Impact of winter sudden stratospheric warmings on the variability of parameters of the upper neutral atmosphere and ionosphere

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Dynamic disturbances in the lower atmosphere can impact on the upper neutral atmosphere and the ionosphere. One of the most significant process of the dynamic interaction of different layers of the atmosphere is winter sudden stratospheric warming (SSW), when occurs a strong and sudden increase in the temperature of the winter polar stratosphere of an "explosive nature". SSW-related effects can be observed over a wide range of latitudes, from the pole to the tropics, and disturbances cover a wide range of altitudes, from the troposphere to the thermosphere. We present the results of studying of the variabilities of the atmospheric temperature in the mesopause region and of the peak electron density NmF2 during the periods of SSWs of various types. The analysis is based on experimental data obtained with the ISTP SB RAS instrumental complex. We used data on the mesopause temperature obtained from spectrometric observations of the hydroxyl emission (OH(6-2) band, 834.0 nm, ∼87 km) at the Geophysical Observatory of the ISTP SB RAS (51.8°N, 103.1°E, Tory), and vertical sounding data on the peak electron density (NmF2) obtained from the Irkutsk DPS-4 ionosonde (52.3° N, 104.3° E). The analysis also involved satellite data from measurements of atmospheric temperature profiles from the MLS Aura and MERRA-2 reanalysis. As a characteristic of the atmospheric variability, the standard deviations of the mesopause temperature in the annual and nighttime variations were used, which makes it possible to analyze the manifestation of the activity of wave processes of different time scales in the upper atmosphere. As a characteristic of the ionospheric variability, we used the variability of the peak electron density in the F2 region of the ionosphere (NmF2). Variations in different time periods were studied and compared: day-to-day variations ($T > 24$ h), tidal variations ($8\ \text{h} \leq T \leq 24$ h), and variations with periods of internal gravity waves ($T < 8$ h). It was found, that during all analyzed SSW events, an increase in atmospheric and ionospheric variability was observed. Significant differences in the manifestation of wave activity at the heights of the mesopause and the ionospheric F2 region during SSWs of various types were revealed. Thus, the minor SSW in February 2016 led to an intensification of the diurnal atmospheric and ionospheric variability with periods of tides and internal gravity waves; the ionospheric disturbance in the tidal range was ∼2 times higher than the mean seasonal values. During the major SSWs in January 2013 and February 2018, there was an increase in day-to-day atmospheric and ionospheric variability (up to ∼400% and up to ∼300% compared to the average seasonal values, respectively), which can be caused by the intensification of planetary wave activity in the upper atmosphere.

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