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Links between boreal forest and clouds inferred from long-term atmospheric observations

Ekaterina Ezhova[1], Aino Aarne[1], Antti Arola[2], Antti Liponen[2], Anna Lintunen[1], Taina Yli-Juuti[3], Jaana Bäck[1], Harri Kokkola[2,3], Veli-Matti Kerminen[1], Tuukka Petäjä[1], Annele Virtanen[3], and Markku Kulmala[1]

[1]INAR - Institute for Atmospheric and Earth system research, University of Helsinki, Helsinki, Finland (ekaterina.ezhova@helsinki.fi)

[2]Atmospheric Research Centre of Eastern Finland, Finnish Meteorological Institute, Kuopio, Finland

[3]Department of Technical Physics, University of Eastern Finland, Kuopio, Finland

Clouds play a vital role in the Earth's radiation budget, with low-level clouds having a net cooling effect. Evidence shows that forests alter low-level clouds' formation and physical properties (e.g., [1-3]). In their turn, clouds modify radiation transfer, influencing near-surface variables and forest carbon uptake. Shallow cumulus clouds can enhance photosynthesis due to the diffuse fertilization effect, and the relative increase in photosynthesis is most significant in boreal forests compared to other ecosystems [4]. All this evidence suggests a strong atmosphere-biosphere link for boreal forests.

We use long-term observations at SMEAR II station in Finland and satellite data sets to study how air mass transformation over boreal forests changes the optical properties of low-level clouds. Further, we assess the dynamics of photosynthesis and net ecosystem exchange in response to changing cloud properties and near-surface variables under different low-level clouds. We show that stratus clouds dampen photosynthesis, and the effect is amplified with the time spent by an air mass over a forest. Oppositely, cumulus clouds enhance photosynthesis compared to the clear sky conditions. If an air mass is exposed to the boreal forest for several days, and cumulus clouds form during the daytime, photosynthesis is efficient, and clouds' transmittance somewhat decreases. Our results suggest that shallow cumulus clouds formed in an air mass interacting with boreal forest can become more reflective. At the same time, these clouds provide ideal conditions for enhanced boreal forest carbon uptake.

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