On the connexion between Early VLF signal perturbations and lightning current amplitude.

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The VLF signal perturbations dues to lightning activity were widely studied. It appears as a modification in amplitude and phase of the signal known as Early events. The association between these perturbations and lightning parameters (peak current and polarity) still unclear. We used the LWPC code to determine the electron density increases due to different CG peak current and polarity. It is also possible with the LWPC code to follow the propagation of the perturbation at different distances from the disturbed region. The results showed that the theoretical signal perturbation amplitude and phase where positives at some distances and negatives at others. These explain the different shape of the recorded signal at different receivers' locations. The electron density reached $10^3 cm^{-3}$ at 80 km.

1. Introduction

Early Very Low Frequency (VLF) signal perturbations due to the Transient Luminous Events (TLEs) have been widely studied [1]. Recently, optical observations of TLEs made during EuroSprite campaigns were found to be associated with Early signal perturbations when the Great Circle Paths (GCPs) of the VLF signals crossed the TLE's region [2] and that the perturbation characteristics were a function of the TLE-transmitter distance, TLE-receiver distance and the scattering angle [3]

During the nighttime, the reflexion of the propagating VLF signal happens at the bottom limit of the E region (around 87 km). Therefore, supplementary ionisation of the mesosphere due to TLE formation reduces the reflexion height to lower altitudes. Thus, a perturbation in the VLF signal amplitude and phase is then recorded. The network observation of the TLE-VLF association showed that the recorded perturbations vary from receiver location to other. Effectively, positive (or increasing) perturbation amplitude recorded at Tunis (Tunisia) receiver was negative (or decreasing) signal amplitude recorded at Sebha (Lybia) receiver.

To understand the propagating signal behaviour, a well known Long-Wavelength Propagation Capability (LWPC) code is used. In the region of the occurred TLE, the propagation parameters (h' and β) of the GCP were modified in order to get the perturbation amplitude that the receiver measured. From these parameter, the electron density increases is determined using the Wait formula.

2. Results and discussion:

In September 2, 2009 a large sprite was captured in the Mediterranean Sea as shown in figure 1. From the map in the top of the figure, several paths to Algiers receiver passes near the sprite region. From the VLF data, only NAA and ICV paths showed signal perturbations. Moreover, the DHO-Algiers path crossed the sprite region but only the lightning emission was recorded. Another example concern the signal perturbations recorded on December 12, 2009 in association with the Gigantic Jet (GJ) event. Since the NRK and GQD paths to Tunis and Sebha are in the same line and crossed the GJ disturbed region, a comparative analysis is presented in figure 2. From this figure, some perturbations appeared as an increase in the Tunis data were a decrease in the Sebha one. To understand the signal behaviour, we used the LWPC code to generate the theoretical amplitude that the receiver record with and without the disturbance. The figure 3 shows the perturbed and unperturbed signal amplitude of the NRK transmitter as function of the distance associated with the event recorded on December 12, 2009 at 23:41. From the plot, and as predicted, at shorter distance from the disturbed region the perturbed signal is sometimes higher than the ordinary signal, sometimes lower and some null point where both amplitudes are equals. At longer distance from the disturbed region, the propagation is stable due to the

evanescence of higher modes that were generated at the disturbed region.

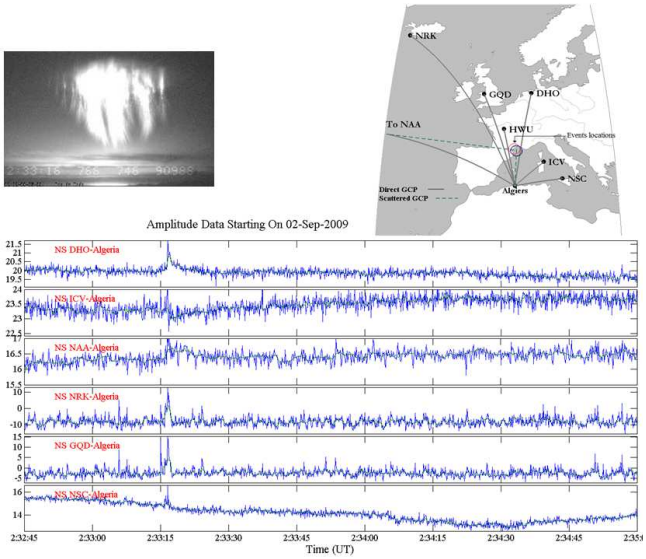


Figure (1): Signal perturbations dues to the sprite

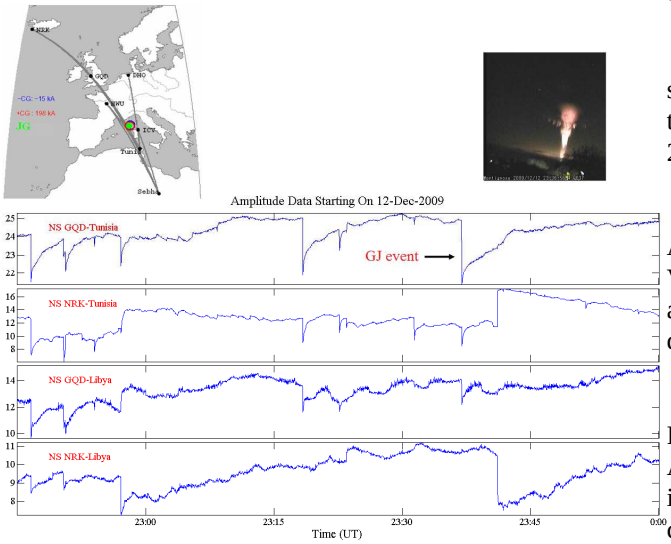
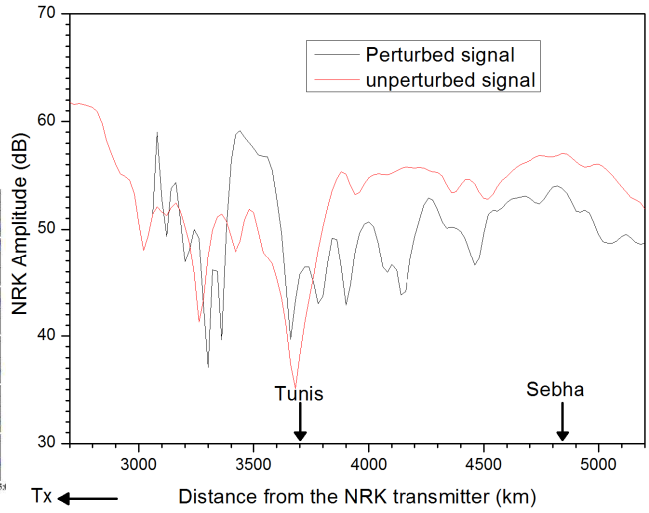


Figure (2): Signal perturbations dues to the GJ.

3. Conclusion:

The results shown above confirm clearly that the Early VLF signal perturbations are strongly dependent on the distance between the disturbed region and both the transmitter and the receivers locations. Effectively, close to the disturbed region several propagating modes are generated and thus the resulting signal is the sum of all of them. At long distances, higher modes are rapidly evanesced and only the fundamental mode is important.



3. References

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