Long-term monitoring of vertical temperature gradient of seawater on the deep seafloor

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Seafloor observations are extremely important to understand the many earthquake and volcanic phenomena in offshore regions. The research group of Tohoku university have contributed to advance understanding of generation processes of interplate huge earthquakes through seafloor observation data acquired before and after the 2011 Tohoku-Oki earthquake. Long-term seafloor observation data may contain not only actual motion of the solid earth but also may record dynamic phenomena in the water column. It is expected that the understanding of the seawater movement would improve the detection ability of the crustal motions from the seafloor data. We have carried out temperature recording collocated with the seafloor crustal deformation observations, expecting that temperature changes are indicators of the motion in the seawater. However, it has turned out that the temperature data may provide important information regarding interaction between the solid earth and the seawater in the deep sea region, such as turbidity currents or fluid expulsion from the seafloor induced by tectonic events. Temperature changes on the seafloor can be caused not only by horizontal advection along the seafloor but also with the heat transportation form the seafloor and it is important to know spatial gradient of the temperature field near the seafloor to characterize the observed temperature changes. Motivated by this idea, we started investigation of vertical gradient the water temperature on the seafloor using multiple high precision recorders attached to a single observation instrument. This paper presents long-term (for about a year) recordings acquired from three trial observations recently made around the Japan Trench and the Hikurangi subductions zones (HSZ).
In a trial experiment conducted in the ultra-deep (7,202 m) seafloor at the Japan Trench, five miniature temperature loggers (RBR-TR1050) were attached to the outside of a 17-inch pressure vessel, two on the top, one on the middle and two at the bottom of the vessel casing. The data allowed us to confirm long-term stability of the temperature measurements owing to the extremely stable environment with temperature variations less than 0.005 ºC. Differences among the observed temperatures, 0.005 to 0.013 ºC, were almost constant suggesting that sensor drifts would be negligible. Correlation between the amounts of temperature difference and the distances across the sensors were found and we interpret the measured differences represent actual spatial differences in the temperature field around the seafloor instrument. We also made two observations using a pair of the temperature loggers attached to the top and bottom of the instruments equipped with the vessels of the identical size to the trial experiment. In the observations made at a site on the outer slope of the Japan Trench (5,465 m) and on the inner slope of HSZ (2,166 m), the variations of temperatures were more than 0.1 ºC, much larger than those in the ultra-deep environment, indicating larger disturbances in the shallower water. The amounts of the temperature differences are similar to those at the stable seafloor but show evident temporal variations, indicating that the temperature gradients are also disturbed in these sites. Interestingly, long-term variation in the vertical temperature gradient was recognized in HSZ, although it is difficult to give physical explanations at this moment.

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