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The role of boundary-layer dynamics in the transition to a blue Arctic

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There are many processes which have introduced strong, regionalized variations to the overall warming observed in the last 50 years. The combination of local feedbacks and the persistent stable stratification found in the Arctic has led to a rapid warming in this region, and the expectation that we will have nearly ice-free summers in the Arctic within a few decades. We have quantified how the climatology of the boundary layer has contributed to the rapid warming in the Arctic by controlling the efficacy of climate forcings, amplifying the effect of forcing perturbations in shallow boundary layers. This forces us to re-evaluate how we assess climate forcings in the Arctic, as we cannot assume that they are linearly additive in this region.

We use new observations and existing reanalysis to assess how the boundary-layer dynamics changes as we move towards a 'Blue-Arctic', characterized by thin sea-ice in the winter and nearly-ice-free summers. We take an example of the regions which have seen rapid sea ice-loss in recent decades and compare the boundary layer dynamics over permanent sea ice, permanent open water, and those regions which have changed from having year-round sea ice to seasonal ice-cover. By quantifying this transition in the boundary-layer dynamics we can determine the importance of different climate feedbacks as we transition towards this new regime, based on how they are coupled to the boundary layer climatology. Furthermore, we have determined how well a global climate model, the Norwegian Earth System Model, captures this transition. This was done by deriving the boundary-layer depth in the model using a bulk-Richardson methodology, and assessing how the climatology of the boundary layer changed in regions which had seem similar transitions from year-round ice cover, to seasonal ice cover.