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Water vapor and carbon dioxide balances of European Russian southern taiga forests under projected climate change

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Investigation of the water vapor and carbon dioxide exchange between the Earth's surface and atmosphere is one of the important issue concerning the global climate change. The aim of this study is model estimation of the water and carbon exchange variations of southern taiga forests under projected for XXI century climate change scenarios. The object of research are mixed (spruce, birch) forests growing in the Valdai Hills (Tver Region). The initial conditions used in numerical experiments were the micrometeorological measurements at the Valdai Hills in 1999. Then climatic trends obtained in the experiments of atmospheric general circulation models ECHAM5 (Max Planck Institute, Germany), CCSM3 (USA, NCAR) and CGCM3.1 (T47) (Canada), according to the scenarios of climate change B1, A1B and A2 (IPCC, 2007) were applied. Projected annual temperature in 2080-2100 relative to 2000-2020 increase by 3.3° (according to different models and scenarios by 1.6 - 4.3°), precipitation rate does not exceed the range of standard deviation, only winter precipitation rate slightly rise. Solar radiation slightly decreases because of cloud intensification.

Numerical experiments were conducted by means of the H_2O and CO_2 soil-vegetation-atmosphere transfer model Mixfor-SVAT (Oltchev, 2008) to simulate water and carbon balance of forests of the southern taiga taking into account the projected climate change. The processes of photosynthesis and respiration vary significantly with increasing temperature. Forest ecosystems primary productivity increase stronger (19-44%, average 30%) than respiration (12-19%, average 16%), so the net exchange of CO_2 decreases significantly (from -310 to -560...-580 g C m-2y-1 for mixed forests dominated by spruce), what means the forest become more stronger sink of carbon from the atmosphere. Rainfall increase by 8% and evapotranspiration increases by 8%, too, but transpiration only by 3%.

Southern taiga forests area does not expect to shift to the north significantly during 100 years because of slow forest bound response to warming, even substantial. Such effects could become important in 200-300 years. But obviously taiga forests fall under non-typical conditions, so threshold effects like unusual intensive pest disturbance or forest fires are quite possible.

According to simulation results, with increase of the annual temperature by 3.3° by 2100 (scenarios B1, A1B, A2 IPCC, experiments of ECHAM5, CCSM3 and CGCM3.1 general circulation models) coniferous and mixed forests of European Russia southern taiga will absorb considerably more carbon dioxide per year than at present (NEE change by -250...-270 g C m-2y-1). Nevertheless, negative effects of pest disturbance or forest fires are likely in conditions of warming. The annual evaporation in the southern taiga forests predicted to increase by 8% with 8% increase of precipitation.