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Response of net ecosystem CO_2 exchange and evapotranspiration of boreal forest ecosystems to projected future climate changes: results of a modeling study

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It is presented the modeling results describing the possible response of net ecosystem exchange of CO_2 (NEE), gross (GPP) and net (NPP) primary production, as well as evapotranspiration (ET) of spruce forest ecosystems situated at central part of European part of Russia at the southern boundary of boreal forest community to projected future changes of climatic conditions and forest species composition.
A process-based MixFor-SVAT model (Olchev et al 2002, 2008, 2009) has been used to describe the CO_2 and H_2O fluxes under present and projected future climate conditions. The main advantage of MixFor-SVAT is its ability not only to describe seasonal and daily dynamics of total CO_2 and H_2O fluxes at an ecosystem level, but also to adequately estimate the contributions of soil, forest understorey, and various tree species in overstorey into total ecosystem fluxes taking into account their individual responses to changes in environmental conditions as well as the differences in structure and biophysical properties.
Results of modeling experiments showed that projected changes of climate conditions (moderate scenario A1B IPCC) and forest species composition at the end of 21 century can lead to small increase of annual evapotranspiration as well as to growth of NEE, GPP and NPP of the forests in case if the projected increase in temperature and elevated CO_2 in the atmosphere in future will be strictly balanced with growth of available nutrients and water in plant and soil. It is obvious that any deficit of e.g. nitrogen in leaves (due to reduced transpiration, nitrogen availability in soil, etc.) may lead to decreases in the photosynthesis and respiration rates of trees and, as a consequence, to decreases in the GPP and NEE of entire forest ecosystem. Conducted modeling experiments have demonstrated that a 20% reduction of available nitrogen in tree leaves in a monospesific spruce forest stand may result in a 14% decrease in NEE, a 8% decrease in NPP, and a 4% decrease in ET. Reduction of available nitrogen in spruce needles by 50–60% can almost completely neutralize the effect of the increase in the photosynthesis rate due to the projected future doubling of the CO_2 concentration in the air and increase in temperature by the end of the 21st century.
The predicted relatively small increase in ET by the end of the 21st century not exceeding 10% versus the projected increase in precipitation (about 20%) may cause a certain increase in soil moisture and surface runoff in the study area, as well as a somewhat decreased frequency of soil droughts.
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