# The Relationship of Sprite Streamer Propagation Velocities and Lightning-Generated Mesospheric Electric Fields

Jingbo Li*, Steven A. Cummer

Electrical and Computer Engineering Department, Duke University, Durham, North Carolina, USA

Measurements of streamer velocity reflect the detailed internal microphysics of sprite development. However, the small temporal scale (in a few ms) of streamer development requires high time resolution imaging. In this work, we report intensified high speed video observations of streamer development acquired at 5,000 to 10,000 frames per second that include the entire altitude range of the sprite. This time resolution made it possible to examine the fine structure and the temporal development for sprite streamers through their entire vertical extent. In our observations, downward streamers initiate at about 70 - 80 km altitude and propagate vertically to a termination altitude of 45 km or above. They usually develop in an acceleration-deceleration process with a maximum velocity less than 1/10 of the speed of light and a maximum acceleration/deceleration rate in the order of $10^{10}$ m/s$^2$. Upward streamers travel a much shorter distance in either an acceleration-deceleration or a simply deceleration process. The maximum velocity and acceleration/deceleration rate are in the same order as downward streamers but contain a significant horizontal component. We also extracted the sprite-producing lightning source current moment from remote measured magnetic field. By applying this lightning source current moment to a 2-D FDTD model, we are able to simulate the ambient background electric field during the entire process of streamer development. Both the observations and the simulation results indicate the dependence of streamer velocity and termination altitude on electric fields. Quantifying these relationships is a first step towards constraining detailed physical and chemical models that can predict the impact of sprites on the mesosphere.