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Sprites as a source of strong ELF/VLF emissions

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Abstract

We report the observation of ELF and VLF signature of sprites recorded on the low altitude satellite DEMETER during thunderstorm activity. At an altitude of ~ 700 km , waves observed on the E-field spectrograms at mid-to-low latitudes during night time are mainly dominated by up-going 0+ whistlers. During the night of July 20, 2007 two sprites have been observed around 20:10:08 UT from the observatory located on the top of the mountain Śnieżka in Poland (50°44' 09" N, 15°44' 21" E 1603 m) and, ELF and VLF data have been recorded by the satellite at about 1200 km from the region of thunderstorm activity. During this event, the DEMETER instruments were switched in the burst mode and it was possible to register the wave forms. It is shown that the two sprites have been triggered by two intense +CG lightning strokes (100 kA) occurring during the same millisecond but not at the same location. Despite the distance DEMETER has recorded at the same time intense and unusual ELF and VLF emissions. It is shown that the whistler wave propagates from the thunderstorm regions in the Earth-ionosphere guide and enters in the ionosphere below the satellite. They last several tens of milliseconds and the intensity of the ELF waveform is close to 1mV/m. A particularly intense proton whistler is also associated with these emissions.

Observations

On the night of July 20/21, 2007 during a strong thunderstorm activity two sets of sprites were recorded from the observatory on the top of the Śnieżka mountain. The first set consisting of two sprites was recorded around 20:10:08 UT, and the second one at 00:18:45 UT. In the following, only the first set of sprites will be considered as the satellite DEMETER was very far at the time of the second event.

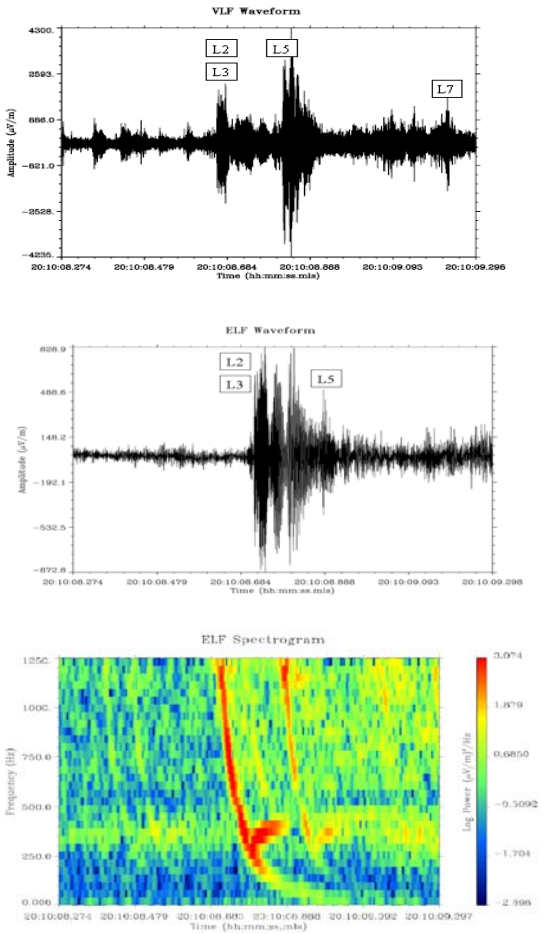

Fig.1 ELF/VLF data from the electric field experiment onboard the DEMETER satellite gathered during the time of the sprite registration: (a) wave form of the VLF signal, horizontal axis - time (UT), vertical axis - value of the electric field in μV/m , (b) wave form of the ELF signal, (c) Spectrogram of the ELF signal shown in (b)

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The registration of the electromagnetic emissions at the time of the observed sprites by DEMETER was done when the satellite was in burst mode with a foot point at about 1200 km. Figure 1 represents these ELF/VLF data recorded by DEMETER during the event between 20:10:08.274 and 20:10:09.298 UT. Figure 3a shows the wave form of the VLF signal whereas Figures 3b displays the same plots for the ELF range Figure 3d presents the corresponding spectrogram of this wave form.. Many whistlers can be observed in Figure 3a but two of them are particularly strong as it can be seen with the waveform. They start at ~ 20:10:08.666 and ~ 20:10:08.817 UT. These two whistlers are also detected in the ELF range (Figures 3c and 3d) with a delay due to the dispersion (20:10:08.703 and 20:10:08.874 UT). They are associated to proton whistlers, the first one being very intense. Looking to the ELF waveform and the intensity of the ELF spectrogram it can be seen that the first whistler is much stronger than the second whereas it is the opposite in the VLF range. The time variation of the waveform of the first whistler (in VLF and in ELF) is not usual as its intensity does not monotonously decrease. In fact the ELF waveform shown in Figure 3b displays four different wave packets. The second is uncommon and the third can be associated with the proton whistler as it can be seen on the spectrogram in Figure 3c.

Conclusions

The observations discussed in this paper are one of the first in situ registrations of the electromagnetic effects of the sprites in the ionosphere. In spite of the quite distant position of the satellite Demeter relative to the events the recorded effects are clearly distinguished and strong. The two sprites observed on ground by the camera installed on the top of the mountain Śnieżka are associated with intense thunderstorm activity. It has been shown that these two sprites can be attributed to two +CG lightning strokes registered by the network EUCLID. These two strokes have large current intensity of the order of 100 kA. But the available information were not enough to estimate the charge moment change although it is important to characterize the parent lightning of sprites. At the same time, Demeter registered very intense emissions in VLF and ELF range (whistlers and proton whistlers). It is shown that these emissions are different from the ones recorded at the time of classical whistlers because they do not monotonously decrease and they last several tens of milliseconds after the occurrence of the parent lightning. Due to this timing, the persistence of wave activity is attributed to the electrostatic discharge in the sprite. This is particularly true for the ELF waves. In the past, it has been shown in [1]; [2] that strong ELF sferic energy could be an indicator of a sprite. [3] have shown that currents associated to sprite exhibit a second peak simultaneous in time with sprite luminosity. They suggest that the ELF radiation is produced by this current. For this event, the ELF wave intensity is close to 1 mV/m and an intense proton whistler is observed.

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Bibliography

The references will be numbered in order of appearance [1] [2] [3]. The reference format is as follows:

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