Analytical method of seafloor crustal deformation corresponding to the large-scale ocean current region

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We monitor seafloor crustal deformation at two observation points (north and south of Nankai Trough (TCA and TOA)) across the Nankai Trough, Japan, from 2013 to 2015. A warm ocean current flows frequently above our points called the Kuroshio current that has temperature difference perpendicular to the flow axis down to 1000 m in depths. Sound speed in the water depends on temperature [Del Grosso, 1974]. Determination of seafloor benchmark position has a bias when the sound speed structure includes a horizontal inhomogeneity in large-scale ocean current area. This bias is caused by trade-off between estimated spatial-temporal variation of sound speed structure and seafloor benchmark position. In this study, we propose a new analytical method adopted a horizontal inhomogeneity of sound speed structure.

We use the following equation to adopt the horizontal inhomogeneity model: $S(X,x,z)=S_0(z)+dS(A(z)\times\tan(q(X,x)-R(X))$, $S(X,x,z)$ where is the spatial variation of slowness but spatial variation is the uniform during the observation period, $S_0(z)$ is the reference sound speed structure from CTD observation, dS is the rasio of slowness variation of horizontal direction, $A(z)$ is the vertical distance between seafloor benchmark and z, $q(X,x)$ is angle of incidence from each benchmark, $R(X)$ is the horizontal distance of the seafloor benchmark position from gradient axis, x is the ship position, and X is the benchmark position, z is the depth of the horizontal inhomogeneity. The gradient axis and magnitude (parameter dS) can be estimated by the travel time residual derived from Ikuta et al. [2008] analysis method (Yasuda et al., 2015 in SSJ fall meeting). The characteristic of the horizontal inhomogeneity appears as the sine curve in three benchmarks in the travel time residual. The gradient axis and magnitude can be estimated by the initial phase and amplitude of three sine curves, respectively. The gradient parameters derived from the travel time residual are low precision. Therefore, we decide gradient parameters when the residual sum of squares becomes minimum by performing a grid search in the range of an error.

We observed four times at TCA and TOA stations, respectively. Kuroshio current flowed above observation point at all epoch. We carried out this new analysis at all epoch of TCA and TOA. As a result, the direction of the fastest speed of sound is south -southeast direction all observation. This direction is consistent with flow direction of the Kuroshio current. RMS of the travel time residual decreases at most 0.027 ms at TCA station on May 2015. RMS of the seafloor benchmark position in conventional analysis and this analysis decreased 40.1 cm in NS component and increased 0.9 cm EW component at TCA station. In TOA station, RMS decreased 38.3 cm and 16.7 cm in NS and EW component, respectively. The bias was largely improved by the analysis of this study.

Keywords: Seafloor crustal deformation, Kuroshio, Nankai Trough

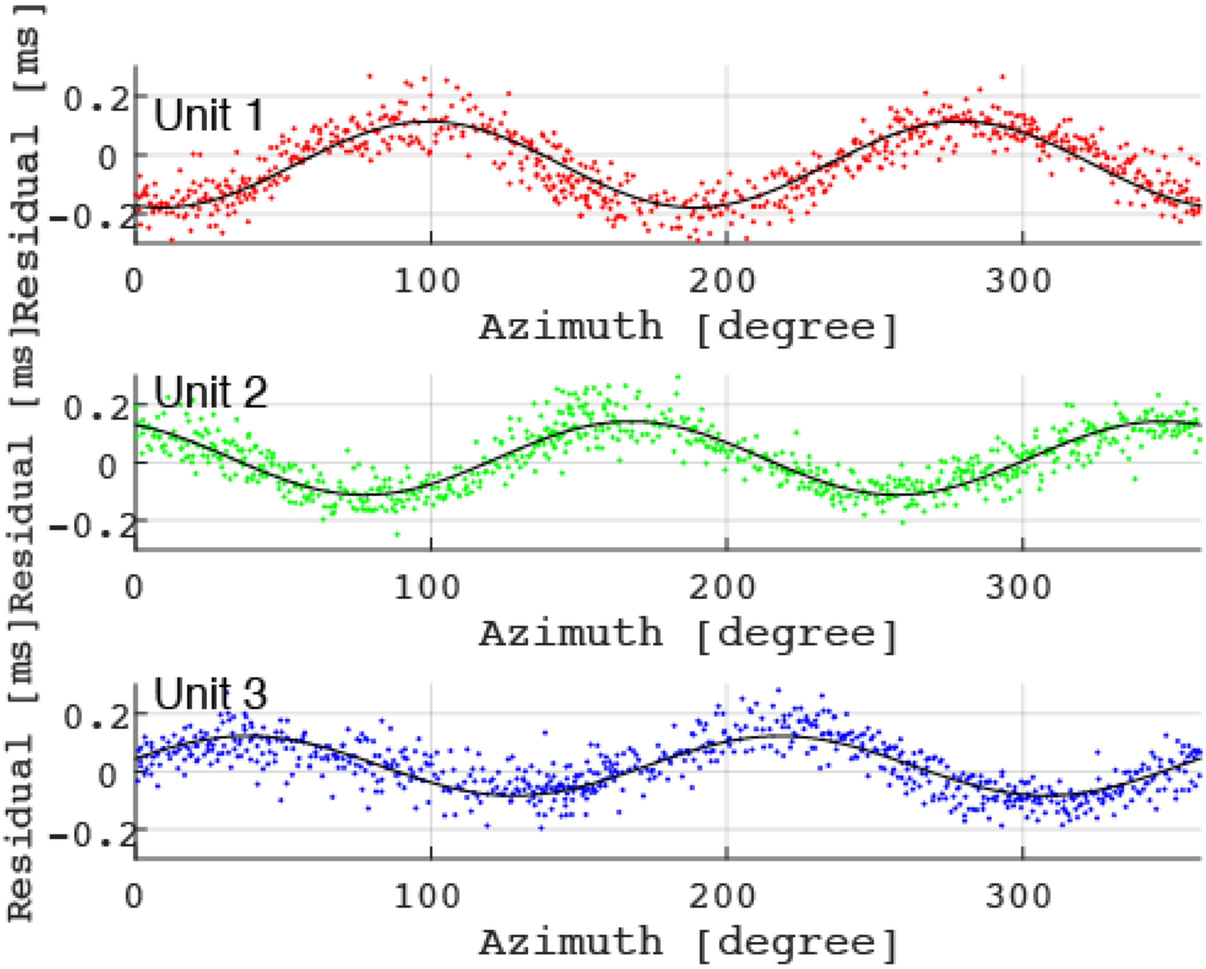

Figure 1. Travel time residual of TCA observation at May 1 2015. Solid line is the curve fitting by Yasuda et al. (2015) in SSJ fall meeting.