Ionospheric disturbances associated with natural hazards

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Introduction

It has been reported that the ionospheric disturbances are observed in association with natural hazard such as earthquakes, volcanic eruptions, typhoons, and so on. These disturbances are due to the atmospheric waves excited by the perturbations of the ground and the atmosphere. This implies that the monitoring of the ionosphere contributes to the warning systems of these natural hazards. To do so, detailed studies of the ionospheric disturbances depending on each natural hazard is inevitable. In this study, the characteristic features of the disturbances associated with natural hazards are examined.

Observation

GPS (Total Electron Content: TEC)

Total Electron Content (TEC) is the total number of electrons in the column with an unit cross section between a satellite and a receiver. The radio waves transmitted from the satellite are retarded by the electrons, depending on the number of TEC and the frequencies of the radio waves. From the difference of these retardation, TEC is determined.

HF Doppler

The ionosphere reflects the HF radio waves. When the reflection point moves vertically, the frequency of the radio wave is varied due to the Doppler effect. Using this fact, the observation detects the vertical perturbation of the ionosphere. In this study, the data observed at three stations installed by the University of Electro-Communications are used.

Natural hazards (Objectives)

Earthquakes

In order to examine the spectrum of the TEC perturbation, the frequency analysis is utilized. Using Fast Fourier Transform, the power spectrum of the perturbations are calculated. In most cases, the spectrums of 3-4 mHz are enhanced about 10 min after the earthquakes. This delay from the earthquake corresponds to the propagation time of acoustic wave generated by the ground motion.

Volcanic eruptions

In association with volcanic eruptions, TEC perturbations are observed. This is because the eruptions generate the vertical atmospheric perturbations. The temporal variation of TEC is similar to that for earthquake. However, the time scales of their variations are different to each other. As for earthquakes, the enhancement of spectrum intensity is usually seen in 3~4 mHz. For volcanic eruptions, it is seen in higher frequency (> 7mHz) as compared to earthquakes.

Typhoons

In HF Doppler observation, the ionospheric disturbances associated with typhoons are observed. The perturbations are enhanced above 5 mHz and the enhancement is coincided with the ground atmospheric perturbations.

Summary

In this study, the ionospheric perturbations in association with natural hazards such as earthquakes, volcanic eruptions, and typhoons are examined using GPS-TEC and HF Doppler observations. The characteristic features of the perturbations are different each other, we have to examine these perturbations according to each hazard. However, the common features of these perturbations is that all perturbations are excited by atmospheric waves generated in the lower atmosphere. Therefore, the examination of these perturbations would give us the new knowledge of ionosphere-atmosphere coupled system. One example of social contributions of this study is the warning system of these natural hazards using ionospheric observations. To do so, the further detailed examination of these perturbations is inevitable.