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Global warming related transient albedo feedback in the Arctic and its relation to the seasonality of sea ice

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The Arctic is warming two to three times faster than the global average. Arctic sea ice cover is very sensitive to this warming and has reached historic minima in late summer in recent years (i.e. 2007, 2012).

Considering that the Arctic Ocean is mainly ice-covered and that the albedo of sea ice is very high compared to that of open water, the change in sea ice cover is very likely to have a strong impact on the local surface albedo feedback. Here we quantify the temporal changes in surface albedo feedback in response to global warming.

Usually feedbacks are evaluated as being representative and constant for long time periods, but we show here that the strength of climate feedbacks in fact varies strongly with time. For instance, time series of the amplitude of the surface albedo feedback, derived from future climate simulations (CIMP5, RCP8.5 up to year 2300) using a kernel method, peaks around the year 2100.

This maximum is likely caused by an increased seasonality in sea-ice cover that is inherently associated with sea ice retreat.

We demonstrate that the Arctic average surface albedo has a strong seasonal signature with a maximum in spring and a minimum in late summer/autumn. In winter when incoming solar radiation is minimal the surface albedo doesn't have an important effect on the energy balance of the climate system. The annual mean surface albedo is thus determined by the seasonality of both downwelling shortwave radiation and sea ice cover.

As sea ice cover reduces the seasonal signature is modified, the transient part from maximum sea ice cover to its minimum is shortened and sharpened. The sea ice cover is reduced when downwelling shortwave radiation is maximum and thus the annual surface albedo is drastically smaller. Consequently the change in annual surface albedo with time will become larger and so will the surface albedo feedback.

We conclude that a stronger seasonality in sea ice leads to a stronger surface albedo feedback, which accelerates melting of sea ice. Hence, the change in seasonality and the associated change in feedback strength is an integral part of the positive surface albedo feedback leading to Arctic amplification and diminishing sea ice cover in the next century when global climate warms.