Mathematical simulation of the atmospheric electric field disturbances during periods of high geomagnetic activity

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It follows from the observational data that during geomagnetic storms, variations of the atmospheric electric field occur. Within the framework of a quasi-stationary model of a conductor consisting of the ionosphere and the part of the atmosphere lying below it, ionospheric and atmospheric electric fields are calculated during a strong geomagnetic storm on March 17, 2015 (the Dst index reached 223 nT).

To describe the magnetospheric electric field generator, data from the AMPERE satellite on the global distribution of the field-aligned currents for a sequence of time points in increments of 1 hour on March 16 and 17, 2015 were used. First of all, the position of the interface between the regions of closed and open magnetic field lines was clarified by the distributions of the field-aligned currents. The region 2 current system is located in the area of closed magnetic field lines, the rest currents are on open ones: the region 1 current system is on those magnetic field lines which connected to the tail of the magnetosphere, the currents of the cusps are on those magnetic field lines which connected to the magnetopause. During this storm, the total field-aligned current (flowing in total into the Earth's ionosphere, and equal to it flowing into the magnetosphere), according to AMPERE data, reached 45 MA.

As a result of the numerical solution of stationary equations of the electric current continuity in the ionosphere, the global distributions of the electric potential are obtained for each moment of time. In particular, the potential difference morning-evening through the polar caps reaches 300 kV, and the average during the storm is about 200 kV. A variation of the electric potential in the ionosphere leads to a variation of the electric field throughout the atmosphere, including its surface layer. During a geomagnetic storm lasting about a day, the observatory in which the atmospheric electric field is measured significantly changes its position relative to the direction to the Sun. This leads to the connection of spatial and temporal variations of the electric field, which must be taken into account when assessing the effect of a geomagnetic storm on the atmospheric electric field when comparing measurement data at a particular observatory with geomagnetic activity indices. For the storm on March 17-18, 2015, taking into account the variations of the ionospheric electric field when calculating the atmospheric electric field made it possible to reproduce the main features of the disturbances of the fair-weather electric field observed at the Borok Geophysical Observatory. The simulation results showed that during extremely strong magnetic storms, variations in the atmospheric electric field of the same scale as the fair-weather field itself can be formed in some places on the Earth.