

Relationship between X-ray and EUV solar flare emissions and the Dellinger phenomenon

*渡邊 恭子¹、荒尾 宗睦¹、西本 将平¹、埜 千尋²、西岡 未知²

*Kyoko Watanabe¹, Munechika Arao¹, Shohei Nishimoto¹, Chihiro Tao², Michi Nishioka²

1. 防衛大学校、2. 情報通信研究機構

1. National Defense Academy of Japan, 2. National Institute of Information and Communications Technology

The radiation from the sun is the most important ionization and heating energy source for the Earth's upper atmosphere. When solar flares occur, the intensity of multi-wavelength electromagnetic emissions suddenly increases. Among these, the intensification of X-rays to extreme ultraviolet (EUV) emissions accelerates the ionization and molecular dissociation of atmospheric components in the ionosphere and thermosphere, and it may cause a sharp increase in electron density. It is generally considered that ultraviolet (UV) emissions with a long wavelength of 100 nm or more affect the lower atmosphere, whereas short-wavelength EUVs and X-rays may also affect the mesosphere (e.g. Woods et al., 2000). These short-wavelength UV radiation reaches the ionosphere D region at 60–90 km, thereby causing an increase in electron density in this region. The communication failure caused by the absorption of the short-wave due to the variations in electron density in the ionosphere D region is known as the Dellinger phenomenon (Dellinger 1937). Generally, the Dellinger phenomenon is considered to be caused by the occurrence of M-class or higher solar flares and predicted by using the magnitude of the solar flares. However, reportedly, the Dellinger phenomenon sometimes occurred even in during C-class flares; however, it did not occur even in during X-class flares (e.g. Tao et al., 2020). From these results, it is considered that the flare emissions contributing to the occurrence of the Dellinger phenomenon may also be affected by emissions that are not proportional to the X-ray intensity.

The occurrence of the Dellinger phenomenon can be known by using the minimum reflection frequency (f_{min}) from vertical incident ionograms. When a strong Dellinger phenomenon occurs, the reflected wave from ionosonde becomes invisible due to ionospheric absorption, and the f_{min} cannot be measured. However, in the case of the Dellinger phenomenon, which is not too strong, increases of f_{min} values are observed. Therefore, we checked the f_{min} observed in the ionosonde held by the National Institute of Information and Communications Technology (NICT) at Kokubunji. And then, we statistically compared with the solar flare emission (X-rays and EUVs). When the fluctuation of f_{min} (about 4,000 events) between 1996 and 2018 was compared with the GOES X-ray intensity, a relationship was seen that was almost in agreement with the results of previous studies (Sato, 1975; Tao et al., 2020).

In this paper, we will report the results of statistical comparison of the Dellinger phenomenon (f_{min} fluctuation) that occurred from 1996 to 2018 with X-ray data. We also report on the results of comparisons between f_{min} and EUV data which are observed by the Solar and Heliospheric Observatory (SOHO)/Solar EUV Monitor (SEM) and Project for On-Board Autonomy (PROBA)-2/Lyman-alpha RAdiometer (LYRA), and discuss the effects of EUV emission on the Dellinger phenomenon.

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