Publications of the Institute of Geophysics, Polish Academy of Sciences
Geophysical Data Bases, Processing and Instrumentation
vol. 425 (M-32), 2019, pp. 71-72
DOI: 10.25171/InstGeoph_PAS_Publs-2019-014
"Electromagnetic ULF/ELF Fields on Earth and in Space" Conference, Warsaw, Poland, 2019

ELF Signatures in Low and High Radio Frequency Signals

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1. INTRODUCTION

The radio waves in ranges from LF (Low Frequency) to HF (High Frequency) which propagate in the Earth's atmosphere are affected by the ionosphere. Observation of phase, amplitude and direction of incoming radio signals can provide information about the current state of the ionised medium. In our studies for HF observations we use PL610 LOFAR (Low-Frequency Array for Radio astronomy) station, which is located in Astrogeodynamical Observatory in Borowiec. For LF and MF (Medium Frequency) band measurements dedicated receiver based on Universal Software Radio Peripheral (USRP) is used. We observe phase and amplitude signals from radio broadcast station. The time measurement is based on GPS.

2. MEASUREMENTS

2.1 PL610 station

The single LOFAR station is divided into two antenna fields, the Low Band Antennas (LBA) field and the High Band Antenna (HBA) field, which consist of a set of 96 antennas. Each of antennas can be used for independent observation of the radio signals. Due to its construction, it is possible for LOFAR station to measure the angle of incidence of the incoming signals and its changes in time. The LBA, which operates in the 8–90 MHz frequency range (de Vos *et al.* 2009), allows to measure the signals from broadcasting station reflected from the ionosphere. This gives us possibility to observe many phenomena, such as multi-path propagation and small changes of the incidence angle, and shows that LOFAR instrument is valuable tool for ionosphere monitoring.

2.2 LF/MF phase monitor

The measurements below frequency of 8 MHz are not possible with LOFAR station. For this reason, we use a special system consisting of USPR software defined radio (SDR) and Wellbrook loop antenna located in Warsaw. The time measure is provided by GPS (PPS). It works

in frequency range 30 kHz – 30 MHz. Current version doesn't allow to measure incidence direction of the signals. For this reason we use signals from commercial broadcast station. The AM transmission in addition to the audio signals contains a carrier. We use 3 transmitters: Polskie Radio Program 1 (1 MW) at 255 kHz from Solec Kujawski (Poland), BBC Radio 4 (500 kW) at 198 kHz transmitted from Droitwich (England) and DCF77 signal (50 kW) at 77.5 kHz from Mainflingen (Germany). Selected radio stations have stable carrier frequencies controlled by an atomic clock. Precise phase measurements can provide evolution of the phase during the day as well as a rapid, small changes.

3. RESULTS

We observe three kinds of phenomena. The first one are rapid changes of signals parameters caused by multi-path nature of the HF propagation. The second type – slow variations which are related to daily changes of the ionosphere and the last one observed as a quick periodic changes of measured parameters.

4. CONCLUSIONS

The presented analysis of radio signals variations is a valuable tool for monitoring and studying changes of the ionosphere, and thus can be used successfully for space weather condition diagnosis.

References

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SYGNATURY ELF W OBSERWACJACH SYGNAŁÓW RADIOWYCH NA FALACH DŁUGICH I KRÓTKICH

Streszczenie

Radiokomunikacja na falach krótkich bazuje na odbiciu fal radiowych od jonosfery. Również propagacja na niższych częstotliwościach, falach długich i średnich jest w dużej mierze zależna jest od jonosfery. Obserwacje komercyjnych rozgłośni radiowych mogą wnieść istotne informacje o stanie i zaburzeniach występujących w jonosferze.

Pomiary wykonane przy użyciu stacji PL610 systemu LOFAR na falach krótkich oraz własnej aparatury na falach długich i średnich pozwalają na monitorowanie zarówno dobowych jak i krótkookresowych zmian fazy. W pracy przedstawiamy wstępne wyniki wykonanych obserwacji.