Numerical evaluation of the sound speed model in the GNSS-A analysis software GARPOS

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Seafloor geodetic observation using the GNSS-Acoustic ranging combination technique (GNSS-A) has revealed the plate boundary coupling conditions at the subduction zones around Japan. GNSS-A is a technique in which GNSS observation on a sea surface platform is combined with underwater acoustic ranging between the surface platform and the seafloor mirror transponders, to measure the absolute position of a seafloor reference point (Spiess 1985; Asada and Yabuki 2001; Fujita et al. 2006).

To realize centimeter-level positioning with GNSS-A, it is necessary to properly estimate the perturbation due to the spatiotemporal variation of the underwater sound speed structure; this is analogous to the correction of the atmospheric delay in GNSS. The group of JCG and the University of Tokyo has developed the open source GNSS-A analysis software “GARPOS” (Watanabe et al. 2020), which is currently used in JCG’s routine analysis. The current version of GARPOS implements empirical Bayes to simultaneously estimate the seafloor transponder positions and the perturbation of the sound speed structure. In GARPOS, the “Γmodel” is introduced to decompose the perturbation to three components; the temporal variation of the average sound speed, and two sound speed gradient components extracted by trilateration between the surface platform and the seafloor transponders.

In this study, we evaluated the sensitivity of the Γmodel and the positioning accuracy to possible error sources during the GNSS-A observation. We conducted numerical simulations of GNSS-A using the Eikonal equation repository PyKonal (White et al. 2020) to simulate synthetic data which were analyzed using GARPOS. Using numerical simulation, we investigated the effects of factors that possibly affect the positioning accuracy, such as GNSS random noise and the distortion of the survey line during the observation.

Keywords: GNSS-A, seafloor geodesy, sound speed field

