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Effect of snow covering and ocean mixed layer on the irreversibility of sea-ice retreat

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The seasonal change of sea-ice extent constitutes one of the largest variations in surface albedo on seasonal time-scales. Because of this large seasonal change and the high difference in surface albedo between sea-ice and open oceans, the dynamical processes related to the presence of sea-ice are crucial drivers in the climate system.

Single-column models and more comprehensive climate models have been proved to be very useful to understand these physical processes and their relations and role in the formation of sea-ice. All these models show that different scenarios can be produced in a warming climate depending on the considered region in the (huge) parameter space: smooth or abrupt transitions to seasonally or annual ice-free conditions. Still it is unclear which is the dominant physical process that is responsible for the occurrence of abrupt ice retreat and gives rise to irreversibility.

We start from the toy model developed by Eisenman (2012) JGR 117, D01111, which represents the essential physics of thermodynamic sea ice in a single column, and we add to this model the effects of snow covering and seasonal variation of the ocean mixed layer. We investigate how the abrupt threshold during ice retreat depends on these additional effects. In particular, we find that the presence of snow reduces the bistability region and we discuss different regimes which depend on the mixed layer time-scale. Temperature profiles in the mixed layer are obtained by performing coupled ice-ocean simulations of the Arctic Ocean with the MIT general circulation model at 36 km horizontal resolution.