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Clouds enhance Greenland ice sheet mass loss

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Clouds have a profound influence on both the Arctic and global climate, while they still represent one of the key uncertainties in climate models, limiting the fidelity of future climate projections. The potentially important role of thin liquid-containing clouds over Greenland in enhancing ice sheet melt has recently gained interest, yet current research is spatially and temporally limited, focusing on particular events, and their large scale impact on the surface mass balance remains unknown.

We used a combination of satellite remote sensing (CloudSat - CALIPSO), ground-based observations and climate model (RACMO) data to show that liquid-containing clouds warm the Greenland ice sheet 94% of the time. High surface reflectivity (albedo) for shortwave radiation reduces the cloud shortwave cooling effect on the absorbed fluxes, while not influencing the absorption of longwave radiation. Cloud warming over the ice sheet therefore dominates year-round. Only when albedo values drop below $\sim$0.6 in the coastal areas during summer, the cooling effect starts to overcome the warming effect. The year-round excess of energy due to the presence of liquid-containing clouds has an extensive influence on the mass balance of the ice sheet. Simulations using the SNOWPACK snow model showed not only a strong influence of these liquid-containing clouds on melt increase, but also on the increased sublimation mass loss. Simulations with the Community Earth System Climate Model for the end of the 21st century (2080-2099) show that Greenland clouds contain more liquid water path and less ice water path. This implies that cloud radiative forcing will be further enhanced in the future.

Our results therefore urge the need for improving cloud microphysics in climate models, to improve future projections of ice sheet mass balance and global sea level rise.