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Ionospheric observations by GPS RO: Height distributions of electron density increases by a large scale solar flare

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Ionosphere is a layer where neutral atmospheric molecules are partially ionized due to solar radiation in e.g. infrared wavelengths. Its properties reflect solar activities. For example, solar flares enhance solar radiations, and cause sudden increase of ionospheric electron densities. Donnelly (1976) suggested that such an increase is composed of two components of different temporal evolution, i.e. impulsive and slow components. They have different frequency spectra, resulting in different height distributions of electron density increases. With a model calculation for a typical solar flare, Donnelly (1976) also showed that the largest and the longest-lasting electron density increase occurs at a height of ~110 km, within the E region where electron density is normally less than the F_2region. Global Positioning System (GPS) satellites are equipped with transmitters of two different carrier frequencies in the L band, and the phase differences between the two carrier waves can be converted into the total number of electron integrated along the line-of-sight (Total Electron Content, TEC). Recently large numbers of GPS receivers have been deployed worldwide, and such a global network made it easy to observe sudden increase of TEC (SITEC) associated with solar flares. However, GPS-TEC has an intrinsic difficulty in investigating the vertical distribution of electron density. Recently, multiple satellites with on-board GPS receivers were launched into low earth orbits, and have obtained numerous reflectivity profiles taken when the observed GPS satellites sinks below or rises from the horizon. In this study, we use electron density profiles taken with such GPS radio occultation measurements by FORMOSAT-3/COSMIC satellites, and studied the electron density increases associated with the X-class solar flare on Dec. 5, 2006. From profiles taken in various places in the sun-lit hemisphere, we identified significant increase of electron density at height 100-110 km due possibly the slow component of the flare. On the other hand, electron density increases for a wide range of height due to the impulsive component were not clearly seen. This is considered to reflect the occurrence of this flare near the edge of the solar disk, i.e. the impulsive component of the flare must have been selectively attenuated by the solar atmosphere. We established the standard profile as the median of the profiles on days before the flare, and obtained the profile of the electron density increase due to the flare by subtracting the standard profile from the profiles obtained after the flare. The profiles of these differences clearly showed peak heights, which showed slight north-south asymmetry and were a little different from the prediction. We will try to analyze SITEC of various types of solar flares in the new solar cycle, and characterize the vertical profile of the electron density increases by them.

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