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[Abstract]

## **Lightning induced Electron Precipitation and related Ionospheric Electron Density Changes estimated from VLF Signal Perturbations recorded in Belgrade**

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### **Abstract:**

Energetic Electron Precipitation (EEP) events are of particular significance for dynamic of Earth's ionosphere (e.g. Prölss 2012; Silber and Price 2017; Mironova, Sinnhuber & Rozanov 2020). In this study, short-lived nocturnal phenomena related to Lightning induced Electron Precipitation (LEP) process taking place at altitude range corresponding to lower ionosphere were studied based on perturbations in propagation of Very Low Frequency (VLF; 3-30 kHz) radio signals recorded in Belgrade, Serbia. Multiple LEP events occurred over several years were inspected, with focus placed on amplitude and phase variations associated with selected LEP events, monitored and observed on two VLF signals with relatively close paths over Europe. Based on numerical simulations using LWPCv21 program (Ferguson 1998), regions of enhanced ionization along propagation paths of two signals (an European signal transmitted on frequency 22.1 kHz from UK towards Belgrade with relatively short path of approx. 2

Mm and an American signal transmitted on frequency 24 kHz from USA towards Belgrade with relatively long path of approx. 6.6 Mm) were determined, placing the zones of enhanced ionization over region corresponding to mid-latitude central European sector. Perturbed lower ionospheric electron density profiles related to analyzed LEP events were estimated, with main specifics and features presented in this research.

**Keywords:** VLF signals, ionospheric perturbations, lightning events, electron precipitation

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