

Effects of forest cover changes in European Russia on regional weather conditions: results of numerical experiments with the COSMO-CLM model

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The forests have a significant effect on the climatic system. They capture CO₂ from the atmosphere, regulate the surface evaporation and runoff, and influence the radiation and thermal conditions of the land surface. It is obvious, that their influence depends on many different factors including regional climate conditions, land use and vegetation structure, surface topography, etc.

The main goal of the study is to assess the possible influence of forest cover changes (under deforestation and/or afforestation) on regional weather conditions in the central part of European Russia using the results of modeling experiments provided by the meso-scale COSMO-CLM model. The need of the study lies in a lack of the experimental and modeling data characterizing the influence of the forest and land-use changes on regional weather conditions in European part of Russia. The forest ecosystems in the study region play a very important biosphere role that is significantly increased in the last decades due to considerable strengthening of anthropogenic activity in the area of European Russia.

The area selected for the study is located in the central part of European Russia between 55 and 59N and 28 and 37E. It comprises several geographical zones including dark-coniferous forests of the South-European taiga in the north, the mixed forests in the central part and the broad-leaved forests in the south. The forests within the study area are very heterogeneous. The total area covered by forests according to recent remote sensing data is about 50%.

The numerical experiments were provided using the COSMO-CLM model with the spatial resolution 13.2 km. As initial and boundary conditions for the numerical experiments the global reanalysis ERA Interim (with the 6-hour resolution in time and 0.75° × 0.75° in space) were used. The weather conditions were simulated in a continuous cycle for several months for the entire area of European Russia using the results of global reanalysis on external boundaries of the modeling domain. For the modeling experiments the warm period (from May to September) of 2010 was selected.

The first modeling experiment assumed total deforestation of the study area. The second experiment suggested complete interruption of economic activity in the region, forest regeneration and total area afforestation. It was assumed that the forest cover increase in the considered scenario was only due to increase of the fraction of pioneer small-leaved tree species (e.g. birch, aspen). Any possible changes in proportion of coniferous species were ignored.

The results of the modeling experiments showed considerable influence of forest cover changes on regional weather conditions. The influence of forest cover was manifested in changes of spatial patterns of the air temperature at different levels in the atmosphere, in changes of amount and intensity of precipitation, dew point, cloud cover, relative humidity, wind speed, and in changes of a number of other meteorological parameters.

It was shown that the total deforestation of the study region can result in increase of the mean air temperature in summer on 0.3°C and in reduction of precipitation by about 6%. The afforestation processes can lead to opposite effects: in case of modeling scenario imitating the total afforestation of the study area the model predicts the decrease of the mean summer temperatures on 0.1°C and increase of precipitation by 4%. The diurnal changes of meteorological parameters can be significantly higher and more heterogeneous. Whereas the changes of the surface air temperature and humidity, wind speed and some other parameters are mainly appeared within the area with changed forest cover only, the changes of precipitation and cloud cover patterns are manifested within the entire European part of Russia including the areas situated outside the study region.

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