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A model study of the role of the non-spherical form of the Earth and horizontal non-uniformity of the atmospheric temperature on the formation of the global circulation of the lower and middle atmosphere

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To investigate how the non-spherical form of the Earth and horizontal non-uniformity of the atmospheric temperature affect the formation of the global circulation of the lower and middle atmosphere, a mathematical model of the global neutral wind system of the Earth's atmosphere, developed earlier in the Polar Geophysical Institute (PGI), is applied. The applied model produces three-dimensional global distributions of the zonal, meridional, and vertical components of the neutral wind and neutral gas density. There are principal distinctions of the applied mathematical model from other existing global atmospheric circulation models. Firstly, the vertical component of the neutral wind velocity is calculated without using the hydrostatic equation. The vertical component of the neutral wind velocity as well as the horizontal components are obtained by means of a numerical solution of a generalized Navier-Stokes equation for compressible gas, with whatever restrictions on the vertical transport of the neutral gas being absent. Secondly, an internal energy equation for the neutral gas is not included in the applied mathematical model. Instead, the global temperature field is assumed to be a given distribution, i.e. the input parameter of the model, and obtained from the NRLMSISE-00 empirical model. The simulation domain is the layer surrounding the Earth globally and stretching from the ground up to the altitude of 120 km at the equator. The finite-difference method is applied in the numerical model. The calculated parameters are determined on a 1^O grid in both longitude and latitude. The height step

is non-uniform and does not exceed the value of 1 km. For the present study, the simulations were performed for summer period in the northern hemisphere (16 July) under moderate solar activity ($F_{10.7}$=101) and low geomagnetic activity (Kp=1). The steady-state distributions of the atmospheric parameters were obtained for inputs to model corresponding to 10.30 UT.

The global distributions of the atmospheric parameters were calculated using two versions of the model. In the first version of the model, the surface of the Earth is supposed to be as round as a ball, whereas in the second version of the model, the Earth's surface is assumed to coincide approximately with an oblate spheroid whose radius at the equator is more than that at the pole. In despite of very little difference between the Earth's radii at the equator and at the pole, the simulation results indicate that the non-sphericity of the Earth affects appreciably the formation of the global neutral wind system in the lower and middle atmosphere. The mechanisms responsible for this effect are conditioned by the action of the centrifugal acceleration and Coriolis acceleration in the rotatable atmosphere.

The second version of the model, in which the Earth's surface is supposed to be an oblate spheroid, was applied in order to investigate how the horizontal non-uniformity of the atmospheric temperature affects the global atmosphere circulation. The results were obtained for two distinct distributions of the atmospheric temperature, namely, for distributions both homogeneous and non-homogeneous in the horizontal directions. Both temperature distributions were irregular in the vertical direction. The simulation results indicated that the horizontal irregularity of the atmospheric temperature ought to influence appreciably on the global atmosphere circulation.