R010-18
C 会場 ：11/5　 AM1 （9:00-10:30）
09:45～10:00

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Scale estimation of the Dellinger phenomenon using the GAIA model

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The sudden increase in X-ray to extreme ultraviolet (EUV) emissions of solar flares promote ionization in the ionosphere and it can cause a rapid variation in electron density. The communication failure caused by the absorption of the radio waves (HF; High Frequency), due to the variations in electron density in the ionospheric D region (60-90 km) is called the Dellinger phenomenon (Dellinger 1937). The occurrence of the Dellinger phenomenon can be known from the value of the minimum reflection frequency (fmin) observed by the vertical incident ionosonde. It is known that the fmin value fluctuation depends on the peak X-ray intensity of flare and the solar zenith angle (e.g., Tao et al., 2020), and the current estimation of Dellinger phenomenon is based only on solar X-ray observations. However, this relationship has large fluctuations and there are many cases in which the fmin value is not proportional to the X-ray peak flux. Thus, it is necessary to consider not only X-rays but also other flare emission wavelengths that affect the electron density in the lower ionosphere. The main candidate for this non-X-ray emission affecting the Dellinger phenomenon is EUV emissions.

First we investigated the relationship between the observed X-ray and EUV emissions during flares and the fmin values. In this study, we analyzed 38 solar flare events of M3 class or larger observed during daytime in Japan (9:00-18:00 JST) between May 2010 and May 2014. We used the GOES/X-ray Sensor (XRS) for X-ray data, the GOES/Extreme Ultraviolet Sensor (EUVS) and the Solar Dynamics Observatory (SDO)/EUV Variability Experiment (EVE) were used for EUV data. The fmin values were obtained from ionograms which are provided by the National Institute of Information and Communications Technology (NICT) in Wakkanai, Kokubunji, Yamagawa and Okinawa.

Comparing these X-ray and EUV emissions with fmin values, we found that the Lyman-alpha emission from the GOES/EUVS-E does not correlate with fmin values. On the other hand, X-ray (0.1-0.8 nm) and EUV (11-14 nm) emissions correlate with fmin values, with correlation coefficients of 0.74 and 0.76, respectively.

Next, we used the Ground-to-Topside Model of Atmosphere and Ionosphere for Aeronomy (GAIA) provided by NICT, a physical model of the Earth's atmosphere, to calculate the ionospheric effects of solar flare emission and compare them with the fmin value. Since GAIA provides the altitude profile of the electron density change at each wavelength of the solar flare spectrum.

We analyzed the X1.7-class flare event on May 13, 2013, in detail. The results show that at an altitude of around 100 km, the ion production rate from X-rays is about 6 orders of magnitude larger than that of 11-14 nm EUV emission, indicating that X-rays are the main source of ion density fluctuations at this altitude. On the other hand, the ion production rates in the E and F regions around 100-150 and 150-400 km altitude are 1 or 2 orders of magnitude larger for the 11- 14 nm EUV emission than for X-rays, indicating that the 11-14 nm EUV emission is the main cause of the ion density fluctuations at the E and F regions.

The absorption rate of HF radio was ~90-95 % around 100 km altitude and ~5- 10 % in the E region (100-150 km altitude).

The current GAIA model is not able to calculate accurately below about 100 km altitude, but Dellinger phenomenon occurs in the D region below about 100 km altitude, and the fmin value is also measured in the D region. Therefore, in this study, we tried to estimate the electron density at altitudes below 100 km by using the electron distribution at 100 km altitude calculated by GAIA as an initial value. In this paper, we will discuss the estimated electron density in the ionosphere D region and their relationship between the Dellinger phenomenon.