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Electromagnetic remote sensing unveils the relationship between sprite current and optical morphology

C. L. da Silva(1), L. Contreras-Vidal(1), R. Sonnenfeld(1),
H. Stenbaek-Nielsen(2), J. Harley(3), M. McHarg(3), R. Haaland(4)
(1) Department of Physics and Langmuir Laboratory, New Mexico Tech, Socorro, NM, USA
(2) University of Alaska Fairbanks, Geophysical Institute, Fairbanks, AK, USA
(3) Department of Physics, U.S. Air Force Academy, Colorado Springs, CO, USA
(4) Augsburg University, Minneapolis, MN, USA

On June 2nd and 3rd, 2019, 63 sprites were captured from Langmuir Laboratory in central New Mexico (34.06° N, 106.90° W, 3.3 km altitude). The two storms investigated were located in northwest Texas, 400 to 800 km away from the observation site. Optical recordings were made with a Phantom V2010 camera operating at up to 100,000 frames per second (fps), and with a Watec camera operating at 30 fps. Electromagnetic remote sensing of lightning and sprite electric fields was performed with a sensitive slow antenna (LEFA) [1, 2]. Data from the Earth Networks Total Lightning Network (ENTLN) were used to locate the sprite parent flashes. The combined information of these three data sets reveals that a staggering fraction of more than half of the sprites observed have a distinguishable electromagnetic signature attributed to currents flowing within the sprite body [3, 4]. Furthermore, these sprite current signatures were unusually large in comparison to previous reports. The sprite electric field changes have roughly half the amplitude of their parent lightning flash's, corresponding to sprite peak currents of 26–58 kA on average. The largest sprites have current moments of up to 2,700 kA km, as inferred from a computationally-efficient method to solve Maxwell's equations. Detailed comparison between the sprites' electromagnetic signatures and high-speed optical recordings show that optically-large sprites containing upward streamers (carrots and jellyfish [5]) tend to have larger electrical currents than the ones displaying only downward streamer development (column sprites). Finally, a clear increasing trend in peak current moment is evident with increasing morphological complexity, from columns to carrots to jellyfish sprites. The findings have been submitted for publication in the Journal of Geophysical Research – Space Physics [6].

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