front. Maximum amplitude of the B-field change is about 0.5 nT and that of the E-field change is about 0.1 microvolt/m, which is 10-50 times higher than the resolution limit of the seafloor apparatuses. Close correlation between the variations of Bx (northern component of the magnetic field) and the sea level change observed by the DPG at site SOC8 indicates that the EM field variations are mainly caused by the tsunami waves and the orientation of the tsunami front is close to the north-south direction. Since the waveforms of the EM field variations are very similar among the 9 stations, the propagation characteristics of the tsunami wave over the network can be accurately restored from the EM measurements. The inferred direction of the restored tsunami propagation is towards N75W and the propagation speed is estimated to be about 720 km/hour. Since the average water depth at the network region is 4000-4800 m, the observed speed is consistent with a long-wave approximation of the tsunami propagation.
The movement of electrically conducting ocean water in the ambient geomagnetic field induces secondary electric and magnetic fields in the oceans. The induction effect has been a subject of research interest as an alternative way of monitoring ocean flow for many years, and ocean water transport is now routinely monitored by a submarine cable. However, seafloor measurement of the EM signals due to tsunamis had not been attained until very recently (Toh et al., 2011) because of their low signal levels. Recent advances in high precision measurements of electric and magnetic field enabled the seafloor measurements of the tsunami signals. Offshore sea-level measurements using the bottom pressure gauges provide useful information for detection and warning of tsunami before its arrival at the coast. Since the measurement of EM signals from tsunamis detect the propagation direction as well as particle motion of seawater, which supplement the sea level change inferred from the bottom pressure gauge, the EM measurements may become indispensable for monitoring the tsunami propagation in deep oceans.