COMMENT

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A new record minimum for Antarctic sea ice

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Antarctic sea ice extent reached a new record low of 1.965 million km^2 on 23 February 2022. This extent is approximately 32% below climatological values and might indicate a transition to new, more extreme, annual fluctuations.

Typically, Antarctic sea ice reaches its maximum extent in mid-September, thereafter retreating to a February-March minimum that averaged 2.917 million km^2 over 1981–2010 (FIG. 1). On 23 February 2022, however, Antarctic sea ice extent (SIE) reached a record minimum of 1.965 million km^2, 0.918 million km^2 lower than the climatological average and 0.085 million km^2 lower than the previous record set in 2017 (FIG. 1a).

The causes of this new record minimum are yet to be identified, but can likely be related to an early winter maximum and a subsequent early retreat at the end of August 2021 (FIG. 1b), dominated by accelerated melt in the Bellingshausen and Weddell Seas. An early retreat in this instance means a longer melt season and a better-than-even chance of reaching below normal values in February[1]. A combination of atmospheric and oceanic drivers likely contributed to this early retreat. The world ocean reached record temperatures in 2021, and the Southern Ocean, an important anthropogenic heat sink[2], also exhibited warmer subsurface temperatures[3]; a warmer ocean leads to thinner ice formation, allowing easier breakup by wind and wave action. Surface pressure was also lower than normal over the continent and there was a persistently strong Amundsen Sea Low (ASL) for most of the year (Kyle Clem, personal communication); northerly winds on the eastern flank of the ASL can act to accelerate ice melt and limit sea ice expansion, and southerly winds on its western flank spreads the ice making it thinner and pushing it northward into warmer ocean where it melts.

This 2022 record comes a mere five years after the February 2017 minimum when SIE shrank to 2.049 million km^2, 0.868 million km^2 lower than the average (FIG. 1b). Not only was the 2017 minimum a record, the size of the reduction in SIE over the period 2015–2017 was unprecedented in both the satellite record (FIG. 1a) and the twentieth century[4]. Because SIE in the years following the 2017 minimum was also lower than average, the reduction (or anomaly) represented by the 2022 minimum is not as large. There are interesting similarities between the 2016–2017 and 2021–2022 seasons. Both were marked by early winter maxima and early retreat, within a day of each other, and both were led by rapid melting in the Bellingshausen Sea rather than synchronous retreat around the continent. The early retreat of sea ice leading to record minima emphasizes the influence of phase (the timing of advance and retreat) on the variability of Antarctic sea ice. The phase contributes about two-thirds of the variability in the daily annual cycle of Antarctic sea ice and was the main contributor to the record minimum in sea ice extent in 2017 (REF.[5]). The early retreat of sea ice in 2016 and subsequent melting to the 2017 record low was attributed to a confluence of factors, atmospheric and oceanic and the changing phase of the Interdecadal Pacific Oscillation[6], reflecting the complexity of the system that supports the variability in Antarctic sea ice.

Both the 2017 and 2022 record minima are standouts in an observed record marked by a small, but significant, positive (increasing) SIE trend since 1979 (FIG. 1a, yellow), contrasting the decline observed in the Arctic. Record-level interannual variability greatly influences the strength and persistence of such long-term trends. For instance, the record minimum in 2017 reduced the net SIE trend (FIG. 1a, purple) by almost 26%, from 21,348 km^2 yr^{-1} to 15,717 km^2 yr^{-1}. The subsequent years of lower-than-average SIE culminating in this new record minimum further reduced that trend by 74%, to 4,137 km^2 yr^{-1} (FIG. 1a, maroon).

Reconstructions of Antarctic sea ice suggest that negative trends existed across most of the twentieth century, and that the positive trend observed over the satellite era might have started in the late 1960s or early 1970s[4]. When the record minimum was reached in February 2017, it seemed to mark the start of a reversal of that positive trend. However, after maintaining subaverage values for 2018 and 2019, sea ice extent gradually reached average values by 2020. Given the history of SIE variation over the observational period, the SIE would be expected to stay at average levels or become above average for several more years. This current abrupt return to record minimum is thus surprising.

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https://doi.org/10.1038/s43017-022-00281-0

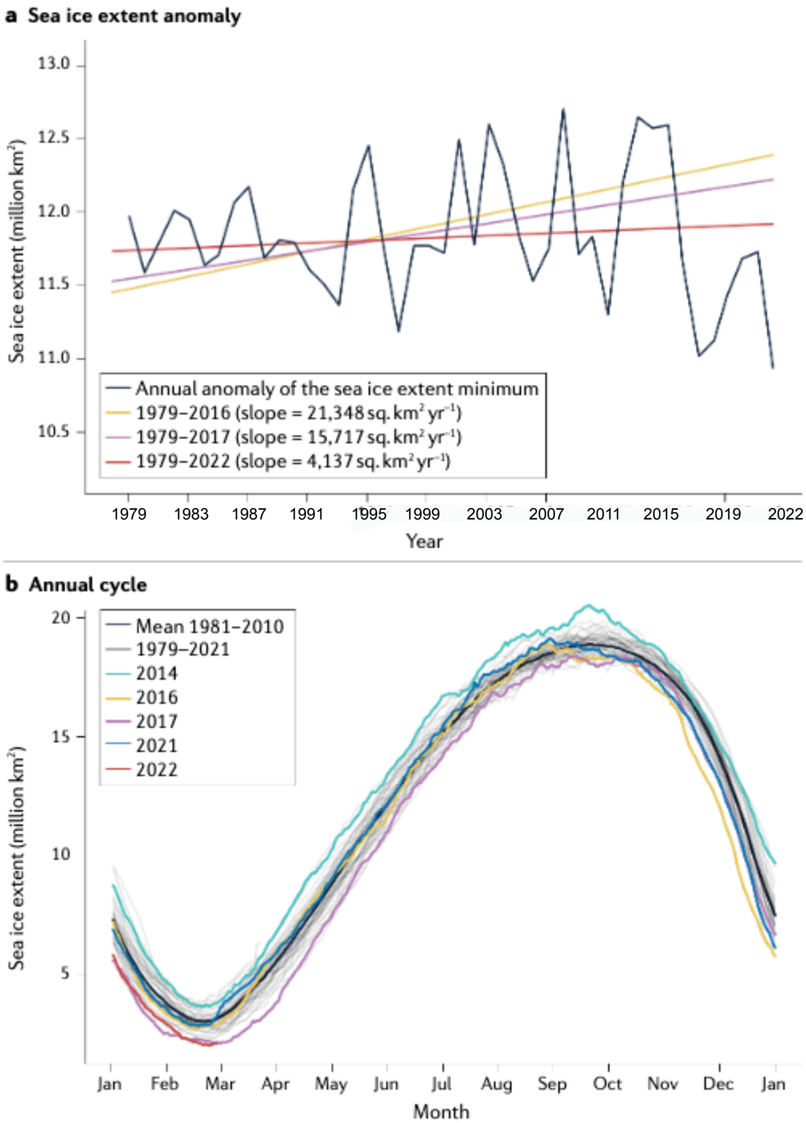

Fig. 1 | **Antarctic sea ice trends and variability. a** | Annual anomaly of Antarctic sea ice extent[8,9] and trends over 1979–2016 (yellow), 1979–2017 (purple) and 1979–2022 (maroon). **b** | Annual cycle of Antarctic sea ice extent for the 1981–2010 mean (black), 2014 (green), 2016 (yellow), 2017 (purple), 2021 (blue) and 2022 (maroon). Pale grey lines are the annual cycle of all individual years from 1979–2021 (REFS[8,9]). The positive trend in Antarctic sea ice, which was led by extremes in the maximum between 2011–2014, has been substantially reduced by the record minima in 2017 and 2022. Note, the sea ice extent values used are near real-time (NRT)[8] and will be confirmed when the NOAA/NSIDC Climate Data Record is updated.

The level of variability exhibited in 2016–2017 and 2021–2022 is unprecedented in the satellite record and might signal a change in the Antarctic sea ice regime as a response to anthropogenic warming. This change might not be a reversal of the trend, but rather a shift to a new state of stability where extremes become more common. Indeed, the new 2022 and 2017 minimums are part of the increased variability in Antarctic SIE that began around 2011, including the record winter maximum of 2014 (FIG. 1b). These record fluctuations thus suggest a new period of extremes — a changing sea ice regime.

Sustained low SIE and increasing variability in SIE have substantial consequences for the climate and ecology of the Antarctic. Sea ice is at the interface between the ocean and the atmosphere, moderating the flux of energy from one to the other. A sustained lack of sea ice can create feedback that will alter that exchange, ultimately altering the climate over the Southern Ocean and the continent. Sea ice can act as a buffer for ice shelves, protecting them from wave action, which can hasten disintegration, ultimately affecting the surface mass balance. Sea ice is a habitat for penguins, seals and other animals around Antarctica, with emperor penguin populations threatened by current and projected loss of sea ice[7]. These record minima in 2017 and 2022 might be the precursors of a period of extremes in SIE, making the future of Antarctic sea ice uncertain. However, further data and analysis are required to evaluate and verify any claims for a changing Antarctic climate.

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Acknowledgements
M.N.R. and M.S.H. are supported by the National Science Foundation, Office of Polar Programs (grant no. NSF-OPP-1745089).

Competing interests
The authors declare no competing interests.