Combined effect of solar flare and geomagnetic storm on the propagation of subionospheric VLF signal and hence D-Region Ionosphere

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The plasma of the D-region of the ionosphere, which is almost inaccessible with other instruments, are continuously monitored by using sub-ionospheric VLF wave transmitted by fixed frequency VLF transmitters [1] operating all over the globe at our low latitude station Varanasi since 2008. These very low frequency (VLF) radio waves propagate with little attenuation ranges up to 10-15 Mm in the Earth-ionosphere waveguide [2]. The waveguide is bounded below by the Earth's surface and above by the ionosphere. Under quite conditions the propagation paths within the waveguide are stable. Electron precipitation causes perturbation of the ionosphere which produces a modification in the geometry of the waveguide resulting in the disruption of the propagation conditions. These can be detected using narrowband receivers which monitor the amplitude and phase of the signal [3]. In this study, D-region ionospheric perturbations caused by solar flare and the geomagnetic storm are studied by means of amplitude and phase anomaly in VLF signal recorded during 2011 - 2012. The phase anomalies are evaluated in terms of X-ray fluence (J/m^2).
The amplitude and phase enhancements associated with solar flare were observed in the signal which is attributed to an increase in the electron density of the D-region as a result of extra ionization caused by the solar flares. Time delay between VLF peak amplitude and X-ray flux peak have been taken in to account to estimate D-region reference height ($H^/$) and sharpness factor (β). The flare time electron density is then estimated by using these $H^/$ and β, which shows maximum increase in the electron density just after flare peak.
Storms also affect the phase and amplitude of VLF waves (of 10–30 kHz). At the time of a magnetic storm there occurs a rapid phase fluctuation of VLF signal. Signal enhancement and subsequent fluctuations were found to be associated with a strong increase of the electron density and particle precipitation due to geomagnetic storm respectively. Quantitative modeling of subionospheric VLF wave propagation incorporating precipitation flux of energetic electrons onto the upper atmosphere yield results consistent with the variations in the VLF signal amplitude observed.

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