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Constraints to do realistic modeling of the electric field at the tip of a lightning leader

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Several computer models have been developed to explain the observation of Terrestrial Gamma-ray Flashes (TGFs). The models estimate the electric field ahead of lightning leaders to simulate its effects on electron acceleration and multiplication, which may be the source of TGFs. In this study, we take into account a new set of constraints and the effects of scaling to do more realistic modeling. We determine initial conditions based on in-situ measurements of electric field, vertical extension and the corresponding potential difference in thunderclouds. The observed maximum electric field strength of 50 kV/cm at sea-level, ahead of laboratory leaders, is introduced as an upper value for the leader electric field. The threshold for electron avalanches to develop of 2.86 kV/cm at sea-level, is introduced as the lower value. Scaling the results from in-cloud altitudes to sea-level constrains the maximum length of the leader channel, sea-level equivalent, to approximately 3 km. By implementing these constraints, we find that only 23 % of the potential ahead of the leader tip is available for acceleration and multiplication of electrons. We also show that there is a linear dependence between the available potential and the maximum energy and intensity of TGFs. We show that a minimum of 174 MV potential drop ahead of the leader is required to produce the TGFs observed from space, which means that only the upper range of lightning leaders are candidates. Less energetic TGF may exist, but are less likely to be detected.