Production of very high potential in intra-cloud lightning in connection with terrestrial gamma ray flashes

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Terrestrial gamma-ray flashes (TGFs) are high energy photon bursts originating from the Earth's atmosphere caused by the brehmsstrahlung emission from energetic electrons. These bursts are observed by space-born detectors in low Earth orbit [e.g., *Fishman et al.*, Science, 264, 1313, 1994]. TGFs have been correlated with the development stage of high altitude positive intra-cloud (+IC) flashes (the negative leader propagates up toward the positive charge region, while the positive leader propagates down to the negative charge region) [*Williams et al.*, JGR, 111, D16209, 2006; *Stanley et al.*, GRL, 33, L06803, 2006]. Bidirectional leaders that initiate IC discharges, develop electric potential differences in the vicinity of their heads with respect to the ambient potential distributions created by the thundercloud charges, that are of essential importance for generation of TGFs [*Celestin and Pasko*, JGR, 116, A03315, 2011].

In the present work, using electrostatic calculations and a 3-D cartesian fractal model, we quantify the electric potential produced in a developing +IC network for given thunderstorm electric configurations, and we determine the electric potential difference between the lightning leader and the ambient large-scale thunderstorm potential in the region of the leader head. We present a case of a +IC lightning network in a thunderstorm configuration that leads to a very high ($\sim$300 MV) potential difference between the leader head and the ambient potential, and we show how a delay in the development of the negative leader can facilitate a high potential difference in the negative leader head region. The impact of these results on the production of TGFs is discussed.