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# Seafloor geodesy-derived sound speed structure in ocean

Motoyuki Kido[1*], Hiromi Fujimoto[1], Yukihito Osada[1]

[1]RCPEV, Tohoku University

Much efforts have been made for improving accuracy and spatio-temporal frequency of seafloor geodetic observation by means of GPS/acoustic technique, which now provides significant data to the earth science field. Actually, GPS/acoustic surveys have detected some important tectonic events, such as coseismic displacement associated with the 2004 off Kii peninsula earthquake, secular movement at off Miyagi, and co- and post-seismic deformation after the 2005 off Miyagi earthquake. However, comparing with current state of the land-based GPS network, GEONET, improvement in its quality and quantity is required in providing more general scientific purpose.

There three factors that affect the accuracy of GPS/acoustic measurement; kinematic GPS analysis to monitor surface platform, acoustic signal processing in identifying traveltimes, and uncertainty in sound speed in ocean for traveltime-range conversion. Among the three, it is getting obvious through the past survey that sound speed variation is most significant.

Sound speed structure is known to be well approximated by time dependent stratified structure, i.e., depth profile. Furthermore, its effect on seafloor positioning can be expressed time-dependent single scholar quantity that in a depth integral of the profile, called vertical delay. We have succeeded in monitor the variation of the vertical delay with time from a GPS/acoustic measurement, and confirmed that it is well coincided with concurrent physical oceanographic in situ measurement. However, apparent fluctuation in horizontal seafloor position up to 20-30cm is remained even after removal of the vertical delay. To achieve 2-3cm accuracy we need more than one-day survey time to average out the fluctuation. As mentioned above, improvement inefficiency of the survey is required, we have to estimate the factor and evaluate its quantity to correct the positioning. The fluctuation is thought to be spatio-temporal variation of sound speed structure, which must be modeled by a simple assumption that can be estimated by sparse and limited traveltime data. When the spatial scale in the variation is large enough, its can be simply approximated as gradient at our survey point, which can be estimated by adding some extra seafloor transponders to increase traveltime data. However our observed data indicate that this assumption may be wrong and variation sometimes has much smaller scale.

In the decade, the resolution in numerical simulations of ocean variability have been greatly improved, the scale of which is getting closer to our scale of interested. For example, vertical delay mentioned above is found to often have a semi-diurnal time-scale. It is also supported by up to 20m semi-diurnal oscillation in the sound speed profile obtained by concurrent in situ measurements. This has been well modeled by numerical simulation of internal wave that modulated by M2 tidal current by Niwa and Hibiya (2001). In addition, long-timescale spatial variation is related to large scale ocean current and/or middle-scale eddy. We are now compared our observation with data-assimilated reanalysis product of ocean variability, JCOPE2 (Miyazaki et al., 2009), that is opened in public. There still remain a gap in scale between our observation and the numerical simulation, some temporal tendency can be highly expected in the comparison. In this talk, we introduce several example of our observation with comparison of above simulations, and address how do the simulations provide significant information to our side.

Keywords: seafloor geodesy, data assimilatio reanalysis, internal wave, sound speed