

The ionospheric disturbances associated with Typhoons observed by HF Doppler, Infrasound, and GPS occultation observations

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Ionospheric disturbances are excited by the atmospheric waves due to extreme weather events, such as typhoons and tornados. However, there are very few studies on these kinds of topics, especially on the altitude distributions of these disturbances. In this study, we have examined ionospheric disturbances associated with typhoons using electron density profiles obtained by GPS radio occultation measurements. GPS radio occultation measurement was performed by FORMOSAT-3/COSMIC satellites, which is located at an altitude of about 800 km and viewed from a GPS satellite. Derivation of electron density profiles by receiving and analyzing slightly refracted and delayed radio waves grazing the atmosphere. The electron density fluctuations were extracted by comparing the GPS occultation data with the Chapman model. In addition to the GPS occultation data, HF Doppler sounding data and infrasound data were also examined. Infrasound is a sound wave whose frequency is lower than 20 Hz, the lower limit of human audible frequency. Using HF Doppler sounding, the vertical disturbance in the ionosphere can be observed.

Typhoons No.21 in 2017 (LAN) formed on 15 October 2017 and hit Japan on 22 October 2017.

It was a quite strong typhoon with a minimum pressure of 915 hPa recorded just before the hit of Japan. In HFD data, the Doppler-shift fluctuation in the frequency increased, especially in the frequency higher than five mHz as the typhoon approached. On the other hand, the disturbances in the infrasound data increased during the period when the typhoon hit on Japan.

Although the observation points of GPS radio occultation measurements were not the same distance from the typhoon, the enhancement of the electron density fluctuations was observed in the height of 150-400 km. The wavelength of the disturbances about several tens kilometers, and the maximum of the disturbance was about 6000 el/cm³. Since the wavelength of these disturbances corresponds to the acoustic mode of the acoustic gravity wave, it is found that the ionospheric disturbances in association with typhoons are caused by the acoustic mode wave generated by typhoons.

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