Modeling the formation of the lightning channel corona sheath

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Extended Abstract

The current-carrying portion of the lightning channel is quite narrow, typically less than 1 cm in diameter. Such a narrow channel cannot carry significant charge density without producing large radial fields that drive charge on the channel outward into a "corona sheath". This sheath of charge surrounding the channel plays a variety of important roles in the overall behavior of lightning. The large effective radius of the corona sheath allows relatively large volumes of charge to be transferred and represents the only real "connection" between the lightning channel and the cloud. The larger effective radius of charge relative to current reduces the propagation speed of currents. The timescale of formation of the corona sheath affects the time structure of preliminary breakdown pulses. Impulsive bursts of activity in or development of the corona sheath are the likely source of the strong electric fields required to produce energetic x-rays. The formation process and structure of the corona sheath also likely play a major role in the channel extension process.

Despite the importance, the behavior and formation of the corona sheath are relatively poorly understood. This presentation describes modeling efforts to treat the corona sheath in a variety of ways. First, we consider fluid models where a continuous function describes the density of charge carried by streamers within the corona sheath, coupled to an electrodynamic model of the lightning channel. Results of such models indicate that the corona sheath formation process is rapid and strongly limits the strength of electric fields, even very near the tip of the lightning channel, though such fields may intensify in a region displaced from the channel tip if the population of streamers grows sufficiently rapidly. Such results have strong implications for models of energetic radiation production by leader channels. Second, we consider particle models, treating discrete streamers within the corona sheath as they grow, develop, and branch. The results of such models, including charge and electric field strength, scale, and spatial structure are given and placed in context of observations of lightning.