

# REDUCTION OF LOWER IONOSPHERE PLASMA FLUCTUATION – NEW EARTHQUAKE PRECURSOR?

A. NINA<sup>1</sup>, S. PULINETS<sup>2</sup>, P.F. BIAGI<sup>3</sup>, G. NICO<sup>4</sup>,  
S. T. MITROVIĆ<sup>5</sup>, M. RADOVANOVIĆ<sup>6</sup> and L. Č. POPOVIĆ<sup>7</sup>

<sup>1</sup>Institute of Physics, University of Belgrade, Serbia, E-mail sandrast@ipb.ac.rs

<sup>2</sup>Space Research Institute, Russian Academy of Sciences, Moscow, Russia

<sup>3</sup>Università di Bari, Physics Department, Bari, Italy

<sup>4</sup>Istituto per le Applicazioni del Calcolo (IAC), Consiglio Nazionale delle Ricerche (CNR), Bari, Italy

<sup>5</sup>Novelic, Belgrade, Serbia

<sup>6</sup>Geographical Institute Jovan Cvijić SASA, Belgrade 11000, Serbia

<sup>7</sup>Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia

We present analysis of the lower ionosphere plasma short-term disturbances during period around the Kraljevo earthquake that occurred in Serbia on 3 November, 2010. Study is based on analysis of the short-term phase noise of the very low frequency (VLF) radio signal emitted by ICV transmitter located in Italy and received in Serbia. In this study we applied the procedure already described in recent research related to the signal amplitude in period around the considered event which point out the amplitude noise reduction as potential new ionospheric precursor of earthquakes. In this work, we process phase of ICV signal and results indicating phase noise reduction similar like those in the case of the amplitude shows that both signal characteristics, the amplitude and phase, can be used in future research of ionospheric plasma variations as possible precursors of earthquakes.

Variations in the ionospheric plasma can be considered as earthquake (EQ) precursors [1, 2]. Observations of these variations are based on different satellite and ground-based techniques and their applications primarily depend on the considered altitude domain.

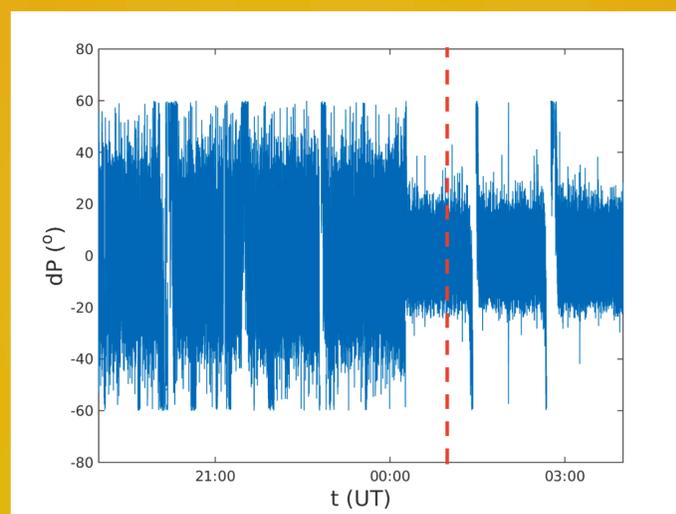
In this study we focused on the lower ionosphere and its remote sensing by the very low frequency (VLF) radio waves. The recent research of the short-term amplitude noise shows that its reduction is recorded less than one hour before the Kraljevo EQ occurred in Serbia on 3 November, 2010 [3].

[1] Pulinets, S., Boyarchuk, K.: 2004, *Ionospheric precursor of earthquakes*. Heidelberg: Springer.

[2] Biagi et al.: 2011, *Nat. Hazards Earth Syst. Sci.*, 11, 333.

[3] Nina et al.: 2020, *Sci. Total Environ.*, 710, 136406.

We analyze data obtained by remote sensing of the lower ionosphere during night-time when Kraljevo EQ occurred with 20.27 kHz signal emitted by ICV transmitter from Isola di Tavolara, Italy (40.92 N, 9.73 E) and received by the Absolute Phase and Amplitude Logger (AbsPAL) receiver located



*Time evolutions of phase deviation  $dP$  of the ICV signal in night-time of the Kraljevo earthquake. Vertical dashed line indicates the time of occurrence of the considered EQ.*

at the Institute of Physics Belgrade in Belgrade, Serbia (44.8 N, 20.4 E). Changes of the phase noise are visualized in this analysis as variations in time evolution of phase deviation  $dP$  defined as difference between recorded,  $P$ , and basic phase  $P_{\text{base}}$  (mean value of  $P$  within defined time bean around time  $t$ ):

$$dP(t) = P(t) - P_{\text{base}}(t).$$

**In comparison with the amplitude noise, which has been analyzed in [3], we can conclude that the noticed changes are very similar and that both analyses point out that reduction in lower ionosphere short-term fluctuations can be considered as new possible EQ precursor.**