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Numerical modeling of the influence of solar activity on the amplitudes of atmospheric tides

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Solar thermal tides have a significant effect on the dynamics of the atmosphere, and at the heights of the mesosphere and lower thermosphere (MLT), tides, along with gravity waves, play a major role in shaping the thermodynamic regime of the atmosphere. Solar tides are global-scale oscillations with periods of a solar day (24 h) and its harmonics (12, 8 and 6 h), which arise mainly as a result of the absorption of solar radiation by water vapor in the troposphere, ozone in the stratosphere and ionization of oxygen by UV radiation in the thermosphere/ionosphere. As part of a series of studies devoted to the sensitivity of large-scale wave processes to changes in solar activity (SA), numerical simulations of the global atmospheric circulation were performed using the nonlinear model of the middle and upper atmosphere (MUAM). Two ensembles of model simulations, consisting of 16 runs, were considered. The tidal amplitudes were averaged over the corresponding ensembles (high/low SA). The following tides were considered: migrating diurnal and semidiurnal tides with zonal wave numbers of 1 and 2, respectively, non-migrating diurnal and semidiurnal tides with zonal numbers 2 and 1, respectively, and a non-migrating eastward diurnal tide with a wave number of 3. The month of January was chosen for the analysis. This allowed us to consider in detail the variability of non-migrating tides: the main mechanism of their generation lies in the nonlinear interactions of migrating tides with quasi-stationary planetary waves, which amplitudes are maximized during the winter months, which increases the efficiency of this mechanism. In the MUAM model, tide generation is self-consistent, due to the parameterization of solar heating and nonlinear interactions between gravity waves and planetary waves. In particular, it is shown that the weakening of the tidal amplitude in the altitude range of 100-150 km, which is characteristic of the increase in solar action, and its strengthening at higher altitudes, are shown. This effect can be explained by the increase in the vertical temperature gradient in the lower thermosphere, as well as by the increase in thermal conductivity, which is proportional to the temperature, which complicates the penetration of tides in the thermosphere to greater altitudes with an increase in SA. However, at altitudes greater than 160 km, the effect of the increase in the absorption of direct EUV radiation, which increases with high SA, dominates, and the tidal amplitudes at higher altitudes with maximum SA increase. Further analysis of the change in the amplitudes of non-migrating tides showed their significant dependence on the features of the propagation of stationary planetary waves with zonal numbers 1 and 2 into the thermosphere. To analyze the direction of propagation, the phases of the tides were also considered.