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Potential effects of forest management on surface albedo

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Currently 70% of the world's forests are managed and this figure is likely to rise due to population growth and increasing demand for wood based products. Forest management has been put forward by the Kyoto-Protocol as one of the key instruments in mitigating climate change. For temperate and boreal forests, the effects of forest management on the stand-level carbon balance are reasonably well understood, but the biophysical effects, for example through changes in the albedo, remain elusive.

Following a modeling approach, we aim to quantify the variability in albedo that can be attributed to forest management through changes in canopy structure and density. The modelling approach chains three separate models: (1) a forest gap model to describe stand dynamics, (2) a Monte-Carlo model to estimate the probability density function of the optical path length of photons through the canopy and (3) a physically-based canopy transfer model to estimate the interaction between photons and leaves.

The forest gap model provides, on a monthly time step the position, height, diameter, crown size and leaf area index of individual trees. The Monte-Carlo model computes from this the probability density function of the distance a photon travels through crown volumes to determine the direct light reaching the forest floor. This information is needed by the canopy transfer model to calculate the effective leaf area index - a quantity that allows it to correctly represent a 3D process with a 1D model. Outgoing radiation is calculated as the result of multiple processes involving the scattering due to the canopy layer and the forest floor. Finally, surface albedo is computed as the ratio between incident solar radiation and calculated outgoing radiation.

The study used two time series representing thinning from below of a beech and a Scots pine forest. The results show a strong temporal evolution in albedo during stand establishment followed by a relatively stable albedo once the canopy is closed. During this period, albedo is affected for a short time by forest operations. The modelling approach allowed us to estimate the importance of ground vegetation in the stand albedo. Given that ground vegetation depends on the light reaching the forest floor, ground vegetation could act as a natural buffer to dampen changes in albedo, allowing the stand to maintain optimal leaf temperature. Consequently, accounting for only the carbon balance component of forest management ignores albedo impacts and is thus likely to yield biased estimates of the climate benefits of forest ecosystems.