Modeling of the energetic particles precipitation influence on atmospheric ozone, circulation and surface climate

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Presented research deals with the problem of energetic particles precipitation (EPP) impact on Earth climate by the means of idealized model experiment with atmospheric general circulation model of Institute of Numerical Mathematics Russian Academy of Sciences (INM AGCM) (Kulyamin and Dymnikov, 2015). Nowadays it is generally accepted that EPP serves as chemical sources for nitrogen oxides in thermospheric layers at high latitudes, which may descend into the stratosphere in winter due to atmospheric circulation structure. Hydrogen components can also be produced by particles below the mesopause, but their influence confines to the mesosphere/upper stratosphere due to short lifetime. Nitrogen oxides compounds are generally long-lived, so they could reach lower layers and catalytically destroy the stratospheric ozone. As ozone is a major radiative air component, its depletion could significantly influence atmospheric circulation and Earth climate. Properties of transport processes in the middle atmosphere during cold season over the high latitudes are such that the downward air motion dominates and long lived tracers can penetrate into winter polar cap region inside the strong polar vortex in stratosphere and lower mesosphere, so such circulation structure allow them to reach stratosphere and ozone layer. Due to complexity of direct modelling of described mechanism we used the vertical profile of ozone perturbation by EPP based on Rozanov et al., (2012) study and prescribed it in INM AGCM using the properties of middle atmospheric circulation reproduced in model. We applied this relative ozone depletion only inside the polar vortex reproduced by model calculation for the 60-90° N.H. latitude band. In order to determine the polar vortex location during the model run we calculate the potential vorticity distribution (at 600 K isentropic surface) and define the position of maximal latitudinal vorticity gradient closest to the North Pole. In this study, we use 1980 year conditions for 20-year long control and ozone altered model runs and compare the results. Preliminary analysis indicates the expected strong cooling of stratopause polar region due to ozone depletion, but as well warming of lower stratosphere and corresponding weakening of polar vortex, which could be connected to dynamical variability. We also found substantial (up to 6 K in amplitude) deviations of the wintertime Arctic surface temperature which could be connected to restructuring of Arctic oscillation and natural variability modes.

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Key words: energetic particles precipitation, ozone layer, Earth climate

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