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Effects of bryophyte and lichen cover on permafrost soil temperature at large scale

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Bryophytes and lichens covering the soil surface at high latitudes act as an insulating layer, which has a net cooling effect on the soil and thereby protects permafrost. Climate change, however, may lead to changes in the average surface coverage of bryophytes and lichens. This can result in thawing of permafrost and an associated release of soil carbon to the atmosphere, which may cause a positive feedback on atmospheric CO_2 concentration. Hence, it is crucial to predict the future large-scale response of bryophyte and lichen cover to climatic change at high latitudes. Current global land surface models, however, contain mostly empirical approaches to represent the surface cover of bryophytes and lichens, which makes it difficult to quantify its future extent and dynamics. Therefore, we integrate a process-based model of bryophyte and lichen growth into the global land surface model JSBACH (Jena Scheme for Biosphere–Atmosphere Coupling in Hamburg). Thereby, we explicitly simulate dynamic thermal properties of the bryophyte and lichen cover and their relation to environmental factors. To quantify the insulating effect of the cover on the soil, we compare simulations with and without simulated bryophyte and lichen cover. We estimate that the bryophyte and lichen cover exerts an average cooling effect of 2.7 K on temperature in the topsoil for the region north of 50^o N under current climatic conditions. Locally, a cooling of up to 5.7 K may be reached. Furthermore, we show that using a simple, empirical representation of the bryophyte and lichen cover instead of a dynamic one results only in an average cooling of around 0.5 K. We conclude that bryophytes and lichens have a significant impact on soil temperature in high-latitude ecosystems and that dynamic thermal properties are necessary for a realistic representation of the cooling effect.