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LOW IONOSPHERE RESPONSE ON ASTRO- AND GEO-PHENOMENA - RECENT RESEARCH

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Abstract. This paper overviews our recent studies of low ionospheric perturbations caused by numerous astrophysical and geophysical phenomena. We present theoretical and numerical procedures developed for modeling the spatial and time distributions of plasma parameters and for detecting the ionospheric disturbances. Here, we examine the effects of solar X-ray flares, gamma ray bursts and tropical depressions preceding a hurricanes. The analyses are based on data of very low and low frequency (VLF/LF) radio signals collected by the receiver located at the Institute of Physics in Belgrade.

1. INTRODUCTION

Processes in the terrestrial atmosphere are very complex due to occurrence of different events and their affects at the considered geographical locations (Mihajlović, 2017, Mihajlović et al, 2017). As a part of the atmosphere, the low ionosphere is under permanent influences of events coming from outer space and Earth's layers. These terrestrial and extraterrestrial phenomena induce variations in the low ionospheric plasma characteristics which can be detected in the ionospheric monitoring by radio waves as well as in radar and rocket measurements. Such variations can further be used for detection of different events and for modeling the low ionospheric plasma.

In this paper we present studies of the low ionosphere based on data collected by the Belgrade VLF/LF receiver station since 2004. We give an overview of the direction in our research and show the most important results published in international journals.

2. EXPERIMENTAL SETUP

The Belgrade VLF station consists of two receivers with one electrical (AbsPAL - Absolute Phase and Amplitude Logger) and two magnetic loop (AWESOME - Atmospheric Weather Electromagnetic System for Observation Modeling and Education) antennas, respectively. They can simultaneously register 6 and 15 signals emitted by different transmitters at fixed frequencies, respectively. These AbsPAL and AWESOME antennas have been operating since 2004 and 2008, respectively. During this period we have collected a large data base containing a written information about numerous low ionospheric responses to different natural and human-induced events allowing for making statistical analyses of considered phenomena and to detect differences within a long-term period.

3. OBSERVATIONS AND RESULTS

Our research is based on detections of the low ionospheric responses to different asro and geophysical phenomena and modeling of the D-region plasma parameters during the corresponding perturbation periods. Examples of detected events and modeled D-region plasma parameters are presented in Figure 1 and Figure 2, respectively.

3. 1. DETECTIONS OF ASTRO AND GEO EVENTS

In our studies we present procedures for detections of signal perturbation signatures which are based on extractions of short-term amplitude peaks from the amplitude noise and on comparison of amplitudes showing in possible perturbed and quiet periods. In addition, we developed a procedure for detection of acoustic and gravity waves (AGWs) induced by a strong sudden impact of radiation. The derived procedures are applied to:

- Confirmation of short-term ionospheric disturbances induced by gamma ray bursts (GRBs) (Nina et al. 2015).
- Statistical analysis of no short-term disturbances in time periods when tropical depressions start to form (Nina et al. 2017a).

- Determination of periods of AGW induced by a solar terminator (Nina and Čadež, 2013).

A detailed review of these procedures is given in Nina et al. (2017b).

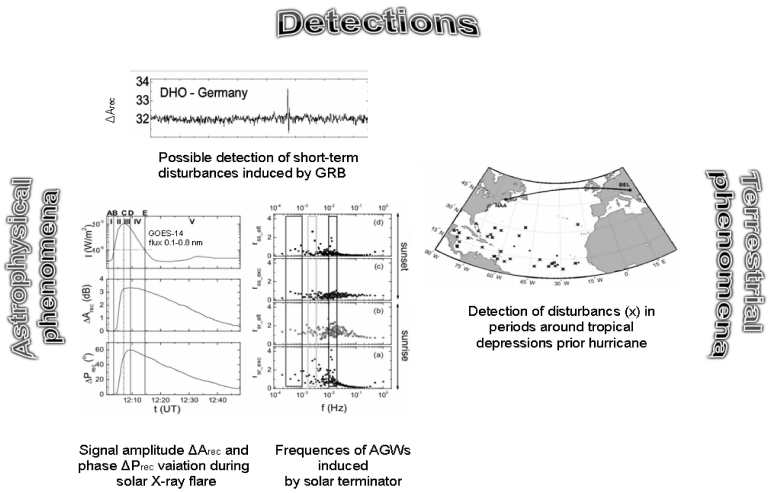

Figure 1: Examples of detected events.

3. 2. LOW IONOSPHERIC PLASMA MODELING

Modeling of the time evolution of the D-region plasma parameters during perturbations is presented in numerous studies where we considered solar X-ray flares influences on:

- The electron density (Nina et al. 2012, Kolarski and Grubor, 2014, Šulić et al. 2016).
- The temperature and refractive index (Bajčetić et al. 2015).
- The electron loss coefficient (Nina and Čadež, 2014).
- The D-region electron content (Todorović Drakul et al. 2016).

Some of these procedures are restricted to specific periods of the D-region responses and their expansion to the entire perturbation period will be in focus of our upcoming studies.

4. SUMMARY

In this paper we presented a review of our recent studies of low ionospheric perturbations caused by various astrophysical and geophysical phenomena. The presented theoretical and numerical procedures for modeling the spatial and temporal distributions of plasma parameters and for detecting the ionospheric disturbances are based

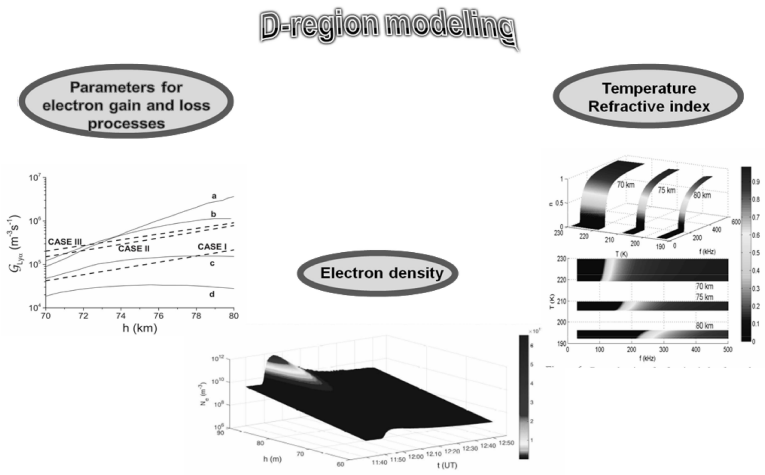

Figure 2: The resulting modeling of the D-region physical parameters.

on analyses of data collected by the radio signal receiver located at the Institute of Physics in Belgrade, Serbia. The obtained results of these investigations are of scientific importance in astro and geo sciences as well as in a practical application in telecommunications and numerous new open questions require studies which will be the subject of our future research.

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