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Heterogenous snow cover derived uncertainty in Arctic carbon budget

Hotaek Park¹ and Youngwook Kim²

¹JAMSTEC, Yokosuka, Japan (park@jamstec.go.jp)

²Department of Biology, College of Science, United Arab Emirates University, UAE (youngwook.kim@ntsg.umt.edu)

The winter of northern Arctic regions is characterized by strong winds that lead to frequent blowing snow and thus heterogeneous snow cover, which critically affects permafrost hydrothermal processes and the associated feedbacks across the northern regions. However until now, observations and models have not documented the blowing snow impacts. The blowing snow process has coupled into a land surface model CHANGE, and the improved model was applied to observational sites in the northeastern Siberia for 1979–2016. The simulated snow depth and soil temperature showed general agreements with the observations. To quantify the impacts of blowing snow on permafrost temperatures and the associated greenhouse gases, two decadal experiments that included or excluded blowing snow, were conducted for the observational sites and over the pan-Arctic scale. The differences between the two experiments represent impacts of the blowing snow on the analytical components. The blowing snow-induced thinner snow depth resulted in cooler permafrost temperature and lower active layer thickness; this lower temperature limited the vegetation photosynthetic activity due to the increased soil moisture stress in terms of larger soil ice portion and hence lower ecosystem productivity. The cooler permafrost temperature is also linked to less decomposition of soil organic matter and lower releases of CO₂ and CH₄ to the atmosphere. These results suggest that the most land models without a blowing snow component likely overestimate the release of greenhouse gases from the tundra regions. There is a strong need to improve land surface models for better simulations and future projections of the northern environmental changes.