SPRITE CURRENT CHARACTERISTICS AND ANALYSIS

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ABSTRACT

We have systematically analyzed a large number of sprite producing lightning discharges in the summer of 2000 using continuous extremely low frequency (ELF) magnetic field recordings at Duke University during the STEPS campaign. We address in this work the 10% of these sprites that contain clear sprite current pulses (short ELF pulses that are temporally linked to the sprite and therefore originate in high altitude currents) in an effort to understand the origin of sprite currents and to use them as a remote sensing tool of the conditions and processes inside this special class of sprites.

INTRODUCTION

During the summer of 2000, continuous extremely low frequency (ELF) magnetic field recordings at Duke University during the STEPS (Severe Thunderstorm Electrification and Precipitation Study) campaign. The transient ELF signals radiated by lightning provide valuable information about the characteristics of lightning that produce sprites. In this work, we concentrate on the small subset of sprites that contain sprite current. This high altitude electric current is manifested in short ELF pulses that are temporally linked to the sprite.

We find that clear sprite current pulses occurred in only approximately 10% of sprites over the entire two month data period. This rate varies significantly from day to day, however, with some days approaching 50% and other (in fact, most) days containing no sprite current pulses. This variability could originate either in the forcing from lightning below or in the mesospheric and ionospheric conditions at sprite altitudes. We closely examine the characteristics of lightning that does and does not generate sprite currents and find that forcing from below alone does not appear responsible for this difference. In other words, similar lightning discharges generate sprites both with and without sprite current. We have also jointly analyzed video sprite images and sprite currents from the summer of 2000 and earlier years and find that sprites with and without sprite current have similar morphology. It thus appears that there is no visible process that is uniquely linked to sprite currents.

Sprite currents are the only known non-optical radiation from sprites themselves and thus are a unique window into the internal processes of mesospheric electrical breakdown. Sprite current is driven by lightning-generated mesospheric electric fields in regions of breakdown-enhanced electrical conductivity [Pasko et al., GRL, 18, 3493, 1998] and therefore contains information about the bulk conductivity in the sprite and the magnitude of the high altitude electric field. This field is also closely linked to lightning charge moment change in the thunderstorm below, which can be independently measured from the lightning ELF radiation. We use a combination of numerical simulations and data to investigate the quantitative characteristics of sprite current to determine experimental bounds on the processes that occur in the sprite.

Lastly, the evidence that these secondary pulses originate in sprite and not lightning currents is overwhelming but still indirect. We propose a ground-based measurement that could unambiguously demonstrate that the source current for these pulses flows at high altitudes.