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機械学習モデルを用いた内部磁気圏における UHR 周波数推定の精度向上

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A Machine Learning Approach for Improving UHR Frequency Determination in the Inner Magnetosphere

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Electron density is one of the important properties of space plasma, especially for understanding the wave-particle interactions in the inner magnetosphere. The upper hybrid resonance (UHR) frequency is commonly used as a proxy of the local electron number density, since the UHR frequency is a function of electron number density and local electron cyclotron frequency. In order to determine the UHR frequencies from electric field spectra, several semi-automatic identification techniques have been developed. For example, Kumamoto et al. (2018) proposed a hybrid approach by combining an algorithm and visual inspection to determine the UHR frequencies measured by the High-Frequency Analyzer (HFA) and the Onboard Frequency Analyzer (OFA) of the Plasma Wave Experiment (PWE) aboard Arase. However, these methods require significant human effort and their reproducibility remains limited in cases where identification is challenging. In this study, we developed and evaluated an automatic UHR frequency detection model based on a convolutional neural network (CNN) model. To improve the accuracy of the UHR frequency determination, we included the additional machine learning inputs (e.g., local electron cyclotron frequency, McIlwain-L value, magnetic local time, magnetic latitude, geomagnetic activity indices, and spacecraft potential). Hasegawa et al. (2019) used the orbital information and geomagnetic indices and evaluate the average of the mean absolute error (MAE) of the determined UHR frequencies over the entire dataset. On the other hand, our study evaluated regional and geomagnetic conditional dependence of the determined UHR frequencies by the CNN model. We found that the additional inputs improve the accuracy of the UHR frequency determination in a specific magnetic local time region.