Identification of plasma waves observed by scientific satellites with machine learning methods

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Data-driven approach has attracted attention in various fields of natural science due to advances in machine learning and statistical methods. In the presentation, we show results of identification and classification of plasma waves observed by scientific satellites from machine learning methods.
(1) Generation mechanism of hiss emission in the Earth's magnetosphere has been controversial for a long time. It is argued that chorus emissions or lightning whistlers evolve into incoherent waves due to propagation effects in the inner magnetosphere. It is also argued that wave-particle interaction can create hiss-like spectrum. In the present study, we statistically examined difference of spectra of hiss and chorus emissions from waveform data obtained by AKEBONO satellite which had continuously observed inner magnetosphere for 26 years. Specifically, we applied a clustering method to the data set, representing the wave spectra as multi-dimensional feature vectors, and evaluated distance of clusters between these two emissions in the feature space. As a result, the clusters corresponding to the hiss and chorus emissions are clearly separated in the feature space. It means that it is difficult to interpret the chorus gradually evolves into the hiss.
(2) Auroral kilometric radiation (AKR) which is radiated from the Earth's auroral field lines in north and south polar regions had been clearly and frequently observed by KAGUYA satellite in a lunar orbit. AKR propagation modes R-X and L-O are important information associated with its generation mechanism. We investigated whether or not the propagation mode can be identified only from spectrum by using a supervised learning method. We first added labels (R-X/L-O) to AKR spectrum from identification results of the propagation mode from occultation observation of KAGUYA and created a classifier with convolutional neural network (CNN). The CNN has become widely used in the field of image recognition. In the CNN, features of the image are automatically extracted during training process. As a result, although the propagation modes were identified with high accuracy for spectra used as training data, the mode identification for the other data was not successfully completed. This implies that the spectra used as training data not include information of the propagation mode.

Keywords: plasma wave, satellite observation, machine learning

