

**Close Observations of an "Upward Illumination"-Type Return Stroke Recorded by a New
Lightning Measurement System at Kennedy Space Center**
Lightning Physics

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Abstract:

A new, six station lightning location and 3D mapping network was recently deployed at the Kennedy Space Center (KSC) in Florida. The stations are each equipped with wideband (~1 GHz, -3 dB) electric field time derivative (dE/dt) and narrow-band (175 MHz center frequency, 10 MHz bandwidth) VHF measurements. The sensor baselines are about 11 km and 8 km in the north-south and east-west directions, respectively. Three mobile stations were also deployed on enclosed, air-conditioned cargo trailers. The trailers each house a Phantom high-speed video camera and a directional optical-triggering sensor. The trailers are used to monitor lightning activity around launch pads at both the Kennedy Space Center and Cape Canaveral Air Force Station. Data obtained from the newly deployed network supports the compact network of electric and magnetic field time derivative sensors and high-speed cameras installed at Launch Complex 39B [e.g., *Mata et al.*, 2012].

During a 90 minute period spanning the evening of October 21 and early morning of October 22, 2013, the Cloud-to-Ground Lightning Surveillance System (CGLSS) reported about 100 lightning events located within 5 nm of Launch Complex 41 (Atlas V). At the time, two of the new mobile stations were positioned to monitor the immediate LC41 area. At 00:04:04.337 (UTC), the primary stepped leader channel of a negative cloud-to-ground flash terminated to the ocean about 2 km north of LC41. About 850 μ s later, a secondary ground termination occurred 1.7 km northwest of LC41. The secondary stroke was of the "upward illumination (UI)"-type return stroke documented by *Stolzenburg et al.* [2013], also at KSC, in which one branch of the downward propagating stepped leader channel becomes cut-off from the primary leader channel, but continues to propagate to ground, initiating a weak return stroke (CGLSS reported a peak current of -7 kA). In this paper, source locations associated with leader tip breakdown during the full duration of the flash are mapped in 3D via the time-of-arrival (TOA) technique with particular emphasis on the time period preceding the UI-type stroke. The geometry of the TOA source locations are correlated with high-speed video observations of the flash.

References:

Mata, C.T. Mata, A. G., "Summary of 2011 direct and nearby lightning strikes to Launch Complex 39B, Kennedy Space Center, Florida," *Lightning Protection (ICLP), 2012 International Conference*, vol., no., pp.1,9, 2-7 Sept. 2012.

Stolzenburg, M., T. C. Marshall, S. Karunarathne, N. Karunarathna, T. A. Warner, and R. E. Orville (2013), Competing and cutoff leaders before "upward illumination"-type lightning ground strokes, *J. Geophys. Res. Atmos.*, 118, 7182–7198.