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Importance of atmospheric feedbacks in simulating the seasonal cycle of the Antarctic sea ice and its response to perturbations.

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The seasonal cycle of the Antarctic sea ice extent is largely controlled by the evolution of the insolation received at the top of the atmosphere. However, sea ice processes and feedbacks with the ocean and the atmosphere can modulate this seasonal cycle. Here, the atmospheric feedbacks are quantified in a series of idealized sensitivity experiments performed with an eddy-permitting (1/4°) NEMO-LIM3 Southern Ocean configuration, including a representation of ice shelf cavities, in which the model was either driven by an atmospheric reanalysis or coupled to the COSMO-CLM^2 regional atmospheric model. In these experiments, sea ice thermodynamics and dynamics as well as the exchanges with the ocean and atmosphere are strongly perturbed. This perturbation is achieved by modifying snow and ice thermal conductivities, the vertical mixing in the ocean top layers, the effect of freshwater uptake/release upon sea ice growth/melt, ice dynamics and surface albedo. We show that the changes in surface heat fluxes are very different between the configurations driven by the reanalysis and those coupled to the atmosphere. Atmospheric feedbacks enhance the response of the modelled winter ice extent to any of the perturbed processes, and the enhancement is strongest when the albedo is modified. The response of sea ice volume and extent to changes in entrainment of subsurface warm waters to the ocean surface is also greatly amplified by the coupling with the atmosphere. By contrast, the atmospheric feedbacks can damp the impact of the perturbations affecting the heat conductivity through sea ice.