15 years of snow manipulation reveals huge impact on lowland permafrost and vegetation

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Snow depth increases observed and predicted in the sub-arctic are of critical importance for the dynamics of lowland permafrost and vegetation. Snow acts as an insulator that protects vegetation but may lead to permafrost degradation. In the Abisko area, in northernmost Sweden, there has been an increasing trend in snow depth during the last Century. Downscaled climate scenarios predict an increase in precipitation by 1.5 - 2% per decade for the coming 60 years. The observed changes in snow cover have affected peat mires in this area as thawing of permafrost, increases in active layer thickness and associated vegetation changes have been reported during the last decades. An experimental manipulation was set up at one of these lowland permafrost sites in the Abisko area (68°20'48"N, 18°58'16"E) 15 years ago, to simulate projected future increases in winter precipitation and to study their effect on permafrost and vegetation. The snow cover has been more than twice as thick in manipulated plots compared to control plots and it has had a large impact on permafrost and vegetation. It resulted in statistically significant differences in mean winter and minimum ground temperatures between the control and the manipulated plots. Already after three years there was a statistically significant difference between active layer thickness in the manipulated plots compared to the control plots. In 2019, the active layer thickness in the control plots were around 70 cm whereas in the manipulated plots it was 110 cm. The increased active layer thickness has led to surface subsidence due to melting of ground ice in all the manipulated plots. The increased snow thickness has prolonged the duration of the snow cover in spring with up to 22 days. However, this loss in early season photosynthesis was well compensated for by the increased absorption of PAR and higher light use efficiency throughout the whole growing seasons in the manipulated plots. Eriophorum vaginatum is a species that has been especially favored in the manipulated plots. It has increased both in number and in size. Underneath the soil surface, the roots have also been affected. There has been a strong increase in total root length and growth in the active layer, and deep roots has invaded the newly thawed permafrost in the manipulated plots. The increased active layer thickness has also had an effect
on the bacterial community composition in the newly thawed areas. According to past, century-long patterns of increasing snow depth and projections of continuing increases, it is very likely that the changes in permafrost and vegetation that have been demonstrated by this experimental treatment will occur in the future under natural conditions.