28-day variation of global lightning activities and its relationship to climate change and solar activities

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Electromagnetic waves in the frequency range less than 60 Hz excited by lightning discharges can propagate globally with low attenuation rates inside the Earth-ionosphere cavity. Interferences of these globally propagating waves result in cavity resonances known as Schumann resonances (SRs). Recently, it is suggested that these waves can be used to monitor not only global lightning activities but also global climate changes. In order to study the characteristics of the periodic variation of global lightning activities and to identify the relationship between global lightning activities and climate changes and solar activities, we have analyzed ELF magnetic field waveform data in the frequency range of 1-100 Hz obtained at Syowa station (69.0^{o}S, 39.6^{o}E) in Antarctica, Onagawa observatory (38.4^{o}N, 141.5^{o}E) in Japan and Esrange (69.8^{o}N, 21.1^{o}E) in Sweden for the period between February 2000 and December 2004. First, we have calculated dynamic spectra of the Syowa ELF data for both the geomagnetic north-south (H) and the east-west (D) component over the period between February 2000 and January 2002. Then, powers of first three SR modes at 8, 14, 20 Hz are extracted from each of the H- and D-component dynamic spectra as an indicator of global lightning activity. Power spectra of the SR power variations are calculated by the maximum entropy method. It is found that there are steep peaks at 28 and 11, and multiple peaks around 4-6 days.

Since the SR waves propagate long distance by reflecting at the highly conducting Earth surface and the ionosphere, 28-day SR spectral power variation might be caused by the modulation of the reflection parameter at the ionosphere. In order to verify these possibilities, we estimated the ionospheric reflection height of SR waves and performed the cross-spectral analysis between the reflection height variation and the SR spectral power. It is identified that the amplitude of the ionospheric reflection height variation is abou 2% of the average value, while that of the SR spectral power variation abou 40%. It is also found that the phase between these variations is estimated to be -90^o. There is no reasonable explanation for this phase relation since the magnetic field spectral intensity is inversely proportional to the ionospheric reflection height. All these facts suggest that the 28-day SR spectral power variation might be caused by not the modulation of the ionospheric reflection height but the 28-day modulation of the global lightning activity itself.

In order to investigate the relationship between the 28 day SR spectral power variation and the variation of high cloud top area, we analyzed the global IR cloud image data obtained by the meteorological satellites. We estimated the variation of the 8 km cloud coverage in the tropics which we defined the latitudinal range from 30S to 30N, then we performed a cross-spectral analysis between the cloud coverage variation and the SR spectral power variation. It is found that the cross spectrum peaked at a period of 24 days with a coherence of 0.65. It is also found that the phase distribution peaks at +/-180 deg for the 24-day period. These facts imply that the SR spectral power decreases when the amount of the tropical upper cloud coverage increases, which would suggest tropical upper cloud coverage has a negative feedback on global lightning activity.

We have calculated dynamic spectra of Onagawa and Esrange ELF data and analyzed SR spectral power variation of first three SR modes. We have also estimated locations of cloud-to-ground (CG) discharges which excited transient SR events. At the presentation, we will discuss these results more in detail.