Evaluation of Automatic Determined UHR Frequencies by a Convolutional Neural Network

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The ambient electron density is one of the important properties of space plasma. Typical regions in the geospace is characterized by the different electron density profile (e.g., plasmasphere, plasma trough and plasma plume.) The most popular way to determine the quantitative electron density is observing the upper hybrid resonance (UHR) emission. The High Frequency Analyzer (HFA) and the Onboard Frequency Analyzer (OFA) is subsystems of Plasma Wave Experiment (PWE) aboard Arase [Miyoshi et al. (2018), Kasahara et al. (2018), Kumamoto et al. (2018), Matsuda et al. (2018)]. The HFA measures wide frequency range (0.1-10 MHz) electric power spectra with a time resolution of 1, 8 or 60 s. This covers a typical frequency range of UHR frequency in the inner magnetosphere. The OFA measures the electric field from DC to 20 kHz with a time resolution of 1 s and a good frequency resolution compared with the HFA.

A neural-network-based approach for the automatic detection of UHR frequencies is proposed by Zhelavskaya et al. (2016), using the local electron cyclotron frequency f_{ce}, orbital parameters (L and MLT), geomagnetic index (Kp), and observed electric field spectra. Recently, Hasegawa et al. (2019) proposed a technique for the automatic UHR frequency determination using convolutional neural network (CNN). They reported that the mean absolute error of the predicted UHR frequencies by the ResNet model was 3.664 bins when excluding additional inputs except for the observed electric field spectra observed by the Arase/PWE and labeled UHR frequency data. They also pointed out that additional features (orbital parameters and geomagnetic index) had almost no impact for the accuracy on the UHR frequency determined by CNN. In this study, we perform the further evaluations of the CNN-based UHR frequency determination from the point of view of science. We found that the error rate of the predicted UHR frequencies from the HFA spectra is less than 0.07 (7% of wave frequency) above 30 kHz. However, the error rate derived from the HFA spectra becomes worse when the wave frequency is below 10 kHz. We considered that this worsening shows a detection limit of UHR emissions due to the increasing of the noise level of the HFA receiver. On the other hand, the noise level in the overlapped frequency range (1-20 kHz) is smaller than the noise level of the HFA. We found that the error rate derived by the OFA spectra is better than the error rate derived from the HFA spectra in this frequency range. The best error rate was 0.07 at 8.41 kHz, while the error rate from HFA spectra was 27.7%.

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