Role of surface snow albedo feedback in boreal climate of northern Eurasia

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In the boreal climate region, snow-covered area begins to spread in autumn, and snow cover increases the surface albedo, that further lowers surface temperature. After snow covered area spreads further winter, in spring, snow-covered area begins to decrease as surface air temperature rises. Finally, almost snow covered area in northern Eurasia disappears in summer. These climatological features on snow and surface air temperature are well known. In the boreal climate region, further, there are areas where monthly mean surface air temperature during the coldest month is close to or lower than -40°C. Among these characteristics, studies quantitatively verifying the role of surface snow albedo feedback on the boreal climate have never been seen. On the other hand. As snow cover decreases due to the global warming, it is predicted that global warming will intensify by surface snow-albedo feedback. Therefore, it is essential to study and understand the role of surface snow albedo feedback in the boreal climate.

In this study, using a climate model (MIROC5.2), to examine an effect of surface snow albedo feedback on the boreal climate we carried out an idealized sensitivity experiment, in which the snow cover albedo assumed to be smaller than in the control experiment.

When the surface snow albedo is lowered, surface air temperature in northern Eurasia in autumn and spring is markedly higher than in the control experiment. Especially in spring, surface air temperature rises by larger than 10°C, and snow-covered area retreats north early. On the other hand, the impact of weakened surface snow albedo feedback is small in winter because solar radiation into the surface is close to 0 in the high-latitude region, and also surface air temperature difference between the experiments is smaller in winter, compared to that in spring. The Siberian high formed between autumn and spring is also weakening, which shows weakened drop of surface air temperature in eastern Siberia. During spring, in the area covered by snow in the control experiment, due to weakening of the surface snow albedo feedback, increase of the shortwave radiation absorbed to the ground surface contributes to increases of snow melting and surface evaporation. Thus, while rainfall and cloud cover increase, cloud radiative forcing increases.

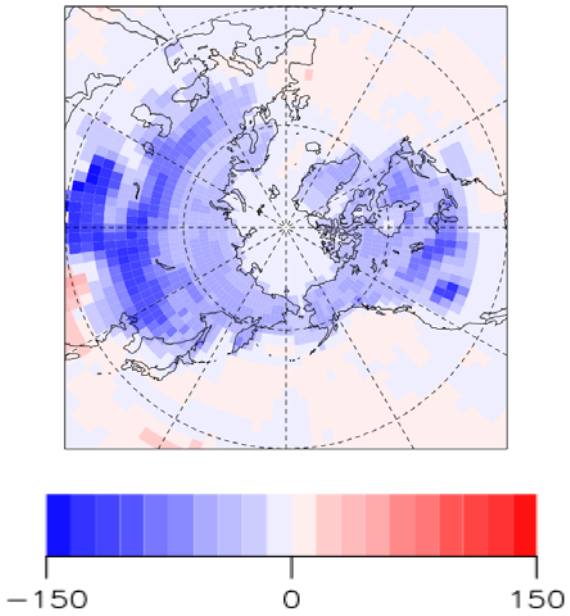

Figure 1. Difference of monthly mean surface shortwave radiation in April between low snow albedo run and control run. Unit: [W m^{-2}]. Negative value mean increase in downward radiation.

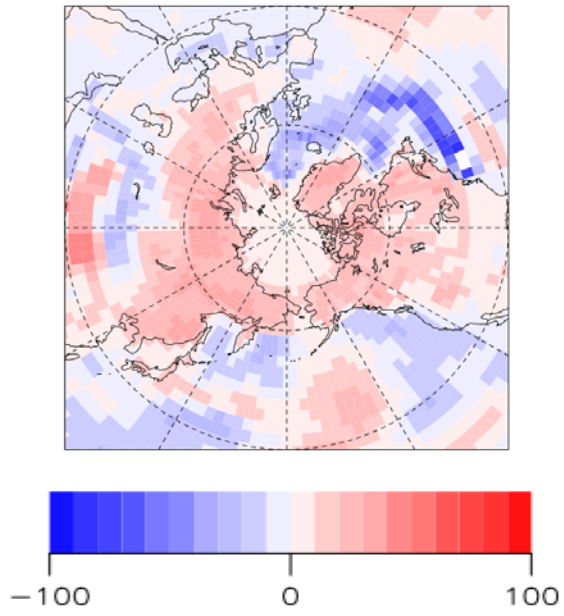

Figure 2. Difference of monthly mean surface latent heat flux in April between low snow albedo run and control run. Unit: [W m^{-2}]. Positive value mean increase in upward radiation.