Feasibility study of passive subsurface radar using waveform data of Jovian decametric radiation

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Feasibility study of passive subsurface radar has been performed using waveform data of Jovian decametric radiation obtained in ground-based observations at Tohoku University Observatory.

In Jupiter Icy Moon Explorer (JUICE) mission, we are planning passive subsurface radar observations of Jupiter's icy moons by using Radio and Plasma Wave Investigation (RPWI), passive receiver covering wide frequency range from 80 kHz to 45 MHz, in addition to Radar for Icy Moon Exploration (RIME), the active radar operated at frequency of 9 MHz.

In passive subsurface radar observations, Jovian decametric (DAM) and hectometric (HOM) emissions are utilized as radar the pulse. By detecting echoes of Jovian radio emissions reflected at the permittivity contrasts on and below the Jovian icy moon's surface, we can measure the surface and subsurface structures of the ice crust of the Jovian icy moons. The echoes can be detected in two methods: (1) Applying auto-correlation analysis to waveform data [Romero-Wolf et al., 2015], and (2) Measuring interference patterns in spectrogram [Kumamoto et al., 2017]. If the duration of the coherence of Jovian radio emissions is shorter than 2ms, round-trip propagation time of radio waves between the spacecraft and icy moon's surface, the former method will be effective. Otherwise, the latter method will be effective.

In this study, we generate simulated data from the waveform data obtained in ground-based observations at Tohoku University Observatory. In order to simulate the surface and subsurface echoes, delayed waveform was added to the observed waveform. Then we performed following analyses with simulated waveform data: (1) The waveform data was divided into 4096-point subsets. (2) Power spectrum was obtained by applying FFT to divided waveforms. (3) Auto-correlation function was obtained by applying FFT to the power spectrum. Finally, we checked interference patterns in the power spectrum and delayed components in auto-correlation function. We could identify subsurface echo component in interference in spectrogram and in auto correlation function if the subsurface echo intensity with respect to surface echo is larger than -30dB. In onboard data processing of RPWI, the raw waveform is divided into those in multiple sub-bands with a bandwidth of 296 kHz. The test of onboard data processing with simulated waveform data will also be reported in the presentation.