No detectable trend in mid-latitude cold extremes during the recent period of Arctic amplification

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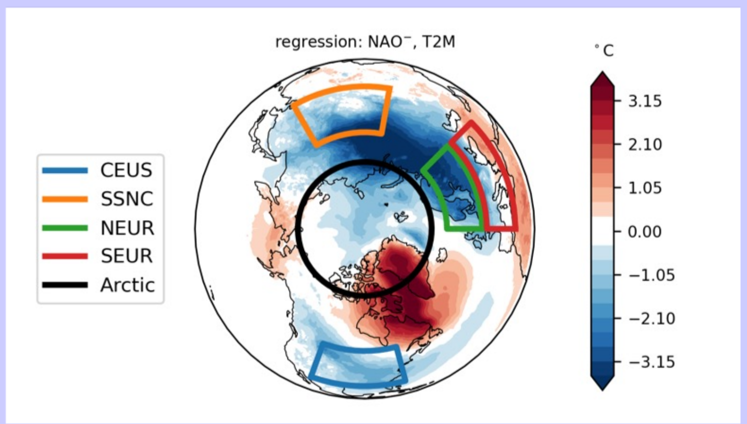

INTRODUCTION. **It is widely accepted that Arctic amplification—accelerated Arctic warming—will increasingly moderate cold air outbreaks to the mid-latitudes. Yet, an increasing number of recent studies also argue that Arctic amplification can contribute to more severe winter weather. Here we show that the temperature of cold extremes across the United States east of the Rockies, Northeast Asia and Europe have remained nearly constant over recent decades, in clear contrast to a robust Arctic warming trend. Analysis of trends in the frequency and magnitude of cold extremes is mixed across the US and Asia but with a clearer decreasing trend in occurrence across Europe, especially Southern Europe. This divergence between robust Arctic warming and no detectable trends in mid-latitude cold extremes highlights the need for a better understanding of the physical links between Arctic amplification and mid-latitude cold extremes.**

Figure. Eastern US, Northern Europe and East Asia all share cold temperatures during the negative polarity of the NAO. Northern Hemisphere December–February (DJF) surface temperatures are regressed onto the NAO index shown for the negative polarity. Also shown are the five mid-latitude regions of analysis: Central and Eastern US (CEUS), Southern Siberia and Northern China (SSNC), Northern Europe (NEUR) and Southern Europe (SEUR).

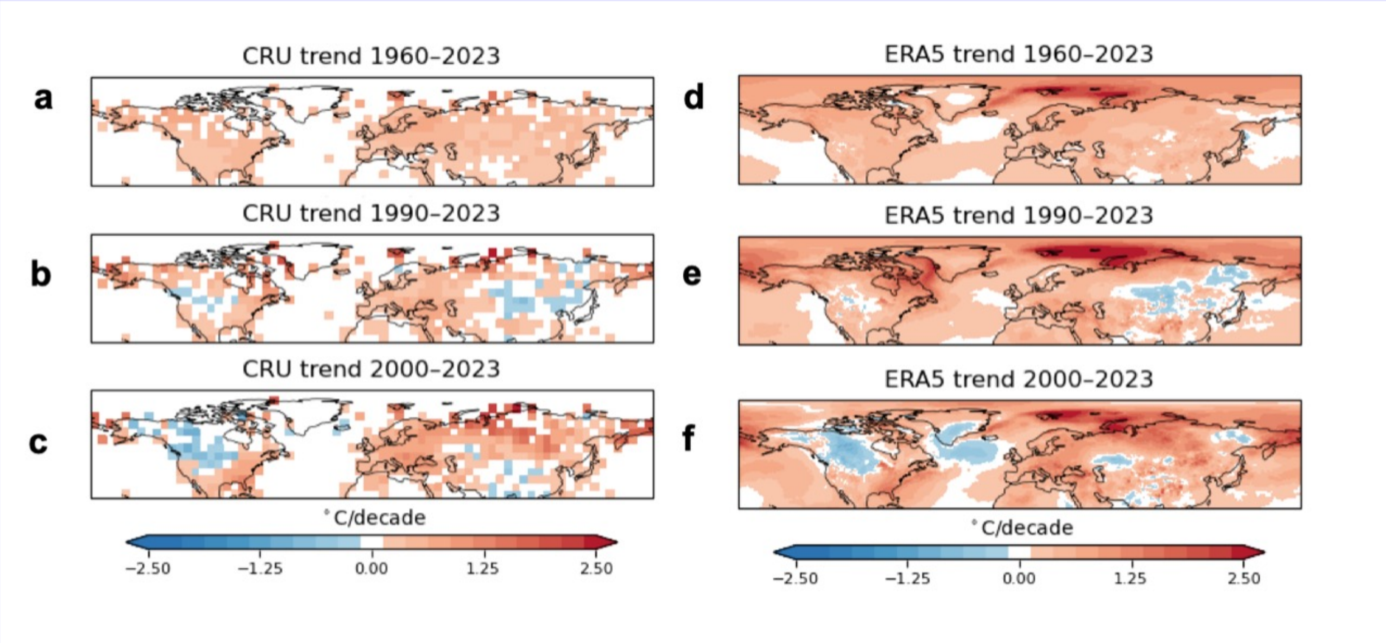

Figure 1. Arctic and mid-latitude temperatures trends are consistent since 1960 but in parts diverge during AA. Northern Hemisphere DJF temperature anomaly trends since a 1960, b 1990 and c 2000 using CRU data. d-f same as a-c but using ERA5.

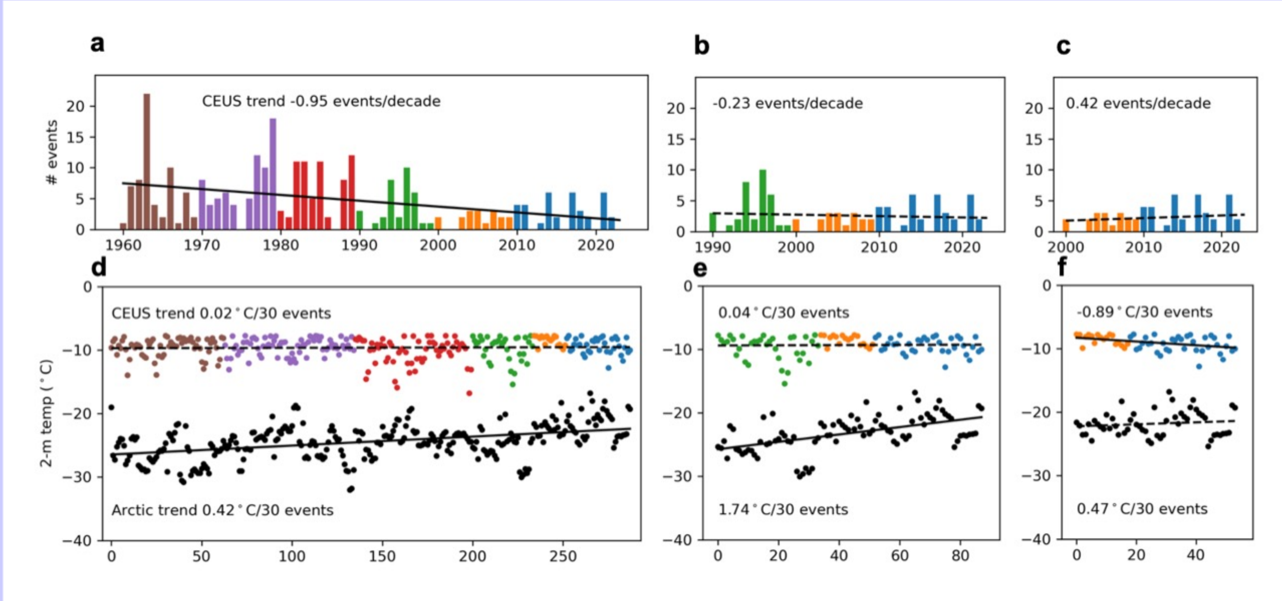

Figure 2. A robust warming trend is observed in the Arctic but no consistent trend is found for Eastern US cold extremes. Frequency of Central-Eastern US (CEUS; shown in Figure above) DJF 5% coldest events for **a** 1960–2023, **b** 1990–2023, and **c** 2000–2023, demarked with colored bars to represent each decade, and showing the linear trend line. The slope of the trend line is indicated in each panel (events/decade). The temperature for each cold CEUS event (colored dots) is shown in panels **d**, **e** and **f** for the same time periods as in panels **a**, **b** and **c**. Corresponding Arctic temperatures are shown with black dots. The trend lines indicate tendency in temperature over the ordered events, and the slope of the trend is indicated in each panel (°C per 30 events). Trend lines are shown solid if trend is significant at the 0.05 level, dashed otherwise.

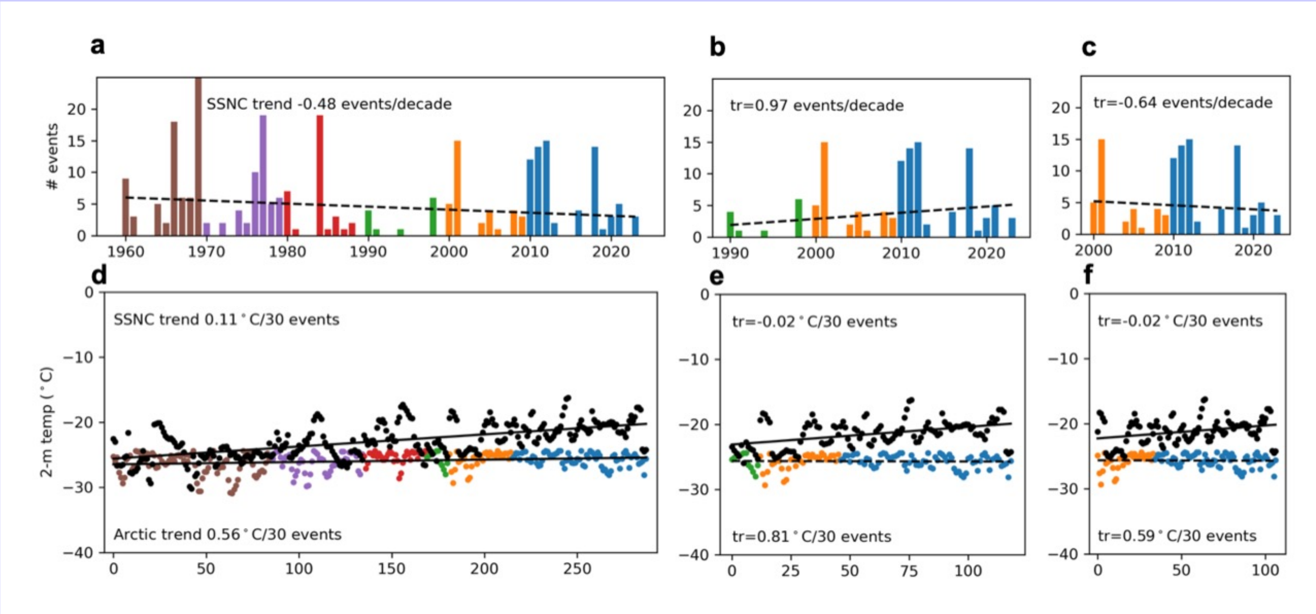

Figure 3. A robust warming trend is observed in the Arctic but no consistent trend is found for Northeast Asia cold extremes. Frequency of Northeast Asia (SSNC; see Figure 1) DJF 5% coldest events for **a** 1960–2023, **b** 1990–2023, and **c** 2000–2023, demarked with colored bars to represent each decade, and showing the linear trend line. The slope of the trend line is indicated in each panel (events/decade). The temperature for each cold SSNC event (colored dots) is shown in panels **d**, **e** and **f** for the same time periods as in panels **a**, **b** and **c**. Corresponding Arctic temperatures are shown with black dots. The trend lines indicate tendency in temperature over the ordered events, and the slope of the trend is indicated in each panel (° C per 30 events). Trend lines are shown solid if trend is significant at the 0.05 level, dashed otherwise.

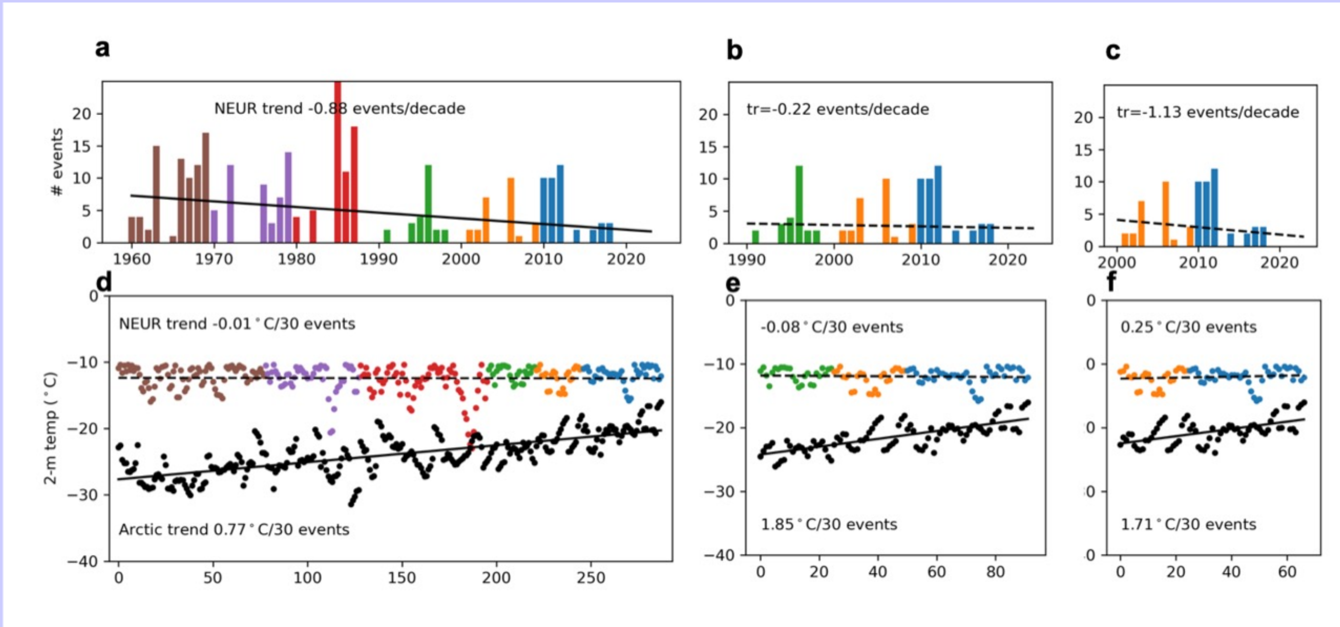

Figure 4. A robust warming trend is observed in the Arctic but no consistent trend is found in the magnitude of Northern Europe cold extremes. Frequency of Northern Europe (NEUR; see Figure 1) DJF 5% coldest events for **a** 1960–2023, **b** 1990–2023, and **c** 2000–2023, demarked with colored bars to represent each decade, and showing the linear trend line. The slope of the trend line is indicated in each panel (events/decade). The temperature for each cold NEUR event (colored dots) is shown in panels **d**, **e** and **f** for the same time periods as in panels **a**, **b** and **c**. Corresponding Arctic temperatures are shown with black dots. The trend lines indicate tendency in temperature over the ordered events, and the slope of the trend is indicated in each panel (° C per 30 events). Trend lines are shown solid if trend is significant at the 0.05 level, dashed otherwise.

SUMMARY. Our analysis shows that, despite the dramatic Arctic warming in the recent period, the temperature of cold extremes in three key midlatitude regions has stayed nearly constant; that is, there has not been a corresponding moderation of midlatitude cold extremes associated with AA. There is a clear divergence between Arctic temperatures, which are increasing rapidly, and the temperature of cold extremes in the central-eastern US, northeast Asia and even Europe which have remained mostly stable. Over the full period, the frequency of cold extremes in those regions has decreased, although this trend is often neutral or increasing during the more-recent period of AA. That is, for the US east of the Rockies and Northeast Asia regions and to a lesser degree Northern Europe, the changes in frequency are consistent with an overall direct influence from global warming but not from AA, based on the trend behavior in the different periods.

Reference: Cohen, J., L. Agel, M. Barlow and D. Entekhabi, 2023: No detectable trend in mid-latitude cold extremes during the recent period of Arctic amplification. *Comm. Earth & Env.*, https://doi.org/10.1038/s43247-023-01008-9.