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Why models fail or suceed in representing the Arctic winter boundary layer – a GASS model intercomparison

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The Arctic boundary layer in winter has been observed to be in either a cloudy or a radiatively clear state. The presence of cloud liquid water, weak, elevated temperature inversions and little to no surface radiative cooling are characteristic of the cloudy state, whereas strong surface radiative cooling and stronger, surface-based temperature inversions prevail in the radiatively clear state. The GASS single-column model intercomparison on Arctic air mass formation examines the capability of different weather and climate models to represent the typical features of both boundary layer states. The case is based on an idealised air mass transformation, following a relatively moist and warm air mass on its trajectory over Arctic sea ice in polar night. The intercomparison reveals that deficiencies in mixed-phase microphysics, in the interaction of different physical processes in models and inadequately high vertical resolution near the surface can hinder the creation and maintenance of mixed-phase clouds and thereby of the cloudy state. Overly high emissivities of ice clouds or the clear sky and the lack of an insulating snowpack can prevent the generation and growth of surface-based inversions, leading to a misrepresentation of the clear state of the Arctic winter boundary layer.