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Calculation of the values of the zonal component of the electric field and the velocity of transfer of the ionospheric plasma due to the electromagnetic drift during strong magnetic storms on October 12, 2021 and November 4, 2021

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It is well known that, under quiet geomagnetic conditions, the contribution of magnetospheric sources to electric fields and currents at middle and low latitudes is small. Under undisturbed conditions, the magnitude of the zonal component of the electric field is several units of mV/m. Plasma transport in the ionosphere caused by these fields plays an insignificant role in contrast to plasma transport due to ambipolar diffusion and neutral (thermospheric) winds. However, during magnetic storms, the penetration of electric fields to the heights of the ionosphere of middle latitudes takes place and, as a consequence, an increase in the plasma velocity is observed due to the electromagnetic drift v_{EB}. In turn, an increase in v_{EB} leads to variations in the neutral wind velocity and, as a consequence, to a change in the parameters of the global thermospheric circulation. Such a change in the dynamic mode of the ionospheric plasma significantly affects the altitude distribution of the ionospheric parameters.

The aim of this work is to estimate the magnitude of the zonal component of the electric field in the ionosphere over Central Europe during strong magnetic storms on October 12 and November 4, 2021, as well as to calculate the velocity of plasma transfer in crossed electric and magnetic fields.

The behavior of the ionospheric parameters was analyzed and the values of the zonal component of the electric field E_y and the velocity of plasma transport due to the electromagnetic drift v_{EB} were estimated during two strong magnetic storms on October 12, 2021 ($Kp_{max} = 6, D_{st} = –64\ nT$) and November 4, 2021 ($Kp_{max} = 7, D_{st} = –115\ nT$).

During the magnetic storm on October 12, 2021, the maximum value of $|E_y|$ was equal to 27 mV/m, and the drift velocity v_{EB} –240 m/s. The magnetic storm was accompanied by a strong negative ionospheric storm. According to the ionosonde st. Pruhonice, Czech Republic (50° N, 14.6° E) during the main phase of the storm, a significant decrease in $NmF2$ density by about 60% was recorded, and the height of $hmF2$ increased by about 40 km compared to the reference day.

The maximum value $|E_y|$ during the magnetic storm on November 4, 2021, it was 29 mV/m, and the plasma transfer velocity v_{EB} reached almost –260 m/s. The magnetic storm on November 4, 2021 was also accompanied by a negative ionospheric storm, during which there was a decrease in the electron density at the maximum of the F2 layer of the ionosphere and a significant rise in the height $hmF2$ – by about 90 km.

The results of a comparative analysis of the experimental data of the st. Pruhonice ionosonde with calculations using the international global model of the ionosphere IRI-2016 and the regional model of the ionosphere CERIM IION, developed at the Institute of Ionosphere, are presented. It is shown that the IRI-2016 model, even with the "F-peak storm model" option, incorrectly reproduces the diurnal variations in both the electron density at the maximum of the F2 layer of the ionosphere and for the height of this maximum $hmF2$ under disturbed conditions. The regional model CERIM IION, designed for calculating the parameters of the ionosphere in quiet conditions, in comparison with the IRI-2016 model, gives a more reliable forecast of variations in the main parameters of the F2 layer.

In general, taking into account the effects of electric fields during magnetic storms makes it possible to refine, analyze and physically interpret variations in the parameters of dynamic processes in the ionospheric plasma.

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