Recent Rocket-and-Wire Triggered Lightning Experiments at Camp Blanding: dE/dt and X-ray Time-of-Arrival Measurements of the Propagation Mechanisms and Ground Attachment Processes of Dart-Stepped Leaders

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Rocket-and-wire triggered lightning operations were conducted at the International Center for Lightning Research and Testing (ICLRT) at Camp Blanding, Florida during the summers of 2011 and 2012 to better characterize the triggered lightning discharge process and to study the physics and mechanisms of leader propagation and ground attachment. During the data collection period, a total of 93 triggering rockets were launched, resulting in 42 triggered lightning events containing, at minimum, a full initial stage (IS) process. Of these 42 events, 31 included at least one subsequent return stroke. A total of 148 negative-polarity return strokes were recorded, 27 (18 %) of which were preceded by leaders of the dart-stepped classification. The observed leader stepping mechanisms and ground attachment processes of dart-stepped leaders preceding triggered lightning strokes serve as reasonable proxies for the similar processes that occur in association with negative-polarity natural lightning return strokes. Properties of triggered lightning dart-stepped leaders measured at the ICLRT include the radiated electric and magnetic fields and their derivatives (dE/dt and dB/dt), energetic radiation (x-rays and gamma rays), electrical current at the lightning channel-base, and high-speed photographic measurements at a rate of 300,000 frames/s. A small-area network of dE/dt and energetic radiation sensors (plastic and $LaBr_3$) oriented about the rocket launching facility form a 10-station time-of-arrival (TOA) system capable of locating radiated sources of both classifications in three dimensions with meter-level accuracy and timing resolution of 4-10 ns. In this study, correlated dE/dt and x-ray TOA measurements of triggered lightning dart-stepped leader steps within 750 m of the ground are presented. The spatial and temporal relationships of the two classes of sources are examined for individual leader steps, and when applicable, correlated with high-speed video observations. In addition, inferences are made on the sequence of electrical breakdowns that occurs during the attachment process to ground based on simultaneous dE/dt and channel-base current measurements. Constraints are calculated for the junction altitude of the downward and the upward connecting leaders, and the lengths, speeds, and durations of the upward connecting leader are quantified.