Numerical modeling of the formation of the screening charge near the thundercloud boundaries and its impact on the initiation and early stages of development of blue jets

Jeremy A. Riousset*[1], Victor P. Pasko[1], Paul R. Krehbiel[2], William Rison[3], Ronald J. Thomas[3], and Mark A. Stanley[4]

[1] Department of Electrical Engineering, Communications and Space Sciences Laboratory (CSSL), The Pennsylvania State University, 211B Electrical Engineering East, University Park, PA 16802, USA. (riousset@psu.edu; vpasko@psu.edu)

[2] Physics Department, New Mexico Institute of Mining and Technology, Socorro, NM 87801, USA.

[3] Electrical Engineering Department, New Mexico Institute of Mining and Technology, Socorro, NM 87801, USA.

[4] 114 Mesa Verde Road, Jemez Springs, NM, 87025, USA.

Classical, normally electrified thunderstorms have a dominant negative charge region adjacent to a comparable upper positive charge region above, and a smaller lower positive charge region beneath [e.g., *Williams*, JGR, 94(D11), 13151, 1989]. The storm charges and electric fields build up with time as a result of precipitation driven charging currents [e.g., *Williams*, 1989], until a breakdown threshold is reached. At this point, bidirectional discharges occur, producing different lightning types depending on where the triggering occurs first [*Krehbiel et al.*, Nature Geoscience, 1(4), 233, 2008]. In this work, we introduce a new 2-D axisymmetric model of Maxwellian relaxation of the atmosphere accounting for time dependent conduction currents and screening charges formed under the influence of the thundercloud charge sources. This model is used in conjunction with *Riousset et al.*'s [JGR, 112, D15203, 2007] model of lightning discharge to demonstrate how realistic cloud dynamics leads to the development of blue jets. Particular attention is given to the numerical modeling of the screening charges near the thundercloud boundaries. Lightning discharges reduce the net charges within the charge regions. These rearrangements of charge provoke the formation of so-called *Greifinger and Greifinger*'s [JGR, 81(13), 2237, 1976] boundaries, which represent charges dynamically formed in the conducting atmosphere due to time variation of thundercloud source charges. Fast charge rearrangements in the troposphere due to any discharge result in downward moving boundaries while slow charge rearrangements due to charge build up in the thunderstorm lead to the formation of a screening charge usually accumulating at the upper boundary of the thundercloud [e.g., *Pasko and George*, JGR, 107(A12), 1458, 2002]. In this paper, we demonstrate how the so-created screening layer enhances the electric field locally between the upper positive charge layer and the screening charge, permitting an initiation of a discharge near the cloud top, but remains insufficient to contain the lightning leader channel within the cloud resulting in the development of upward propagating blue jet events [*Krehbiel et al.*, 2008]. We also show how occurrence of intracloud discharges prior to the jet initiation can sufficiently weaken the central negative and upper positive charge layers to prevent occurrence of an intracloud discharge at the time of jet initiation while a cloud-to-ground discharge developing several seconds before the jet events enhances the excess of positive charge in the cloud by bringing negative charge to the ground.