II. LATEST STUDIES

LIGHTNING INDUCED SCHUMANN RESONANCE TRANSIENTS AND SPRITES

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The results presented here is a contribution to the EUROSPRITE2003 campaign (Neubert et al. 2005) based on the observations of Schumann resonance transients recorded at the Széchenyi István Geophysical Observatory at Nagycenk.

Electromagnetic waves radiated by a lightning discharge in the lowest band of the ELF (Extremely Low Frequency: 3 Hz–3 kHz) range can excite the earth-ionosphere cavity. The resonance frequencies, known as Schumann resonances (SR) (Schumann 1952), are determined by the effective circumference of the earth and the phase speed of electromagnetic waves in the earth-ionosphere waveguide. The fundamental resonant frequency is close to 8 Hz, with higher-order modes spaced at intervals of about 6 Hz. Schumann resonance observations started in the Széchenyi István Geophysical Observatory at Nagycenk in 1993 (Sátori et al. 1996). Energetic lightning discharges excite the cavity, and the pulsed discrete variations, lasting for a fraction of a second, appear as coherent signals in the vertical electric and horizontal magnetic field components superimposed on the background ELF noise.

The energetic and mainly positive cloud-to-ground discharges (+CG) are very often accompanied by transient luminous events (TLEs) occurring between the top of the thunderstorms and the lower ionosphere. One of the TLEs, known as sprite, occupies huge space with vertical extension of 30–60 km and diameter of 5–15 km. Their lifetime is only some tens milliseconds. This was the reason why they were discovered rather late in 1989, apart from anecdotal evidences for many years, and documented in scientific journal in 1990 (Frantz 1990).

The charge moment (CM) change of a discharge is the amount of charge times the distance it has been moved. This parameter has been shown to be more relevant in quantifying the ability of a lightning stroke to generate TLEs than the often measured peak current of a discharge (Huang et al. 1999).

From SR transients, one can estimate the CM change of a flash. SRs were detected during the TLE observation campaign in the frequency band 5–30 Hz

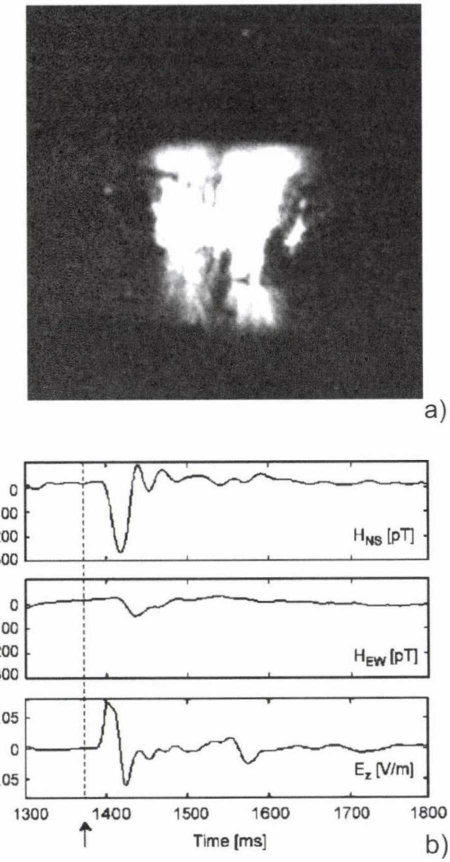

Fig. 1. a) Sprite on August 28, 2003 at 23:11:10.839 UT. b) SR transients recorded in the horizontal magnetic (HNS and HEW) and vertical electric EZ field components at Nagycenk, Hungary. The estimated charge moment change is about 2200 Ckm. The arrow and dashed line mark the time of sprite

at Nagycenk, Hungary. The CM changes associated with the +CGs that were identified for sprite events (a group of TLEs) were calculated by using one of the methods described by Huang et al. (1999), which assumes an exponential decay of the lightning current. Spectra of the SR field components depend on the source-observer distance, which is known from lightning detection networks. The ratio of the observed and theoretical spectra of each SR field component computed for the distance of the causative flash gives the current moment spectrum of the discharge. CM estimation is based on finding that exponential function for which the Fourier transform gives the best approximation of the current moment spectrum (Burke and Jones 1996, Huang et al. 1999). Theoretical spectra are calculated assuming

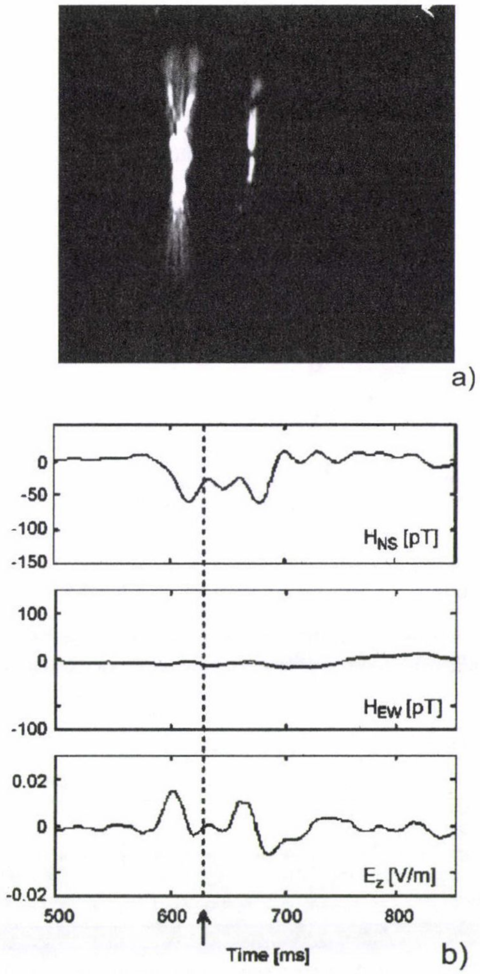

Fig. 2. a) Sprite generated by intracloud (IC) discharges on July 23, 2003 at 21:34:58.160 UT. b) SR transients recorded at Nagycenk, Hungary. Dashed line indicates the time of the sprite. The charge moment change is 800 Ckm computed from the SR transient following the sprite

a vertical dipole discharge approximation (Wait 1962), and EM wave propagation from the source to the observer in the earth-ionosphere waveguide with a perfectly conducting ground and an ionospheric conductivity that is isotropic and given by the mean of three conductivity profiles (Jones 1967). The method has been shown to give good correspondence between measured and observed spectra (Jones and Kemp 1970).

One example of a sprite over South-Eastern France on August 28 at 23:11:10.839 UT, and the SR transient from the causative +CG are shown in Fig. 1. The CM

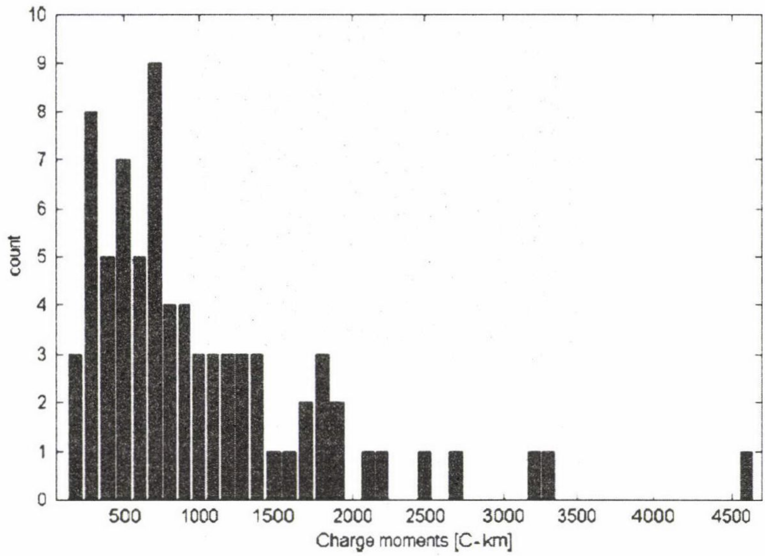

Fig. 3. Histogram of charge moment (CM) changes deduced from 76 Schumann resonance (SR) transients recorded at Nagycenk, Hungary and excited by sprite producing parent strokes

change estimated for this event is 2200 Ckm. Another example of sprite generated by intracloud (IC) discharges on July 23, 2003 at 21:34:58.160 UT and SR transients recorded at Nagycenk, Hungary are presented in Fig. 2. The distribution of CM change estimates is shown in Fig. 3. Out of the 101 TLE events, 76 SRs were suitable to deduce CM changes. The largest value reached is about 4500 Ckm, while the typical values are about 300–700 Ckm.

Acknowledgement

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