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Continuing currents and M-components in sprite-producing positive cloud-to-ground lightning: coordinated optical and electromagnetic observations

Ivana Kolmašová* (1,2), Ondřej Santolík (1,2), Pavel Spurný (3), Jiří Borovička (3), Janusz Mlynarczyk (4), and Martin Popek (1)
(1) Department of Space Physics, Institute of Atmospheric Physics, Czech. Acad. Sci., Prague, Czechia, email: iko@ufa.cas.cz
(2) Faculty of Mathematics and Physics, Charles University, Prague, Czechia
(3) Astronomical Institute, Czech. Acad. Sci., Ondřejov, Czechia
(4) AGH University of Science and Technology, Department of Electronics, Krakow, Poland

A charge transfers from cloud to ground in lightning flashes is carried out by three different mechanisms: lightning return strokes, continuing currents and M-components. The continuing current represents a sustained mode of charge transfer, typically lasting tens of milliseconds. The M-component manifests as an increased luminosity in the channel while the continuing current occurs. The amount of charge transferred to the ground from the cloud's altitude is reflected in the charge moment change value, a critical factor influencing the conditions for the initiation of sprites.

We selected several sprite events captured by a low-light camera installed in Nýdek, Czechia. We studied details of luminosity curves for their causative positive lightning strokes recorded by an array of high-speed photometers deployed at 14 places in Czechia in the frame of the European fireball network. All selected events were simultaneously detected by several photometer stations. Our findings indicate that all luminosity curves associated with lightning strokes generating sprites exhibit distinct signatures of the continuing current. Sometimes, we can also clearly identify the luminosity enhancements related to the M-components. We combine the local optical measurements with the remote electromagnetic recordings in the ELF (Hylaty station, Poland) and VLF (Rustrel, France) bands. We found that the optical wave shapes of the continuing current vary significantly from one event to another. Additionally, we observed a strong resemblance between the luminosity and current moment curves obtained from ELF magnetic field measurements for all the events we analyzed. By combining luminosity data from multiple photometers with the current moment curves, we aimed to contribute to the discussion regarding the relationship between the luminosity and the current moment waveforms at various stages of the return stroke.