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Intensive sound speed monitoring in ocean and its impact on the GPS/acoustic seafloor geodetic measurement

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GPS/acoustic (GPS/A) technique, based on GPS positioning and acoustic ranging, is now getting a popular tool to measure seafloor crustal movement. Several groups in the world have been intensively conducted campaign surveys in the region of scientifically interest. As the technology of measurement has been matured and plenty of data are accumulated, researchers are now aware of the limit of its precision mainly due to unexpected undulation of sound speed in ocean, which significantly degrades acoustic ranging. If sound speed structure keeps its figure during survey period, e.g., more than a couple of hours, it can be estimated by a moving survey to get sufficient paths from various directions to illustrate the structure. However the sound speed structure often varies quickly with in a hour due to internal gravitational wave excited by interaction of tidal current and seafloor topography. In this case one cannot separate temporal and spatial variations.

We revisited our numerous sound speed profile data derived from numbers of XBT measurements, which were concurrently carried out with GPS/A survey along the Nankai Trough and Japan Trench. Among the measurements, we found notably short-period variation in sound speed profile through intensive XBT survey repeatedly cast every 6 minutes for one hour, which also appeared in residuals in traveltime of acoustic ranging. The same feature is also found in more moderate rate for semidiurnal undulation, in which vertical oscillation of the middle of the profile can be clearly seen rather than variation of absolute sound speed. This also reflects traveltime residuals in the GPS/A measurement.

These typical frequencies represent dominant wavelengths of spatial sound speed variation. In the latter, local horizontal variation can be negligible in the vicinity of a point survey area and the traditional analysis can be applicable that assumes time-varying stratified sound speed structure. In the former case, on the contrary, local horizontal variation takes effect on apparent position of a seafloor benchmark. The key point is whether the local variation is smooth enough to be characterized with a linear trend or gradient. If this is the case, modified analysis that allows simple horizontal gradient in the sound speed structure can overcome the problem. Recently we have investigated the typical variation of sound speed structure with intensive XBT measurements in Japan Trench. In the presentation, we will compare the latest in-situ observations of sound speed with GPS/A survey and its contribution to the accuracy in positioning of seafloor benchmarks.