Current Modeling of High-Altitude Discharges at Los Alamos

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First principles, fully electromagnetic, 2-D simulations of high-altitude discharges are presented. Both conventional and runaway air breakdown are included self-consistently. The details of the discharge process including streamer initiation and evolution and the electrical conditions necessary to drive a high-altitude discharge are discussed. The results of our simulations fall into two categories dictated by the duration of the parent lightning. For fast (< a few ms), high current (> 100 kA) positive lightning, the high altitude discharge in our simulations is dominated by a diffuse air glow driven by conventional breakdown at high altitudes (> 60-70 km) followed by runaway breakdown that initiates at the top of the cloud (~15 km) and develops upward to altitudes exceeding 90 km. For longer duration continuing currents (> a few ms), streamers driven by conventional breakdown develop at high altitudes (~75 km) and evolve downward to lower altitudes (terminating at ~50 km). The streamers are then followed by a runaway discharge that is initiated at the top of the cloud and propagates to high altitudes. One of the important new results from our fully electromagnetic simulations is the development of a strong self-focusing magnetic field around the runaway streamer. This azimuthal field is strong enough to compete with the background geomagnetic field and maintain the focus of the runaway beam. Detailed calculations of the optical emissions and of the optical spectra associated with our simulations are presented. Rough estimates of the NO_x and O_3 concentrations are also summarized.