Seasonal impact of Southern Annular Mode on Antarctic sea ice extent

Massachusetts Institute of Technology

Edward Doddridge & John Marshall, MIT, USA

The seasonal ice zone in the Southern Ocean is vast; it covers roughly the same area as Australia. Through analysis of remotely sensed sea surface temperature (SST) and sea ice concentration data, we investigate the impact of winds related to the Southern Annular Mode (SAM) on the seasonal cycle of sea ice extent around Antarctica.

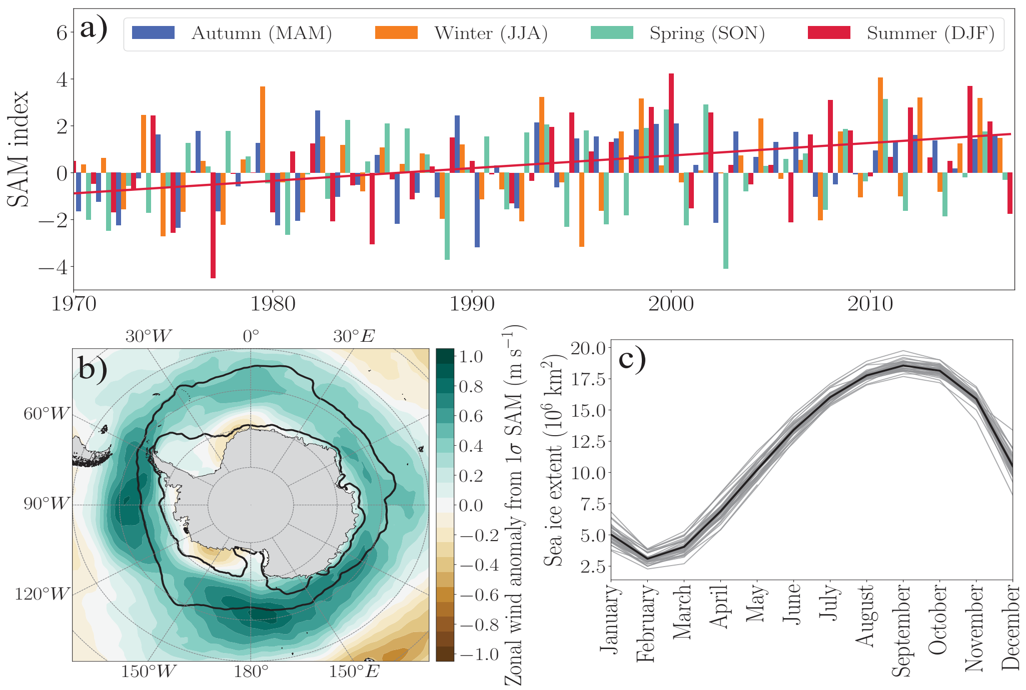


Fig. 1 a) Time series of seasonal Southern Annular Mode values, and trend line for austral summertime. Data from Marshall (2003). b) Zonal wind anomaly related to 1σ SAM anomaly from ERA-Interim reanalysis (Dee et al., 2011), and 15% sea ice concentration contours in February and September from NOAA optimal interpolation sea ice concentration. c) Seasonal cycle of sea ice extent in the Southern Ocean.

We show that positive SAM anomalies in the austral summer are associated with anomalously cold SSTs that persist and lead to anomalous ice growth in the following autumn, while negative SAM anomalies precede warm SSTs and a reduction in sea ice extent during autumn.

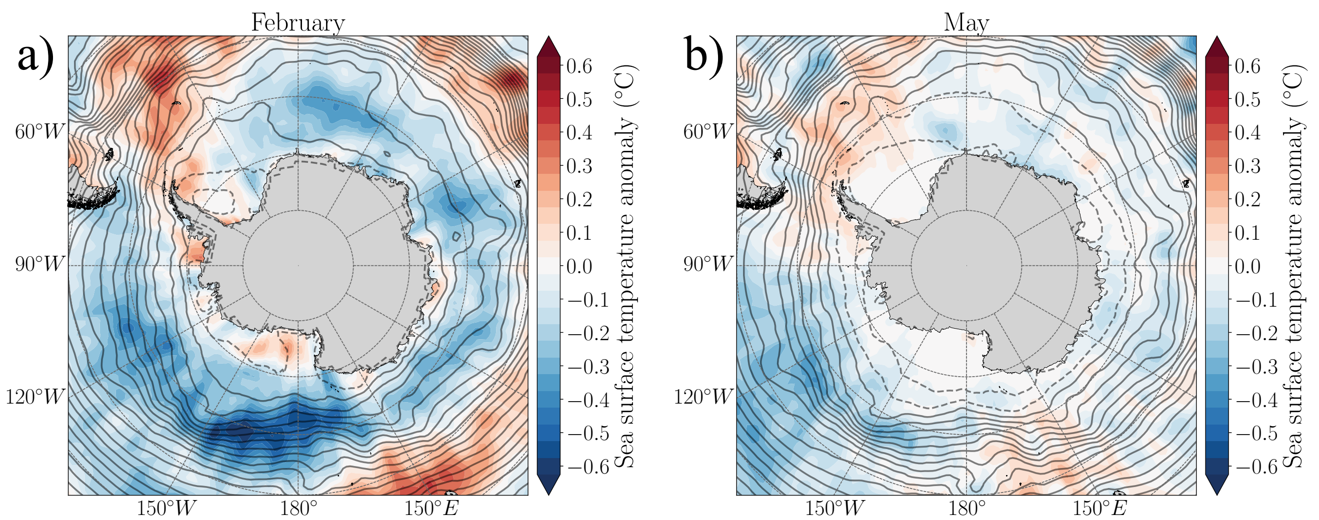
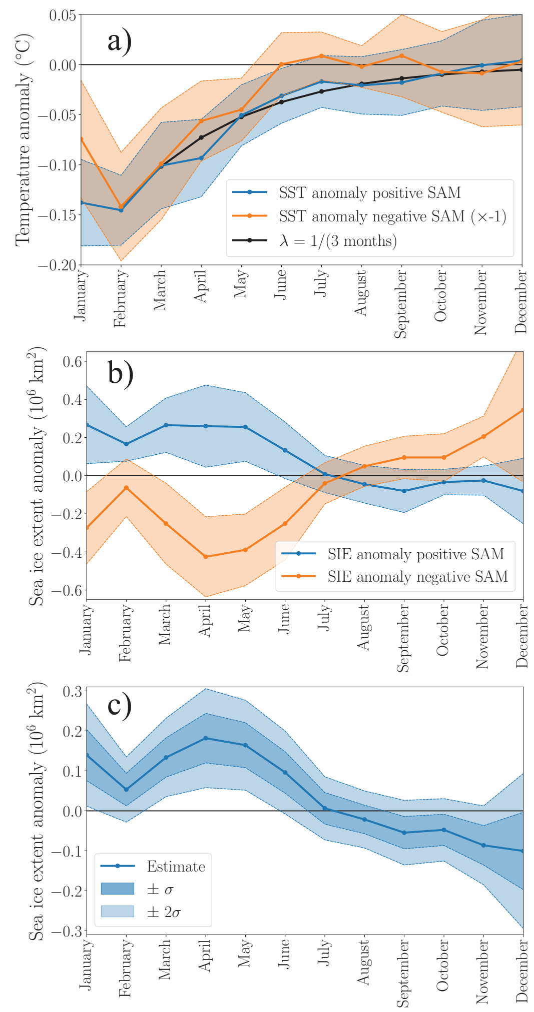


Fig. 2 Sea surface temperature anomalies calculated as the positive DJF SAM composite minus the negative DJF SAM composite divided by 2 in a) February and b) May.



The largest SST anomaly occurs in February and subsequently decays away. The effect on sea ice exhibits a substantially different seasonality; the effect builds over several months, peaking in April when a unit change in the detrended summertime SAM is followed by a 1.8±0.6 $\times 10^5$ km^2 change in detrended sea ice extent. Due to the large uncertainties in the observations, we are unable to discern a signal from DJF SAM on the wintertime sea ice extent maximum.

Fig. 3 (left) a) Composites of seasonal SST anomalies for positive (blue) and negative (orange) DJF SAM anomalies. b) Composites of sea ice extent anomalies for positive (blue) and negative (orange) DJF SAM anomalies. c) Impact of 1σ DJF SAM on sea ice extent estimate from linear regression.

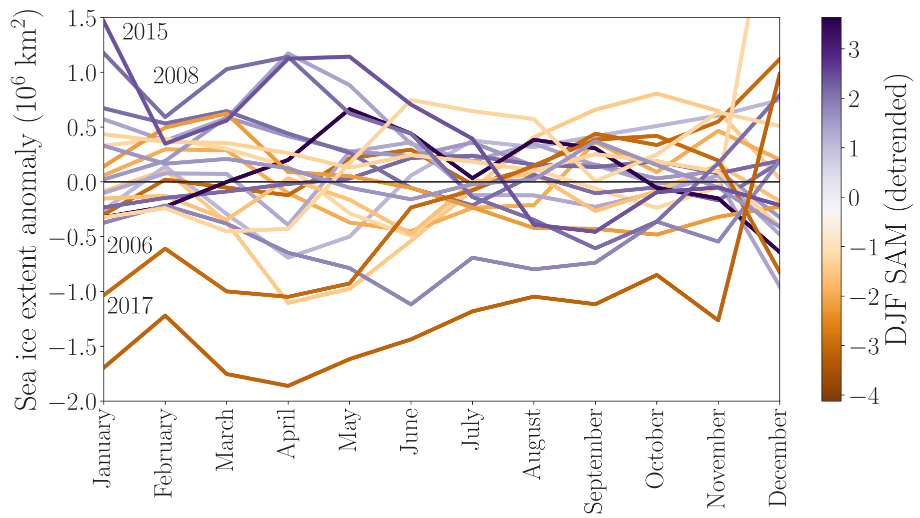


Fig. 4 Individual years from sea ice extent anomaly composites. Note the trend for orange years (following negative DJF SAM) to have less ice, and purple years (following positive DJF SAM) to have more ice.

Our analysis shows that the wind anomalies related to the negative SAM during the 2016/2017 austral summer contributed to the record minimum Antarctic sea ice extent observed in March 2017.

References

Dee, D. P., Uppala, S. M., Simmons, A. J., Berrisford, P., Poli, P., Kobayashi, S., … Vitart, F. (2011). The ERA-Interim reanalysis: configuration and performance of the data assimilation system. Quarterly Journal of the Royal Meteorological Society, 137(656), 553–597.

Doddridge, E. W., & Marshall, J. C. (2017). Modulation of the Seasonal Cycle of Antarctic Sea Ice Extent Related to the Southern Annular Mode. Geophysical Research Letters, 44(19), 9761–9768.

Marshall, G. J. (2003). Trends in the Southern Annular Mode from Observations and Reanalyses. Journal of Climate, 16(24), 4134–4143.

NOAA_OI_SST_V2 data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at https://www.esrl.noaa.gov/psd/

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