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ESTIMATION OF THE ELECTRIC FIELD ZONAL COMPONENT VALUE AND PARTICLE TRANSFER VELOCITY DUE TO ELECTROMAGNETIC DRIFT IN THE IONOSPHERE DURING MAGNETIC STORM ON SEPTEMBER 25, 2016 OVER KHARKIV

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Background. *Dynamic processes in plasma play a significant role in the formation of the spatial structure of the ionosphere at altitudes above the main ionization maximum. During geomagnetic disturbances, the dynamic mode of the ionospheric plasma noticeably changes, and these changes in the variations in the physical process parameters directly affect the spatial-temporal distribution of the main parameters of the ionosphere. One of the mechanisms affecting the behavior of the dynamic process parameters in the ionosphere is the penetration of electric fields of magnetospheric origin into the mid-latitude ionosphere during magnetic storms. The effects of the electric field, which are practically absent in quiet conditions, during geomagnetic storms lead to an additional transfer of charged particles due to electromagnetic drift. Accounting for these effects in variations in the dynamic process parameters and, as a consequence, in variations in the parameters of the ionosphere, is necessary for a more adequate prediction of the behavior of geospace parameters during geomagnetic disturbances. Development of ionospheric models of the disturbed ionosphere for solving applied problems in the field of radio communication, radio navigation and uninterrupted operation of telecommunication systems for various purposes.*

The aim of this work *is to estimate the magnitude of the zonal component of the electric field in the ionosphere over Kharkiv during a weak magnetic storm on September 25, 2016, as well as to calculate the neutral wind velocity taking into account plasma transport in crossed electric and magnetic fields.*

Materials and methods. *To calculate the parameters of dynamic processes in the ionosphere, the experimental data of the Kharkiv incoherent scatter radar were used.*

Results. *The value of the zonal component of the electric field* E_y *was calculated during a weak magnetic storm on September 25, 2016. The maximum value of* E_y *took place around 23:00 EEST on September 25, 2016 and was equal to 5.9 mV/m. Calculated values of particle transfer velocity due to electromagnetic drift* v_{EB} *during the September 25, 2016 magnetic storm are obtained. Variations in* v_{EB} *correlate with variations in* E_y*, and the maximum velocity was –52 m/s. The calculation results showed that during weak magnetic storms (*$K_p = 4$*) it is necessary to take into account the plasma transfer due to electromagnetic drift. The contribution of the velocity* v_{EB} *to the total velocity of charged particle transfer is significant. The neutral (thermospheric) wind velocity* v_{nx} *is calculated without and taking into account the particle transfer velocity in crossed electric and magnetic fields.*

Conclusions. *As shown by the results of the comparative analysis, taking into account the influence of the electric field made it possible to refine the values of the velocities* v_{nx} *during a magnetic storm, which, in turn, makes it possible to explain the behavior of the main parameters of the F2 layer of the ionosphere under disturbed conditions.*

Keywords: *ionosphere, geomagnetic storm, zonal electric field, dynamic processes, plasma drift.*

1. Introduction

Under quiet heliogeophysical conditions, the contribution of magnetospheric sources to electric fields and currents at middle and low latitudes is small. In studies [1–5], based on theoretical calculations and experimental results, it is shown that the magnitude of the electric field in the ionosphere of middle latitudes in undisturbed conditions is several units of mV/m. In turn, the charged particle transport caused by these fields plays an insignificant role, in contrast to the plasma transport due to ambipolar diffusion and neutral (thermospheric) winds, and its contribution to the total velocity of plasma motion is rather small [2, 3]. However, the situation changes dramatically during strong geomagnetic disturbances. During magnetic storms, electric fields penetrate to the altitudes of the mid-latitude ionosphere and, as a consequence, increases in the plasma transport velocity due to electromagnetic drift. Such a change in the dynamic mode of the ionospheric plasma during periods of the geomagnetic disturbances noticeably affects the spatial distribution of the main parameters of the F2 region of the ionosphere (primarily, in the electron density) [6–12].

The aim of this work is to estimate the magnitude of the zonal component of the electric field in the ionosphere over Kharkiv during a weak magnetic storm on September 25, 2016, as well as to calculate the velocity of the neutral wind taking into account the transfer of plasma in crossed electric and magnetic fields.

2. The observation means

For modeling of the neutral wind parameter variations were used the Kharkiv incoherent scatter radar (ISR) (geographic coordinates: 49.6º N, 36.3º E; geomagnetic coordinates: 45.7º, 117.8º) data. At present time the Kharkiv ISR is the only reliable and most informative data source of the geospace plasma state at the mid-latitudes of Central Europe.

Radar allows measuring with high accuracy (usually error is 1 – 10%) and acceptable altitude resolution (10 – 100 km) the following ionospheric parameters: electron density N, electron T_e and ion T_i temperatures, a vertical component of the plasma drift velocity v_z, and ion composition. The investigated altitude range is 100 – 1500 km.

3. Space weather condition

In fig. 1 shows the variations in the parameters of the solar wind (SW) and interplanetary magnetic field (IMF) during a weak magnetic storm on September 25 and the reference day on September 23. Weak magnetic storm (MS) began on September 24, 2016 at 17:11 UT (20:11 EEST). The transition to the active phase of the magnetic storm began with a change in the sign of the IMF component B_z and its rotation to the south.

Solar wind (SW) parameters during the period under consideration were not extreme. The SW speed on September 23 decreased from 440 km/s to 380 km/s. Over the next day of September 24, the speed v_{sw} varied in the range of 360–380 km/s. On the disturbed day of September 25, an increase in the solar wind speed was observed from 360 to 410 km/s. Density of the SW particles N_{sw} on September 23–24 did not change much. On the control day of September 23, the value N_{sw} changed in the range $(3.6 – 6.6)\cdot 10^6$ m^{-3}. After the MS began, the charged particle density of the SW increased, and in the main phase of the storm, the maximum value of N_{sw} was $21.5\cdot 10^6$ m^{-3}.

The solar wind pressure P_{sw} did not change much during the quiet day of September 23 and until the beginning of the MS on September 24.

After the beginning of the storm, the SW pressure began to increase from 2 to 3.3 nPa and reached its maximum values in the MS main phase to approximately 5 nPa.

The value of the interplanetary magnetic field (IMF) B_z-component was –7.6 nT. The K_p index of geomagnetic activity during the MS main phase reached magnitude 4 and $D_{st\max}$= –32 nT. The auroral activity index $AE_{\max}$ ≈ 645 nT.

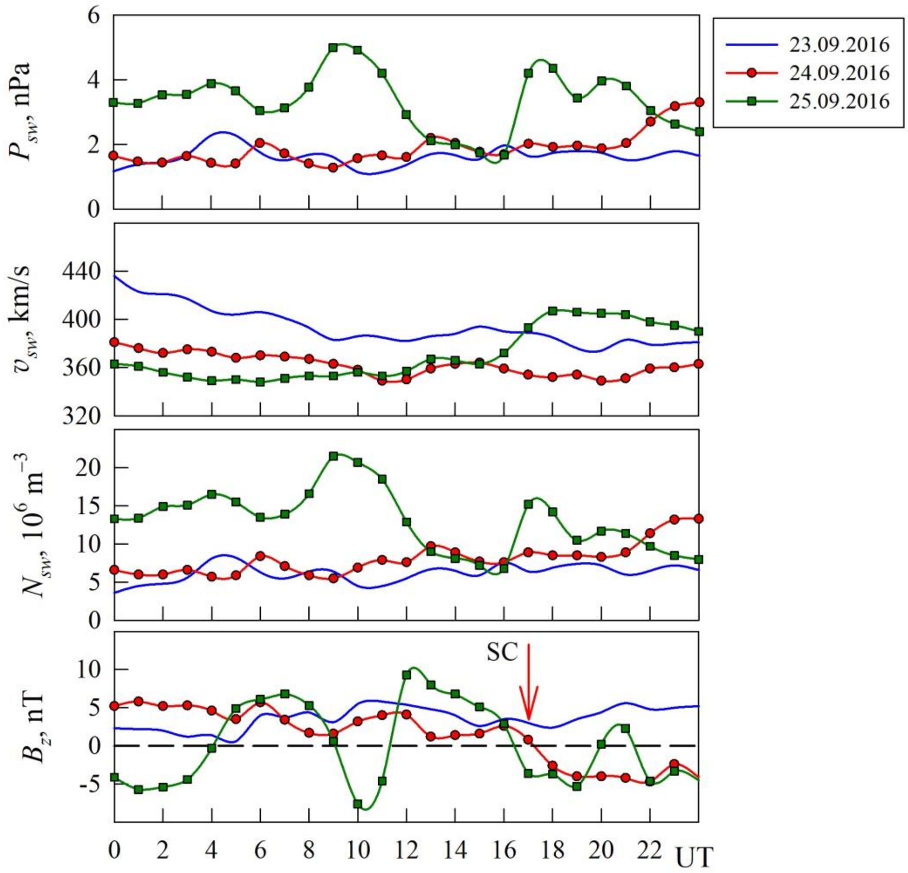

Fig. 1. Space weather condition parameters during magnetic storm September 25, 2016 and reference days on September 23–24, 2016

4. Theoretical relations for calculating the zonal component of the electric field and dynamic process parameters in the ionosphere

As noted above, during geomagnetic storms in the mid-latitude ionosphere, electric fields are enhanced due to magnetospheric convection, which significantly affects the dynamic mode of the ionospheric plasma. Taking into account the fact that in middle latitudes the influence of the declination of the geomagnetic field can be neglected, the main contribution to the vertical motion of the ionospheric plasma is made by the transport caused by the zonal electric field [1, 13]. In this case, the electric field directed to the east causes the upward transport of charged particles, and the field directed to the west causes the downward plasma drift. To calculate the vertical component of the plasma transport velocity due to electromagnetic drift v_{EB}, it is necessary to estimate the magnitude of the zonal component of the electric field E_y.

To calculate E_y we use the following expression [14]:

$$E_y = (0.55 - 0.01AE)\cdot 10^{-3},$$

where *AE* – auroral activity index (in nT). The experimental data of *AE* index were taken from the World Data Center Kyoto (http://wdc.kugi.kyoto-u.ac.jp/wdc/Sec3.html). This method for estimating the value of the zonal component E_y is in good agreement with the calculation results obtained by other authors [2, 3, 10–12].

Neglecting declination effects, the expression for calculating the plasma transport velocity due to electromagnetic drift has the form [13]

$$v_{EB} \approx (E_y/B)\cos I, \qquad (1)$$

where B – the geomagnetic field modulus, I – the geomagnetic field inclination. For Kharkiv city $I = 66.5^{\circ}$ and $B = 4.43 \cdot 10^4$ nT at the altitude of 300 km by the IGRF Geomagnetic Field Model [15].

In general, the vertical component of the wind drag velocity arising as a result of charged particle collisions with moving particles of a neutral gas has the form [13]

$$\begin{aligned}(v_{n\|})_z &= v_{nx}\sin I\cos I\cos D - \\ &-v_{ny}\sin I\cos I\sin D + v_{nz}\sin^2 I\end{aligned}, \qquad (2)$$

where v_{nx}, v_{ny} and v_{nz} – meridional, zonal and vertical components of the neutral gas velocity in the Cartesian coordinate system, D – the geomagnetic declination.

Neglecting the effects of declination of the geomagnetic field at mid-latitudes and, taking into account the fact that usually $v_{nx}, v_{ny} \gg v_{nz}$, the expression for the vertical component of the plasma wind drag v_{EB} takes the following form

$$(v_{n\|})_z \approx v_{nx}\sin I\cos I .$$

The total velocity of vertical transfer of charged particles v_z is determined by the velocity of plasma transfer due to ambipolar diffusion v_d, neutral wind velocity v_{nx} and particle velocity due to electromagnetic drift. In this case, the value of the neutral wind velocity v_{nx} can be found using an expression of the form

$$v_{nx} = (v_z - v_d - v_{EB})/(\sin I\cos I),$$

where v_z – the vertical component of the plasma velocity (Kharkiv ISR experimental data), v_d – the vertical component of the plasma transport velocity due to ambipolar diffusion, v_{EB} – the velocity of plasma transport due to electromagnetic drift from (1).

The transfer velocity of particles due to ambipolar diffusion can be calculated using the formula

$$v_d = -D_a\sin^2 I\left(\frac{1}{H_p} + \frac{1}{N}\frac{\partial N}{\partial z} + \frac{1}{T_p}\frac{\partial T_p}{\partial z}\right),$$

where D_a – longitudinal component of ambipolar diffusion tensor, $H_p = kT_p/m_i g$ – the plasma scale height, k – Boltzmann constant, $T_p = T_e + T_i$ – the plasma temperature, T_e and T_i – the electron and ion temperatures (Kharkiv ISR experimental data), m_i – the oxygen ion mass, ν_{in} – the total ion collision frequencies with the major components of the neutral gas, g – the free fall acceleration, N – the electron density (Kharkiv ISR experimental data), z – the altitude.

5. Calculation results and discussion

In fig. 2 shows the results of calculating the zonal component of the electric field E_y and the particle transport velocity due to the electromagnetic drift v_{EB} at the altitude of 300 km above Kharkiv. As can be seen from the figure, variations of the E_y correlate well with variations in the auroral activity index *AE*. An increase in E_y in absolute value starts from the moment of an increase in the *AE* index. Maximum “bursts” of the $|E_y|$ took place at 01:00, 06:00, 14:00 and 23:00 EEST on September 25 with the corresponding values 3.5, 4.6, 4.4 and 5.9 mV/m. The values of the velocity v_{EB} at the considered moments of time were –31, –40, –38 and –52 m/s respectively. In quiet geomagnetic conditions, E_y values are in units of mV/m, and the drift velocity v_{EB} is close to zero.

Calculations have shown that with an increase in the electric field strength under disturbed conditions, there is a noticeable change in the dynamic mode of ionospheric plasma. The contribution of the velocity v_{EB} to the total velocity of plasma transfer becomes significant, and it begins to play an essential role in the formation of the altitudinal structure of the ionosphere during periods of geomagnetic disturbances.

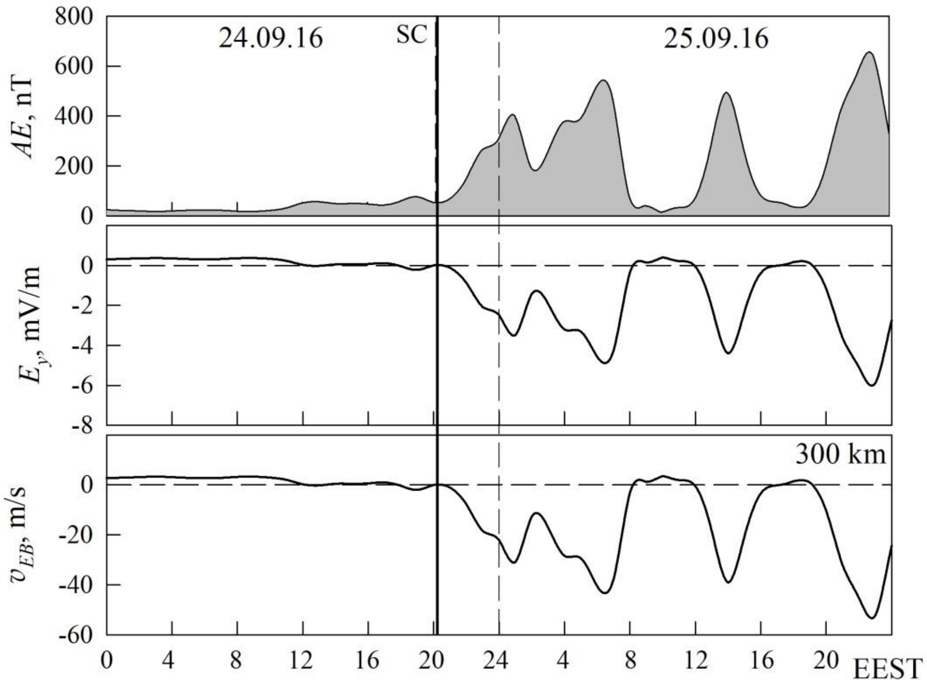

Fig. 2. Temporal variations of the auroral activity index *AE* (http://wdc.kugi.kyoto-u.ac.jp/wdc/Sec3.html), the magnitude of the zonal component of the electric field E_y and the plasma transfer velocity due to electromagnetic drift v_{EB} during a magnetic storm on September 25, 2016 and reference day on September 25, 2016 at the altitude of 300 km

In fig. 3 shows the modeling results of the dynamic process parameters in the ionosphere during a magnetic storm on September 25, 2016 and a reference day on September 24, 2016. The figure shows the temporal variations of the vertical component of the plasma transfer velocity v_z (Kharkiv IS radar data) and the calculated values of the plasma velocity due to ambipolar diffusion v_d, the plasma transfer velocity due to the electromagnetic drift v_{EB}, and the neutral (thermospheric) wind velocity v_{nx}. The neutral wind velocity v_{nx} is represented by two curves. The dashed line shows the temporal variations in v_{nx} without taking into account the electric field effects and the absence of plasma transport in crossed magnetic and electric fields. The solid line shows the change in velocity v_{nx} taking into account the effects of the electric field in the ionosphere during a magnetic storm.

As can be seen from the figure, in the storm main phase there is an increase in the upward plasma motion velocity v_z. At about 08:30 and

15:00 EEST, the total transport velocity v_z was 25 and 10 m/s, respectively. The diffusion component of the plasma velocity v_d in the considered time intervals was small and fluctuated around zero. In comparison with the reference day, during the storm main phase, an insignificant downward transport of the ionospheric plasma was observed. In the interval 14:00–17:00 EEST, the magnitude of the charge particle transport velocity increased noticeably and was equal to about 5–7 m/s, while in the undisturbed period in the considered time interval, v_d was close to zero.

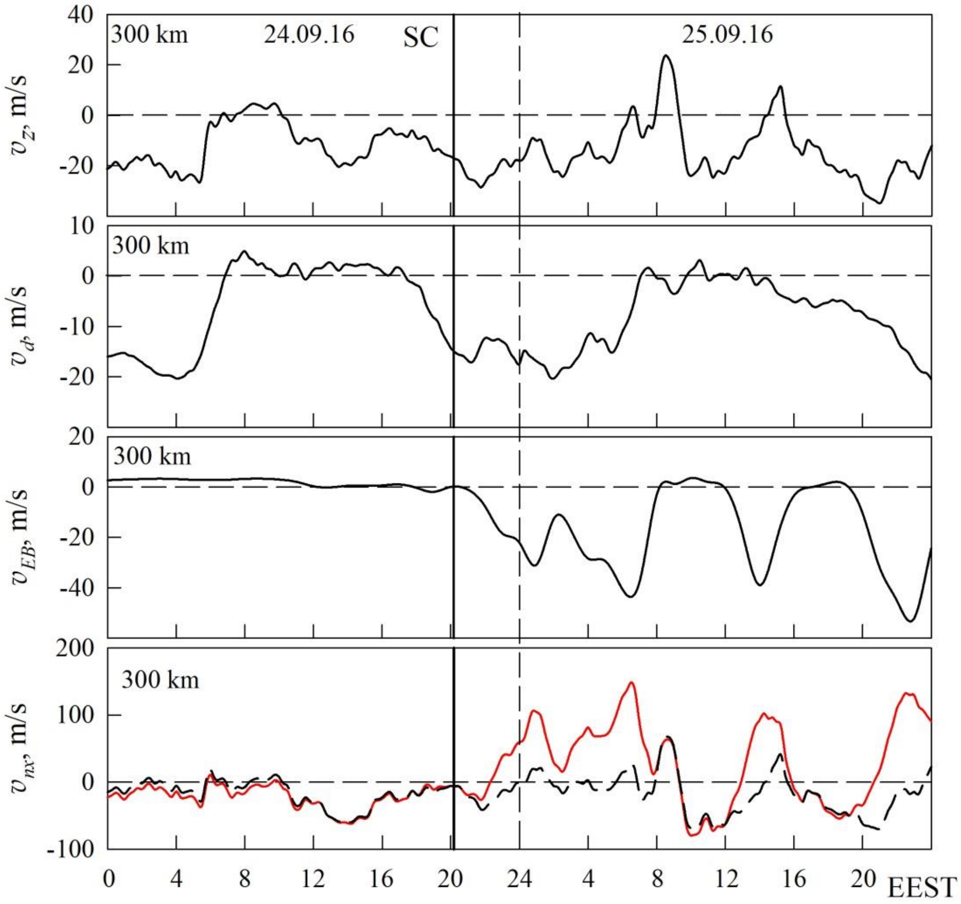

Fig. 3. Temporal variations in the vertical component of the plasma transport velocity v_z (Kharkiv ISR experimental data), the plasma transport velocity due to ambipolar diffusion v_d (calculation), the plasma transport velocity due to electromagnetic drift v_{EB} (calculation) and meridional neutral wind velocity v_{nx} (calculation) during the magnetic storm on September 25, 2016 and reference day on September 26, 2016 at the altitude of 300 km

As can be seen from the figure, taking into account the effects of the electric field during a magnetic storm made it possible to significantly clarify the picture of the behavior of the meridional component of the plasma transport velocity and estimate its contribution to the total plasma transport velocity. In the absence of disturbances on September 24, the neutral wind had a direction from the equator to the pole and the maximum velocity v_{nx} did not exceed –70 m/s. Such variations in v_{nx} are typical for equinox periods and are confirmed by earlier results [13]. Under disturbed conditions, due to

Joule heating of charged particles and increased ion convection in high-latitude regions, a global rearrangement of the thermospheric wind system takes place. As the calculation results performed in this study show, with the penetration of electric fields into middle latitudes and, as a result, the appearance of additional transport of particles due to electromagnetic drift, a change in the direction of the neutral wind and an increase in its velocity are observed. During disturbed periods, the neutral wind is directed from the pole to the equator, which is confirmed by the studies of other authors [9–12]. In our case, in the variations in v_{nx} on September 25, 2016, there were “bursts” that correspond to variations in the zonal component of the electric field E_y and the velocity v_{EB}. The maximum increase in v_{nx} was observed at about 01:00, 06:30, 14:00 and 22:00 EEST and was approximately 104, 148, 93 and 122 m/s, respectively.

It is a well-known fact that plasma transport along magnetic field lines is caused by variations in the meridional component of the velocity of the horizontal motion of a neutral gas. A neutral wind directed from the pole to the equator causes the ionospheric plasma to move upward along the lines of force of the magnetic field, and the wind directed from the equator to the pole causes the downward transport of charged particles [6]. As seen from fig. 3, an increase in the thermospheric wind directed to the equator leads to a decrease in the velocity v_z in absolute value (as compared to the reference day) at the first “burst” of v_{nx} at about 01:00 EEST. Then, after 06:00 EEST, a change in the sign of v_z is observed, which corresponds to a change in the direction of plasma motion along the magnetic field lines. After 10:00 EEST, v_z again changes its sign and the downward plasma transfer takes place. At the next v_{nx} “burst” at about 14:15 EEST, upward particle transport is again observed. It should also be noted that at night hours at the altitudes of the F2 region of the ionosphere, there is a transfer of charged particles from the plasmasphere to the ionosphere. In this case, a neutral wind can either enhance the drift of particles into the ionosphere, or hinder this process.

Let us consider the behavior of the main parameters of the F2 layer of the ionosphere (electron density *Nm*F2 and the height of the maximum *hm*F2) during a magnetic storm on September 25, 2016 and their relationship with variations in the meridional component of the neutral wind velocity (see fig. 4).

With an increase in the wind velocity v_{nx} at 01:00 EEST, an uplift of the F2 layer was observed with a maximum value of *hm*F2 ≈ 337 km at 01:45 EEST, which is about 43 km more than in quiet conditions. The electron density *Nm*F2 decreased insignificantly compared to the reference day and amounted to approximately $2.2 \cdot 10^{11}$ m^{-3}. At the next “burst” of v_{nx} at about 06:30 EEST, *hm*F2 was 258 km, which is about 10 km more than on a quiet day. Although, for a given moment in time, such a sharp increase in the wind did not lead to an increase in the height of the maximum of the F2 region of the ionosphere. The value of the electron density at the maximum of the layer at the considered time moment is *Nm*F2 ≈ $2.28 \cdot 10^{11}$ m^{-3}, while under quiet conditions *Nm*F2 was about 38.7% more. At 09:15 EEST, in the diurnal variation of *hm*F2, an atypical rise in the height of the layer maximum is observed. For this time moment, *hm*F2 was 240 km and this increase in *hm*F2 can be correlated with an increase in the neutral wind velocity to 62 m/s at 08:30 EEST. Under undisturbed conditions *hm*F2 was 209 km. The concentration at the maximum of the F2 layer is approximately equal to $4.15 \cdot 10^{11}$ m^{-3} and in quiet conditions for the considered moment of time *Nm*F2 ≈ $4.7 \cdot 10^{11}$ m^{-3} (about 12% more than during a magnetic storm). For the considered time interval, a negative ionospheric storm took place in the geospace. As can be seen, the electron density at the maximum of the F2 region of the ionosphere was noticeably lower compared to the same period on a quiet day. After 11:00 EEST, the storm phase changed from negative to positive. Subsequent sharp increase in neutral wind velocity (at about 14:00 EEST to values v_{nx} ≈ 93 m/s) caused the rise of the F2 layer to a height *hm*F2 ≈ 257 km (16:00 EEST). In variations of the electron density, an increase in its values was observed up to $6.3 \cdot 10^{11}$ m^{-3} (16:30 EEST), which is about 34% more than in quiet conditions. Further, the electron density *Nm*F2 begins to decrease, and the maximum of the F2 layer was located at an altitude of 257 km until approximately 20:00 EEST. After the increase in the neutral wind velocity at 22:00 EEST to v_{nx} ≈ 122 m/s, *hm*F2 increased to 303 km and *Nm*F2 density decreased to $2.15 \cdot 10^{11}$ m^{-3}. On an undisturbed day at the considered moment of time, the value of *hm*F2 was 384 km, and *Nm*F2 ≈ $3.25 \cdot 10^{11}$ m^{-3}.

In general, it can be concluded that there is a correlation between variations in the neutral wind velocity and the main parameters of the F2 layer of the ionosphere. Thus, in calculating of v_{nx} during magnetic storms (even weak ones), it is necessary to take into account the effects of an electric field of magnetospheric origin and the electromagnetic drift of charged particles caused by it.

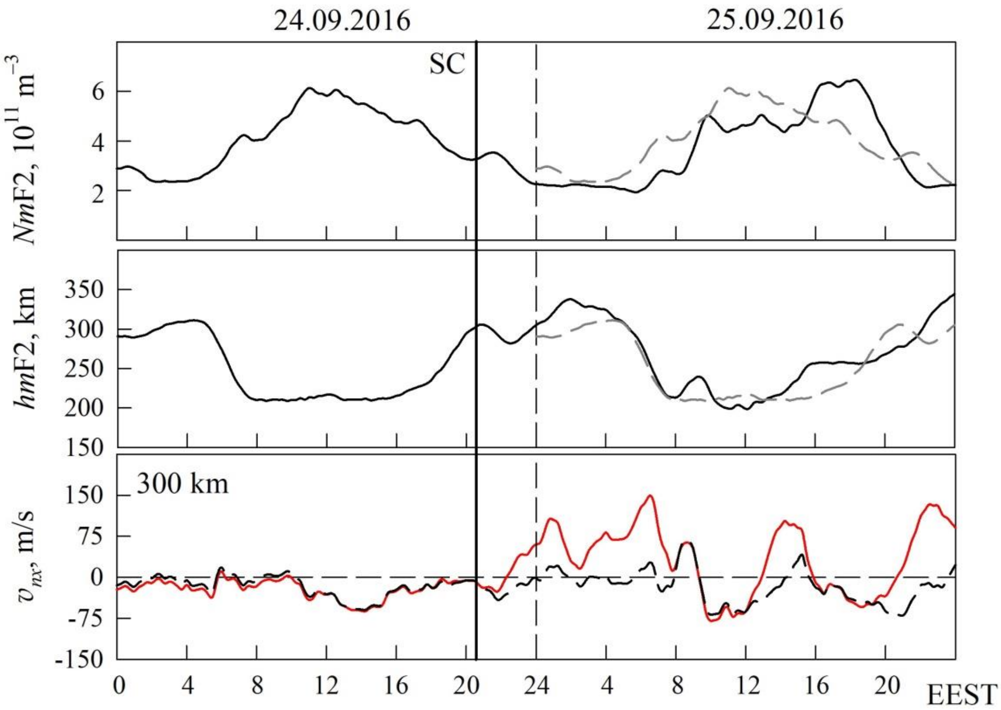

Fig. 4. Temporal variations in the F2 peak electron density *Nm*F2, the F2 peak height *hm*F2 and neutral wind velocity v_{nx} during the magnetic storm on September 25, 2016 and reference day on September 26, 2016 (marked with a dash line on the graphs)

6. Conclusion

1) The value of the zonal component of the electric field E_y during a weak magnetic storm on September 25, 2016 was calculated. The maximum value of E_y took place at about 23:00 EEST on September 25, 2016 and amounted to 5.9 mV/m.

2) Calculated values of particle transfer rate due to electromagnetic drift v_{EB} during a magnetic storm on September 25, 2016 are obtained. Variations in v_{EB} correlate with variations in E_y, and the maximum velocity was –52 m/s. The calculation results showed that during weak magnetic storms (K_p = 4) it is necessary to take into account the plasma transport due to electromagnetic drift. The contribution of the velocity v_{EB} to the total transfer velocity of charged particles is significant.

3) The velocity of the neutral (thermospheric) wind v_{nx} is calculated without and taking into account the particle transfer velocity in crossed electric and magnetic fields. Accounting for the influence of the electric field made it possible to refine the values of the velocities v_{nx} during a magnetic storm and, in turn, to explain the behavior of the main parameters of the ionospheric F2 layer under disturbed conditions.

4) It is shown that during a magnetic storm the dynamic regime of the ionospheric plasma changes significantly.

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Оцінка величини зональної компоненти електричного поля та швидкості переносу частинок за рахунок електромагнітного дрейфу в іоносфері під час магнітної бурі 25 вересня 2016 р. над Харковом

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Актуальність. Динамічні процеси в плазмі грають істотну роль у формуванні просторової структури іоносфери на висотах вище головного максимуму іонізації. Під час геомагнітних збурень динамічний режим іоносферної плазми помітно змінюється та ці зміни в варіаціях параметрів фізичних процесів безпосередньо впливають на просторово-часовий розподіл основних параметрів іоносфери. Одним з механізмів, який впливає на поведінку параметрів динамічних процесів в іоносфері під час магнітних бур, є проникнення електричних полів магнітосферного походження у середньоширотну іоносферу. Ефекти електричного поля, які практично відсутні в спокійних умовах, під час геомагнітних бур призводять до додаткового переносу заряджених частинок за рахунок електромагнітного дрейфу. Урахування цих ефектів у варіаціях параметрів динамічних процесів і, як наслідок, у варіаціях параметрів іоносфери, необхідно для більш адекватного прогнозу поведінки параметрів геокосмосу під час геомагнітних збурень. Розвиток іоносферних моделей збуреної іоносфери необхідний для розв’язання прикладних задач в області радіозв’язку, радіонавігації та безперебійної роботи телекомунікаційних систем різного призначення.

Метою роботи є оцінка величини зональної складової електричного поля в іоносфері над Харковом під час слабкої магнітної бурі 25 вересня 2016 р., а також розрахунок швидкості нейтрального вітру із урахуванням переносу плазми у схрещених електричному та магнітному полях.

Матеріали та методи. Для розрахунку параметрів динамічних процесів в іоносфері використано експериментальні дані харківського радара некогерентного розсіяння.

Результати. Виконано розрахунок величини зональної компоненти електричного поля E_y під час слабкої магнітної бурі 25 вересня 2016 р. Максимальне значення E_y мало місце близько 23:00 EEST 25 вересня 2016 р. і дорівнювало 5.9 мВ/м. Отримано розрахункові значення швидкості перенесення частинок за рахунок електромагнітного дрейфу v_{EB} під час магнітної бурі 25 вересня 2016 р. Варіації v_{EB} корелюють із варіаціями E_y і максимальна швидкість дорівнювала –52 м/с. Результати розрахунків показали, що під час слабких магнітних бур (K_p = 4) необхідно враховувати перенесення плазми за рахунок електромагнітного дрейфу. Внесок швидкості v_{EB} у сумарну швидкість переносу заряджених частинок є суттєвим. Виконано розрахунок швидкості нейтрального (термосферного) вітру v_{nx} без та з урахуванням швидкості перенесу частинок у схрещених електричному та магнітному полях.

Висновки. Результати порівняльного аналізу показали, що врахування впливу електричного поля дозволило уточнити величини швидкостей v_{nx} під час магнітної бурі, що, у свою чергу, дало можливість пояснити поведінку основних параметрів шару F2 іоносфери у збурених умовах.

Ключові слова: іоносфера, геомагнітна буря, зональне електричне поле, динамічні процеси, дрейф плазми.

Оценка величины зональной компоненты электрического поля и скорости переноса частиц за счет электромагнитного дрейфа в ионосфере во время магнитной бури 25 сентября 2016 г. над Харьковом

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Актуальность. Динамические процессы в плазме играют существенную роль в формировании пространственной структуры ионосферы на высотах выше главного максимума ионизации. Во время геомагнитных возмущений динамический режим ионосферной плазмы заметно меняется и эти изменения в вариациях параметров физических процессов непосредственно влияют на пространственно-временное распределение основных параметров ионосферы. Одним из механизмов, влияющим на поведение параметров динамических процессов в ионосфере во время магнитных бурь, является проникновение электрических полей магнитосферного происхождения в среднеширотную ионосферу. Эффекты электрического поля, практически отсутствующие в спокойных условиях, во время геомагнитных бурь приводят к дополнительному переносу заряженных частиц за счет электромагнитного дрейфа. Учет этих эффектов в вариациях параметров динамических процессов и, как следствие, в вариациях параметров ионосферы, необходим для более адекватного прогноза поведения параметров геокосмоса во время геомагнитных возмущений. Развитие ионосферных моделей возмущенной ионосферы для решения прикладных задач в области радиосвязи, радионавигации и бесперебойной работы телекоммуникационных систем различного назначения.

Целью работы является оценка величины зональной составляющей электрического поля в ионосфере над Харьковом во время слабой магнитной бури 25 сентября 2016 г., а также расчет скорости нейтрального ветра с учетом переноса плазмы в скрещенных электрическом и магнитном полях.

Материалы и методы. Для расчета параметров динамических процессов в ионосфере использованы экспериментальные данные харьковского радара некогерентного рассеяния.

Результаты. Выполнен расчет величины зональной компоненты электрического поля E_y во время слабой магнитной бури 25 сентября 2016 г. Максимальное значение E_y имело место около 23:00 EEST 25 сентября 2016 г. и равнялось 5.9 мВ/м. Получены расчетные значения скорости переноса частиц за счет электромагнитного дрейфа v_{EB} во время магнитной бури 25 сентября 2016 г. Вариации v_{EB} коррелируют с вариациями E_y и максимальная скорость равнялась – 52 м/с. Результаты расчетов показали, что во время слабых магнитных бурь (K_p = 4) необходимо учитывать перенос плазмы за счет электромагнитного дрейфа. Вклад в суммарную скорость переноса заряженных частиц скорости v_{EB} является существенным. Выполнен расчет скорости нейтрального (термосферного) ветра v_{nx} без и с учетом скорости переноса частиц в скрещенных электрическом и магнитном полях.

Выводы. Результаты сравнительного анализа показали, что учет влияния электрического поля позволил уточнить величины скоростей v_{nx} во время магнитной бури, что, в свою очередь, дает возможность объяснить поведение основных параметров слоя F2 ионосферы в возмущенных условиях.

Ключевые слова: ионосфера, геомагнитная буря, зональное электрическое поле, динамические процессы, дрейф плазмы.

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