Electron Density Enhancements During Solar X-ray Flares from VLF Sounding of the Lower Ionosphere

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Summary

Very low frequency (VLF < 30 kHz), electromagnetic signals with well stabilized phase and amplitude, emitted from a world-wide network of communication transmitters, and propagating along the Earth-ionosphere waveguide make an efficient tool in sounding the lower ionosphere (60-90 km altitude above Earth surface). Continuously emitted, as well as monitored by recording systems, VLF signals reveal regular diurnal and seasonal variations under undisturbed ionospheric conditions. During eruptive Solar activity, released X-ray flares, penetrate deeply into the lower ionosphere (the 0.1-0.8. nm radiation band in particular), leaving their signatures in notable disturbances of monitored VLF-signal phase and amplitude. These ground-based observations of abrupt phase and amplitude increase or decrease, as monitored by the Belgrade AbsPAL facility (Absolute Phase and Amplitude Logger), for signals from transmitters GQD/22.1 kHz, UK and NAA/24.0 kHz, USA, have been related to the space-based GOES 12 satellite measurements of the X-ray irradiance in the 0.1-0.8 nm band, and a correspondence for around 120 VLF-detected flare events in the period May-August 2004-2007 was established. On this basis the reconstruction of the D-region electron density enhancements caused by Solar flares has been carried out. Two independent approaches have been used: the NOSC waveguide simulation program LWPC, resting on the Wait model of the ionosphere, leading to the electron density height profile *N(z)* at a specified time of the flare occurrence and the one relying on the solution of the electron continuity equation, giving the electron density time profile *N(t)* at a given height, throughout the flare duration. The two models, though operating with different VLF- parameters, are shown to compare favourably and indicate the way towards an unified description of the electron density profile *N(z,t)* variations during Solar flares.