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Spatial features of the ionospheric disturbance caused by a meteorological squall

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The investigation presents the results of modelling studies of the impact of a meteorological squall on 29 May 2017 in the Moscow region on the parameters of the thermosphere and ionosphere.

The modeling utilized two models: the numerical high-resolution regional atmospheric model AtmoSym and the Global Self-Consistent Model of the Thermosphere, Ionosphere, and Protonosphere (GSM TIP). The large-scale model incorporates the influence of acoustic and internal gravity waves originating from the troposphere by introducing an extra heat source derived from numerical simulations conducted at AtmoSym.

The multimodel study showed that wave propagation from the troposphere leads to a noticeable (up to 10%) increase in temperature above the epicentre of the meteorological event. The temperature increase leads to corresponding changes in the thermosphere and ionosphere parameters. Our simulations showed that a dipole-like structure with positive and negative TEC values in the vicinity of the atmospheric waves source is formed in the spatial distribution of the total electron content (TEC) perturbation in the first hours from the onset of the squall. Additionally, the positive TEC disturbance is generated to the southeast of the wave activity source, while the negative TEC perturbation is formed to the northwest of the wave activity source. Additional analysis revealed that the dipole character present in the meridional wind perturbation at the F2 ionosphere region is similar to the TEC perturbation. Furthermore, the direction of the velocity perturbation aligns with the formation mechanism of both positive and negative TEC perturbations.

The study of neutral composition changes showed only a decrease in the n(O)/n(N2) concentration ratio near the squall epicentre, which only enhances the negative TEC perturbation.

As the meteorological source weakens, the dipole structure of perturbations in the meridional wind and TEC starts to deteriorate, taking on a wave-like quality.

The calculated results demonstrate that a quasi-dipole disturbance in Total Electron Content measurements can be observed during intense meteorological events in the troposphere. Such TEC disturbances can serve as indicators of various phenomena that cause the propagation of atmospheric gravity waves (AGWs) from the lower layers of the atmosphere to high altitudes (for example, hurricanes, tsunamis, earthquakes, etc).

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