Abstract The ground magnetic field variation in the extremely low frequency (ELF) range has been measured by an induction magnetometer at Kuju, Japan (KUJ; M.Lat. = 23.4 degrees, M. Lon. = 201.0 degrees) since 2003. The first mode of the Schumann resonance (SR) around 8 Hz can be seen at KUJ. The SR in H (horizontal northward component) shows maximum peaks around 08 UT and 15 UT. In the case of D (horizontal eastward component), the SR shows its maximum peak around 08 UT. These peaks are coincident with the enhancement of lightning activity in Africa and Asia. Thus, we found the influence of the lightning activity on the observed SR at KUJ.

1 Introduction

The Schumann resonance (SR), which was detected by Blaser and Wagner [1960, 1962] for the first time, is the global resonance of electromagnetic waves generated by the global lightning activity. The resonance is formed by the Earth-ionosphere cavity and the specific resonance frequencies, which are about 8, 14, 21, and 26 Hz, appear in the ground magnetic field variation.

The diurnal variations of SR parameters reflect the properties of both the global lightning activity and the state of the Earth-ionosphere cavity. The variation in the amplitude of SR in a day show peaks which correspond with the three major thunderstorm centers, namely, African, Asian, and American [e.g., Sátori et al., 1996; Zhou et al., 2013].

In addition, SR parameters connect with the earth’s climate [e.g., Williams, 1992; Price, 2000]. Williams [1992] suggested that the variation of SR frequency indicates the variations in the tropical temperature. Thus, the variation of SR can be used to monitor the earth’s climate.

In order to use the SR parameters for monitoring the earth’s climate, we need a better understanding of the SR detected at our observatory Kuju, Japan (KUJ; M.Lat. = 23.4 degrees, M. Lon. = 201.0 degrees). We present the effects of the global lightning activity to the fundamental mode of the SR at KUJ.
2 Data Set

The ground magnetic field variation in the extremely low frequency (ELF) range has been measured by an induction magnetometer at KUJ since 2003. The observation is a part of activities by International Center for Space Weather Science and Education, Kyushu University. The components of ground magnetic field used in this study are horizontal northward component (H) and horizontal eastward component (D). The sampling rate of the ground magnetic field data is 50 Hz. In this study, we examined the magnetic field data obtained from 2003 to 2012.

To identify SR parameters, which are frequency and power of the fundamental mode of the SR, we calculated PSD (power spectral density) every 10 seconds segment by using FFT (First Fourier Transformation). Since, the fundamental mode of SR is about 7.8 Hz, we find a peak frequency ranging 6.0 Hz to 9.0 Hz for running average of the PSD data. Then we obtained the power at the peak which is denoted as SR power.

3 Data Analysis

Figure 1 shows the mean seasonal variations of the SR power for 10 years from 2003 to 2012. Here the SR power is the median of the daily SR amplitudes. The largest amplitudes appear in June for H and in July for D. The SR amplitude becomes maximum in summer. On the other hand, SR amplitudes of H and D show the minimums in winter.

The mean daily variations for four seasons are shown in Figure 2. The SR power in H has a peak around 15 UT except for summer. In summer, the peak at 09 UT appears and the peak around 23 UT becomes conspicuous. In the case of D, the peak at 07 UT is particularly prominent. The peak around 23 UT can be seen in the same way as H.

4 Discussions and Summary

The three major regions of lightning activity (i.e., Asia, Africa, and America) affect amplitude of SR [e.g., Zhou et al., 2013]. Since thunderstorms become most active in the afternoon local time, the maximum of the global lightning activity is found somewhere between the point of local noon and the evening terminator. Thus, the peak time of thunderstorm activity in Asia, Africa, and America are fixed at around 08 UT, 14 UT, and 21 UT, respectively [Whipple and Scrase, 1936].

The largest and the smallest SR power appear in summer and winter, respectively (Fig. 1). It is reasonable to predict that the influence of the lightning activity becomes intense in summer at KUJ.

We can find the relationship between the global lightning activity and the SR at KUJ from Figure 2. The peak around 15 UT in H at KUJ can be related to the lightning activity from Africa. In summer, the peaks at 08 UT and 23 UT are enhanced and the peak at 15 UT is buried. The peak at 08 UT corresponds with the peak time of the lightning in Asia. Thus, the SR at Kuju indicates that the lightning activity from Africa affects through the year and the lightning activity from Asian center becomes stronger in summer. In the case of D, the most prominent peak at 07 UT seems to be associated with the lightning activity from Asian center. While the peaks at 23 UT are noticeable both in H and D, they bear no reference to the three major regions of lightning activity.

As stated above, we found the response of the SR power at Kuju to the global lightning activity. The variation of the SR power seems to be affected by the thunderstorm regions which become active in relation to the observation site. However, the relationship between
the peak at 23 UT and the global lightning activity is unclear. Setman and Fraser [1991] suggested that the local height of the ionospheric D region for a given observation site also affects the SR amplitude. In addition, Melnikov et al. [2004] indicated the terminator effect on the SR, and concluded that the effect is caused by the lateral ionospheric gradient across the terminator region. Thus, we need to take into account the state of the local ionosphere for the better understanding.

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