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Significant shortwave radiative forcing through boreal forest loss in eastern Siberia

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The study of Hansen et al., 2013 has revealed major boreal forest cover loss in the coldest region of the northern hemisphere, in the area around Yakutsk, eastern Siberia. While this loss impacts climate through immediate carbon emission to the atmosphere and a reduction in carbon sequestration, the extent and trajectory of related biophysical feedbacks to climate remain highly uncertain. Such feedbacks include land surface albedo changes which might dampen or amplify the positive feedback to climate warming through carbon emissions. This study aims at quantifying the albedo trajectory and related shortwave radiative forcing after boreal forest loss through fire. We analyzed the shortwave land surface albedo of areas with forest loss identified by Hansen et al., 2013, using MODIS albedo time-series of larch dominated forests around Yakutsk. We calculated the surface shortwave radiative forcing of forest loss for the years 2000-2014 as compared to control areas, i.e. undisturbed areas with their natural albedo variability. We show that the direction of the radiative forcing after a fire event depends on the properties of the underlying ground and the degree of the destruction. In all areas, the surface shortwave radiative forcing shows a sharp response to the forest loss, indicating a transition towards a less complex and less vegetated surface. The forcing reaches values greater than +14 W/m^2 for the summer months of the first 5 years after a high-intensity fire. Due to the missing vegetation, the forcing is highly negative during snow-covered months, starting with -3.7 W/m^2 after 1 year and increasing to a maximum of -13.6 W/m^2 after 11 years. The annual mean forcing is -4.28 W/m^2 for the first 5 years and -6.03 W/m^2 for the first 13 years after forest loss. The summer forcing ceases after a recovery time of 5 years, whereas the negative winter forcing does not decrease over the studied time of 13 years. Like all the other components, such as the forcing through greenhouse gases, the surface shortwave radiative forcing must be considered of equal importance to fully assess the influence of boreal forest disturbance on the global climate. The positive summer forcing might be of less temporal importance for now. However, longer and hotter summers, as well as decreasing snow-cover will increase its significance and might lead to additional feedbacks such as increased permafrost thaw and longer time spans needed for forest recovery or permanent loss of forest and transition to alternative ecosystem states.

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