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Boundary layer stability and Arctic climate change: a feedback study using EC-Earth

R. Bintanja, E.C. van der Linden, and W. Hazeleger
Royal Netherlands Meteorological Institute (KNMI), Global Climate, Netherlands (bintanja@knmi.nl)

Amplified Arctic warming is one of the key features of climate change. It is evident in observations as well as in climate model simulations. Usually referred to as Arctic amplification, it is generally recognized that the surface albedo feedback governs the response. However, a number of feedback mechanisms play a role in AA, of which those related to the prevalent near-surface inversion have received relatively little attention. Here we investigate the role of the near-surface thermal inversion, which is caused by radiative surface cooling in autumn and winter, on Arctic warming. We employ idealized climate change experiments using the climate model EC-Earth together with ERA-Interim reanalysis data to show that boundarylayer mixing governs the efficiency by which the surface warming signal is 'diluted' to higher levels. Reduced vertical mixing, as in the stably stratified inversion layer in Arctic winter, thus amplifies surface warming. Modelling results suggest that both shortwave—through the (seasonal) interaction with the sea ice feedback—and longwave feedbacks are affected by boundary-layer mixing, both in the Arctic and globally, with the effect on the shortwave feedback dominating. The amplifying effect will decrease, however, with climate warming because the surface inversion becomes progressively weaker. We estimate that the reduced Arctic inversion has slowed down global warming by about 5% over the past 2 decades, and we anticipate that it will continue to do so with ongoing Arctic warming.