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Solar flare caused ionospheric disturbances measured with a dense GPS TEC network and an incoherent scatter radar

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ABSTRACT

GNSS sensors can provide ionospheric information at a high spatial-tempral cadence continuously and nearly globally, and thus are well suited for monitoring geophysical disturbances caused by space weather events such as solar flares. Since the start of GNSS era, numerous GPS receivers and networks have been increasingly available for ionospheric disturbance studies. Analysis of single site GPS observations is no longer of superior interest, instead, organizing individual sites of data to yield meaningful regional, meso-scale and global coverage helps tremendously generate new understanding and discoveries. Over the North America continent which spans regions of strong geophysical and societal interests from auroral, subauroral, middle, to low latitudes, dense distributions of thousands of GPS receivers yield total electron content (TEC) observations with amazing details of ionospheric structures.

In this presentation, we focus on solar flare caused meso-scale ionospheric disturbances measured over the North America continent using TEC from a dense network of GPS receivers. A few solar flare events in September 2005 will be presented, including the X17 flare on September 7, the X5.4 flare on September 8, and the X6.2 flare on September 9. As an example, Figure 1 shows the TEC variation at 75W longitude from 30-50N geographic latitudes where immediate enhancement and gradual decay are very obvious with clear solar zenith angle dependence. We will also report a TID-like ionospheric waves associated with the solar flares.

Simultaneous incoherent scatter radar (ISR) observations at Millstone Hill are also available during these events (Figure 2). These are very rare cases for the ISRs to capture solar flares, as they, unlike ionosondes, do not typically run continuously. These data allow us examine the source height of TEC enhancements and the associated ionospheric chemical and dynamical changes following the flares. We will discuss these results.

Key words: GPS TEC, solar flare, ionosphere, and incoherent scatter radar

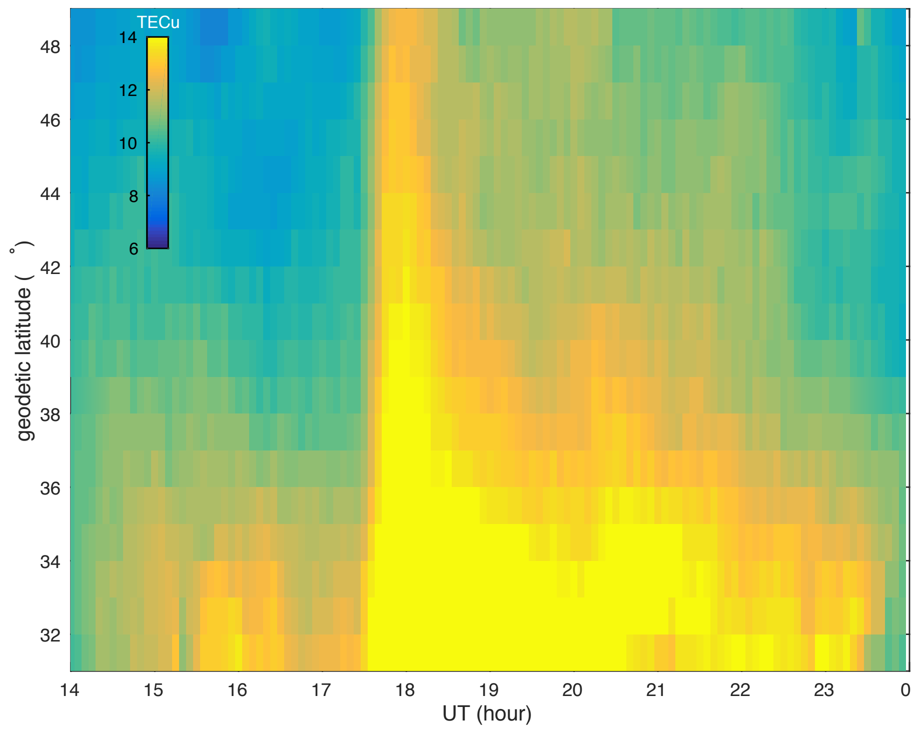

Figure 1. GPS TEC response to the solar flare X17 on September 7, 2005. GPS TEC were obtained with 1x1^{o} spatial resolution and 5 min temporal resolution. Data are mean values over 75 ± 5W longitudes

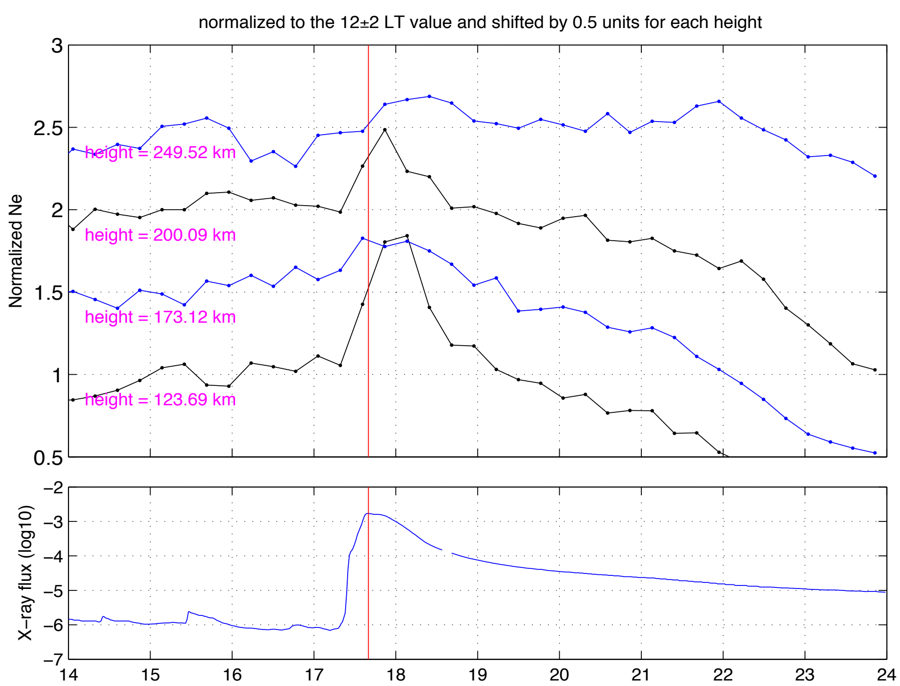

Figure 2. Millstone Hill incoherent scatter radar observations of the X17 solar flare on September 7, 2005. Electron density at several altitudes (normalized to the noon time mean of each altitude) indicates the large responses below 200 km, in particular, near 100km.