

Overview

The manuscript investigates the contribution of the surface temperature inversion to projected 21st-century near-surface warming in Antarctica. The authors downscale four CMIP6 GCMs using the regional atmospheric model MAR. They show that an important share of future warming in Antarctica is caused by decrease in surface inversion. They show that the changes in this inversion are not homogeneous around Antarctica, providing the major contribution over the sea ice. We believe that the approach followed by the authors is well suited to the research question, and the methodology is clearly presented, although it is missing some details. The results section is comprehensive but dense. Many statistics are reported in the text, and the main findings could be highlighted more clearly. Overall, the study is well formulated and innovative, but some sections could be rewritten or expanded for more completeness. We provide hereafter some changes and questions we recommend the authors to address by sections:

Introduction: The introduction includes an extensive explanation of the mechanisms for polar amplification and, specifically, with a large set of references. It is in general well written, but there is room for improvement. For example:

- L1-54: Right now, the first part of the introduction is merging constantly the more general polar amplification processes with the more specific Antarctic counterpart. This makes it difficult to follow whether the authors are talking about one or the other. We recommend to clearly separate the two.
- L 38 (and by extension all the paragraph L38-54): It suggests that temperature inversion is another feature not previously explained. However it is already explained in L 27, since it is very tied to the positive lapse-rate feedback as the authors later explain. Linking with our previous comment, the first paragraph could be more focused on general polar feedbacks and the second on Antarctic specific. This would improve the readability of the introduction.
- L. 50-54: The current version reads as if the presence of a cold inversion generates surface warming by itself. It should be specified that this occurs only under warming conditions.
- L65-75: This part seems more suitable for Methodology. It is indeed summarized and repeated in L76-77. It can be replaced by a more general paragraph stating how RCMs (not MAR specific; but also RACMO, PWRF, CRYOWRF, HCLIM) are able to improve our confidence on boundary-layer processes with respect to GCMs. It would be interesting to include either vertical resolution factors and physical processes not resolved by GCMs and included in different RCMs.

Methods: The analysis relies heavily on MAR's ability to simulate the stable boundary layer and the surface inversion, yet the model description does not state the turbulence closure or the surface-layer stability correction functions. Neither of the cited papers of Kittel (2021) or Davrinche (2024) state this either. In strongly stable conditions, the amount of mixing varies slightly depending on the stability correction function.

- L. 96-97: Maybe you could add a short sentence on what equilibrium climate sensitivity means in this context.

- L. 105: 2m is usually in atmospheric models a diagnosed variable and not a model layer. Can the authors confirm that it is a model layer?
- Furthermore, 24 vertical layers are in the lower end for RCMs. Since the study is based on the vertical profile, is this number of layers enough to properly resolve the atmospheric profile and measuring the temperature deficit?
- L.100-118: What is the horizontal resolution of the downscaling?
- L. 179-176: The magnitude of TKE is dependent on the turbulence closure used in the PBL scheme of MAR. Shortly describe which PBL scheme is used in the simulations
- L. 178-180: Define the meaning of the symbols straight after the equation.

Results:

- Table 2: The correlation between TKE and WS is to be expected when using certain local E-closure TKE schemes. Therefore the TKE scheme should be mentioned (see methods) and the meaning of these correlations should be revisited based on how the variables are defined.
- L. 264 - 2645: 'the ability of surface inversions to increase atmospheric stability' - A surface inversion is stable stratification by definition, so it can not "increase" atmospheric stability, and this is also not shown from the results.

Discussion:

- The uncertainties of the results should be discussed in more detail, in particular those related to the representation of the stable boundary layer in MAR. Davrinche et al. (2024) report that MAR overestimates near-surface wind speeds in stable conditions on the plateau and attribute that to the local turbulence scheme. This could be a useful discussion point in the results of this study. Also, the results are sensitive to the stability correction functions and briefly discuss the expected sensitivity.
- L. 389- 400. The authors compare different PAF with the ones found in their study. although they state that PAF in literature is calculated using different methods, they do not stress that maybe the main source of difference is the period calculated. In this case, the authors only focus on July (core winter), when PAF may be higher.
- The same principle applies for discussing paleoclimate research.