32nd URSI GASS, Montreal, 19-26 August 2017

A review of Kannuslehto ELF-VLF observations during wintertime campaign in 2016-2017

Jyrki Manninen* and Tauno Turunen
Sodankylä Geophysical Observatory, FI-99600 Sodankylä, Finland, http://www.sgo.fi

Extended Abstract

Although more than 50 years have passed since the classical work by Helliwell [1], and despite significant successes of many different ground-based and satellite observations, the full nature and behaviour of different VLF waves is still not fully understood. Many naturally occurring VLF waves at higher frequencies (above 4-6 kHz) could not be studied because strong atmospherics (sferics) hide all such waves. To study these waves, we have to apply special digital programs which filter out the strong impulsive sferics.

Our results are based on the VLF observations made in Northern Finland at Kannuslehto, with the geographic coordinates (67.74°N, 26.27°E), and L~ 5.5. Several wintertime VLF campaigns (2006-2017) have been carried out at this remote, low noise field site some 35 km North of the Sodankylä Geophysical Observatory, in the auroral zone. The VLF emissions were recorded digitally in the frequency band of 0.2–39 kHz by two orthogonal magnetic loop antennas oriented in the North-South and East-West directions. The threshold of the receiver sensitivity is about 0.1 fT, (i.e. ~ 10^{-14} nT^2 Hz^{-1}), which equals to 0 dB in our colour bars.

Figure 1 provides an example of a traditional non-filtered 1-hour spectrogram in the frequency range of 0–16 kHz, and same spectrogram after digital sferics filtering. However, it has been quite a surprise also for us to see what new events can be found after suitable filtering.

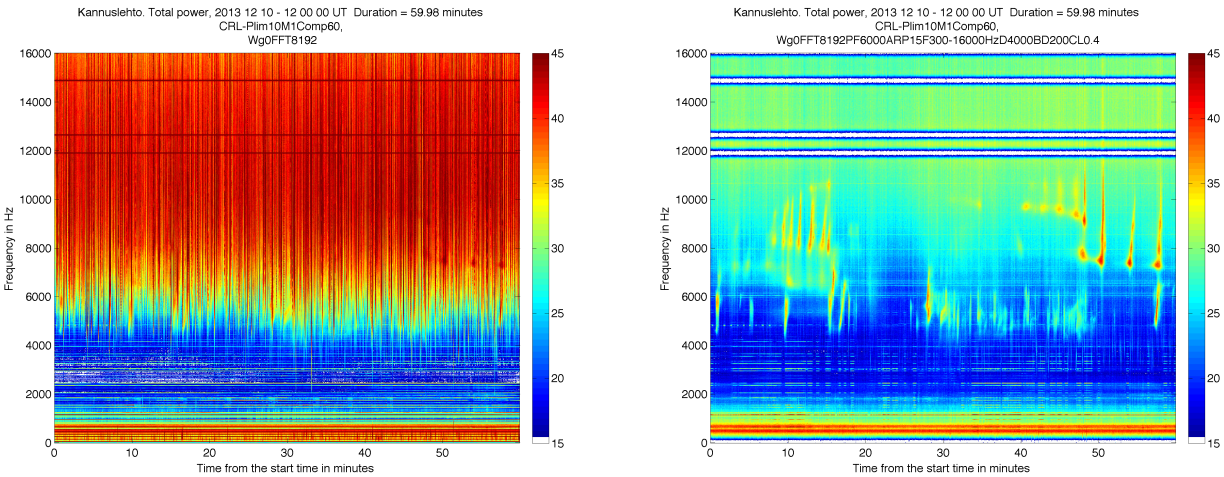

Figure 1. Left panel shows normal one-hour dynamic spectrum (0–16 kHz) without any filtering during data analysis, i.e. 'normal' colour plot. Right panel shows exactly same data, but now after filtering in data analysis. Strong navigation transmitter signals above 11 kHz have also been filtered out. Colour bars are given in dB.

In this presentation, we will show several new events, and most of them could not be observed without sferics filtering. We have discovered many new and unexpected natural electromagnetic emissions of magnetospheric origin at frequencies higher than 4 kHz. Only after filtering these sferics out were the peculiar VLF emissions discovered. Older examples were given by Manninen et al. [2]. These recently revealed emissions (RREs) are probably generated close to the geomagnetic equator yet deep in the magnetosphere, at a considerably lower L-value (L~3.5) than that of the observation site (L~5.5). The details of the mechanism of the generation and propagation of these newly discovered VLF emissions remain unknown.

1. R. A. Helliwell, *Whistlers and related ionospheric phenomena*, 1965 (Stanford: Stanford Univ. Press)

2. J. Manninen, T. Turunen, N. G. Kleimenova, M. J. Rycroft, L. Gromova, and I. Sirviö, "Unusually high frequency natural VLF radio emissions observed during daytime in Northern Finland", *Environmental Research Letters*, **11**, November 2016, 124006, 8 p, doi:10.1088/1748-9326/11/12/124006.