



## Do All Lightning Flashes Have Initial Breakdown Pulses?

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The initial breakdown (IB) stage of lightning flashes typically occurs in the first 5-15 ms of a flash. The IB stage is characterized in electric field change (E-change) records by a sequence of pulses (called “classic” IB pulses), each with relatively large amplitude and duration of tens of microseconds. Nag and Rakov [JGR, 2008] investigated the IB stage of cloud to ground (CG) lightning flashes in Florida thunderstorms and found that only 18% of CG flashes had classic IB pulses. Nag and Rakov [GRL, 2009] hypothesized that CG flashes without classic IB pulses initiated in thunderstorms with a weak or non-existent lower positive cloud charge. In this presentation we show the results of studying E-change data of 127 negative CG flashes and 90 intracloud (IC) flashes recorded at the Kennedy Space Center in Florida in the summers of 2010 and 2011. In 2011 we deployed 10 E-change sensors spread across an area of 70 km x 100 km; in 2010 5 E-change sensors were deployed over a smaller area. The bandwidth of the E-change sensors was 0.16 Hz – 2.6 MHz; the data were digitized at 12 bits with a sampling rate of 1, 5, or 10 MHz and a typical record length of 500 ms, including 150 ms of pre-trigger data. The analysis focuses on flashes that occurred within 30 km of at least one sensor. We find that all 127 CG flashes and all 90 IC flashes began with classic IB pulses, though the amplitude of these pulses varies significantly from flash to flash. For flashes with weak IB pulses, the more distant sensors did not always detect the IB pulses seen by closer sensors.