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Asymmetry of the surface air temperature response on climatological heat imbalances due to differences in the planetary boundary layer height

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There are a number of asymmetries in the surface air temperature response to forcing including polar amplification and changes to the diurnal and seasonal temperature ranges. We propose that such spatial-temporal signatures of climate change can, in part, be explained from differences in effective heat capacity of the atmosphere – defined by the depth of the planetary boundary-layer. We have demonstrated that predictions arising from this hypothesis are simultaneously satisfied through the analysis of temperature records from daily to inter-decadal timescales using observational and reanalysis datasets. This mechanism can help explain why we see the largest temperature trends in the winter months (0.42 K/decade in winter compared to 0.18 K/decade in summer) and why diurnal temperature range decreases in a warming world, having decreased by $\sim$0.4 K since 1950.
The unevenness in effective heat capacity of the atmosphere also underlies some of the global differences in natural variability, which explains the difficulty in identifying the signature of anthropogenic global warming against the background of natural variability, even in places with rapid warming such as the arctic.