# GNSS-A seafloor positioning with the Markov-Chain Monte Carlo for applying single sound speed gradient model

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GNSS-A technique has been developed to directly solve the global seafloor positions with the precision of centimeters. Different from the terrestrial GNSS observations, the GNSS-A has a lot of difficulties both in the observation operation and the error corrections. For the latter issue, the researchers should take care that the GNSS-A solutions strongly affected by the underwater sound speed perturbation because it uses acoustic waves for ranging between the sea-surface and seafloor instruments. The sound speed in the ocean depends on water temperature and salinity (e.g., DelGrosso, 1974). Therefore, to improve the positioning accuracy, spatio-temporal perturbation of seawater should be adequately corrected. The authors had developed the method where the seafloor positions and the perturbation effects are simultaneously solved based on the empirical Bayes (EB) approach, implemented into a python-based analysis software named "GARPOS" (Watanabe et al., 2020, Front. Earth Sci.).
GARPOS can extract the 4-dimensional perturbation filed by expanding the effects of sound speed perturbation on acoustic travel time data. The Akaike Bayesian Information Criterion (ABIC; Akaike, 1980) is used for searching the appropriate strength of smoothness constraint to the temporal change of perturbation field. This algorithm can avoid the overfitting of the travel-time residuals and provided the sufficiently stable solutions to discuss the time-dependent crustal deformation (e.g., Watanabe et al., 2021, Earth Planets Space).
Meanwhile, to provide the information on the variance of estimated positions as the joint posterior probability, the probability distributions of hyperparameters should be accounted. Therefore, we developed the program for sampling from the full-Bayesian (FB) posterior probability, based on the Markov-Chain Monte Carlo (MCMC). The results suggest that the distributions of hyperparameter less affect the posterior marginal distribution of positions for most of tested datasets.
On the other hand, oceanographic structure tends to be simple in the regions under the steady strong current such as Kuroshio. It coincides with a temperature gradient perpendicular to the current, which will dominate the whole sound speed perturbation structure. By applying the assumption of single gradient structure, positioning accuracy for some datasets would be improved because it can help to suppress the misestimation of perturbation field due to other error sources.
In this presentation, we will show the MCMC results for the GNSS-A data obtained at sites of the Seafloor Geodetic Observation Array (SGO-A) operated by the Japan Coast Guard, to discuss the difference between the EB-based and FB-based solutions. We will also introduce the results with additional constraint on the perturbation field with a single gradient layer, which approximates the simpler oceanographic structure.

Keywords: GNSS-A, Seafloor geodetic observation, GARPOS, Markov-Chain Monte Carlo, Sound speed structure in the ocean

 