Atmospheric temperature stratification in dependence on the annual cycle length: Numerical experiments with climate model of general circulation

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Numerical simulations were carried out with the climate model of general circulation (CGCM) for different lengths of the annual cycle. The model results confirm the conclusion made from the analysis of temperature data with the use of special method of amplitude-phase characteristics [1,2]. According to the results obtained in [1,2], the height of the troposphere (tropopause) corresponds to the height of the temperature skin layer for the atmosphere periodically heated from the surface in the annual cycle [3]. In particular, according to model simulations, the tropopause height H for a shorter period T of the annual cycle was correspondingly lower.

We analyzed simulations with the CGCM version used in [4]. This CGCM version uses the general atmospheric circulation unit ECHAM5 [5] and the general ocean circulation unit MOM5 [6]. Atmospheric (T31L39) and oceanic (with a resolution of 1.125°x1.125°) blocks are combined using the OASIS communication system [7]. In our numerical experiments we used different lengths of the annual cycle for solar irradiance as an external periodic forcing for the climate system. In [4], in particular, the analysis of the results of control simulations for a 150-year period were carried out. Simulations with this GCM (hereinafter IAP RAS GCM) indicate an adequate reproduction of the main features of modern distributions for key climate characteristics (including surface air temperature, sea level pressure, precipitation etc.). Also, a quite adequate reproduction of the key features of the El Niño quasi-cyclic processes, with which the strongest interannual variability of the global surface temperature is associated, was noted. In particular, the model is able to reproduce the features of the repeatability of phase transitions for El Niño processes [4].

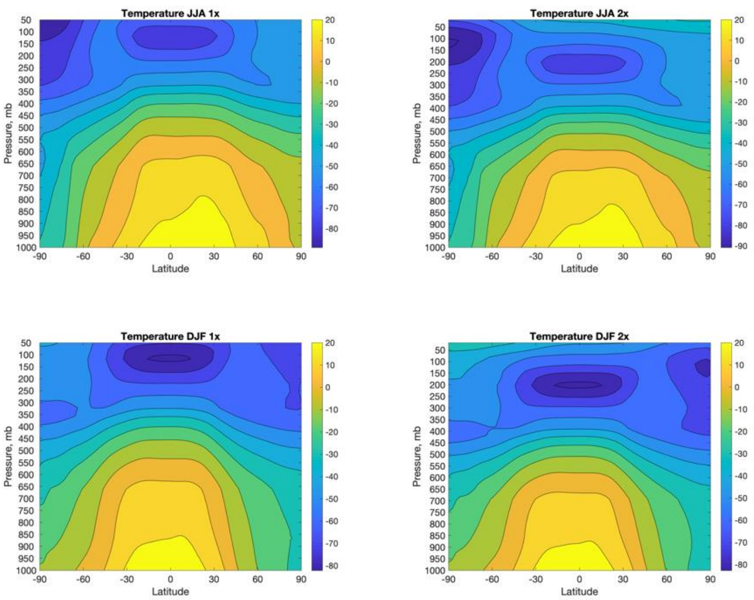

Fig. 1. Seasonal latitude-altitude temperature distributions in the atmosphere in June-July-August (upper row) and December-January-February (lower row) from model simulations with the current length T_o of the annual cycle (left) and with the length $T_o/2$ (right).

Figure 1 presents seasonal latitude-altitude temperature distributions in the atmosphere in June-July-August and December-January-February from model simulations with the current length T_o (365 days) of the annual cycle and with the $T_o/2$ period. According to Fig. 1, both in summer and winter, at twice the annual frequency, the height of the corresponding isotherms at all latitudes decreases. This is especially clearly manifested in a decrease in the region with minimal temperature in the vicinity of the tropical tropopause.

Figure 2 shows the vertical temperature profiles in the atmosphere of different latitudes in the summer from the IAP RAS GCM simulations for the T_o and $T_o/2$ periods of the annual cycle. Similar profiles were obtained for other latitudes of the Northern and Southern Hemispheres for the different seasons. According to Fig. 2, the values of the tropopause height, characterized by an abrupt change in the temperature profile, vary according to model simulations for the T_o length of the annual cycle from about 15 km near the equator to about 8 km in the polar regions. With the $T_o/2$ length of the annual cycle the tropopause height is about 11 km near the equator and about 6-7 km in the polar regions.

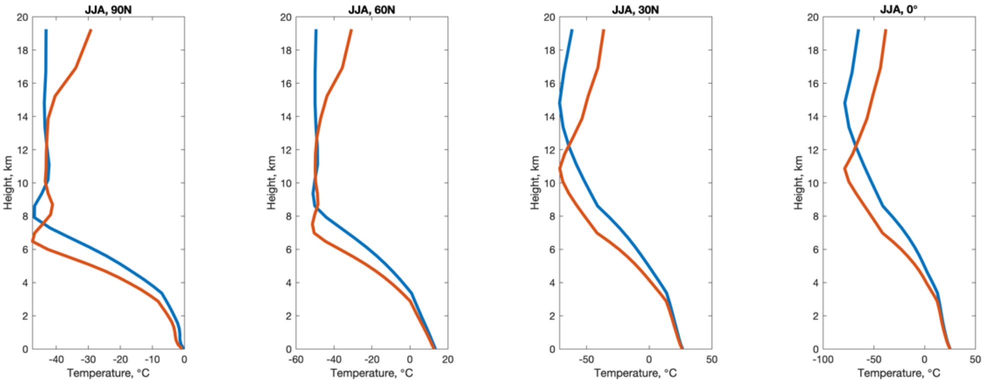

Fig. 2. Vertical temperature profiles in the atmosphere of different latitudes in the summer from model simulations for two lengths of the annual cycle: T_o (blue lines) and $T_o/2$ (red lines).

An analysis of H values at different latitudes from model simulations with the different annual cycle lengths T indicates that relationship between H and T corresponds to the root dependence $H \sim T^{1/2}$. It is similar to the appropriate dependence for the characteristic depth of the heat wave penetration associated with periodic forcing (skin-effect) as was suggested in [1,2].

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