ELF Noise Test in the Széchenyi István Geophysical Observatory

Tamás Bozóki[1,2]*, József Bór[1], Dániel Piri[1], Attila Novák[1] and Csaba Molnár[1]

[1]Institute of Earth Physics and Space Science (ELKH EPSS), Sopron, Hungary

[2]Doctoral School of Environmental Sciences, University of Szeged, Hungary

Abstract

On the 9^{th} of July, 2020, a detailed noise test was carried out in the Széchenyi István Geophysical Observatory in order to survey the electromagnetic noises generated in the very low frequency (VLF; 3-30 kHz) and extremely low frequency (ELF; 3 Hz - 3 kHz) bands by different electrical devices operating in the observatory. During a ~ 3 hour long period, the measurements of the observatory, the power supply of buildings as well as solar panels and charging of the batteries were shut down one-by-one and finally the main power supply from the nearby village Fertőboz was interrupted for a few minutes. A pair of induction coil magnetometers run from a battery had been installed for this test period and provided information on the changes in the ELF noise environment during the test. Although the ELF-band noise contamination in the measurements reduced in connection to the elimination of internal noise sources in the observatory, it seems that external noise sources outside the observatory are too powerful and prohibit local monitoring of the Schumann resonances in the atmospheric magnetic field. Therefore, a new location for a permanent magnetic SR station is needed.

Keywords: Extremely low frequency, Schumann resonance, ELF noise.

Motivation

Measurements of the atmospheric magnetic field by induction coils in the Széchenyi István Geophysical Observatory (NCK) are contaminated by different artificial noises which hinder the detection of Schumann resonances (SRs) (Sátori et al., 2013; Bór et al., 2020). We usually attribute this noise contamination to the railway lines which run near the observatory and have been electrified well after the establishment of the observatory. In the summer of 2020 a survey of electromagnetic noises was carried out in connection to the re-installation of the renovated VLF antenna. This opportunity enabled us to revisit the question on the origin of ELF noise. The setup of the experiment allowed the separation of ELF noises of internal or external origin in the observatory.

Description of the test measurements

A pair of induction coil magnetometers were installed temporarily near the observatory in the time period from 07/07/2020 to 13/07/2020. The sampling frequency

*Corresponding author: Tamás Bozóki (bozoki.tamas@epss.hu)

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was set to 500 Hz. The measurement ran from a battery which assured the continuous operation throughout the test period. The ∼3 hour long noise test was carried out on the 9^{th} of July, 2020. It began at 08:45 UT and ended at 11:30 UT. The regular measurements of the observatory, the power supply of buildings as well as solar panels and the batteries they charge were shut down one-by-one during this period. Finally, the main power supply from the nearby village Fertőboz was also interrupted for 6-7 minutes between 11:22 and 11:29 UT.

Results

Figure 1 shows dynamic spectra corresponding to the H_{NS} and H_{EW} field components from the day of the noise test. By comparing them to dynamic spectra corresponding to the very same day but measured in a low ELF noise environment near Magyargencs, Hungary (see Fig. 1 in Bozóki et al., 2021) it is clear that the measurements are highly contaminated by noise. The noise contamination is higher in the H_{NS} field component than in the H_{EW} field component. SRs are faintly visible in the H_{EW} field component, especially before midnight when the noise contamination seems to be the lowest on this day. During the noise test (which took place between 08:45 and 11:30 UT) the diminishment of certain narrowband noises (e.g., at around 30 Hz) can be observed. An intensive, wideband noise (present in both field components) vanished as well around 9:00 UT but it is not clear whether this disappearance had something to do with the noise test because the noise did not appear again after finishing the noise test.

Figure 2 shows a view zoomed in on the test period. The upper limit of the color scale has been modified in this figure to reduce the number of saturated data points. SRs are more clearly visible in the H_{EW} field component during the test period and they faintly appear in the H_{NS} field component as well. However, the noise contamination is still high in both field components. Note that at around 11:30 UT, a narrow stripe with remarkably reduced noise contamination can be seen in the dynamic spectrum of the H_{NS} field component. This time interval seems to coincide with the full shutdown of the observatory's power supply which took place between 11:22 and 11:29 UT. To investigate the ELF noise conditions during this time interval we averaged spectra for 6-min long intervals before (11:16-11:21 UT), during (11:23-11:28 UT) and after (11:30-11:35 UT) the full shutdown (Fig. 3). It is clear that the full shutdown of the observatory's power supply reduced the noise contamination in the H_{NS} field component significantly. However, SRs are still not really visible in the spectrum during this time interval with reduced noise. The remaining noise contamination must come from outside the observatory, probably in connection to the nearby electrified railway line. On the other hand, the noise level in the H_{EW} field component is practically the same in all of the three time intervals which suggest that the internal noise sources in the observatory are direction specific.

We can conclude that even by eliminating all the internal noise sources in the observatory (which is a huge technical challenge that is not solved yet) we cannot obtain clear ELF spectra, therefore a new location is needed for a permanent magnetic ELF station where SRs can be detected in a low ELF noise environment.

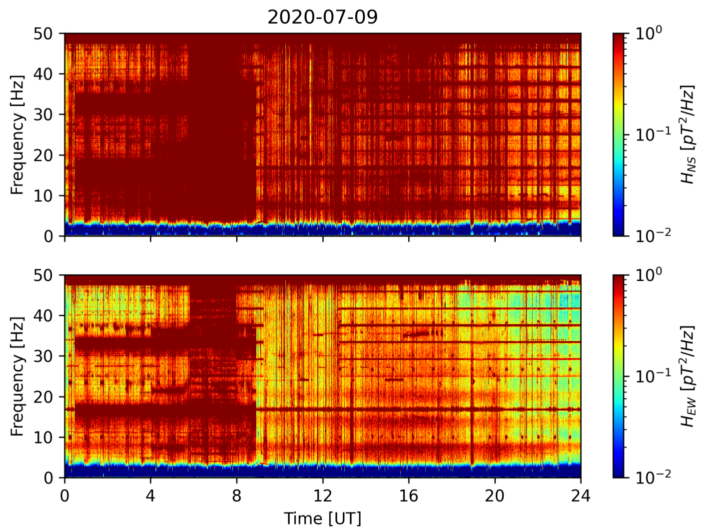

Fig. 1: Dynamic spectra corresponding to the H_{NS} (top panel) and H_{EW} (bottom panel) field components from the day of the noise test which began at 08:45 UT and ended at 11:30 UT.

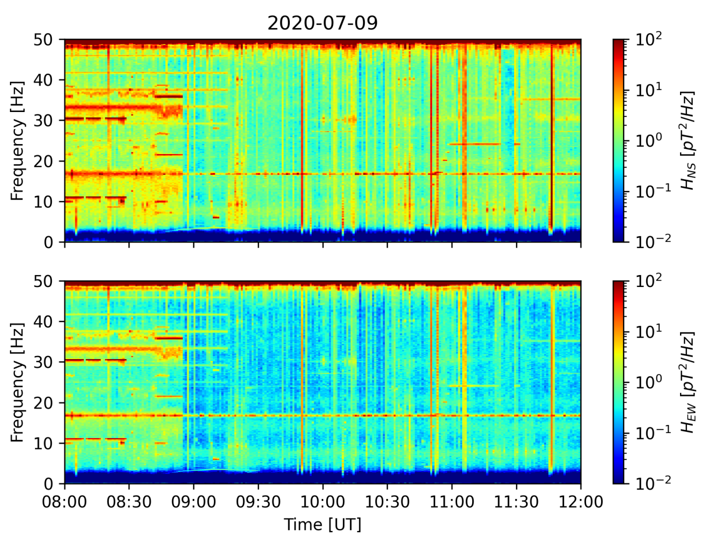

Fig. 2: The same dynamic spectra as in Fig. 1 for the 8:00 - 12:00 UT time period.

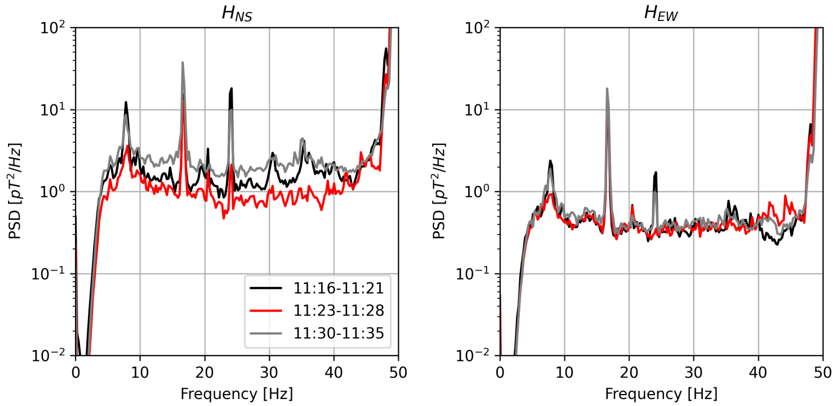

Fig. 3: 6-min average power spectral density (PSD) spectra corresponding to time intervals before (11:16-11:21 UT), during (11:23-11:28 UT) and after (11:30-11:35 UT) the full shutdown of the observatory's power supply on the 9^{th} of July, 2020.

Acknowledgements

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