# Paleoclimate modeling experiments

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Selecting the periods of the Earth evolution for climate modeling numerical experiments, we decided to choose those with the greatest differences in the continent pattern. Only the relatively late stages of evolution were considered so that more or less accurate data of the solar constant, the $CO_2$ concentration and continents configuration could be used [1].

Climate modelling was carried out for two periods of the Earth evolution characterized by completely different ocean-continent patterns. The first period, 120.4 million years ago, was characterized by high $CO_2$ concentrations and a continent lying in meridional direction. During the second period, 200 million years ago, a super continent was located in the Northern polar region extending to the South but not reaching the South Pole.

A numerical climate model of intermediate complexity was used in the work. The study is based on the three-dimensional hydrodynamic global climate coupled model, including ocean model with real depths and continents configuration, sea ice evolution model and energy and moisture balance atmosphere model [2, 3].

The ocean model is based on the thermocline (or planetary geostrophic) equations, with the addition of a linear drag term in the horizontal momentum equations. In the resulting frictional geostrophic system, density depends nonlinearly on the local values of temperature and salinity, which obey separate advection-diffusion equations and are also subject to convective adjustment. The model vertical levels are uniformly spaced in the logarithmic coordinate so that the upper layers are thinner, while the horizontal grid is uniform in longitude and in sine of latitude (giving boxes of equal area in physical space). There are 8 density vertical levels on a logarithmically stretched grid with vertical spacing increasing with depth from 140 m to 1120 m. The maximum depth is set to 5 km.

The global climate model is supplemented by a horizontal wind calculation procedure. It takes into account geostrophic, thermal and surface friction wind components. This allows us to qualitatively correctly describe the wind speed field depending on the state of the climate system.

The main parameters of the climate system were determined for the examined two periods. It was established that the climate system reached its steady state in 1500-2000 years. Global and spatial main climatic characteristics for the atmosphere, ocean, and sea ice were obtained. The calculated average global temperature of the atmosphere is within the limits reconstructed from observation data.

The ocean circulation features were studied for the relevant periods. Very strong circulation differences were found for two experiments. This is connected with highly different continents configurations and ocean depths distribution. A strong positive horizontal circulation was detected in the Southern hemisphere and an extended negative circulation was found in the western part of the ocean for the 120.4 million year period. Circulation in the northern part was rather weak. A suppressed circulation was observed in the northern region of the World Ocean accompanied by rather complex circulation patterns in the southern region for the 200 million year period.

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**References**

1. *Sorokhtin O.G., Ushakov S.A.* Development of the Earth. M: Izd-vo MGU, 2002. 506 p. (in Russian).

2. *Marsh R., Edwards N.R., Shepherd J.G.*. “Development of a fast climate model (C-GOLDSTEIN) for Earth System Science.” SOC, 2002, No.83. 54 p.

3. *Parkhomenko V.P.* “Climate model with consideration World ocean deep circulation,” Vestnik MGTU im. Baumana. Issue Mathematical Modelling, p. 186-200 (2011) (in Russian).