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Studying the influence of strong meteorological disturbances in the Earth's lower atmosphere on variations of ionospheric parameters in the Asian region of Russia

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Short-period temporal variations of ionospheric parameters were analyzed to study probabilities of manifestation of strong meteorological disturbances in the Earth's lower atmosphere in variations of upper atmosphere parameters in a zone far removed from a disturbance source. In the analysis, we used data on maximum observed frequencies (MOF) of oblique sounding (OS) signals along Norilsk–Irkutsk, Magadan–Irkutsk, and Khabarovsk–Irkutsk paths in East Siberia and the Far East. These data were obtained during solar minimum at equinoxes (March, September) in 2008–2009. Analyzing effects of wave disturbances in ionospheric parameters, we take into account helio-geomagnetic and meteorological conditions in regions under study to do an effective separation between disturbances associated with magnetospheric-ionospheric coupling and those induced by the influence of the lower atmosphere on the upper one. The frequency analysis we conducted revealed time intervals with higher intensity of short-period oscillations which may have been interpreted as manifestation of large-scale traveling ionospheric disturbances (TIDs) whose sources were internal gravity waves (IGWs) with periods of 1–5 hours. The complex analysis of helio-geomagnetic, ionospheric, and atmospheric data as well as data on tropical cyclones established that the detected TIDs were unrelated to helio-geomagnetic disturbances (2008–2009 exhibited solar minimum and quiet geomagnetic conditions). The analysis of other potential sources of the observed short-period wave disturbances shows that observed TIDs do not always coincide in time with passage of local meteorological fronts through the region of subionospheric points of OS paths and are not associated with passage of solar terminator. An attempt was made to connect a number of detected TIDs with ionospheric responses to tropical cyclones (TC) which were in active phase in the north-west of the Pacific Ocean during the periods considered. A considerable increase in energy of short-period wave disturbances was observed along Khabarovsk–Irkutsk, Magadan–Irkutsk, and Norilsk–Irkutsk paths during the active tropical cyclogenesis in September 2008–2009. Intensity of the observed TIDs decreased as midpoints of OS paths moved westward away from potential IGW sources. Ionospheric responses to wave disturbance propagation from the same IGW sources differ in the OS paths under analysis. This must be associated with different geometry of the OS paths as well as with the fact that the IGW source under consideration changes in intensity and its coordinates (stages and motion paths of tropical cyclones) during TC development. Thus there is an angular dependence between the wave disturbance propagation direction and the line connecting midpoints of the OS paths. Velocities of wave disturbance propagation ($\sim$90–170 m/s) were measured from the delay period of TIDs passage in regions of midpoints of spaced-apart OS paths. Short-period TIDs can also be observed at spring equinox in March 2008–2009 under quiet helio-geomagnetic conditions and in the absence of active tropical cyclones in the north-west of the Pacific Ocean, but TIDs energy is much lower than that in autumn.
Authors note it was not possible to identify potential IGW sources for some TIDs within the scope of this work. These TIDs may be related to ionospheric responses to seasonal transitions in the upper atmosphere dynamic regime during the equinoxes under study. Further systematic investigations in this area of study are required to store statistics of observations of ionospheric responses to strong meteorological disturbances.
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