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Investigation of the GEC sensitivity to the natural and anthropogenic perturbations of the conductivity and thunderstorm generators

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Over the past few years, the interest in global electric circuit (GEC) modeling has been gradually increasing. This is caused by both permanently increasing power of numerical calculations and the understanding of the fact that many processes in atmospheric electrodynamics are naturally global and must be studied within a global approach. The most notable recent GEC models include a three-dimensional stationary model [1], an axisymmetric non-stationary model [2] and axisymmetric stationary and non-stationary models developed by the authors [3]. The most important directions in which global circuit models are being further advanced include the development and enhancement of conductivity parameterizations, taking into account, in particular, the cosmic ray flux variability, energetic particle precipitations, aerosols, radioactivity and the attachment of ions to hydrometeors in clouds [4-6].

It turns out however that the source current density description of thunderstorm generators, used in almost every contemporary GEC model and corresponding to current-source generators in electrical networks, is an insufficiently accurate simplification, and other types of thunderstorm generators must be introduced in GEC models so as to account for the existing observations. We have proposed a more general approach within which the source current density depends on the electric field intensity; this allows taking into account other charge separation mechanisms, and current-source and voltage-source generators become the two limiting cases of the general situation. We have demonstrated that at least voltage-source generators can be consistently implemented in realistic numerical models of the GEC. The further development of these ideas and their realization in actual models seems one of those directions in which GEC models need to be improved.

Substantial attention in this study is devoted to the analysis of sensitivity of the distribution of fields and currents in the ionosphere to the natural and anthropogenic perturbations of the conductivity and thunderstorm generators.

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