3. Rockstrom, J. et al. *Science* **355**, 1269–1271 (2017).
4. Rekker, S., O'Brien, K. & Humphrey, J. *Nat. Clim. Change* **8**, 489–492 (2018).
5. Du Pont, Y. R. et al. *Nat. Clim. Change* **7**, 38–43 (2017).
6. Public Consultation. *Science Based Targets Initiative* https://sciencebasedtargets.org/oil-and-gas/ (2020).
7. *The Oil and Gas Industry in Energy Transitions* (International Energy Agency, 2020); https://www.iea.org/reports/the-oil-and-gas-industry-in-energy-transitions
8. Folke, C. et al. *Nat. Ecol. Evol.* **3**, 1396–1403 (2019).
9. Aberdeen Standard Investments et al. Oil and gas groups must do more to support climate accord. *Financial Times* https://www.ft.com/content/fda63c26-5906-11e8-b8b2-d6ceb45fa9d0 (2018).
10. *Recommendations of the Task Force on Climate-related Financial Disclosures* (TCFD, 2017); https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Report-062817.pdf
11. Hutley, N. & Hartford-Davis, S. *Climate Change and Directors' Duties: Memorandum of Opinion* (The Centre for Policy Development and the Future Business Council, 2016).
12. Hutley, N. & Hartford-Davis, S. *Climate Change and Directors' Duties: Supplementary Memorandum of Opinion* (The Centre for Policy Development and the Future Business Council, 2019).

Competing interests

The authors declare no competing interests.

Weakened evidence for mid-latitude impacts of Arctic warming

To the Editor — The idea that rapid Arctic warming might be changing weather patterns at lower latitudes rose to prominence in 2012. At that time, amidst rising global temperatures and record low Arctic sea-ice cover, parts of the mid-latitudes had just experienced a run of extremely cold winters[1]. Some scientists speculated that these cold snaps were driven by Arctic-induced changes in the atmospheric circulation, pointing to an unexpected 25-year winter cooling trend over Eurasia, an ostensible shift in the Arctic Oscillation and increased meandering of the jet stream as evidence[2,3]. These tendencies would continue as the Arctic warmed further, they predicted. Such ideas were controversial from the outset. Very quickly, other scientists questioned the idea, arguing that the cooling and circulation trends were not robust and unlikely to continue in the longer term[4,5]. Jennifer Francis, whose seminal work proposed that Arctic warming was leading to a wavier jet stream, predicted in 2014 that "within a few years, as Arctic amplification continues, we will have enough data to know whether or not we're right"[6].

So, six years on, what has changed? Arctic amplification and sea-ice loss have indeed continued (Fig. 1). But predictions of a more negative Arctic Oscillation, wavier jet stream, colder winters in mid-latitudes or, more specifically, in Eurasia, and more frequent and/or widespread cold extremes have not become reality (Fig. 1). The short-term tendencies from the late 1980s through to early 2010s that fuelled the initial speculation of Arctic influence have not continued over the past decade (Fig. 1). Long-term trends in the Arctic Oscillation and waviness, updated to winter 2019/20, are small and indistinguishable from internal variability (Fig. 1). Temperature-related metrics all indicate warming in the longer term, with fewer and milder cold extremes (Fig. 1). The multidecadal warming of minimum daily temperature is larger than that of average winter temperature (Fig. 1), implying a detectable reduction in mid-latitudes of subseasonal temperature variability[7].

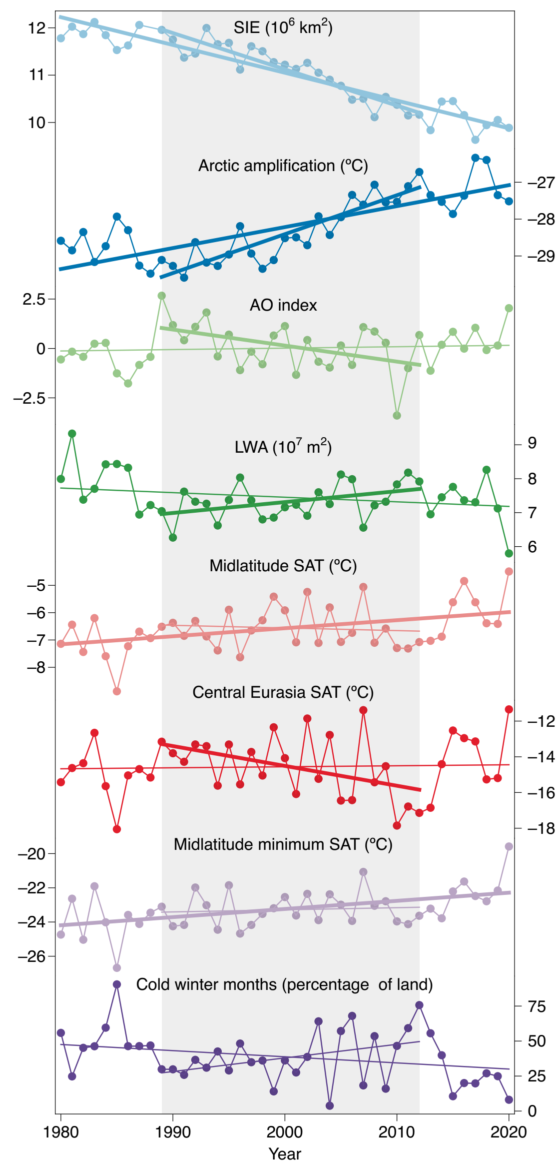

Fig. 1 | Indicators of Arctic change and its possible mid-latitude impacts. Time series of Arctic sea-ice extent (SIE; light blue), Arctic amplification (dark blue), Arctic Oscillation (AO; light green), atmospheric waviness (dark green), midlatitude (30–60° N) land surface air temperature (SAT; light red), central Eurasia (40–60° N; 60–120° E) SAT (dark red), midlatitude land minimum daily SAT (light purple) and the percentage area of mid-latitude land experiencing at least one cold (1 s.d. below average) winter month (dark purple). The SIE and Arctic amplification indices are averages for autumn and winter (September–February), whereas all other indices are for winter (December–February). Linear trends are shown for two time-periods: 1979/80 to 2019/20 and 1988/89 to 2011/12, the latter highlighted by grey shading. Thicker lines demark trends significant at the 95% confidence level. Arctic amplification is defined as the difference between Arctic (65–90° N) and Northern Hemisphere (0–90° N) SAT. Waviness is defined by the local wave activity[11] (LWA) averaged over mid-latitudes (40–60° N). The Arctic sea-ice index was provided by the National Snow and Ice Data Center[21]. Atmospheric indices were calculated from the European Centre for Medium-Range Weather Forecasts ERA-5 reanalysis[23], except for the Arctic Oscillation that was provided by the NOAA Climate Prediction Center.

Also, over the past six or so years, there has been a surge of modelling studies suggesting only a weak influence of Arctic warming on mid-latitudes[8–13]. The magnitudes of the simulated responses are consistently weaker than observations might imply, for reasons that are uncertain and contentious[14–16]. A recent review concluded that observations provide strong evidence of Arctic influence on mid-latitudes[16]; this conclusion, however, was drawn from surveying influential studies that reported now-outdated trends. We argue that updated observational and reanalysis records (Fig. 1) tell much the same story as models: that the Arctic influence on mid-latitudes is small compared to other aspects of climate variability, and that observed periods of strong correlation (such as 1988/89 to 2011/12) are an artefact of internal variability[11,17,18].

An alternative interpretation is that causal relationships are intermittent[19,20], being strong at times and weak at other times. Our opinion, however, is there is not enough evidence for, or physical understanding of, intermittency in Arctic-to-mid-latitude connections to allow us to disregard the simpler explanation. That is, short-term fluctuations in the coherence of Arctic and mid-latitude trends are a manifestation of internal variability, and the forced response to Arctic warming, better estimated from long-term trends and/or models, is weak in mid-latitudes. Regardless of the cause, and despite continued Arctic amplification, the reversal in the past decade of prior tendencies and the absence of long-term trends in the Arctic Oscillation, jet stream waviness and Eurasian winter temperatures should be better acknowledged in the scientific literature. It is indefensible to continue to rely on past short-term trends, which have since disappeared, as evidence of a large influence of Arctic warming on mid-latitude winter climate and extreme weather[14,16]. Here we have shown that multiple metrics purported to be affected by Arctic amplification corroborate a weakening of evidence for detectable mid-latitude effects of Arctic warming. ❐

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Published online: 16 November 2020
https://doi.org/10.1038/s41558-020-00954-y

References

1. Cohen, J. et al. *Nat. Geosci.* **7**, 627–637 (2014).
2. Francis, J. A. & Vavrus, S. J. *Geophys. Res. Lett.* **39**, L06801 (2012).
3. Cohen, J. L., Furtado, J. C., Barlow, M. A., Alexeev, V. A. & Cherry, J. E. *Environ. Res. Lett.* **7**, 014007 (2012).
4. Screen, J. A. & Simmonds, I. *Geophys. Res. Lett.* **40**, 959–964 (2013).
5. Barnes, E. A. *Geophys. Res. Lett.* **40**, 4734–4739 (2013).
6. Kintisch, E. *Science* **344**, 250–253 (2014).
7. Screen, J. A. *Nat. Clim. Change* **4**, 577–582 (2014).
8. McCusker, K. E., Fyfe, J. C. & Sigmond, M. *Nat. Geosci.* **9**, 838–842 (2016).
9. Sun, L., Perlwitz, J. & Hoerling, M. *Geophys. Res. Lett.* **43**, 5345–5352 (2016).
10. Blackport, R., Screen, J. A., van der Wiel, K. & Bintanja, R. *Nat. Clim. Change* **9**, 697–704 (2019).
11. Blackport, R. & Screen, J. A. *Sci. Adv.* **6**, eaay2880 (2020).
12. Dai, A. & Song, M. *Nat. Clim. Change* **10**, 231–237 (2020).
13. Ogawa, F. et al. *Geophys. Res. Lett.* **45**, 3255–3263 (2018).
14. Mori, M., Kosaka, Y., Watanabe, M., Nakamura, H. & Kimoto, M. *Nat. Clim. Change* **9**, 123 (2019).
15. Screen, J. A. & Blackport, R. *Nat. Clim. Change* **9**, 934–936 (2019).
16. Cohen, J. et al. *Nat. Clim. Change* **10**, 20–29 (2020).
17. Kolstad, E. W. & Screen, J. A. *Geophys. Res. Lett.* **46**, 7583–7591 (2019).
18. Warner, J. L., Screen, J. A. & Scaife, A. A. *Geophys. Res. Lett.* **47**, e2019GL085679 (2020).
19. Overland, J. E. et al. *Nat. Clim. Change* **6**, 992–999 (2016).
20. Siew, P. Y. F., Li, C., Sobolowski, S. P. & King, M. P. *Weather Clim. Dynam.* **1**, 261–275 (2020).
21. Fetterer, F., Knowles, K, Meier, W. N, Savoie, M. & Windnagel, A. *Sea Ice Index* Version 3 (National Snow and Ice Data Center, 2017).
22. Arctic oscillation. *NOAA Climate Prediction Center* https://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/ao.shtml (2020).
23. Hersbach, H. et al. *Q. J. Roy. Meteor. Soc.* **146**, 1999–2049 (2020).

Acknowledgements

The authors were supported by a UK Natural Environmental Research Council (NERC) grant (NE/P006760/1). The sea-ice extent data are available from the National Snow and Ice Data Center[21]. The Arctic Oscillation index is provided by the NOAA Climate Prediction Center (ref. [22]). ERA-5 reanalysis[23] data are freely available at the Copernicus Climate Change Service Climate Data Store (https://cds.climate.copernicus.eu/cdsapp#!/home).

Competing interests

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