Charge balance, electric field and ionospheric potential signatures in time dependent global electric circuit model

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Abstract

We have developed three-dimensional (3-D) time dependent model of the global electric circuit in spherical coordinates. The model solves time dependent continuity equation coupled with Poisson's equation. Implicit time stepping is used to avoid strict dielectric relaxation time step limitation [1,2]. Earth is included inside a computational domain as a highly conductive sphere to allow dynamical evolution of potential distribution on Earth and bottom ionospheric boundary. Model then predicts specific time resolved 3-D signatures of charge, potential, field and current density.

Influence of lightning discharges of different types on ionospheric potential is studied and the results are compared with existing analog model based on electrical circuit calculations [3], showing a good qualitative agreement. The charge is mainly located near Earth and on the Earth surface and the ionospheric potential is of same order as reported in [3]. Quantitative improvement provided by new model formulation will be discussed. We will report time evolution of the ionospheric potential and will demonstrate that peak values are represented more accurately in the new model formulation and that relaxation time is dependent on altitude from which lightning removes charge. To support the understanding of the phenomenon, results are interpreted using a simplified model and approximate analytical formulae.

References

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