Comparison between temporal variation of sound velocity derived from GPS/acoustic and CTD measurements

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The GPS/acoustic (GPS/A) technique enables us to detect the seafloor crustal deformation by combining Global Positioning System and acoustic ranging. In the GPS/A technique, horizontal displacement of a seafloor transponder array, which composed of at least three instruments, can be estimated for each of single ranging shot (e.g., Spiess, 1985; Kido et al., 2006). The traveltime residual in the estimate is related to sound speed variation when it is normalized to nadir total delay (NTD), which is equivalent to zenith total delay (ZTD) in GNSS analysis. The equivalent quantity can be also obtained from in-situ measurements of sound speed profiles by integrating its slowness throughout the profile. Kido et al. (2008) compared the two quantities and found that they are in good agreement at least for the semidiurnal variation. In this study, we investigate two subjects as applications of Kido et al. (2008).
First, we investigated whether the shorter (~1 hour) timescale variation of NTD obtained through GPS/A analysis also reflect the sound speed variations. For this purpose, we conducted intensive XBT casts every six minutes for one hour and calculated corresponding NTD. After adapting proper correction for sensor bias of each XBT cast, we confirmed that the GPS/A analysis well resolves the sound speed variation even in a short timescale.
Second, we investigated the potential accuracy to resolve vertical crustal displacements using precise sound speed profile obtained by CTD measurements. In the GPS/A analysis, absolute NTD intrinsically contains uncertainty of the transponder depth. However, this NTD must be unchanged through campaigns; therefore, relative change between campaigns may indicate vertical movement of the transponders. For this context, we evaluated the potential accuracy by comparing the discrepancy between up and down CTD casts relative to GPS/A estimates of NTD for several observation sites. Considering CTD errors both in temperature and time axes (because each CTD cast takes finite time), we found the detectable level of the vertical movement is about 15 cm.

Keywords: seafloor geodesy, GPS/acoustic observation, sound velocity, CTD measurements

