

Recent decline in Antarctic sea ice cover from 2016 to 2022: Insights from satellite observations, Argo floats, and model reanalysis

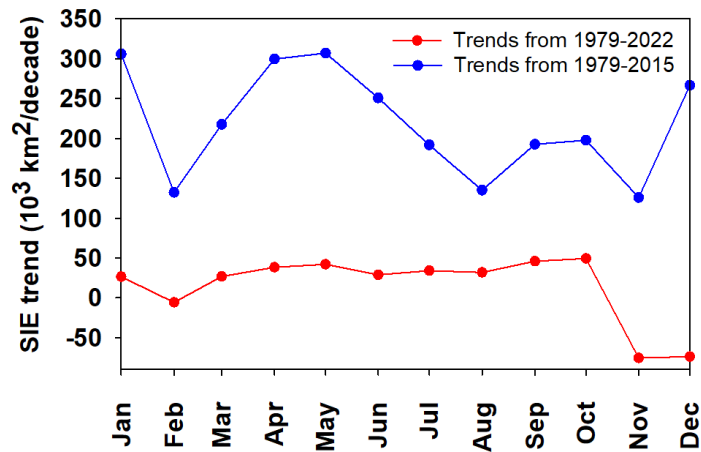
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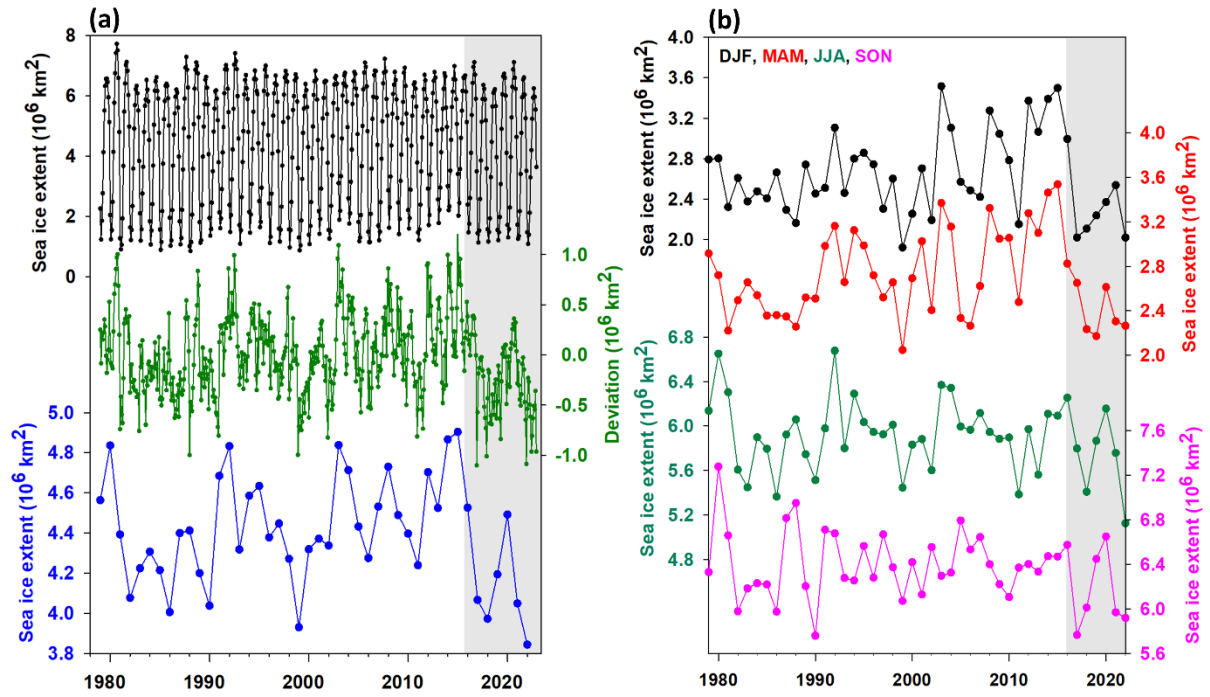
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Supplementary figures

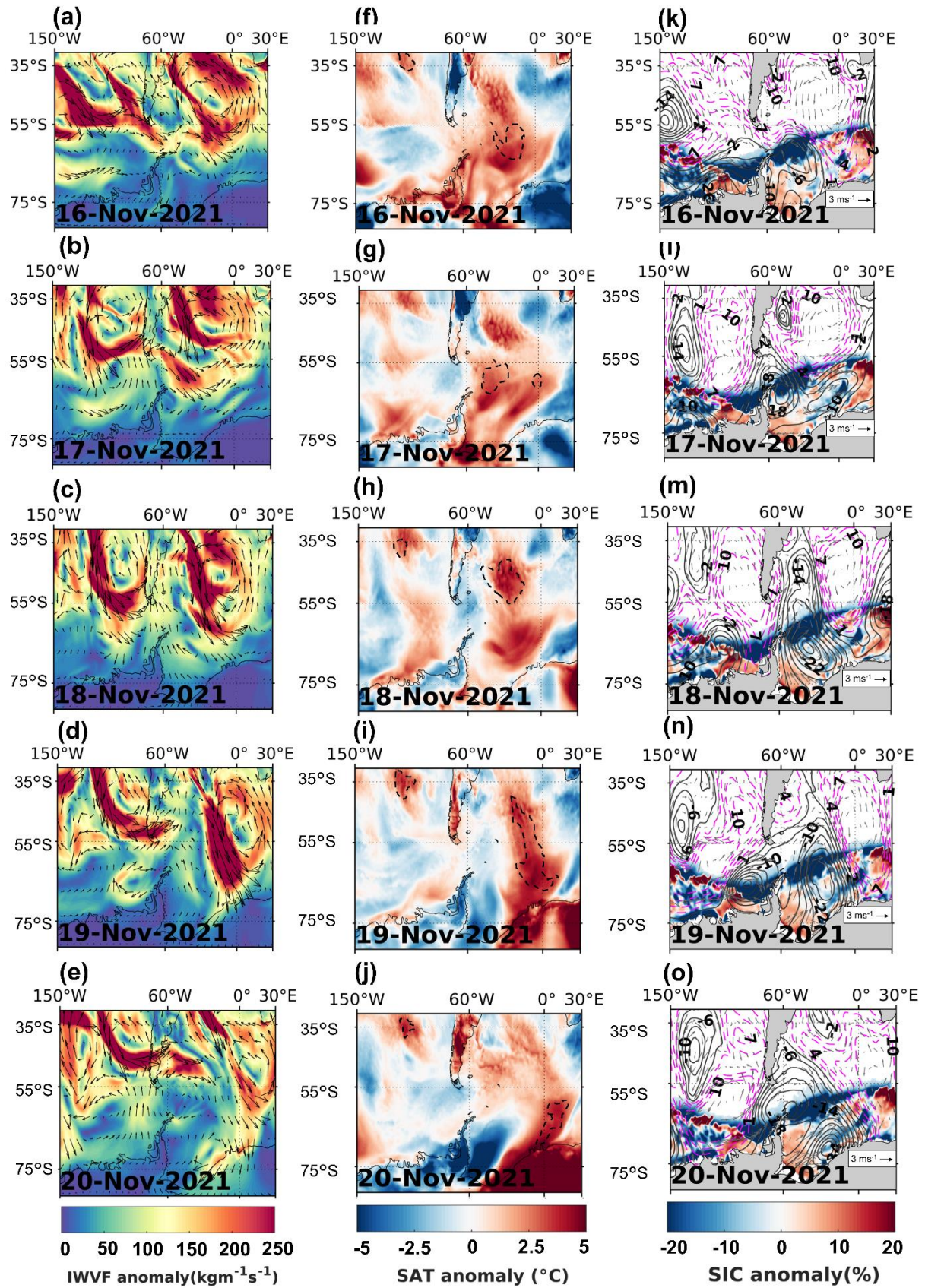


Supporting Figure S1: The monthly sea ice trend ($10^3 \text{ km}^2 \text{ decade}^{-1}$) for Southern Ocean from (a)1979 to 2022 (red) and (b) 1979 to 2015 (blue)



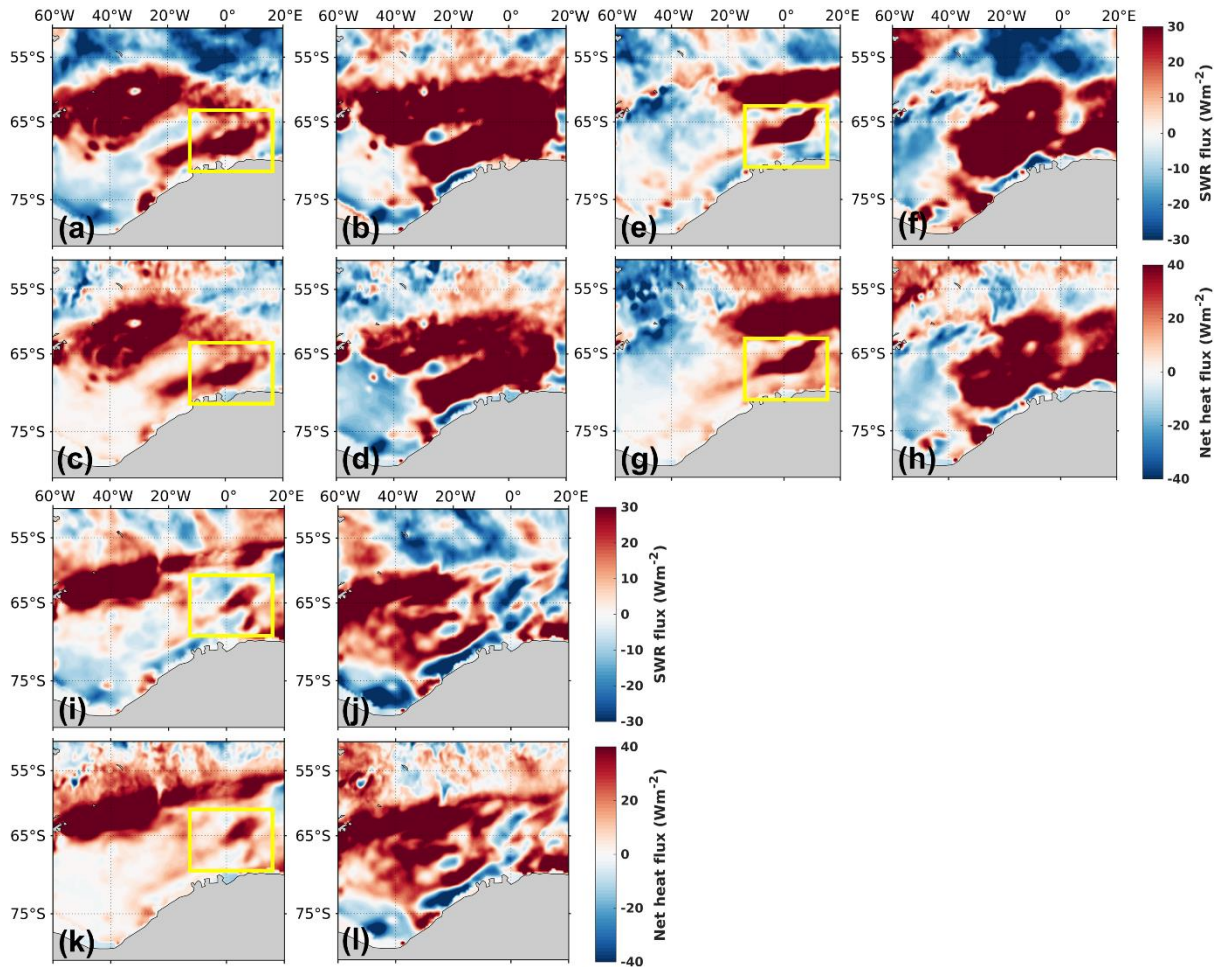
Supporting Figure S2: The monthly, yearly and seasonal variability of sea ice extent (10^6 km^2) in Weddell Sea.

(a) Monthly average sea ice extents represented in black line plot, Monthly deviation in green, and blue represents the yearly average sea ice extent from 1979 to 2022. (b) Seasonal average sea ice extents for summer (DJF), autumn (MAM), winter (JJA), and spring (SON) seasons. The period of sea ice decline from 2016 to 2022 is highlighted in grey

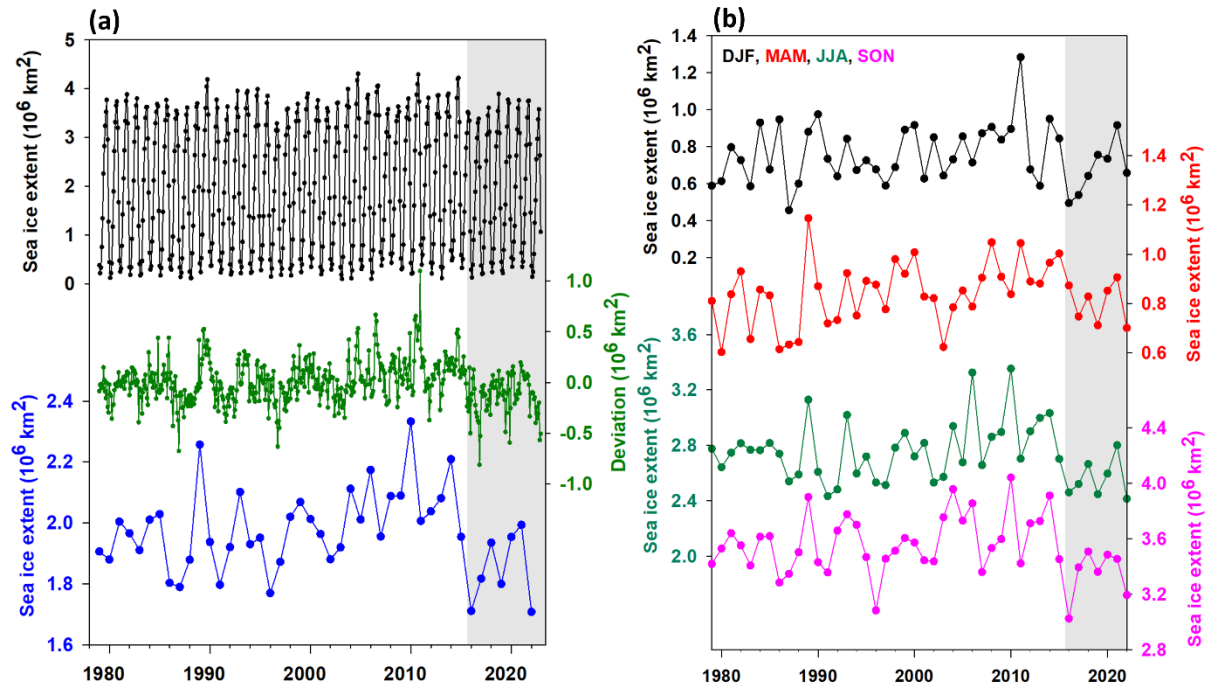


Supporting Figure S3: Daily anomalies of (a-e) Integrated water vapour flux (IWVF), (f-j) surface air temperature (SAT), and (k-o) sea ice concentration (SIC) overlaid by the anomalies of mean sea level pressure

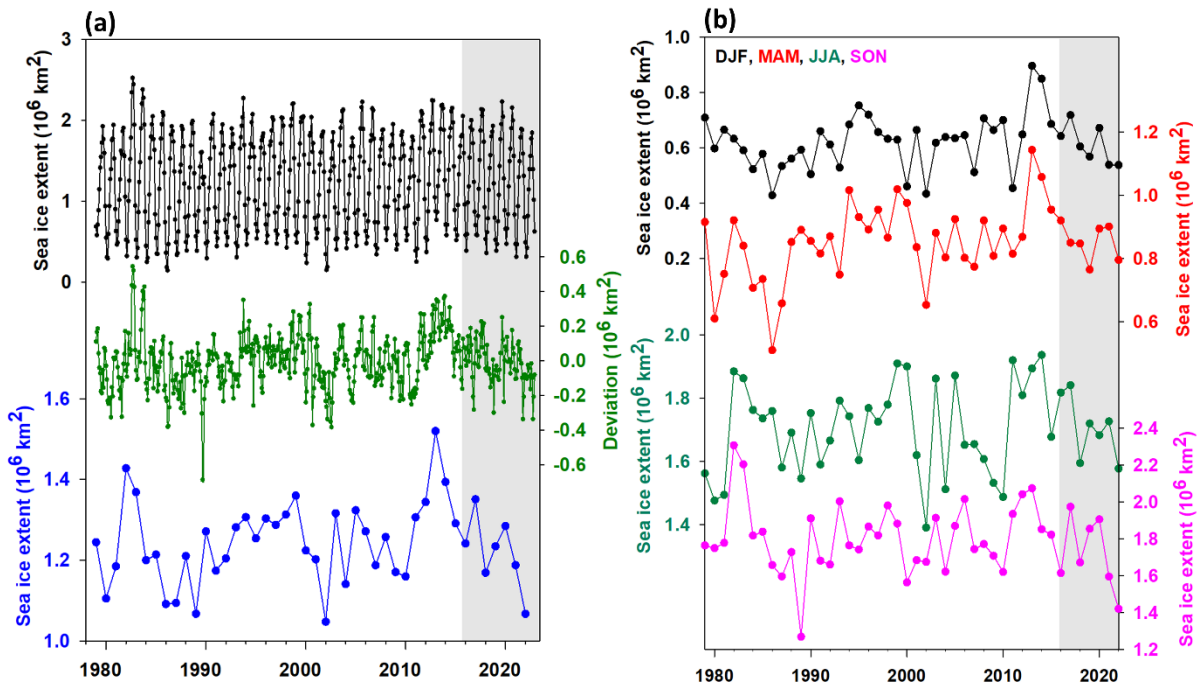
(MSLP) and wind directions (grey) from 16 to 20 November 2021. The solid black line contours represent the negative MSLP anomaly and the dashed line (magenta) contours represent the positive MSLP anomaly. The black dashed contours in (f-j) represent the record maximum SAT during the entire time period from 1979 to 2022.



Supporting Figure S4: The short-wave radiation flux (a-b-e-f-i-j) and net heat flux (c-d-g-h-k-l) anomalies for (a & c) November 2016, (b & d) December 2016, (e & g) November 2017, (f & h) December 2017, (i & k) November 2021, (j & l) December 2021. The Maud rise polynya is highlighted in a yellow colored box. The anomalies are calculated with respect to the climatology from 1979 to 2015

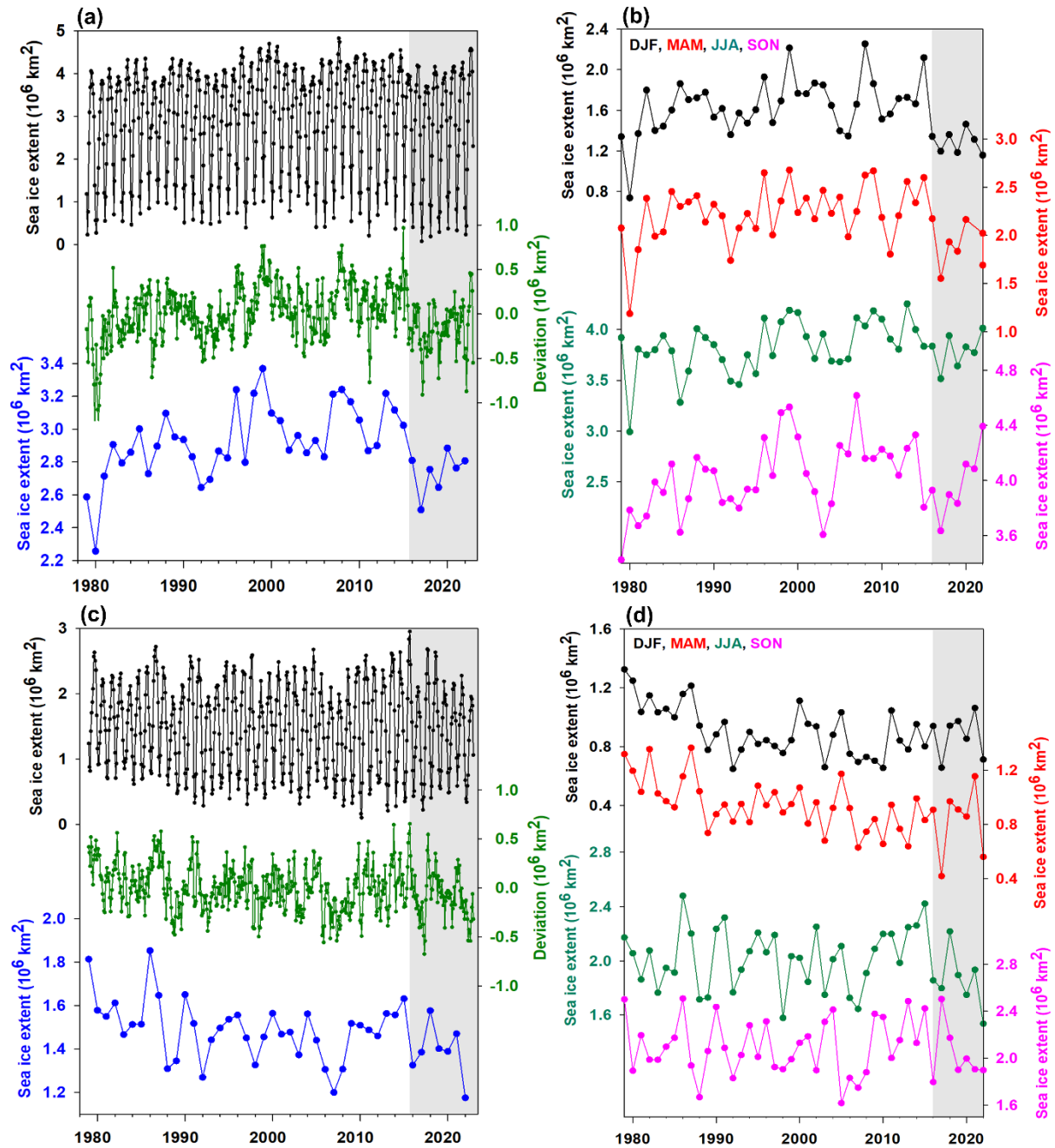


Supporting Figure S5: The monthly, yearly and seasonal variability of sea ice extent (10^6 km^2) in Indian Ocean sector. (a) Monthly average sea ice extents represented in black line plot, Monthly deviation in green, and blue represents the yearly average sea ice extent from 1979 to 2022. (b) Seasonal average sea ice extents for summer (DJF), autumn (MAM), winter (JJA), and spring (SON) seasons. The period of sea ice decline from 2016 to 2022 is highlighted in grey



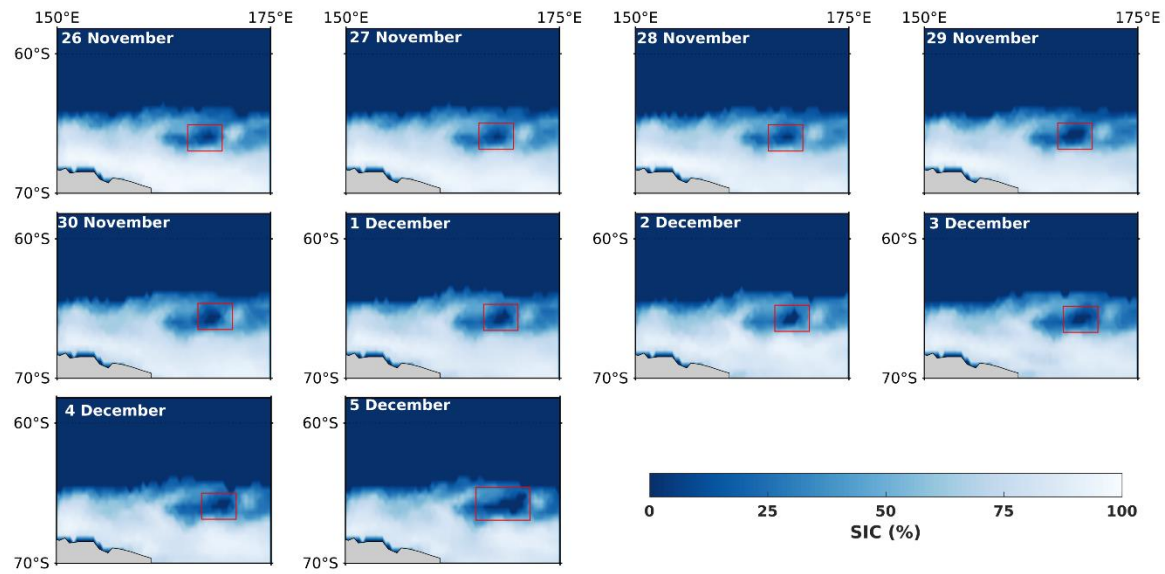
Supporting Figure S6: The monthly, yearly and seasonal variability of sea ice extent (10^6 km^2) in Western Pacific. (a) Monthly average sea ice extents represented in black line plot, Monthly deviation in green, and blue

represents the yearly average sea ice extent from 1979 to 2022. (b) Seasonal average sea ice extent for summer (DJF), autumn (MAM), winter (JJA), and spring (SON) seasons. The period of sea ice decline from 2016 to 2022 is highlighted in grey

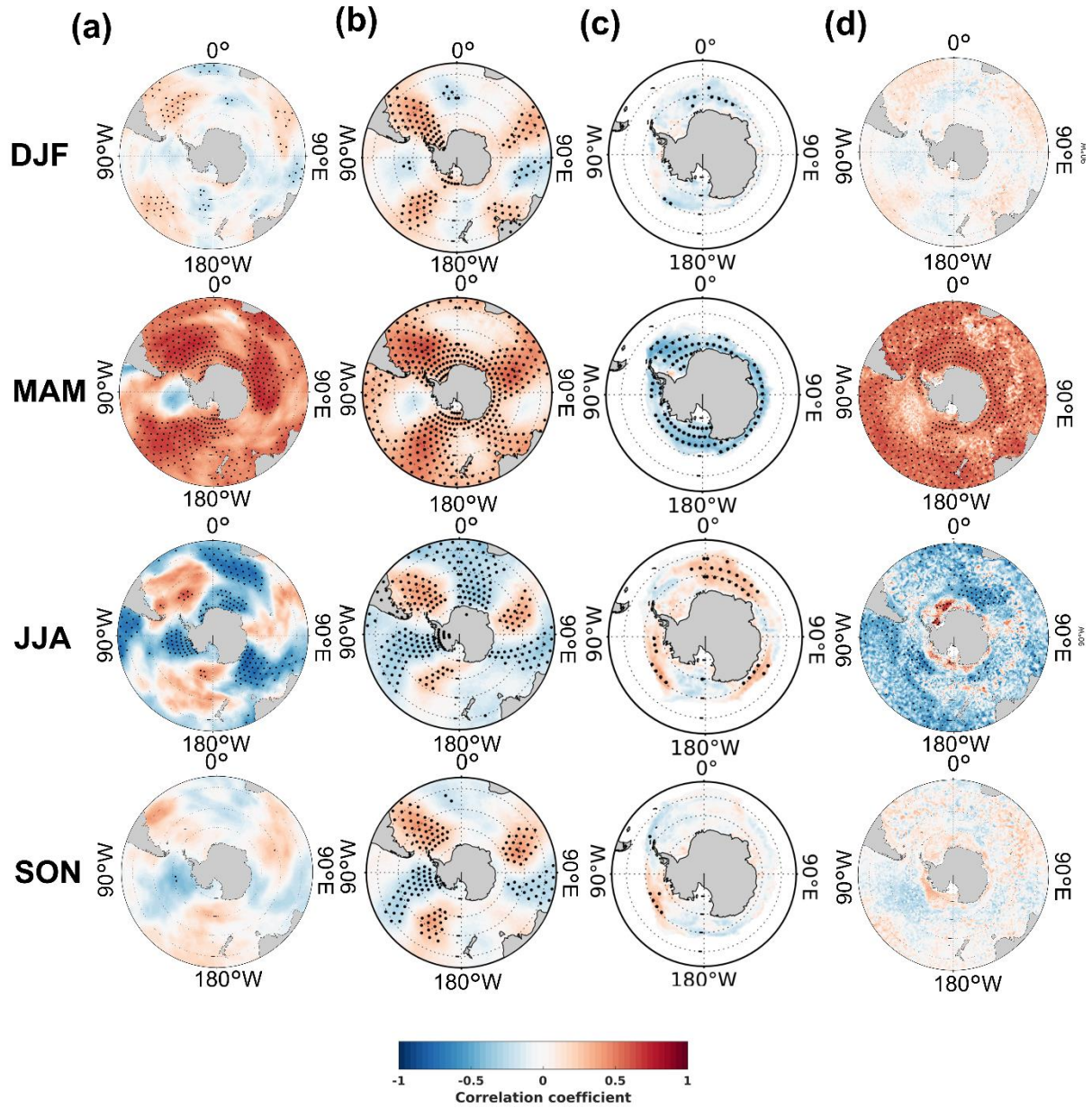


Supporting Figure S7: The monthly, yearly and seasonal variability of sea ice extent (10^6 km^2) in the (a-b) Ross Sea and (c-d) Bellingshausen-Amundsen Seas. In Figures a and c, monthly average sea ice extents are represented in black line, monthly deviation in green, and blue represents the yearly average sea ice extent from 1979 to 2022.

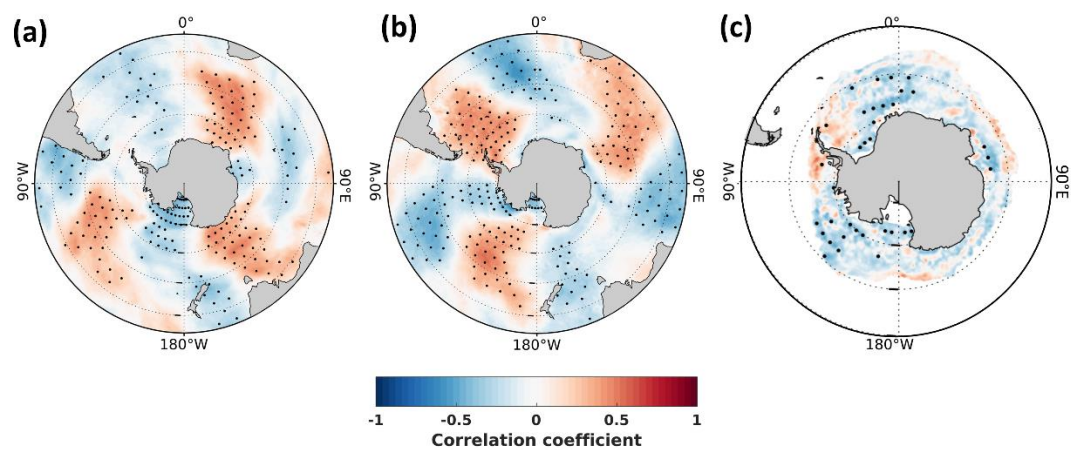
Figures b and d represent the seasonal average of sea ice extents for summer (DJF), autumn (MAM), winter (JJA), and spring (SON) seasons. The period of sea ice decline from 2016 to 2022 is highlighted in grey



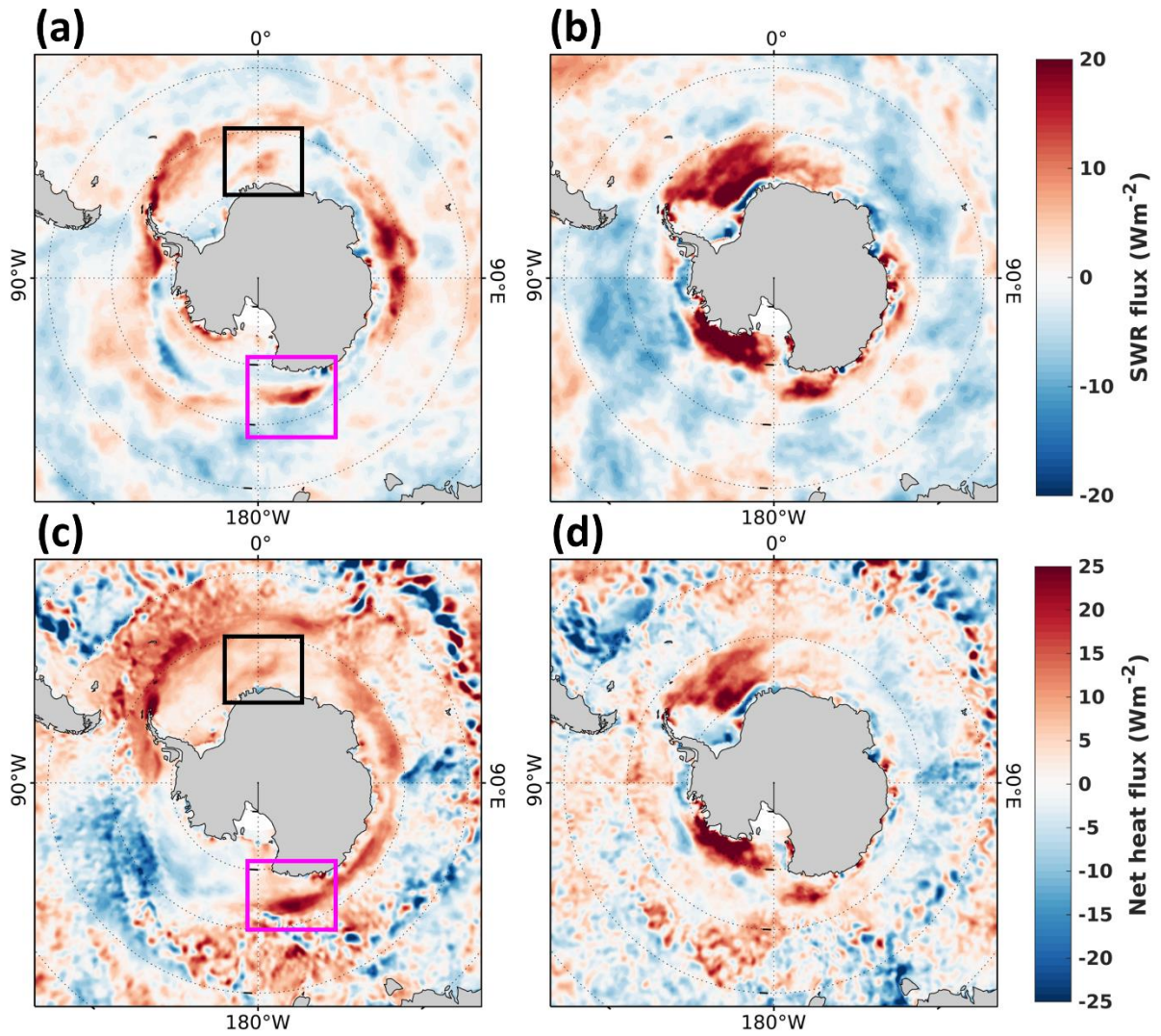
Supporting Figure S8: The reoccurrence of Ross Sea polynya (Red rectangle) from 26 November 2021 to 5 December 2021



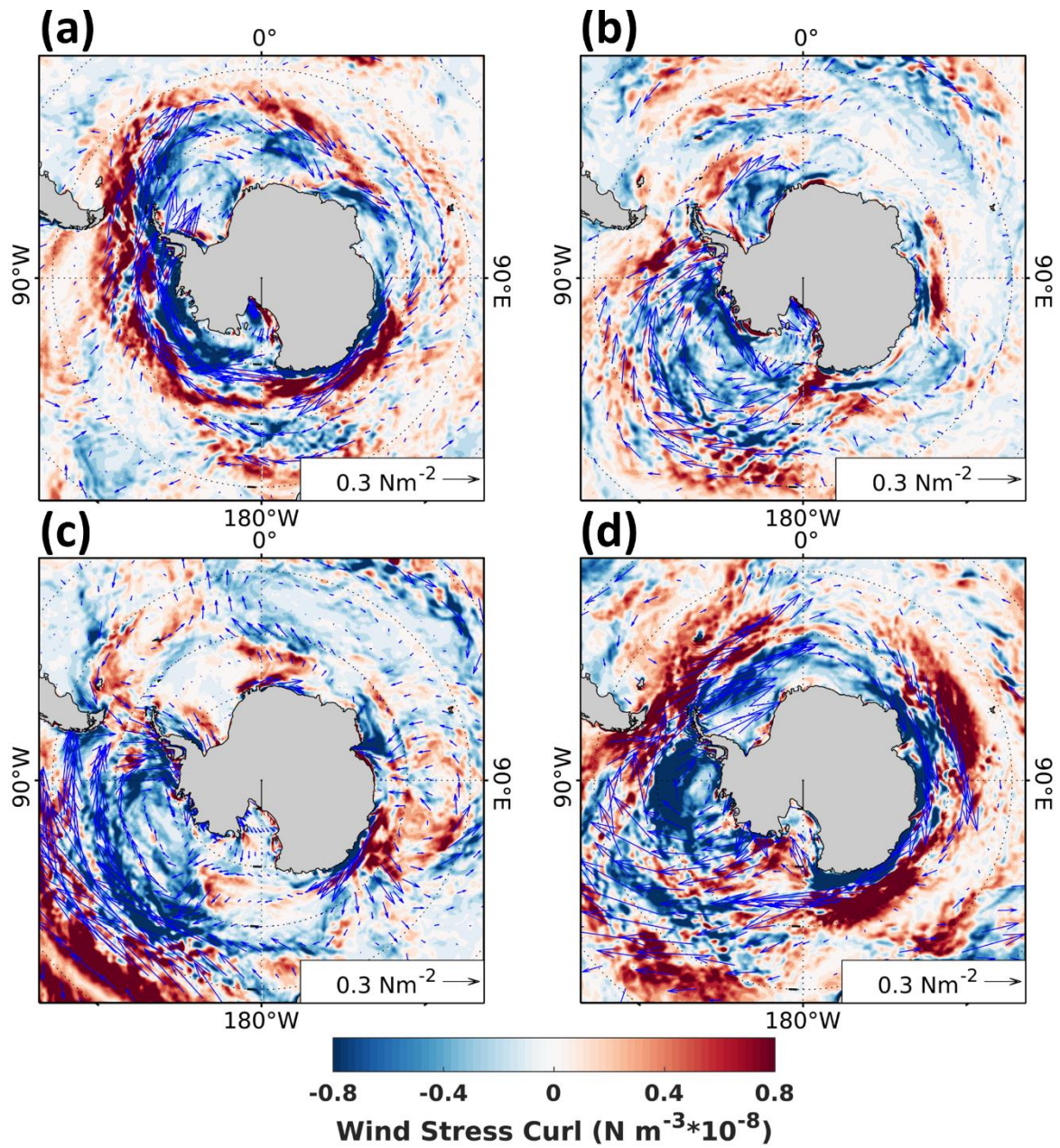
Supporting Figure S9: Correlation of zonal wave 3 index ($p < 0.05$) with (a) total column water vapor (b) surface air temperature (c) sea ice concentration (d) mixed layer temperature for DJF, MAM, JJA, and SON of 2016-2022.



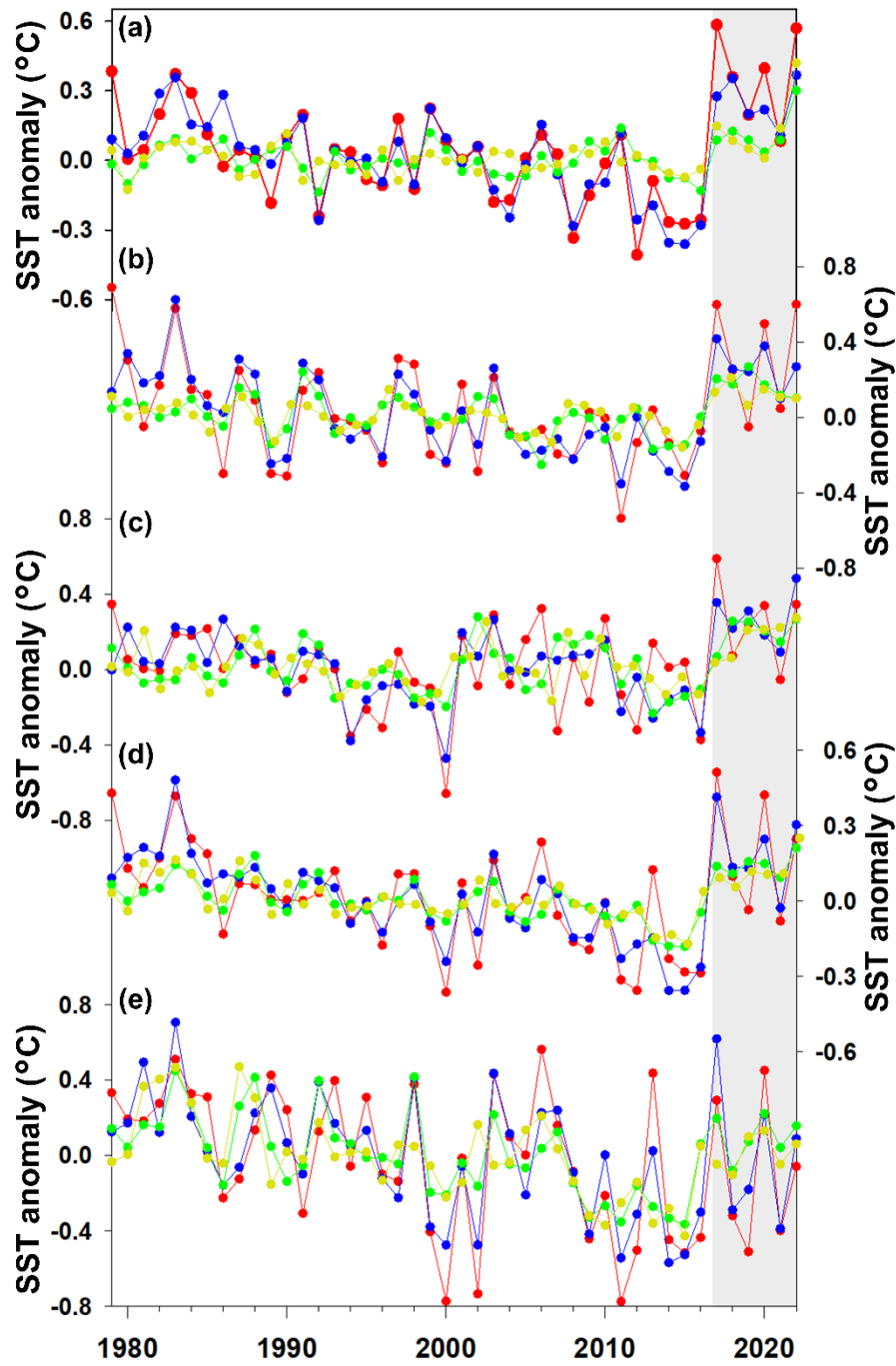
Supporting Figure S10: Correlation of zonal wave 3 index ($p < 0.05$) with (a) total column water vapor (b) surface air temperature (c) sea ice concentration for spring (SON) of 2016-2022.



Supporting Figure S11: The seasonal average anomaly of short-wave radiation flux (Wm^{-2}) and net heat flux (Wm^{-2}) composite from 2016 to 2022 for (a & c) spring (SON) and, (b & d) summer (DJF) seasons. The black (magenta) colored box indicates the polynya region in Weddell (Ross) Seas. The anomaly is calculated with respect to the climatology from 1979 to 2015



Supporting Figure S12: The seasonal average anomaly of wind stress curl (Nm^{-3}) composite from 2016 to 2022 overlaid by the wind stress vectors (blue arrows, Nm^{-2}) for (a) summer (DJF), (b) autumn (MAM), (c) winter (JJA), and (d) spring (SON). The anomaly is computed with respect to the climatology from 1979 to 2015



Supporting Figure S13: The seasonal sea surface temperature (SST) anomaly for (a) Weddell Sea (WS), (b) Indian Ocean, (IO) (c) Western Pacific (WP), (d) Ross Sea (RS), (e) Amundsen-Bellingshausen Sea (BAS) from 1979 to 2022. The anomaly is computed with respect to the climatology from 1979 to 2015. The period of sea ice decline from 2016 to 2022 is highlighted in grey