On the possible seismo-ionospheric signatures in the simultaneous ionosonde and GPS TEC measurements over Indian sector to recent 2015 Nepal Earthquake

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Abstract: In this study, we present some results of seismo-ionospheric coupling using electron density anomalies during pre and post seismic activity during 2015 Nepal (28.147°N, 84.708°E) Earthquake that occurred at 06:11:26 UT on 25 April 2015 (M_w7.8) with major aftershock observed at 07:05:19 UT (M_w7.3) on 12 May 2015 using ionosondes and GPS TEC measurements at several locations across India. While the epicenter of the first earthquake was located at ~77 km north-west of Kathmandu, the epicenter of the aftershock was located at ~75 km east of Kathmandu. Both of these earthquakes were of shallow depth of ~15 km. It is believed that during such large earthquakes vertical motion of the earth's surface create mechanical disturbances in the neutral atmosphere known as acoustic gravity waves (AGWs) which propagate into the ionosphere and interact with the ionized gas known as seismo traveling ionospheric disturbance (STID). Both Raleigh and gravity waves are generated during co-seismic activity period. Leonard and Barnes (1965) were the first to observe ionospheric disturbances induced by M9.2 Alaskan earthquake on 27 March, 1964 using ionosondes at four sites located in Alaska and California. They observed fluctuations in the ionogram traces after the earthquake. Although fluctuations in the ionogram traces were observed after the earthquake, the origin and propagation of STIDs were not studied in detail. In the recent past, such unusual fluctuations known as multiple-cusp signature (MCS) in the ionograms are believed to be produced by AGWs along with TEC disturbances. These disturbances were characterized by a vertical structure that is difficult to be detected by TEC measurement. Accordingly, detection of these multiple stratifications such as appearance of an intermediate E layer or high-type sporadic *E* layer, an enhancement of the *F*1 cusp, and additional cusps in the *F*2 region suggest that it is possible to use ionosondes at a nearby location after an earthquake to study altitude structure of the seismic signatures using high resolution ionograms. In addition, significant variations in ionospheric F2 layer critical frequency (foF2) few days before the earthquakes are believed to be due to pre-seismic signatures. According to some studies, the seismogenic electric fields due to the radon gas emission or other charged aerosol particles and the atmospheric gravity waves generated surrounding the earthquake preparation zone propagates into the F-region altitude and produces density perturbations there. Once caused, these perturbations may propagate along the magnetic field lines away from the epicenter and can be detected at distant locations. Since earthquakes usually produce significant damage in terms of loss of life and property, understanding the characteristics of the ionospheric behavior during such large magnitude earthquakes is very important for possible precursory identification for early warning systems. In addition, the seismic waves propagate well before the onset of the Earth-quake through Radon gas emissions. Accordingly, it is believed that ionospheric precursors do exist before the onset of earthquake by few days to few 10s of days. Keeping these aspects in mind, we examined the ionograms and ionsopheric parameters such as foF2, foEs and h'Es, h'F, hmF2 at nearby stations to search for co-seismic as well as pre-seismic signatures. We have also used TEC observations at select locations to investigate the seismic signatures in these locations. Our results suggest that there is a strong coupling between seismic activity and ionized density perturbations during the co-seismic activity but mixed response is observed for the precursory signatures. Based on the analyzed results, attempts are being made to understand their signatures in the light of current understanding on the coupling of lithosphere-ionosphere processes.