Effects of deforestation of boreal forests on atmospheric fluxes and weather conditions at the local and regional scales

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Effects of clear-cutting and forest disturbances on weather conditions and atmospheric fluxes at the local and regional scales were investigated by an aggregated approach that includes continuous field measurements of energy and CO_2 fluxes at the recently clear-cut area and in an undisturbed forest stand, as well as modeling experiments using process-based regional and local scale models. Field measurements of energy and CO_2 fluxes were provided at clear-cut area using the eddy covariance method over the three year period following harvest. Results showed a clear dependence of clear-cut net radiation and energy fluxes on surface albedo and amount of grassy and woody vegetation actively regenerated within the clear-cut area after the harvest. The energy budget of the clear-cut area is characterized by higher latent heat (LE) comparing with sensible heat (H) fluxes over the entire period of flux measurements. The seasonal pattern of the Bowen ratio (β=H/LE) is characterized by its gradual decrease from spring to summer. Whereas in the spring and in the first half of June the β value varied usually around 1.0, in the middle of summer the β value decreased to 0.3-0.5. The mean β values for period from May to October were 0.5 in 2016, 0.3 - in 2017 and 0.4 - in 2018. Analysis of cumulative Net Ecosystem Exchange (*NEE*) rates for the entire growing season from May to October for 2016, 2017 and 2018 years showed that the clear-cur area for the periods was a source of CO_2 for the atmosphere. Comparisons of the sensible and latent heat fluxes measured at the clear-cut area and in an undisturbed spruce forest stand situated not far away from the clear-cut area showed that the largest differences in sensible heat, H_2O and CO_2 fluxes between both sites were observed during the first year (2016) after timber harvesting, and were mainly influenced by differences in surface albedo (Mamkin et al 2019). Comparisons of the sensible and latent heat fluxes measured at the clear-cut area and in the spruce forest stand showed that in the undisturbed forest the latent heat fluxes are steadily exceeded the corresponding clear-cut fluxes even in periods with sufficient soil moisture conditions promoting active regeneration and growth of grassy and woody vegetation at the cleared area. Comparisons of the NEE components for the clear-cut and undisturbed spruce forest are revealed significant differences in NEE rates for the first year after forest clearing, and gradual decrease of their disparities in the following years. Whereas the clear-cut area during the first three years after timber harvesting is functioned as a CO_2 source for the atmosphere, the CO_2 balance of undisturbed mature spruce forest in the period was close to zero (Mamkin et al., 2016, 2019).

All obtained results are well agreed with flux estimations provided by a local 3D turbulent exchange model and the COSMO-Ru-NWR model for regional weather predictions. In particular the numerical experiments provided using the COSMO-Ru-NWR model for several modeling scenarios imitating total deforestation of a large area situated within European southern taiga zone showed that total forest disturbances can result in changes of radiation and energy budgets of the area and consequently in increasing the annual amplitude of the air temperature (decrease of winter temperatures and their growth in summer) and in reducing the precipitation amount in all seasons of the year (projected annual decrease is about 4%) (Olchev et al., 2018).

The results obtained in the present study can be very useful for better understanding the effects of forest

disturbances on atmospheric fluxes at land surface - atmosphere interface and estimating their possible influence on regional weather conditions.

References

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