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Modelling effect of frost on carbon dioxide gas exchange in northern boreal coniferous forest

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Boreal coniferous forests play an important role in the global carbon budget. Their annual cycle is characterized by a short summer growing season and a long, cold winter break, requiring extensive cold acclimation strategies. Autumn cessation and spring recovery are intermitted by severe night-frost events, with the potential to cause substantial damage to the temperature vulnerable photosynthetic electron transport apparatus. These intermitting frost events have so far not been appropriately considered in current CO_2 gas exchange models.

In this study, the gradual spring recovery of vegetation is modelled for 2001 to 2008 taking into account the effect of intermitting frost events. The study site is a Scots pine forest in Sodankylä, located 100 km north of the Arctic Circle. The approach uses a combination of eddy covariance and chlorophyll fluorescence measurements together with inverse parameter estimation.

A canopy model based on the biochemical model developed by Farquhar et al. (1980) is used. A combination of model and eddy covariance measurements shows the influence of night frosts on the base rates of maximum carboxylation, $V_{c(max)}$, and maximum electron transport, J_{max}. Chlorophyll fluorescence measurements indicate frost-induced changes in the photochemical efficiency of the vegetation. These measurements, together with inverse parameter estimation, can be used to separate changes in the photochemical efficiency and other processes which occur in plants during spring. The results can be further used in modelling of the photochemical status of the vegetation. The next step after a better description of spring recovery will be the description of cessation of the vegetation activity in autumn. The approach will then be applied to more southern sites for further validation.