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Dynamic and thermodynamic drivers of Arctic extreme near surface temperature anomalies

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Recent decades have revealed dramatic changes in the high Arctic (> 80°N) related to both natural variability and anthropogenic climate change. In particular, recent episodes of warm temperatures and their role for sea ice melting have gained considerable attention. While it has been recognized that injections of warm and humid air masses contribute to wintertime warm anomalies, summertime warm anomalies have been linked to blocking anticyclones within the high Arctic. Yet, the relative importance of the many possible processes that could contribute to the formation of extreme warm as well as cold temperature anomalies in the high Arctic is poorly understood.

In this work we present a systematic analysis of the processes leading to the formation of winter- and summertime extreme near surface temperature anomalies in the high Arctic by means of kinematic backward trajectories based on the ERA-Interim reanalysis. Warm temperature anomalies, for example, can form due to transport from (potentially) warmer regions - accomplished by meridional advection from the south and subsidence from aloft -, and diabatic warming. The trajectories enable us to assess the relative contributions of these processes. Furthermore, we relate the processes to atmospheric dynamical flow features such as atmospheric blocking and extratropical cyclones.

Our analyses reveal that cold anomalies occur preferentially in the aftermath of a strengthening of the tropospheric polar vortex and the associated sheltering of the Arctic from meridional air mass exchange, which results in sustained radiative cooling of the air masses within the high Arctic. Subsidence in blocking anticyclones and diabatic warming are the key mechanisms leading to wintertime warm anomalies, whereas the transport from southerly latitudes is of secondary importance only. Summertime warm anomalies, in contrast, are essentially the result of subsidence in blocking anticyclones. Thus, our findings point towards a rich, seasonally varying spectrum of processes contributing to Arctic extreme temperature anomalies that result from a complex interplay between transport induced by dynamical weather systems and diabatic processes.