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Can snow save us from global warming? (Louis Agassiz Medal Lecture)

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How snow will interact with climate in the current warming context is an open issue. There is of course the well known snow-albedo feedback, whereby the replacement of snow by darker surfaces positively feedbacks on climate. But many other snow-climate feedbacks have been proposed recently, both positive and negative, so that predictions of future polar climate are rather uncertain. Warming will change precipitation and metamorphic conditions in the snowpack, affecting snow physical properties such as grain size, albedo and thermal conductivity. Their consequences are difficult to predict, with threshold effects between different regimes in snow metamorphism. A significant negative feedback between precipitation, snow albedo and climate has been detected in Antarctica, where increased precipitation increase albedo by bringing small grains to the surface, and this is not compensated by the warmer temperatures that accelerate grain growth. On the contrary, similar processes acting in the Arctic have led to a positive feedback. Changes in snow thermal conductivity can have important effects on the growth of sea ice, with spatially variable effects. In the Arctic, the warming-induced growth of higher vegetation such as shrubs can produce additional effects. Shrubs trap snow, increase snow depth and shield snow from wind erosion. Snow physical properties will change, with the likely partial replacement of wind slabs by layers of depth hoar of lower thermal conductivity. This may limit winter ground cooling, with effects on permafrost stability and on the release of greenhouse gases from thawing carbon stocks. Several examples will be detailed to illustrate the complexity of snow-climate interactions and to stress the need for a detailed description of snow physical properties in climate models, before we can conclude as to whether snow will slow down polar warming or on the contrary accelerate it, with possible catastrophic consequences.