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Matters arising

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Reply to: Observed warming of cold extremes is not captured with a fixed threshold definition

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REPLYING TO R. Blackport & M. Sigmond *Communications Earth & Environment* https://doi.org/10.1038/s43247-025-02629-y (2025)

Blackport and Sigmond[1] argue that in Cohen et al.[2] our method of computing trends on cold extremes (that is, keeping the definition of a cold extreme fixed over the entire period (coldest 5% of days 1960–2023)) artificially masked any warming trends in cold extremes. We chose this method to avoid the case where no trend appears in a limited period, for example, since 2000, but clearly, the cold extremes are warmer than in the previous period 1960–2000 due to the warming being more of a step function than a gradual trend. By keeping the definition of a cold extreme fixed across the entire period of analysis, we believed that would make it harder to identify a cold extreme in the latter milder winters. Alternatively, with a moving or non-fixed definition of a cold extreme in effect, we would be comparing cold extremes that were defined differently across periods, and not a consistently defined cold extreme.

Blackport and Sigmond[1] use synthetic data to demonstrate that, even with warming temperatures including cold extremes, by using a fixed threshold no statistically significant trends can be detected in cold extremes. If, instead, cold extremes are defined only within the period of analysis, then the warming trend in cold extremes can be correctly detected. We did consider computing the trend in cold extremes using a moving threshold as suggested by Blackport and Sigmond[1] where cold extremes are computed only in the period for which the trend is being considered. We also acknowledge that no metric of measuring a trend in cold extremes is perfect, and multiple methods and metrics are likely needed for a comprehensive understanding of changes in cold extremes.

We show box and whisker plots of Arctic and CEUS temperature, where cold extremes are computed for each decade separately in keeping with the guidance of Blackport and Sigmond[1]. In the Arctic (Fig. 1), both cold extremes and mean temperatures have steadily warmed, and post-2010, none of the observed cold extremes reach the extremity of the warmest cold extremes observed before 1980. In the CEUS (Fig. 2), the box and whisker plot does not resemble so much a linear warming trend across the decades but more like a step function with cold extremes and mean temperatures steady from 1960 through 1990 and again steady from 1990 through the present at a warmer temperature. Visually there is no trend in cold extremes during the period of AA (post-1990) in the CEUS, even though a moving threshold is applied. And in stark contrast to Arctic temperatures, cold extremes in the CEUS in the most recent decade are comparable to those from the previous five decades going back to 1960. Though from Fig. 2 the mean temperature of cold extremes is higher during the period of AA than before the period of AA.

We also note that Table 1 from Blackport and Sigmond[1] (comparing a fixed threshold of cold extremes and a moving threshold of cold extremes) shows little difference in trends in cold extremes during the period of AA. In the CEUS, negative trends were found since 2000 for both methods, and in SSNC, the moving threshold resulted in a larger negative trend since 1990. In the period of AA for the CEUS and SSNC regions, only the trend in the CEUS since 1990 became statistically significant.

In summary, we welcome the Blackport and Sigmond Matters Arising piece[1] as it provides greater context to the trends in cold extremes across the mid-latitude continents. We emphasize that no single metric can fully capture the character and changes in extreme events. Our original paper of Cohen et al.[2] and the criticism of Blackport and Sigmond[1] demonstrate that identification and analysis of cold extremes are sensitive to the definition of a cold extreme. Future studies of cold extremes and trends provide greater context when multiple approaches to the analysis are used rather than just one.

However, we also don't feel that using an alternative trend computation of using a moving threshold of cold extremes negates our general conclusions that global warming has led to a detectable warming of cold extremes, but that warming is not consistent with AA in several mid-latitude locations. This is further supported by the fact that between the two methodologies for the CEUS and SSNC regions, in seven of the eight trends computed for the two definitions of the recent period, no statistically significant warming trend was found. Therefore, the alternative derivations of cold extremes in our study and that of Blackport and Sigmond[1] do not necessarily produce contradictory results or conclusions. Moreover, our interpretation is not based solely on our analysis. A recent study on mid-latitude cold extremes corroborated our findings using a completely independent analysis of non-stationary generalized extreme value (GEV) distribution, which assumes non-stationary climate change as Blackport and Sigmond[1] advocate. Ye

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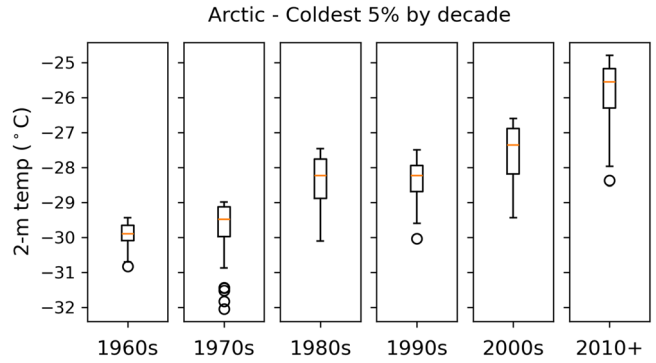

Fig. 1 | Boxplots (25–75th percentiles) of the coldest 5% 2-meter temperatures in the Arctic region (70–90°N) for each decade 1960–2023. The threshold is applied for each decade separately.

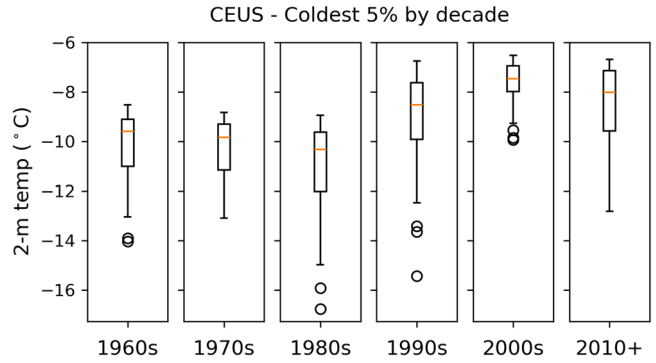

Fig. 2 | Boxplots (25–75th percentiles) of the coldest 5% 2-meter temperatures in the CEUS region (30–50°N, 250–285°E) for each decade 1960–2023. The threshold is applied for each decade separately.

et al.[3] conclude: "These findings are in line with the conclusions of Cohen et al.[2] that the changes in the frequency of winter cold events in some mid-latitude regions may be influenced mainly by global warming rather than by Arctic amplification".

Data availability

The ERA5 reanalysis data[4] sets cover the period from 1950 to present with a resolution of approximately 30 km, which can be accessed at https://www.ecmwf.int/en/forecasts/dataset/ecmwf-reanalysis-v5.

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Author contributions

J.C., L.A., M.B. and D.E. all contributed to the writing of the text. J.C. and L.A. designed the figures.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s43247-025-02630-5.

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