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Why is the Arctic warming?

R. G. Graversen, M. Tjernström, E. Källén and T. Mauritsen

Department of Meteorology, Stockholm University, Sweden. (Corresponding author: rune@misu.su.se.)

The warming of the near-surface air in the Arctic region has been larger than the corresponding global mean warming during the last decades. This is referred to as the Arctic amplification.

Several mechanisms have been suggested in order to explain the Arctic amplification. It has generally been accepted that snow- and ice-albedo feedbacks are playing a dominant role. Models ranging from simple box models to complex coupled climate models almost all agree on the effect that when the global temperature rises, the high-latitude snow and ice cover retreats causing albedo changes and excessive warming here. Another mechanism is related to the fact that stable boundary-layer conditions are often prevailing in the polar areas. Consequently, it is believed that energy input at the surface induces a larger surface-warming response at high latitudes than elsewhere.

A common characteristic of both these mechanisms is that the warming response should be largest at the surface. However, we present results suggesting that for winter and summer seasons, the warming of the Arctic atmosphere is largest at levels well above the ground. In the area north of 70° N, and in the summer season, when the ice-albedo effect is expected to be considerable, a warming reaching 0.5 $^\circ$C per decade is found at levels around 1-2 km whereas the corresponding surface warming is only about 0.2 $^\circ$C per decade. These results are based on ERA-40 reanalysis data from the European Center for Medium Range Weather Forecast.

Other mechanisms, which are important for the Arctic amplification, and which are consonant with the observed vertical structure of the Arctic warming, include changes of cloudiness in the Arctic and changes of mid-latitude circulation patterns associated with increases in northward energy and moisture advection. We find that a small but statistically significant part of the Arctic warming is due to an increase in the atmo-

spheric northward energy transport (ANET) across 60° N. This effect is largest in the spring and autumn seasons when ANET across 60° N explains at least 20 % of the Arctic surface warming.