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Cloud processes in air-mass transformations between the Arctic and mid-latitudes

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Pulses of warm and moist air from lower latitudes provide energy to the Arctic and form its main energy source outside of the summer months. These pulses can cause substantial surface warming and trigger ice melt. Air-mass transport in the opposite direction, away from the Arctic, leads to cold-air outbreaks. The outbreaks are often associated with cold extremes over continents,and extreme surface heat fluxes and occasional polar lows over oceans. Air masses advected across the strong Arctic-to-mid-latitude temperature gradient are rapidly transformed into colder and dryer or warmer and moister air masses by clouds, radiative and turbulent processes, particularly in the boundary layer. Phase changes from liquid to ice within boundary-layer clouds are critical in these air-mass transformations. The presence of liquid water determines the radiative effects of these clouds, whereas the presence of ice is crucial for subsequent cloud decay or dissipation, processes that are poorly represented in weather and climate models. We argue that a better understanding of how air masses are transformed on their way into and out of the Arctic is essential for improved prediction of weather and climate in the Arctic and mid-latitudes. Observational and modelling exercises should take an air-mass-following Lagrangian approach to attain these goals. We demonstrate how Eulerian observations from the SHEBA campaign can be used in a Lagrangian approach to understand the transformation of moist air masses advected towards the site.