

Lightning Effect on the Lower Ionosphere deduced from MF Recordings

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Previous studies of direct lightning effect on the ionosphere have been done using VLF signals. These studies shown that the quasi-electrostatic field theory explain most of the observed 'early/fast' VLF perturbations. However, some recent results showed that the EMP, produced by the lightning, could also perturb the VLF propagation. This property is even used to monitor the lower ionosphere.

During the summer 2004, in the frame of the 2004 Eurosprite campaign, the CEA installed in the centre of France a station to measure the vertical electric field with dipole whip antenna. The measurement is not continuous but triggered when the electric field exceeds a threshold of 3 V/m. The data are dated with GPS. The electric field is digitalised in two bands from few kHz to 1 MHz and from 500 kHz to 10 MHz.

Lightning appear on spectrograms of the MF-HF component as a vertical line; furthermore during the night, the numerous radio carriers are horizontal lines. We observe on the spectrograms the fading, and even sometimes the disappearance, of some of the MF radio carriers during several milliseconds a millisecond after lightning. About 4000 cloud to ground lightning, during two months, triggered our system. All these lightning have been associated to lightning localised by Météorage (the French lightning detection network). All the signals have been digitally filtered around several selected carrier signals from 900 to 1600 kHz. For each of lightning detected and each selected carrier frequency, the characteristics of the fading waveform have been measured: attenuation, duration of this attenuation, onset time, time where the signal is at the most attenuated and recovery time.

Using these data, we make statistics and plot the impact map of the fading. Lightning of peak current higher than 60 kA may perturb a zone of a radius larger than 300 km. The shape of the attenuation in function of the distance (from the lightning to the crossing point of the radio carrier path and the ionosphere at 80-90 km) is similar to the shape of the ionisation produced by a lightning by the EMP, in other words with a maximum at 80-90 km of the lightning.

The fading of a radio carrier is mainly a function of the electron density and the collision frequency. The collision frequency is directly related to the electron temperature. Previous studies showed that the electron density recovery time to the level before the lightning is 10-100 s while the electron temperature recovery time is 0.1-1 s. The mean duration of the attenuation being ~5 ms, the observed fading is thus mainly controlled by the collision frequency change.