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Inhibition of the positive snow-albedo feedback by precipitation on the Antarctic plateau

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The high albedo of snow largely determines the climate of polar regions by controlling the absorption of energy at the surface. In Antarctica, where light-absorbing impurities are few, snow albedo is mostly determined by the size of snow grains. Snow metamorphism, the process of coarsening of initially small snow grains, occurs at a rate mainly determined by snow temperature and by the temperature gradient in the snow. Therefore, snow albedo in Antarctica is determined by climatic variables. In turn, albedo strongly affects climate, through the energy budget of the surface. This leads to a positive snow-albedo feedback even in perennially snow covered areas.

We used passive microwave satellite data and model outputs to show that this positive feedback can be inhibited by small amounts of precipitation. This can be explained by the fact that grain coarsening in Antarctica is more sensitive than previously thought to solar absorption and that the deposition of small grains on the surface significantly reduces both the albedo and the penetration depth of solar radiation.

We deduce that projected future increases in precipitation (+20%) can increase snow albedo by 0.004 in average (and up to 0.02) during the XXIst century, thus reducing the absorbed solar energy by about 1.5 W m-2 in summer. Based on general circulation model simulations, we show that these processes can lead to a decrease of temperature of 0.5°C in summer and 0.3°C in the annual mean. The interplay between snow physical properties and climate therefore appears as a critical aspect for the accurate prediction of climate.