URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Long-term monitoring of the power line harmonic radiation at 60 Hz at the Ukrainian Antarctic Station

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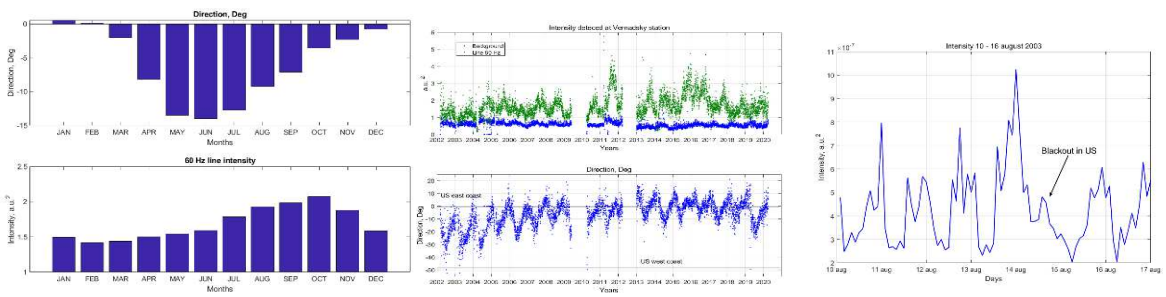
Monitoring of the electromagnetic fields in the ELF waveband has been systematically carried out at the Ukrainian Antarctic Station (UAS) "Akademik Vernadsky" (65.25ºS and 64.25ºW) since 2002. Two orthogonal horizontal components of magnetic field in the frequency range (0.001-80 Hz) are recorded by induction coils oriented along the geographic meridian and parallel. The main natural source of radiation in this frequency range is the radio emission from worldwide thunderstorms. This emission is accumulated in a cavity formed by the ground surface and the lower ionospheric boundary forming the global phenomena called Schumann resonance (SR). Observation of the SR signal makes it possible to study both the thunderstorm activity on the entire planet and the characteristics of the lower ionosphere. The main interference sources in SR frequency range are radiation of local lightning discharges, as well as man-made interference including the power line harmonic radiation (PLHR) of local and global electrical networks with frequencies 50/60 Hz. The best conditions for observations are realized in Antarctica, where there is no local thunderstorm activity and the level of man-made interference is minimal. A local diesel power plant at the UAS generates electricity at a frequency of 50 Hz. Therefore, detection of remote emission at this frequency is impossible. However, it is possible to observe radiation of the North American electrical network, which is the world's most powerful source of emission at a frequency of 60 Hz. The paper presents and discusses the results of monitoring of this emission in Antarctica from 2002 to 2020. Spectral and polarization processing technics were used to calculate and study daily, weekly and interannual variations of the intensity of radiation at 60 Hz and to track the azimuth of the source. The comparison of the characteristics of the PLHR recorded at UAS with the data of the electricity production in the USA power mains is performed. The behavior of the parameters of the signal at a frequency of 60 Hz is compared with the variations of the characteristics of Schumann resonance signal observed at UAS. The weekend effect in the characteristics of the ELF emission observed in the Antarctic is demonstrated and analyzed. A widespread power outage throughout some parts of the United States, and Canada on August 14, 2003 was detected in the Antarctic ELF records. It is assumed that, in the future the emission at a frequency of 60 Hz produced by distant electrical networks might be used as a "probe signal" for diagnostics of the lower ionosphere. Figure 1 demonstrates the behavior of different parameters of PLHR observed in the Antarctic. Fig. 1 a shows averaged over 19 years values of: azimuth of the source for each month of the year (top panel) and signal intensity in relative units (bottom panel). On the top panel of Fig. 1 b the green dots demonstrate daily averaged signal intensity and the blue dots show the behavior of ELF noise level outside of 60 Hz spectral peak. The bottom panel of Fig. 1 b shows the daily mean values of the azimuth of the source, the black horizontal lines correspond to the azimuths of the west and east coasts of the United States. Fig. 1 c depicts the behavior of the signal intensity during a power outage in August 2003.



(a) (b) (c)

Figure 1. Examples of the behavior of PLHR parameters observed in the Antarctic.