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Simulations of electric field at the initiation altitudes of sprites and halos generated by the thundercloud charge structure and lightning channels of causative return strokes

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Sprites and halos are transient luminous events occurring above thunderclouds. They can be observed simultaneously or they can also appear individually. Circumstances leading to initiation of these events are still not completely understood. In order to clarify the role of lightning channels of causative lightning return strokes and the corresponding thundercloud charge structure, we have developed a new model of electric field amplitudes at halo/sprite altitudes. It consists of electrostatic and inductive components of the electromagnetic field generated by the lightning channel in free space at a height of 15 km. Above this altitude we solve Maxwell's equations self-consistently including the nonlinear effects of heating and ionization/attachment of the electrons. At the same time, we investigate the role of a development of the thundercloud charge structure and related induced charges above the thundercloud. We show how these charges lead to the different distributions of the electric field at the initiation heights of the halos and sprites. We adjust free parameters of the model using observations of halos and sprites at the Nydek TLE observatory and using measurements of luminosity curves of the corresponding return strokes measured by an array of fast photometers. The latter measurements are also used to set the boundary conditions of the model.