Interpretation of Recent Antarctic Sea Ice Loss: The Key Role of Atmospheric Circulation During the Seasonal Sea Ice Maximum

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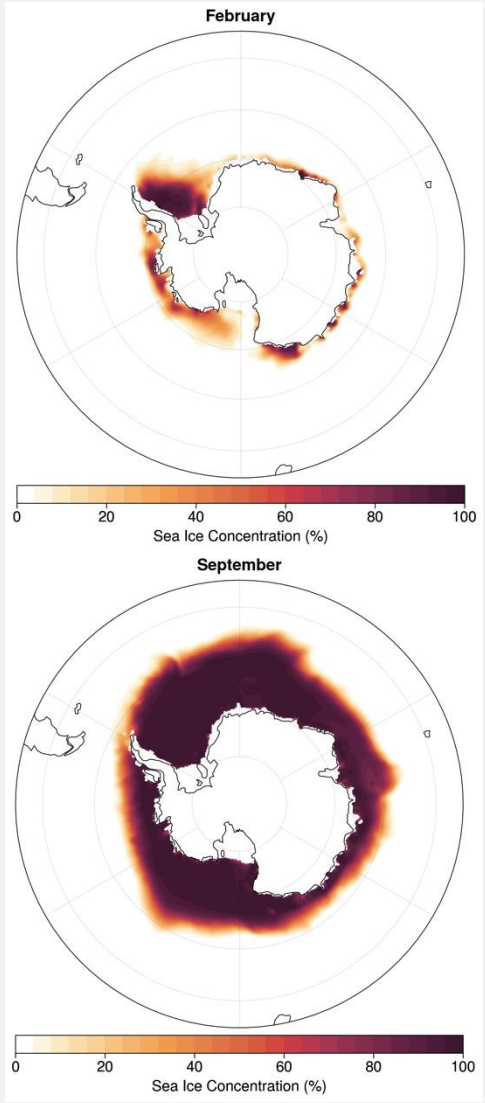
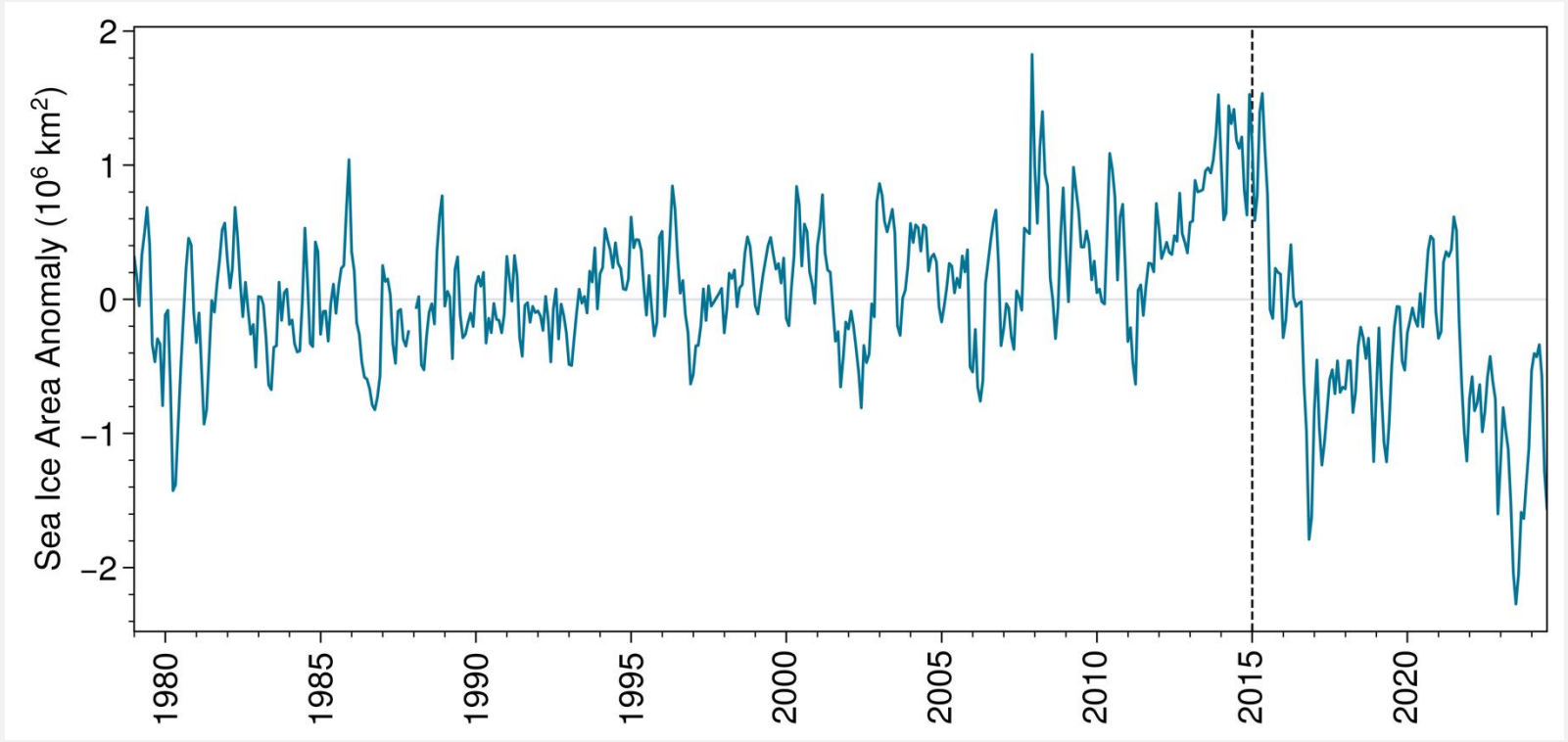
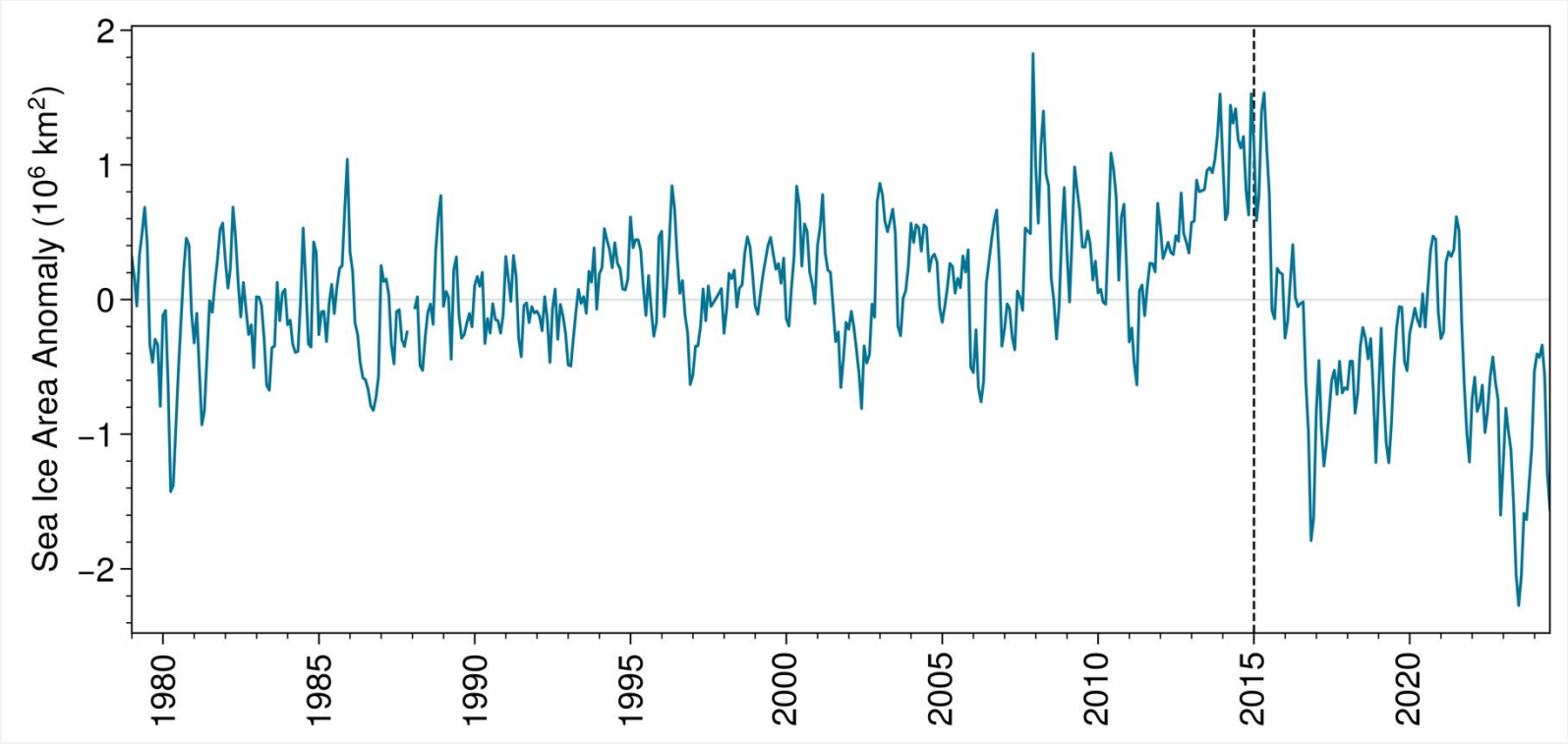
Annual-mean Antarctic sea ice extent has decreased roughly 2.5 million km^2 in the last decade.





Numerous physical factors are thought to underlie the marked changes in Antarctic sea ice.

- Increases in upper-ocean heat content (Meehl et al. 2019; Purich and Doddridge 2023)
- Teleconnections to tropical climate variability (Stuecker et al. 2017; Purich and England 2019; Li et al. 2021)
- Atmospheric anomalies, such as the zonal wave number three pattern and the Southern Annular Mode (Raphael and Hobbs 2014; Turner et al. 2017; Doddridge and Marshall 2017; Schlosser et al. 2018; Polvani et al. 2021)



What is the role of the Southern Annular Mode in driving recent sea ice anomalies? How does it vary by season and lag?

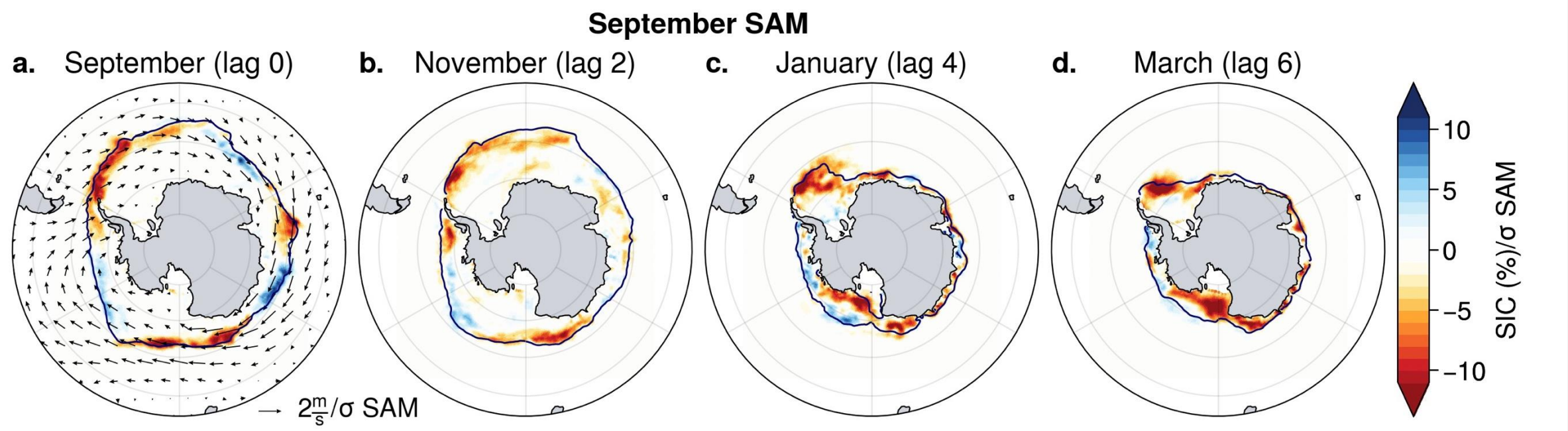
Data

- Monthly gridded sea ice concentration (SIC) data from NSIDC
- Monthly gridded wind and temperature data from ERA5 reanalysis
- Monthly SAM index from NOAA CPC
  - Computed via EOF analysis on monthly-mean 700-hPa height anomalies
- Data covers period January 1979 – July 2024

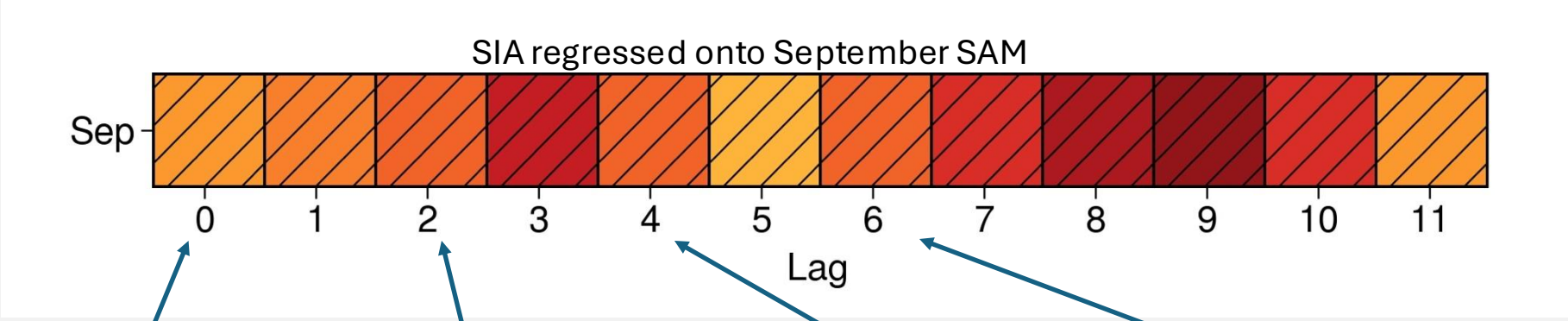
Methodology

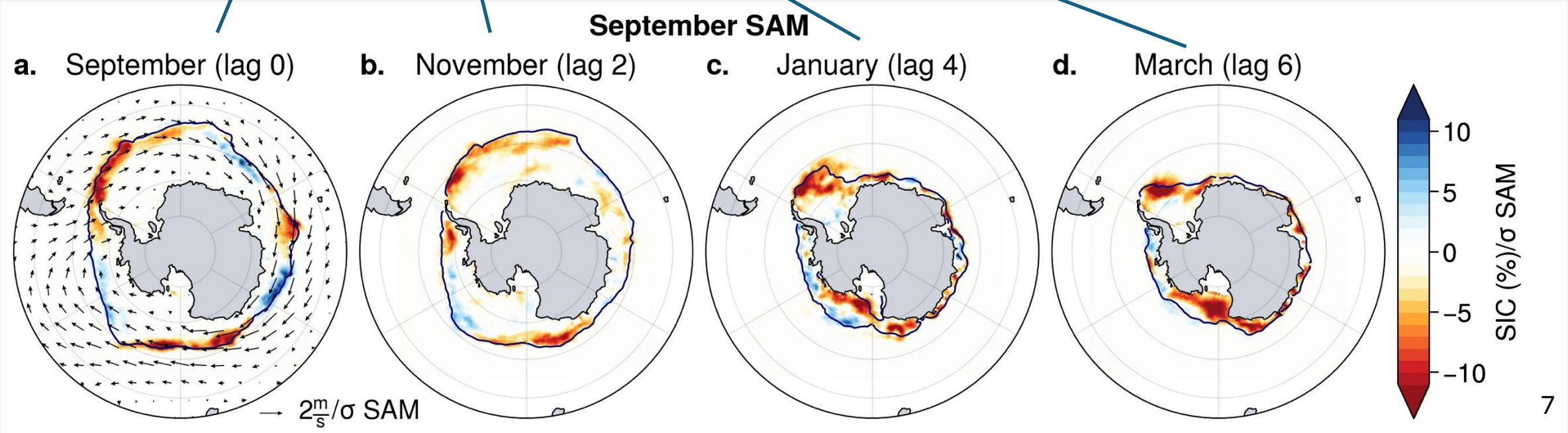
- Southern Hemisphere (SH) mean sea ice area (SIA) computed by multiplying SIC data by grid box area, then summing across SH
- All data detrended and deseasonalized

Variations in the September SAM are associated with a heterogeneous pattern of sea ice anomalies.

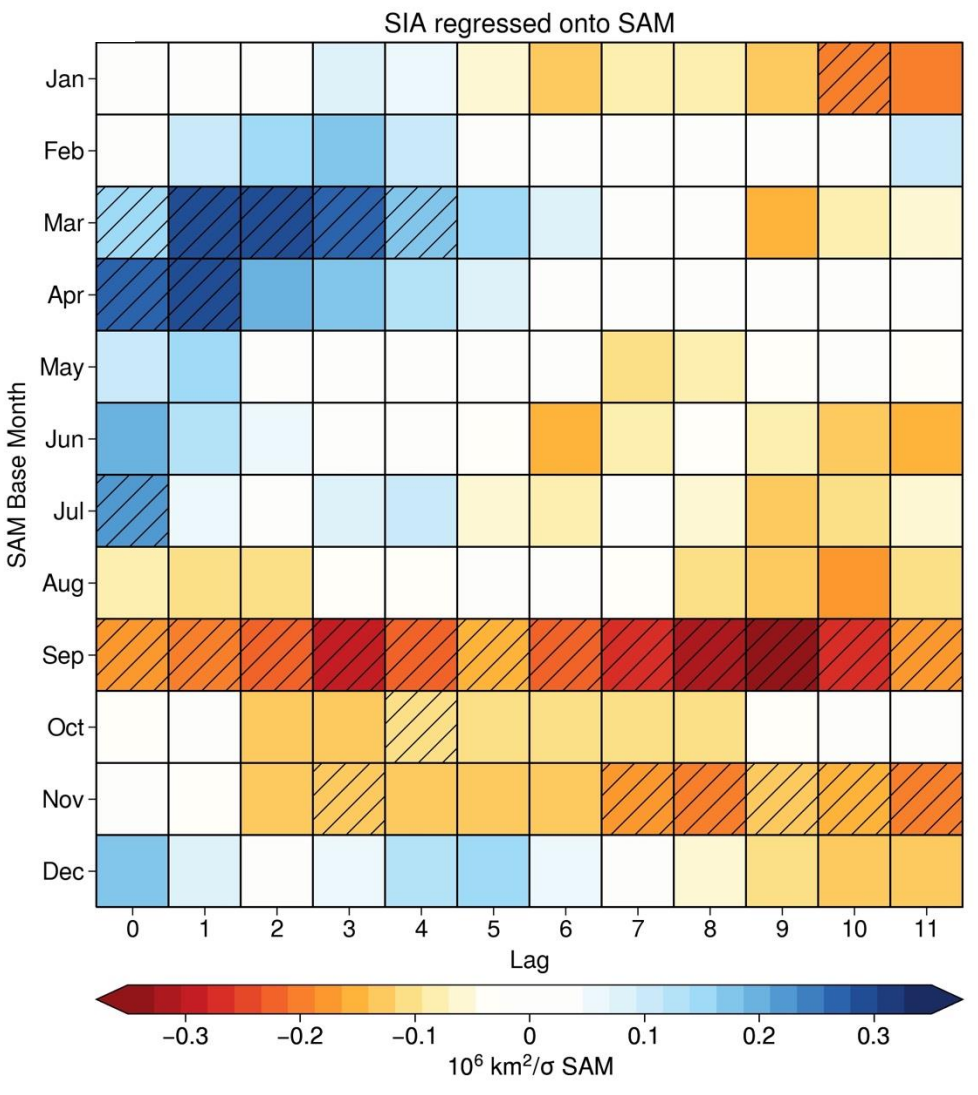


In the hemispheric mean, these SIC anomalies result in a net decrease in sea ice area (SIA).





Monthly regression analysis of the linkages between SIA and the SAM.



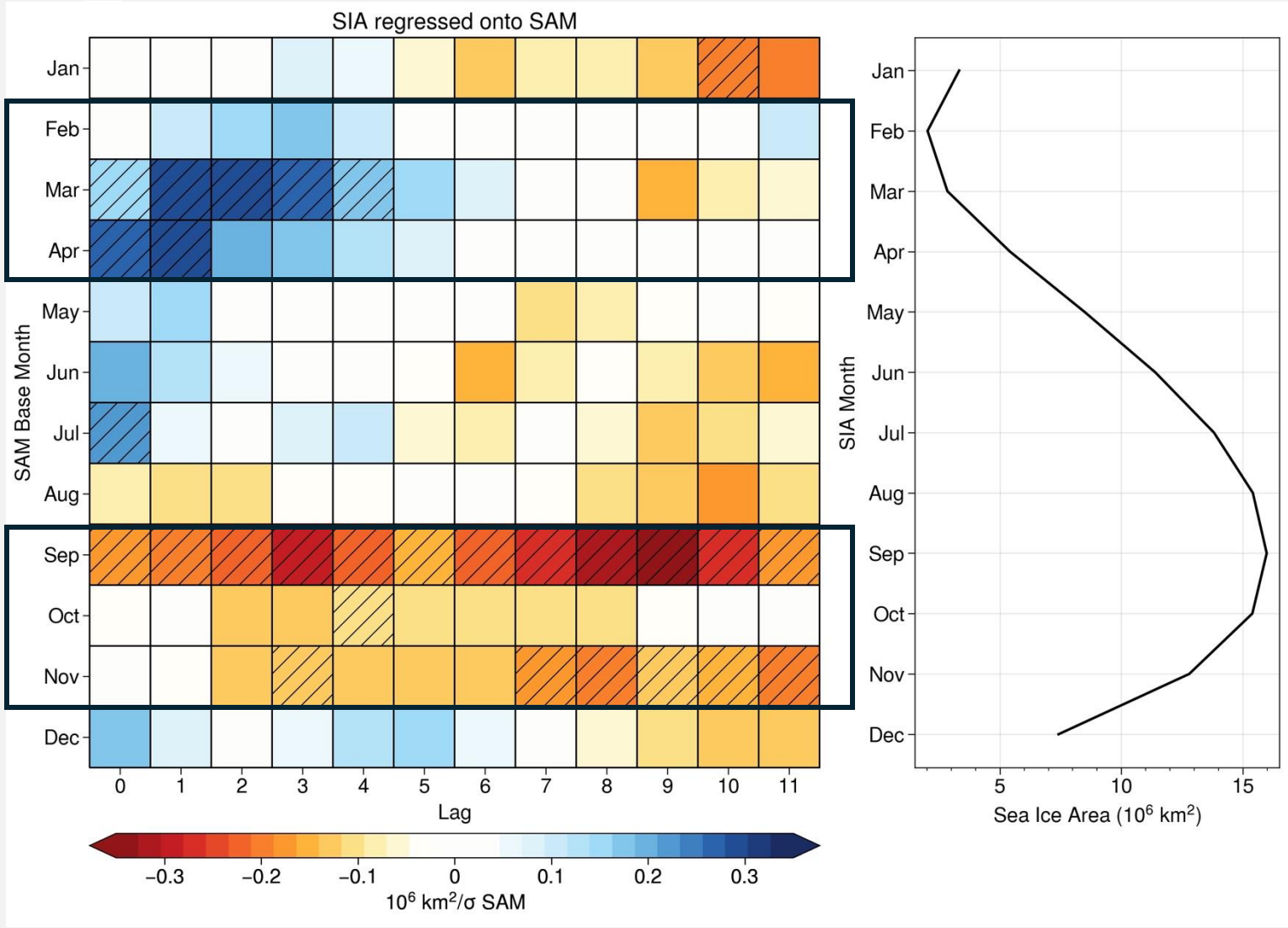
SIA regressed onto September SAM

Hatching indicates statistical significance at 95% confidence interval.

The sign of the relationship between the SAM and SIA anomalies has a clear seasonality.

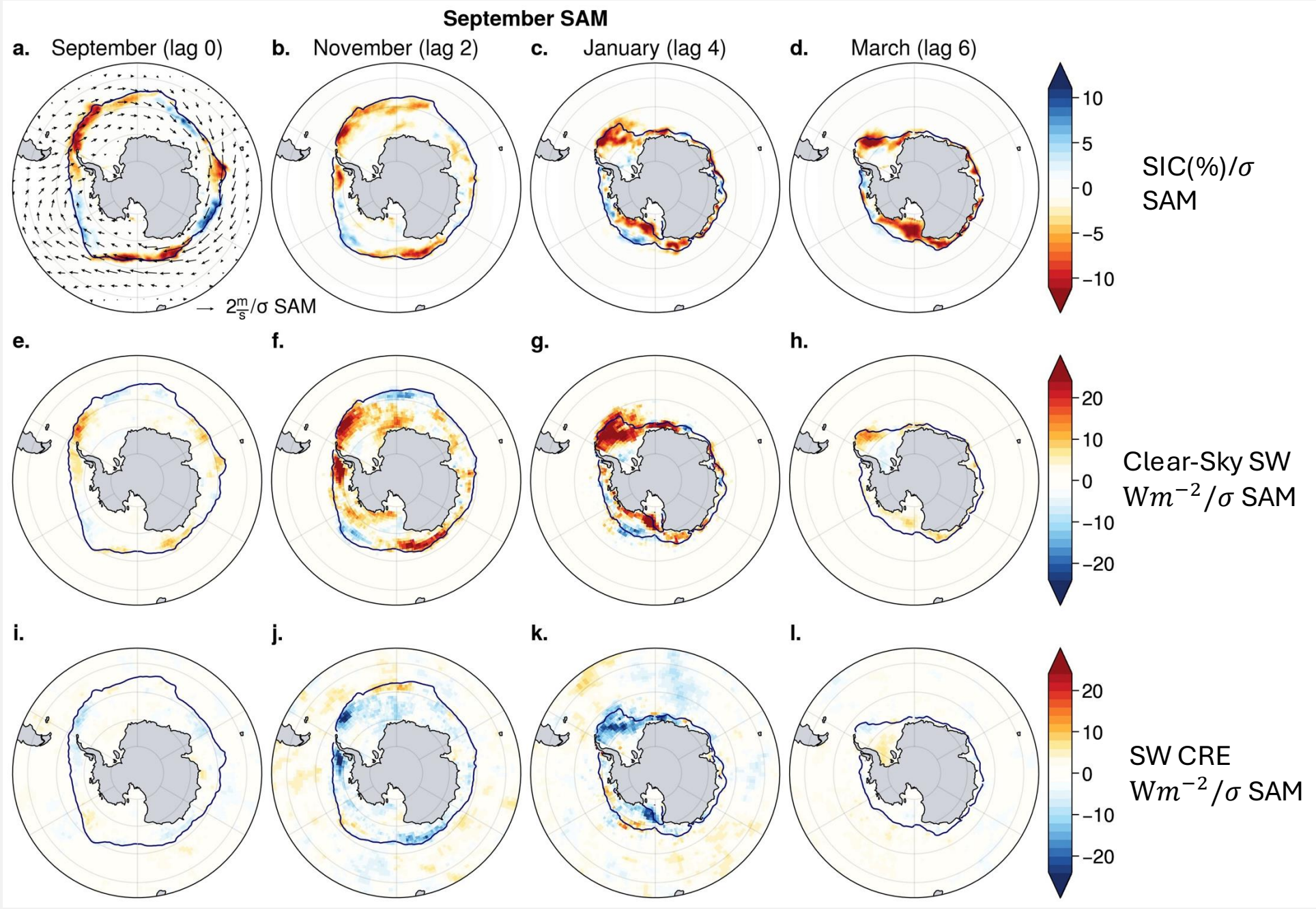
Sea Ice Minimum Season

Sea Ice Maximum Season



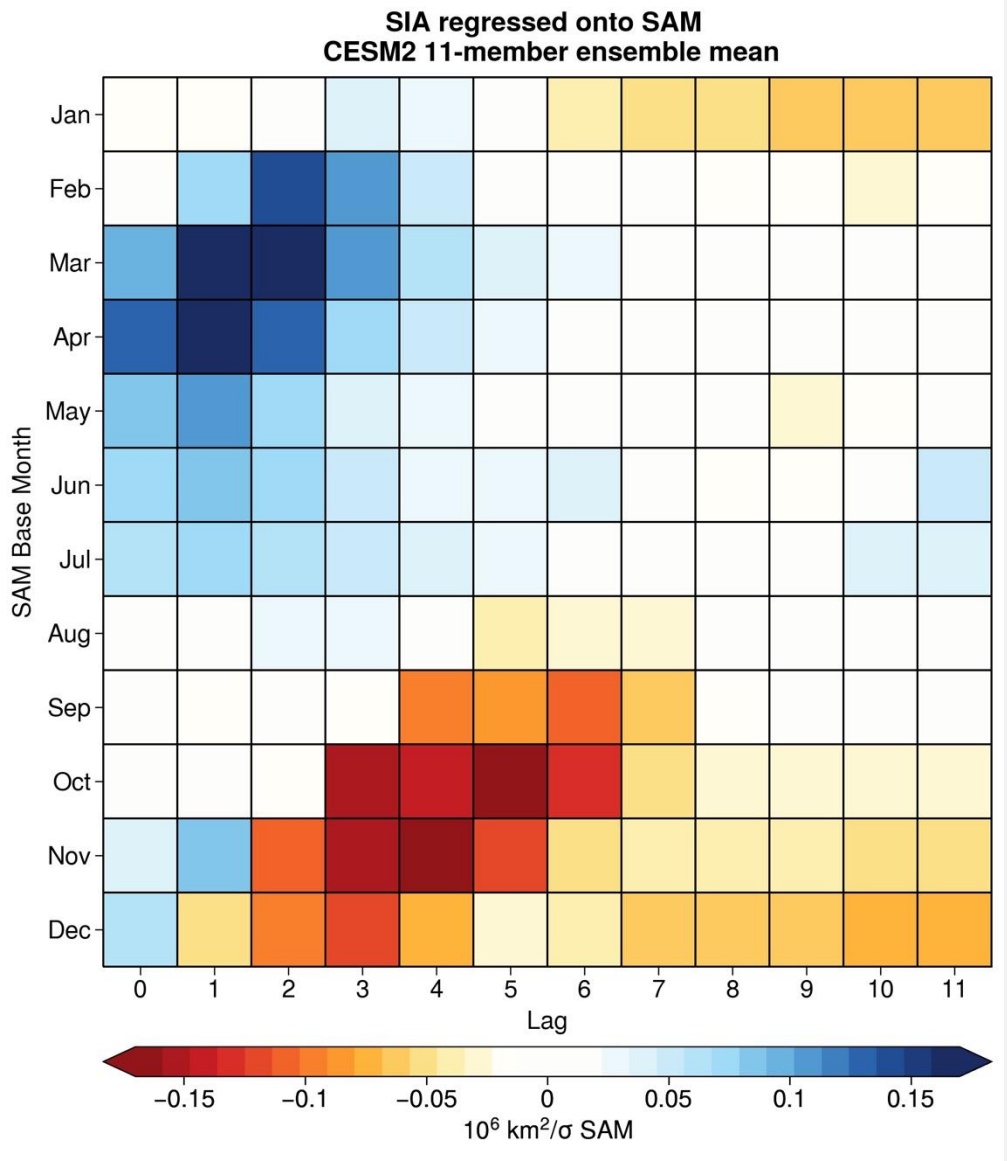
Hatching indicates statistical significance at 95% confidence interval.

What drives the persistence of the sea ice anomalies associated with the September SAM?

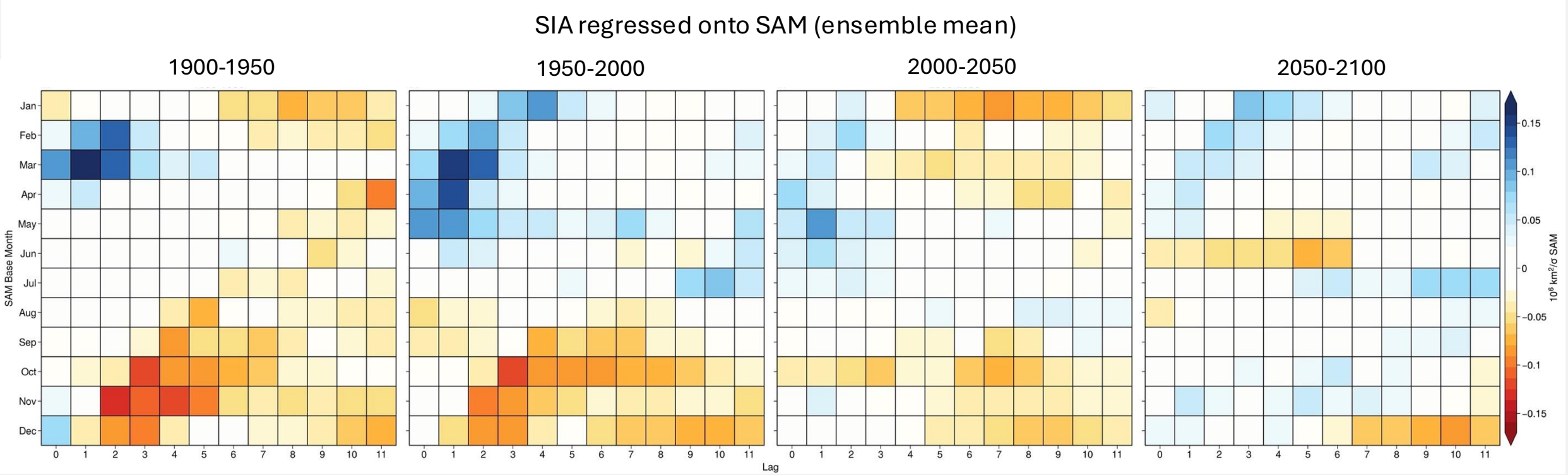


Fluxes are positive when energy is deposited into the surface.

The seasonality of the SIA-SAM relationship is reproducible in the CESM2 historical simulation.

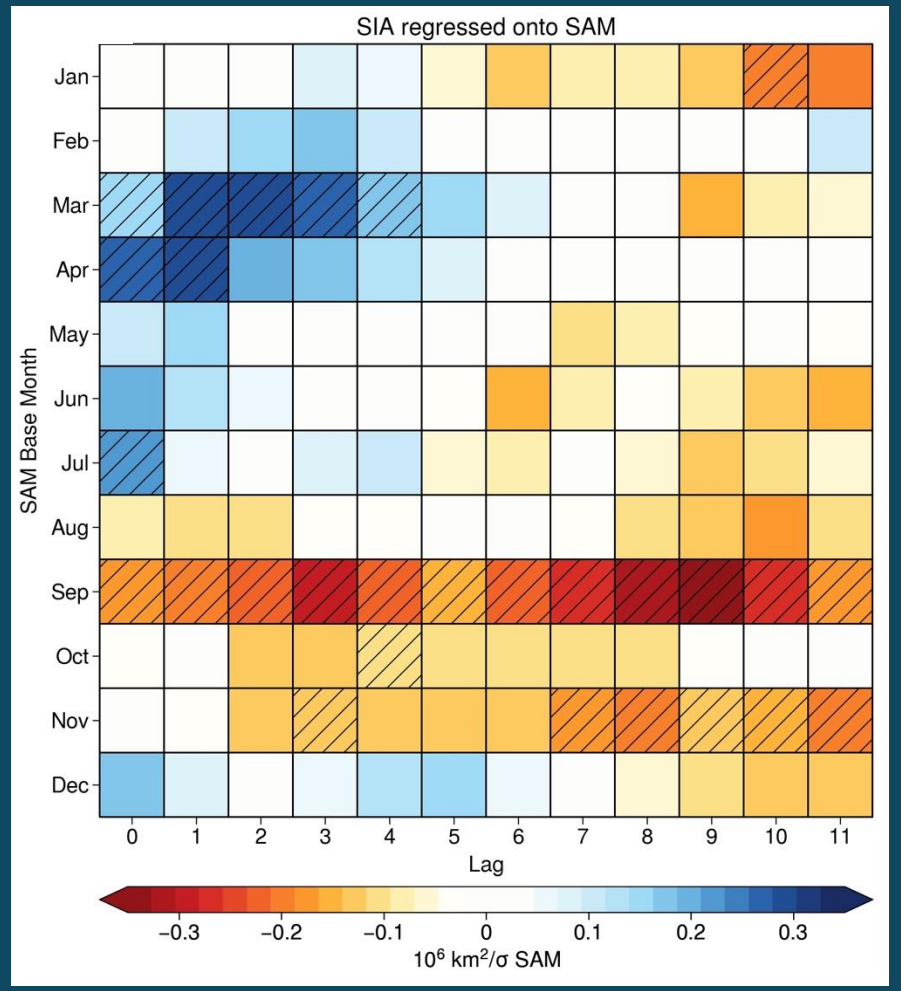


The SIA-SAM linkages weaken as the sea ice coverage decreases in the 21st century.



- CESM2 historical simulation and SSP5-8.5 simulation

- Changes in the SAM impacts sea ice anomalies during two key seasons: the annual sea ice maximum and the annual sea ice minimum.
- The persistence of SIA anomalies from changes in the SAM during the annual maximum have a marked impact on annual-mean changes in SH SIA.
- Linkages between SIA and the SAM are reproducible in CESM2



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Boehm, C., D. W. J. Thompson, E. Blanchard-Wrigglesworth, 2025: Interpretation of Recent Southern Hemisphere Sea Ice Loss: The Key Role of the Southern Annular Mode During the Seasonal Sea Ice Maximum, in prep.