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On the relation between Arctic Amplification, the Arctic inversion and the lapse-rate feedback

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The representation of the Arctic temperature inversion in climate models has been suggested to play an important role for Arctic Amplification in recent studies. In contrast to the Tropics, the absence of moist deep convective mixing in the stably stratified Arctic atmosphere is expected to lead to a stronger warming near the surface than higher up in the atmosphere. For a given surface warming, this results in a smaller increase in OLR compared to a vertically uniform warming – an effect known as the regionally positive lapse-rate feedback, conceptually already alluded to by Manabe and Wetherald (1975).

This understanding was challenged by an analysis of CMIP3 model results, where stronger inversions, which should be associated with a positive lapse-rate feedback, instead correlate with a stronger negative longwave feedback, and are therefore indicative of less warming under climate change (Boé et al. 2009). We find that statistical self-correlation explains the majority of the signal found, and hence the implied relation between inversion strength and Arctic warming was mainly an artifact of the analysis-framework using ocean temperature change. No relation between inversion strength and Arctic amplification is found among the CMIP3 models when using instead the conventional surface air temperature change in the analysis.

Another study qualitatively confirmed the original understanding of the influence of a positive lapse-rate feedback in Arctic Amplification by varying the turbulence diffusivity under stable stratification in the EC-Earth climate model (Bintanja et al. 2011). Here we attempt to verify this result by varying turbulence diffusivity in the ECHAM 6.0 climate model within a realistic range. We find a significantly smaller impact on Arctic Amplification than Bintanja et al. (2011) in the preliminary results of experiments where we quadruple the CO_2 concentration. The impact in ECHAM 6.0 is found mainly to be due to an increased sea-ice cover in the control climate and the associated strengthening of the ice-albedo feedback as the ice melts away. A smaller part of the already small enhancement of Arctic Amplification can be attributed to a change in the longwave feedback, which includes the lapse-rate feedback.

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