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Onboard identification of plasma waves based on large-data clustering and its feature aggregation

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Abstract

Onboard identification of plasma waves would play an important role in their observations in future spacecraft projects. Akebono satellite has observed plasma waves for these 25 years and has acquired a huge data set of them. The data set is of great value as a catalog of various plasma waves. We applied a clustering method to the data set of Akebono and classified the observed waves into several categories according to their spectrum features. The statistical features of the classified waves can be used to identify observed waves quickly.

1. Introduction

Onboard data selection is an important issue in plasma wave observations in future spacecraft projects, such as the missions to Mercury, Jupiter in addition to Earth's magnetosphere exploration, from the point of effective use of restricted data-transmission capacity. Identification of the plasma waves is helpful in such data selection. The Japanese scientific satellite, Akebono [1], has observed plasma waves for these 25 years and has acquired a huge data set of them. The data set is of great value as a comprehensive catalog of various plasma waves. The purpose of this study is to develop a simple and quick identification method of plasma waves based on their statistical features that are derived from the Akebono wave data.

2. Data and Methodology

Fig.1 shows an example frequency-time diagram of the wave data obtained by Akebono. Akebono continuously obtains waveform data through analog telemetry during tracking. The amount of the raw data is more than 15 TB (~15,000 hours) at present. In the figure, three kinds of waves whose intensities show different time variations are found at frequencies of around 6 kHz, 8 kHz and 10-12 kHz, respectively. Note that the data include 4 sec modulation due to the satellite spin. Except for the effect of the spin, the time variations are caused by generation mechanisms or propagation characteristics. That is, different waves tend to exhibit different time variations in their intensities. Then, a simple identification of plasma waves can be conducted depending on the time variation in each frequency band. In this study, we represent the time variations of the Akebono wave data by an autoregressive (AR) model whose parameters are determined according to the Akaike information criterion (AIC). Since the power spectrum of the time variation is uniquely determined by the model parameters, feature vectors of the time variation can be defined by them. Then, the feature vectors are classified into groups using a clustering method called k-means++ [2] and their statistical characteristics are respectively estimated. As for the onboard data processing, normalized distances between the feature vector of an observed wave and the average vectors of the classified waves can be used to identify the observed wave quickly.

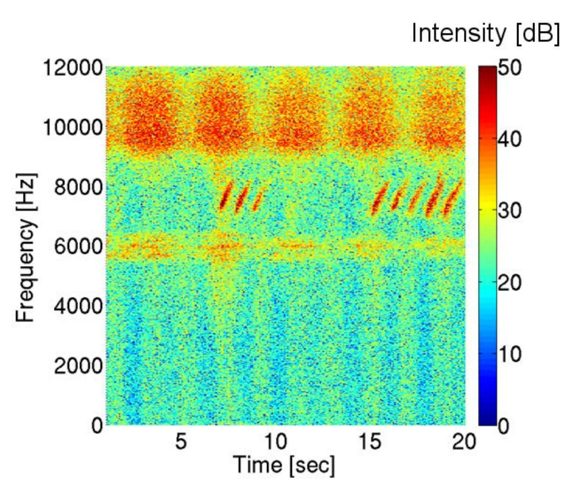

Figure 1: Example frequency-time diagram of the wave data obtained by the Akebono satellite.

3. Clustering results

As a result of clustering analysis on multiple years of the Akebono wave data, the feature vectors have been classified into several groups. Some groups in them correspond to well-known plasma waves, such as chorus, hiss and so on. The waves that have distinctive time variations, as shown in Fig.1, have been properly classified into appropriate groups.

4. Conclusion

In the present study, we applied a clustering method to the plasma wave data obtained by Akebono and classified them into several groups according to their spectrum features. Statistical characteristics of the classified plasma waves can be regarded as guidelines to identify observed waves quickly. Such identification would be essential for onboard data selections in plasma wave observations by spacecraft.

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