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Quantifying the effect of lichen and bryophyte cover on permafrost soil within a global land surface model

Philipp Porada (1,2), Altug Ekici (3), Christian Beer (1,2)

(1) Stockholm University, Stockholm, Sweden (philipp.porada@aces.su.se), (2) Bolin Centre for Climate Research, Stockholm University, Stockholm, Sweden (Christian.Beer@aces.su.se), (3) Earth System Sciences, University of Exeter, Exeter, UK (A.Ekici@exeter.ac.uk)

Vegetation near the surface, such as bryophytes and lichens, has an insulating effect on the soil at high latitudes and it can therefore protect permafrost conditions. Warming due to climate change, however, may change the average surface coverage of bryophytes and lichens. This can result in permafrost thawing associated with a release of soil carbon to the atmosphere, which may lead to a positive feedback on atmospheric CO_2. Thus, it is important to predict how the bryophyte and lichen cover at high latitudes will react to environmental change. However, current global land surface models so far contain mostly empirical approaches to represent bryophytes and lichens, which makes it impractical to predict their future state and function. For this reason, we integrate a process-based model of bryophyte and lichen growth into the global land surface model JSBACH. We explicitly represent dynamic thermal properties of the bryophyte and lichen cover and their relation to climate. Subsequently, we compare simulations with and without bryophyte and lichen cover to quantify the insulating effect.

We estimate an annual average cooling effect of the bryophyte and lichen cover of 2.7 K on topsoil temperature for the northern high latitudes under current climate. Locally, the cooling may reach up to 5.7 K. Moreover, we show that neglecting dynamic properties of the bryophyte and lichen cover by using a simple, empirical scheme only results in an average cooling of around 0.5 K. This suggests that bryophytes and lichens have a significant impact on soil temperature in high-latitude ecosystems and also that a process-based description of their thermal properties is necessary for a realistic representation of the cooling effect.