Geophysical Research Abstracts
Vol. 20, EGU2018-6836, 2018
EGU General Assembly 2018

Predicting surface albedo in high latitude forests in the present and future: How much does forest structure matter?

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Predicting the surface albedo of a forest of a given species composition or plant functional type (PFT) is complicated by the wide range of structural attributes it may display. Robust characterizations of forest structure are therefore essential to reducing the uncertainty of albedo predictions in forests, particularly in the presence of snow. However, many climate models continue to generate erroneous albedo predictions for forests, and the magnitude attributable to insufficient characterization of forest structure remains unclear. Here, we employ a novel forest classification scheme based on the assimilation of Fennoscandic (i.e. Norway, Sweden, and Finland) national forest inventory data to quantify the magnitude of the albedo prediction error solely attributable to poor characterizations of forest structure. We find that such error may be as large as 0.09 in Fennoscandic forests – a magnitude which is on par with albedo prediction errors associated with poor climate model parameterizations of factors controlling canopy snow interception and unloading, or poor model parameterizations of snow metamorphosis and aging.

Further, we evaluate the implication of excluding time-dependent albedo trajectories linked to structural transitions in forests in climate model simulations of transient anthropogenic land use/land cover change (LULCC). We find that, for an intensively managed forestry region in southeastern Norway, neglecting structural transitions over the next quarter century results in a foregone (undetected) radiatively equivalent impact of $\sim$178 Mt-CO_2-eq. yr-1 on average during this period – a magnitude which is roughly comparable to the annual greenhouse gas emissions (GHGs) of a country such as The Netherlands. Our results affirm the importance of improving the characterization of forest structure in time and space when predicting or simulating surface albedo and associated climate effects.