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Improvement of the accuracy in seafloor acoustic ranging by estimating the spatio-temporal temperature variation

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Direct-path seafloor acoustic ranging is widely used to detect crustal deformation. The idea is simply to monitor a baseline length by multiplying sound speed to the round-trip time between transducer and transponder installed on the seafloor. A transducer transmits the acoustic wave and a transponder record. Sound velocity is a function of temperature, pressure and salinity, among which the temperature is most effective on seafloor. Thus, evaluation of temperature field plays a key roll on this measurement.

In the past studies, time-varying uniform temperature field is assumed employing a simple average of measured temperature at the both ends of the baseline. This results in large apparent fluctuation in measured baseline length, especially during rapid temperature change. So, we tried to infer the spatio-temporal temperature field by applying a simple advection model of temperature field..

We proposed an equation of temperature T(x,t) which linearly interpolates between measured temperature data for both x (space) and t (time). Typical change in the temperature is thought to be associated with the semidiurnal tide, so field advection is postulatedas simple 12-hours harmonic oscillation with arbitrary phase and amplitude. Measured temperature at both ends are basically in coherent with certain time-lag. Any individual deviation at each site can be consistently formulated by linear interpolation in time and space. We assessed the formulation by inverting a given temperature field using synthetic temperature data. If there are temperature data at three sites, the formula can be easily expanded to 2-D temperature field by linear interpolation between the two baselines..

We also tried to apply the formula to real data. In 2007, the acoustic ranging test was conducted at Kumano-nada [Osada, Y., M. Kido, and H. Fujimoto, *Ocean Engineering*, 2012]. Significant improvements in the stability of apparent baseline length were found when the advection vector is clear from the original temperature data. Base on this result, the formula is effective if the sampling frequency of temperatures is high enough (about 30 min. to 1 hour), while the acoustic ranging itself can be infrequent.

Currently, we only verified the formula for the time windows in where the advection vector is clear. Without knowing advection, the formulation cannot be applicable. The advection is estimated based on coherency and time-lag between the temperatures at the both ends of the baseline, however, it is not possible to estimate it for time window with smaller temperature variation or non-coherent behavior. The best way to know temperature field is dense measurement along the baseline. Although the advection of temperature field is not always equivalent with flow of water, it should be valuable to introduce currently meter or to make rough estimate from time varying attitude of the instrument. In the different point of view, it could be worth to utilize the fine-scale assimilated ocean model, JCOPE-T (provided by Application Laboratory, JAMSTEC), which can predict local temperature variation.

Keywords: Seafloor geodesy, Acoustic ranging, Seafloor temperature, Tidal current, Extensometer