LOWER IONOSPHERE DISTURBANCES: THEIR POSSIBLE RELATIONSHIP WITH EARTHQUAKES, AND INFLUENCE ON SATELLITE SIGNALS

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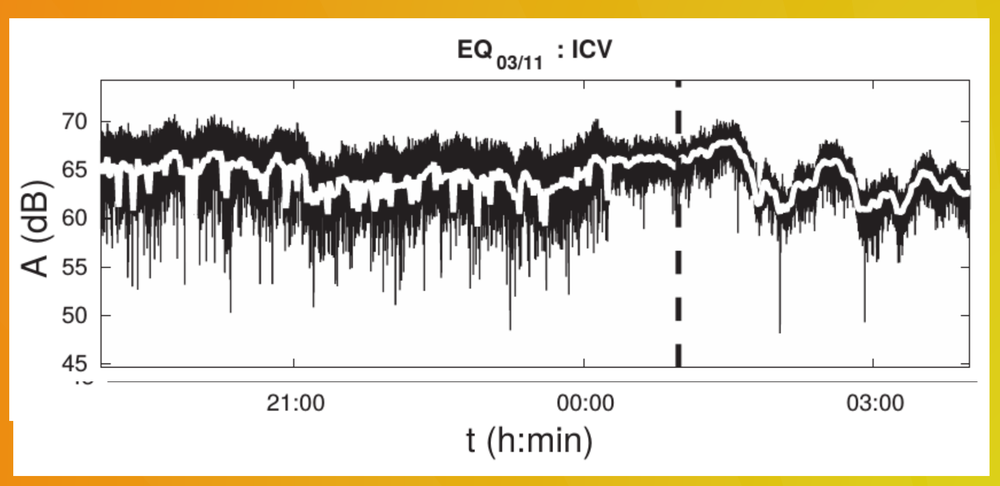
We present two directions in recent studies of the lower ionosphere related to natural hazards and to the satellite signal propagation. In the first part, we focus attention on variations in the short-period noise amplitude within the time period around an earthquake onset which can be considered as a possible earthquake precursor. The second part contains detailed explanations about effects of the perturbed D-region on propagation of satellite signals utilized for positioning and Earth observation purposes.

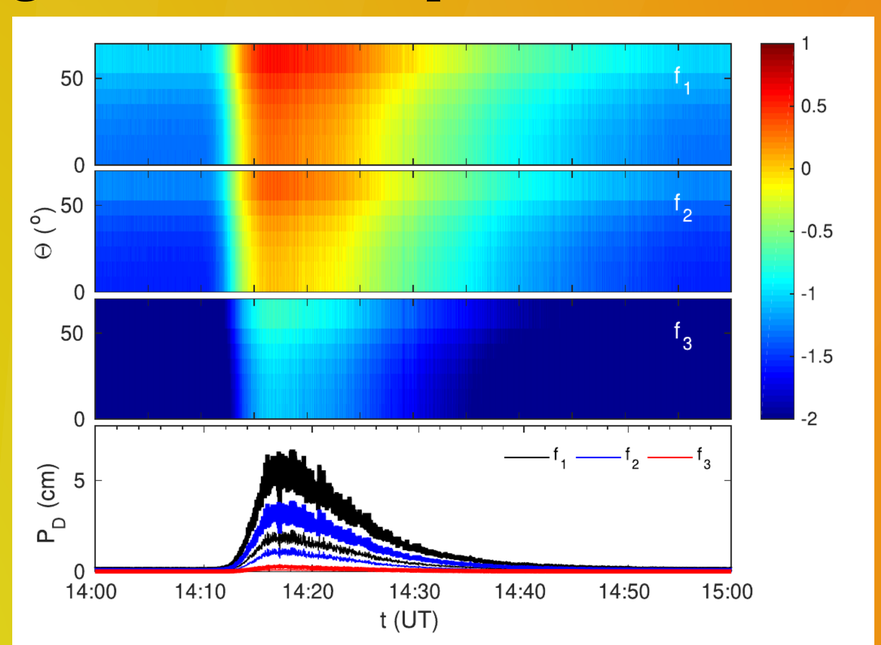
Variations in the ionospheric plasma can be considered as earthquake (EQ) precursors [1, 2]. Observations of these variations are based on different satellite and ground-based techniques and their applications primarily depend on the considered altitude domain.

In [3] we focused on the lower ionosphere and its remote sensing by the very low frequency (VLF) radio waves. This study shows that the short-term noise amplitude reduction is recoded less than one hour before the Kraljevo EQ occurred in Serbia on 3 November, 2010 for ICV signal emmited in Italy and recorded in Serbia [3]. This property is also recorded for several other EQ events.



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.

We investigate the influence of the perturbed (by a solar X-ray flare) ionospheric D-region on GNSS and (SAR) synthetic aperture radar signals. We calculate a signal delay in the D-region P_D based on the low ionospheric monitoring by very-low-frequency (VLF) radio waves. The results presented in [4] show that should be taken into account in modeling the ionospheric influence on the GNSS and SAR signal propagation. This conclusion is significant because numerous existing models ignore the impact of this ionospheric part on the GNSS and SAR signals due to its small electron density which is true only in quiet conditions and can result in significant errors in space geodesy during intensive ionospheric disturbances.



(Top three panels) Time evolutions of log(P_D/1 cm) for incident angles 0 in the range 0o – 70° and GNSS/SAR frequencies f_1 = 1.2 GHz, f_2 = 1.6 GHz, and f_3 = 5.4 GHz. (Bottom panel) Time evolutions of P_D for incident angles of 0° and 70° for the considered frequencies.

[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.
[4] Nina et al.: 2020, IEEE *Geosci. Remote Sens. Lett*. 17(7), 1198-1202