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Interaction effects of climate change and disturbance regimes on high latitude forest dynamics

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Ecosystem disturbances such as wildfires, storms or insect outbreaks are important elements of forest dynamics. As a changing and more extreme climate is expected to lead to an increase in such disturbances in many places, they have to be considered in coupled land surface – atmosphere dynamics.

Next to releasing large pulses of carbon to the atmosphere through large-scale forest mortality, disturbances can also play an important role in catalyzing or enhancing ecosystem state shifts. In the boreal zone, results from field and landscape modeling studies indicate that disturbances drive transient or permanent shifts from needleleaf evergreen to broadleaf deciduous species. While such changes are also visible in biome-wide simulations, the role of disturbances therein remains open.

We here investigate the impact of changing disturbance regimes on the species composition of the boreal zone under climate change. We perform simulations with the Dynamic Global Vegetation Model LPJ-GUESS, which allows simulating disturbances and post-disturbance recovery through its representation of vegetation demographics and patch dynamics. We combine varying rates of stylized disturbances with different climate scenarios to create controlled simulation experiments of changing climate, changing disturbance regimes and their interactions.

Our simulations reproduce findings from previous studies and theory, with increasing disturbance rates leading to higher shares of deciduous trees in areas where they would be negligible in the absence of disturbance. We further investigate if these changes represent (1) a transient state of early-successional species that disappears again once disturbance pressure is lifted or (2) a stable reorganization of the ecosystem towards a deciduous-dominated forest.