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Development and examination of new methods for traveltime detection in GPS/A geodetic data to high-precise and automatic

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The development of a technique for GPS-acoustic (GPS/A) geodetic observations has enabled us to understand the slip distribution of the 2011 Tohoku-oki earthquake. However, there remains an issue with the precision of GPS/A measurement is still lower by two orders of magnitude than that of on-land GPS measurement due to problems in observations and data processing methods. In this study, we focus on the problem for determination of traveltimes of acoustic signals obtained from GPS/A measurement.

The conventional approach for determining the two-way traveltime of observed acoustic signals is to determine the maximum peak of the cross-correlation waveforms between the transmitted and returned signals. However, the maximum peak often differs from the true peak due to the distortion in the correlation waveform which depends on the relative spatial geometry of the ship and station. These misread traveltimes have been re-read manually so far. Such procedure is no longer applicable for processing vast array of data obtained at newly installed over 20 GPS/A stations after the 2011 Tohoku-oki earthquake. The aim of this study is to develop fully automated algorithms for analyzing GPS/A data with high precision. We introduce here two algorithms.

1) We read the maximum peak in the observed correlogram and then deconvolve it by the synthetic correlogram. Then, we apply the same operation to the deconvolved waveform. This procedure is iterated until the correlation coefficient decreases lower than a pre-defined threshold. A true traveltime is defined as the fastest traveltime during the iterations.

2) We classify the observed correlograms into several groups based on their similarity through cluster analyses and choose a master waveform in each group. Then evaluate the traveltime residual between the maximum peak and the true peak in the observed correlogram. Thus obtained residual is applied as the correction value of each clustered group.

We also use a seismic data analysis tool to visually inspect whether above algorithms work properly. We confirmed that the both new methods properly correct for misreadings in the current method, which sometimes amount to several hundred micro seconds. This corresponds roughly to a 0.3-m difference in the slant range. Therefore, with the new algorithms, significant improvement in the estimation of the station location is expected. However, both methods have to be assigned an arbitrary value as a threshold. Further analyses are needed to determine arbitrary threshold values and to construct fully automated algorithms.

Keywords: ocean bottom geodetic observation

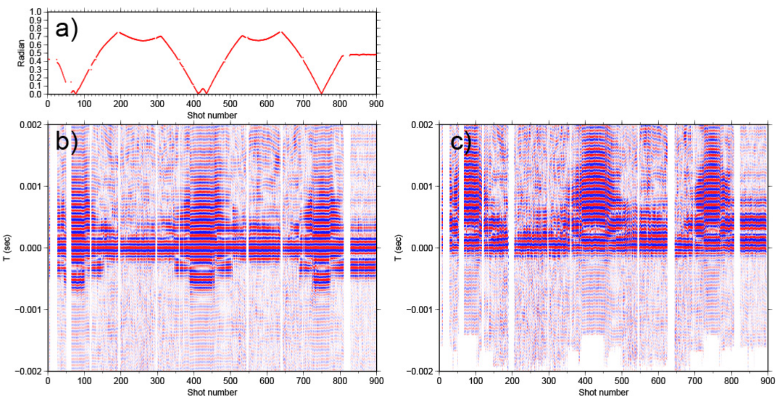

Fig. Incident angle of transmitted signals (a). Pasted corelation waveforms analyzed by reading maximum peak (b) and reading iteratively-deconvolved peak (c). Each trace was moved out by the observed traveltime.